Methods for Aquatic Connectivity Barrier Prioritization: A Decision Support Tool for the Penobscot Watershed in Maine

2019 MAINE SUSTAINABILITY & WATER CONFERENCE

PROVIDING SCIENCE-BASED DECISION SUPPORT FOR SUSTAINABILITY

THURSDAY, MARCH 28, 2019
AUGUSTA CIVIC CENTER, AUGUSTA, MAINE

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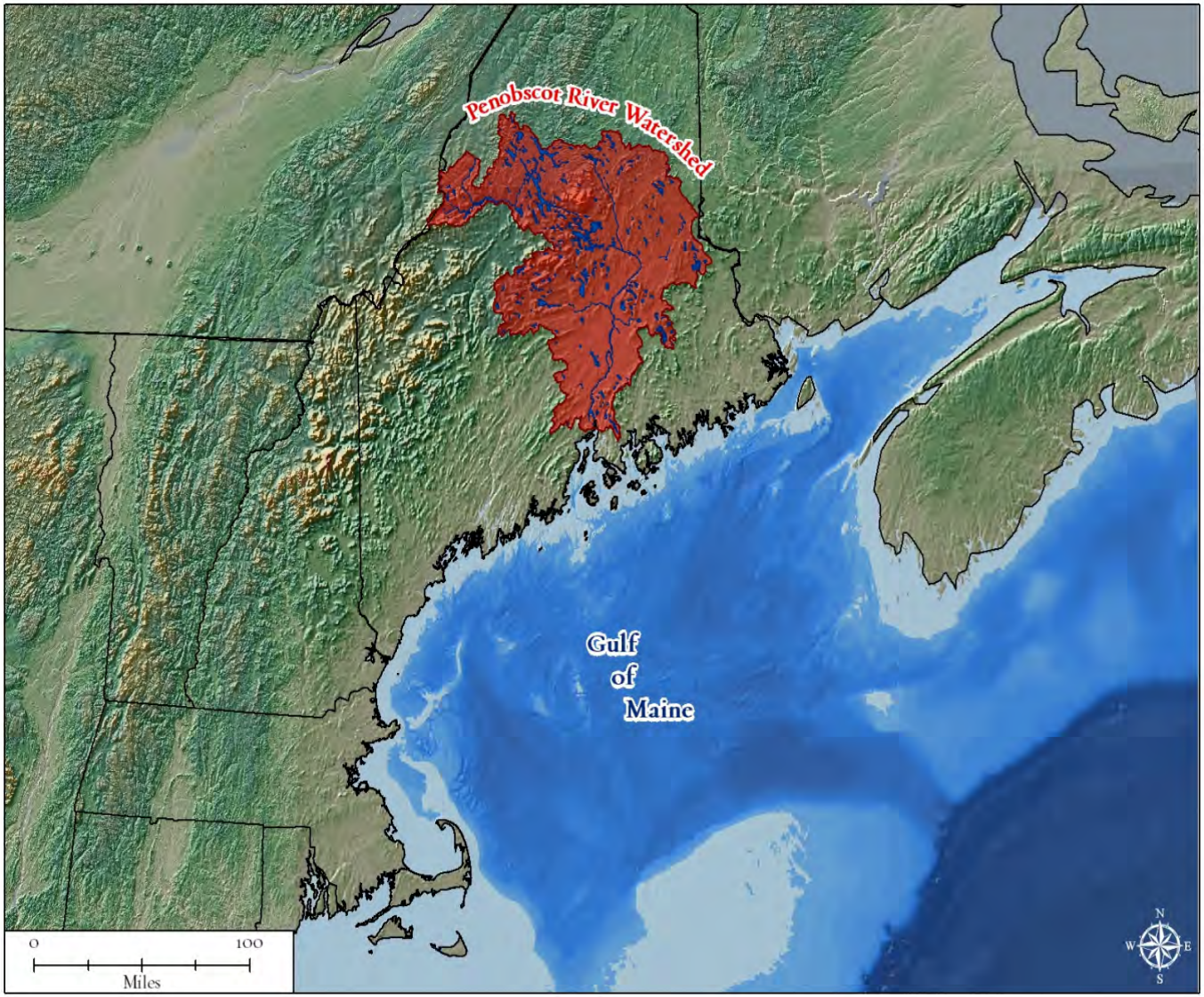
Penobscot River Watershed

- Largest watershed in Maine ~22,000 km²
- Fewest dams for its size in the Eastern US
- One of the few remaining Atlantic Salmon runs in the U.S.
- Cold water habitat – brook trout



Penobscot River Restoration

- Two dams removed
- Improved passage at two others
- Slightly more power generation
- Improved access to almost 2,000 miles of river

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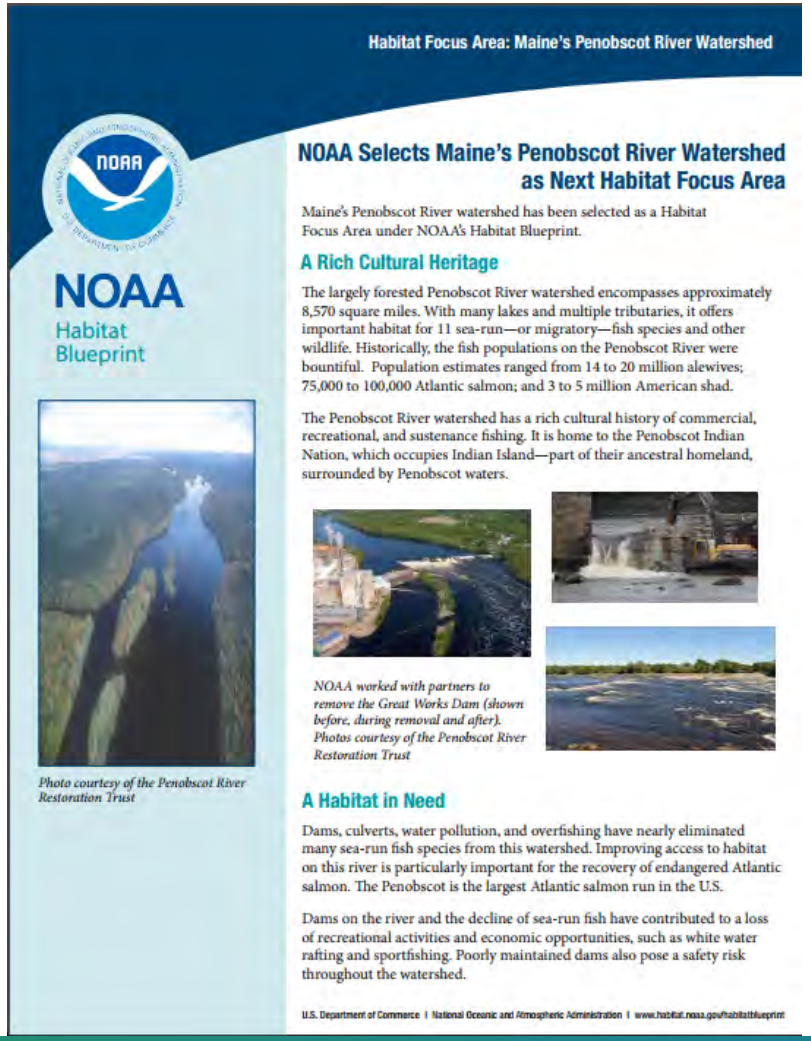
What’s the next Penobscot?


