

# SIFN SE Regional River Classification Project Kickoff

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# Why classify?

- To simplify communication
- To facilitate generalization of results
- To improve statistical analyses by minimizing within-class variation
- To facilitate biological/ecological monitoring and research design
- To identify river segments expected to respond similarly to flow alteration

# Why classify?

*from SIFN 2010 Research Agenda:*

The use of limited ecological data can be extended with the assumption that ecosystems with similar streamflow attributes and geomorphic characteristics respond similarly to flow alteration. A regional river classification system would allow states to supplement their own limited data for flow-ecology relationships with information from other states.

# Classification approaches

- Hierarchical vs. non-hierarchical
  - Non-hierarchical: single set of classes
    - e.g., Bisson et al. (1982) channel habitat units
  - Hierarchical: one or more levels of nested subclasses
    - e.g., Rosgen stream classification; ecoregions
- Single-scale vs. multiscale
  - Single-scale classifications have one scale of spatial resolution (e.g., Rosgen)
  - Multiscale: nested spatial scales (spatially hierarchical)
    - e.g., ecoregions (Level I, II, III, IV)

# Classification approaches

- Geographically dependent vs. geographically independent (*sensu* Detenbeck et al. 2000)
  - *Geographically dependent* classifications (e.g., ecoregions) are based in part on geographic location
    - each unit or category often contains only a single region
    - really a form of spatial partitioning
  - *Geographically independent* classifications are based on similarities on one or more characteristics without regard to location
    - Each class may contain many noncontiguous regions distributed throughout domain (e.g., Higgins et al. 2005; NAHC)

# Factors commonly used for classification

- Stream size (e.g., Strahler stream order, drainage area)
- Stream gradient
- Geomorphology and channel form (e.g., river pattern, channel morphology, channel constraint)
- Water temperature (e.g., cold, cool, and warm-water rivers)
- Hydrologic flow regime
- Landscape characteristics (geospatial data)
- Biological communities

# Methods of determining classes and class membership

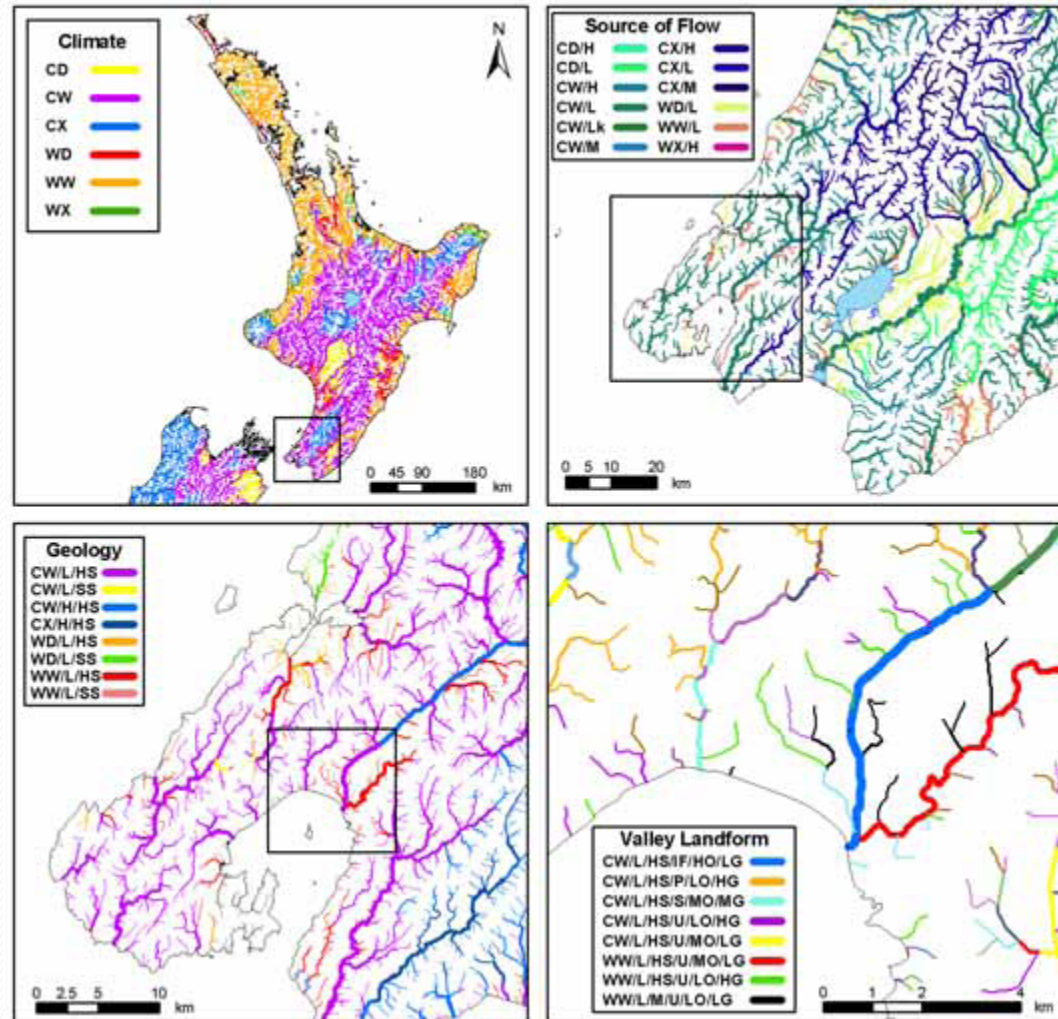
- Ad-Hoc – primarily descriptive or utilitarian
  - Subjective (incl. “expert opinion” approaches)  
e.g., ecoregions, channel habitat units
  - Quantitative (with arbitrary cutoff values)  
e.g., Rosgen stream types
- Conceptual/Theoretical
  - Based on factors hypothesized to affect system behavior or function (may still be subjective)
  - Examples: Montgomery and Buffington (1997) reach types; River Environment Classification (Snelder & Biggs 2002)
- Statistical/Algorithmic (i.e., let the computer do it...)
  - Based on variety of statistical/computational techniques (PCA, clustering algorithms, CART, NMDS, etc.)

