# NWIPlus

## *Geospatial Database for Watershed-Level Functional Assessment*

*The U.S. Fish and Wildlife Service has added descriptors to the National Wetlands Inventory to strengthen the database's applications. The new tool, NWIPlus, can help wetland professionals formulate conservation strategies and assess the impact of wetland losses and gains on watershed functions.*

By Ralph Tiner

Much government attention has focused on creating methods for site-specific analysis of wetland functions to evaluate the impacts of proposed development and predict the condition of wetlands through probabilistic sampling. The U.S. Fish and Wildlife Service (FWS) has been developing techniques to use its National Wetlands Inventory (NWI) data to predict wetland functions at the landscape-level, especially for watersheds. The expansion and availability of geospatial data in digital form and advances in geographic information system (GIS) technology over the last 20 years have made it possible to integrate various datasets to: (1) improve NWI mapping; (2) expand wetland classification beyond the standard NWI classification (Cowardin et al. 1979); and (3) use the expanded database to predict wetland functions. The purpose of this article is to introduce additional descriptors for wetland mapping and an inventory-based method for landscape-level functional assessment and also highlight current applications of this method by the NWI and others.

**Geospatial Technology Improves the NWI**

When the FWS initiated the NWI in the mid-1970s, GIS technology was in its infancy. The focus of the NWI was on producing hard-copy wetland maps. In preparing these maps, the NWI utilized 1:24,000 U.S. Geological Survey topographic maps as the base to display wetlands and deepwater habitats identified through conventional photo-interpretation techniques. When viewing the maps, people could see the size, shape, and type of wetlands situated in a particular location on the landscape and their connection to other wetlands and waters. For example, a person could see if the wetland was contiguous with a lake, river, stream, or pond, or whether it was "geographically isolated" (i.e., completely surrounded by upland) and could use this information to gain insight into likely functions. While this could easily be done for a particular wetland or small group of wetlands, it was virtually impossible to visualize the landscape context of all wetlands within a watershed or larger geographic area, without pasting together a large number of maps in some way.

With the growth of GIS technology, the NWI began to digitize its data, creating a geospatial database containing information on the size, shape, classification, and location of mapped wetlands and deepwater habitats. This database made it possible to generate statistics on the extent of wetlands and deepwater habitats for geographic areas of varying dimensions, including entire states. The first state summary of NWI data was produced in 1985 for the state of New Jersey (Tiner 1985). Today, the NWI digital data are available for approximately 70 percent of the conterminous United States and 30 percent of Alaska, and users can produce online custom maps for areas of interest (Tiner 2009).

The capabilities of geospatial technology also made it possible to incorporate data created by other agencies and organizations into the wetland interpretation and mapping process. Now, the results of soil surveys, state wetland inventories, aquatic bed surveys, stream mapping, and even on-the-ground delineations in digital geospatial formats can be readily accessed and added to the NWI database. As digital geospatial data became more available and GIS technology advanced to become a desktop tool for scientists and planners, it became possible to use NWI data for watershed and regional analyses. It soon became evident that additional information needed to be added to the classification to predict a wide range of wetland functions for such areas.

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## The Need for Other Attributes

To use NWI data for landscape-level analysis, one could either expand the classification of individual wetlands or use other geospatial databases and analytical procedures to group wetlands into categories suitable for predicting wetland functions. The latter could be done on a project-by-project basis, while the former would provide a more comprehensive wetland database that could be used for functional assessment, as well as for other purposes. Given that the NWI will continue to be updated, it made sense to develop more descriptors to expand the NWI database. Since the Cowardin classification was developed mainly for separating wetlands into types that would be shown on maps, there was little concern about including in the classification system other variables that could be interpreted directly from the maps. These other variables, including the position of the wetland on the landscape, its connectivity to water bodies, its relationship to other wetlands, and the directional flow of water, are important characteristics that influence a wetland's ability to perform certain functions. Dr. Mark Brinson was perhaps the first to address the limitation of the Cowardin classification for wetland functional assessment. While recognizing the value of the Cowardin system for addressing biotic components of wetlands, he found it lacking in coverage of certain abiotic features (i.e., geomorphic setting, water sources, and hydrodynamics) that were vital for assessing wetland functions. Consequently, he developed the hydrogeomorphic classification (Brinson 1993). Yet in this system, he used some of the Cowardin terms but defined them differently (e.g., Riverine and Lacustrine), making it impossible to simply add the hydrogeomorphic terms to the NWI wetland types to improve wetland classification. Brinson stated that his classification was, however, "a generic approach to classification and not a specific one to be used in practice." (Brinson 1993) Expectations were that the approach would be modified regionally and eventually merged with other classifications that dealt with biotic features.

