Landscape Profiling and Better Wetland Restoration: How HGM Can Help

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Abstract

Wetland profiling is the classification and cataloging of wetland types for a given watershed. Classification of wetland types follows the Hydrogeomorphic (HGM) Approach that emphasizes landscape position and hydrology as driving factors of wetland function. Information regarding wetland types, distribution, and geospatial location assists decision makers in assessing the impacts and subsequent compensatory mitigation of wetland fill permits under Section 404 of the Clean Water Act. GIS lends itself to the efficient compilation of this wetland information over large areas.

Landform descriptors are used to define the hydrographic and morphological characteristics of various hydrogeomorphic wetland types, which can then be compiled by watershed. In this collaborative project, between the Environmental Protection Agency, Region 4 and the U.S. Fish and Wildlife Service, wetland profiles are created from several watersheds in the Southeastern United States. Creation of the wetland profiles involved taking the U.S. Fish and Wildlife Service's Wetland and Deepwater Habitat classification, also know at the Cowardin Classification, and modifying it to fit the Hydrogeomorphic Classification.

Background

Section 404 of the Clean Water Act pertains to the federal program by which permits are obtained from the U.S. Army Corps of Engineers (Corps) to place solid fill material into waters of the United States, including wetlands. In reviewing permit applications, the Corps must assure that the permit complies with four substantive environmental criteria developed by the U.S. Environmental Protection Agency (EPA) and embodied in the Section 404(b)(1) Guidelines (Clean Water Act (33 U.S.C. 1344)). EPA oversees the review of these permit applications to ensure compliance with the 404(b)(1) Guidelines. These four criteria are: 1) Is there a less, environmentally damaging, practicable alternative to the one proposed in the permit application; 2) Does the permit application comply with other environmental regulations (e.g., Endangered Species Act, State water quality regulations, toxic effluent standards, etc.); 3) Will the permit significantly degrade waters/wetlands; and 4) How does the applicant propose to minimize/mitigate impacts of the project. It is the last two steps of the Section 404(b)(1) Guidelines that warrant the use of techniques assessing attributes of individual wetlands and the landscapes in which they reside.

Wetlands can be classified in a variety of ways depending upon the purpose of the classification. One way to classify wetlands is using the Cowardin Classification System that is used by the U. S. Fish and Wildlife Service's National Wetland Inventory (Cowardin et al 1979). The purpose of this classification is to provide a basis for mapping wetland extent and characteristics as well as tracking status and trends. The Cowardin system is hierarchical going from Systems (e.g., Estuarine, Riverine, Palustrine, etc.), subsystems (e.g., subtidal, intertidal, lower perennial and upper perennial, etc), Class and subclass (e.g., bottom-type or vegetation type), and dominance type. This classification scheme, albeit widely used, provides little information to ecologically differentiate wetland types based on their capacity to function. The hydrogeomorphic wetland classification (HGM) was developed to group wetlands by characteristics which influence the way in which these ecosystems function (Brinson 1993). Specifically, the HGM classifies wetlands based on geomorphic position (where the wetland is positioned in the landscape), water source (where the water comes from before entering the wetland), and hydrodynamics (how much energy the water carries when it enters the wetland). The basis for the HGM is that these three factors affect how a wetland will function to the extent that wetlands in similar landscape positions with similar hydrology will function similarly (Table 1).

Table 2
Hydrogeomorphic Wetland Classes at the Continental Scale (Brinson 1993)

