Wetland Classification and Assessment: The Hydrogeomorphic Approach

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Background

HGM Functional Assessment (FA)

The Hydrogeomorphic (HGM) approach is a collection of concepts and methods for developing functional indices and subsequently using them to assess the capacity of a wetland to perform functions relative to similar wetlands in a region

1. Classification
2. Assessment

Wilder and Roberts 2002

Background

The Hydrogeomorphic Approach

"…it (HGM) relies almost exclusively on geomorphic, physical, and chemical descriptors."
- Brinson 1993

1. Developed for compensatory mitigation of wetlands lost or damaged by human activities as regulated by Section 404 of the Clean Water Act
2. Used widely in state and federal regulatory programs
3. Permit review sequence to:
   a) consider alternatives
   b) minimize impacts
   c) assess unavoidable project impacts
   d) determine mitigation requirements
   e) monitor the success of mitigation projects

Stevenson and Hauer 2002 Wilder and Roberts 2002

Background

HGM – What it…

Is…..

1. A means for comparison and aggregation of wetlands with similar functions
2. A means of reducing variability exhibited by the wetlands being considered

Is not…

1. A valuation system
   a) "not (originally) intended to be a 'valuation' procedure that ranks one wetland (type) relative to another for specific functions"
2. Hydrogeomorphic classifications by their very nature are not designed to be sensitive to species composition of vegetation

Brinson 1993, Smith et al. 1995

Classification

HGM vs. Cowardin

1. HGM classification depends on landscape context, not just morphological characteristics within the wetland
2. Using the Cowardin system, the user can envision what the wetland looks like – using HGM, the user can envision how the wetland works
3. HGM = Function and position
4. Cowardin = Physical characteristics within (e.g., vegetation)

Brinson 1993

Classification

Components of HGM Classification

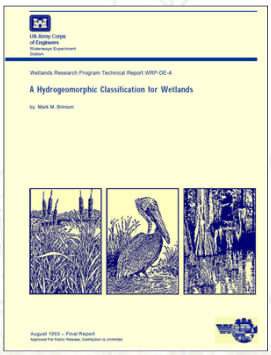
1. Geomorphic setting: topographic location within the surrounding landscape
2. Water source and transport: precipitation, surface/near surface flow, and ground water discharge
3. Hydrodynamics: direction and strength (hydrologic head) of flow

Brinson 1993

Classification

HGM Classes

1. Depression
2. Tidal Fringe
3. Lacustrine Fringe
4. Slope
5. Mineral Soil Flats
6. Organic Soil Flats
7. Riverine



Classification

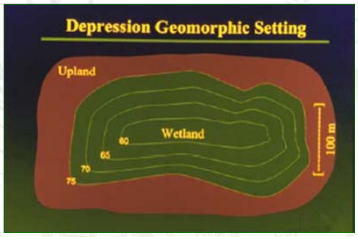
Depression

Classification

Depression

1. Closed elevation contours that allow the accumulation of surface water
2. Water sources: overland flow and groundwater – some from streams and precipitation
3. Direction of flow: from the higher elevations toward the center of the depression
4. Predominant hydrodynamics: vertical fluctuations that range from diurnal to seasonal (e.g., through evapotranspiration, intermittent or perennial outlets, or recharge to groundwater)
5. Prairie potholes, playa lakes, and cypress domes

Classification



Classification

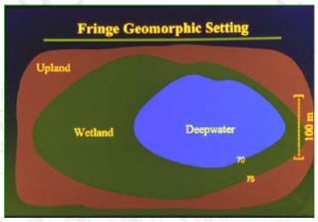
Tidal Fringe

Classification

Tidal Fringe

1. Occur along coasts and estuaries and are under the influence of sea level
2. Intergrade landward with riverine wetlands
   a) The interface between the tidal fringe and riverine classes is where bidirectional flows from tides dominate over unidirectional ones controlled by floodplain slope of riverine wetlands
3. Water sources: Ocean – some from rivers, groundwater discharge and precipitation.
   a) seldom dry for significant periods
4. Predominant hydrodynamics: horizontal and vertical tidal flow and riverine influence
5. Water loss water by tidal exchange, by overland flow to tidal creek channels, and by evapotranspiration
6. *Spartina alterniflora* salt marshes

Classification



Classification

Lacustrine Fringe

Classification

Lacustrine Fringe

1. Adjacent to lakes where the water elevation of the lake maintains the water table in the wetland (sometimes vegetation occurs as a floating mat attached to land)
2. Water sources: Lake – some from precipitation and groundwater discharge
3. Hydrodynamics: surface-subsurface water flow is bidirectional, usually controlled by water-level fluctuations in the lake resulting from wind or other disturbance - water loss can occur by flow returning to the lake after flooding and evapotranspiration
4. Great Lakes marshes

