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Wetland Mapping – From Mylar to Mosaics and Beyond

by Leah Stetson, ASWM

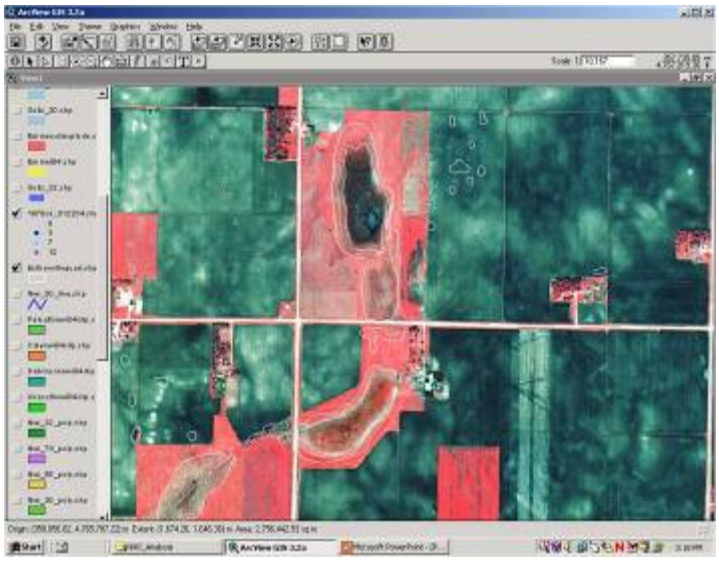
Mapping has indeed come a long way from the introduction of paper maps that have been used for centuries. Geographic information systems (GIS) maps have been around since the 1960s, but primarily available to the federal government and to a limited number of groups who had the technical expertise to apply it. Since the 1990s, however, a wider range of organizations, including state wetland programs, have been equipped with the technology, funding and the basic data to begin mapping natural resources. Today's digital mapping technology provides exciting opportunities to expand databases such as the U.S. Fish & Wildlife Service's (FWS) National Wetlands Inventory (NWI) as well as to tap into new applications for wetlands. GIS users are also changing the way wetland mapping is done—making improvements to data layers, for example, or integrating river and floodplain mapping. Wetland managers are using GIS as a tool to identify wetlands and priority areas, conduct studies, undertake conditional and function-based assessments, and explore sea level rise scenarios, among other potential impacts of climate change.

Jeanne Christie photo

Adopting a New Wetland Mapping Standard

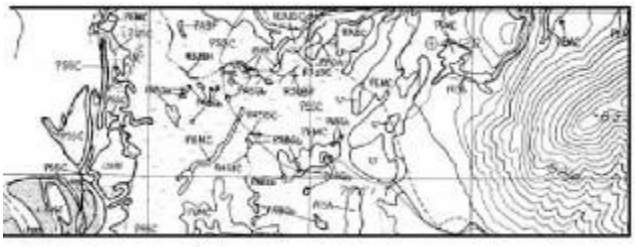
Historically the FWS held responsibilities for mapping wetlands in the United States. This has been accomplished through stages—first by mapping and transferring wetlands to USGS topographical maps, and in more recent decades, by providing digital wetlands data that can be displayed on images of USGS maps, or rectified images like orthophoto quads. However, as federal funding for mapping has decreased, other agencies, nonprofit organizations and states have taken an interest in mapping wetlands in recent years. Due to the lack of standardized techniques for wetland mapping, their data has not always been directly compatible with the NWI maps. According to the Federal Geographic Data Committee (FGDC), it "has become increasingly important to have consistency and to develop a wetlands mapping standard that everyone can use to map and share wetlands data in a digital format." Having a series of wetland data layers that are compatible—in scale, age, etc.—is important when considering the many applications of wetland maps and digital wetland geospatial data. The FGDC is interested in supporting an up-to-date national wetlands geospatial database. Consequently, in order to insure that federal funds for wetland mapping produce data that can be incorporated into that database, wetland mapping conducted using federal funds will be required to meet a new wetland mapping standard, which is currently in the final stages of FGDC review.