HGM Wetland Class	Definition
Depression	Depression wetlands occur in topographic depressions (i.e., closed elevation contours) that allow the accumulation of surface water. Potential water sources are precipitation, overland flow, streams, or groundwater/interflow from adjacent uplands. The predominant direction of flow is from the higher elevations toward the center of the depression.
Tidal Fringe	Tidal fringe wetlands occur along coasts and estuaries and are under the influence of sea level. They intergrade landward with riverine wetlands where tidal current diminishes and river flow becomes the dominant water source. Additional water sources may be groundwater discharge and precipitation. .
Lacustrine Fringe	Lacustrine fringe wetlands are adjacent to lakes where the water elevation of the lake maintains the water table in the wetland. In some cases, these wetlands consist of a floating mat attached to land. Additional sources of water are precipitation and groundwater discharge, the latter dominating where lacustrine fringe wetlands intergrade with uplands or slope uplands.
Slope	Slope wetlands are found in association with the discharge of groundwater to the land surface or sites with saturated overflow with no channel formation. They normally occur on sloping land ranging from slight to steep. The predominant source of water is groundwater or interflow discharging at the land surface. Precipitation is often a secondary contributing source of water. Hydrodynamics are dominated by downslope unidirectional water flow. Slope wetlands can occur in nearly flat landscapes if groundwater discharge is a dominant source to the wetland surface.
Mineral Soil Flats	Mineral soil flats are most common on interfluves, extensive relic lake bottoms, or large floodplain terraces where the main source of water is precipitation. They receive virtually no groundwater discharge, which distinguishes them from depressions and slopes.
Organic Soil Flats	Organic soil flats, or extensive peatlands, differ from mineral soil flats in part because their elevation and topography are controlled by vertical accretion of organic matter. They occur commonly on flat interfluves, but may also be located where depressions have become filled with peat to form a relatively large flat surface. Water source is dominated by precipitation, while water loss is by overland flow and seepage to underlying groundwater.
Riverine	Riverine wetlands occur in floodplains and riparian corridors in association with stream channels. Dominant water sources are overbank flow from the channel or subsurface hydraulic connections between the stream channel and wetlands. Additional sources may be interflow, overland flow from adjacent uplands, tributary inflow, and precipitation.

The Section 404 program regulates NWI and HGM is used to classify wetlands on a site-specific scale. However, there is growing recognition that wetlands are influenced by their surrounding landscapes and play a role in the function and condition of larger watersheds. The National Research Council (NRC) recognized the juxtaposition of wetlands and watersheds in their report, Compensating for Wetland Losses under the Clean Water Act (NRC 2001). Bedford (1996) contends that landscape level, hydrogeologic, and climatic factors govern the diversity and distribution of wetlands.

Wetlands develop and are maintained through the interaction of the hydrologic cycle and the landscape over time; they are the local manifestations of ecologically larger scale processes. These processes give rise to a diversity of wetland types that form a signature or template for a given geographic area. “Wetland templates”, representing the diversity of settings created in specific landscapes by interactions of hydrogeologic factors and climate, can be used for setting the basis for hydrologic equivalence in wetland mitigation (Bedford 1996). These templates may also serve as a potential basis for decision making in issuing Section 404 permits and requiring mitigation for those permits.

Establishment of these templates could foster the development of: 1) a catalog and mapping of the hydrogeological and climatic settings for wetland formation that exist within the landscape being considered; 2) a geographical analysis showing which templates for wetland formation have been lost or modified by human action within that landscape and which templates still remain; and 3) a catalog of the different types and relative abundances of wetland ecosytems that occur within the current landscape, noting those which are unique or of high natural heritage value (presence of rare or endangered species) (Bedford 1996).

The wetland template or landscape profile, depicting hydrologic equivalence at a landscape scale, utilizes HGM to represent wetland landscape position and hydrology. Gwin et al. (1999) developed landscape/wetland profiles for the metropolitan Portland, Oregon area by visiting 96 wetlands on the ground and classifying them hydrogeomorphically, before mapping their location. The process of compiling the landscape profile by HGM wetland type provided valuable information to the Section 404 program on the success of past mitigation in the Portland area. However, the extensive ground-truthing made the approach used by Gwin et al (1999) very resource intensive and impractical for large geographic areas. Therefore, an approach utilizing Geographic Information Systems (GIS) was investigated because of the large size of Region 4 and limited field resources.

EPA Region 4 covers the eight southeastern states: Kentucky, Tennessee, North and South Carolina, Florida, Alabama, and Mississippi. Approximately 80% of the southeast’s wetlands have been mapped by NWI, making it the most extensive wetland coverage. However, due to the original inventory intent of NWI, the maps were not designed to convey information pertinent to wetland function. Thus, to create a large-area wetland profile the coverage of NWI was merged with the HGM classification. In general, palustrine wetlands were modified using the HGM classification: (1) riverine class, if they were located on floodplains, (2) depression class, if located within a closed depression, (3) fringe wetlands, if designated by NWI as estuarine or located on the edge of large lakes, (4) flats/slopes, if located on level areas not flooded under current conditions.

Methodology

It was decided that GIS would be used for the HGM classification at a Regional level. Many map layers were considered for the several classifications. One of the most difficult HGM classifications to determine was that of the riverine wetlands. To classify whether or not a wetland was riverine, the floodplain had to be delineated. This process turned out to be much more complicated than was originally anticipated. The first data layer considered for the floodplain was the Soil Survey Geographic Database (SSURGO). SSURGO data seemed ideal with the mapping scales ranging from 1:12,000 to 1:63,360, and the information that was available from the database included flooding. The problem that quickly became evident was that much of this data was not in a digital format. Since this was regional project covering eight southeastern states, coverage for most of the states was needed.