## What Is NWIPlus?

Recognizing the value of adding hydrogeomorphic properties to the NWI database (i.e., increased functionality), I used Brinson's approach to create a set of hydrogeomorphic-type descriptors that could be added to NWI types to facilitate predicting wetland functions. The combination of these attributes with traditional NWI types can be called NWIPlus, resulting in an enhanced NWI database. The new attributes describe:

- landscape position (relation of a wetland to a water body if present: marine—ocean, estuarine—tidal brackish, lotic—river/stream, lentic—lake/reservoir, and terrene—not affected by such waters);
- landform (physical shape of the wetland—basin, flat, floodplain, fringe, interfluve, island, and slope),
- water flow path (inflow, outflow, throughflow, isolated, bidirectional-nontidal, and bidirectional-tidal); and
- water body type (different types of estuaries, rivers, lakes, and ponds).

Collectively, they are known as LLWW descriptors, which stand for the first letter in each descriptor (landscape position, landform, water flow path, and water body type).

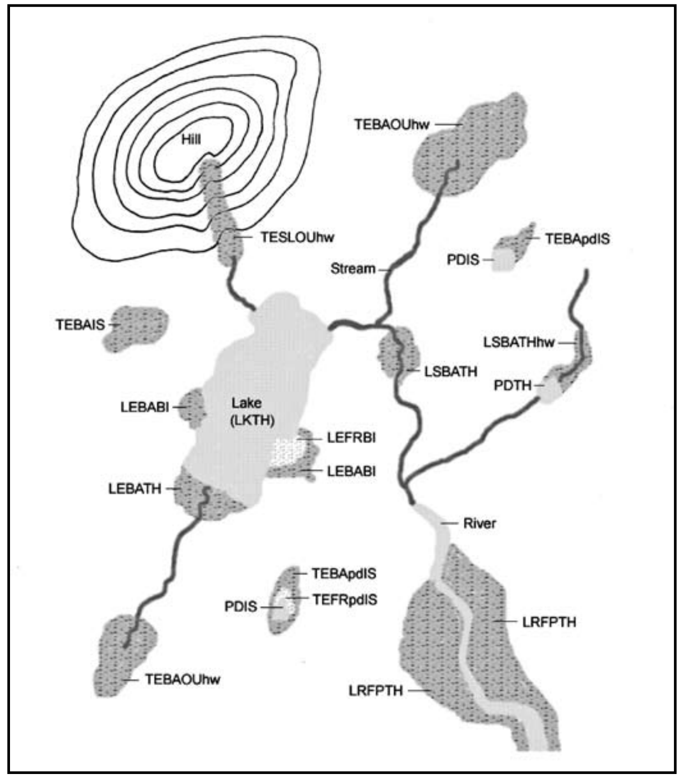


Figure 1: Schematic showing examples of nontidal wetlands classified by landscape position, landform, water flow path, and water body type (LLWW) descriptors.

