Biological Fidelity Analysis of EFS Stream Classes

Funded by: *Environmental Defense Fund*

Conducted by: *RTI International*

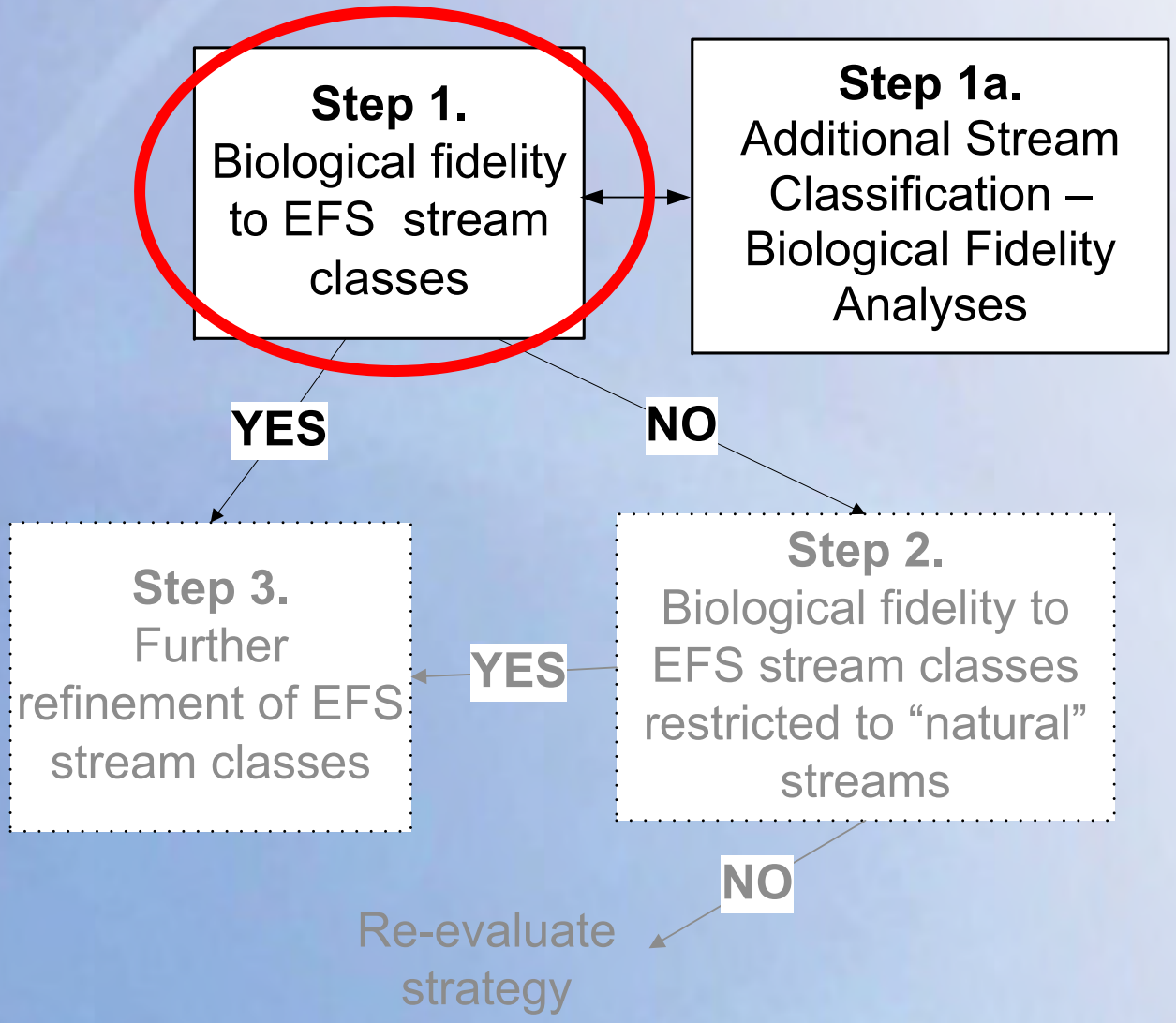
Project Objectives:

- To adopt a stream classification system that represents the distribution of aquatic biota in North Carolina
  - evaluate the 7 stream classes of the Environmental Flow Specialist (EFS) hydrological stream classification system:
    - A. Coastal Streams
    - B. Small Stable Streams
    - F. Medium Stable Streams
    - C. Large Stable Streams
    - E. Large Piedmont Rivers
    - D. Small Flashy Streams
    - G. Small Seasonal

Project Objectives:

- To adopt a stream classification system that represents the distribution of aquatic biota in North Carolina
  - Compare fidelities of aquatic biota to different stream classification systems
  - If necessary, modify the EFS stream classes to more accurately describe the distribution of biota

Stream Class – Biological Fidelity Analysis



Step 1.

Objective: Examine the biological fidelity of aquatic biota to the 7 EFS stream classes

- **Pair USGS gages (185 gages) to biota at biological monitoring sites to determine stream class – biology assignments**

Step 1.

Aquatic Biota Database	Supporting NC Agency, Department or Program
Benthic macroinvertebrate	N.C. Department of Environment and Natural Resources (NCDENR) Division of Water Quality (DWQ)
Stream fish community	NCDENR DWQ
Natural Heritage Inventory	NCDENR Natural Heritage Program
Trout database	N.C. Wildlife Resources Commission

Step 1.