©B. Beesaw/TNC

NOAA Habitat Focus Area

Penobscot one of the first three Focus Areas (2014)

- Remove dams
- Construct fishways
- Replacing culverts
- Conducting pre- and post-monitoring of restoration projects
- Identify priority areas for fish passage



Habitat Focus Area: Maine's Penobscot River Watershed

NOAA Habitat Blueprint

NOAA Selects Maine's Penobscot River Watershed as Next Habitat Focus Area

Maine's Penobscot River watershed has been selected as a Habitat Focus Area under NOAA's Habitat Blueprint.

A Rich Cultural Heritage

The largely forested Penobscot River watershed encompasses approximately 8,570 square miles. With many lakes and multiple tributaries, it offers important habitat for 11 sea-run—or migratory—fish species and other wildlife. Historically, the fish populations on the Penobscot River were bountiful. Population estimates ranged from 14 to 20 million alewives; 75,000 to 100,000 Atlantic salmon; and 3 to 5 million American shad.

The Penobscot River watershed has a rich cultural history of commercial, recreational, and sustenance fishing. It is home to the Penobscot Indian Nation, which occupies Indian Island—part of their ancestral homeland, surrounded by Penobscot waters.

Photo courtesy of the Penobscot River Restoration Trust

NOAA worked with partners to remove the Great Works Dam (shown before, during removal and after). Photos courtesy of the Penobscot River Restoration Trust

A Habitat in Need

Dams, culverts, water pollution, and overfishing have nearly eliminated many sea-run fish species from this watershed. Improving access to habitat on this river is particularly important for the recovery of endangered Atlantic salmon. The Penobscot is the largest Atlantic salmon run in the U.S.

Dams on the river and the decline of sea-run fish have contributed to a loss of recreational activities and economic opportunities, such as white water rafting and sportfishing. Poorly maintained dams also pose a safety risk throughout the watershed.

U.S. Department of Commerce | National Oceanic and Atmospheric Administration | www.habitat.noaa.gov/habitatblueprint

Road-Stream Crossing Data Collection

TNC / USFWS crews conducting field surveys

Assess passability of crossing structures

North Atlantic Aquatic Connectivity Collaborative (NAACC) assessment protocol

Photo: USFWS

Previous aquatic connectivity projects

JAWRA
JOURNAL OF THE AMERICAN WATER RESOURCES ASSOCIATION
AMERICAN WATER RESOURCES ASSOCIATION

Technical Paper

Assessing and Prioritizing Barriers to Aquatic Connectivity in the Eastern United States

Erik H. Martin

First published: 05 November 2018 | https://doi.org/10.1111/1752-1688.12694

Paper No. JAWRA-18-0009-P of the *Journal of the American Water Resources Association* (JAWRA).
Discussions are open until six months from issue publication.
Research Impact Statement: Fish passage prioritizations in the eastern United States can help identify aquatic connectivity restoration projects and support efficient decision making.

Read the full text > PDF TOOLS SHARE

Abstract

There are tens of thousands of dams and millions of road-stream crossings in the eastern United States (U.S.) which can prevent fish and other aquatic organisms from accessing key habitats. There is growing momentum in the eastern U.S., and throughout the country, to remove dams which no longer serve their intended purpose, provide improved fish passage facilities at those dams that cannot feasibly be removed, and upgrade road-stream crossings to benefit aquatic organism passage (AOP). However, these projects are expensive and given the extensive scope of the problem and the

https://doi.org/10.1111/1752-1688.12694

Database of ecologically relevant ***metrics***

Tiered result → potential ecological benefit if removed / improved passage

Flexible tool → customized results based on user's parameters

Conceptual Approach

Identify barriers that would provide the greatest ecological gain if removed

200 units of modeled Salmon spawning Habitat Upstream

watershed with healthy brook trout populations

15 miles connected river upstream

Current habitat for 3 migratory species downstream of Barrier

4 other Barriers downstream/ 2 barrier Upstream

400 acres of Alewife ponds in upstream watershed

80 % Forest Cover in Upstream Drainage Area

In a Critical Habitat For Sea-Run Atlantic Salmon

Not all metrics are of equal importance → Selected & weighted metrics → Developed scenarios that meet project objectives

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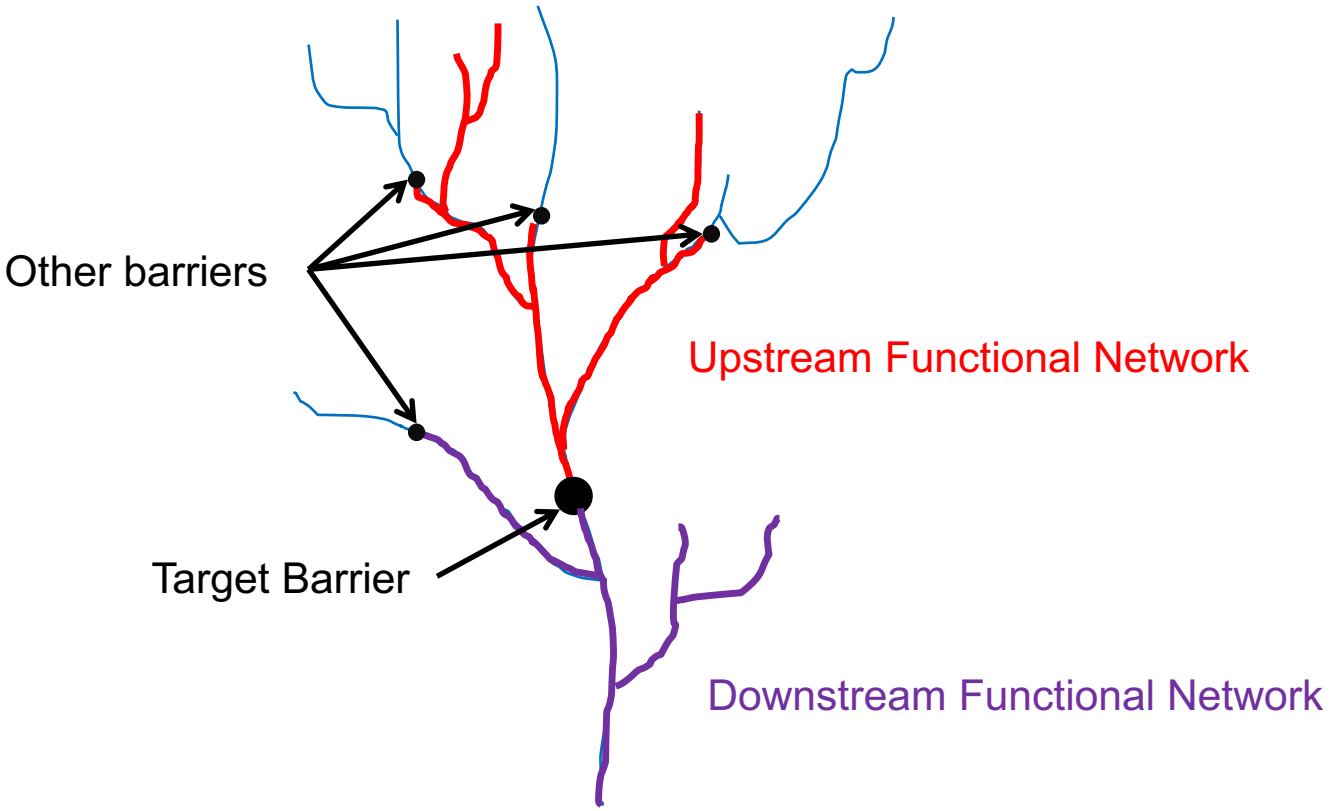
Functional River Network



