Improved Wetland Mapping

Through the Use of Advanced Geospatial Technologies

Recently developed remote sensing technologies and techniques have the potential to improve the detail and reliability of wetland maps, update existing National Wetlands Inventory wetlands data, monitor changes in the wetland layer of the National Spatial Data Infrastructure, and improve the ability to monitor key parameters that impact the ability of wetlands to provide ecosystem services at a watershed scale.

By Megan Lang, Jane Awl, Bill Wilen, Greg McCarty, and John Galbraith

For the United States to effectively manage its remaining wetlands, their abundance, distribution, boundaries, and inherent characteristics must be better understood. As natural resource management becomes more holistic and moves toward ecosystem management, the synoptic view that remotely sensed data provide will become increasingly important. Remote observation of wetlands is particularly necessary because they are often difficult to access on the ground, and on-site mapping at the landscape scale is usually cost prohibitive. Remotely sensed images aid our understanding of wetlands within a wider landscape setting and help to ensure wetland preservation via an increased appreciation of the services that wetlands provide and more informed management practices.

Significant effort has been made by scientists and managers to provide quality wetland map products, and recently developed remote sensing technologies have the potential to further improve their detail and reliability. The diversity of remotely sensed data and the techniques available to process these data have increased rapidly since the 1970s, when the United States first began to systematically map national wetland resources. Still, the dynamic nature of these ecosystems (e.g., often intermittent hydrology), their diversity (e.g., variations in plant structure and phenology), and the often small proportion of the landscape that they occupy, challenge traditionally utilized datasets, such as aerial photography. Using available National Wetlands Inventory data as collateral information, some wetland mapping programs are now using satellite-based moderate resolution multispectral images to map wetlands across the United States. Although the digital format and broader coverage of these images has increased the rate at which wetland maps can be produced, the coarser spatial resolution (about 30 meters) and inherent limits of sensors that rely on solar energy and detect limited portions of the electromagnetic spectrum remain. However, it has been demonstrated that moderate resolution satellite data can be used to identify where existing wetland maps need to be updated. Newer multispectral satellite sensors, such as IKONOS and Quickbird, provide finer spatial resolution multispectral data, 4 and 2.4 meters respectively. However, the collection of fine-resolution multispectral data over large areas can be challenging with currently available satellite sensors. Although the remotely sensed data and technology used to map wetlands have improved since the 1970s, national wetland mapping programs in the United States are still primarily using aerial photography to create original wetland maps.

Recent advances in the quality and availability of remotely sensed data, which have not traditionally been used to map wetlands, as well as the introduction of new processing and modeling methods, hold great

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potential for the further advancement of regional and national wetland mapping and monitoring efforts. Although it is unlikely that this novel geospatial data will completely replace the use of aerial photography or other fine-resolution optical data, such data provide complementary information about wetland presence and function, which can be used to improve wetland mapping, as well as estimates of wetland condition and the provision of ecosystem services. These novel datasets, and the techniques necessary to capitalize upon them, are developing rapidly and quickly becoming available over much of the United States. While this has led to an increased awareness of these new tools within the wetland mapping community, only through improved understanding of all available datasets, pilot studies, and operational implementation of hybrid approaches, will the full benefit of these new technologies be actualized.

New Technologies for Improved Wetland Mapping

While aerial photography has a proven operational wetland mapping track record, one type of imagery cannot be expected to map all wetland types accurately, nor can one type of data detect all environmental parameters that are indicative of wetland condition or function. Different types of data are sensitive to different components of the landscape. These components (e.g., soil moisture, presence or absence of standing water, biomass, vegetation height, cellular structure, and more) can then be synthesized to produce a superior wetland map and gain a better understanding of the services that wetlands provide. This data fusion is aimed at reducing classification error by incorporating more spectral and possibly temporal information. The following paragraphs will briefly outline the strengths that two rapidly developing types of remotely sensed data, RADAR and LiDAR, can offer the wetland mapping and monitoring process. In addition, the benefits of hyperspectral data are also mentioned—although the expense and poor availability of these data over large areas makes the operational use of hyperspectral data less likely in the near future.

Radio Detection and Ranging (RADAR)

Although wetlands have traditionally been mapped and monitored using optical data like aerial photographs, the need to monitor wetlands during wet periods, when they are most evident on the landscape, and the necessity of accurately mapping and monitoring forested wetlands, the most abundant type of wetland within the United States, calls for a new approach. Synthetic Aperture RADAR (SAR) data can provide information that is fundamentally different from sensors that operate in the visible and infrared portions of the electromagnetic spectrum (i.e., optical sensors). This is primarily due to the much longer wavelengths used by SAR sensors and the fact that they transmit and receive their own energy (i.e., active sensors). SAR sensors can collect data regardless of solar illumination, cloud cover, and most rain events. This ability to successfully collect data under almost any condition, along with the ability of SAR sensors to collect data at multiple view angles and the availability of multiple well-calibrated, satellite-borne sensors, can substantially increase the effective temporal resolution of SAR data. The longer wavelength energies used by SAR sensors are sensitive to variations in soil moisture and inundation, and are only partially attenuated by vegetation canopies.