Objective: Examine the biological fidelity of aquatic biota to the 7 EFS stream classes

- Pair USGS gages (185 gages) to biota at biological monitoring sites to determine stream class – biology assignments
- **Generate 500 "virtual gages" with WaterFALL™ hydrologic data to assign stream classes to biological monitoring stations without gages**

Criteria for biological monitoring stations

- Monitoring stations distributed evenly across the state
- Eliminate:
  - catchments with impaired water quality (as determined by NC Division of Water Quality – 303d listings)
  - catchments with major in-stream flow alterations (impoundments, discharges and/or intake points)
  - catchments with “poor” or “questionable” biological monitoring data

Criteria for biological monitoring stations

- Select:
  - catchments that contain biological monitoring stations from multiple aquatic biota datasets
  - biological monitoring stations sampled during years with average climate conditions
  - biological monitoring stations with most recent biological data
  - biological monitoring stations with multiple biological measurement dates and presence/absence that doesn't change by > 10%
  - biological monitoring stations upstream from USGS reference gages

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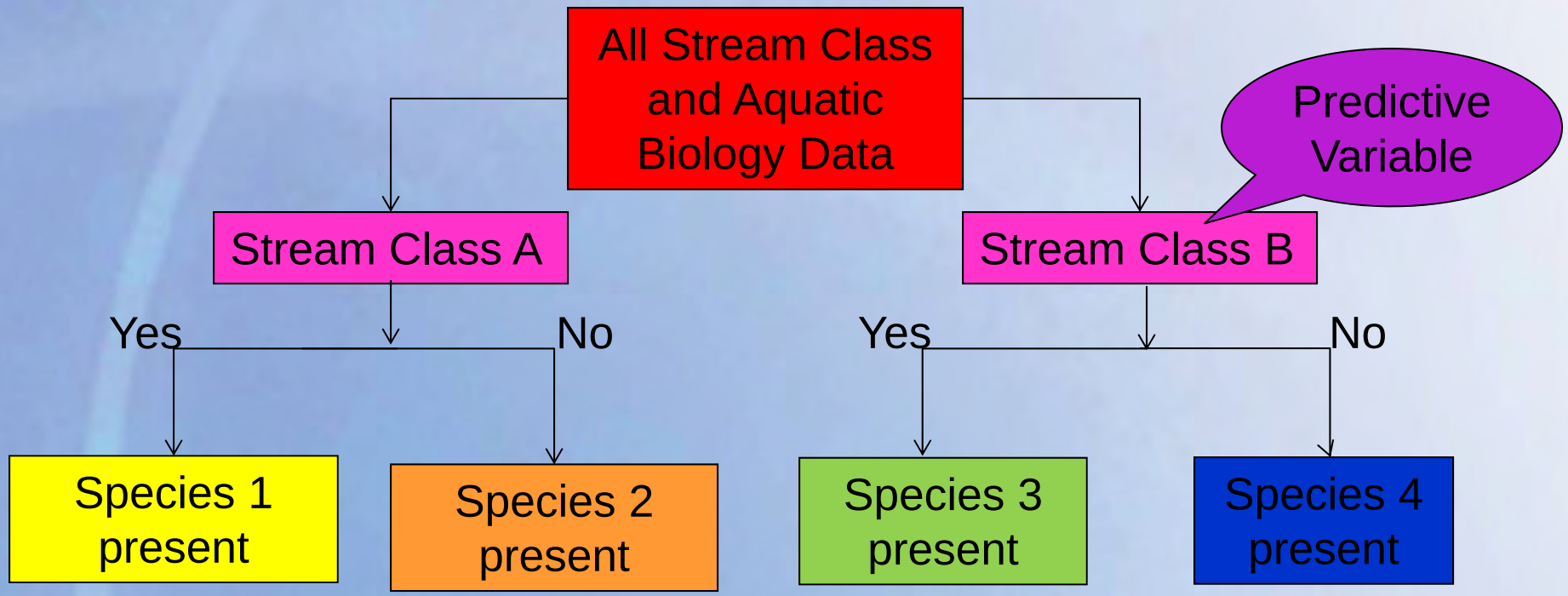
- Pair USGS gages (185 gages) to biota at biological monitoring sites to determine stream class – biology assignments
- Generate 500 “virtual gages” with WaterFALL™ hydrologic data to assign stream classes to biological monitoring stations without gages
- **Random Forest non-parametric analyses to determine probability of species occurrence and biological fidelity to stream classes**

Random Forest Approach

- Random Forest is a decision-tree modeling and classification approach (Cutler et al., 2007)
- A decision tree is a predictive model that uses a set of binary rules (yes/no) to split the data based on the predictor variable



Random Forest Analysis - *Biological fidelity to stream class*

Aquatic species	Stream Class						
	A	B	C	D	E	F	G
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							