The next dataset considered was the Q3 Flood data from the Federal Emergency Management Agency (FEMA). Although this was 100-year and 500-year floodplain, it looked promising. After all of the CDs for the Q3 data were obtained for the eight states in our Region, it was again discovered that a good many of the counties in each state did not have floodplain data. The lack of data was attributed to the fact that a good portion of the data was derived from Flood Insurance Rate Maps which focused on the economic considerations of the floodplain.

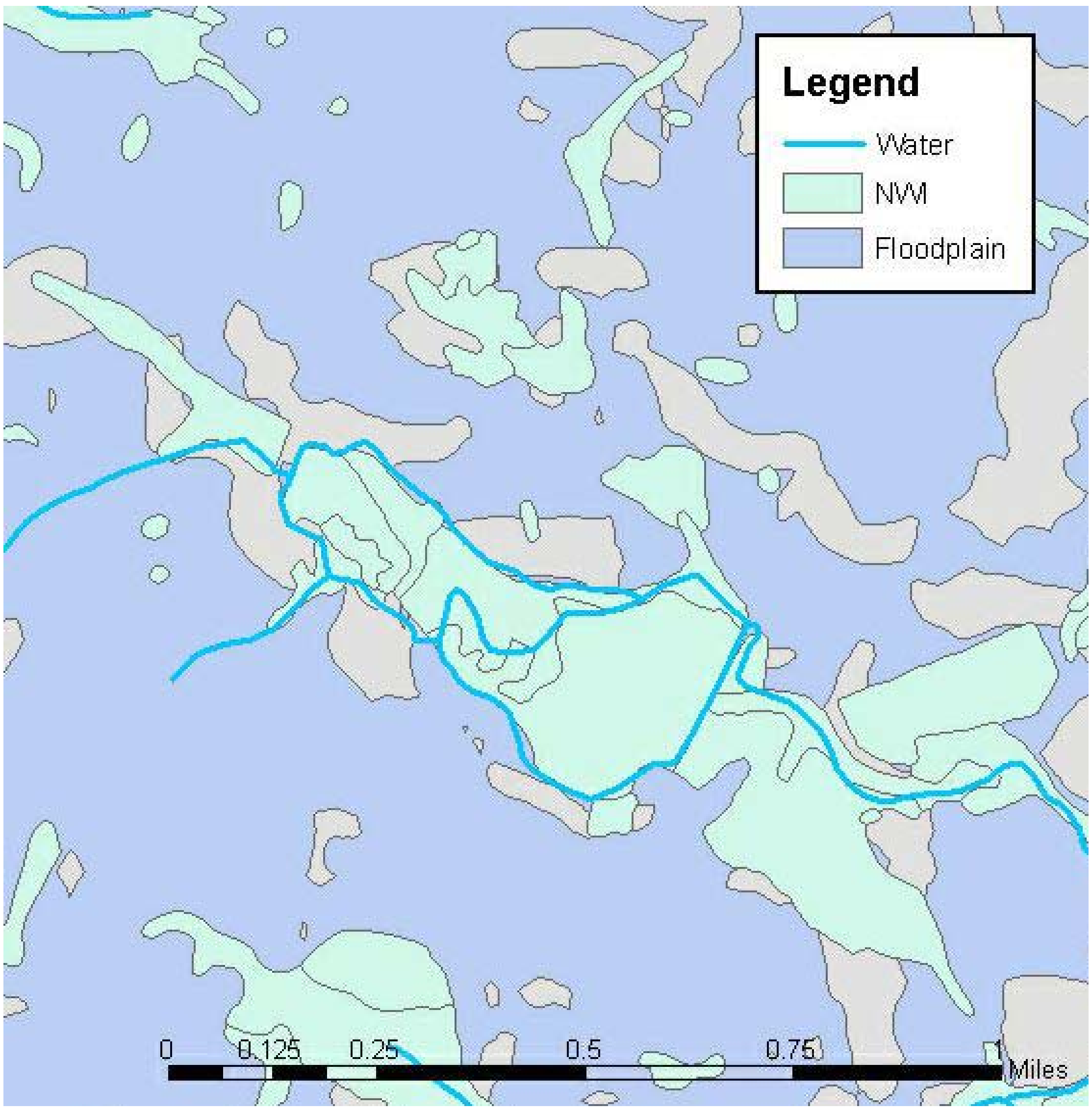
The State Soil Geographic (STATSGO) Database was another consideration for floodplain data. Concerns for using this data came about when the map scale was discovered to be 1:250,000 and the smallest area that had been mapped was 1,544 acres. Additionally, each STATSGO map is linked to an attribute database that gives the proportionate extent of each of the 1 to 21 soil types and their properties, but not an exact location of where the soils lie within the mapping unit.

