SHEEPSCOT WATERSHED:
RAPID STREAM ASSESSMENT

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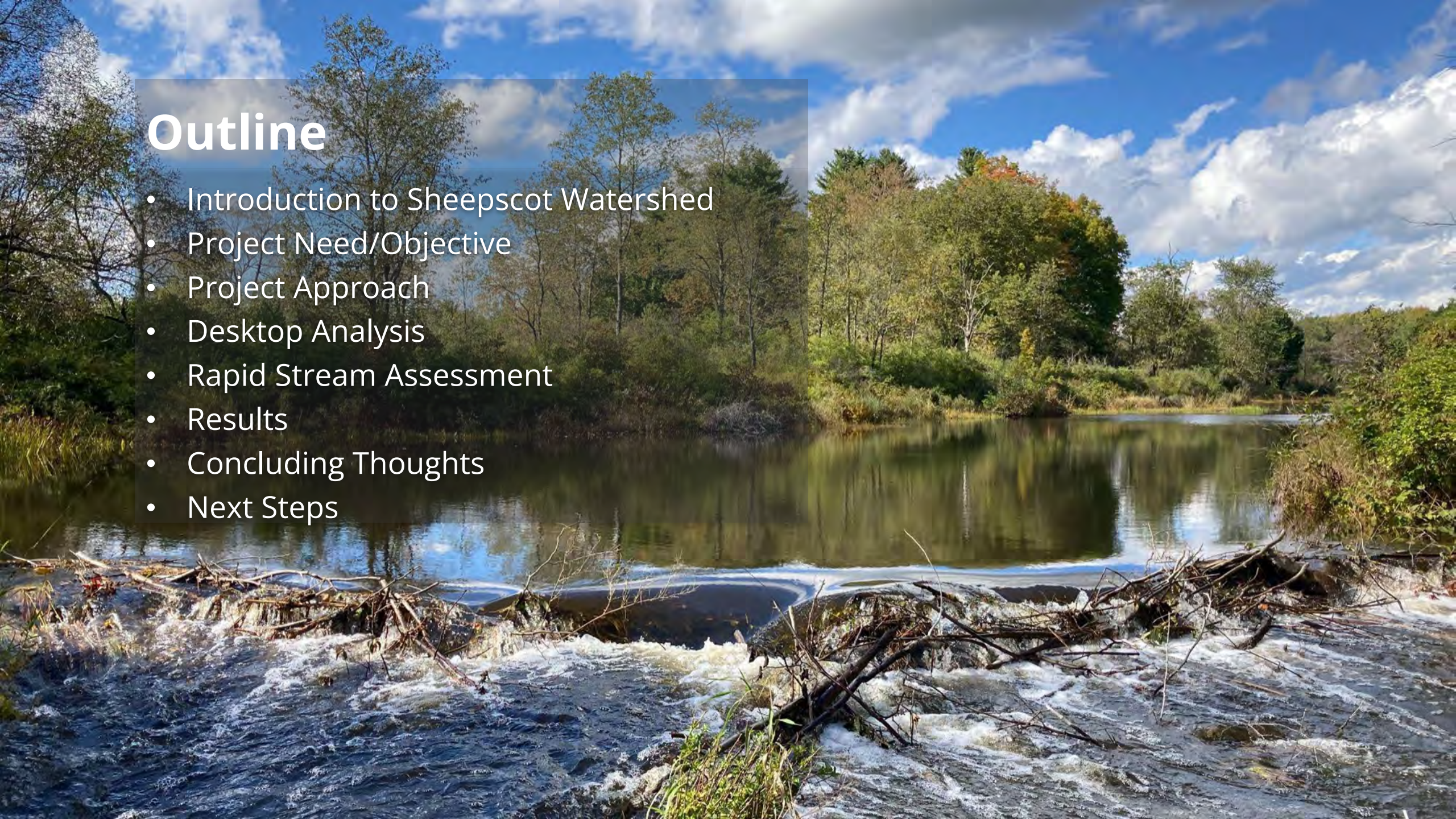
03/31/23



Outline

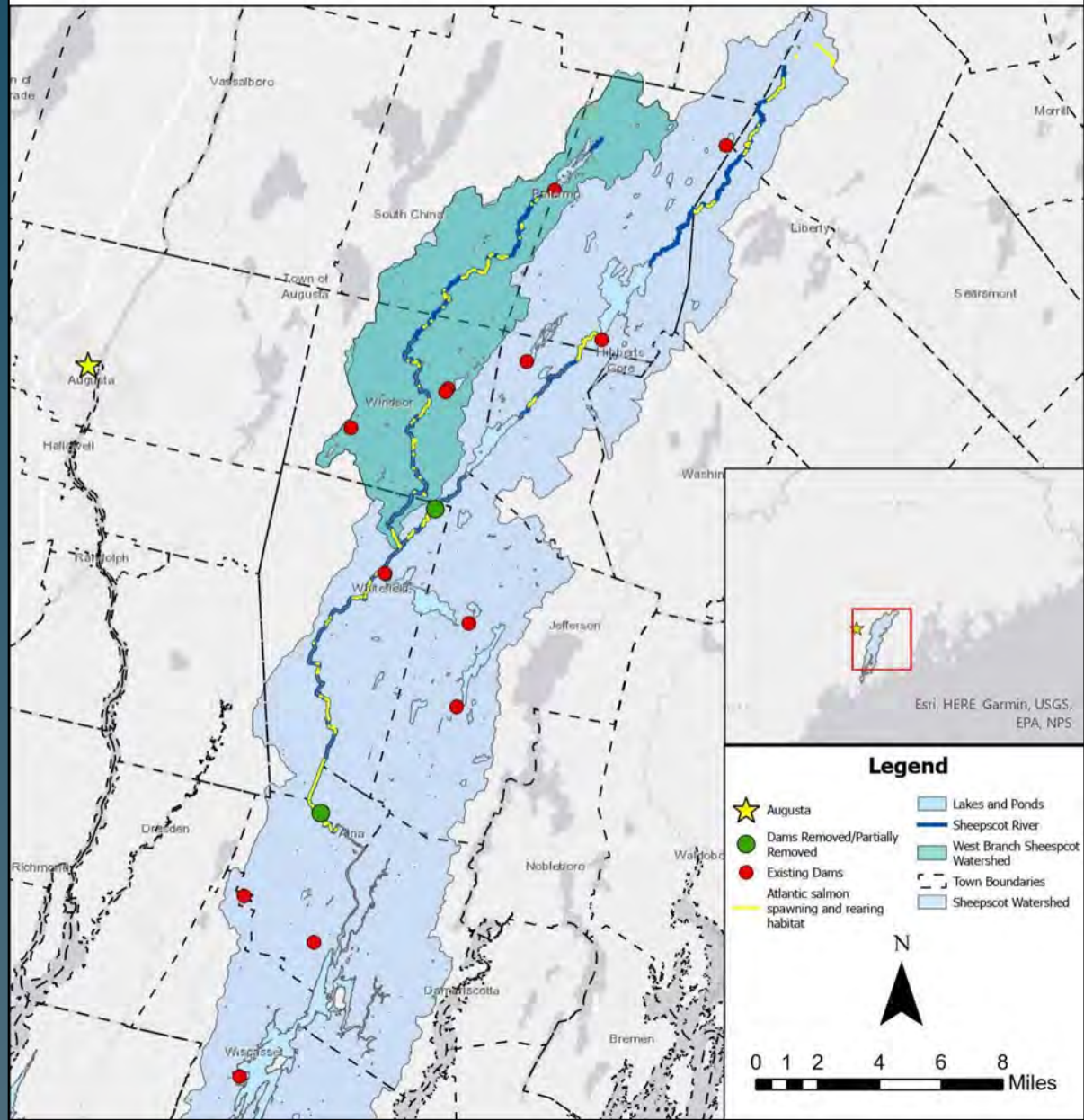
- Introduction to Sheepscot Watershed
- Project Need/Objective
- Project Approach
- Desktop Analysis
- Rapid Stream Assessment
- Results
- Concluding Thoughts
- Next Steps

SHEEPSCOT WATERSHED

- Located in Midcoast Maine
- 320 sq. miles, 58 miles long
- Supports a diverse community of habitats and at-risk species:
  - —All 12 of Maine's native sea-run fish, including the southern-most genetically distinct population of Atlantic salmon (*Salmo salar*)
  - —brook floater mussel
  - —wild eastern brook trout
  - —state listed turtles
  - —migratory birds

Sheepscot River Watershed Atlantic Salmon Habitat and Dams

Map created by Melissa Cote 3/24/23

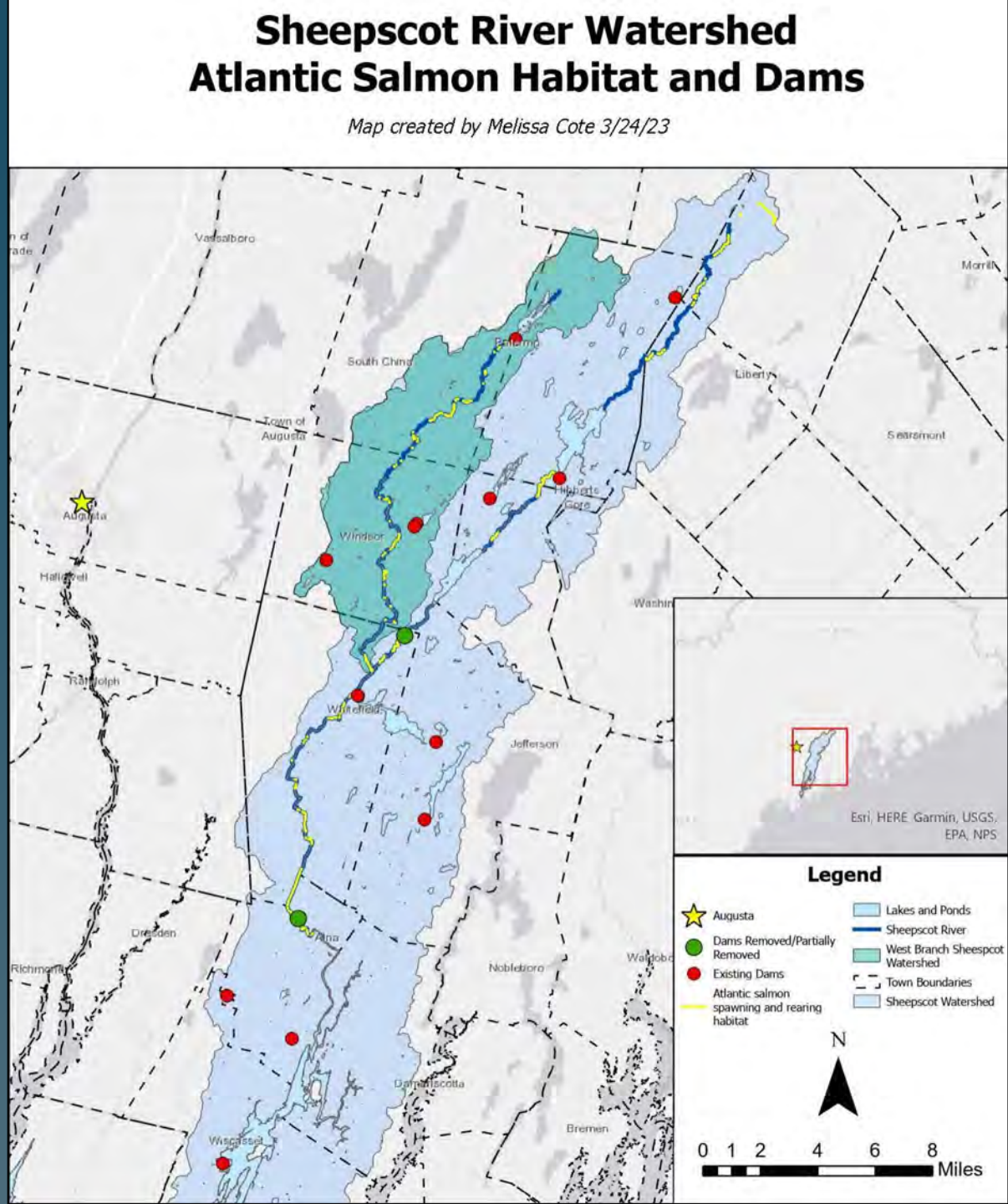


SHEEPSCOT WATERSHED

- Two recent major dam removals:
  - Coopers Mills Dam in Whitefield (2018)
  - Head Tide Dam in Alna, partial removal (2019)

Photos from Inter-Fluve

With major barriers removed, there is a greater need for in-stream habitat restoration.