= high probability
= medium probability
= low probability
= absent

Random Forest Analysis – *NO Biological fidelity to stream class*

Aquatic species	Stream Class						
	A	B	C	D	E	F	G
1							
2							
3							
4							
5							
6							
7							
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= high probability
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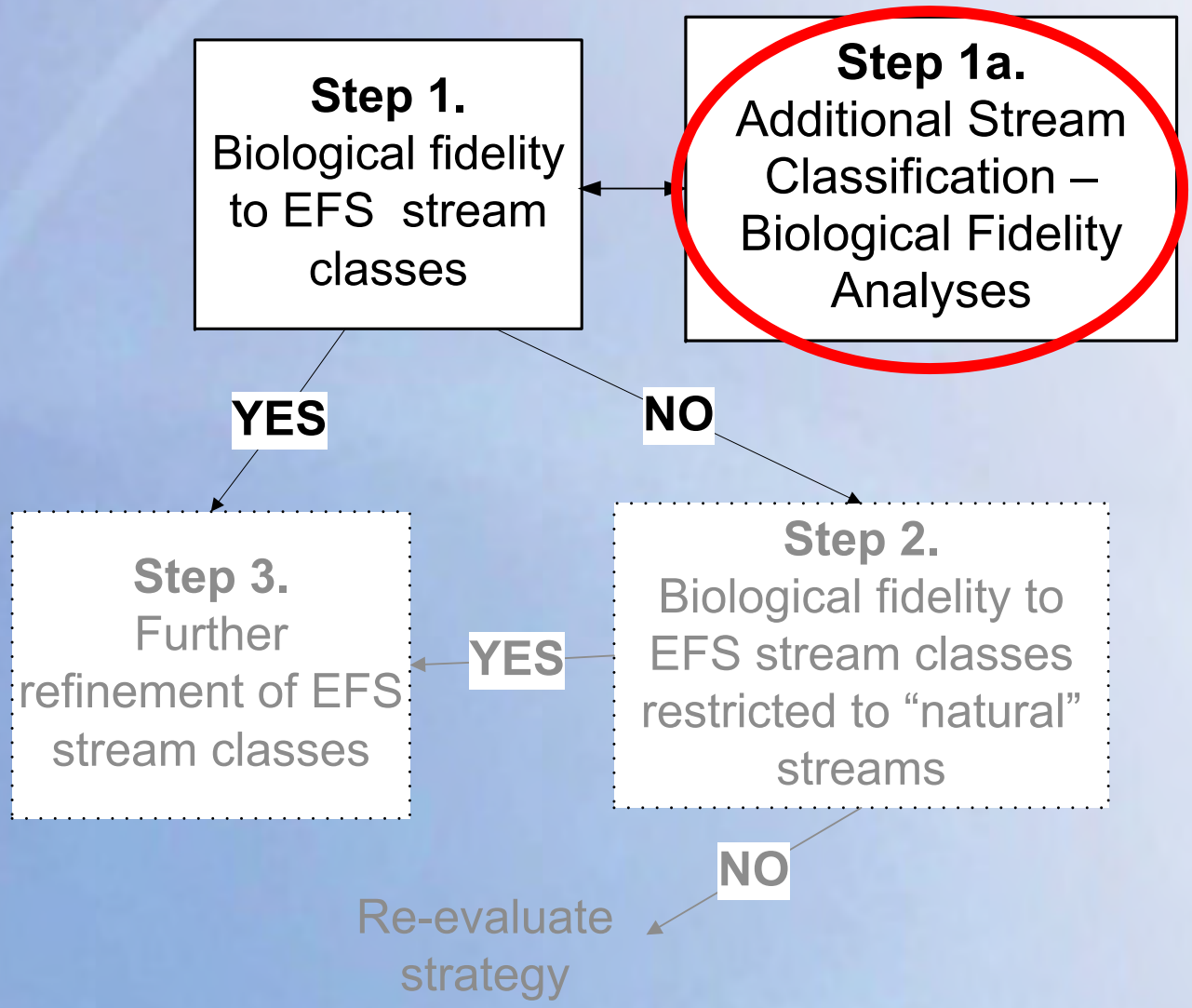
= absent

Step 1.

Objective: Examine the biological fidelity of aquatic biota to the 7 EFS stream classes

- Pair USGS gages (185 gages) to biota at biological monitoring sites to determine stream class – biology assignments
- Generate 500 “virtual gages” with WaterFALL™ hydrologic data and EFS software to assign stream classes to biological monitoring stations without gages
- Random Forest non-parametric analyses to determine probability of species occurrence and biological fidelity to stream classes

