

Ecological Flows Framework for North Carolina's Coastal Region

Coastal Ecological Flows Work Group

Ecological flow or eco-flow is the flow necessary to maintain ecological integrity. In accordance with state law and anticipation of future withdrawals, the NC Department of Environment and Natural Resources (DENR) is in the process of identifying eco-flows for the state. DENR's Ecological Flows Scientific Advisory Board tasked a group of coastal stream experts from universities, private industry, and government agencies, known as the Coastal Ecological Flows Work Group (CEFWG), with identifying approaches for modeling eco-flows NC's Coastal Plain (figure 1).

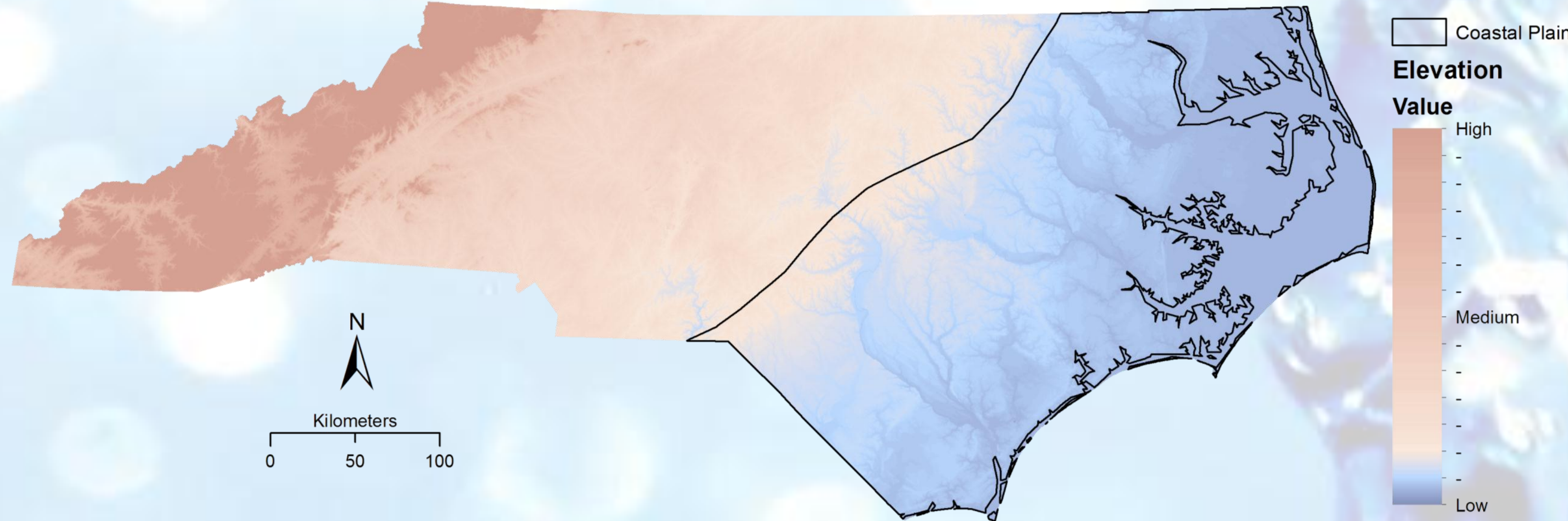


Figure 1 – North Carolina Elevation Map with Coastal Plain Study Area Outlined

Coastal Ecological Flows

Due to tidal influence and tail water conditions common to the region, coastal stream flow is often independent of stage, invalidating a fundamental concept of traditional eco-flow models. A relative lack of long-term and spatially distributed flow records impede characterization of regional flow regimes. Unique regional ecologies also developed from natural water quality characteristics interdependent with flow, such as low pH and dissolved oxygen, saltwater gradients, and higher dissolved organic carbon. Developing a framework for classifying stream reaches serves as the first step for determining regional eco-flows. The CEFWG's framework development process is presented here.

