USACE Ecosystem Assessment Methodology for the Appalachian Region

Elizabeth Summers

United States Army Corps of Engineers, ERDC

US Army Corps of Engineers
BUILDING STRONG®

OUTLINE

1) HGM Approach Overview
   - Ecological Functions
   - Assessment Variables
2) Steps to assessment development
3) Existing regional assessments

1) HGM APPROACH OVERVIEW

HYDROGEOMORPHIC (HGM) APPROACH

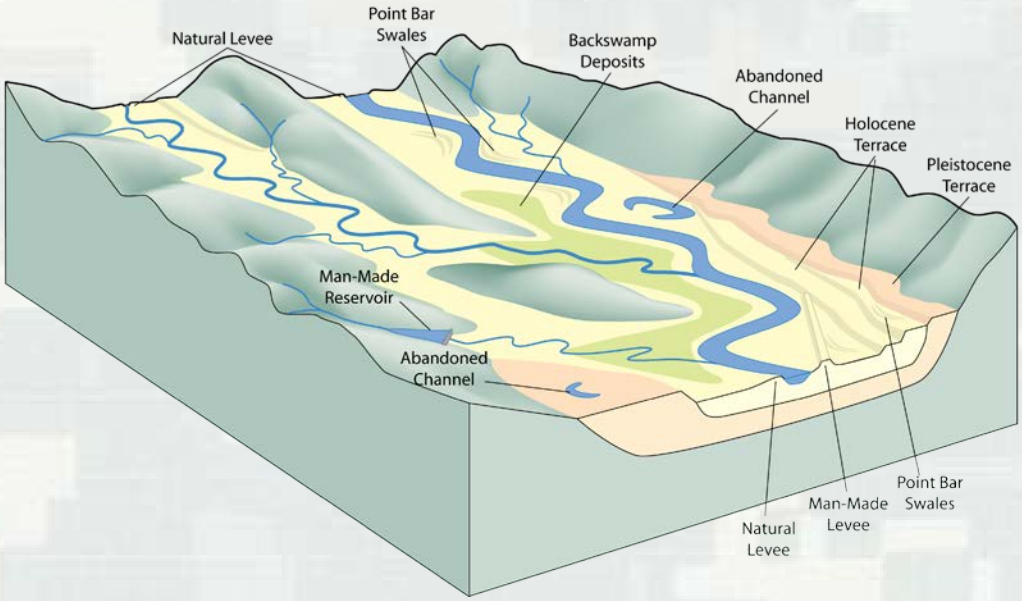
- Developed by Brinson (1993) as a classification system for wetlands
  - Landscape position
  - Hydrologic source
  - Hydrodynamics
- Within each wetland class, developed rapid assessment models for wetland functions
- Functional assessment method also applies to streams

CLASSIFICATION IS IMPORTANT PRIOR TO ASSESSMENT

- Compare ecosystems that perform similar functions
- Reduces variability
  - Specify only relevant functions
  - Simplify construction of assessment models
- Reduce time needed to perform assessments

HYDROGEOMORPHIC CLASSIFICATION

1) Geomorphic Setting (position in landscape)



2) Primary Water Source
- ▶ Precipitation
- ▶ Groundwater
- ▶ Surface Water

3) Hydrodynamics
- ▶ Direction
  - Vertical Fluctuation
  - Unidirectional Flow
  - Bidirectional Flow
- ▶ Level of Energy

APPLICATIONS OF ECOLOGICAL ASSESSMENTS

- Estimate baseline functional capacity
- Estimate impacts of a proposed project
- Evaluate project alternatives
- Determine mitigation requirements
- Estimate the effects of management
- Monitor the performance of restored ecosystems
- Does not exclude other assessment methods

EXAMPLE PROJECT TYPES

- Section 404 Permits
- Special Area Management Plans
- Alternatives analyses
- Advanced Identification (ADID)