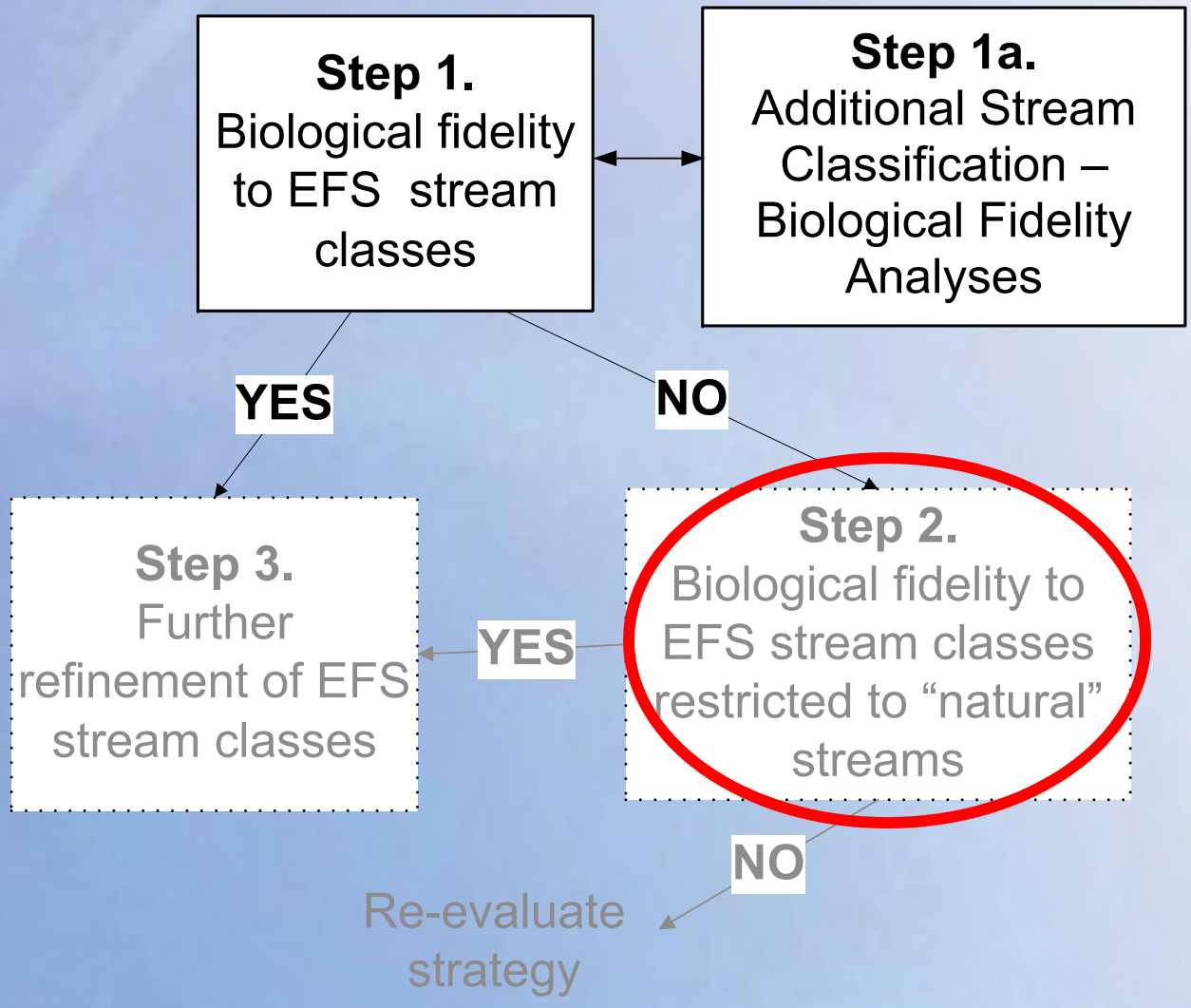
Stream Class – Biological Fidelity Analysis



Step 1a.

- Objective: To test biological fidelity to other stream classification systems and compare with EFS
  - Other stream classifications:
    - McManamay et al. (2011) – regional classification of unregulated streams
    - Konrad (*in review)* – hydrological classification in southeastern U.S.
  - Analyses:
    - comparison of classes determined by the three classification systems
    - comparison of biological fidelities to the three stream classification systems