Framework Development

The initial typology (figure 2) was developed from the CEFWG's knowledge and studies of distinguishing ecological characteristics and classifications across the region. Habitats were assigned to each classification.

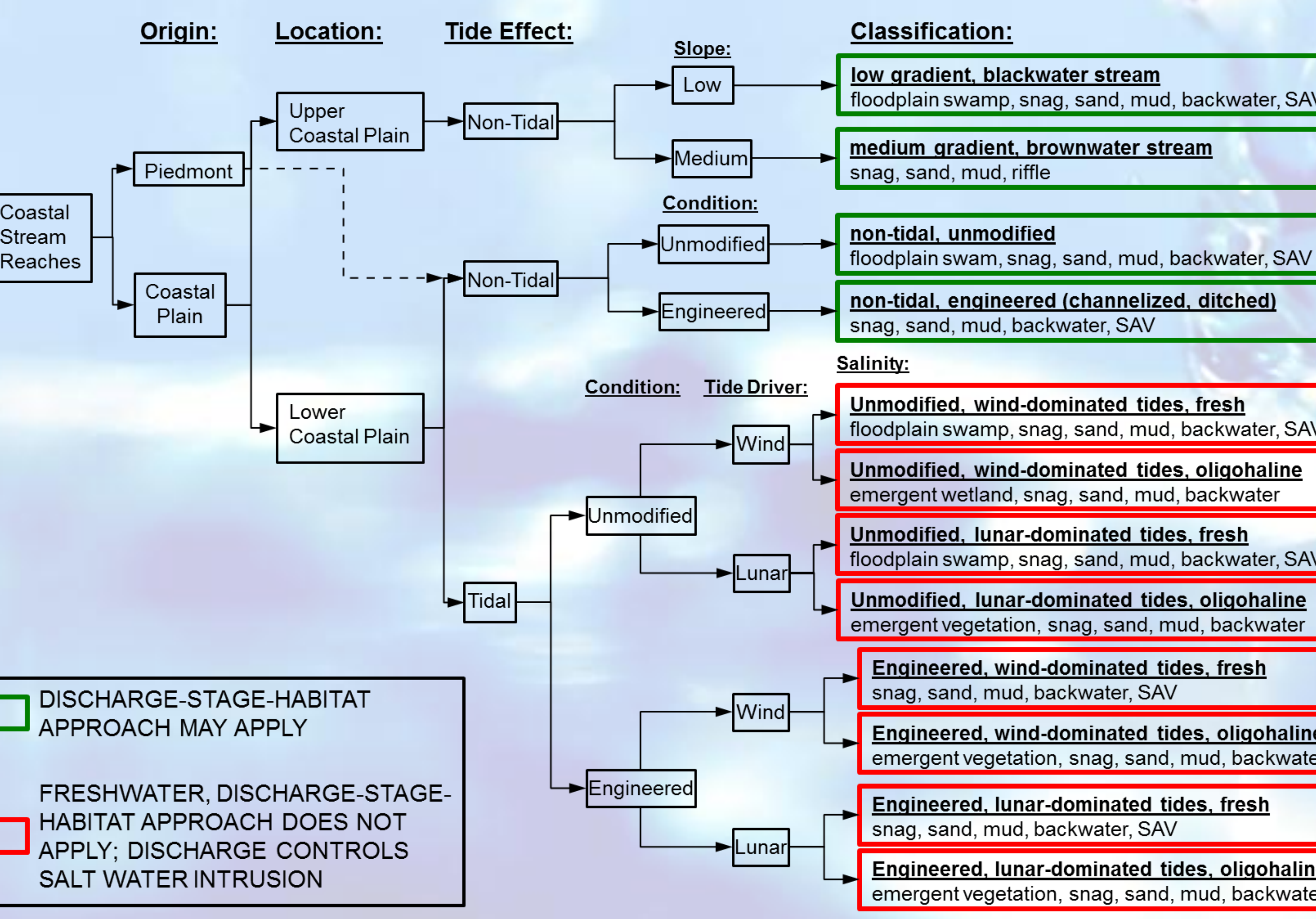


Figure 2 – Initial Coastal Stream Reach Characteristic and Classification Typology