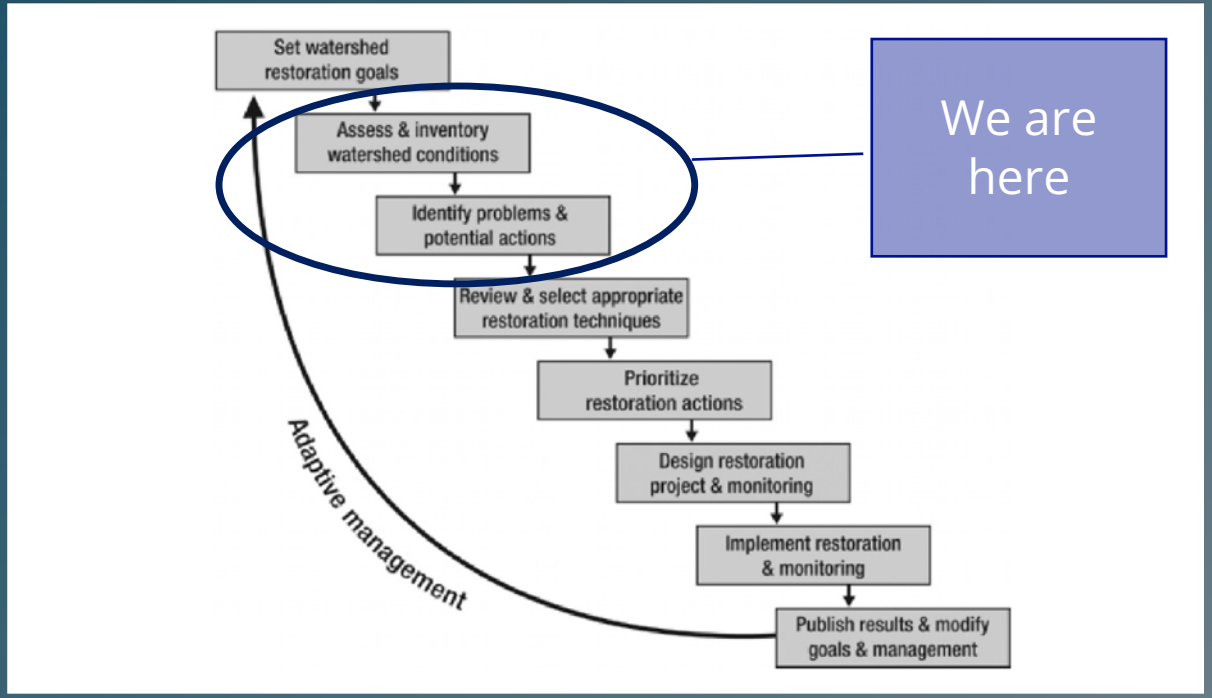


Project Need:

An understanding of on-the-ground habitat conditions and factors impacting watershed processes is needed to develop a strategic approach that restores the watershed in a holistic manner.

Objective:

Create a Watershed Action Plan with a series of maps describing the watershed and prioritizing conservation actions for the recovery of Atlantic salmon and other endemic species in need of conservation.



Graphic from Stream and Watershed Restoration A Guide to Restoring Riverine Processes and Habitats by Roni & Beechie 2013

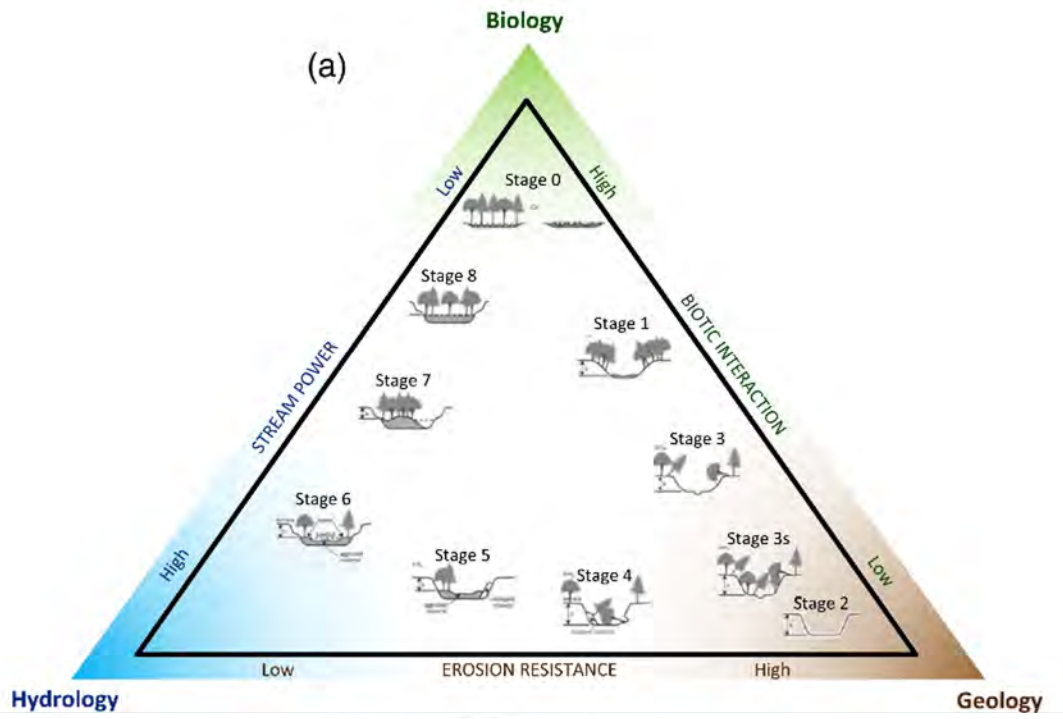
PROJECT APPROACH

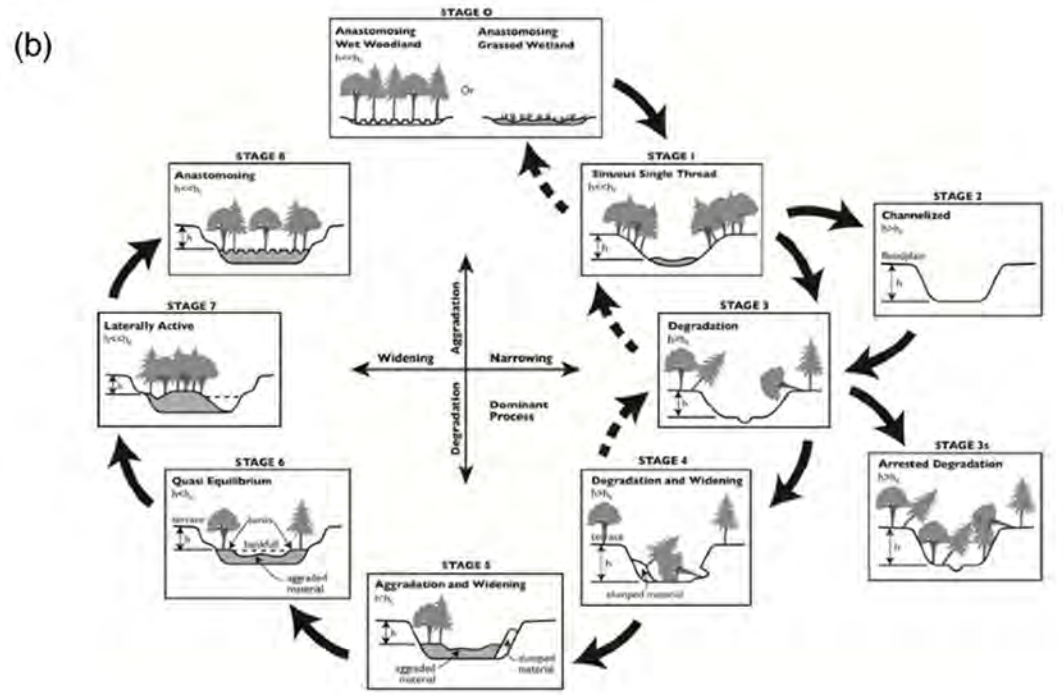
Focus on West Branch Sheepscot Watershed to test and refine methodology while also identifying potential habitat restoration opportunities.

Desktop Analysis in ArcGIS PRO to assess watershed health, identify landscape scale controlling factors, and break reaches into similar units for comparison.

Rapid Field Assessment to ground truth and refine spatial model. Compare reaches to a reference reach and identify stage within Stream Evolution Triangle (SET) to aid the development of habitat restoration alternatives.

Graphics (A) from Castro and Thorne 2019 of Stream Evolution Triangle adapted from (B) Cluer & Thorne 2014 Stream Evolution Model of geomorphic condition