ATTRIBUTES OF HGM ASSESSMENTS

- A rapid method for assessing the functional capacity of regional streams/wetlands
  - < 1 day, any time of year
- Scientifically based
  - Scoring based on data from reference sites
  - Defensible
- Ease of use
  - Specialized knowledge not required

REFERENCE SITES

- A group of sites that encompasses the range of variability exhibited by a regional subclass
- Variability results from:
  - Natural processes and disturbance
  - Anthropogenic alteration
- **Reference Standard**
  - Most fully functional, least altered ecosystems in the region

ECOLOGICAL FUNCTIONS

- Physical, chemical and biological processes or activities that take place in wetlands or streams
- For assessments, functions are not measured directly – variables are selected which reflect functioning
- Each guidebook uses different functions depending on wetland/stream subclass

FUNCTIONAL CAPACITY

- The degree or magnitude to which a stream or wetland performs a function
  - Hydrologic Functions
  - Biogeochemical Functions
  - Habitat Functions

FUNCTIONAL CAPACITY

- Depends on characteristics of the stream/wetland and the surrounding landscape
- Similar streams/wetlands exhibit a range of functional capacities due to inherent characteristics, natural disturbance, and anthropogenic alteration

FUNCTIONAL CAPACITY INDEX (FCI)

A score ranging from 0 – 1.0 that indicates the capacity of a stream or wetland to perform a function relative to **reference standard sites**

FUNCTIONAL CAPACITY IS RELATIVE TO REFERENCE STANDARD

$$FCI = \frac{\text{Functional Capacity of the Target Site}}{\text{Functional Capacity of Reference Standard Ecosystem}}$$

EXAMPLE FUNCTION: VEGETATION

- Ability to support a vegetation community characteristic of least disturbed streams/wetlands in the subclass

VEGETATION FUNCTION: RATIONALE

- Plant species found in a given stream or wetland subclass often are unique and not found in other ecosystems
- Influences primary productivity and is a source of nutrients that are cycled internally or exported to down-gradient systems
- Provides food and cover for animal community

THE PLANT COMMUNITY INFLUENCES:

- Primary productivity
- Carbon and nutrient cycling
- Carbon and nutrient export
- Biological diversity and Habitat structure
  - Direct impacts to richness and evenness of the plant community itself
  - Degradation or complete elimination of particular life requisites of the animal community – specific foods, cavities and other cover
  - Patch level (community diversity)
  - Landscape level (diversity of ecosystems)
- Trophic level processes

EXAMPLE FUNCTION: WILDLIFE

Ability of a wetland or stream to provide habitat for wildlife

- Amphibians and birds often a priority
- Focus on community typically observed at least disturbed sites, as well as habitat for specialists and species of concern

WILDLIFE FUNCTION: RATIONALE

- Species found in wetlands or streams often are unique and not found in other ecosystems
- Responsible for secondary productivity and energy flows among trophic levels

THE WILDLIFE COMMUNITY INFLUENCES:

- Secondary productivity
- Carbon and nutrient export/transport
- Biological diversity including richness and evenness of the animal community itself and of the plant community
  - Patch level
  - Landscape level
- Trophic level processes

HYDROLOGY FUNCTIONS: EXAMPLES

- Water storage
  - Capacity to store water within the soil for a few days to a few weeks and slowly release this water to down-slope wetlands or streams
- Maintain characteristic water level regime
- Dissipate energy associated with flow velocity and transport water downstream (stream ecosystems)

EFFECTS OF HYDROLOGY ON ELEMENTAL CYCLING

- Soil saturation leads to anaerobic soil conditions
  - Initiates redox reactions
  - O_2 concentration effects redox potential and nutrient availability
  - Improvement to water quality

EFFECTS OF HYDROLOGY ON HABITAT

- Habitat availability for invertebrates, fish, amphibians
- Seasonally inundated wetlands are refuges
- Amphibian breeding habitat

IMPACTS TO HYDROLOGY

- Natural conditions
  - Climate
  - Geomorphic characteristics
  - Soil
- Anthropogenic alterations
  - Land use
    - Tilling
    - Cattle grazing
    - Logging
  - Draining (ditching or damming)
  - Damming