# River Environment Classification (REC)

(Snelder & Biggs 2002; Snelder et al. 2004)

- Geographically independent hierarchical classification at 4 spatial scales (NZ ex.)
  1. Climate  $10^3 - 10^5 \text{ km}^2$  5 classes
  2. Topography  $10^2 - 10^3 \text{ km}^2$  3 classes
  3. Geology  $10 - 100 \text{ km}^2$  4 classes
  4. Land cover  $1 - 10 \text{ km}^2$  3 classes
- No. of classes & cutoff values set *a priori*
- Tested using aquatic macroinvertebrate data
- Higher classification strength than other a priori classifications (e.g., ecoregions), but still weak
- Conceptually simple, objective, easy to apply

# River Environment Classification (REC) Example



Source: REC User Guide

Available at <http://www.niwa.co.nz/our-science/freshwater/tools/rec>

## Example Approaches

# Higgins et al. (2005) approach

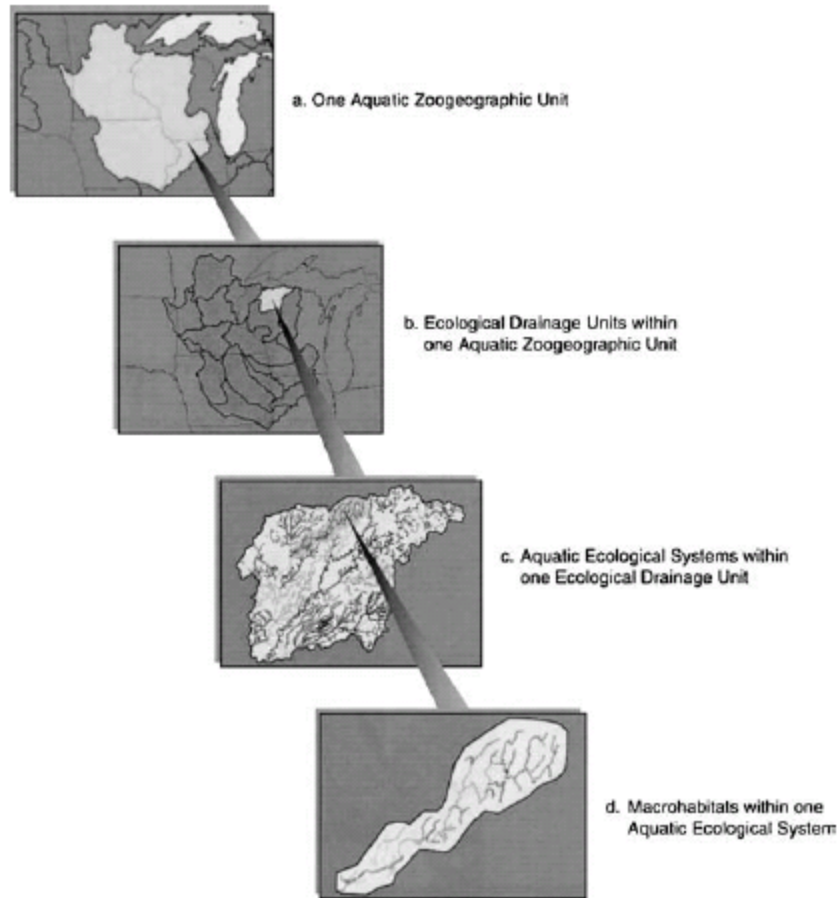
(*Conservation Biology* 19(2), 432-445)