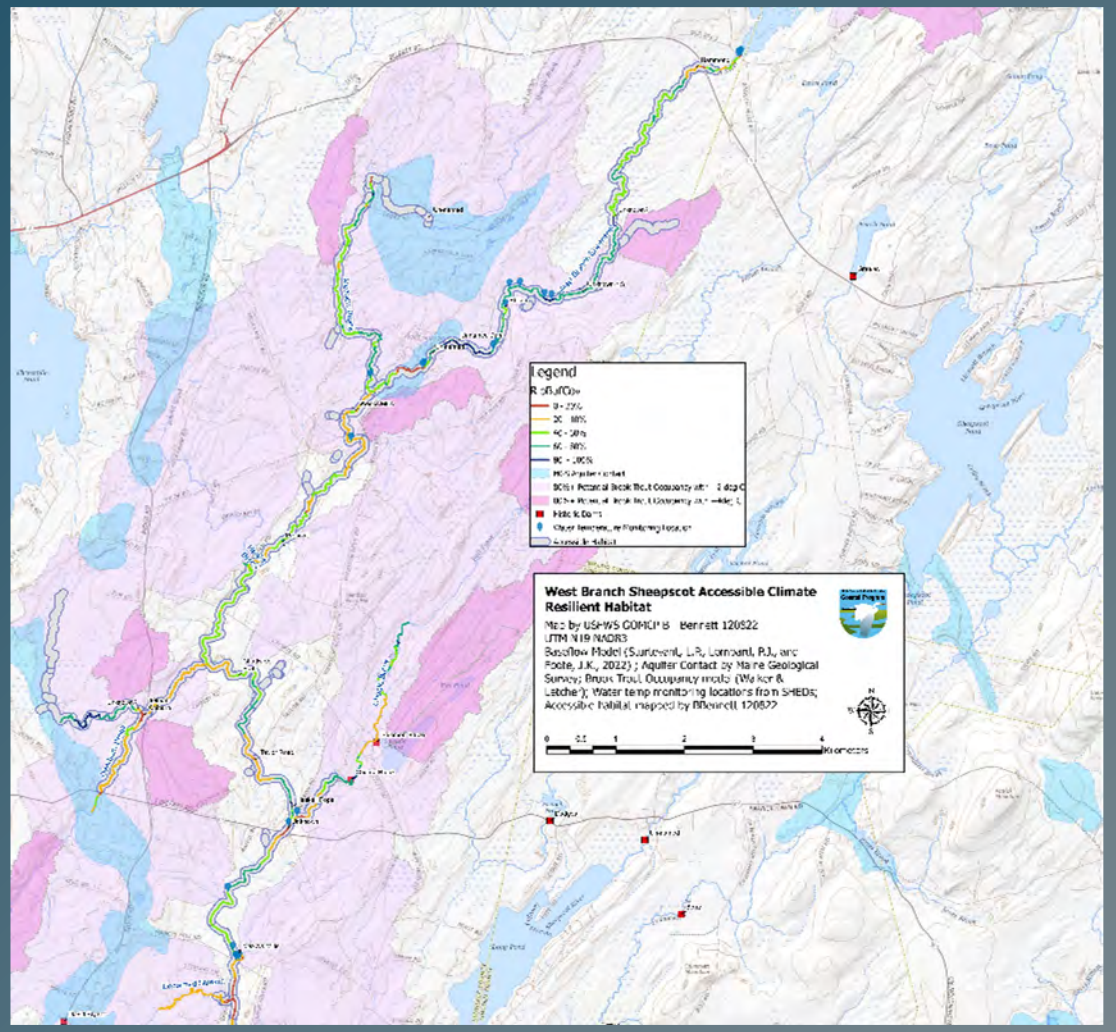
DESKTOP ANALYSIS IN ARCGIS PRO

- ***Accessible habitat*** by aquatic organisms identified using Network Analysis using barrier data from the Maine Stream Habitat Viewer

- ***Thermal refugia*** identified utilizing:
  - USGS Interactive Catchment Explore (ICE)
  - Spatial Hydro-Ecological Decision System (SHEDS)
  - USGS Baseflow Model (Lombard and Sturtevant 2022)
  - Surficial Aquifer data layer by Maine Geological Survey

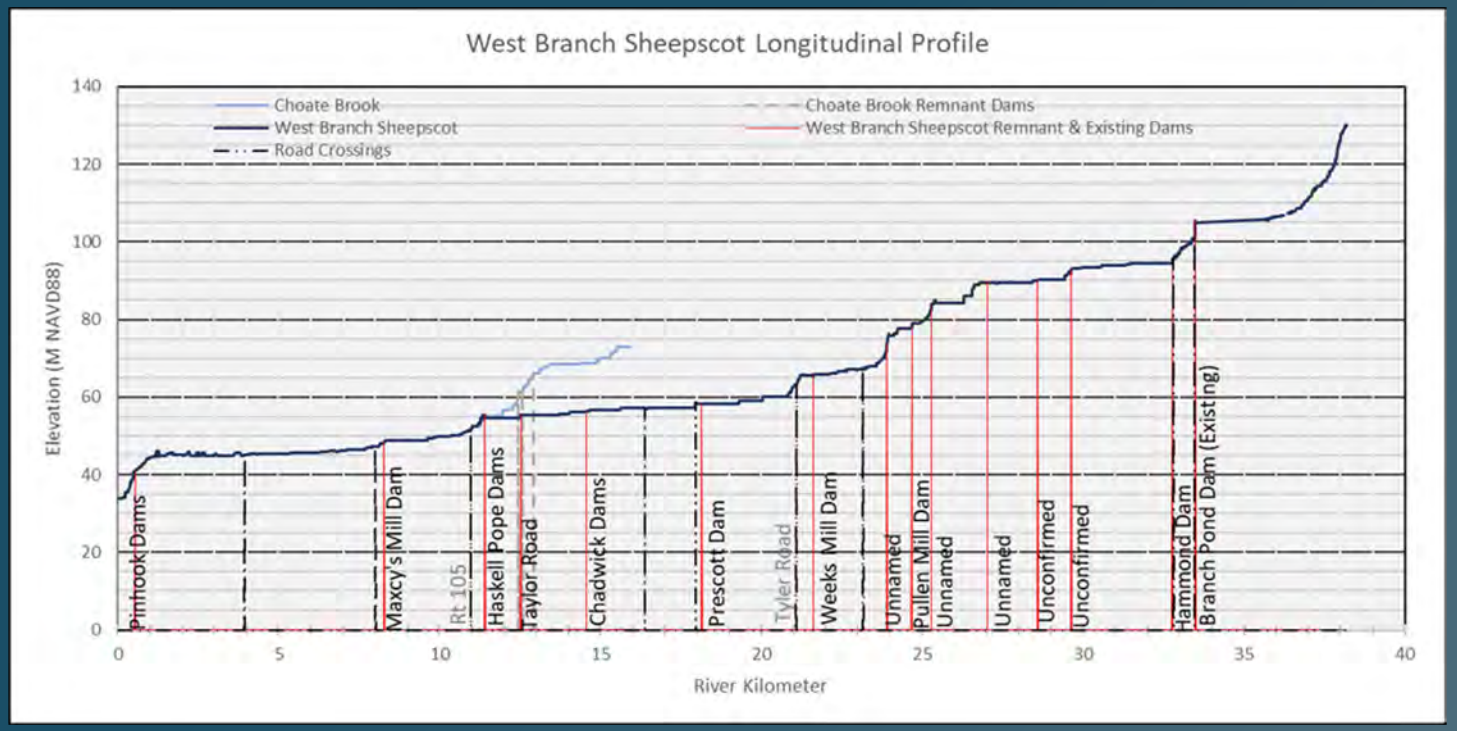
- ***Riparian Buffer Condition*** (LANDFIRE data)
  - *Percent Riparian Buffer* in forested condition (90 m width)
  - *Large wood recruitment potential* (tree height greater than or equal to bankfull width)

- Mapped all remnant dams within the watershed adding to those identified by Noah Snyder 2016
- Surficial Geology data layer by MGS
- Land Cover and Land Use (including imperviousness) by NOAA OCM 2022

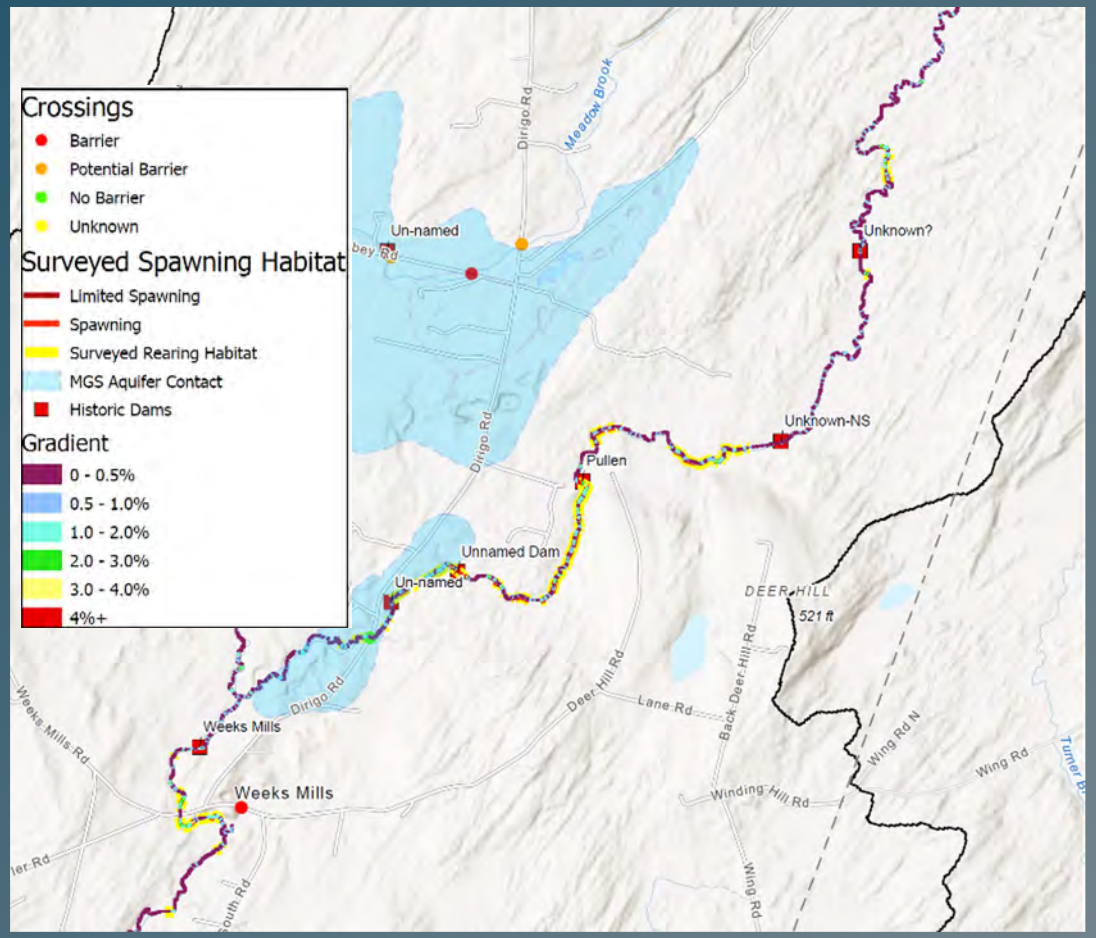


DESKTOP ANALYSIS IN ARCGIS PRO

- ***Stream Slope*** – A longitudinal profile was generated, and stream slope calculated from the 2020 lidar in Spatial Analyst.
- Long low gradient segments caused by natural grade controls or remnant dams act as sediment sinks (Snyder et al. 2013).