**Coding for LLWW descriptors**
Landscape Position: TE—Terrene; LE—Lentic; LS—Lotic Stream; and LR—Lotic River. Landform: BA—Basin; FP—Floodplain; FR—Fringe; and SL—Slope. Water Flow Path: BI—Bidirectional-nontidal; IS—Isolated; OU—Outflow; and TH—Throughflow. Waterbody: LK—Lake and PD—Pond. Other Descriptors: hw—headwater and pd—pond (wetland bordering pond). Examples of how the code is used in Figure 1: TEBAIS—Terrene basin isolated; LSBATH—Lotic stream basin throughflow; and LEFRBI—Lentic fringe bidirectional-nontidal.

Dichotomous keys have been developed to interpret these attributes (Tiner 2003a). LLWW descriptors are added to the NWI database by interpreting topography from digital raster graphics or digital elevation model data, stream courses from national hydrographic data (NHD), and water body types from aerial imagery (Figure 1). The interpretations were initially done manually by trained wetland photointerpreters, but today automated tools are available for GIS-based classifications, which then are reviewed and edited by wetland specialists. This effort now increases the NWI workload by less than 10 percent.

Besides providing more features that can be used to predict wetland functions from the NWI database, NWIPlus makes it possible to better characterize the nation's wetlands. For example, all the palustrine wetlands, which account for 95 percent of the wetlands in the conterminous United States, can now be linked to rivers, streams, lakes, and ponds where appropriate, so that the acreage of floodplain wetlands, lakeside wetlands, and geographically isolated wetlands can be reported. The Wetlands Subcommittee of the Federal Geographic Data Committee (FGDC) recognized the value added by the LLWW descriptors and recommended that they be included in wetland mapping to

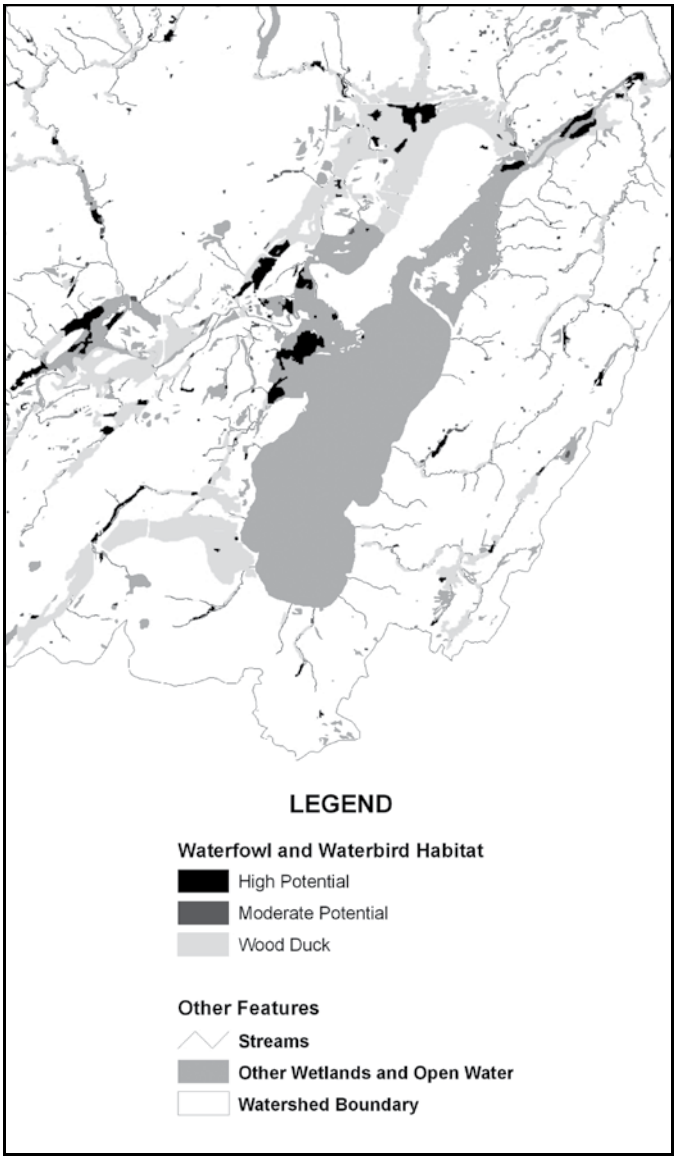


Figure 2: Portion of wetland function map for a watershed in Saratoga County, New York.

increase the functionality of wetland inventory databases (FGDC Wetlands Subcommittee 2009).