- Explicitly hierarchical, catchment-based, 4+ spatial scales
  1. Aquatic zoogeographic units ( $10^3 - 10^5$  km<sup>2</sup>)
    - Expert opinion classification based on species distributions
  2. Ecological drainage units ( $10^3 - 10^4$  km<sup>2</sup>)
    - Expert opinion classification based on species distributions plus physical & climate info, pre-existing classifications (e.g., ecoregions)
  3. Aquatic ecological systems ( $10^2 - 10^3$  km<sup>2</sup>)
    - Geographically independent classification based on geospatial data incl. elevation, gradient, stream size, inferred hydrologic regime
    - Can be defined at multiple spatial scales (e.g., 4 scales in Willamette R. ex.)
  4. Macrohabitats (river valley segments, typ. 1 -10 km long)
    - Based on NHD-Plus river segments
- Conceptually simple and appealing, but subjective and geographically dependent (1<sup>st</sup> two tiers)

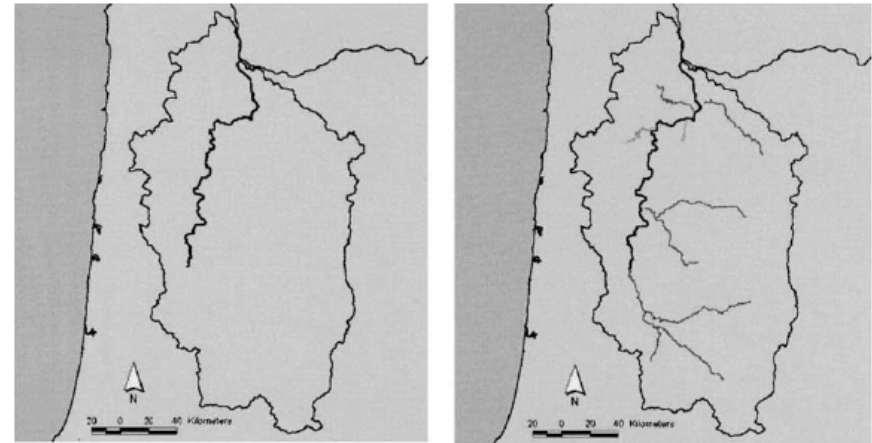
# Higgins et al. (2005) example

(*Conservation Biology* 19, 432-445)

