2010 WETLAND MAPPING SUMMARY

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WETLAND MAPPING – WHERE ARE THE WETLANDS?

Wetlands are dynamic, living systems subject to a broad array of changes on a variety of time scales. Rivers change their course as a result of ongoing erosion and deposition; shrub scrub wetlands grow into forested wetlands; beavers create impoundments that expand wetlands; and human activities can destroy or restore wetlands. In order to be effective tools for wetland managers, information about wetlands needs to stay current and reflect forces like succession and especially human alteration of the landscape. Good data have high predictive value and help planners, wetland managers and other program managers to focus their efforts. Mapping products designed with accurate, regularly updated data can reduce the costs associated with conserving, regulating and protecting wetlands.

In 2010 the Association of State Wetland Managers (ASWM) set out to take a snapshot of the status of wetland mapping in the United States. ASWM staff produced documents summarizing the age and extent of wetland maps for each state using the U.S. Fish and Wildlife Service's National Wetlands Inventory (NWI) dataset from January 2010. These documents were forwarded to state contacts with a request for information about additional mapping efforts that might not appear in the NWI. The project concluded in December, with 35 of the 50 states responding to inquiries. These responses as well as discussions with a handful of other states were compiled into a website with available information summarized on a state-by-state basis. Nationwide, wetland maps are badly in need of improvement and updating.

There are a number of reasons why wetland maps don't meet the needs of today's users. Over 80% of the NWI was mapped from color infrared aerial photography taken in the 1980s or earlier. These maps were the first effort of their kind and used the best methodology available at the time. Prior to this there were no wetland maps at all so the NWI maps were a huge step forward. Thirty years later, however, the maps are not as useful as they once were, or could be. Many state respondents raised concerns about the accuracy of maps based on 1980s photography. The data include areas mapped as wetlands that aren't wetlands and areas not mapped as wetlands that are, resulting either from human activities that altered the extent of wetlands, shortcomings in the methodology and small scale imagery used 30 years ago to identify wetlands and produce the maps, or the inherent limitations of mapping the full suite of wetlands along a soil moisture gradient from flooded to seasonally saturated via remote sensing. During its 35 years in operation, the NWI's success as a data delivery program has created a market of professionals, landscape planners, wetland managers and others, who have identified uses for wetland maps and it is to be expected that these applications will continue to grow in number. To operate successfully in areas of significant and rapid wetland changes, these users require real-time information appropriate for decision-making. Unfortunately, the NWI has not been funded at a level that would have allowed it to keep pace with the demand for current data with additional functionality and higher levels of precision and accuracy as applied to mapping. The NWI's latest delivery system, the Wetlands Mapper, is an excellent tool for this, but the base data for much of the nation is still 1980s-era. The Wetlands Mapper can only be as good as the information it provides.

The Time Factor

Since the original imagery, an unknown portion of the wetlands mapped by the NWI have undergone succession and are no longer accurately described by the data acquired in the 1980s, while others have been drained or filled, and other areas restored through conservation efforts. Wetland maps need to be updated to keep pace with changes on the landscape. Repeated observations over time have the additional benefit of contributing to our overall understanding of wetlands and how they change from geomorphic, ecological, and human impacts. This, in turn, helps to improve the quality of wetland maps as well as the predictive accuracy of Geographic Information Systems (GIS) models and tools. These techniques also assist with mapping changes in wetlands (Status and Trends) and allow wetland managers and regulatory agencies to more accurately estimate rates of loss or gain of wetlands as well as identify areas where conservation and restoration resources are most needed.

Limitations of Technology

Aerial color infrared photography (CIR) is the current generation technology for landscape imagery that allows the identification of wetlands by an image interpreter. While CIR is an excellent tool for the job, it has some limitations which hamper its effectiveness for wetland detection. Infrared light is unable to penetrate tree canopies, which means that CIR imagery should be acquired "leaf-off" (usually in the early spring). Even then, wetland identification using CIR is extremely difficult in areas dominated by evergreen trees. Next-generation technologies and methodologies are emerging, which offer hope for more accurate and precise maps as well as greater context. The development of advanced GIS allows the integration of vast amounts of raw data into mapping documents in a dynamic fashion and at far less cost than integrating that same data during the age of pen-and-transparency overlay mapping.