Stream Class – Biological Fidelity Analysis

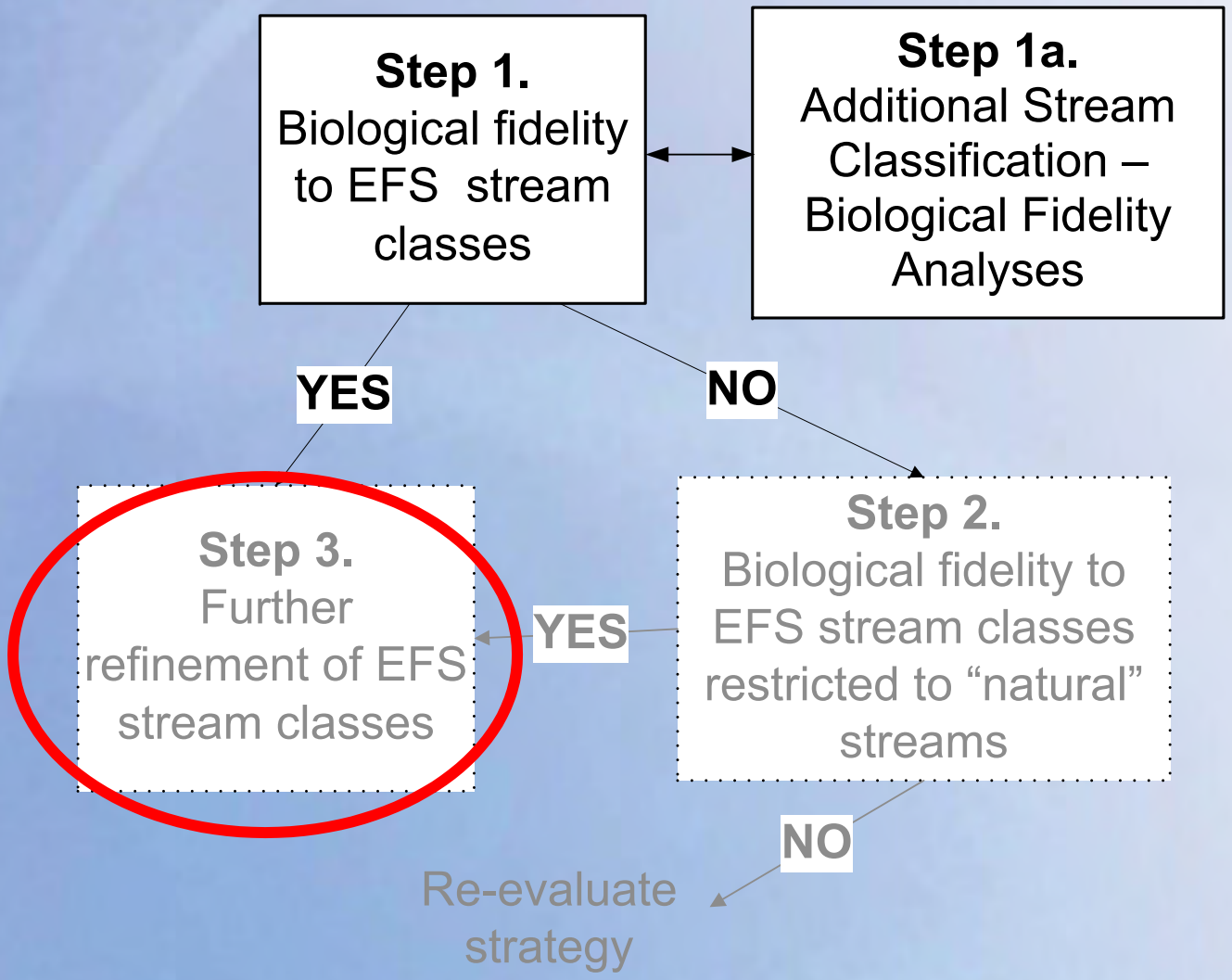


Step 2.

Objective: Assess the biological fidelity of aquatic biota to stream classes that only include streams that are not altered (i.e., minimal instream flow alterations).

- re-classify streams (at 185 gage locations) using WaterFALL™ hydrologic data (unaltered condition) and EFS software
- streams that change classes with the reclassification are considered “altered”
- eliminate “altered” streams from dataset
- repeat Random Forest non-parametric analyses to determine if biological fidelity to stream classes is improved with dataset restricted to non-altered streams

Stream Class – Biological Fidelity Analysis



Step 3.

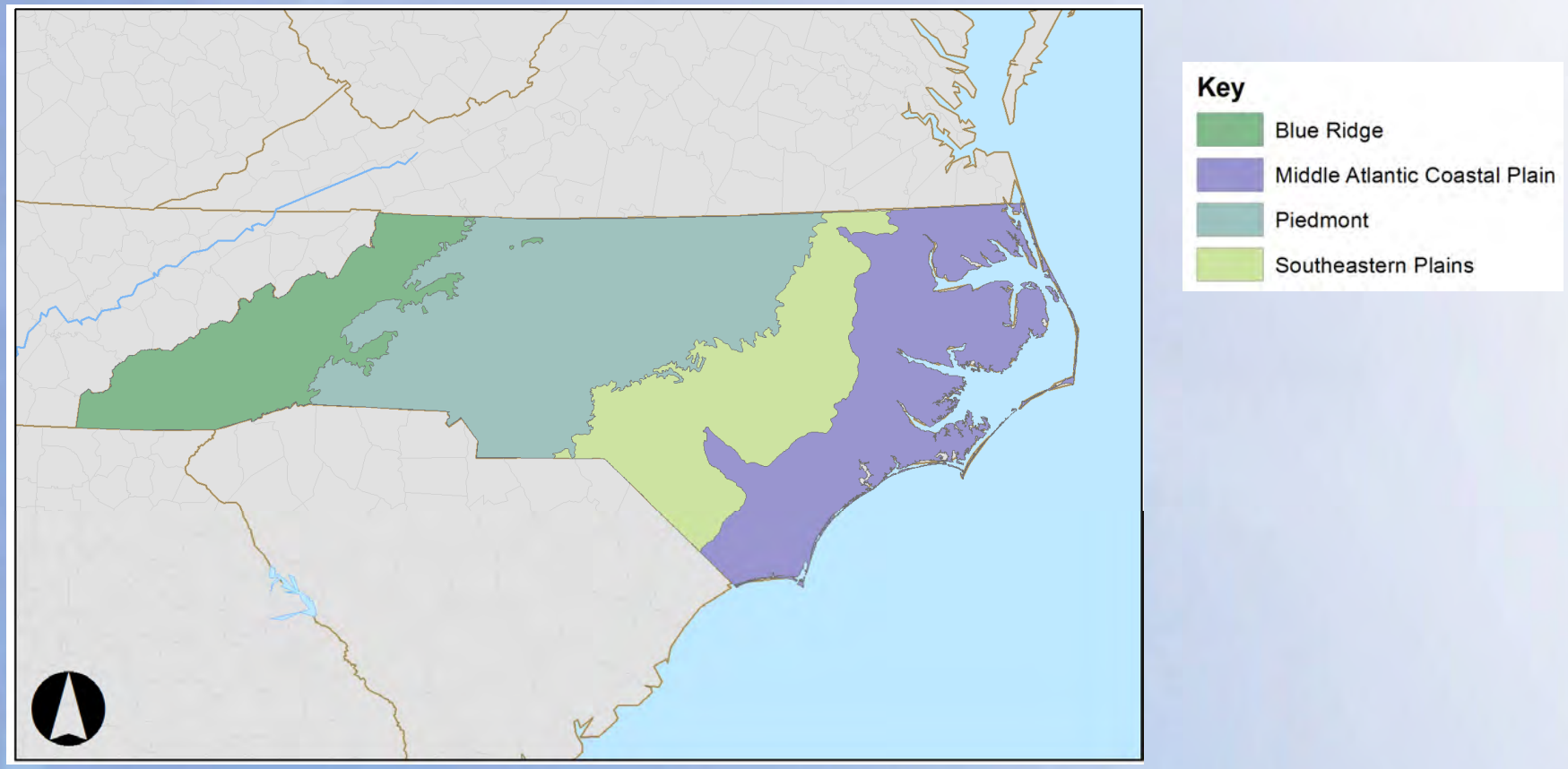
Objective: Evaluate the ability to improve biological fidelity to stream classes by sub-dividing and/or aggregating the 7 EFS stream classes