In a GIS context, different "maps" or data layers can be combined. When creating a GIS map, data layers can be selected, including USGS topographic maps, hydrologic (showing rivers, streams and watersheds from the National Hydrography Dataset), land use/cover, transportation (roads), as well as US Army Corps of Engineers (US ACE) maps showing dams, USDA Natural Resources Conservation Service (NRCS) soils and FWS NWI wetland and deepwater habitat data. The new wetland mapping standard provides a mechanism to allow users to have their mapping data incorporated into the national data layer. By meeting the minimum criteria of the standard, the data can become part of the national database.



The FGDC Wetland Subcommittee and its Wetland Mapping Standard Workgroup have recently posted the draft wetlands mapping standard. The proposed standard recognizes the recent change in the NWI Program from a "paper"-based map production operation to a GIS-based mapping environment. The FWS's wetland classification system (Cowardin, et. al.), already adopted as the FGDC standard for wetland classification, is incorporated into this standard by reference. The objective of the wetland mapping standard is to support the accurate mapping and classification of wetlands while ensuring mechanisms for its revision and update. The FGDC Wetlands Mapping Standard is designed to direct the current and future digital mapping of wetlands and deepwater habitats where federal funds are involved. For a direct link to this draft, go to: http://www.fgdc.gov/standards/projects/FGDC-standards-projects/wetlands-mapping/FINAL%20-%20FGDC%20Draft%20Wetland%20Mapping%20Standard%20July%202008.pdf

Expansion of the NWI Database



FWS NWI

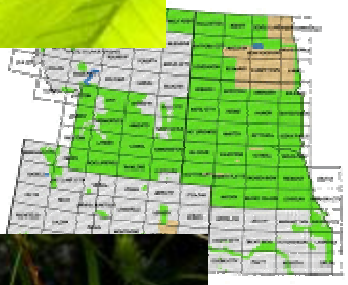
The National Wetlands Inventory (NWI) dataset is the largest polygonal database in the world. No other country or national program has a polygonal mapping layer of this size. Most of the wetland maps in the NWI database were made with data from the 1980s. Consequently these maps do not include wetland gains or losses that have taken place since then. Advancements in technology and refined scales of imagery now allow mapping of smaller wetlands that previously could not be detected. Unfortunately, NWI funding has been reduced to such an extent that NWI can only update less than 1% of the nation per year. Several states, tribes and other organizations are working with the FWS on regional projects to update the NWI digital wetlands layer.

The existing Cowardin classification system used by NWI emphasizes vegetation, hydrology, salinity, soils and substrates as well as human impacts. The hierarchy places systems at the top, including marine, estuarine, palustrine, riverine and lacustrine. Classes are grouped into vegetation types, e.g. EM (emergent), SS (scrub shrub), FO (forested), AB (aquatic bed), nonvegetation types, e.g. US (unconsolidated shore), RS (rocky shore), UB (unconsolidated bottom), followed by subclass and modifiers such as water regime (tidal, nontidal), water chemistry (salinity, PH), soils and special modifiers describing the influence of man. For a diagram of this classification system, go to: http://www.aswm.org/member/august_2008/cowardin_class_system.pdf For the legend of the map codes, go to: http://www.aswm.org/member/august_2008/cowardin_map_code_legend.pdf

The results of the NWI are presented through maps, statistics and reports. The FWS produces a national wetland status and trends report based on a statistical sampling. Such reports are published every ten years as reports to Congress to aid in evaluating the national status of wetlands. The NWI has also conducted wetland trends studies for some local areas. For these studies, wetland trends data are based on local mapping (photo to photo comparisons for entire map areas). The data can answer some questions like, "What wetland types are being lost on the landscape and what kinds are being gained? What are the major causes of wetland loss or gain?"