The sensitivity of microwave energy to water and its ability to penetrate vegetative canopies make SAR sensors ideal for the detection of hydrologic features below vegetation (Kasischke et al. 1997; Townsend and Walsh 1998; Kasischke et al. 2003; Lang and Kasischke 2008). Information regarding wetland hydroperiod (i.e., temporal fluctuations in inundation and soil moisture) is essential for not only mapping wetlands but inferring the provision of key ecosystem services, such as nutrient regulation. The ability to monitor wetland hydroperiod is vital due to its strong influence on biota (e.g., provision of habitat to rare or endangered species), biogeochemical processes (e.g., denitrification), and other ecosystem functions. These hydroperiod maps cannot only be used to infer wetland function (e.g., denitrification), they can also be used to update wetland boundaries as they shift in response to climate and land use or land cover change, and to identify lands that are transitional between wetlands and uplands. These transitional lands, which are not flooded or saturated long enough to be considered wetlands, may still serve important ecosystem services.

SAR data can be used to further elucidate wetland extent and function through their ability to quantify plant structure, biomass, and topography, as well as water levels, when the images are collected as interferometric pairs. However, optical data provide superior information concerning the identity of vegetation communities derived mainly from the molecular and cellular structure of the plants. Since RADAR and optical data are sensitive to very different landscape characteristics, the combination of RADAR and optical data can significantly improve wetland mapping and provide a superior land cover map (Rignot 1997; Ramsey et al. 1998).

As the advantages of using SAR data to map ecosystems and monitor fundamental ecosystem processes are elucidated, natural resource managers are becoming increasingly reliant on this data source. The increasing availability of finer spatial resolution (e.g., 3 m) multiple wavelength and polarization SAR data (e.g., Advanced Land Observation System [ALOS] Phased-Array type L-band Synthetic-Aperture RADAR [PALSAR] and Radarsat-2) and the planned launch of additional SAR satellites by the United States (e.g., the Deformation, Ecosystem Structure and Dynamics of Ice [DESDynI], the Soil Moisture Active-Passive [SMAP], and the Surface Water and Ocean Topography [SWOT]) and other countries (RADAR Imaging Satellite [RISAT] and the Multi-Application Purpose SAR [MAPSAR]) will increase the utility of SAR for wetland mapping and monitoring applications. The increasing availability of polarimetric data and image pairs suitable for interferometric analysis is encouraging the development of new applications by providing information on water levels. The availability of RADAR data and techniques to process RADAR data have improved to the point that the Canadian government is now using SAR data as part of their national wetland mapping program (Milton et al. 2003; Li and Chen 2005).

Light Detection and Ranging (LiDAR)

Similar to RADARs, LiDARs are also active sensors, but they use energy with much shorter wavelengths (visible and near-infrared) than RADAR sensors (microwave). LiDAR data are commonly used to create topographic maps called digital elevation models (DEMs). Although topographic information is generally available (e.g., photogrametrically derived data and U.S. Geological Survey topographic maps) for the United States, the spatial resolution of these data is often not sufficient for wetland identification, especially in areas of subtle topographic change. LiDAR-derived DEMs have been used to enhance wetland mapping based on optical (Lichvar et al. 2006; Vierling et al. 2008) data, RADAR data, or both (Li and Chen 2005; Töyrä and Pietroniro 2005). In this way, landscape position (e.g., slope, depression, or peak) can be made part of the wetland mapping process similar to the information provided by stereoscopic viewing of aerial photographs, but with greater vertical resolution. Additionally, LiDAR-derived DEMs are digital, and the information that they provide can be rapidly incorporated into the wetland mapping process in an automated fashion. A promising method for the semi-automated incorporation of topographic data into the mapping process is the use of topographic wetness indices. These wetness indices determine the potential for wetland conditions based on slope and contributing area (Tenenbaum et al. 2006; Murphy et al. 2007). This additional fine-resolution topographic information can aid in the detection of wetlands that are normally difficult to identify, such as vernal pools. The identification of vernal pools is important since these small areas often have a disproportionate impact on biodiversity, especially when compared to the small area they occupy on the landscape. In addition, their ability to provide habitat is particularly vulnerable to climate change, with small changes in hydroperiod potentially impacting the local survival of amphibian species. LiDAR-derived topographic information can also be used to map hydrologic flow pathways, which regulate the ability of wetlands to provide ecosystem services (e.g., water quality). The ability to identify these hydrologic connections could be key to the preservation of many forested wetlands. Recent federal court case rulings incorporating the "significant nexus" concept in the jurisdiction of the Clean Water Act have presented additional information requirements for establishing wetland regulatory status. New tools that can establish connectivity between wetlands and stream networks would better inform debates and enhance the ability to preserve wetlands under current laws (Kusler et al. 2007).