Today wetland mapping is done with digital imagery and interpretation is done on-screen. Some maps may suffer from limitations due to seasonality (including some of the images being "leaf-on," which obscures wetlands) or being true color instead of CIR. This imagery also tends to lack stereo coverage which is not an insignificant issue. Also in some cases, the quality of the imagery is not the best for wetland mapping. The development of Light Detection and Ranging (LiDAR) with its astonishing precision in elevation, and satellites equipped with imaging Radio Detection and Ranging (Imaging RADAR) with its ability to see through tree canopies and detect subsurface water, both portend greater ability to detect and identify wetlands remotely. The best map products may likely result when many different sources and kinds of data are gathered together. Satellite technologies allow for mapping products to include the ever important 'fourth dimension' – time. Change mapping is a very powerful tool that becomes possible only through regularly repeated imagery updates.

There is a lot of work to be done before these new technologies can be routinely used for producing wetland maps, however. Resources will be needed to test, develop, and refine these tools. Fortunately for the nation's wetlands, some of that work has begun. Kansas is working under an EPA grant to develop an automatic detection method based on LiDAR data and a Topographic Wetness Index. Imaging RADAR technologies such as Synthetic Aperture RADAR (SAR) can be deployed on aircraft, however, currently the SAR does not meet the federal mapping standard for wetlands. Currently the high cost of acquiring multiple types of imagery – especially satellite imagery – has prevented widespread and operational use of these

tools. However, as technologies age and mature their costs generally come down as well (e.g. the Department of Defense's declassification of half-meter resolution satellite imagery opens the door for private firms to begin offering this imagery on a broader scale, and perhaps less expensively). These new types of imagery will also provide opportunities for the development of new derivative data tools, which are of use to more than one entity — creating opportunities for municipal, state and federal entities to pool resources. This will allow imagery to be used in a multitude of GIS products. Using multiple types of imagery taken from multiple points in time allows for predictive computer models, which may reduce the costs of wetland detection and mapping in the long-term.

All of the above will only happen if state and federal agencies, as well as other organizations, start moving forward with mapping projects, especially projects that test, develop, or make use of new technologies. Of the 35 states that responded to ASWM's inquiries, only 20 states have reported that they are engaged in new wetland mapping projects, most of which were limited to small areas, e.g. counties, at a time. An additional two states are moving older maps into a digital format and/or working to increase the Internet availability of the old maps. Rhode Island is the only state whose maps are (statewide) based on imagery less than ten years old, though a handful of states predict attaining this level of currency before the end of 2011. So far, only New Jersey, Kansas, Minnesota and Delaware have reported that they are using additional data or new technology (mostly LiDAR) in their mapping efforts. The remaining nine states that are working on wetland maps are doing so with leaf-off color infrared imagery obtained within the last decade, mostly within the 2004-2007 timeframe.

Individual state efforts and the small amount of federal funding available to support mapping can only move the technologies and maps so far. The financial muscle needed to bring the entire NWI up-to-date and add new technologies on a national scale will require more than piecemeal efforts. Since the 1980s, wetland programs have grown in capacity and scope. Computers, GIS and the ability to use data layers such as wetland maps to support local governments' zoning and planning has occurred only in the last 20 years. Wildlife management, water conservation, flood loss reduction, sea level rise mitigation and many other areas of public policy would benefit from wetland maps that are detailed and kept current.

There is a strong need for a comprehensive imaging and wetland mapping effort in the United States. Some fragmented movement in this direction has taken place, but funding for a wetland mapping technology research program in coordination with completing and updating wetland maps nationwide has yet to emerge. Maps using the best available technology could someday cost less, improving the long-term planning for wetlands and other aquatic resources.

WETLAND MAPPING COMMUNICATIONS – WHERE IS THE MAPPING INFORMATION?