BIOGEOCHEMICAL FUNCTIONS: EXAMPLES

- Nutrient and elemental cycling
- Biogeochemical transformations
- Export of dissolved organic compounds
- Storage of nutrients and compounds
  - Methylmercury (MeHg): peatlands

PROCESSES THAT INFLUENCE BIOGEOCHEMISTRY

- Nutrient and elemental cycling
  - Soil
  - Plants
  - Consumers (animals, fungi, bacteria)
  - Detritus
- Hydrology
  - Alterations that affect plant community influence carbon cycling
  - Soil saturation leads to anaerobic soil conditions

ASSESSMENT VARIABLES

- Instead of measuring ecological functions directly, assessments use measures of site and landscape characteristics that represent each function
- Variables agreed upon by Project Development Team
- Variables are selected for efficiency and significance to functions
  - Rapidly measured
  - Repeatable
  - Non-redundant

VARIABLE SCALES (1)

Landscape Scale

- Measured using aerial photos, on-site recon
- Examples:
  - Watershed land use
  - Habitat connections

VARIABLE SCALES (2)

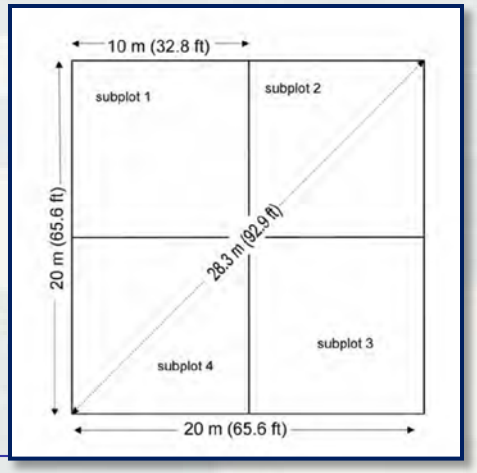
Site Scale

- Collected in entire wetland assessment area
- Examples:
  - Hydrologic alterations
  - Wetland tract area

VARIABLE SCALES(3)

Plot Scale

- Collected in multiple plots at site
- Examples:
  - Tree diameter
  - Large woody debris density
  - Soil detritus
  - Ground vegetation cover



EXAMPLE VEGETATION VARIABLES

- Percent canopy cover
- Tree density
- Average tree diameter
- Floristic quality
- Tree species richness
- Presence of indicator species
- Sapling/shrub density
- Ground vegetation cover

EXAMPLE HABITAT VARIABLES

- Percent canopy cover
- Large woody debris biomass
- Snag density
- Soil detritus cover
- Habitat connections
- Upland land use
- Hydrologic alterations
- Substrate embeddedness (streams)
- Substrate size (streams)

EXAMPLE HYDROLOGY VARIABLES

- Hydrologic alterations
- Outflow
- Change in catchment size
- Upland land use
- Canopy tree density
- Water depth
- Watershed land use
- Channel bank erosion (streams)

EXAMPLE BIOGEOCHEMISTRY VARIABLES

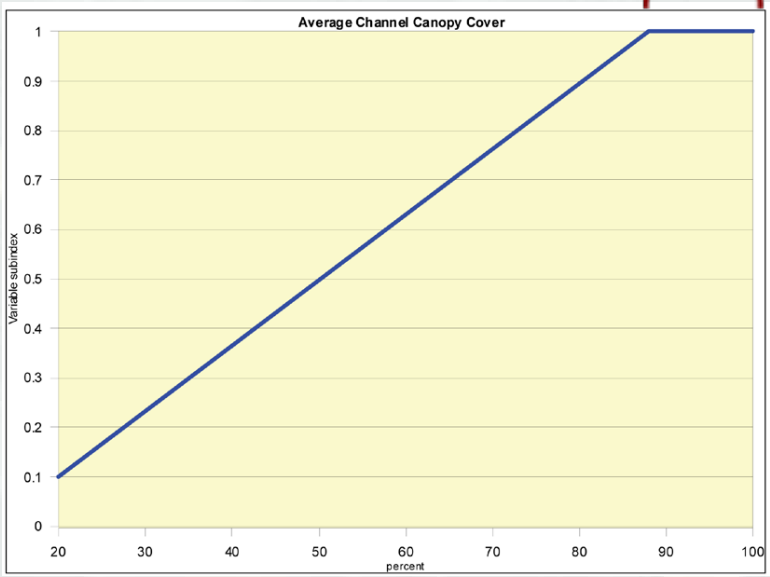
- Hydrology variables
- Vegetation variables
- Watershed land use
- Soil detritus
- O horizon thickness
- Large woody debris biomass
- Substrate embeddedness (streams)

