A Continent-wide Map of all Things Aquatic: The eDNA Atlas and Archive for North America

Mike Young, Dan Isaak, Mike Schwartz, Kevin McKelvey, John Rothlisberger*, Dan Shively, and a cast of hundreds...
“To keep every cog and wheel is the first precaution of intelligent tinkering”

Aldo Leopold

What Are the Cogs & Wheels in Aquatic Ecosystems?
Most Species Information is Coarse
Limited Utility to Managers & Conservationists
& Our View is Skewed…
Lots of Data for a Few Species…

Little Data for Most…

<table>
<thead>
<tr>
<th>Species</th>
<th>Occurrences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Longnose dace</td>
<td>169</td>
</tr>
<tr>
<td>Speckled dace</td>
<td>52</td>
</tr>
<tr>
<td>Redside shiner</td>
<td>129</td>
</tr>
<tr>
<td>Longnose sucker</td>
<td>235</td>
</tr>
<tr>
<td>Whitefish</td>
<td>2,026</td>
</tr>
<tr>
<td>Cutthroat trout</td>
<td>11,543</td>
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<tr>
<td>Rainbow trout</td>
<td>3,977</td>
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<tr>
<td>Chinook salmon</td>
<td>1,728</td>
</tr>
<tr>
<td>Brown trout</td>
<td>1,228</td>
</tr>
<tr>
<td>Bull trout</td>
<td>2,809</td>
</tr>
<tr>
<td>Brook trout</td>
<td>7,036</td>
</tr>
</tbody>
</table>

Ridiculously Large Area to Survey

- 3,000,000 km of perennial streams & rivers
- Thousands of lakes, springs, ponds
- >150 National Forests & Grasslands
A Solution: eDNA Sampling

- Fast & portable
- Rapid, broad-scale surveys are feasible
- Exceptionally accurate & specific
- Presence/absence estimates are robust (abundance estimates also possible)


$r^2 = 0.60-0.75$
USFS National Genomics Center for Wildlife & Fish Conservation

Promoting eDNA sampling

- Design of species-specific markers (40 so far, another 50 in development)
- Field-proven sampling protocol
- Field equipment loans
- Sample processing @ Missoula lab
- Long-term sample archiving (eDNArvice)
- Peer-reviewed science
Why Crowd-Source eDNA Sampling?

Advantages: Cost-Effective & Broad Engagement

Many stakeholders

“Boots-on-the-Ground”

Robust scientific information

Standardized data collection protocol

Advantages: Cost-Effective & Broad Engagement

“Boots-on-the-Ground”
Thousands of New Sites are Being Sampled Annually by Dozens of Partner Agencies

The eDNA Alliance

BLM
Bureau of Reclamation
Chehalis Tribe
Clark Fork Coalition
Coeur d'Alene Tribes
Great Northern LCC
Idaho Conservation League
Idaho DEQ
Idaho Fish and Game
Idaho Power Company
Kalispel Tribes
Montana Dept. Natural Resources Conservation
Montana Fish, Wildlife & Parks
National Fish & Wildlife Foundation
The Nature Conservancy

National Park Service
Oregon Dept. Fish & Wildlife
Shoshone-Bannock Tribes
Trout Unlimited
University of Washington
U.S. Fish and Wildlife Service
USFS National Forests:
USFS Regions 1, 4, and 6
Washington Dept. Fish & Wildlife
Yakama Nation
Significant redundancies, gaps in coverage, & difficulty using data

If No Database, Result is Expensive Chaos

e.g., Temperature monitoring in the West
>20,000 unique stream sites
>$10,000,000 to collect

>100 agencies
If Database, Result is Order & Efficiency

eDNAAtlas Database Development

Data collected with standard protocol

A Protocol for Collecting Environmental DNA Samples From Streams

Kellie J. Carim, Kevin S. McKelvey, Michael K. Young, Taylor M. Wilcox, and Michael K. Schwartz
General Technical Report
RMRS-GTR-355

QA/QC procedures (laboratory & data)

Metadata documentation & website delivery in user-friendly formats

Database entry (relational & geospatial)
Aquatic eDNAAtlas Project Website:
https://www.fs.fed.us/rm/boise/AWAE/projects/the-aquatic-eDNAAtlas-project.html
Dynamic Maptool Delivers Data in User-Friendly Digital Formats w/Metadata

eDNA sample metadata
eDNAtlas Samples are Also a Reusable Database (i.e., eDNAArchive)

One eDNA sample useful for many species
Filling in the Atlas: eDNA Sampling Site Grid for New Field Collections

- 1-km spacing of points with unique database IDs
- Snapped to 1:100,000 NHD streamlines
- Download point coordinates & load to GPS
- Collect sample & mail to NGC
eDNAAtlas Database Uses...

1) Species distribution models for prediction of climate refugia
2) Species status assessments (e.g., regional bull trout project, spikedace/loach minnow, Pacific lamprey...)
3) Trend monitoring at one or many sites (scalable extent & grain)
4) Detection & tracking of nonnative species invasions
5) Assessment of habitat restoration efforts (e.g., fish passage improvements, eradication of invasive species, etc.)
Advantages of Centralized, Open-Access eDNAAtlas Database:

1) Efficiencies of scale (i.e., you become part of a massive biological sensing network)
2) System gains efficiency as database size increases each year
3) System coevolves & improves from close collaborations between researchers & managers
4) Consistent data format & metadata documentation facilitates communication within & among agencies
5) Samples archived at NGC can be reused in the future
6) No reinventing of technical wheels (i.e., website/database design, geospatial stuff, etc.)
Goal: Big Databases & Good Information for All Species

High-resolution landscape models

I’m going to invest here...

...instead of here
If Interested in Joining the eDNA Alliance to Map Aquatic Biodiversity, Contact...

Mike Schwartz
John Rothlisberger
Mike Young
Dan Isaak
Dan Shively
Kevin McKelvey

NGC Website: https://www.fs.fed.us/research/genomics-center/