Classification

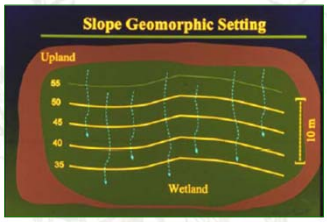
Slope

Classification

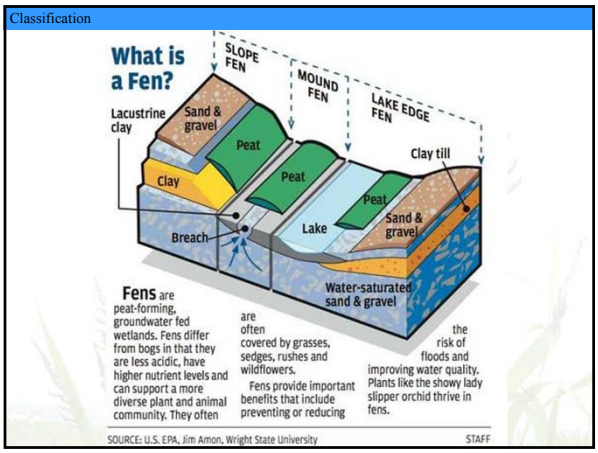
Slope

1. Discharge of groundwater to the land surface or sites with saturated overland flow with no channel formation.
   a) sloping land ranging from slight to steep
2. Predominant water source: groundwater – less commonly interflow and precipitation
3. Hydrodynamics: downslope unidirectional water flow - water loss primarily by saturated subsurface flows, surface flows, and evapotranspiration
4. Slope wetlands differ from depression wetlands by the lack of a closed topographic depression and the predominance of the groundwater/interflow water source
5. Fens

Classification



Classification



Classification

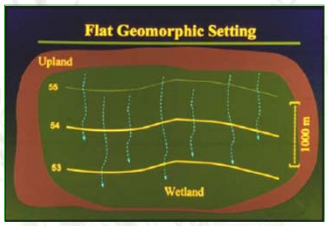
Mineral Soil Flats

Classification

Mineral Soil Flats

1. Common on interfluves, extensive on relic lake bottoms, or large floodplain terraces
   a) typically occur in relatively humid climates
2. Water source: precipitation – very little groundwater discharge, which distinguishes them from depressions and slopes
3. Hydrodynamics: vertical fluctuations from evapotranspiration, overland flow - poor vertical drainage due to impermeable layers (e.g., hardpans), slow lateral drainage, and low hydraulic gradients.
4. Pine flatwoods with hydric soils

Classification



Classification

Organic Soil Flats

Classification

Organic Soil Flats

1. Distinguishing characteristic is vertical accretion of organic matter.
2. Occur commonly on flat interfluves, or where depressions have become filled with peat to form a relatively large flat surface
   a) Often occurring in relatively humid climates
3. Water source: precipitation
4. Water loss is by overland flow and seepage to underlying groundwater
5. Portions of the Everglades and northern Minnesota peat lands

Classification

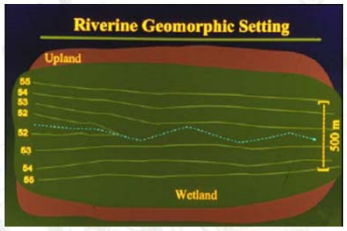
Riverine

Classification

Riverine

1. Occur in floodplains and riparian corridors in association with stream channels
2. Water source: overbank flow from channel and to a lesser extent subsurface flow. Additional sources may be interflow, overland flow from adjacent uplands, tributary inflow, and precipitation
   a) Surface water loss via overland return of floodwater to the channel after flooding, through surface flow to the channel during rainfall events, and evapotranspiration
   b) subsurface water loss by discharge to the channel, movement to deeper groundwater
3. Predominant hydrodynamics: Unidirectional (channel flow), horizontal
4. In headwaters, riverine wetlands often intergrade with slope, depression, poorly drained flat wetlands, or uplands
5. Hardwood bottomlands on floodplains or river oxbows

Classification



Classification

Subclasses

1. Vary regionally
2. Same "big 3" criteria (geomorphic setting, water source, hydrodynamics)
3. Often used to limit the geographical extent of a model (e.g., within ecoregions – coastal plain)
4. Based on physical and functional characteristics
   1. Water source
   2. Salinity gradient
   3. Degree of slope
   4. Stream order