Longitudinal profile with remnant dams and crossings overlaid



Stream gradient with MSHV crossings and mapped salmon habitat

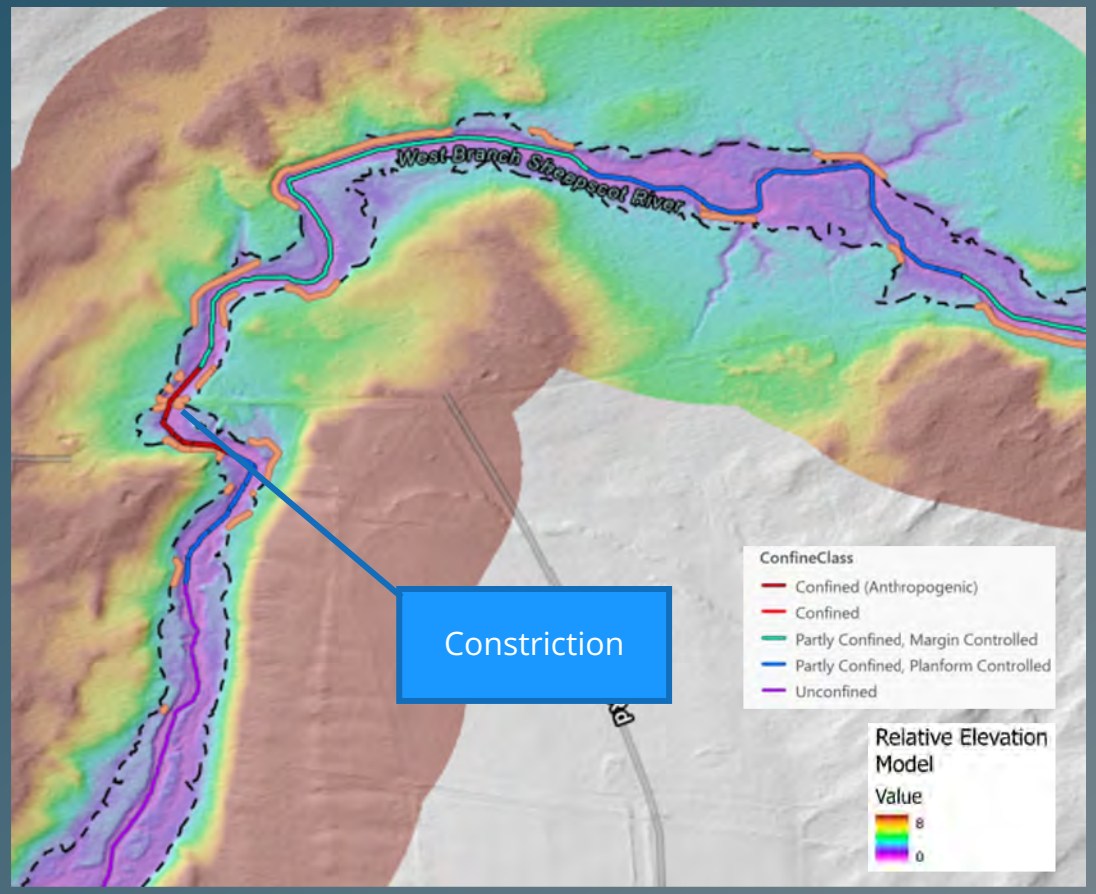
DESKTOP ANALYSIS IN ARCGIS PRO

Geology and Topography are the dominant controls on restoration potential (Beechie et al. 2013)

- ***Valley Floor Width & Confinement*** - determines the ability of a river to adjust laterally and vertically (somewhat) affecting sediment transport and deposition. **Cost Analysis** ran laterally across a conditioned DEM with the river as the source (Sechu et al. 2021) & then identified reach segments interacting with confining margin (O'Brien et al. 2019)

- **Relative Elevation Model (REM)** making side channels, levees, constrictions, and terraces visible (Olson and Legg 2014). **Geomorphic Grade Line (GGL) toolbox** (by Powers et al. 2019) used to further identify incision on selected reaches

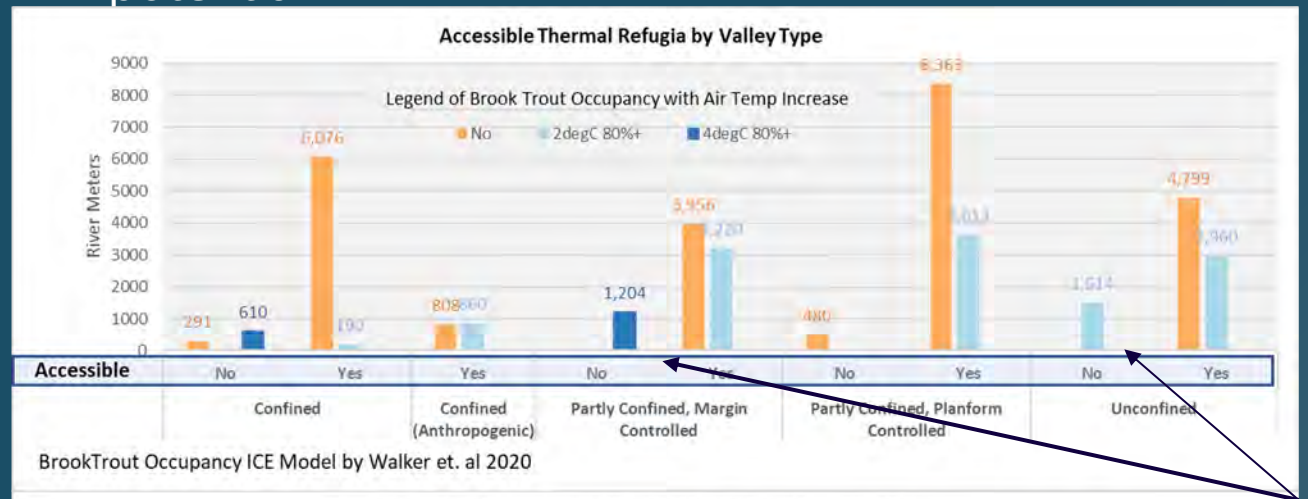
- **Sinuosity** calculated for all reaches of similar valley confinement and stream slope

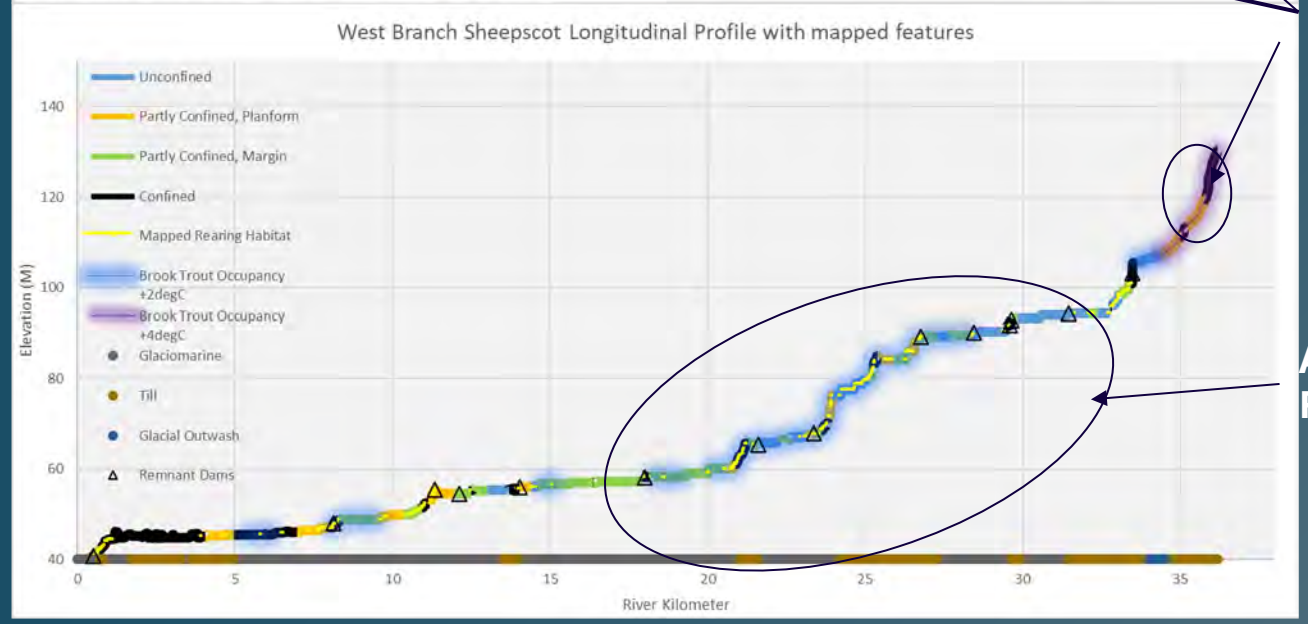


Valley Edge in black over REM

DESKTOP ANALYSIS RESULTS

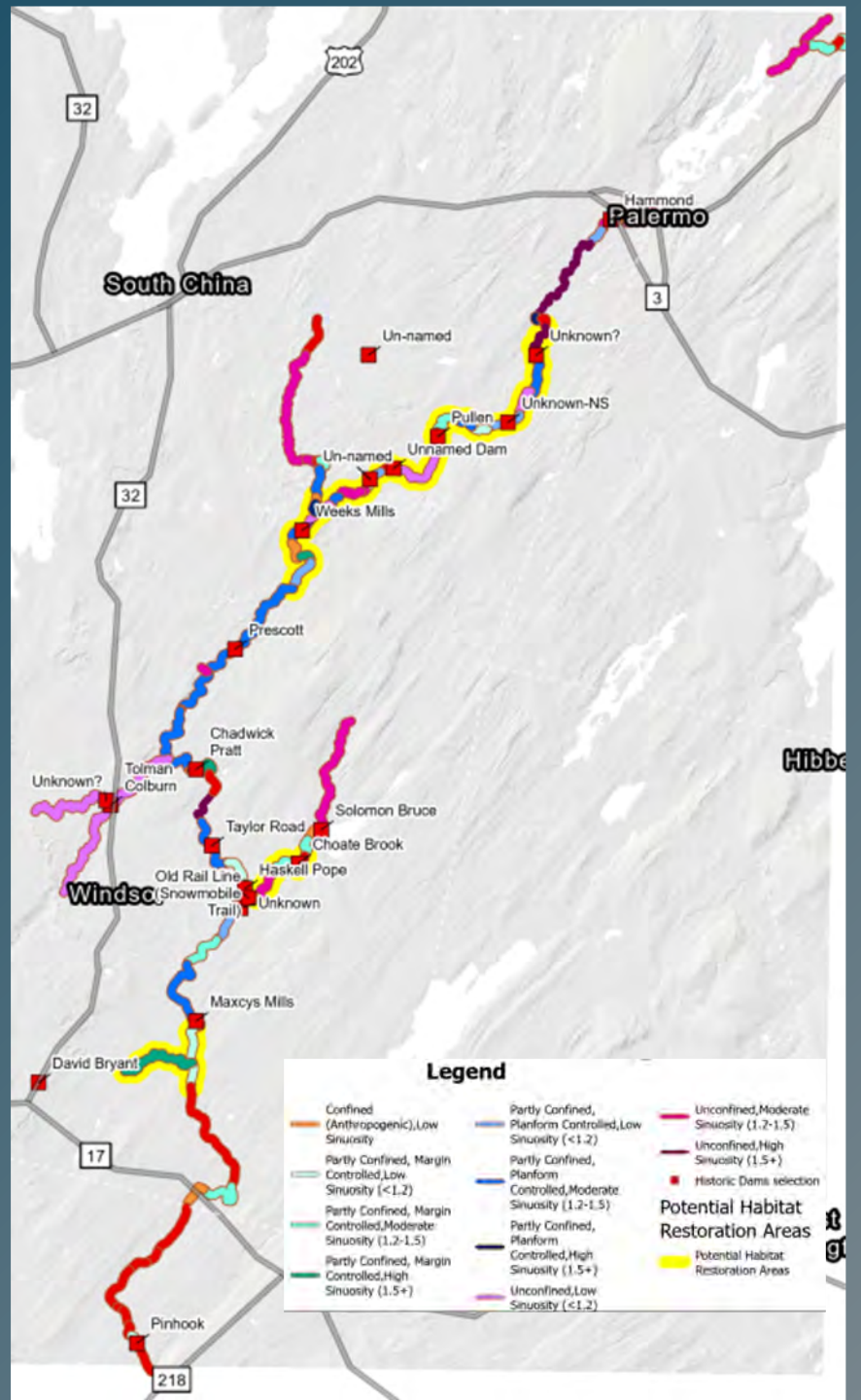
- Reaches prioritized for assessment identified as potentially climate resilient, existing biological knowledge, and habitat restoration potential