Barrier Passability Score

Scale from 0-1

0: Total Barrier, No Aquatic Organism Passage

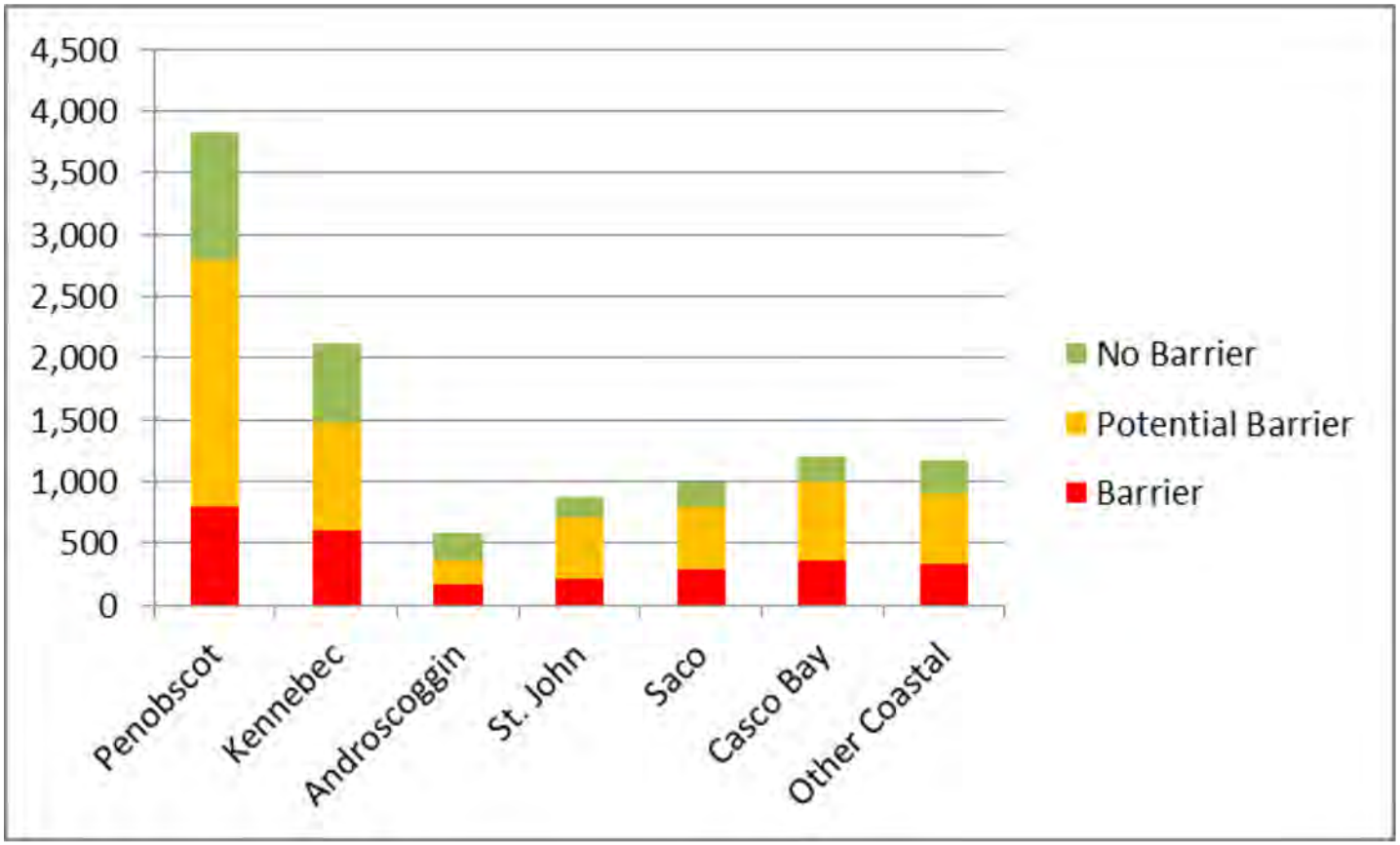
1: Complete Passage, No Physical Or Velocity Barriers

Passability Score– Road/Stream Crossing Barrier Screening Model

First-Pass Screen to identify Complete Barriers & Fully Connected Crossings

Metric	Flow Condition	Crossing Classification		
		Full AOP	Reduced AOP	No AOP
		If all are true	*If any are true*	*If any are true*
Inlet Grade		At Stream Grade	Inlet Drop or Perched	
Outlet Grade		At Stream Grade		Cascade, Free Fall onto Cascade
Outlet Drop to Water Surface		= 0		≥ 1 ft
Outlet Drop to Water Surface/ Outlet Drop to Stream Bottom				> 0.5
Inlet or Outlet Water Depth	Typical-Low	> 0.3 ft		< 0.3 ft w/Outlet Drop to Water Surface > 0
	Moderate	> 0.4 ft		< 0.4 ft w/Outlet Drop to Water Surface > 0
Structure Substrate Matches Stream		Comparable or Contrasting		
Structure Substrate Coverage		100%	< 100%	
Physical Barrier Severity		None	Minor or Moderate	Severe