- Repeat Random Forest non-parametric statistical analyses to determine aquatic biota associations to stream classes divided by:
  - **Physiographic/Eco region**

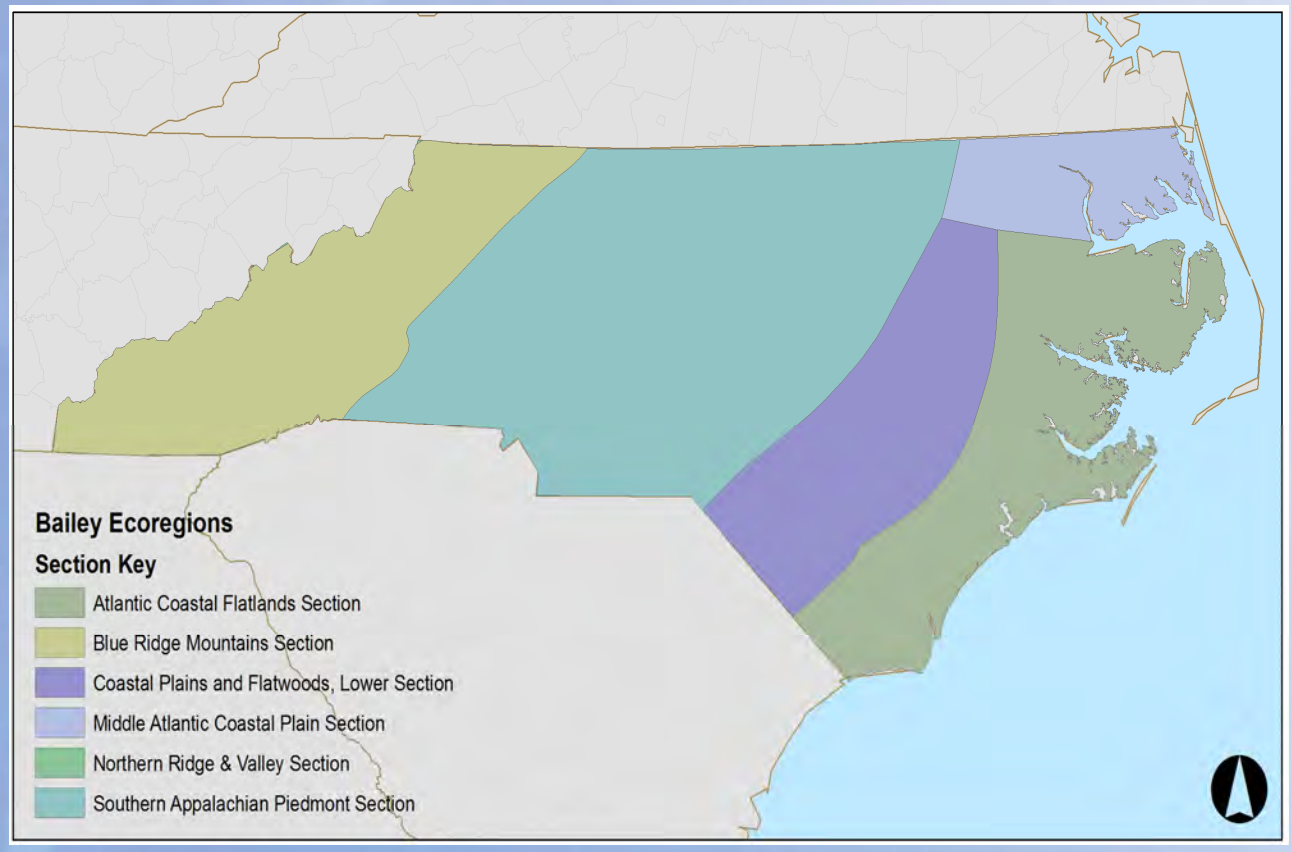
Physiographic/Eco Region Classifications

Classification System	Reference
Ecoregions of the Conterminous United States	Omernik (1987)
Bailey's Ecoregions and Subregions of the United States	http://www.nationalatlas.gov/mld/ecoregp.html, http://na.fs.fed.us/sustainability/ecomap/section_descriptions.pdf
Physiographic Regions of the Conterminous United States	Fenneman and Johnson (1964)
TNC Ecological Drainage Units	http://www.2c1forest.org/atlas/metadata/edu_metadata.htm
Hydrologic Landscapes	Wolock (2003)