Adding New Information to NWI Maps & Using Maps to Assess Wetland Functions

There are digital wetlands geospatial data available for sixty percent (60%) of the nation. Starting with this NWI data and adding to it other important geospatially-referenced wetlands data will create a comprehensive wetlands database with many important benefits. Completing the wetlands layer and adding data modernized by bringing it up to date and refining the data are the first steps. A number of projects have been initiated to add other layers to the wetlands database. For a possible wetlands functional assessment layer, hydrogeomorphic (HGM) type descriptors for wetlands are being added to a limited number of maps in test pilot-projects selected nationwide. The system being tested has been given the nickname of "LLWW" for landscape position, landform, water flow path and water body type. "NWI is routinely applying LLWW descriptors to areas where they're updating data in the Northeast," explains Ralph Tiner, FWS. This system is being tested to determine how well it applies in other regions or if regional changes are needed.



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The value of enhancing the NWI database through efforts such as LLWW is threefold: 1) It will provide a more refined characterization of wetlands for the national wetland database; 2) will allow users to perform landscape-level wetland functional assessments; and 3) will help assess the impacts of wetland losses and gains from a functional standpoint.

Tiner developed the LLWW descriptors as a rapid assessment desktop (first-cut) approach to predicting wetland functions for large geographic areas (i.e. landscape-level functional assessments). The landscape position is the relationship between a wetland and an adjacent water body: marine and estuarine—near the ocean or estuary; lentic, referring to wetlands along a lake or in a lake basin; lotic—wetlands along rivers and streams and subject to periodic overbank flooding; and terrene, which includes geographically isolated wetlands, stream-source wetlands and wetlands not subject to frequent river and stream overflow. The landform is the shape, or appearance of the wetland: slope, island, or fringe wetlands. Fringe wetlands are in water most of the time, and include semi-permanent marshes, floating bogs and creek beds. Two other types of landforms are floodplains and interfluves, the broad flats between streams. The water flow path addresses the directional course of water, which can be bidirectional-tidal (incoming and outgoing tides), or bidirectional-nontidal (subject to rise and fall with lake levels), for example. Water flow path can also be throughflow (e.g., perennial (year-round), intermittent, entrenched, artificial), outflow, inflow, isolated, or paludified (typically associated with boreal environments). The water body type adds more specificity; it could be a dammed river, a channelized stream, natural or artificial lake, salt-wedge estuary, or many types of ponds (e.g., farm, woodland, vernal, coastal plain, pothole, or stormwater treatment).

One advantage of adapting the NWI wetlands database to include the LLWW system is to assist in preliminary functional assessments and also to compliment the national wetlands condition assessment that is underway at EPA. Once LLWW descriptors are added to the NWI database, the data can be used to generate preliminary assessments of wetland functions for large geographic areas. Wetland descriptors, used to attribute features to wetland map layers, and wetland classifications are based largely on map interpretation. For information on wetland assessments and the differences between condition and function-based assessments, go to: http://www.aswm.org/fwp/assessment/index.htm

Landscape-level assessments using enhanced NWI data are a first approximation. There are source data limitations, for example, not all wetlands, streams or other features are shown on the maps, and the age of the NWI data can also be a limiting factor. Sample watershed assessment reports can be viewed online at: http://www.fws.gov/nwi/

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States, Organizations Working with FWS on Updating NWI Layer

The FWS is or will be working with several states, including Massachusetts, Maryland, Florida, and Wisconsin, to incorporate existing or more recent and/or more refined standards-compliant data into the wetlands layer. For example the Massachusetts Department of Environmental Protection (MassDEP) is working to crosswalk the state's wetland maps into the NWI classification system, according to Charlie Costello with MassDEP. Once the wetland codes are crosswalked, they will be brought into NWI and become part of the wetlands layer of the National Spatial Data Infrastructure. This should provide the FWS with 2005 updates for the entire state.

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"If a wetland is mapped on a USGS map, it has recognition but not a very high level," explains Costello. However when the wetland is mapped digitally, that polygon can be used for different purposes. The more you can characterize a wetland (i.e., the more attributes assigned to a particular wetland) and then integrate it with other GIS layers, the more rigorous the assessment can be performed. It is important to get the data (on digital maps) to a wide range of users, get it out of the GIS office and distribute it to every facet of commerce—from town government to private consulting firms and developers, engineering firms and land trusts. This increases the likelihood for avoidance of wetlands by development projects because developers can take wetlands into consideration early in the planning process.