Ecosystem Assessment Focus

- Anadromous Fish
- Regional economic and ecological importance
 - Wide geographic area over lifespan
 - Many species reside in tidal waterways
 - Available habitat suitability models
 - Flow important for spawning & maturation.
 - Roanoke River links habitat suitability to flow
 - Resident fish and vegetation also considered

Table 1 – Physical Spawning (Adult) and Egg Development Requirements for Resident Freshwater and Anadromous Fishes Inhabiting Coastal North Carolina from the 2010 North Carolina Coastal Habitat Protection Plan (Deaton et al., 2010)

Species	Salinity (ppt)		Temperature (C)		Dissolved Oxygen (mg/l)		Flow (cm/s)
	Adult	Spawn/Egg	Adult	Spawn/Egg	Adult	Spawn/Egg	Spawning
Alewife	[S] 0-5	[S] 0-5 [O] 0-2	[S] 11-28 [O] 17-21	[S] 11-28 [O] 17-21	[S] >3.6	[S] >4	[O] slow current
American shad	[S] 0-18	[S] 0-18 [O] 0-2	[S] 10-30	[S] 13.0-26	[S] >5		[S] 30-90
Blueback herring	[S] 0-5	[S] 0-22 [O] 0-2	[S] 14-26	[O] 20-24	[S] >5		[O] strong current
Striped bass	[S] 0-5	[S] 0.5-10	[S] 20-22	[S] 12-24 [O] ~18-22	[S] >5		[S] 30.5-500 [O] 100-200
Yellow perch	[S] 0-13	[S] 0-2	[S] 6-30		[S] >5		
White perch	[S] 5-18	[S] 0-2	[S] 10-30	[S] 12-20	[S] >5		
Sturgeon, Atlantic	[S] 0 to >30	[S] 0-5	[S] 0 to >30	[S] 11-20			
Sturgeon, Shortnose	[S] 0 to >30	[S] 0-5	[S] 0 to >30	[S] 5-15			

[S] = Suitable, and [O] = Optimum

Typology Refined via Spatial Data

- Evaluated characteristics & classifications using GIS resources (see examples below)
- NC DENR: Water Quality Classifications (salt waters, swamp waters)
- US Fish & Wildlife Service: National Wetlands Inventory (tidal, fresh water)
- USGS: National Elevation Dataset (reach slopes), National Hydrography Dataset (reach paths)

- Thresholds:
- Medium/Low Slope: 2.5 mm/m (0.25%)
 - Tidal influence: < 1 m above sea level
 - Upper/Lower Coastal Plain: Suffolk Scarp
- Insufficient Data: Characteristics Eliminated
- Tide Driver: Wind vs. Lunar
 - Condition: Unmodified vs. Engineered
 - Blackwater/Brownwater
 - Saltwater withdrawal impacts