Potential Barriers Across Survey Crossings



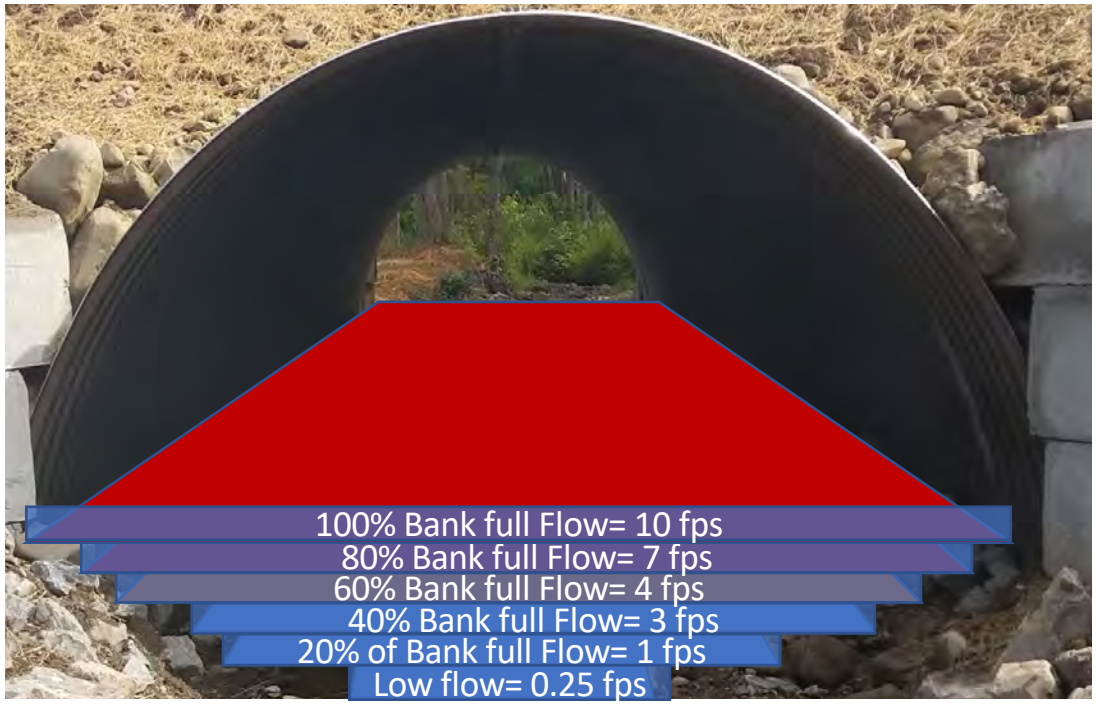
6 %

53 %

41%

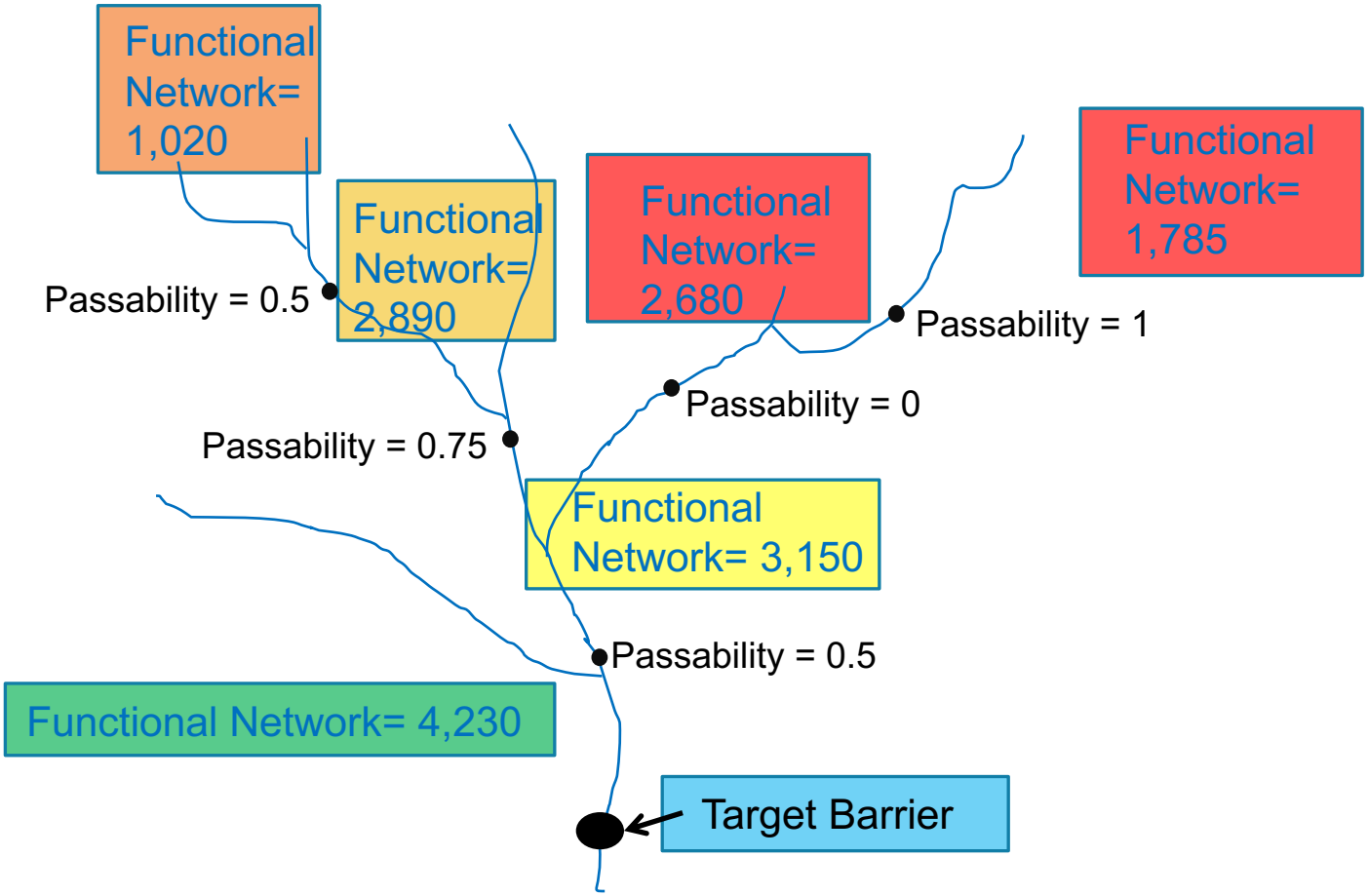
Pass ability Score– Road/Stream Crossing Reduced AOP Hydraulic Model

Input Variables	Usage
Structure Type	Logic parameter used to select the correct geometry calculation for pipes, boxes
Total Crossing Span	Measurement of Diameter or Width for X-sectional Area calculations
Crossing Height	Measurement of Diameter or Height for X-sectional Area calculations
Inlet Water Depth	Measurement of Water Depth in Culvert for back calculation of flow from manning's equation
Corrugations	Binary Classification of culvert Corrugation for estimate of manning's N Roughness coefficient
Number Of Culverts	Logic parameter to divide Flow and Span by to control for Multiple Culverts
Latitude & Longitude of Crossing Point	Grid location of crossing snapped to NHD flowline for StreamStats regression calculations
Q2 & Mean& day Low Flow from Stream Stats	Used to model range of flow conditions--(((Q2-LowQ) X 1/10)+ LowQ) based on and comparing the distribution of these derived low flows to the Observed Flow during Survey to find best fit.
Observed Flow during Survey	Classification of flow as High, Moderate or Low based on crew observations at time of NAACC survey.
Slope from NHD PLUS	Slope of Reach passing through culvert for Calculation of Velocity



Cumulative Upstream Functional Network

(index of restoration value)