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However, LiDAR data provide information not only on elevation, but also on vegetation characteristics and the identity of materials via the intensity of the LiDAR return. Although optical data can be used to detect and characterize vegetation, LiDAR data can be used to enhance this characterization through increased information on vegetation height, biomass, and structure (Vierling et al. 2008). The intensity of the bare Earth LiDAR return is helpful for estimating wetland hydrology below the surface of vegetative canopies by detecting areas of inundation, provided those canopies have gaps during LiDAR data acquisition. This is primarily due to the fact that water is a strong absorber of near-infrared energy, which is the type of energy most commonly used by LiDAR sensors.

LiDAR technology is quickly advancing, while the availability and quality of available airborne LiDAR data is also rapidly increasing throughout the United States. The potential of these data to improve regional or national wetland mapping and monitoring projects is already strong and will only increase as data become available for the entire United States and the methods to fully exploit and incorporate these data into the mapping and monitoring process evolve. However, it should be noted that LiDAR data should be collected to different specifications, based on their application, and data collected for one application may not be suitable for another. Although the potential of LiDAR data to improve wetland mapping is strong, these data are best used in combination with other types of remotely sensed data in order to enhance the accuracy and utility of wetland maps.

Hyperspectral Data

Hyperspectral data are another potential wetland mapping tool, which can be used to identify wetland patches that are spectrally indiscernible using multispectral data, and are often better at identifying individual plant species than multispectral data, making detection of invasive plants easier. In contrast to RADAR and LiDAR data, hyperspectral data are passively collected optical data, which are similar to multispectral data, but characterized by numerous, narrow spectral bands. These numerous, finely segregated spectral bands allow analysts to identify different materials based on their "spectral signature" or diagnostic patterns of absorption and reflection. Although the use of spectral signatures can be very helpful in imagery analysis, these signatures can vary temporally with phenology and environmental conditions (Judd et al. 2007; Silva et al. 2008) making generalizations difficult, and therefore mapping through time and space challenging (Schmidt and Skidmore 2003). Hyperspectral data have commonly been used to detect vegetation species, and they have the potential to detect biochemical properties such as nutrient and chlorophyll content (Schmidt and Skidmore 2003; Judd et al. 2007).

Although the use of hyperspectral data is more challenging than more traditional optical data (i.e., aerial photographs and multispectral images) due to its large data volume and less developed/more complex image-processing techniques (Phinn et al. 1999; Klemas 2001; Hirano et al. 2003; Laba et al. 2005), the primary obstacle to incorporating hyperspectral data into regional or national wetland mapping operations is the relatively poor availability of hyperspectral data in general and high cost of data acquisition. Until these barriers are overcome, hyperspectral data use in operational wetland mapping programs is unlikely. Nevertheless, hyperspectral data has strong potential to supplement other types of remotely sensed data in regional wetlands mapping, especially if more specific information on plant species presence or other factors is necessary.

Moving Toward a More Robust Wetland Mapping Toolkit

Newly available remote sensing technologies have great potential to solve many of our most intractable wetland mapping challenges. SAR data can be used to reveal subtle patterns in hydrology, which indicate the presence of wetlands that are normally difficult to identify (e.g., forested wetlands) and the functioning of all wetlands. LiDAR data can be used to locate low-lying areas, which often harbor wetlands and to map hydrologic flow pathways that regulate the ability of wetlands to provide valuable ecosystem services (e.g., water quality). Hyperspectral data can be used to identify wetland patches that are spectrally indiscernible using multispectral data and are often better at identifying individual plant species (e.g., invasive plants) than multispectral data. The future holds prom-

Remotely Sensed Data

Four different types of remotely sensed data or data products displayed for a U.S. Department of Agriculture study site located in Caroline County, Maryland. All images illustrate the same forested wetland complex but provide complementary information that can be used to map or characterize wetlands.