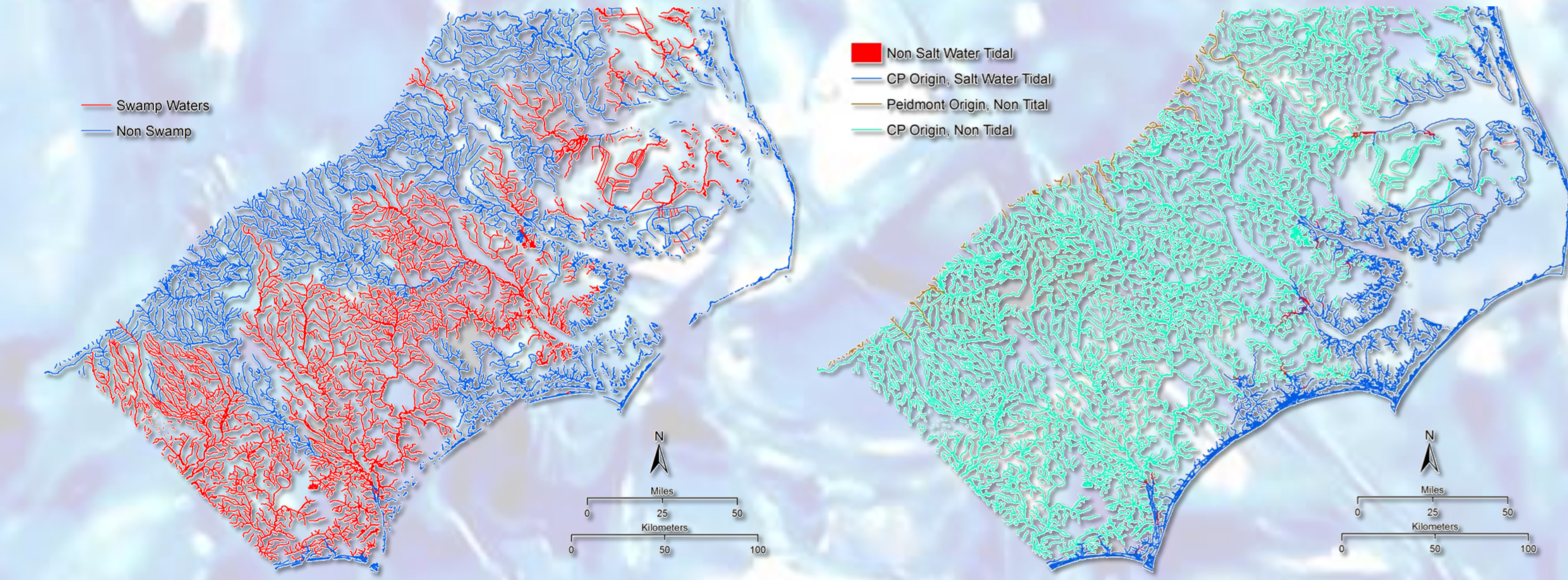


Figure 3 – NC DENR "swamp waters" classified stream reaches (estimate of "blackwater") Figure 4 – Coastal reach origin, tidal influence, and saltwater classification (DENR)