The decision was made to continue looking for possible floodplain datasets. The National Land Cover Dataset 1992 (NLCD 92) was reviewed. Again concerns arose because the data was over ten years old and the land cover can change dramatically from year to year. Wetland data was found to be extremely difficult to extract from the Landsat TM spectral data. Additional information from the National Wetlands Inventory (NWI) was invaluable for determining wetland coverage.

Although NLCD data can change rapidly from year to year, elevation data from the National Elevation Datset (NED), would be less likely to change from year to year. We decided, using NED, we could derive the slope and then create contours from it to arrive at the floodplain. The decision was made after extensive fieldwork, that floodplain would be considered to be at a slope of 2 percent or less (Ainslie et al 1999). We decided to try converting the elevation dataset at a state level to a slope and then cutting out the grid at a Hydrologic Unit Catalogue (HUC). Before the conversion, the HUC was buffered to 90 meters to obtain all the possible data used to create correct contours. The contours were created at the contour interval of 2 in Spatial Analyst of ArcGIS 8.3. After creating the contours the original HUC arc coverage, without the buffer, was then unioned with the contoured shape to close off all lines. This was not successful in ArcMap; it was necessary to use the command line Arc/Info to accomplish this process. The existing labels were then deleted from the point coverage and news ones created; a new point coverage was created from these labels. All items were dropped from the new point coverage after the id field and then a new item was added for the lattice spot result. The latticespot command was used to obtain the slope at points from the original clipped out slope grid and a point-in-polygon identity process was used to re-establish the topological relationship between the points and the polygons from which they were derived. By using the joinitem command the result from latticespot was put back into the original slope polygon coverage; the coverage was then brought into ArcMap and all slopes 2 percent or less were exported to make a shapefile. We felt that since the NED was at a one arc-second (30 meters) scale then we would intersect the new created shapefile with the stream data (1:24,000 Digital Line Graphs (DRGs) from the USGS), with 30 meter buffer. This was then used as our floodpain. The stream data we used was 1:24,000 Digital Line Graphs (DLGs) from the USGS.

After we felt fairly comfortable that the floodplain could be derived from the slope of the NED, we were able to move forward and decide what other layers to use in this project. The National Wetland Inventory quads obtained from the US Fish and Wildlife Service were critical for viewing the wetlands. Initially, Digital Raster Graphics (DRGs) were used to view the lay of the land, but it was later determined that TOPO!, National Geographics's interactive map product, was a better choice of software for viewing this data. By installing the TOPO extension in ArcMap and then loading the state data onto the hard drive, the 1:24,000 topos could be easily viewed.

When data layers were determined and processed for use, a text field was created in the NWI called HGM. Below is an example of processed data near the coast in South Carolina:



The green represents the NWI and the lilac represents the floodplain. All of the wetlands that intersected the floodplain would be considered riverine wetlands even though NWI attributes for some of these wetlands would provide a different classification than riverine. According to Ralph Tiner, Regional Wetland Coordinator, at the U.S. Fish and Wildlife Service in Hadley, MA, the modifiers of A, B, and C are considered Flats in HGM terminology (Personal Communication 2002). The NWI describes these modifiers as being temporarily flooded, saturated, and seasonally flooded. Most of these wetlands have these modifiers, but for HGM to be effectively used in wetland restoration it can only have one code. Since the wetlands have not been ground-truthed, we are uncertain of exactly what would be the best code to use; the modifier codes are useful in Massachusetts, but may not be applicable in the southeast. This work started out as a regional project that would certainly have generalizations, but further GIS analysis could be helpful in determining the best code to use. The GIS analysis could prove to be invaluable since there are limited resources to ascertain what is happening in the field.

Conclusions

From the spatial analysis that was conducted in South Carolina, many wetlands could fall in both the riverine and flat HGM category. For example, if there was a higher elevation, low slope, and no channel running through a wetland then this would more likely be a flat since flats are driven more by rainwater, while riverine wetlands are caused by overbank flooding. Possibly, viewing the elevation contours for this area could aid in determining the direction of elevation; although slope was extremely useful it does not present which way the elevation was changing. Additional data layers and analysis would be helpful in the future for clarification of the HGM code for a wetland when there is a discrepancy.

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