USACE Ecosystem Assessment Methodology for the Appalachian Region

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OUTLINE

1) HGM Approach Overview
   • Ecological Functions
   • Assessment Variables

2) Steps to assessment development

3) Existing regional assessments
1) HGM APPROACH
OVERVIEW
HYDROGEOgeomorphic (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

\[ \text{FCI} = \frac{\text{Functional Capacity of the Target Site}}{\text{Functional Capacity of Reference Standard Ecosystem}} \]
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
  - $\text{O}_2$ 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

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.

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

Reference Standard Sites

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
Excel calculator outputs:

1) Subindex for each variable

2) Functional Capacity Index for each function
2) STEPS TO ASSESSMENT DEVELOPMENT
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
2) Collect data from reference sites

► Select functions of interest
  • Hydrology
  • Nutrient Cycling
  • Habitat

► Select and define potential variables and metrics

► Select reference sites
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*
- MNWI Organic Flats
- East TX Alluvial Valleys*
- Southeast*
- SC Headwater Slopes
- K/WW 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
    