The FWS is also cooperating with a number of states or other organizations for updating of existing wetlands data. For example, the Minnesota Department of Natural Resources, in collaboration with several partners, plans to update the NWI layer for the state in phases to be completed in 2014. In cooperation with FWS, Minnesota has completed some pilot updates of the NWI coverage in three regions of the state: 1) northeast (Duluth/Cloquet); 2) east central (northeastern St. Paul) and 3) southwest agricultural region including most of the Redwood River Watershed. The Duluth/Cloquet work was conducted in cooperation with the Fond du Lac Band of the Chippewa and coordinated by Rick Gitar. Nine 1:24K quads were updated in the Duluth/Cloquet area and more recently Gitar has had a contractor complete interpretation of the LLWW descriptors for these quads. In east central Minnesota (metro region), the state's Wetland Assessment, Monitoring and Mapping Program staff have updated two NWI quads and in the Redwood River Watershed, have updated 23 1:24K quads, which comprise most of this watershed. In addition they have had LLWW interpretations done in the four quads of the Redwood River Watershed centered around Marshall, Minnesota. They are in the process of analyzing results from these updated quads. For a link to the Fond du Lac Band's Wetland Protection and Conservation Plan, which includes discussion of the mapping efforts, visit: http://www.fdlrez.com/newnr/environ/wetlands.htm

Through a series of joint projects with Ducks Unlimited, several departments from Illinois, Indiana, Ohio and Michigan are in the process of updating NWI map layers. Currently Ducks Unlimited seeks volunteers to assist in verifying wetland data in the field, taking photographs, identifying wetland types, etc. Individuals in these states who are interested in contributing to this project may contact Robb Macleod at (734) 623-2000 or rmacleod@ducks.org. For more information, visit: http://www.ducks.org/Conservation/GLARO/3752/GISNWIUpdate.html

Wisconsin's wetland program has begun to partner with FWS NWI to incorporate the state's wetland data into the NWI national map database, according to Lois Simon with the Wisconsin Wetland Inventory (WWI). The WWI staff are currently working on a crossover between the state and NWI classification systems. NWI has also assisted the state's wetland program (when they have had available funding) in tackling some of the digitizing backlog through the use of NWI's sole contractor (St. Mary's University of Minnesota GeoSpatial Services in Winona, MN). The state was also successful in obtaining EPA grant funds to update wetland maps for seven rapidly developing counties in the southeast part of the state through an intergovernmental agreement with the Southeast Wisconsin Regional Planning Commission (SEWRPC). The WWI staff mapped wetlands as small as a quarter of an acre in size using orthophotography at a scale of 1 inch equals 400 feet. SEWRPC was then able to update their environmental corridor maps using the updated wetland data. Additionally, Simon says that the WWI plans to update three to four counties a year under the wetland map update program, which entails obtaining new stereo aerial photography and complete remapping, digital orthophotography creation and digitizing of the entire county. For information on WWI, visit: http://dnr.wi.gov/wetlands/mapping.html For information on GeoSpatial Services, visit: http://www.geospatialservices.com/

California and Oregon have both seized a unique opportunity to accomplish the digitizing of hundreds of wetland maps over the past several years. Elaine Blok with FWS explained that contracting costs were high but these two states were able to save money by working with the prison systems. Inmates digitized over 700 hardcopy NWI maps in these states. FWS provided the inmates with lists of priority quads to be digitized, sent scanned maps, provided training and quality control. In Oregon the inmates have digitized 350 quads and are currently contracted with the state to complete another 240 in 2008 and 481 in 2009. In California the inmates have been trained to digitize, interpret aerial photos, delineate wet features and make a first cut for a wetlands map. According to Blok, this has been a very positive working relationship and some of the inmates have expressed a desire to pursue a related course of study after they get out of prison.