## Spatially hierarchical structure

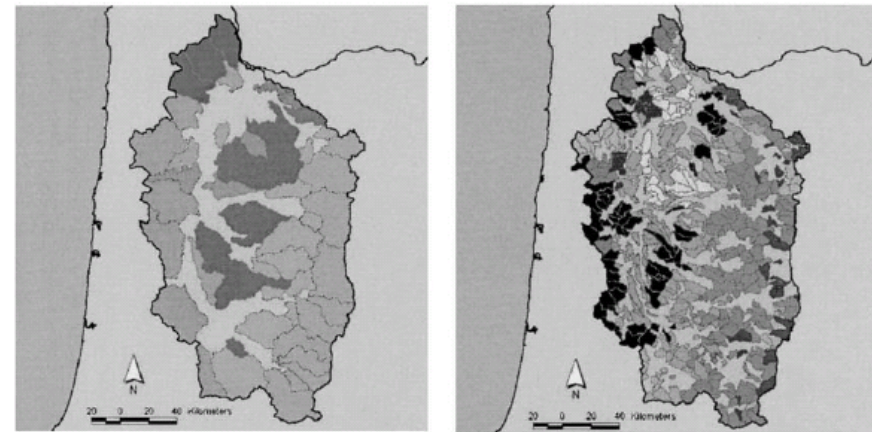


## Aquatic Ecological Systems Willamette Valley, Oregon



a

b



c

d



# ELOHA framework

(Poff et al. 2010, *Freshwater Biology* 55, 147-170)

- Statistical classification based on streamflow metrics characterizing flow magnitude, frequency, duration, timing, and rate of change
- Assumes flow regime is dominant control on biology
  - But geomorphic subclassification may be important because geomorphology can mediate impacts of flow alterations
- Really requires two classifications:
  1. Flow regime classification based on long-term stream gage data
  2. Geospatial classification to extrapolate flow regime classes to entire river network (not really discussed in Poff et al. 2010)
- Software tools exist to generate and select metrics for flow regime characterization (e.g., IHA, HAT)
- But no generally accepted method exists to select flow metrics or generate hydrologic classes