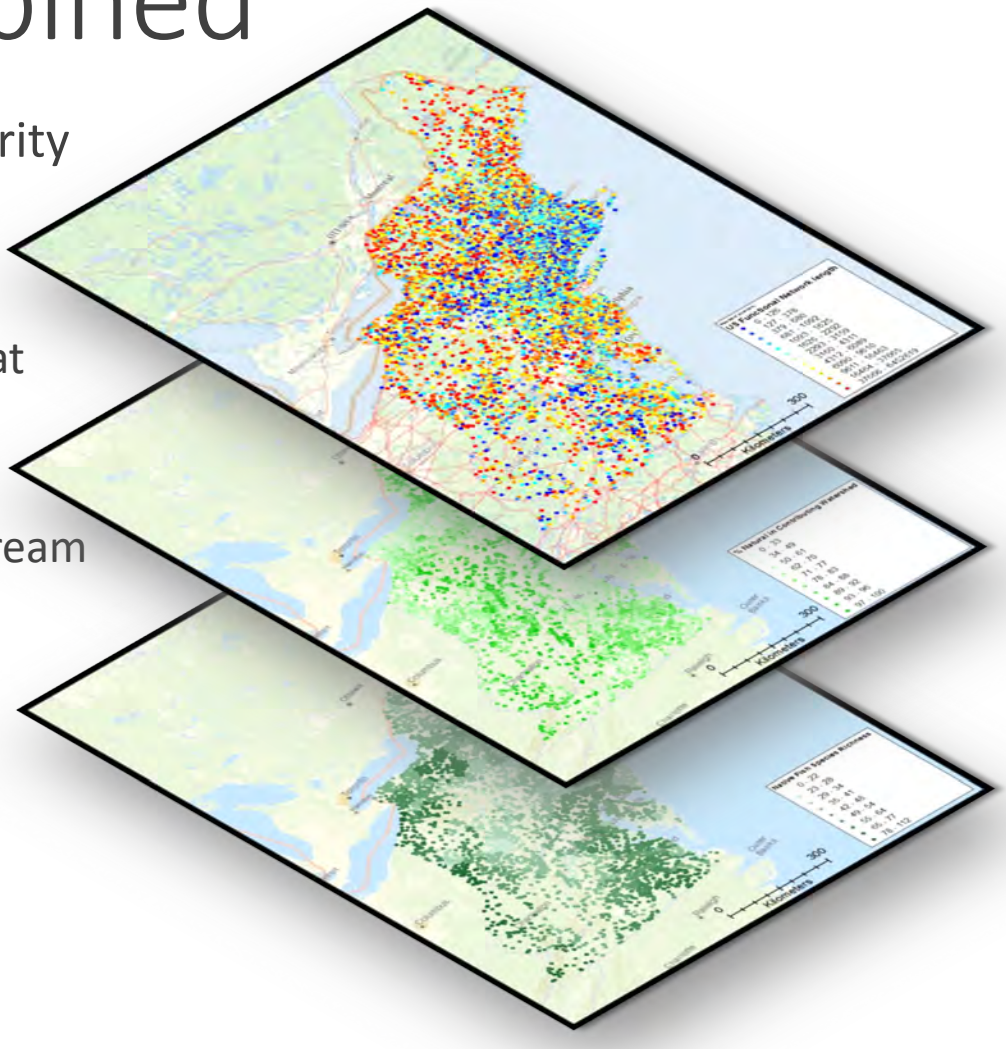
(4,230)+ (3,150*0.5)+ (2,890*0.5*0.75)+ (1,020*0.5*0.75*0.5)+ (2,680*0.5*0)+ (1,785*0.5*0*1)

=7,080

Metrics Combined

The (hypothetical) highest priority passage project would….

- open the most upstream habitat
- be within designated salmon Critical Habitat watersheds
- Have the most acreage of upstream alewife spawning ponds
- Etc., etc., etc.,