The NWI was a huge step forward for wetland mapping. Its creation heralded a centralized organizing force to create standardized wetland maps and promote wetland mapping nationwide. Many states cooperated with the Service, which at one time had a cost-sharing program to encourage state participation in building a consistent national wetland database. The data presently available from the NWI, especially the GIS data available from the NWI Wetlands Mapper website, provide an easy-to-grasp snapshot of the status of wetland mapping in the U.S. at a particular point in time. Users can create GIS-style overlays on-the-fly and apply the data in

a variety of scales. Used as a data layer together with the data library of immediately usable GIS shapefiles on a state-by-state basis (which formed the foundation for ASWM's Mapping Snapshot documents) NWI is an invaluable tool.

Since passage of the Emergency Wetlands Resources Act of 1986, the National Wetlands Inventory program, together with partners, completed digital or hard-copy wetland maps for 71% of the lower 48 states. However, in recent years funding has been drastically reduced and NWI funding now is only able to support new or updated geospatial data for 1-2% of the country each year. At the same time, the greatly improved accessibility of GIS tools and remote imagery has made it possible for towns, states and private industry to undertake wetland mapping projects. The adoption of the Federal Geographic Data Committee's national Wetlands Mapping Standard in 2009 established a minimum set of requirements required by all new federally-funded wetland mapping projects. To implement the standard, the Service published a document describing the requirements for data collection and preparation for submission of mapping data for incorporation into the National Wetlands Inventory. In addition, it worked with the Association of State Wetland Managers and other parties to provide basic training materials on the new wetlands mapping standard.

The stage was set for collaborative, decentralized wetland mapping to provide the current and future basis for a national wetland data layer. However, over the past two years, it has become evident that there are significant hurdles to overcome.

1) **It is difficult to identify wetland mapping projects underway.** The decentralization of wetland mapping means there is no one in charge of identifying where any new projects are occurring. The NWI regional staff will know about projects they are directly funding or supporting with guidance, training or quality control, but they are only engaged in projects for 1-2% of the nation annually. Information about other mapping activities may only be anecdotal until those maps are formally submitted for inclusion in the NWI data layer. In the course of developing the 2010 snapshot of wetland mapping, ASWM didn't garner a complete picture of all States and the Territories, only receiving responses from 35 of 50 states. Similar efforts to gather information in the future are likely to lead to incomplete information. Based on ASWM's information collection, it appears the majority of projects underway cover a city, a region of a state or parcels of federal land. There are very few large state or regional mapping efforts underway.

2) **Concerns were raised over whether new maps will consistently meet the FGDC wetlands mapping standard.** In the course of collecting information about current mapping efforts, ASWM received some anecdotal information indicating that some maps currently nearing completion might not meet the new mapping standard. It is not clear whether this was a transitional issue associated with completing mapping initiated prior to the establishment of the national standard, part of the process of getting mappers up to speed and in compliance with the new standard or noncompliance that would be problematic long-term. The accuracy of wetland maps is evaluated before it is added to NWI by the U.S. Fish and Wildlife Service and this review process provides an opportunity to identify and address any problems that are identified.

Wetland mapping techniques and experimentation with various kinds of base imagery may also lead to some challenges. For example two new types of imagery can provide information about what is happening on the ground under a tree canopy. LiDAR shows more precise elevation and RADAR displays wet soils. However, they look radically different from an orthophoto quad image. Thus, wetland mappers are not only becoming acquainted with the new standard, they are also experimenting with new kinds of imagery, automated methods for identifying wetlands and other innovations that will require experimentation before the respective opportunities and limitations provided by these new tools are fully evaluated and integrated into reliable, repeatable standardized approaches with qualitatively-acceptable results.

3) **Wetland mapping is undertaken for a variety of reasons.** Different methods, standards and objectives are applied in the mapping of wetlands: some mapping projects focus on small areas of a state, some focus on individual watersheds, some focus on particular wildlife or plant species, others are part of Department of Transportation construction projects, and so on. Each project may have a different objective, and so each mapping product represents a different set of project needs. In part because of these different project sizes, any given project can be useful to one wetland professional, or any data user, and largely unhelpful to another.

4) **Time and resources.** The cost of producing wetland data has increased over time due to increased costs of imagery, mapping improvements from more refined image scale and smaller target mapping units, more highly trained interpreters or analysts, and expenses incurred with using improvements in technology. Wetland mapping is therefore both resource and labor-intensive. A North Carolina study estimated it would cost $2.5 million to update existing maps for the state. Rhode Island estimated it would cost just under $1 million. The Service has estimated it would cost $60 million to update and complete the wetland maps for the lower 48 states. It is also important to recognize that a number of states also rely on federal funding (e.g., EPA grants) to support wetland mapping projects and these funds may be harder to secure given the outlook on future federal budgets.