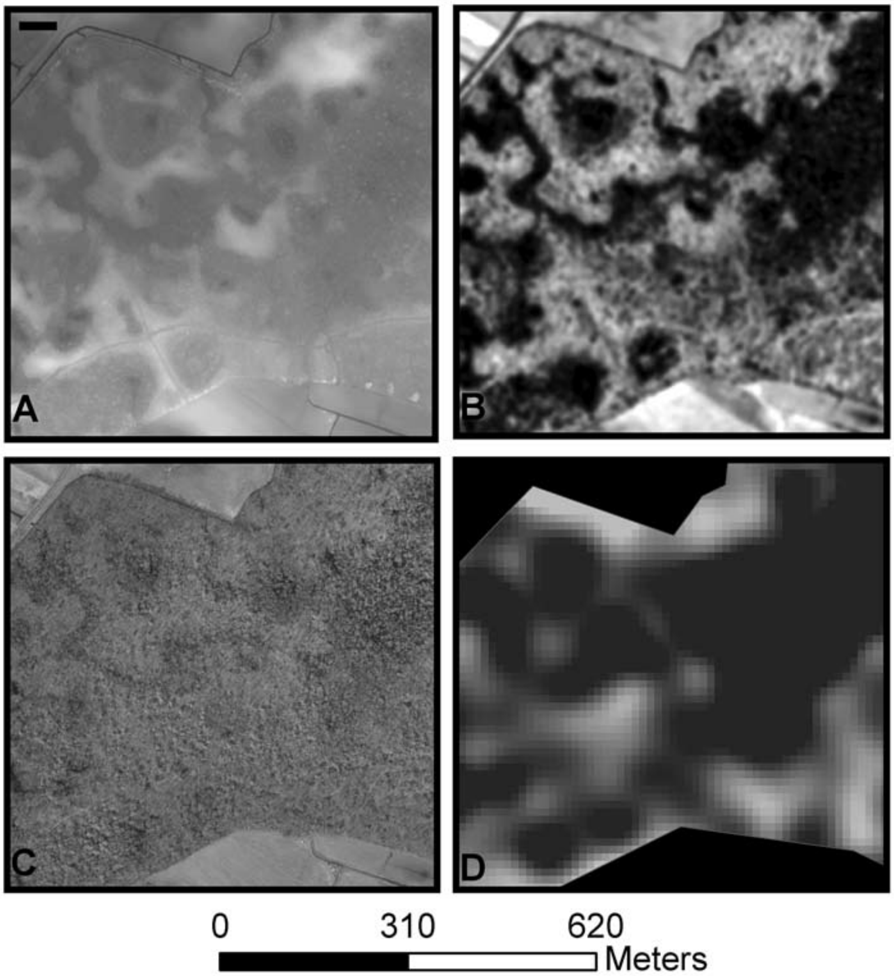

Image A is a one-meter horizontal spatial resolution, 16-centimeter vertical resolution digital elevation model where wetlands are generally exhibited as areas of lower elevation (darker).

Image B illustrates LiDAR intensity derived from ground returns that were collected during a period of average yearly peak wetland inundation (darker areas are inundated).

Image C is a one-meter spatial resolution false color near-infrared aerial photograph that was collected at the same time as image B. Note that the darker forested areas correspond with the inundated areas seen on image B but that these areas are much easier to visualize on image B.

Image D is a 30-meter spatial resolution RADAR-derived map of forested wetland hydroperiod where the darker areas are wetter for longer periods of time. This type of product can also be produced using newly available three-meter spatial resolution RADAR data and depicts not only variations in inundation but also differences in soil moisture. Note that there is strong general agreement between all data sources.

ise for an expanded wetland mapping toolbox with greater availability of currently used remotely sensed data, new remotely sensed data, more robust hardware, and new processing capabilities. The spatial and spectral resolutions of the available sensors are expected to increase rapidly along with the accessibility of the data. It is also important to note that wetlands are inherently dynamic systems, and multitemporal data are often needed to detect these changes. Technology assessments in 1996 concluded that the full potential of then-current remote sensing imagery had not been satisfactorily explored (Sahagian and Melack 1996; Wilen and Smith 1996). But now, recently available imagery provide an even greater opportunity for advances in wetland mapping. For a detailed review of different remote sensing technologies and their contribution to wetland mapping, please see Lang and McCarty 2008.

Selection of the appropriate type or types of imagery is vital to enhanced wetland mapping, but the addition of ancillary data and the use of geographic information systems (GIS) and hydrologic models can also greatly benefit the mapping process. The National Research Council (1995) found that GIS holds great possibilities for the study of wetlands and that models make wetland delineation more successful and expeditious. The rapidly updateable maps that digital data (especially satellite images) provide support adaptive management of wetland ecosystem services, and these digital data are easily incorporated into GIS and modeling frameworks. The value of a wetland map can be increased dramatically when it is used in a GIS or modeling framework. GIS can be used to combine and analyze wetland maps and ancillary data that provide complimentary information about wetland boundaries and characteristics in order to best leverage these synergistic sources of information and meet the needs of natural resource managers. At the same time, models can use biogeochemical and physical relationships and interactions to gain a more complete understanding of wetland extent, but more importantly, of the services that wetlands provide. ■