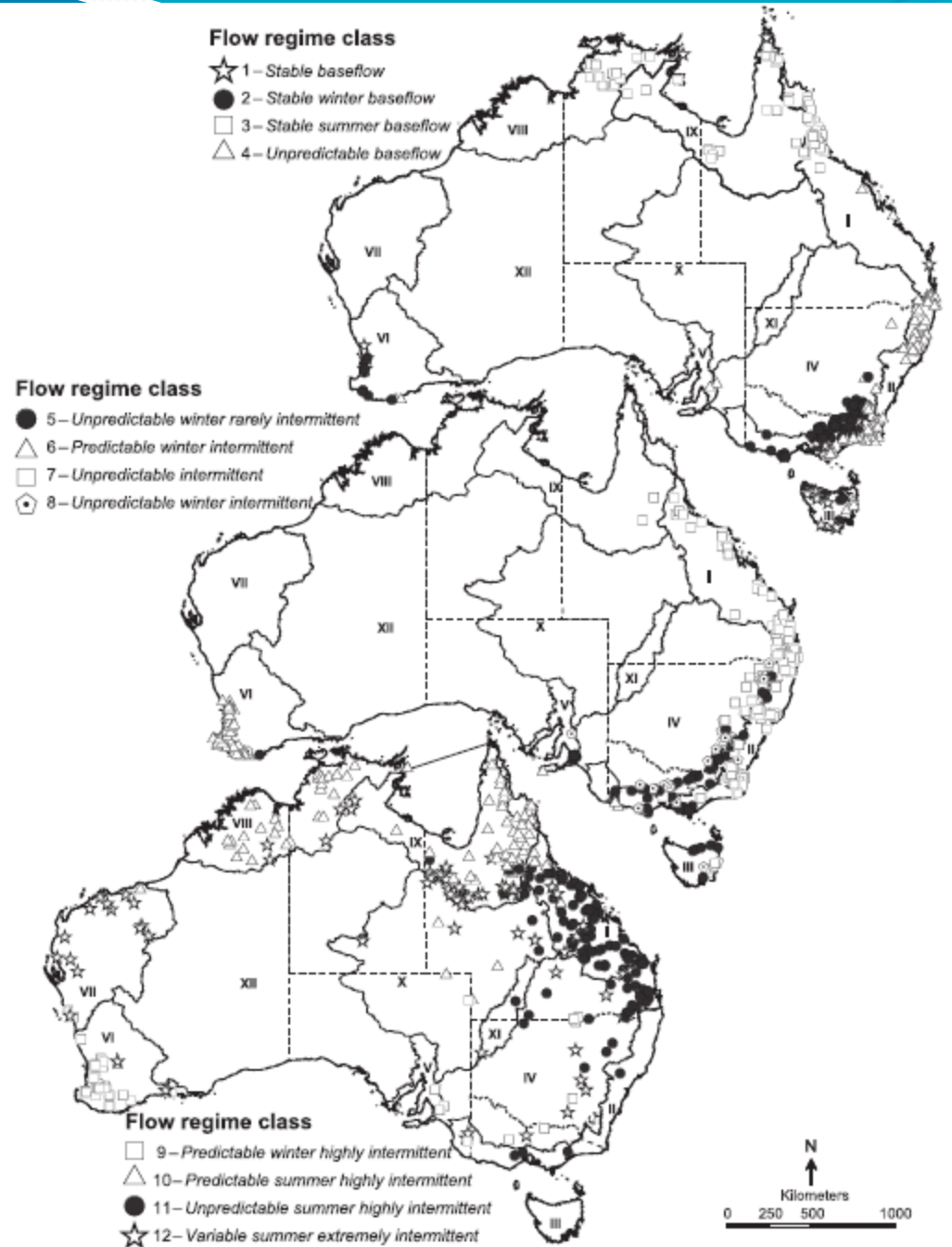
# ELOHA framework – AUS example

(Kennard et al. 2010, *Freshwater Biology* 55, 171-193)

- Continental-scale application (Australia), yielded 12 classes
- Statistical methods (Bayesian mixture modeling) used to identify 12 hydrologic classes based on 120 metrics
- 120 initial hydrologic metrics reduced to 12
- Geospatial data (topography, geology/soils, areal cover by forest and grasses, climate) used to predict flow regime class using CART
  - 62% correct classification for best model
  - Could be used to extrapolate hydrologic classification to entire landscape
- Rigorous and objective, but complex to develop and apply

# ELOHA Flow Regime Classification for Australia

(Kennard et al. 2010, *Freshwater Biology* 55, 171-193)



# Northeast Aquatic Habitat Classification (TNC, NEAFWA)

- Loosely modeled after Higgins (2005), but only applied at “macrohabitat” scale (i.e., not spatially hierarchical)
- Four key classification variables
  1. Catchment size (7 classes)
  2. Gradient (6 classes)
  3. Geology (buffering capacity) (3 classes)
  4. Stream temperature (4 classes)
- Statistical methods (e.g., cluster analysis) used to relate abiotic parameters to species distributions to determine no. of classes and cutoff values
- 259 aquatic habitat types (of 504 possible) [Yikes!!]