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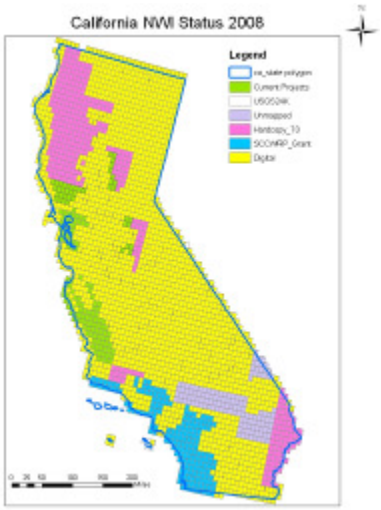
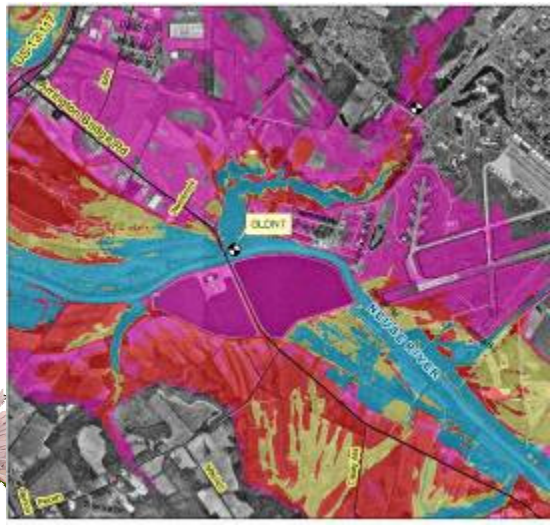
In 2001 the California Resources Agency in collaboration with the NWI, launched a Statewide Wetlands Inventory. Funding for this project has come from the state general fund, state bond measures and the NWI itself. The state has also been working to crosswalk the typologies between the different databases. A total of 97 digital wetlands maps were uploaded to the



NWI's geodatabase in 2006. A concerted effort is needed to establish one typology or 1:1 crosswalks between typologies for NWI, the State Wetlands Inventory, State Riparian Inventory, California Rapid Assessment Method (CRAM) typology, Wetland Tracker typology, etc. The State Wetland Inventory and NWI's staff have been communicating on the best ways to integrate these updates into the NWI for California, according to Chris Potter of the California Resources Agency. By the end of 2008, California will have 80% NWI coverage in digital format. The Resources Agency intends to complete the inventory by the end of the decade.

There is a growing accumulation of elevation datasets that can be used for wetland planning, management and restoration in Missouri among state and federal agencies, according to Tony Spicci, GIS Supervisor with the Missouri Department of Conservation. While there is no unified effort for wetland mapping in Missouri, there are several projects underway in this state. For a brief description of each of these projects, go to: http://www.aswm.org/swp/mapping/wetland_mapping_efforts_in_missouri_8_08.pdf

Using an Integrated Approach to Map Wetlands



River specialists can use an integrated approach to mapping and conducting wetland assessments. These maps might cover habitat loss due to various factors, such as changes in hydrologic or sediment regime, latitudinal and longitudinal connectivity, and temperature regimes, e.g. from a loss of canopy. Maps can also be used as visual and interactive tools to help users evaluate things such as thresholds for floodways.

In addition to maps that show the 100-year (or 1-percent-annual-chance) floodplain, the Federal Emergency Management Agency (FEMA) often publishes boundaries showing regulatory floodways that lie within the 100-year floodplain. These FEMA floodways represent a portion of the floodplain that must remain free of encroachments to allow the 100-year flood to pass without raising water levels more than a specified height. The FEMA floodway is a minimum standard required of communities to comply with the National Flood Insurance Program (NFIP); however, communities are encouraged to implement "higher" standards to better protect lives, property and natural functions of floodplains in their jurisdictions.

Jeanne Christie photo

Kevin Coulton, an engineering consultant and certified floodplain manager, has explored and proposed an alternative "natural floodway," which would augment the FEMA floodway and potentially serve as a higher NFIP standard for communities. The "natural floodway" represents that portion of the 100-year floodplain where natural floodplain storage would be optimized.