Define objectives & quantify importance of each metric for the objective

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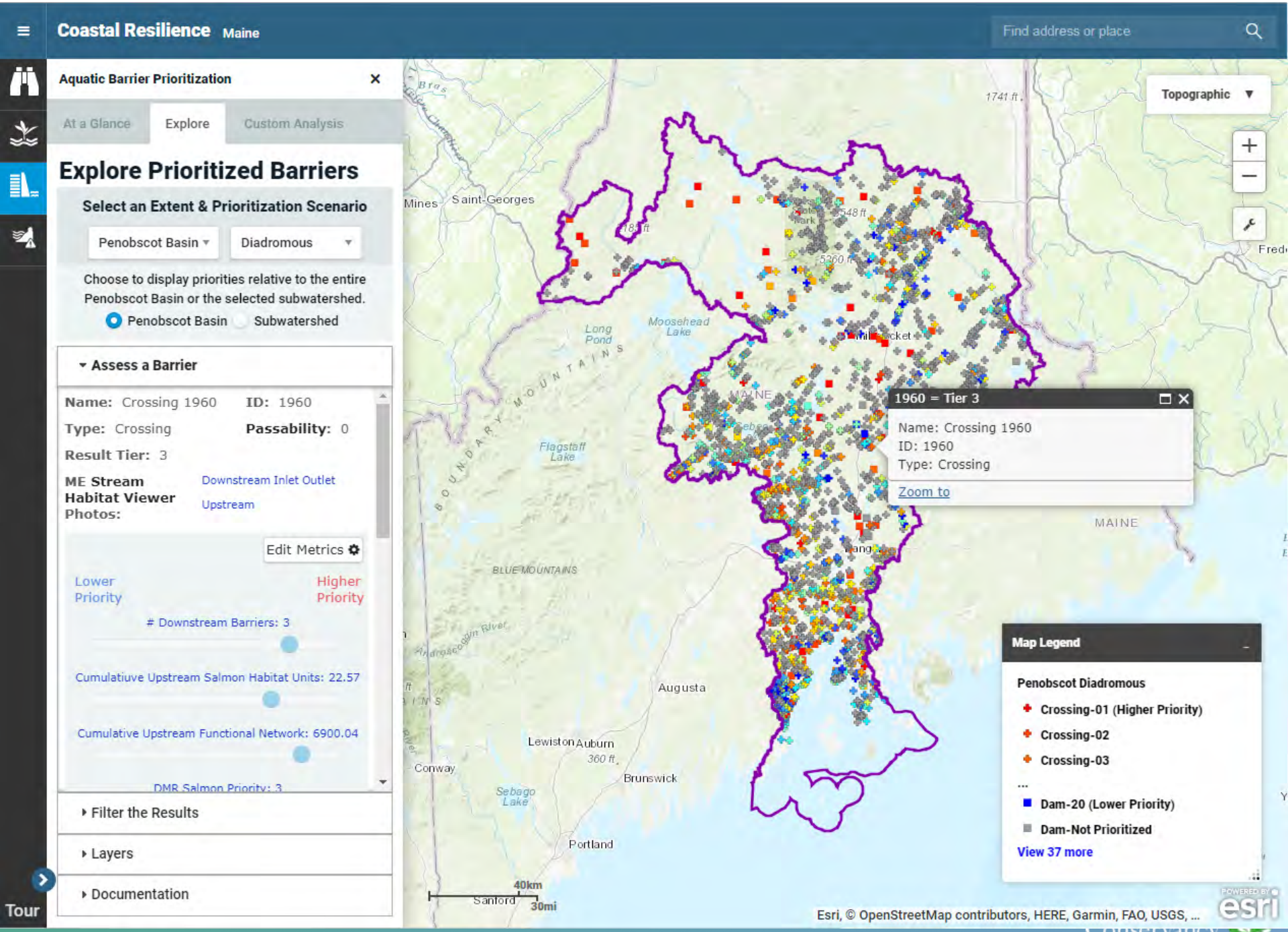
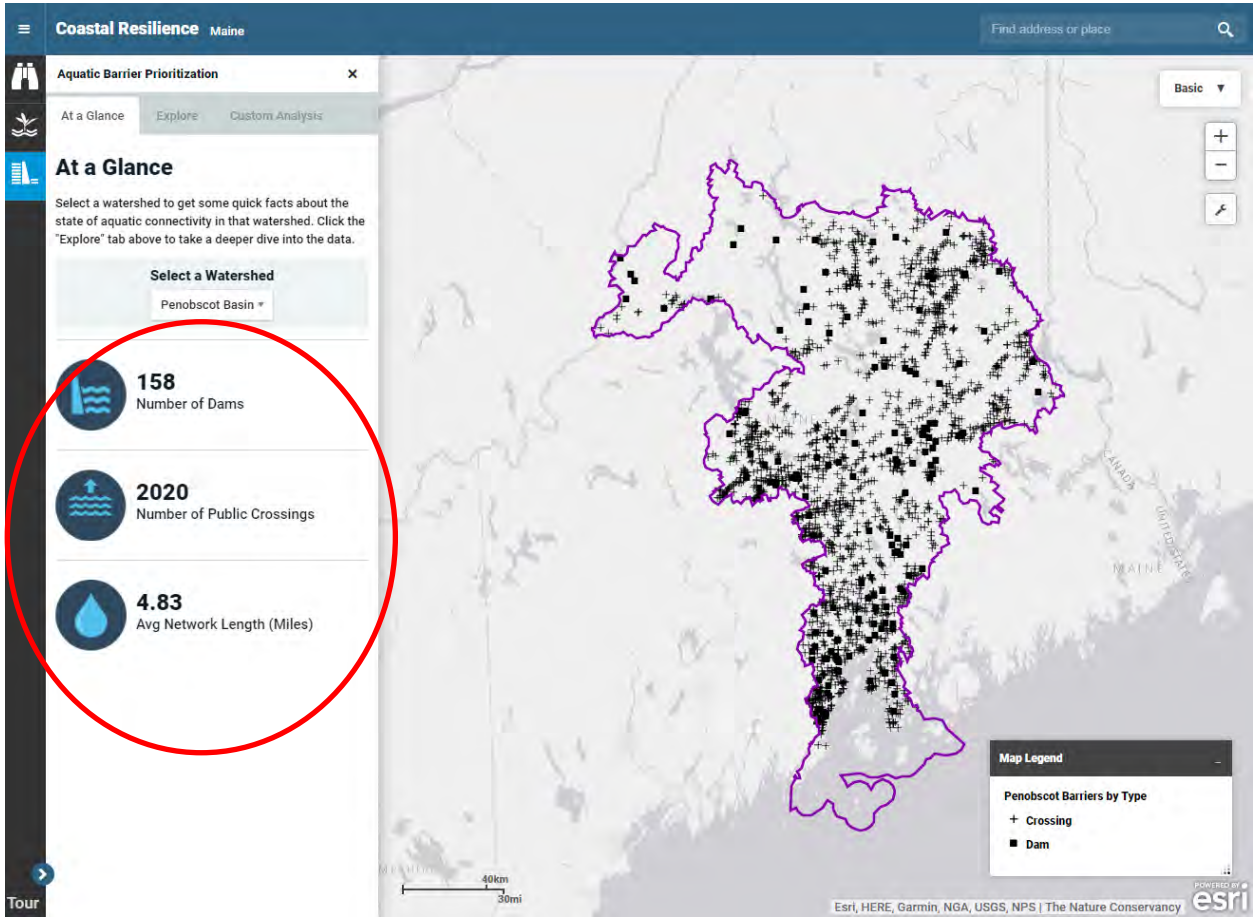

Coastal Resilience Maine
Find address or place
Aquatic Barrier Prioritization
At a Glance
Explore
Custom Analysis
Explore Prioritized Barriers
Select an Extent & Prioritization Scenario
Penobscot Basin
Diadromous
Choose to display priorities relative to the entire Penobscot Basin or the selected subwatershed.
Penobscot Basin
Subwatershed
Assess a Barrier
Name: Crossing 1960
ID: 1960
Type: Crossing
Passability: 0
Result Tier: 3
ME Stream Habitat Viewer Photos:
Downstream Inlet Outlet
Upstream
Edit Metrics
Lower Priority
Higher Priority
Downstream Barriers: 3
Cumulatiuve Upstream Salmon Habitat Units: 22.57
Cumulative Upstream Functional Network: 6900.04
DMR Salmon Priority: 3
Filter the Results
Layers
Documentation
Tour
Topographic
1960 = Tier 3
Name: Crossing 1960
ID: 1960
Type: Crossing
Zoom to
Map Legend
Penobscot Diadromous
Crossing-01 (Higher Priority)
Crossing-02
Crossing-03
Dam-20 (Lower Priority)
Dam-Not Prioritized
View 37 more
Saint-Georges
Moosehead Lake
Long Pond
Flagstaff Lake
MAINE
BOUNDARY MOUNTAINS
BLUE MOUNTAINS
Androscoggin River
Augusta
Lewiston
Auburn
Brunswick
Portland
Conway
Sebago Lake
Sanford
40km
30mi
Esri, © OpenStreetMap contributors, HERE, Garmin, FAO, USGS, ...