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A New Mapping Standard

By Jane Awl, Jeanne Christie, Margarete Heber, Megan Lang, and Bill Wilen
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On July 7, 2009, a new national standard for mapping wetlands was approved by the Federal Geographic Data Committee (FGDC), the interagency organization that promotes national-level coordination and data-sharing for federal mapping activities. The wetlands mapping standard supplements an existing national classification standard for wetlands. Compliance with these national standards is required for all federal agencies and any other entities that use federal funds to map wetlands. Finalization of the national wetlands mapping standard follows three years of interagency coordination and response to public comments.

Global climate change, sea-level rise, storm-severity changes, drought, water rights, energy development, population shifts, and infrastructure expansion are all factors driving efforts to modernize wetland mapping and increase sharing of this data between government agencies, nongovernmental organizations, industry, and the public. For over three decades, the U.S. Fish and Wildlife Service (FWS) has been acquiring, updating, and providing wetlands inventory mapping data. Their Wetlands Master Geodatabase (also known as the National Wetlands Inventory (NWI)) contains the most comprehensive digital map coverage of U.S. wetlands available. Currently, about 65 percent of the United States has been mapped for wetlands in modern digital format and is available online.

However, to date, federal funding has only allowed for an average of less than two percent of the national wetlands map to be completed each year. At this rate, it would take over 50 years to complete this mapping of U.S. wetlands. Even at a 20-year refresh interval as currently planned by FWS, the Wetlands Master Geodatabase would be unlikely to meet the demand for the high-quality, up-to-date digital wetland mapping data that will be needed to support current federal, state, and tribal environmental initiatives. Obviously, more agencies and organizations will need to join in the effort of acquiring and providing mapping data for wetlands in order to complete the national picture. Thus, a standard is needed to allow diverse groups to produce wetlands mapping data that would be compatible and consistent in quality.

The intent of the national wetlands mapping standard is to provide a set of minimum quality guidelines that anyone can follow to produce wetland mapping data suitable for inclusion in the wetlands master geodatabase, the National Spatial Data Infrastructure (NSDI), or the National Map. The standard presents technical specifications for both source and base imagery, feature classification, accuracy, data verification, projection (for data submission), metadata, quality control, and coordination with the FWS.

The standard is not designed to limit mapping detail or scale, only to set base or minimum requirements, which mapping entities may exceed if funding is available or if greater detail is needed. Nothing in the standard prevents the use of additional source data or methods to improve wetland mapping (such as soil data, Digital Elevation Models, LiDAR, radar, etc.). In fact, it is anticipated that these ancillary or collateral data sources will become even more important as technology progresses.

Having such a standard in place drives the production of consistent and compatible geographic data that can be easily shared and meets the needs of many end-users. In this way, the wetland mapping efforts of all federal agencies can be "recycled," providing greater value to the public for the investment of time and money. While the standard is required for use by federal agencies, it is also designed to encourage and facilitate wetland inventory mapping by states, tribes, counties, local governments, nongovernmental organizations, and the private sector. With a standard in place, there will be more opportunities to collaborate and more possible sources of funding.

The new standard draws upon conventional biological and remote sensing criteria for mapping the occurrence of wetland habitats. It builds upon the definitions and criteria in the existing national wetlands classification standard. For the purposes of the NSDI, wetlands are mapped as a habitat type or land-cover classification, regardless of their potentially changing legal status.

Most importantly, the national wetlands mapping standard does NOT rely on or apply to the mapping of wetland jurisdictional or legal boundaries under any federal, state, tribal, or other regulatory program. For example, the site-specific mapping of an individual wetland, such as the wetland jurisdictional boundary for Clean Water Act §404 permitting, is exempt from meeting the requirements of the standard.

The standard is also not applicable to map data produced prior to the standard's FGDC endorsement. Existing wetlands mapping data, and data already in production prior to July 7, 2009, need not be brought up to the standard. Additionally, the standard allows that if there is no compliant wetlands mapping data available, FWS will always be allowed to provide public access to the best available wetlands mapping data at their discretion.

An implementation plan for the new standard is being developed. The Implementation Working Group is focusing on two core areas, administrative assistance and technical support, in order to address needs such as:

Resources

The Federal Geographic Data Committee's Endorsed Wetlands Mapping Standard can be found online at www.fgdc.gov/standards/projects/FGDC-standards-projects/wetlands-mapping/index_html.

The project history, response to public comments, and link to the Wetlands Subcommittee are also on the FDGC website.