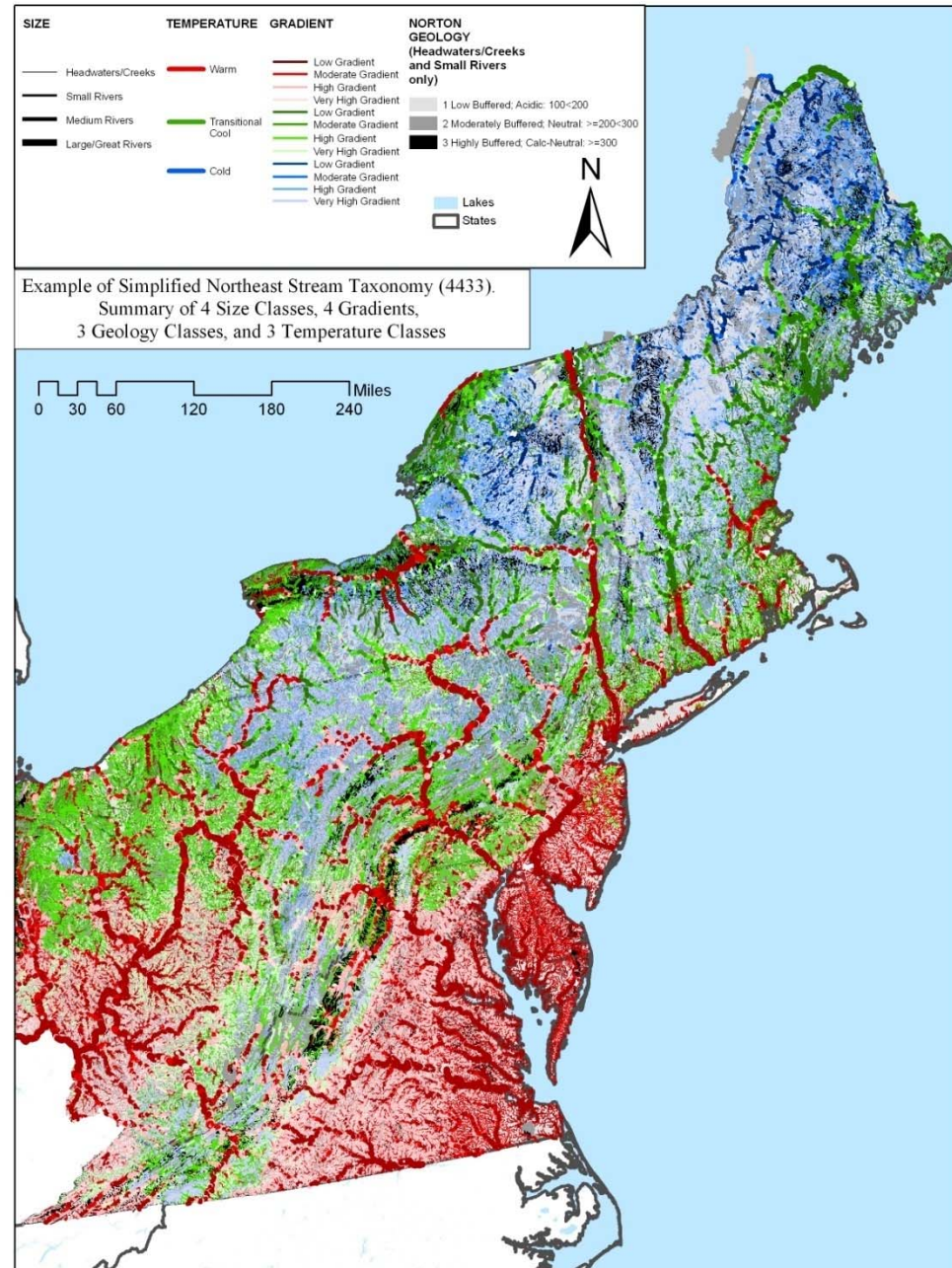
# Northeast Aquatic Habitat Classification (TNC, NEAFWA)

- Three strategies offered for simplifying classification:
  1. Variable prioritization (i.e., hierarchical approach)
    - Stream size > Gradient > Geology > Stream temperature
    - e.g., use only stream size (7 classes) and gradient (6 classes)  
→ 42 possible types
  2. “Collapsing rules” to reduce no. of classes for each variable
    - Provided example yields “only” 92 stream types
  3. Remove “biotically insignificant” combinations
- Flexible, but maybe *too* flexible?
  - No “official” simplified version, just guidelines leading to many possibilities
  - Complex to apply

## NAHCS simplified river classification (92 classes)

- 4 size classes
- 4 gradient classes
- 3 geology classes
- 3 temperature classes

Source: Northeast Aquatic Habitat Classification System report (Sep. 30, 2008), available at <http://rcngrants.org/node/38>



# What do we need classification to do?

- Provide a regionally consistent framework
- Capture main *natural* drivers of geographic variation in biological communities
- Generate manageable number of classes (<15?) at any scale of application
- According to SIFN 2010 Research Agenda, it should:
  - Be based initially on ecologically-relevant streamflow characteristics
  - Support subclassifications based on other factors that influence how biota respond to hydrologic alteration, such as water temperature, channel form, and substrate
  - Ideally, be integrated with classification efforts in NE and nationally under the National Fish Habitat Action Plan