VARIABLE SUBINDEX

- During assessment development, each variable is scaled using data from reference wetlands/streams
- Results in **Variable Subindex**: score for individual variable
- Example: Tree Canopy Cover

Reference Standard Sites

Variable Subindex (i.e., score; range 0-1)



Percent Cover

Functional Capacity Indices (FCIs)

- Variables are grouped into simple logic equations, resulting in a Functional Capacity Index for each ecological function

- Multiple functions may use some of the same variables

Functional Capacity Index Equations

Example: Habitat function in peatlands

- WD = Water table depth
- COMP = Floristic quality
- TRACT = wetland size
- CORE = Wetland core area

$$FCI = \left[V_{WD} \times V_{COMP} \times \left(\frac{V_{TRACT} + V_{CORE}}{2} \right) \right]^{1/3}$$

Data Entry

- FCI equations are provided in guidebooks, can be calculated by hand

-OR-

- Excel data forms are available which automatically calculate FCI scores

High-Gradient Headwater Streams in Eastern Kentucky and Western West Virginia
Field Data Sheet and Calculator

Assessment Team: UTM Easting:
Project Name: UTM Northing:
Location: Sampling Date:
SAR Number: Reach Length (ft): Stream Type: Ephemeral/Intermittent (circle one)

Top Strata: (determined from percent calculated in $V_{CCANOPY}$)

Site and Timing: Project/Mitigation Site (circle one) Before/After Project (Circle One)

Sample Variables 1-4 in stream channel

1 $V_{CCANOPY}$ Average percent cover over channel by tree and sapling canopy. Measure at no fewer than 10 roughly equidistant points along the stream. Measure only if tree cover is at least 20%. (If less than 20%, enter at least one value between 0 and 19 to trigger Top Strata choice.)

List the percent cover measurements at each point below:

2 V_{EMBED} Average embeddedness of the stream channel. Measure at no fewer than 30 roughly equidistant points along the stream. Select a particle from the bed. Before moving it, determine the percentage of the surface and area surrounding the particle that is covered by fine sediment, and enter the rating according to the following table:

Embeddedness rating for gravel, cobble and boulder particles (rescaled from Platts, Megahan, and Minshall 1983).

Rating	Rating Description
5	<5 percent of surface covered, surrounded, or buried by fine sediment
4	5 to 25 percent of surface covered, surrounded, or buried by fine sediment
3	26 to 50 percent of surface covered, surrounded, or buried by fine sediment
2	51 to 75 percent of surface covered, surrounded, or buried by fine sediment
1	>75 percent of surface covered, surrounded, or buried by fine sediment

List the ratings at each point below:

3 $V_{SUBSTRATE}$ Median stream channel substrate particle size. Measure at no fewer than 30 roughly equidistant points along the stream; use the same points and particles as used in V_{EMBED}.

Enter particle size in inches to the nearest 0.1 inch at each point below (bedrock should be counted as 99 in., asphalt or concrete as 0.0 in., sand or finer particles as 0.08 in.):

4 V_{BERD} Total percent of eroded stream channel bank. Enter the total number of feet of eroded bank on each side and the total percentage will be calculated. If both banks are eroded, total erosion for the stream may be up to 200%.