NRCS 2008

Classification

Subclasses

Table 2
Potential Regional Wetland Subclasses in Relation to Geomorphic Setting, Dominant Water Source, and Hydrodynamics

Geomorphic Setting	Dominant Water Source	Dominant Hydrodynamics	Potential Regional Wetland Subclasses	
			Eastern USA	Western USA/Alaska
Depression	Groundwater or interflow	Vertical	Prairie pothole marshes, Carolina bays	California vernal pools
Fringe (tidal)	Ocean	Bidirectional, horizontal	Chesapeake Bay and Gulf of Mexico tidal marshes	San Francisco Bay marshes
Fringe (lacustrine)	Lake	Bidirectional, horizontal	Great Lakes marshes	Flathead Lake marshes
Slope	Groundwater	Unidirectional, horizontal	Fens	Avalanche chutes
Flat (mineral soil)	Precipitation	Vertical	Wet pine flatwoods	Large playas
Flat (organic soil)	Precipitation	Vertical	Peat bogs; portions of Everglades	Peatlands over permafrost
Riverine	Overbank flow from channels	Unidirectional, horizontal	Bottomland hardwood forests	Riparian wetlands

Wilder and Roberts 2002

Classification

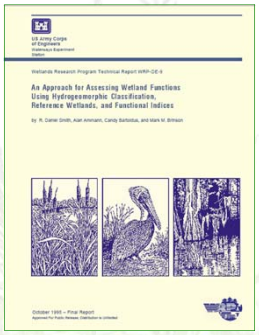
Modifiers

1. Often used to include vegetation attributes
   a) cypress domes
   b) pitcher plant bog
   c) scrub-shrub
2. Can be multiphase
   a) Forested / clay soils
   b) Forested / cypress-tupelo / clay soil
3. Unite HGM and other classification schemes
   a) Cowardin
   b) Anderson
   c) USFWS Circular 39

Assessment

Functional Assessments - HGM

1. Quantify functions for comparisons among wetlands
2. Model (representation of processes and relationships)
3. Variables
4. Reference wetlands



Pers. Com., E. Stein 2011

Assessment

HGM FA Assumptions

1. Wetland structure and function are intrinsically linked such that loss of structure results in a proportional loss of function
2. An array of functions can be described for each wetland type
3. That a series of variables or metrics that measure various structural components within a wetland provide an accurate assessment of functional performance and, thus, vary with loss of function

Stevenson and Hauer 2002

Assessment

HGM FA Core Elements

1. HGM classification system: defines regional classes of functionally similar wetlands whose characteristics can be quantitatively compared
2. Assessment Models: a simple representation of a wetland function - Identification of wetland functions described by logic models consisting of a suite of variables to assess the capacity of the wetland to perform each function
3. Data from an array of reference wetlands ranging between least to most impacted for a regional class of wetlands
4. Assessment protocols: available in regional guidebooks

Stevenson and Hauer 2002, Wilder and Roberts 2002

Assessment

Reference Wetlands

1. "Characteristic Functions"
2. Range of variability in condition associated with succession, normal disturbance, and alteration
3. Concrete physical representation of target ecosystems
4. Provide the data necessary for calibrating model variables and assessment models
5. Standard reference wetlands: a subset of *ideal* or *target* wetlands (representing the least altered state)

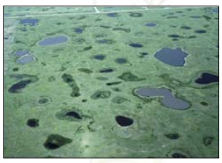
Stevenson and Hauer 2002, Wilder and Roberts 2002

Assessment

FA - How it Works

Step 1

Classification - Wetland grouping based on similarity (e.g., prairie potholes – depression wetlands)



Step 2

Characterize broadly-based functions (e.g., surface water storage, nutrient cycling)

Table 4.2 Relationship of Variables to Functions for San Juan River System

Functions / Variables	Surface- and Ground-Water Storage and Flow	Nutrient Cycling and Export of Organic Carbon	Storage and Release of Organic and Inorganic Particles			

Assessment

How it Works

Step 3

Define variables (measurable attributes) for each function (e.g., basal area, slope, tree biomass, redoximorphic features, roughness)

Table 4
Components of a Model Variable

Name (Symbol)	Measure / Procedural Statement	Resulting Values	Units (Scale)
Redoximorphic Features (V_{REDOX})	Status of redoximorphic features/visual inspection of soil profile for redoximorphic features	present absent	unitless (nominal scale)
Floodplain Roughness (V_{ROUGH})	Manning's Roughness Coefficient (n) Observe wet-land characteristics to determine adjustment values for roughness component to add to base value	0.01 0.1 0.21	unitless (interval scale)
Tree Biomass (V_{TBA})	Tree basal area/measure diameter of trees in sample plots (cm), convert to area (m^2), and extrapolate to per hectare basis	5 12.8 36	m^2/ha (ratio scale)