Restore Connectivity

Assess For Restoration



RAPID STREAM ASSESSMENT

- Ground truth and verify Desktop Analysis
- Identify Reference Reaches supporting high numbers of Atlantic salmon and establish desired baseline conditions by which other reaches will be compared
- Assessment needs to be rapid and repeatable by different personnel
- Assessed 11 reaches and 2 potential reference sites

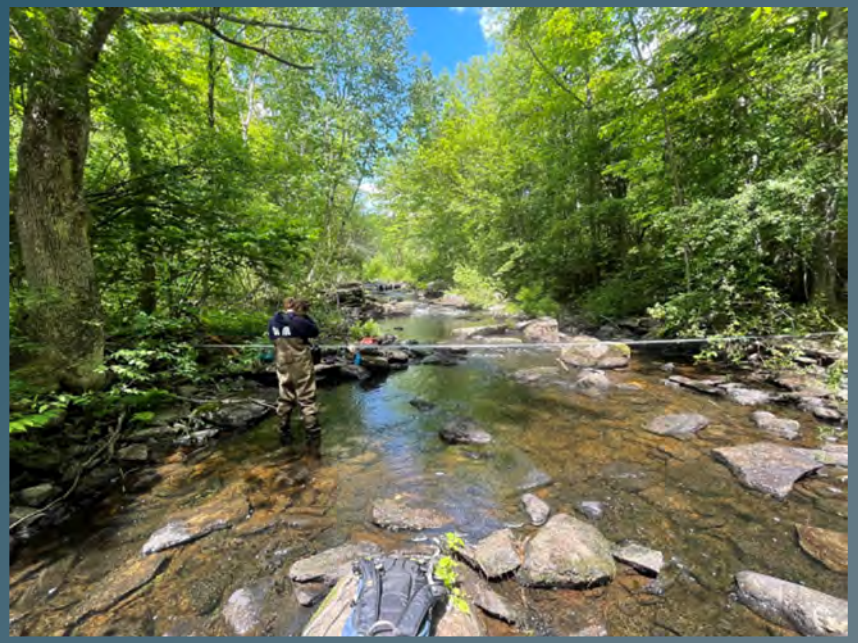
Elements Assessed in Assessment

- **Substrate**
- **Large wood**
- **Geomorphic Variables**
- **Pools**
- **Habitat Features**
- **Riparian condition**
- **Streambank condition**
- **Photographs**
- **Other notes of interest**

RAPID FIELD ASSESSMENT - Establish Reference Reach

- **Sites selected based upon DMR higher parr productivity at Palermo Preserve (Sheepscot River) and Pullen Mill (West Branch Sheepscot)**
  - **Reference reaches were intensively monitored to verify if high quality salmonid habitat**
    - **Water depth, temperature and dissolved oxygen levels were continuously monitored May – Nov 2022 for habitat suitability**
    - **Efishing data collected**
    - **Cross sections established with velocity measurements to generate discharge rating curve**
    - **Rapid Assessment completed in these two reaches first**

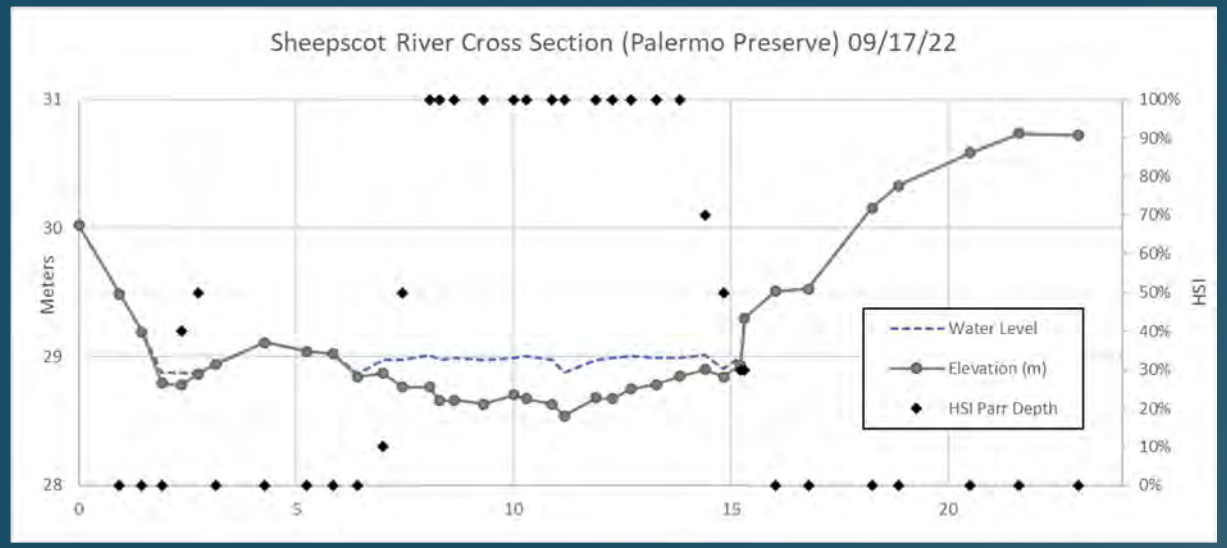
Palermo Preserve, Sheepscot River

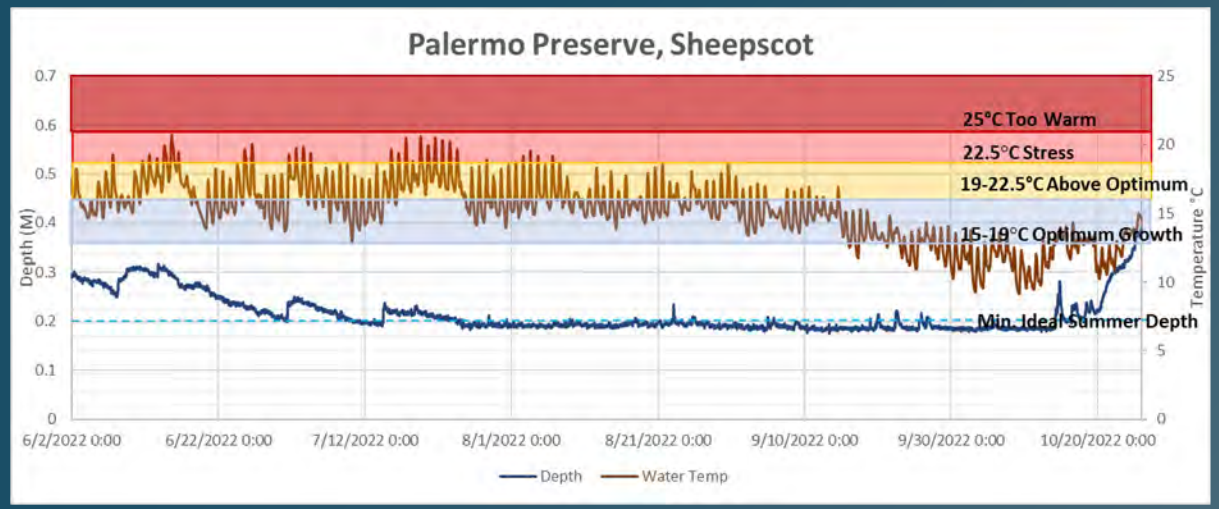


Pullen Mill Reach, West Branch Sheepscot

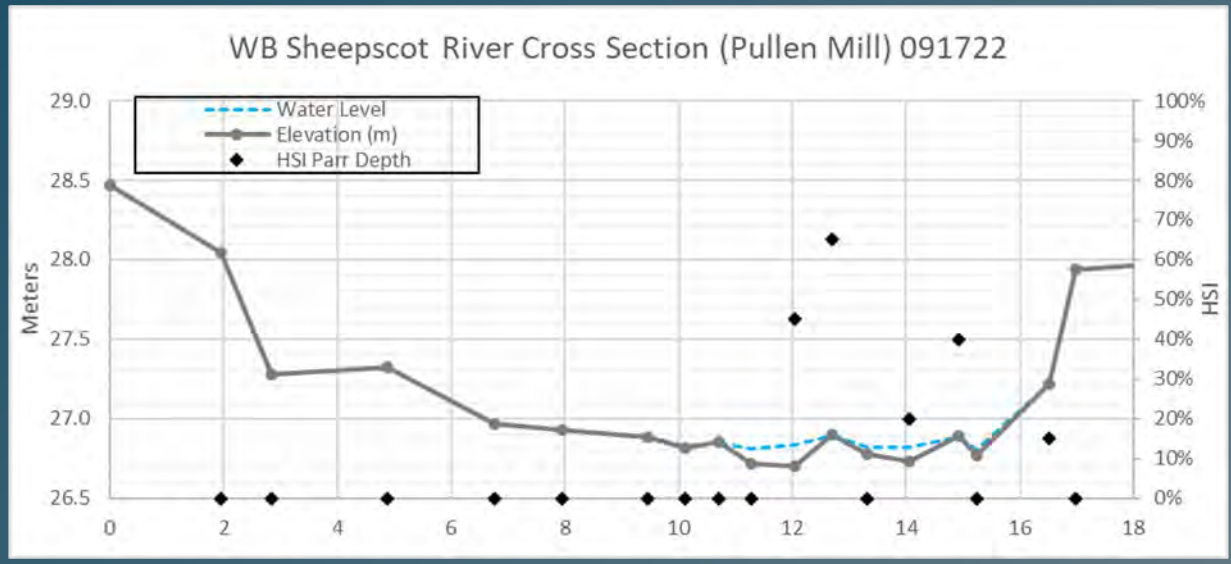
Continuous Water Quality Monitoring of Potential Reference Reaches