Left Bank: Right Bank:

Figure 31. Field data sheet for high-gradient headwater streams in eastern Kentucky and western West Virginia.

Excel calculator outputs:

1) Subindex for each variable

2) Functional Capacity Index for each function

2) STEPS TO ASSESSMENT DEVELOPMENT

PROJECT DEVELOPMENT TEAM

- An interagency Project Development Team (PDT) consisting of regional experts meets and agrees upon how assessments will be developed

STEPS TO DEVELOPMENT

1) Classification

- Select and characterize stream/wetland subclass and define reference domain

STEPS TO DEVELOPMENT (cont.)

2) Collect data from reference sites

- Select functions of interest
  - Hydrology
  - Nutrient Cycling
  - Habitat
- Select and define potential variables and metrics
- Select reference sites

STEPS TO DEVELOPMENT (cont.)

3) FCI Equation Development

- Test suitability of metrics
  - Select metrics which respond to a gradient of site conditions
  - Signal-to-noise ratio
  - Range of metric values
  - Correlation between variables
- Model development
  - Define the relationship between variables and functional capacity
  - Calibrate metric values
- Field test assessment models

FIELD TESTING

- Test repeatability of results with independent groups of users
- Compare FCI outcomes to best professional judgment, verify that outcomes are logical

REVIEW PROCESS

- Internal Review
- PDT Review
- External Peer Review
  - Academic institutions
  - Other agencies

VALIDATION STUDIES

- Test the efficacy and application of models using comparisons with independent measures of ecosystem function
- Validation considered successful if model outcomes display the ability to discern between least-altered and altered locations
- To date, only done for High-gradient stream assessments for Appalachia
  - Effectively differentiated between high and low functioning headwater stream ecosystems

REGIONAL EXPANSION

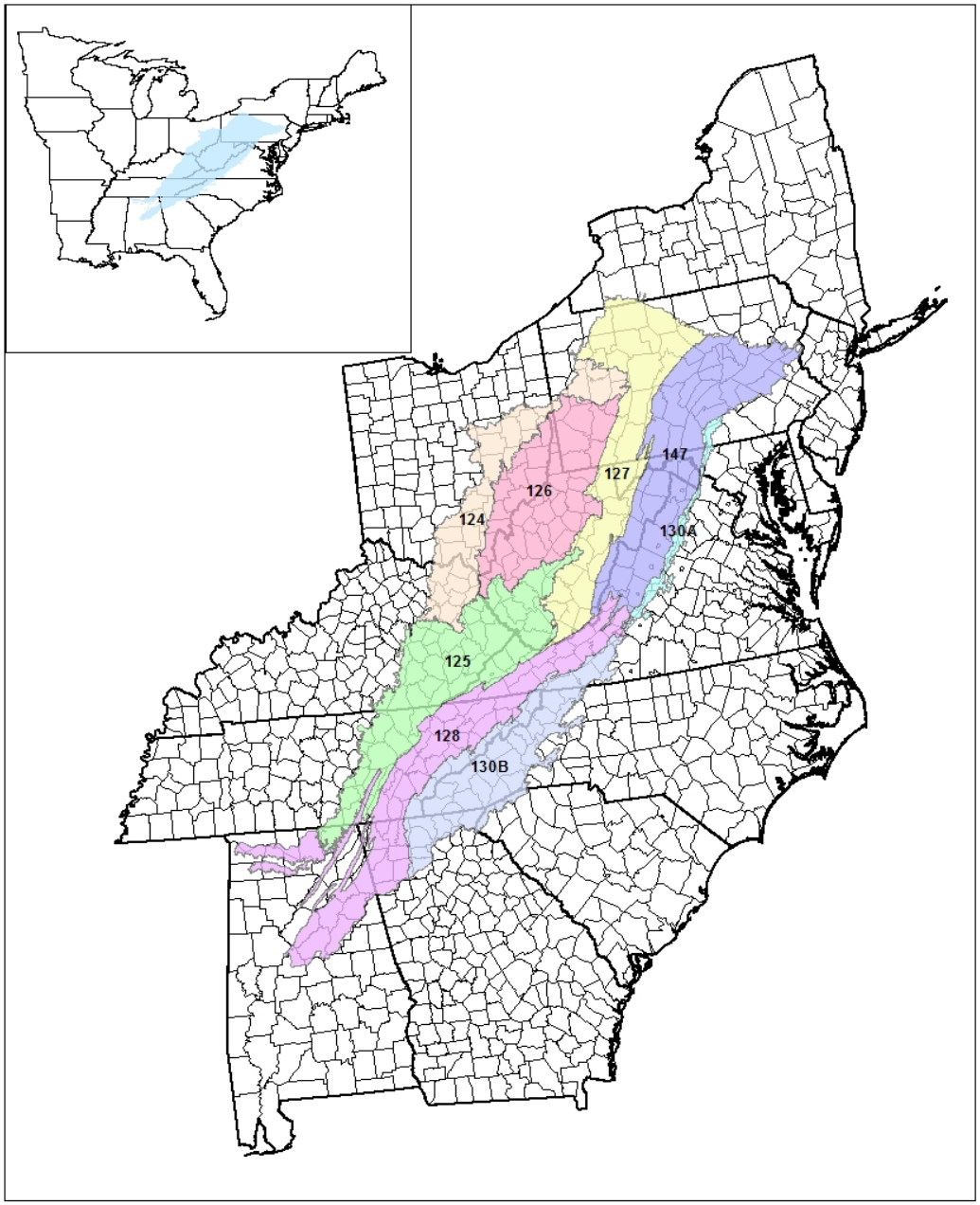
- Current efforts to expand assessment to larger geographic regions
  - Headwater streams – expanded to OH, TN, PA, VA
  - Perennial streams – will be tested in expanded reference domain
  - Wetland assessments originally developed for small reference domains