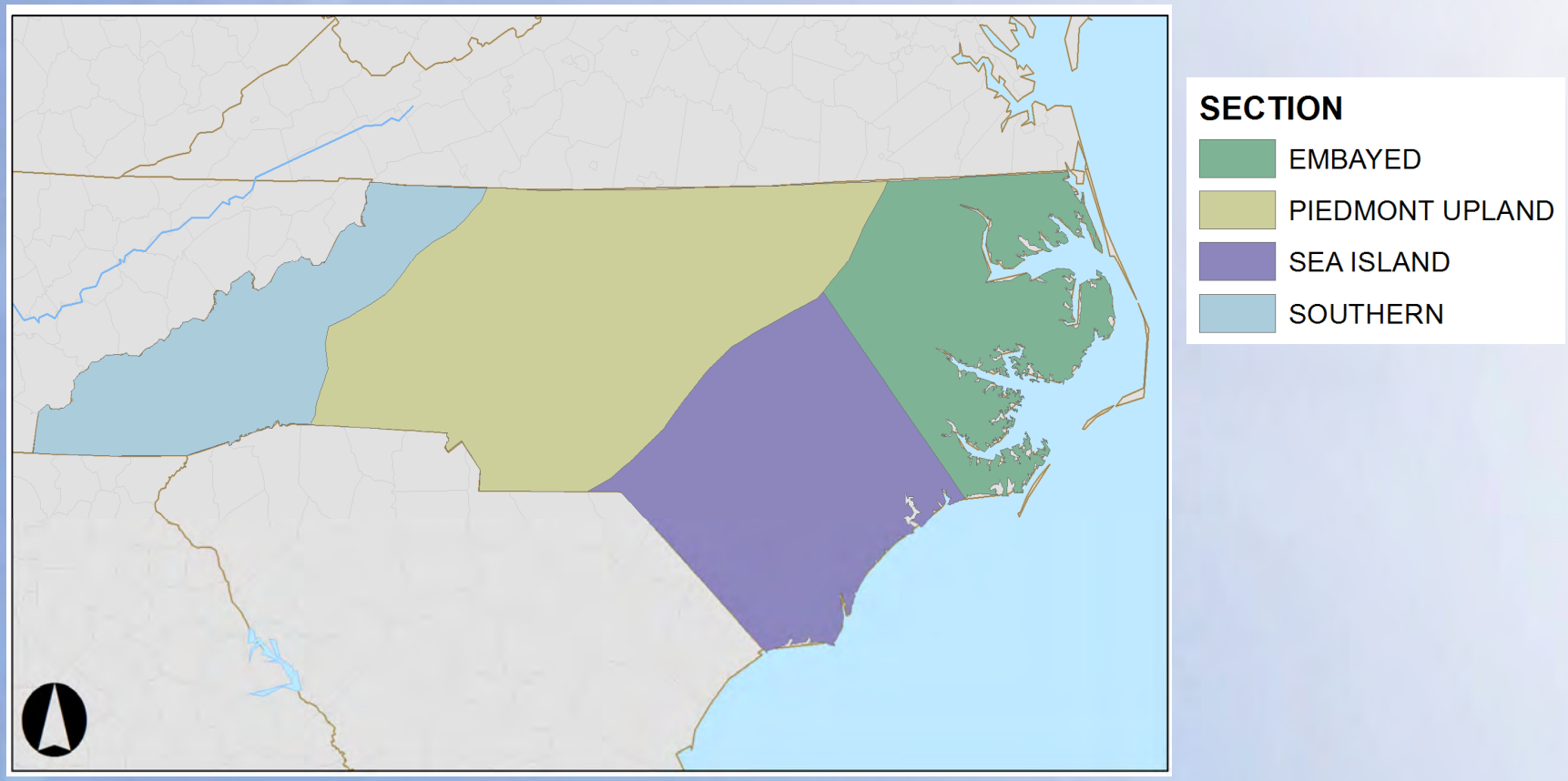
Omernik Ecoregions – Level III



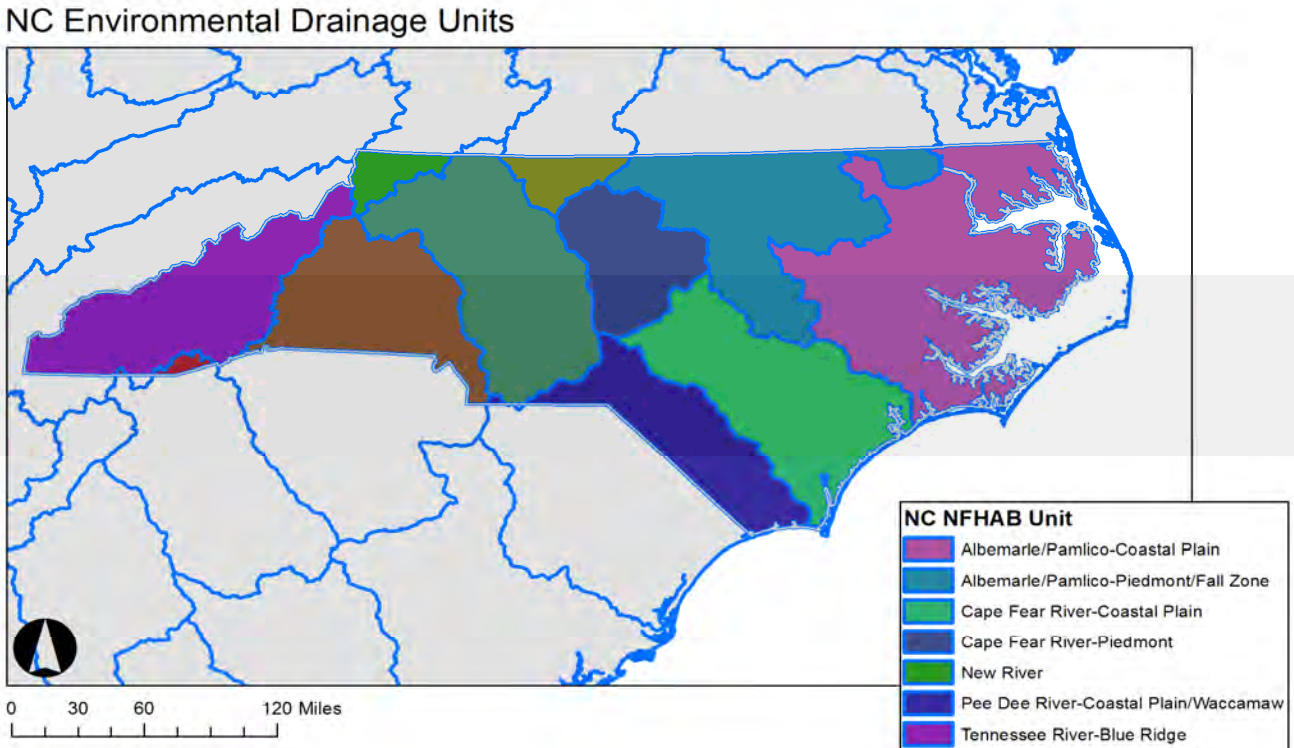
Bailey Ecoregions



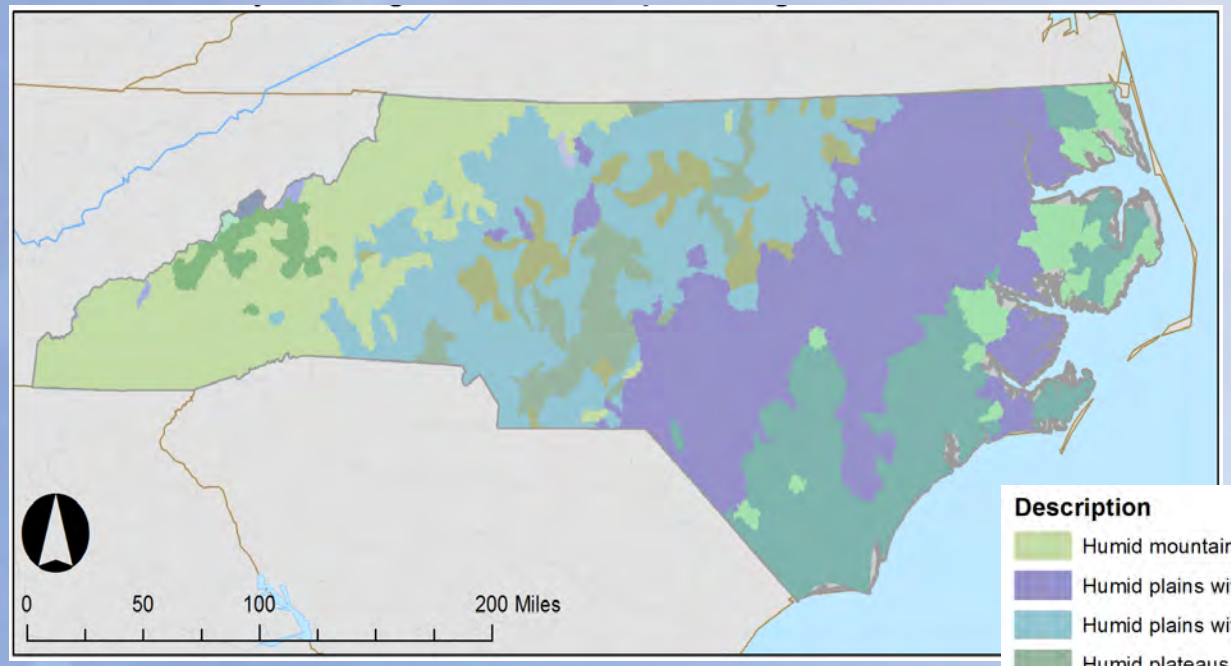
Fenneman Physiographic Regions



TNC Environmental Drainage Units



Wolock's Hydrologic Landscape Regions



Description

- Humid mountains with permeable soils and impermeable bedrock
- Humid plains with permeable soils and bedrock
- Humid plains with permeable soils and impermeable bedrock
- Humid plateaus with impermeable soils and bedrock
- Humid plateaus with impermeable soils and permeable bedrock
- Semiarid mountains with permeable soils and impermeable bedrock
- Semiarid plateaus with impermeable soils and bedrock
- Semiarid plateaus with permeable soils and impermeable bedrock
- Subhumid plains with impermeable soils and bedrock
- Subhumid plains with impermeable soils and permeable bedrock
- Subhumid plains with permeable soils and bedrock
- Very humid mountains with permeable soils and impermeable bedrock

Step 3.

Objective: Evaluate the ability to improve biological fidelity to stream classes by sub-dividing and/or aggregating the current NC hydrological stream classifications

- Repeat Random Forest non-parametric statistical analyses to determine aquatic biota associations to stream classes divided by:
  - Physiographic/Eco region
  - **Flow metrics that determine stream class**

Step 3.

Objective: Evaluate the ability to improve biological fidelity to stream classes by sub-dividing and/or aggregating the current NC hydrological stream classifications

- "Clusters" of biota may indicate the ability to divide stream classes
- Biota occurring in multiple stream classes may offer opportunity to combine classes

Questions?