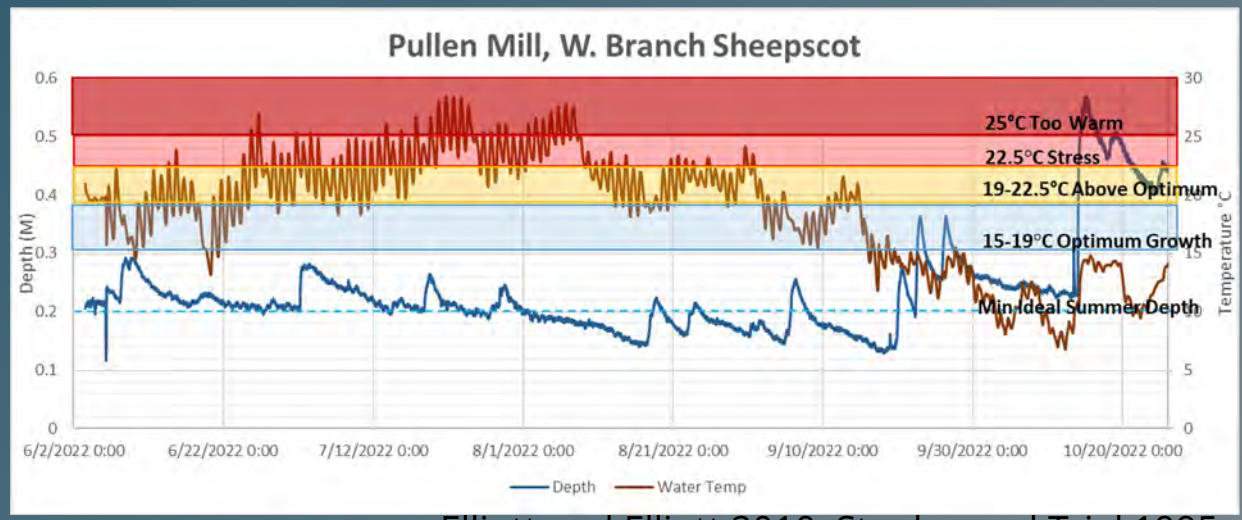
Palermo Preserve





Pullen Mill



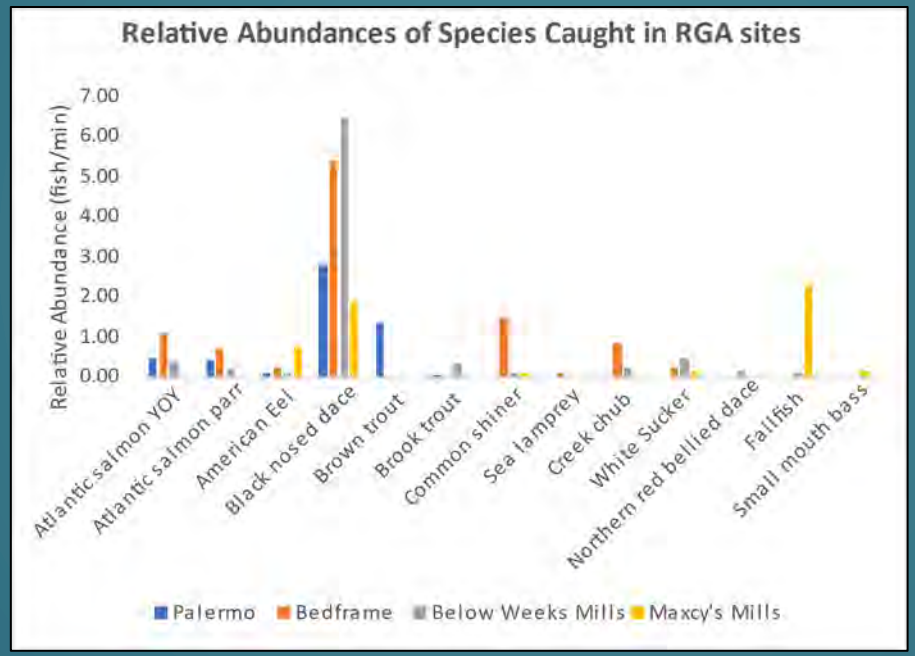


Elliott and Elliott 2010; Stanley and Trial 1995

BIOLOGICAL DATA

Objectives:

1. Collect relative abundances of all species in site to document species presence
2. Collect length/weight data for an indication of fish health



Relative abundances of species caught in RGA sites				
	Palermo	Pullen Mills	Below Weeks Mills	Maxcy's Mills
Atlantic salmon YOY	0.48	1.14	0.38	0.00
Atlantic salmon parr	0.43	0.71	0.19	0.00
American Eel	0.11	0.24	0.09	0.75
Black nosed dace	2.80	5.39	6.50	1.85
Brown trout	1.34	0.00	0.00	0.00
Brook trout	0.05	0.00	0.33	0.00
Common shiner	0.00	1.51	0.09	0.10
Sea lamprey	0.00	0.09	0.00	0.00
Creek chub	0.00	0.85	0.24	0.00
White Sucker	0.00	0.24	0.47	0.15
Northern red bellied dace	0.00	0.00	0.14	0.00
Fallfish	0.00	0.00	0.09	2.30
Small mouth bass	0.00	0.00	0.00	0.15
Relative abundances = fish/minute				

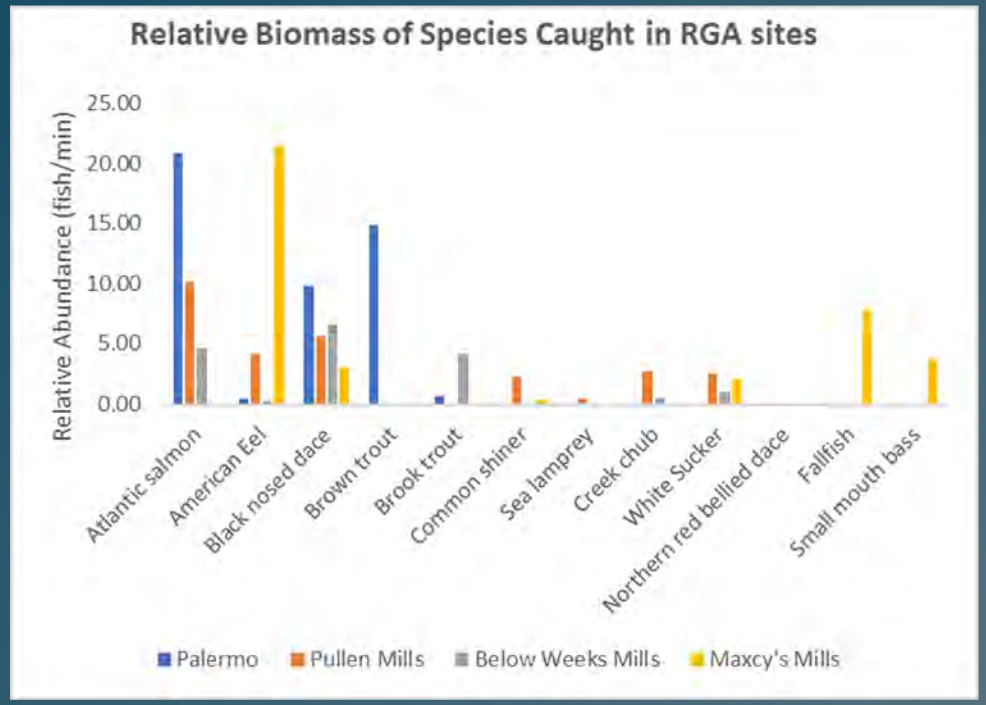
Sites:

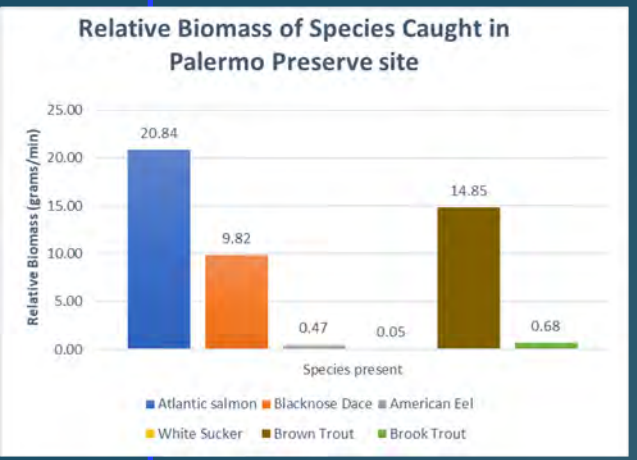
- Palermo and Pullen Mills are “index sites”
- Weeks Mills and Maxcy’s Mills are study sites

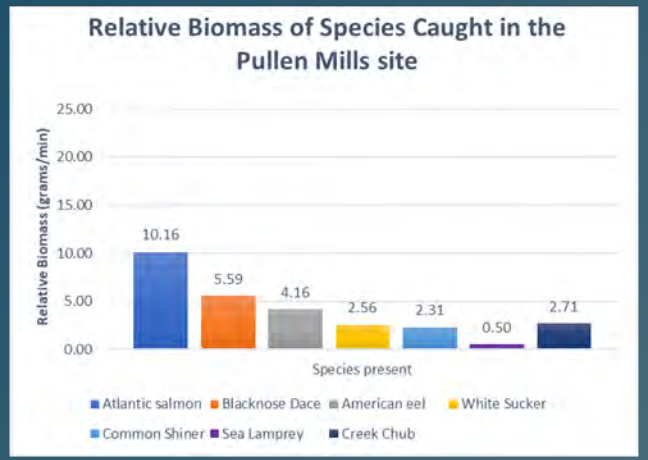
Salmon Sizes in each RGA site					
		Palermo	Pullen Mills	Below Weeks	Maxcy's Mills
YOY	Av. Length (mm)	80.6	50.4	57.4	N/A
	Av. Weight (g)	6.5	1.3	1.9	N/A
Parr	Av. Length (mm)	153.4	105.0	124.5	N/A
	Av. Weight (g)	41.2	12.3	20.7	N/A

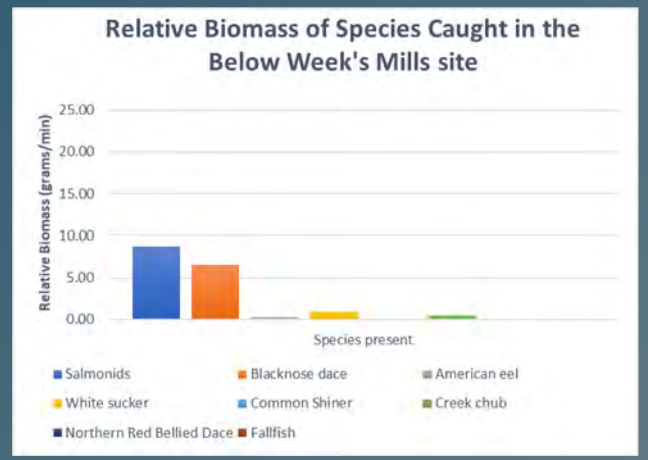
Community/Biomass Data

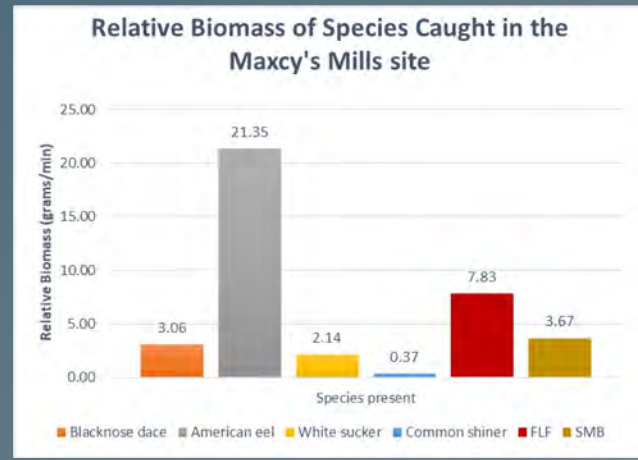
Relative biomass of species caught in RGA sites				
	Palermo	Pullen Mills	Below Weeks Mills	Maxcy's Mills
Atlantic salmon	20.84	10.16	4.61	0.00
American Eel	0.47	4.16	0.28	21.35
Black nosed dace	9.82	5.59	6.55	3.06
Brown trout	14.85	0.00	0.00	0.00
Brook trout	0.68	0.00	4.11	0.00
Common shiner	0.00	2.31	0.06	0.37
Sea lamprey	0.00	0.50	0.00	0.00
Creek chub	0.00	2.71	0.52	0.00
White Sucker	0.05	2.56	0.99	2.14
Northern red bellied dace	0.00	0.00	0.11	0.00
Fallfish	0.00	0.00	0.07	7.83
Small mouth bass	0.00	0.00	0.00	3.67
Total	**46.72**	**27.97**	**17.29**	**38.41**
Total salmonid biomass	36.37	10.16	8.72	0.00
	Relative biomass = grams/minute			