**NWIPlus for Functional Assessment**

The impetus for the LLWW descriptors was to provide a convenient and consistent means of using NWI data to predict wetland functions for watersheds. Correlations between the parameters in the NWIPlus database and a number of wetland functions have been developed in working with scientists from various agencies in the Northeast (Tiner 2003b). To date, 11 functions can be predicted by this expert-designed assessment method: (1) surface water detention; (2) streamflow maintenance; (3) nutrient transformation; (4) sediment and particulate retention; (5) carbon sequestration; (6) shoreline stabilization; (7) coastal storm surge detention; (8) provision of fish and shellfish habitat; (9) provision of waterfowl and waterbird habitat; (10) provision of habitat for other wildlife; and (11) conservation of biodiversity. The latter function emphasizes regionally significant wetland types as well as locally uncommon types based on NWI results. At this time, it does not incorporate data from other sources such as state natural heritage programs that could be added by others. The emphasis is on using NWIPlus to generate a preliminary watershed-based assessment of wetland functions. It is a starting point for wetland evaluation, not the end point. The correlations will be updated as needed and have, in one known case, been modified by a state (i.e., Montana) to incorporate local knowledge of wetlands into the functional relationships and to emphasize functions important to the state.

The watershed assessment approach using NWIPlus has been called Watershed-based Preliminary Assessment of Wetland Functions (W-PAWF), since it produces a first-cut evaluation based on map information. It is an inventory-based assessment method that evaluates every mapped wetland based on properties contained in the NWIPlus database. It applies general knowledge about wetlands and their functions to produce a watershed overview highlighting wetlands predicted to perform certain functions at high or moderate levels. It does not account for the opportunity that a wetland has to provide a higher level of function resulting from a certain land-use practice upstream or the presence of certain structures or land uses downstream. For example, two wetlands of equal size and like vegetation may be in the right landscape position to retain sediments. One may be downstream of a landclearing operation that has generated considerable suspended sediments in the water column, while the other is downstream from an undisturbed forest. The first wetland is trapping more sediment due to increased suspended sediment, while the second wetland is not doing so at the same rate. W-PAWF is designed to reflect the potential of a wetland to provide a function. It also does not consider the condition of the adjacent upland (e.g., level of outside disturbance) or the actual water quality of the associated water body, which may be regarded as important metrics for assessing the "health" or condition of individual wetlands.

The final product of this inventory-based assessment is a report containing a narrative description of the study area, methods, wetland types and functions plus a series of thematic maps showing wetlands by type (NWI, landscape position, landform, and water flow path), and wetlands of significance for each of 11 functions (Figure 2). Accompanying digital geospatial data are also available for other analyses. For examples of reports, go to the FWS' Conservation library, at http://library.fws.gov/WetlandPublications.html or to the NWI website (http://www.fws.gov/wetlands/; click on the "documents search engine"icon and then type in "wetland characterization" or "functional assessment"). Documents containing the maps are quite large and may take a few moments to download.

**Applications of NWIPlus Data**

The first applications of NWIPlus data were done in Massachusetts to produce watershed analyses of wetland functions with special attention placed on predicting likely functions of potential wetland restoration sites (Tiner 1997). These data were the foundation for the state's watershed-based restoration planning to help target restoration in areas providing significant benefits for flood protection, water quality improvement, or habitat.