Flood insurance data are available for a 100-year peak flood and that is reflected in the maps for communities. However, FEMA has data for the 10-, 50-, 100- and 500-year floodplains, computer models and other flood insurance study products, but much of these data are not being used for creative land use planning purposes. Coulton asserts that it can be important to "mine" these data to account for a "natural floodplain," typically an area with more frequent flooding such as 1-10 year flood cycles. For example, Coulton compared the relationship between the 10-year floodplain with FEMA's regulatory floodway in a preliminary pilot study. The 10-year floodplain typically encompassed the floodway and provided a larger area to accommodate floodplain storage; however, the two boundaries may often coincide in lower gradient reaches of large river systems.

Maps can help users make informed decisions for the purposes of regulatory and restoration planning. A map layer that can identify and assist in analyzing floodplain storage--together with habitat values beyond the floodway and within the 100-year floodplain can be useful for planning purposes. Coulton's comparative analysis of wetland areas indicated a majority of these areas occur outside of the FEMA floodway but within the 100-year floodplain. This indicates that filling in the floodplain to the edge of the FEMA floodway (which is allowed in many communities) may actually lead to a reduction in natural floodplain storage and loss of wetlands.

Other possible future applications of this approach might be to explore seasonal variations in flood attenuation with changing conditions (due to development or climate change), to develop schemes to increase floodplain storage capability and to establish the economic value of the beneficial functions of natural floodways. Using the Community Rating System (CRS), when a community meets criteria in four categories, it receives points and discounts on insurance rates; one of these categories is floodplain mapping. With a broader database to help define a higher standard for natural floodways, communities may be better prepared to reduce flood impacts and preserve beneficial floodplain functions. For more information, visit: http://www.kevincoulton.com

The Nature Conservancy is working with Wyoming's Wetlands Strategy Working Group to analyze Wyoming's wetlands and produce a priority wetland complex report for the state. This report will include maps and descriptions of each priority area, including threats and strategies. The spatial analysis will include compiling spatial data from the NWI and National Hydrologic Dataset to produce a unified map of wetlands across Wyoming at the 1:24,000 scale. The wetlands team will also conduct a conditional assessment of each area, using GIS models based on four factors: mean wetland density, condition, biological value and future threat. According to Holly Copeland, Director of GIS with TNC's Wyoming chapter, the assessments are approached from a biodiversity perspective. The staff conduct conditional assessments on wetland habitat to identify the most valuable species and related habitat. Staff perform landscape level assessments using aerial photography. The age of the data varies, dating back to the 1990s. TNC collaborates with Wyoming Fish & Game Service, USFWS, and other agencies to do the wetland analysis of specific habitats statewide. One of the objectives is to determine the importance of these wetlands, define a conditional value, future threats, establish a rank, etc. The maps and analysis will be available in a few months. TNC will work with the Wyoming Game and Fish to incorporate this prioritization as an addendum to the Wyoming Comprehensive Wildlife Conservation Strategy, Copeland adds. They are also planning to design a rapid wetland assessment method next year. For more information, visit: http://www.nature.org/wherewework/northamerica/states/wyoming/misc/art21354.html

Leah Stetson photo

Leah Stetson photo

Applying the Sea-Level Affecting Marsh Model

Congress provided a modest increase in the NWI budget for "additional wetland mapping capabilities associated with preparing for and reacting to climate change." The FWS has selected a wide range of small pilot projects to occur nationwide in areas of high regional priority that are related to preparing for or reacting to climate change. Each project will be used to address a different set of conditions, habitats or species assemblages, conservation concerns, and uses of the map data. For a list of approved NWI projects for 2008, go to: http://www.aswm.org/member/august_2008/nwi_2008_approved_projects.pdf

Leah Stetson photo

A series of projects have used the sea level affecting marsh model (SLAMM), which was originally developed by Dr. Richard A. Park. SLAMM projects explore a range of sea-level rise scenarios based on emission, temperature and sea-level change estimates. Scenarios might extend to years 2025, 2050, 2075 to 2100, for example. SLAMM users can identify anticipated results, such as habitat conversion, e.g. conversion of tidal marshes to open water habitat, and many other factors in connection with climate change. But the SLAM model does not account for all components, structures and functions of coastal ecosystems. One of the limitations of SLAMM is that it lacks feedback mechanisms to modify accretion rates.