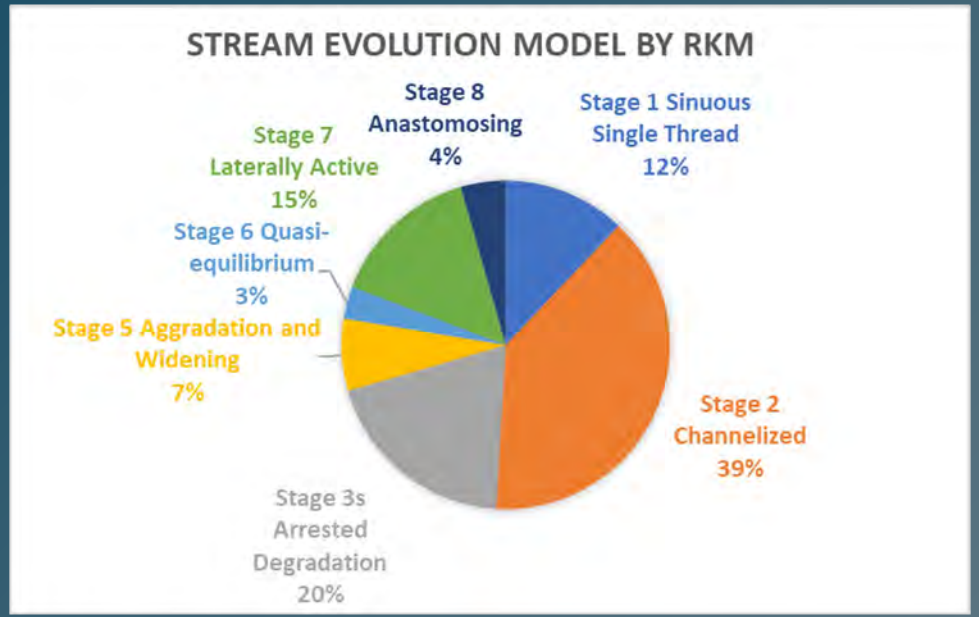
Reference Reach Comparison

Excellent	Good	Fair	Poor

	Palermo	Pullen Mills
Water Quality (Stanley & Trial 1995)	Highly Suitable Temp, Depth & DO	Poor Temps on 61 days & Depth on 4 days
Salmonid Relative Biomass	36.37 grams/minute	10.16 grams/minute
Large Wood 656 pieces per RKM (Kratzer & Warren 2013)	50.4 per RKM	60.5 per RKM
Large Wood Target 98 Key Pieces per RKM (MFS)	16.76 key pieces per RKM	6.7 key pieces per RKM
Entrenchment Ratio (Rosgen 1996)	1.54	1.59
Bankfull Width (Dudley 2004)	Measured 15.36 vs 17.2 Regional Curve	Measured 12.6 vs 8.87 Regional Curve
Width/Depth Ratio (Buffington et al. 2021; Rosgen 1996)	25.6	33.15
#Pool Depth>0.6m (avg depth)	1 (0.45 m)	0 (0.3 m)
Pool to Pool Spacing	20 m	34 m
Substrate (Stanley & Trial 1995)	Coarse Gravel/Cobble	Cobble/Rubble
Riparian Cover (community)	100% (2nd generation Hemlock Forest)	100% (young Hardwood Seepage Forest)
Streambank Condition	Excellent (some limited erosion)	Modifications by previous mill operations
Refugia (side channels; springs etc.)	None (mapped as cold water)	None (mapped as cold water)
Geomorphic Condition (Castro and Thorne 2019)	Laterally Active (Stage 7)	Stage 3s Arrested Degradation

OVERALL SUMMARY OF REACHES SAMPLED

- Only one of 13 reaches assessed met MFS large wood recommendations, which had been previously enhanced
- No reaches met key pieces of wood recommendations
- Most all reaches had gone through some form of degradation and widening in the past with 6 undergoing active transitions due to historic anthropogenic activities
- 4 out 13 reaches had pools over 0.6 m
- Observed how stair stepped nature of river inhibits river's ability to move sediment and recover from legacy impacts (Snyder et al. 2013)

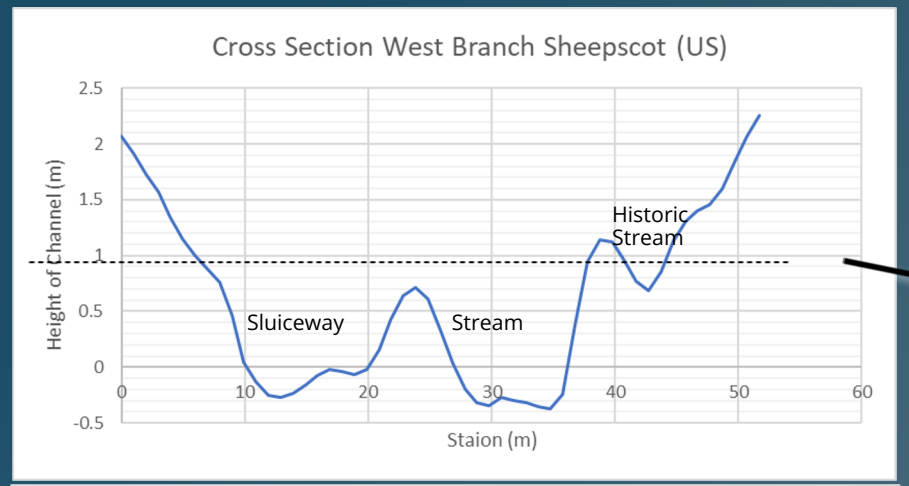


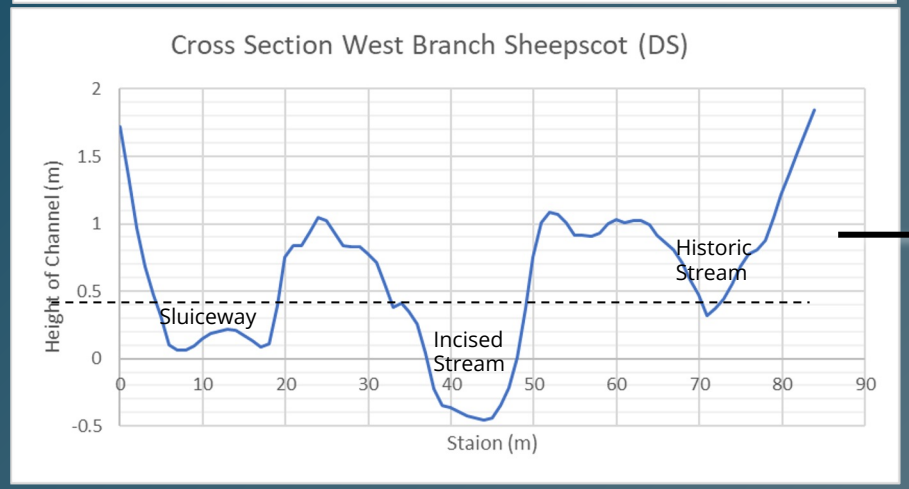
PALS installed in 2019 slowly shifting Stage 3s to 5

LOWER PULLEN MILLS

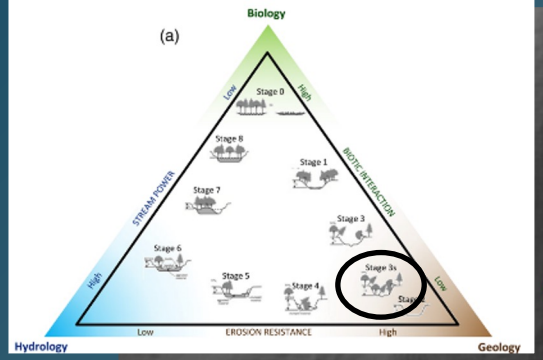
- ***Channel is in an Arrested Degradation (Stage 3s) from historic mill dam operations***
- ***Geomorphic Grade Line*** toolbox (by Powers et al. 2019) used to identify level of stream incision

Sluiceway in floodplain





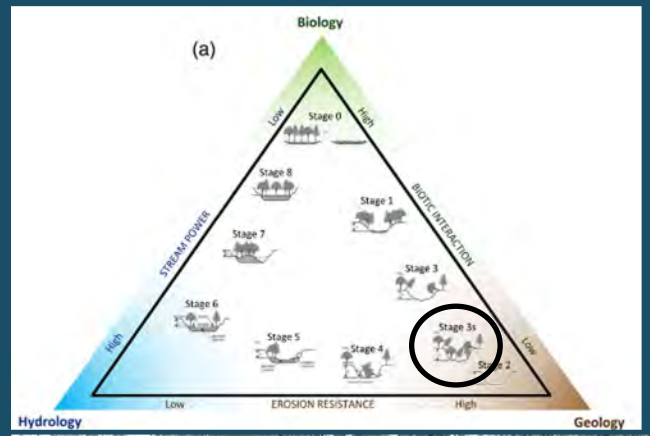
Looking Downstream with sluiceway on River Right