To date, NWIPlus data have been used to: (1) better characterize wetlands and relate wetlands to water bodies and various functions (e.g., Tiner et al. 2007, Newlon and Burns 2009); (2) increase public awareness of the functions of wetlands and understanding that all wetlands are not alike in either form or function (e.g., New York City Department of Environmental Protection 2009, Homsey 2009); (3) assist agencies in developing wetland conservation strategies (e.g., Berner 2009, Martin 2008, Maryland Department of Environment 2006); (4) help agencies evaluate the effect of recent court decisions on wetlands (e.g., isolated wetlands, Vance 2009); (5) stratify wetlands for research purposes (e.g., Jacobs et al. 2009); (6) estimate the effect of wetland trends on the capacity of watersheds to provide wetland services (e.g., Kudray and Schemm 2008); and (7) assess the cumulative effect of historic wetland loss on functions (e.g., Tiner 2005, Fizzell 2007). Referring to NWIPlus maps of Maine's Casco Bay watershed, which show wetlands of significance by function, William Honachefsky, in his 1999 book, *Ecologically Based Municipal Land Use Planning*, stated that "these newest maps allow decisionmakers and land planners to better assess the true worth of individual wetlands" and that such information should be incorporated in local municipal master plans. The Center for Watershed Protection's report, "Using Local Watershed Plans to Protect Wetlands," mentioned the value of LLWW descriptors in estimating wetland functions for managing wetlands at the watershed level, and suggested that these types of assessments should be part of any wetland inventory (Capiella et al. 2006).

NWIPlus data have been generated for numerous areas in the country. It has become a standard practice for updating NWI data in the Northeast and will be considered for updates elsewhere depending on regional priorities and budgets. Using these data, W-PAWF has been applied or will be applied to numerous areas in the country by the FWS. Various states have begun using these LLWW descriptors in their inventories to create an NWIPlus database. For example, the state of Montana is applying these attributes to aid in assessing wetland functions for its watersheds (e.g., Kudray and Schemm 2008, Newlon and Burns 2009). The states of Michigan and Delaware have applied the descriptors to wetland inventory projects. Minnesota has included these descriptors in their requirements for updating NWI data (Minnesota Department of Natural Resources 2009). Other states where wetland inventories are underway and that are considering the application of LLWW descriptors include Georgia, Kansas, New Mexico, and Oklahoma.

**Conclusion**

Adding LLWW descriptors to the NWI database creates a more functional and powerful database—NWIPlus. It can be used in formulating wetland conservation strategies to help prioritize wetlands for acquisition, restoration, or strengthened protection, as an educational tool to improve the public's understanding of wetland functions, and as a cumulative impact assessment tool to estimate the impact of wetland losses and gains on watershed functions. By creating NWIPlus data, the results of wetland inventories can better describe the variability between and among wetlands and include watershed-based or landscape-level wetland functional assessments. For more than three decades, NWI maps have been used by various levels of government in compiling natural resource inventories, watershed planning, and improving wetland protection. Now, by enhancing NWI data and using it for wetland functional assessment, they have a more valuable tool at their disposal for resource conservation and management. ■

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**Resources**

*The NWI can be viewed online at* http://www.fws.gov/wetlands/.

This May, in the spirit of American Wetlands Month, let us celebrate our coastal wetlands . . . connecting us all with their beauty, their ability to protect our communities from some of nature's most destructive forces, and their vital support of water quality, fish, and wildlife that enhance our lives, no matter how far inland we live or travel. We have a shared responsibility to conserve coastal wetlands so that future generations can also enjoy all the benefits these vibrant and important places have to offer. To learn more about American Wetlands Month and activities in your area, or for additional resources to explore, protect, and restore wetlands, visit www.epa.gov/owow/wetlands/awm. ■

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Resources

*Learn more about how coastal communities can protect their environmental resources, at* www.coastalsmartgrowth.noaa.gov *and* www.epa.gov/smartgrowth/sg-coastal.html.

*Information about the Workgroup's regional reviews can be read at* www.epa.gov/owow/wetlands *and* www.nmfs.noaa.gov/habitat/habitatprotection/wetlands/index.htm.

*For information about American Wetlands Month and events in your area, visit* www.epa.gov/owow/wetlands/awm.

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