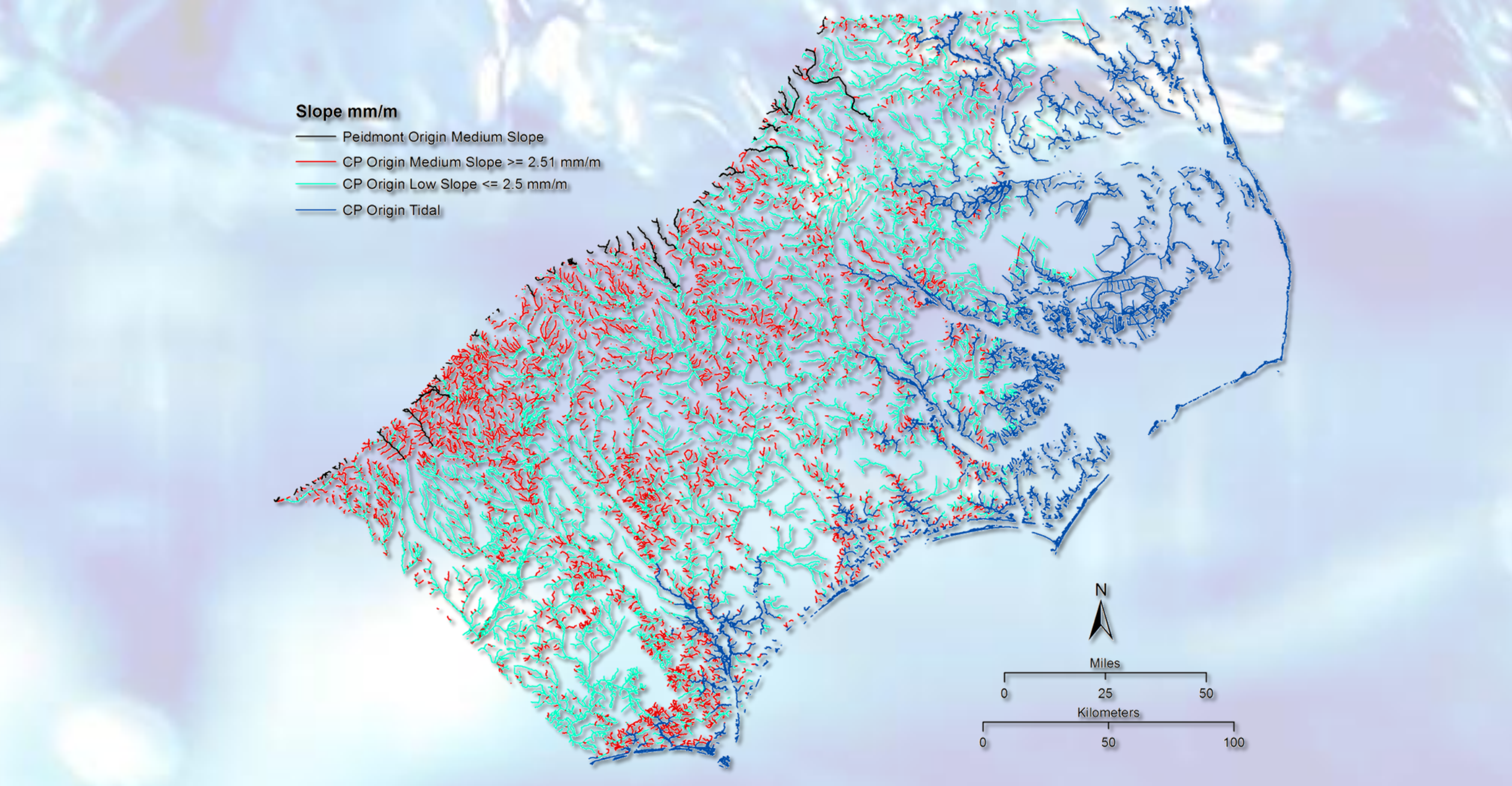


Figure 5 – Stream reach classifications by origin, slope (+/- 2.5 mm/m), and tidal (<1 m asl) influence.

Final Typology

Typology classifications were consolidated by removing characteristics with insufficient data and uncertain or insignificant distinctions. The final typology provides the basis for the recommended determinants and assessment assemblages for estimating coastal stream reach eco-flows (Table 2).