Wetland mapping professionals, members of academia, wetland managers and others will need to work together toward addressing these and other issues yet to be identified. Also the fact remains that identification of wetlands via remote sensing is still limited by the nature of wetlands. The wetter ones will continue to be readily identified, while the drier-end wetlands (e.g., temporarily flooded or seasonally saturated types) will still present significant challenges for remote sensing given the natural variation in hydrologic, weather and climatic conditions.

RECOMMENDATIONS

Many of the challenges identified above are the result of the limited resources dedicated to the mapping of wetlands. In the current economic climate it seems unlikely that there will be an increase in resources in the short-term. Nevertheless there are actions that the NWI, professional wetlands community, and other partners , e.g. the Wetlands Mapping Consortium can undertake to improve current efforts and be prepared to implement and expanded effort with greater wetland mapping accuracy and efficiency if future opportunities arise.

1. Implement the New Wetlands Mapping Standard. Information and training needs to be available to assist wetland mappers in coming into compliance with the new wetlands mapping standard. The online wetland training hosted by the U.S. Fish and Wildlife Service is a good

start. ASWM recommends that NWI should expand the training to include webinars and on-site training sessions held on a regular basis around the country. Upon adoption of the wetland mapping standard, the FGDC Wetland Subcommittee developed an action plan to support widespread adoption of the mapping standard by establishing a communications framework. The recommendations in action plan should be implemented. http://www.fws.gov/wetlands/_documents/gNSDI/DRAFTImplementationPlanFGDCWetlandsMappingStandard.pdf

2. Create a Clearing House of Mapping Information Technology and Tools. The Wetland Mapping Consortium (WMC) is a collaborative effort hosted by the Association of State Wetland Managers and Virginia Tech to enhance communication, improve awareness of new remote sensing tools and techniques, prevent duplication of funded research efforts, allow for leveraging or resources and expertise, and support interdisciplinary research funding and projects that can't easily be carried out by a single institution or agencies. WMC can provide a forum for advancing wetland mapping projects, tools and techniques.

3. New Mapping Imagery Should Be Explored. The LiDAR studies in Kansas and other states hold promise for the future of wetlands mapping. Wetland professionals should share information about how to use these new kinds of imagery successfully. For example, ASWM or the WMC could host a webinar inviting professionals to share this information.

4. Showcase stories of successful applications of wetland maps to solve natural resource and natural hazards problems. ASWM and WMC should share and highlight information about the various ways managers use wetland maps to solve problems with other wetland managers and decisionmakers by distributing this information in an online forum.

5. Share information about new and developing technologies, particularly how to use them successfully. For example automation of wetland mapping has the potential to significantly reduce costs, but it must be undertaken in a way that does not reduce accuracy. Again, ASWM and WMC should share and highlight information about the various ways managers use wetland maps to solve problems with other wetland managers and decisionmakers by distributing this information in an online forum.

6. Provide access analysis of additional GIS datasets. There are datasets such as the national hydric soils database that could be made available to wetland mappers if the larger soils database were queried correctly. Efforts should be made to identify how additional GIS data layers can be used to more accurately identify wetland mapping efforts. For example, the NWI Program in the Northeast Region has begun to combine hydric soil data with NWI data to create a composite database showing photointerpretable wetlands (NWI types) and possible wetlands based on hydric soil designations. The Northeast Region in working with other agencies and organizations has created what is called an "NWIPlus" database in which hydrogeomorphic-type attributes for landscape position, landform, water flow path, and waterbody type (LLWW descriptors) are added to the existing NWI database. These results are typically published in a technical report with the geospatial data available to cooperators and others upon request (see reports posted under "Watershed-based Wetland Studies" at http://www.fws.gov/northeast/wetlands/publications.html). Ideally the geospatial data should be posted on the Wetland Mapper and therefore available to everyone.