# Key attributes for classification to meet SIFN objectives

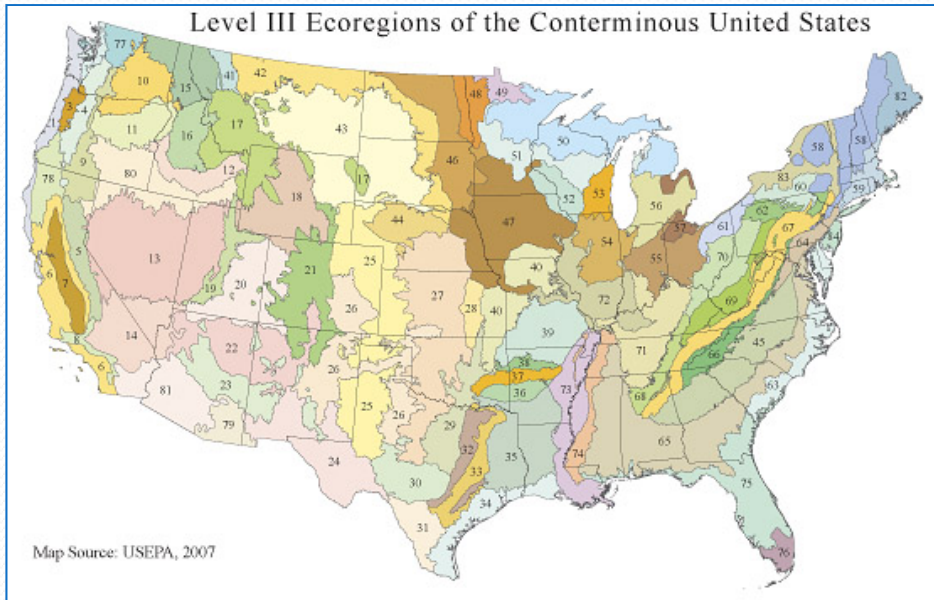
- Hierarchical and multiscale
- Geographically independent (at least at finer spatial scales)
- Generate manageable number of classes (<15?) at any scale of application
- Incorporate key ecologically relevant characteristics of flow regime
- At some scale incorporate other key factors affecting biota, likely including:
  - River size and gradient
  - Geomorphology (channel constraint, floodplain presence & connectivity)
  - Water temperature
  - Geology (esp. limestone presence/absence)

# Process: How do we make it happen?

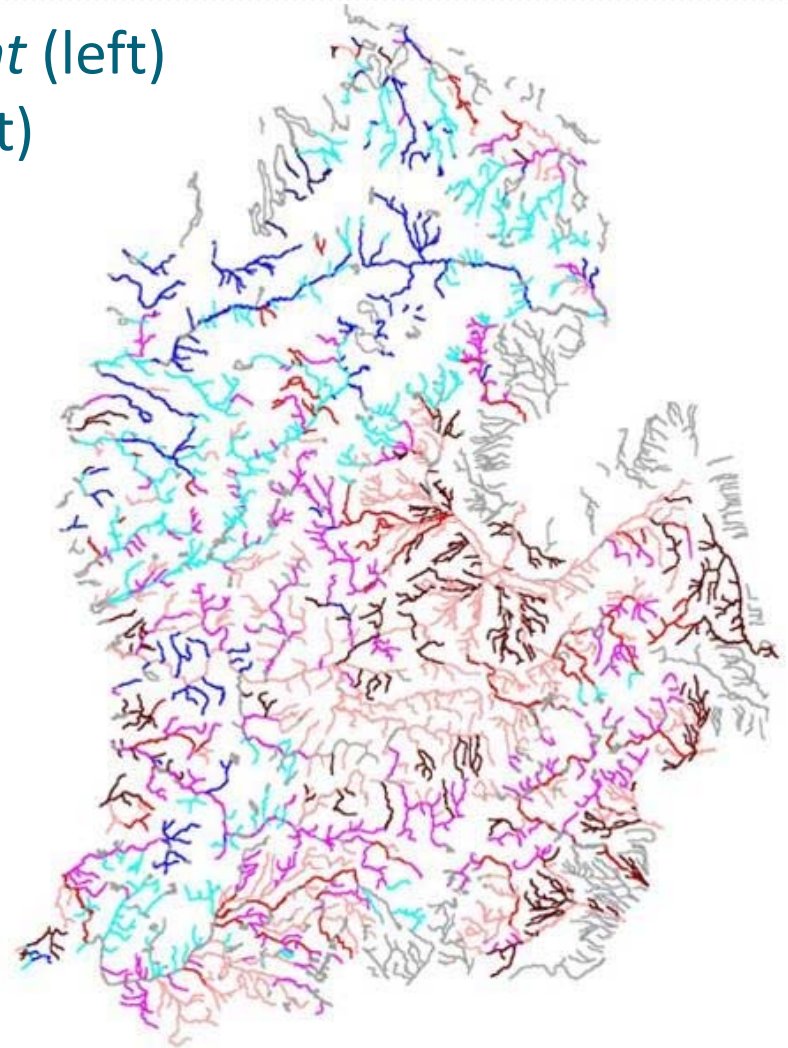
- To maximize acceptance, need to develop the classification using an inclusive process
- NEAFWA example (development of NAHCS):
  - Freshwater planning agency staff from all states in region invited to participate
  - >30 state, federal, university & NGO representatives participated
  - Project website (login required) to access and post project materials
  - Monthly conference calls including “round-robin” sharing session; notes posted on project website
  - Consensus-based decision-making