Read more about the Wetland Mapping Consortium on the Association of State Wetland Manager's website, www.aswm.org/swp/mapping/index.htm.

Check out the National Spatial Data Infrastructure at www.fgdc.gov/nsdi/nsdi.html.

The U.S. Fish and Wildlife Service's National Wetlands Inventory is located at www.fws.gov/wetlands/.

Learn how to contribute data to the Wetlands Master Geodatabase, at www.fws.gov/wetlands/WetlandsLayer/ContributedData.html.

The National Map produced by the U.S. Geological Survey can be found at www.nationalmap.gov/.

Visit the U.S. Department of Agriculture's Agricultural Research Service website at www.ars.usda.gov.

Classification of Wetlands and Deepwater Habitats of the United States can be found at www.fgdc.gov/standards/projects/FGDC-standards-projects/wetlands/index_html, as well as at www.fws.gov/.

Geospatial one-stop, the U.S. Government's geospatial portal for information about GIS resources is located at http://gos2.geodata.gov/wps/portal/gos.

Lastly, check out www.data.gov, designed to help the public access high-value datasets produced by the executive branch.

- accelerating the availability of data to update the Wetlands Master Geodatabase
- providing outreach/training related to standard requirements
- building funding coalitions and identifying grant opportunities
- providing examples of contractual language
- developing a communication forum to provide discussion and support for ongoing technical challenges, and facilitate access to technical expertise within the wetland science and geospatial communities
- addressing other technical and strategic issues from public comments

In support of implementing the national wetlands mapping standard, and promoting its adoption among states, local governments, and wetland professionals, the Association of State Wetlands Managers has formed the Wetland Mapping Consortium to provide long-term support for wetlands mapping and the integration of new technologies. This new group hopes to provide a valuable discussion forum for the emerging wetlands mapping community. Plans for developing online training materials with FWS and U.S. Environmental Protection Agency are underway.

The standard was developed by a diverse working group of the FGDC Wetlands Subcommittee. The working group was comprised of members of federal agencies, states, tribes, environmental organizations, management associations, and local government associations with an interest in improving quality and consistency in wetlands mapping efforts. The draft standard was used on a trial basis by FWS to support acceptance of data into the Wetlands Master Geodatabase for over a year prior to its final FGDC endorsement. ■

Mapping Coalitions

By Jeanne Christie and Leah Stetson
Association of State Wetland Managers

Federal funding for large-scale wetland mapping, particularly the U.S. Fish and Wildlife Service (FWS) funds that supported the creation of the National Wetlands Inventory, are mostly a thing of the past. FWS is still very active in the business of making wetland maps; but nowadays their role has been reduced from all-inclusive services to a more limited portfolio of coordination and quality control. Currently, FWS can support new or updated maps on only two percent of the lower 48 states each year, and they generally use this funding to match state and local initiatives.

The good news is that geographic information system (GIS) tools have made it so anyone with high-quality imagery, a good computer and the right training can map wetlands. Alternatively organizations can acquire the imagery and subcontract the wetland mapping to an expert third party.

These changes have led to the creation of successful wetland mapping coalitions, which may be regional, state-based, or local.

There are two kinds of coalitions to think about: one to acquire the imagery, and the second to develop the wetland maps. Some potential partners may have no interest in mapping wetlands; but they do want good imagery, including high-resolution color infrared photography for other purposes. For example, local communities need the infrared photography to map impervious surfaces. Other groups may want to partner to create wetland maps. A conservation organization may have an interest in identifying wetland wildlife habitat. A public utility may want to know where wetlands are to include in plans for future transmission or sewer lines.

A good place to start searching for coalition members is the statewide GIS coordinator. Every state has one and they will know a lot about mapping efforts within the state. In addition, the U.S. Geological Survey (USGS) has National Spatial Data Infrastructure (NSDI) specialists, who are knowledgeable about mapping in the federal agencies. A list of state GIS coordinators can be found on the National State Geographic Information Committee website at www.nsgic.org/. The liaisons are listed by state on the National Geospatial Program, Geospatial Liaison Network www.usgs.gov/ngpo/ngp_liaisons.html. In addition, the Farm Services Agency does aerial photography on a regular basis. Usually this is after the growing season is well established—too late for the leaf-off imagery generally required for identifying wetlands—but they may be involved in other mapping efforts and have resources to share.

Do not stop there. It is amazing how many individual agencies, units of government, nonprofits, and private organizations are trying to develop maps, and it is important to seek out all potential parties. Restoring rivers, managing for natural hazards, building roads and highways, managing wildlife populations, and developing land ownership maps are only a few of the many reasons why groups need either good imagery or new wetland maps.