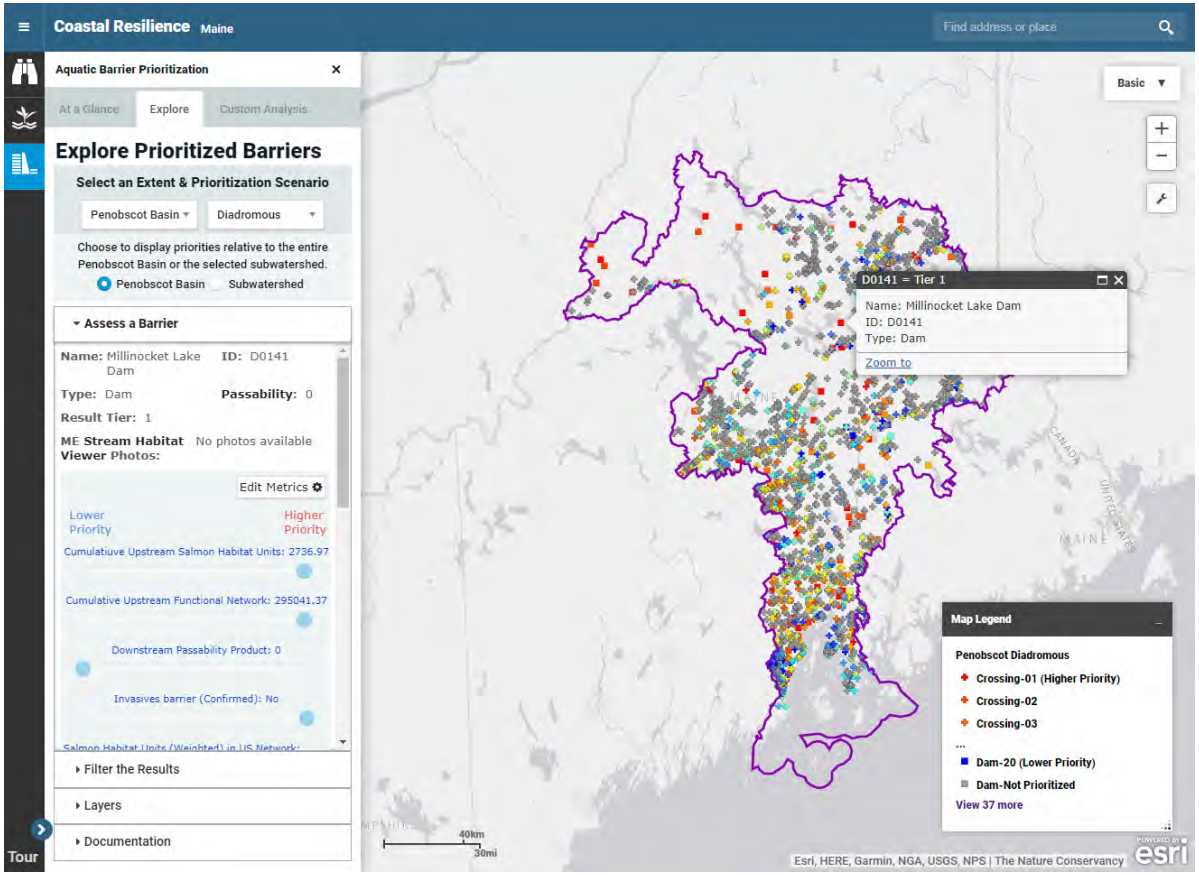
http://maps.coastalresilience.org/maine/

- Summaries of the status of connectivity in key watersheds
  - # Dams
  - # Crossings
  - Network length
- Barriers prioritized based on the potential benefits to anadromous fish if removed / bypassed

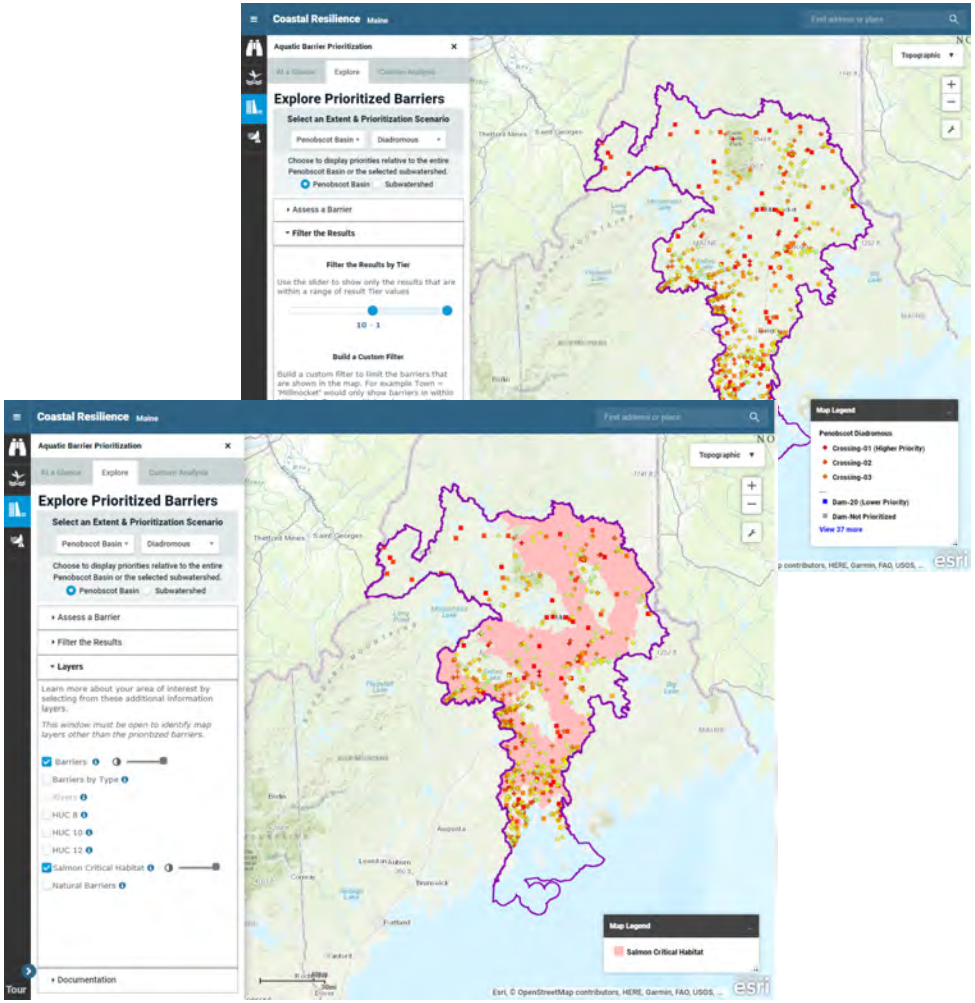


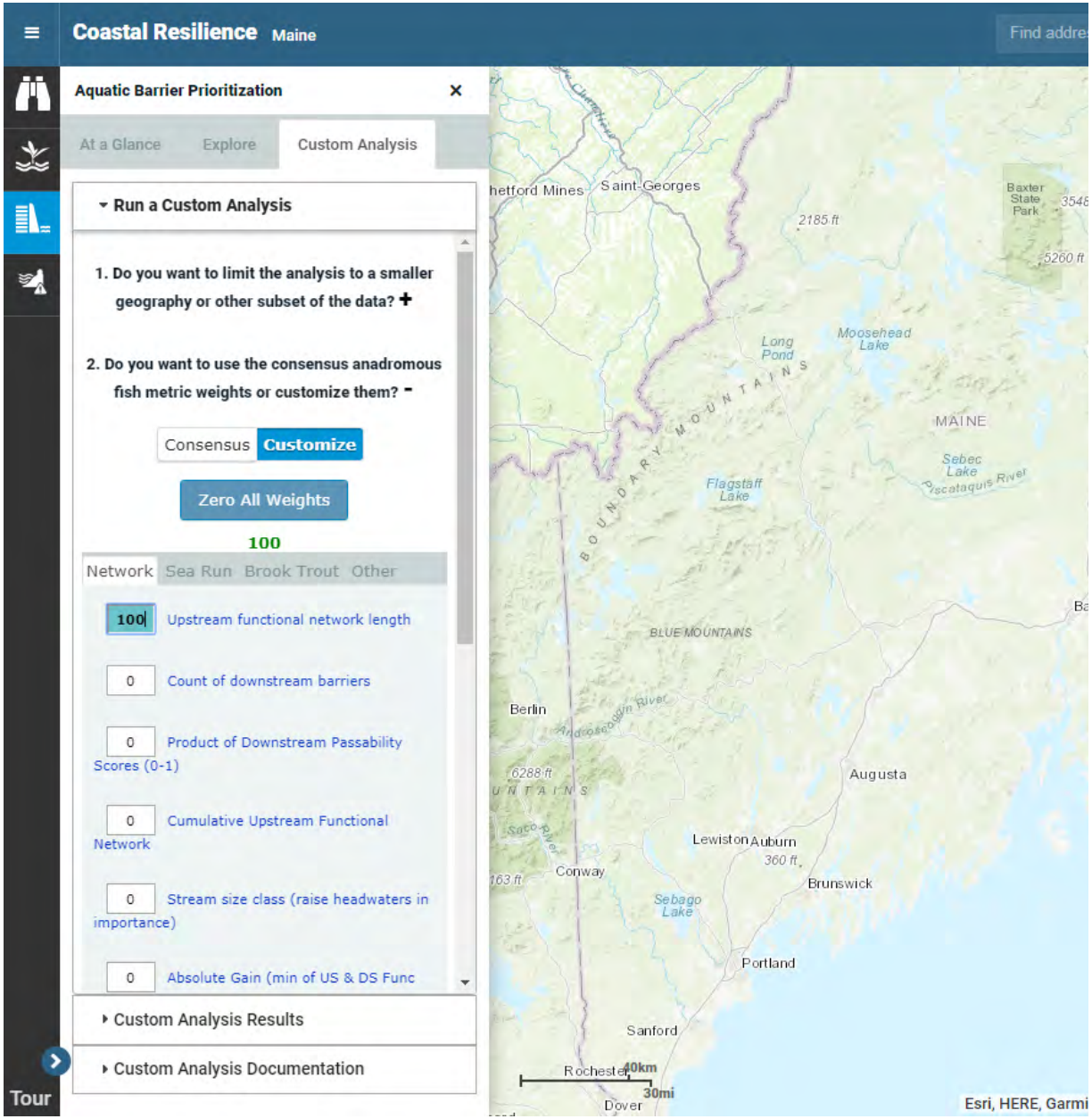
Prioritized Results & Database of Metrics