The Big Branch Marsh National Wildlife Refuge project in Louisiana studied sea-level rise scenarios and the anticipated impacts to the marsh, including habitat conversion, loss of dry land and inland wetland migration. For a link to the project report, go to: http://www.aswm.org/member/august_2008/slamm_report.pdf

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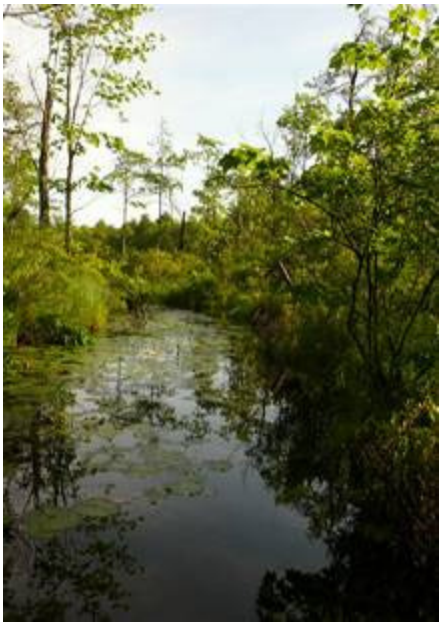
Among the objectives used for SLAMM projects is that of quantifying ecosystem services of tidal and freshwater marshes. Users can overlay the map layer showing the ecosystem services on NWI maps, then simulate different scenarios of accelerated sea level rise to predict changes in those wetland areas. One study applied the SLAM model to three estuaries representing three marsh types—tidal fresh, brackish and salt. They measured the carbon sequestration in the soils, nitrogen and phosphorus accumulation, denitrification (removal or reduction of nitrogen). SLAMM uses elevation, NWI data, tide range, historic sea level rise and site-specific accretion rate data to run the model. A salinity algorithm is used to simulate saltwater intrusion into river-dominated estuaries as sea level rises. For a presentation by Christopher Craft, Indiana University; Jonathan Clough, Warrant Pinnacle Consulting; Richard Park, Eco Modeling; and Jeff Ehman, Image Matters LLC, go to: http://www.spea.indiana.edu/wetlandsandclimatechange/documents/Craft%20Wetland%20Biogeochem%20Presentation_files/frame.htm

Currently there is an opportunity for users in coastal Georgia and South Carolina, as well as the Chesapeake Bay, to test and comment on the SLAMM-Viewer, a unique web-mapping tool. Project leaders Jeff Ehman and Jonathan Clough would appreciate feedback sent directly to them. For instructions and links to the SLAMM-Viewer, along with their contact information, go to: http://www.aswm.org/member/august_2008/slamm_comments_welcome.pdf For a direct link to the SLAMM-Viewer, go to: http://www.spea.indiana.edu/wetlandsandclimatechange/

Other GIS Mapping Tools and Applications for Wetlands

The Vermont River Management Program has been collaborating with the wetland restoration program staff on combining the assessment (mapping), planning and restoration efforts through various projects. The River Management Program staff developed a fluvial geomorphic assessment and corridor planning guide. The planning guide speaks to using a data layer developed by wetland restoration scientist April Moulaert, plus other wetland and soil data layers to map wetlands in the context of

modifications to the hydrologic regime, according to Mike Kline with the DEC River Management Program. "These are then mapped with other hydrologic, sediment regime and hydraulic stressors to understand the cause of stream instability and prescribe protection and restoration projects at a reach scale," Kline explained. For more information on the wetland restoration projects, visit: http://www.vtfpr.org/wprp/programaccomplishments.cfm For a direct link to the River Management Program's fluvial geomorphic assessment and corridor planning guide, go to: http://www.anr.state.vt.us/dec/waterq/rivers/docs/rv_rivercorridorguide.pdf