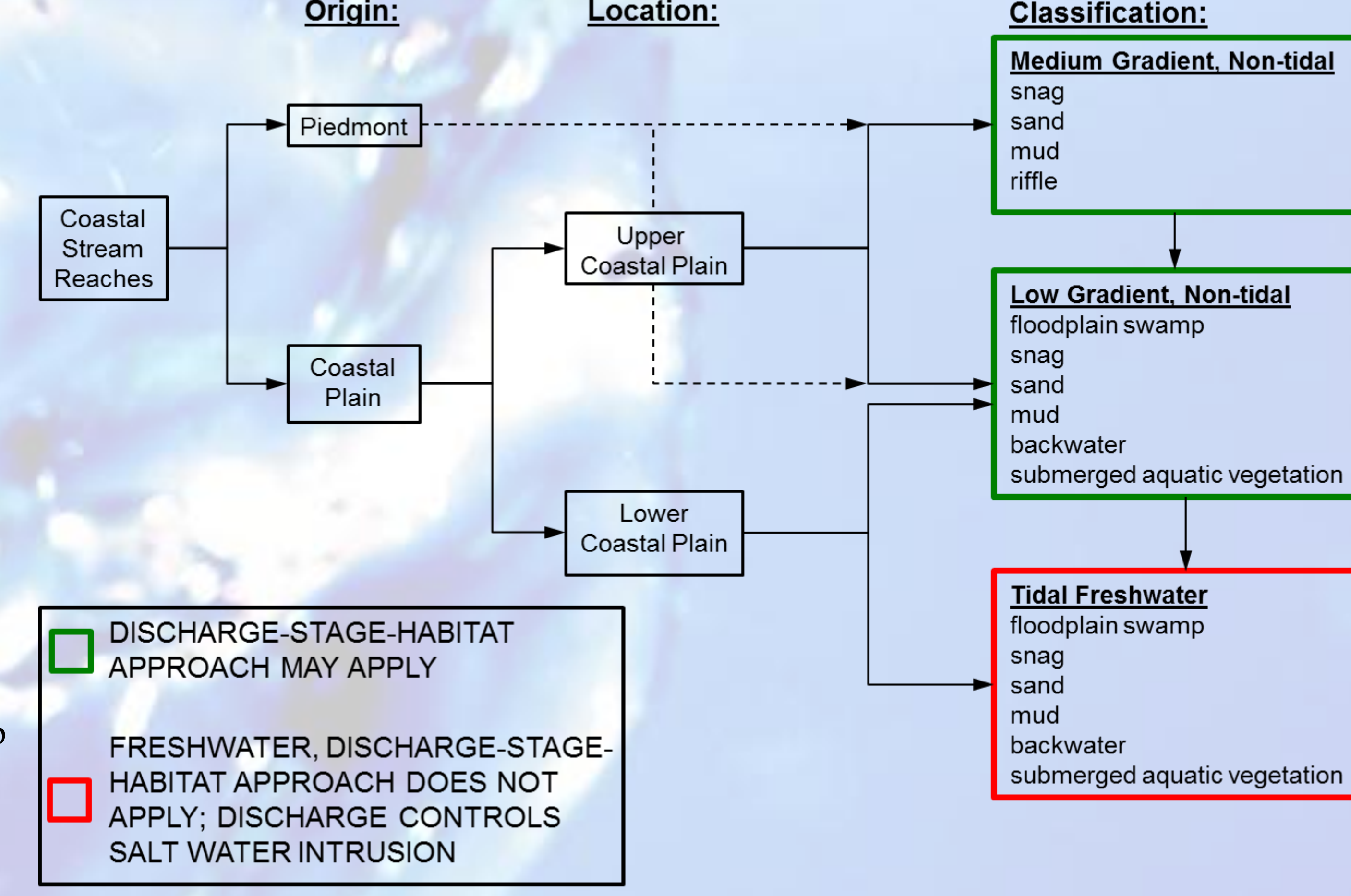


Figure 6 – Final Coastal Stream Reach Characteristic and Classification Typology

Recommendations

Table 2 – Recommended Eco-Flow (EF) Determinants and Assessment Assemblages based on Final Typology for Coastal Stream Reach Eco-Flows

Origin	Slope Gradient	Relevant EF Determinants				Assemblages for EF Assessment		
		EFSAB Extension	Discharge & Habitat	Downstream Salinity	Overbank Flow	Anadromous Fish	Resident Fish	Vegetation
Piedmont	Medium (> 0.25%)	X	X	X		X		
Upper Coastal Plain	Medium (> 0.25%)	X	X	X		X		
Upper Coastal Plain	Low (< 2.5 mm/m)		X	X	X	X		X
Lower Coastal Plain	Low (< 2.5 mm/m)		X	X	X	X		X
Lower Coastal Plain	Tidally Driven Flow			X	X		X	X

- Essential continuing efforts for Coastal Streams moving forward:
- Determine relationship of discharge patterns and stream flow
 - Assess inland extent of tidal influence
 - Identify critical water quality indicators for juvenile species
 - Further definition of hydrologic characteristics in each stream reach
 - Determine baseline flow regimes in respective basins
 - Inventory and account for current and projected withdrawal and discharge rates

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