States have access to various funding sources, local government may be able to tap others, and both private companies and nonprofit organizations can request funding from places unavailable to government. In the past, sources of funding for purchasing imagery and making maps has included the Department of Homeland Security, the State Department of Public Health, conservation organizations such as Ducks Unlimited, the Forest Service, USGS, local governments, and metropolitan mosquito control districts.

Make sure the coalition seeks out information about the best technology for the project. RADAR is a promising new form of remote sensing for mapping forested wetlands. However, aerial imagery works very well in nonforested areas, such as the prairie potholes. Explore whether combining wetland mapping with other waters, such as rivers and streams, will bring more partners to the table. Planning the project carefully, reaching out broadly, and thinking creatively can lead to a successful mapping project and perhaps even greater benefits. ■

National Parks Conservation Ass'n v. Salazar, No. 09-00115 (D.D.C. Aug. 12, 2009) (Kennedy, J.). A district court denied the federal government's motion to remand and vacate an OSM rule promulgated in December 2008 that regulates excess mining spoil, disposal of mine waste, stream buffer zones, and stream-channel diversions in connection with mountaintop and surface mining operations. An environmental group filed suit in January 2009 alleging that OSM violated several statutes in issuing the rule. In April 2009, the Secretary of the Interior sought to have the rule remanded and vacated after he determined that the OSM, under a previous Administration, erred in failing to initiate consultation with the FWS under the ESA to evaluate possible effects the rule might have on threatened and endangered species. But the court found no precedent to support the proposition that it should remand and vacate the rule under the circumstances presented here. The government seeks a remand and vacatur of the rule without a determination on the merits that it is legally deficient. Moreover, the APA requires government agencies to follow certain procedures, including providing for public notice and comment, before enacting or amending a rule. An agency must follow the same procedure in order to repeal a rule. While notice and comment procedure is not required where a court vacates a rule after making a finding on the merits, granting vacatur here would allow the government to do what they cannot do under the APA, repeal a rule without public notice and comment, without judicial consideration of the merits. See https://ecf.dcd.uscourts.gov/cgi-bin/show_public_doc?2009cv0115-18.

United States v. Bailey, No. 08-1908 (8th Cir. July 9, 2009). The Eighth Circuit upheld a lower court decision ordering a landowner who built a road on a parcel of wetlands without a permit to comply with a U.S. Army Corps of Engineers' restoration order requiring him to restore the wetlands to their pre-violation condition. The lower court properly concluded that the Corps has jurisdiction over the wetlands at issue. The Eighth Circuit held that the Corps has jurisdiction under CWA §309(b) if either the plurality's test or Justice Kennedy's substantial nexus test in *Rapanos v. United States*, 126 S. Ct. 2208 (2006), is met. Here, the Corps satisfied the substantial nexus test since the landowner's property was situated in a wetland adjacent to navigable-in-fact waters. In addition, the Corps' restoration order did not violate his equal protection rights. The landowner argued that because the Corps issued a permit to the county for a nearby road, it should have issued him a permit as well and then allowed him to mitigate the damage, rather than denying his permit application and ordering him to restore the site. But the circumstances surrounding the two roads are quite different and, thus, the Corps had a rational basis for treating the landowner and the county differently. Last, the lower court did not abuse its discretion in issuing a permanent injunction ordering the landowner to restore the wetlands to their pre-violation condition. See www.ca8.uscourts.gov/opndir/09/07/081908P.pdf.

Congress

The Appalachia Restoration Act, **S. 696**, introduced by Sens. Benjamin L. Cardin (D-Md.) and Lamar Alexander (R-Tenn.) in March to ban mountaintop mining has faced new challenges in past couple of months. In June, the Congressional Research Service released a report that the bill's redefinition of "fill material" would subject all surface coal mining to strict EPA discharge permits under §402 of the CWA, and not just §404 requirements administered by the Corps. Senator Alexander has expressed surprise and reiterated his desire simply to protect Tennessee's mountains and not eliminate coal mining as a key industry. A group of coal miners from West Virginia subsequently instituted a ban against Tennessee tourism attractions in retaliation. In the meantime the bill continues to accrue co-sponsors, now at eight. Senator Alexander remains the lone Republican. Read more at www.washingtonpost.com/wp-dyn/content/article/2009/07/25/AR2009072502357.html.

Rep. James Oberstar (D-Minn.) is drafting companion legislation to Sen. Russ Feingold's (D-Wisc.) Clean Water Restoration Act, **S. 787**, which passed the Senate Environment and Public Works Committee in June. Opposition to the legislation remains strongest among those who fear the expansion of CWA jurisdiction would create heavy burdens on new construction projects and on agricultural lands. Representative Oberstar is considering a role for the U.S. Department of Agriculture to determine which farmlands would fall under the "Swampbuster" provision of of prior-converted cropland, to allay the concerns of the agricultural community.