Jeanne Christie photo

Another future tool identifies the likely location of wetlands. "In the Northeast region, we are attempting to add 'undeveloped hydric soil mapping units' to update NWI data to represent likely wetlands that were not identifiable through conventional photointerpretation techniques," Ralph Tiner explained. "In our database," he adds, "we are labeling them as H-NWI type wetlands (e.g., HPFO1B), so that users will know that these areas were interpreted from soil data. These wetlands are typically the drier end wetlands and in many cases, their hydrology may be best described as 'seasonally saturated,' e.g. water tables at or near the surface during the winter and spring. The reason for adding these data is to show users that there are other areas where wetlands are likely to occur that were not detectable by our inventory procedures. So one might consider them [to be] areas with a high probability of wetland occurrence." Such data are not presently accessible through the NWI online wetlands mapper as the mapper was not designed to accommodate this kind of data but that may be resolved in the future.

Wisconsin has created a similar layer. The new Wetland Indicator GIS layer using NRCS somewhat poorly, poorly and very poorly drained soils is now available to the public on the Surface Water Data Viewer, as well as the Wetland Theme, which packages the Wisconsin Wetland Inventory (WWI) and the indicator layer with the 2005 aerial. Wisconsin wetland program staff are in the process of updating the wetland map webpages so the public can access the wetland theme right from the wetland map page. Currently, access to this theme can also be gained from the Surface Water Data Viewer (SWDV). The purpose of this indicator layer is to help the public identify wetlands and potential wetlands on private property. These maps can also be used as a starting point for conducting functional assessments. For a link to these indicator maps, go to: http://dnrmaps.wisconsin.gov/imf/imf.jsp?site=SurfaceWaterViewer.wetlands and http://dnrmaps.wisconsin.gov/imf/imf.jsp?site=SurfaceWaterViewer For questions about this indicator layer, contact Cherie Hagen, Wisconsin DNR, (608)266-7360 or cherie.hagen@wisconsin.gov

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There are many opportunities for state wetland programs and other invested groups to collaborate on mapping projects, and a critical need to update the wetland data for the nation. Updated data layers will provide for more informed decision-making for wetland protection and management policies.

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Links of Interest

Glossary of mapping terms, GIS Development
http://www.gisdevelopment.net/glossary/index.htm

Interactive Wetland Mapping tool with North Carolina Div. of Coastal Management
http://dcm3.enr.state.nc.us/website/nccoastal_wetlands/viewer.htm

National Wetland Inventory – Info on Cowardin Classification System
http://www.fws.gov/nwi/Pubs_Reports/Class_Manual/class_titlepg.htm

USFWS Wetlands Geodatabase & wetland mapper
http://wetlandsfws.er.usgs.gov/NWI/index.html

VT Stream Geomorphic Assessment Protocols
http://www.anr.state.vt.us/dec/waterq/rivers/htm/rv_geoassesspro.htm

Montana's Natural Heritage Program – watershed assessments using NWI data
http://nhp.nris.mt.gov/Reports_List.asp?key=4

FEMA Map Center
http://msc.fema.gov/webapp/wcs/stores/servlet/FemaWelcomeView?storeId=10001&catalogId=10001&langId=-1

California Awareness Floodplains
http://www.fpm.water.ca.gov/mapping/awareness_mapping.cfm

FEMA's Community Rating System (CRS)
http://www.fema.gov/business/nfip/crs.shtm

SLAMM – related projects and presentations via Indiana University
http://www.spea.indiana.edu/wetlandsandclimatechange/archive.htm

SLAMM – Warren Pinnacle Consulting (contains a good overview of the dev't of SLAMM)
http://warrenpinnacle.com/prof/SLAMM/index.html

SLAMM Bibliography – list of publications related to the Sea Level Affecting Marsh Model
http://warrenpinnacle.com/prof/SLAMM/Bibliography.html