Examples of *geographically dependent* (left) and *geographically independent* (right) classifications



Level III Ecoregions of the U.S.  
(source U.S. EPA)



Michigan Flow Regimes (source Paul Seelback, MI DNR)

# NAHC collapsing rules for gradient classes



Full 6 Gradient Classes	Description Full 6 Gradient Classes	5 Classes: Size 1a, 1b	Description 5 Classes; for size 1a, 1b: Headwaters + Creeks	5 Classes: Size 2+	Description 5 Classes; for size 2+: Rivers	4 Classes: for size 1a, 1b: Headwaters + Creeks	4 Classes: for size 1a, 1b: Headwaters + Creeks	Description 4 Classes; for size 2+: Rivers	3 Classes: for size 1a, 1b: Headwaters + Creeks	3 Classes: for size 1a, 1b: Headwaters + Creeks	Description 3 Classes; for size 2+: Rivers		
1	Very Low Gradient: <0.02%	1	Low Gradient: < 0.1%	1	Low Gradient: <0.02%	1	Low Gradient: < 0.1%	1	Low Gradient: <0.02%	1	Low Gradient: < 0.5%		
NESLPCL	D_NESLPCL	SLPCL5A	D_SLPCL5A	SLPCL5B	D_SLPCL5B	SLPCL4A	D_SLPCL4A	SLPCL4B	D_SLPCL4B	SLPCL3A	D_SLPCL3A	SLPCL3B	D_SLPCL3B
2	Low Gradient: $\geq 0.02 < 0.1\%$	1	Low Gradient: < 0.1%	2	Low - Moderate Gradient: $\geq 0.02 < 0.1\%$	1	Low Gradient: < 0.1%	2	Low - Moderate Gradient: $\geq 0.02 < 0.1\%$	1	Low Gradient: < 0.5%	2	Moderate Gradient: $\geq 0.02 < 0.1\%$
3	Low - Moderate	2	Low - Moderate Gradient: $\geq$	3	Moderate - High	2	Low - Moderate	3	Moderate - High	1	Low Gradient: <	3	High Gradient: $\geq$
4	Moderate - High Gradient: $\geq 0.5 < 2\%$	3	Moderate - High Gradient: $\geq 0.5 < 2\%$	4	High Gradient: $\geq 0.5 < 2\%$	3	Moderate - High Gradient: $\geq 0.5 < 2\%$	4	High Gradient: $\geq 0.5\%$	2	Moderate Gradient: $\geq 0.5 < 2\%$	3	High Gradient: $\geq 0.1\%$
5	High Gradient: $\geq 2 < 5\%$	4	High Gradient: $\geq 2 < 5\%$	5	Very High Gradient: $\geq 2\%$	4	High Gradient: $\geq 2\%$	4	High Gradient: $\geq 0.5\%$	3	High Gradient: $\geq 2\%$	3	High Gradient: $\geq 0.1\%$
6	Very High Gradient: $> 5\%$	5	Very High Gradient: $> 5\%$	5	Very High Gradient: $\geq 2\%$	4	High Gradient: $\geq 2\%$	4	High Gradient: $\geq 0.5\%$	3	High Gradient: $\geq 2\%$	3	High Gradient: $\geq 0.1\%$

Source: Northeast Aquatic Habitat Classification System report (Sep. 30, 2008), available at <http://rcngrants.org/node/38>