Assessment

Hydrogeomorphic Method (*Corps of Engineers*)

Table 4.2 Relationship of Variables to Functions for San Juan River System

Variables \ Functions	Surface- and Ground-Water Storage and Flow	Nutrient Cycling and Export of Organic Carbon	Storage and Release of Organic and Inorganic Particles	Characteristic Plant Community	Characteristic Aquatic Invertebrate Habitats	Characteristic Vertebrate Habitats
$V_{BUFFCON}$						X
$V_{COMPLEX}$		X	X	X	X	X
V_{CHD}		X	X		X	
V_{FPCON}						X
V_{GEOMOD}	X					
$V_{HYDROMOD}$	X					
$V_{LONGPROF}$	X		X			
V_{MACRO}	X	X	X		X	
V_{NPHERB}		X		X	X	
$V_{NPSHRUB}$		X		X	X	
V_{NPTREE}		X		X	X	
$V_{ORGDECOMP}$		X				
V_{PDEN}	X	X			X	
$V_{SEDSOURCE}$			X			
V_{SHDW}	X	X			X	
$V_{SURFFEED}$	X	X	X		X	

1. Easily measurable field indicators
2. 0.0 to 1.0 scale
3. Specific models for each wetland class

Assessment

How it Works

Step 4

Assemble Assessment Models – variables arranged in algorithms

$$FCI = \left(\frac{V_{PDEN} + V_{NPDIV} + V_{NPCOV} + V_{\alpha DIV}}{4}\right)$$

V_{PDEN} = plant density

V_{NPDIV} = native plant richness

V_{NPCOV} = native plant cover

$V_{\alpha DIV}$ = plant richness

1. Functional Capacity Index: Numerical representation of the ability of a wetland to perform a function compared to the level of performance in reference wetlands
2. FCI varies from 1.0 to 0
3. Condition is not quantified – rather, FCI illustrates the departure from "reference conditions"

Stevenson and Hauer 2002

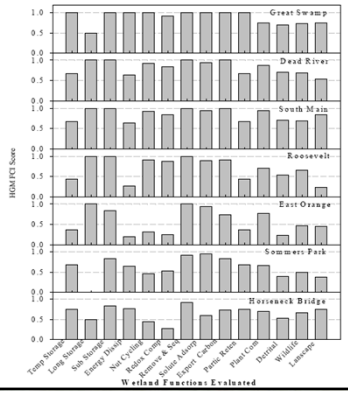
Assessment

Application of HGM

1. Pre vs. Post
   a) Management
   b) Restoration
   c) Alteration
2. Mitigation
3. Site comparisons
4. Identify limiting factors
5. Compare management alternatives

Hatfield et al. 2004

Figure 5. HGM scores that rate functional capacity indices (FCIs) for the seven wetlands.



Assessment

Applications

Regional Guidebooks

Function 1: Temporarily Store Surface Water

Function 2: Maintain Characteristic Subsurface Hydrology

Function 3: Cycle Nutrients

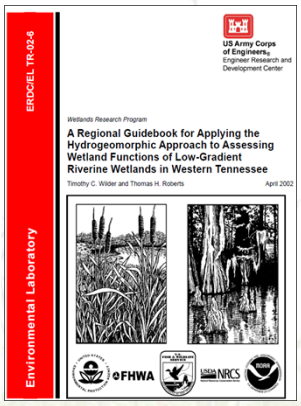
Function 4: Remove and Sequester Elements and Compounds

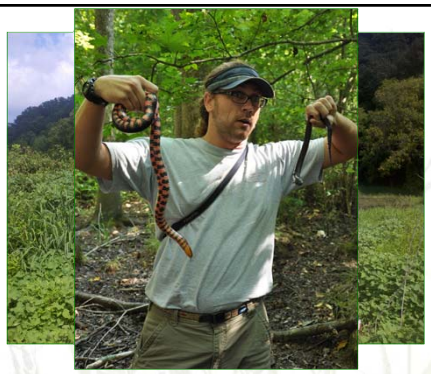
Function 5: Retain Particulates

Function 6: Export Organic Carbon

Function 7: Maintain Characteristic Plant Community

Function 8: Provide Habitat for Wildlife





“Bioassessment Bill”