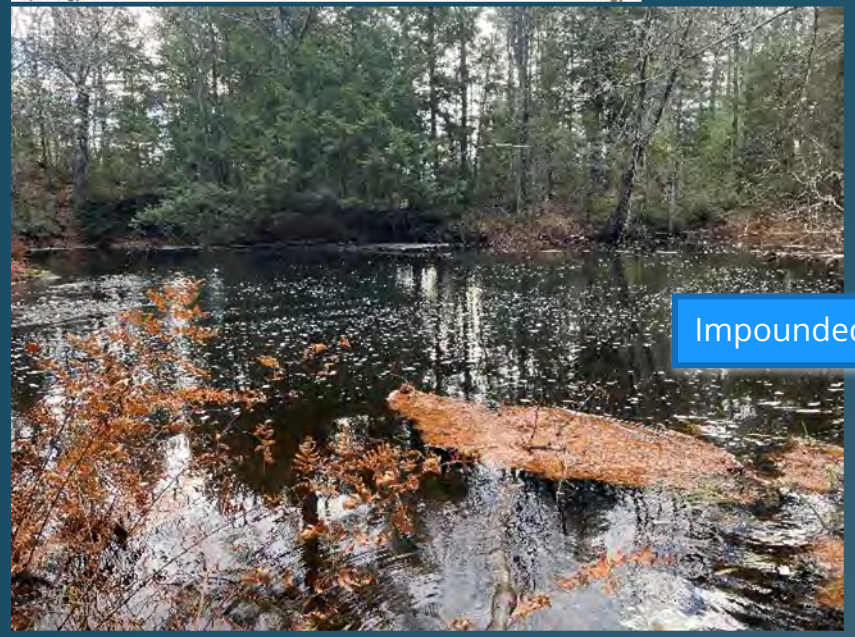


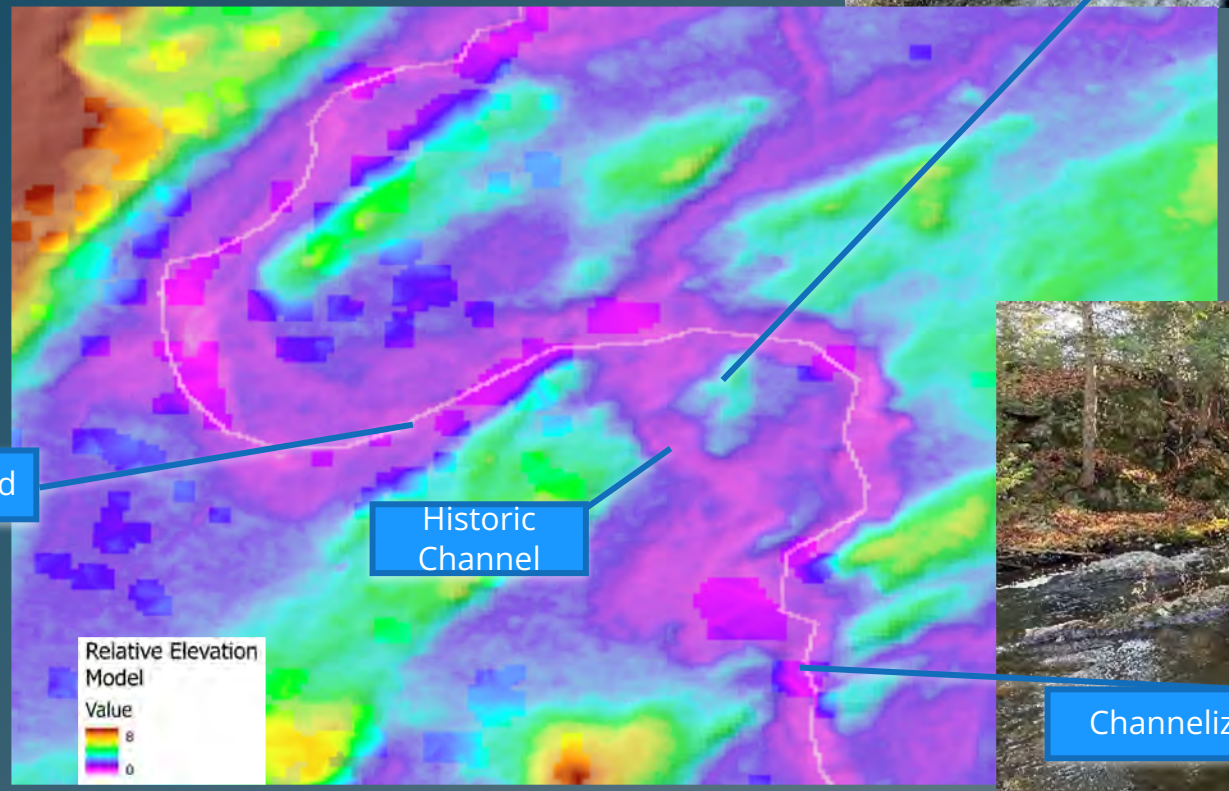
Incised channel in pink & sluiceway in floodplain

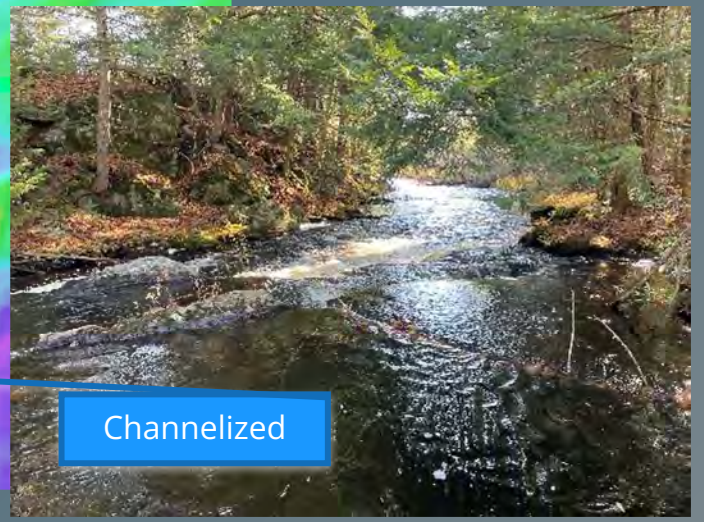
UPPER WEST BRANCH SHEEPSCOT

- ***Upstream channel is impounded***
- ***Downstream channel is in a state of Arrested Degradation (Stage 3s)***









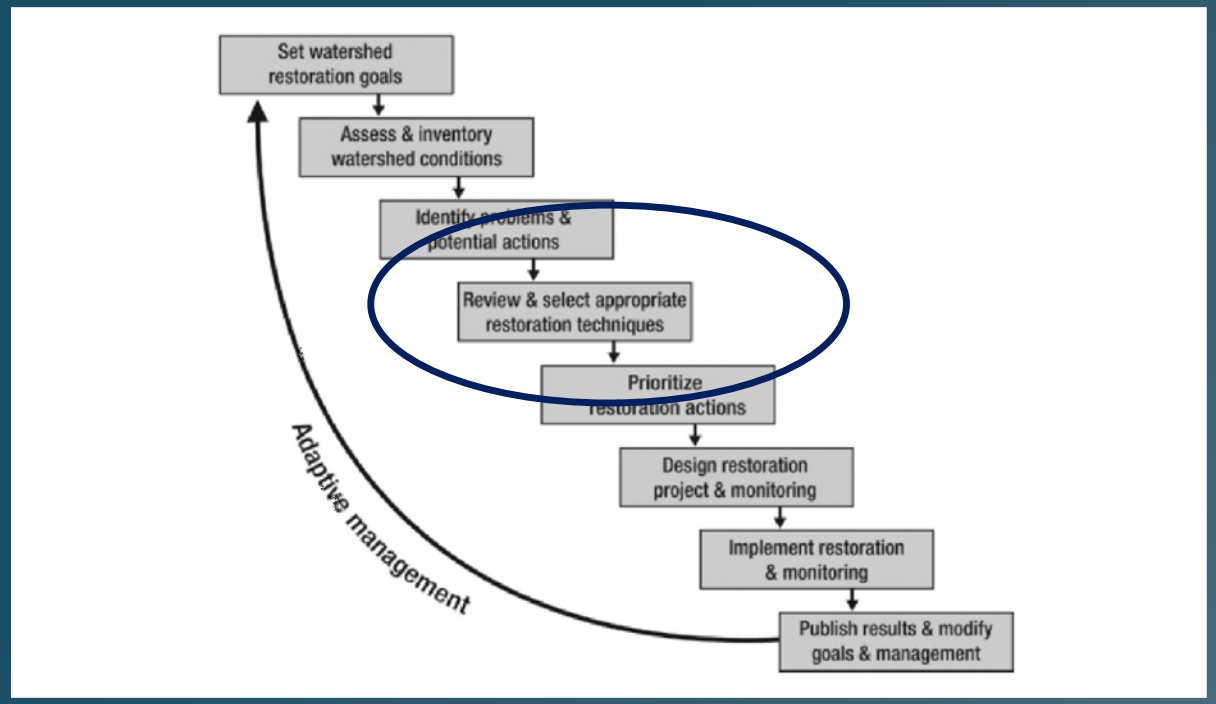
Excellent	Good	Fair	Poor	Lower Pullen Mills	Upper WB Sheepscot
Large Wood per 1 RKM	656 pieces per RKM (Kratzer & Warren 2013)			56.85	5.7
Key LW per 1 RKM	98 Key Pieces per RKM (Maine Forest Service 2022)			0	0
Debris Jams	Good 3+; 3-2; 1; 0 (VT Rapid Stream Assessment 2009)			3.56	0
Slope	<0.5%; 0.5-1%;1-2%;3%+ (Stanley & Trial 1995)			1%	1.2%
Entrenchment Ratio	(Good) 2+; 2.0-1.4; 1.4-1.2;1.2> (Bad) (Rosgen 1996)			1.25	1.49
Bankfull Width vs Regional Curve (m)	Degree within/outside Regression Confidence Interval (Dudley 2004)			11.8 vs. 8.8	7.3 vs 8.13
Width/Depth Ratio	Good <15; 15-25; 25-40; 40+ Bad (Buffington et. al 2021; Rosgen 1996)			25.77	14.03
# Pools >0.6m (avg Pool Depth)	3+; 2; 1; 0 and (VT Rapid Stream Assessment 2009)			0 (0.3 m)	4 (1.1 m)
Substrate	Fines/Sand; Gravel-Cobble; Boulder (Stanley & Trial 1995)			Cobble	Gravel/Cobble
Embeddedness	Good 0-25%; 25-50%;50-75%;75-100% Bad			50%	5-25%
Riparian Cover (Community)	Good 0-25%; 25-50%;50-75%;75-100% Bad			100% (Hardwood Seepage Forest)	100% (Spruce-Fir Cinnamon Fern Forest)
Streambank Condition/Corridor	Excellent			Steep/Eroding; historic dams	Confined by historic dam operation
Refugia (side channels; springs etc.)	Springs, side channels, cold water			None (sluiceway along floodplain)	None observed, some refugia
Stream Evolution Model	Stages 0,1,7,8 (Cluer and Thorne 2013)			Stage 3s Arrested Degradation	Stage 3s Arrested Degradation
Atlantic salmon habitat	Spawning and Rearing			Spawning and Rearing	Spawning

CONCLUDING THOUGHTS

- No true reference reaches were found
- Slope, sinuosity, riparian condition matches well with desktop analysis, confinement needing adjustment
- Water Depth and Temperature appear to be one of the greatest limiting factors to parr survival
- All reaches have insufficient wood loading when compared to reference forest stands not cut in 200+ yrs (Kratzer & Warren 2013; Keeton et al. 2007)
- Most rearing habitat is often near historic mill dams due to higher stream gradient, which frequently have modified channels that are incised, widened and in some cases have large impoundments upstream with poorer water quality
- Limited pool frequency and many are shallow impacting adult salmon refugia

NEXT STEPS

- Watershed Restoration Plan summarizing habitat conditions and restoration actions for currently assessed reaches
- Apply spatial analysis to the mainstem Sheepscot River
- Landowner outreach
- Pursue funding to expand field assessments across watershed and fund identified restoration actions




Many thanks to members of Sheepscot Collaborative for providing guidance and input and to the landowners who provided access to their properties!

Questions?

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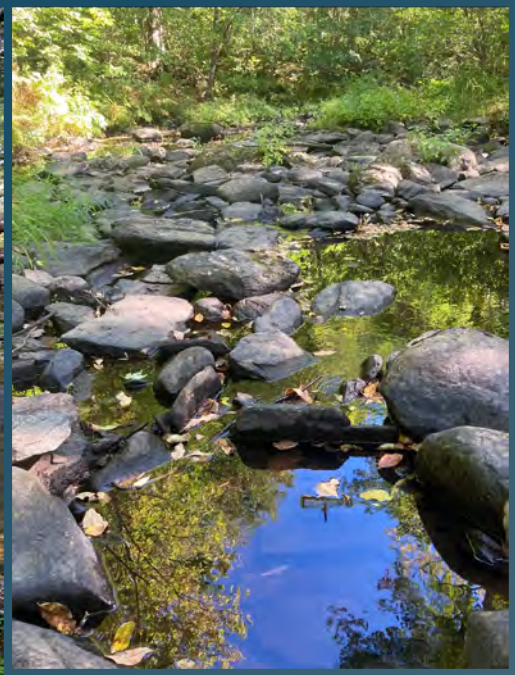






PROJECT APPROACH

Focus on West Branch Sheepscot Watershed to test and refine methodology while also identifying potential habitat restoration opportunities.

- Tributary of the Sheepscot River
- ~ 25 miles long, 50 sq. mile drainage area
- Most productive salmon habitat in the Sheepscot
- Land use:
  - natural land cover (86%)
  - 1% Impervious Cover (NOAA OCM 2022)
- Geology predominantly glacial till and glaciomarine deposits (Maine Geological Survey)