7. Increase Riparian Habitat Classification and Mapping**.** In the arid West, where evaporation exceeds precipitation, riparian habitats are as critical for wildlife as wetlands are in the more humid eastern portions of the nation. As much as 80 percent of wildlife species in arid areas depend on riparian habitats. Such habitats are important migration corridors. The condition of riparian habitats is also important for maintaining healthy aquatic systems. Given these well-recognized values, the NWI felt it would be beneficial to include these habitats in its inventory in Service Regions 1, 2, 6, and 8. To standardize this mapping, the NWI developed a riparian classification system and mapping conventions (U.S. Fish and Wildlife Service 1997). This classification has been used in combination with the Service's wetland classification system to produce NWI maps showing both riparian areas and wetlands in the arid regions of the country.

8. Enhanced NWI Data for Landscape-level Wetland Characterizations and Functional Assessments. In the 1970s and 1980s, the basic need for wetland data was inventory-based, that is, knowing where wetlands were on the landscape and how they differed in terms of vegetation type and hydrology. With strengthened wetland regulations since the late 1980s and early 1990s, another need has surfaced —wetland functional assessment. As techniques were being developed for on-the-ground assessment of wetland functions, the NWI sought ways to enhance its inventory so that landscape-level assessments of wetland functions could be derived from its database. To accomplish this, hydrogeomorphic-type descriptors were created to describe landscape position, landform, water flow path, and waterbody type. The NWI has used these techniques to produce watershed-based wetland characterizations and preliminary functional assessments for a number of watersheds in the Northeast and is applying these procedures in pilot study areas across the Nation (e.g., Anchorage Alaska, California's Ventura River watershed, Corpus Christi area of Texas, South Carolina's Horry and Jasper Counties, the Mississippi coast, and Wyoming's Shirley Basin). The results of the pilot studies will be published in 2011. A few states are applying these attributes to their wetland data. Going forward these hydrogeomorphic-type descriptors should be used to help identify potential functions of wetlands.

There is no substitute for accurate and current maps. Mapping something as dynamic as wetlands requires vigilance and constant innovation and frequent updating to maintain data accuracy and relevance. A lot of progress has been made since the inception of the NWI in 1975 and the NWI community is ready to take the next step forward. Call it NWI 2.0.

Additional Resources

National Wetlands Inventory Mapper
http://www.fws.gov/wetlands/Data/Mapper.html

Wetlands Layer - National Spatial Data Infrastructure: A Phased Approach to Completion and Modernization
http://www.fws.gov/wetlands/_documents/gNSDI/WetlandsLayerNSDIPhasedApproachtoCompletionModernization.pdf

Wetland Mapping Standard: FGDC Document Number FGDC-STD-015-2009
http://www.fgdc.gov/standards/projects/FGDC-standards-projects/wetlands-mapping/2009-08%20FGDC%20Wetlands%20Mapping%20Standard_final.pdf

Wetland mapping and Inventory: http://water.usgs.gov/nwsum/WSP2425/mapping.html

Wetland Mapping Consortium website: http://clic.cses.vt.edu/WMC/

Implementation Plan for the FGDC Wetlands Mapping Standard Version 1.0
http://www.fws.gov/wetlands/_documents/gNSDI/DRAFTImplementationPlanFGDCWetlandsMappingStandard.pdf

Data Collection Requirements and Procedures for Mapping Wetlands, Deepwater and Related Habitats of the United States
http://www.fws.gov/wetlands/_documents/gNSDI/DataCollectionRequirementsProcedures.pdf

Main webpage for National Wetlands Inventory: http://www.fws.gov/wetlands/

Wetland Mapping Training (online):
http://www.fws.gov/habitatconservation/nwi/wetlands_mapping_training/

Mapping Wetlands for North Carolina: New Maps and New Approaches
http://149.168.87.13/NCGISConference2011/presentations/Newcomb_Fri_130.pdf

Options for Mapping Rhode Island's Wetlands:
http://www.dem.ri.gov/programs/benviron/water/wetlands/pdfs/mapriwet.pdf

National Wetlands Inventory Document Search Engine
http://www.fws.gov/wetlands/_documents/search.asp?TOPIC=-1&DOC_CATEGORY=-1&STATUS=0