- Database of metrics available for each barrier
- Sliders shows performance of each barrier relative to other barriers, across the range of metrics
- Understand what's driving the priorities



- Query barriers & link to photos
- Filter the results
- View additional contextual layers
- Run custom analyses





Custom analyses

- Limit the analysis to a geography or other subset of data
- Select the metrics to use and their weights
- Model the removal of up to 10 barriers
- Run summary statistics

Caution: these results…

Are **not** a hit list of barriers

Are **not** a replacement for site-specific knowledge and field work

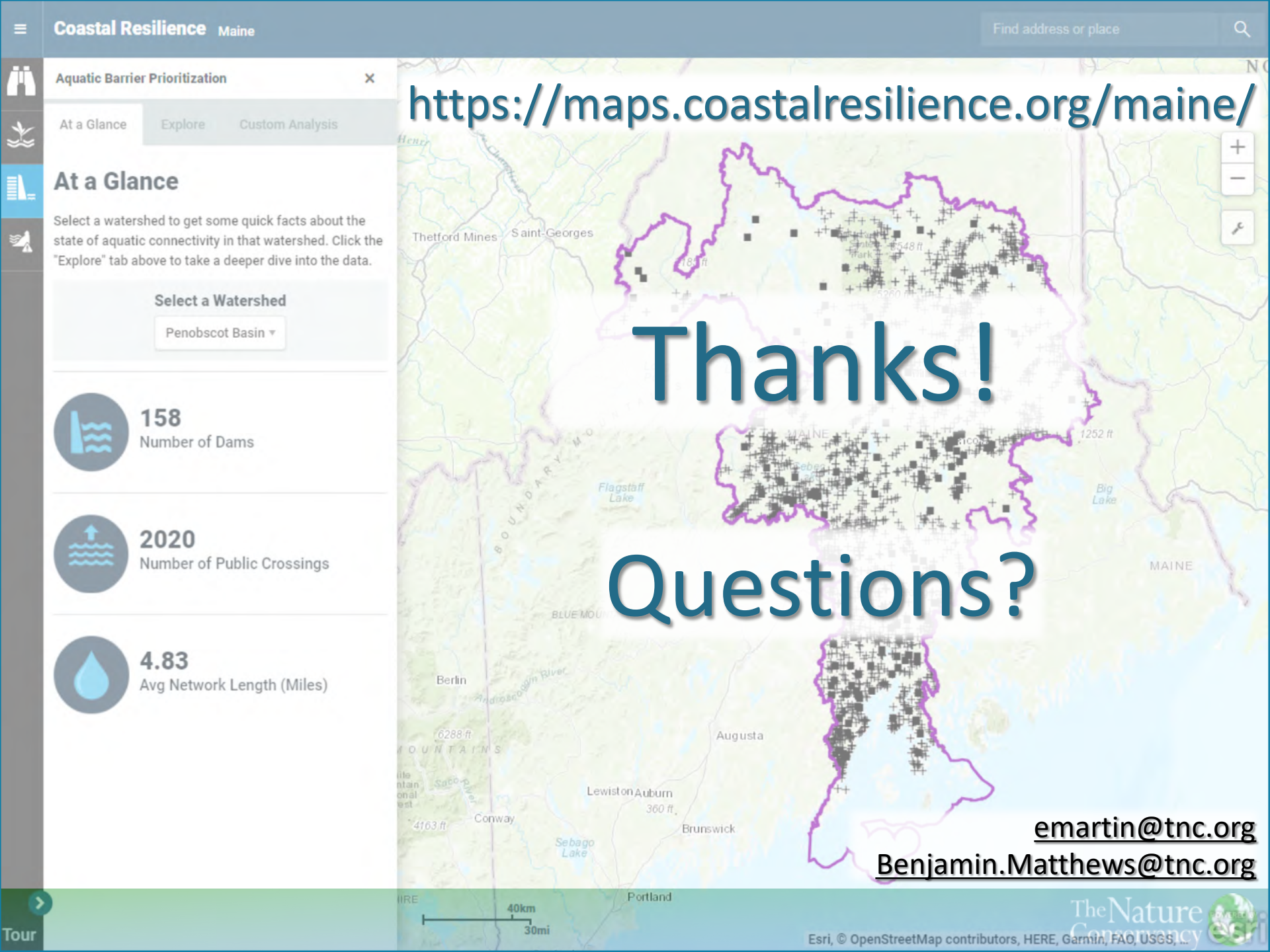
Do **not** incorporate important social, economic, or feasibility factors

Do **not** incorporate every possible aspect of potential ecological benefit

Are a screening-level tool

Use the **best available** data

Help inform on-the-ground decision making


Coastal Resilience Maine
Find address or place
Aquatic Barrier Prioritization
At a Glance
Explore
Custom Analysis
At a Glance
Select a watershed to get some quick facts about the state of aquatic connectivity in that watershed. Click the "Explore" tab above to take a deeper dive into the data.
Select a Watershed
Penobscot Basin
158
Number of Dams
2020
Number of Public Crossings
4.83
Avg Network Length (Miles)
https://maps.coastalresilience.org/maine/
Thanks!
Questions?
emartin@tnc.org
Benjamin.Matthews@tnc.org
Tour
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