3) EXISTING REGIONAL HGM ASSESSMENTS

HEADWATER STREAMS

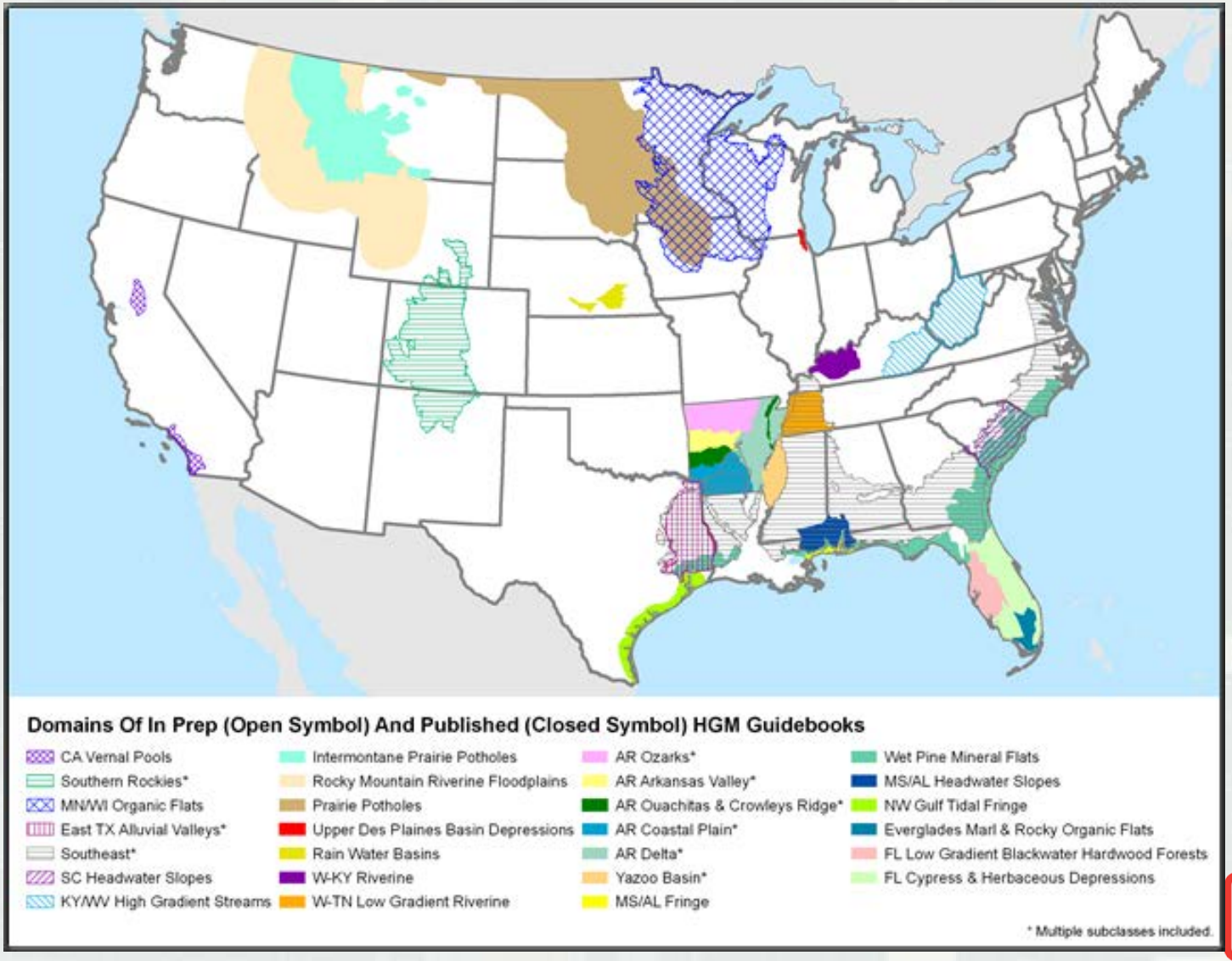
- High-gradient:
  - ≥4% slope
  - coarse substrate
  - Developed for WV and eastern KY
  - Now expanded to OH, TN, PA, VA
    - Will be published in 2015

Expanded reference domain for headwater stream assessments



PERENNIAL STREAMS

- Perennial Streams
  - Currently in final development stages
  - Low-gradient: <4% slope
  - Coarse substrate
  - Wadeable and shadeable
  - Guidebook will be published in 2015
  - Will be tested for expansion to OH, TN, PA, VA


Domains Of In Prep (Open Symbol) And Published (Closed Symbol) HGM Guidebooks
CA Vernal Pools
Southern Rockies*
MN/WI Organic Flats
East TX Alluvial Valleys*
Southeast*
SC Headwater Slopes
KY/WV High Gradient Streams
Intermontane Prairie Potholes
Rocky Mountain Riverine Floodplains
Prairie Potholes
Upper Des Plaines Basin Depressions
Rain Water Basins
W-KY Riverine
W-TN Low Gradient Riverine
AR Ozarks*
AR Arkansas Valley*
AR Ouachitas & Crowleys Ridge*
AR Coastal Plain*
AR Delta*
Yazoo Basin*
MS/AL Fringe
Wet Pine Mineral Flats
MS/AL Headwater Slopes
NW Gulf Tidal Fringe
Everglades Marl & Rocky Organic Flats
FL Low Gradient Blackwater Hardwood Forests
FL Cypress & Herbaceous Depressions
* Multiple subclasses included.

Supporting Documents

- HGM Website
  - Guidebooks
  - Headwater stream validation study

  http://el.erdc.usace.army.mil/wetlands/hgmhp.html

- Hydrogeomorphic (HGM) Approach to Assessing Wetland Functions: Guidelines for Developing Guidebooks (Version 2)
  - ERDC/EL TR-13-11

  http://el.erdc.usace.army.mil/elpubs/pdf/trel13-11.pdf