The Chesapeake Bay continues to receive further attention since President Obama's executive order declaring it a national treasure. The Chesapeake Bay Accountability and Recovery Act of 2009, **H.R. 1053**, sponsored by Rep. Rob Wittman (R-Va.), would require the Office of Management and Budget to develop a budget plan for all 10 federal agencies working on the Bay's restoration. It would also require the U.S. Environmental Protection Agency to create a three-year adaptive management plan for the Bay and would clarify congressional oversight. Opponents argue that it risks duplication of the president's order.

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pump supply elements for the Yazoo Backwater Pumping Plant. Congress appropriated another $5 million for construction of the Yazoo Pumps in the FY 2009 Omnibus Appropriations Act after the veto was issued. Sen. Barbara Boxer (D-Cal.), Chair of the Environment and Public Works Committee, included a statement in the legislative history of that Act clarifying that neither the appropriation nor any language in the Act was intended to override or otherwise affect the Clean Water Act veto of the Yazoo Pumps. 155 Cong. Rec. S2818 (daily ed. Mar. 5, 2009) (statement of Sen. Boxer).

16. The Bush Administration had four different EPA Administrators (Christine Todd Whitman, Marianne Lamont Horinko (acting), Michael Leavitt, and Stephen Johnson).

17. Under EPA's impact assessment, the Yazoo Pumps would damage more than 25 times the combined wetland impacts of all other vetoed projects. Even under the Corps' incomplete impact assessment, the project would damage more than 8.5 times the combined wetland impacts of all other vetoed projects.

18. One veto was issued under the Carter Administration, seven under the Reagan Administration, and three under the George H.W. Bush Administration.

19. Under Clean Water Act §404(c), the Administrator of EPA can veto a project that would have an "unacceptable adverse effect on municipal water supplies, shellfish beds and fishery areas (including spawning and breeding areas), wildlife, or recreational areas."

20. For example, from 1996 to 2001, the federal government distributed at least $15.3 million in federal farm subsidies to just 51 landowners in the two-year floodplain of the Yazoo Pumps project area.

21. During the 24-year period from 1979 to 2002, only 62 properties within the Yazoo Pumps project area filed flood insurance claims under the National Flood Insurance Program. Collectively, these properties filed 209 claims for damages totaling $1.7 million.

22. For example, the Corps did not evaluate impacts to short-hydroperiod wetlands or to wetlands that were not sustained by backwater flooding.

23. As noted above, EPA opted not to fight the Corps' impact assessment during the veto process, instead finding that 67,000 acres was more than enough to warrant a veto. We commissioned the hydrology assessment to further bolster a final veto decision by providing clear evidence in the §404(c) record that the impacts would in fact be far greater than acknowledged by the Corps.

24. The annual per child cost of this coverage is $288.93, of which 80 percent is paid by the federal government and 20 percent by the Mississippi State Department of Health. CHIP Expenditures Report, *available at* http://www.msdh.state.ms.us/msdh-site/index.cfm/13,0,163,html.

25. EPA has documented needed upgrades of $198 million for these facilities. This constitutes a significant portion of the $300 million total wastewater treatment needs documented for small communities (defined as communities with populations of 10,000 or fewer) in Mississippi. A documented need is "a water quality or public health problem and an associated abatement cost that is eligible for funding under the [Clean Water State Revolving Fund]." U.S. EPA, Clean Watersheds Needs Survey 2000, Report to Congress, EPA-832-R-03-001, Aug. 2003.

26. A bulletproof vest costs approximately $700. U.S. Bureau of Justice Assistance, *at* http://www.ojp.usdoj.gov/BJA/.

27. The annual average per person cost of food stamps is $1,226. Food and Nutrition Service, *Supplemental Nutrition Assistance Program* website at http://www.fns.usda.gov/fsp/faqs.htm (last visited July 21, 2003).

28. Editorial, *Abusing the Environment*, N.Y. Times, Jan. 26, 2003; Editorial, *Yazoo Boondoggle*, N.Y. Times, Feb. 5, 2003; Editorial, *Yazoo Pumps: They're Back!*, N.Y. Times, Nov. 6, 2007; Editorial, *Yazoo Pumps, R.I.P.?*, N.Y. Times, Feb. 26, 2008; Editorial, *Mr. Johnson Steps Up*, N.Y. Times, Aug. 23, 2008; Editorial, *Death of a Boondoggle*, N.Y. Times, Sept. 5, 2008.

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4. U.S. EPA, Functions and Values of Wetlands 1, EPA 843-F-01-002c, (2001).

5. *Id.*

6. *Id.* at 2.

7. Jean Hanson, *Your Elevator Speech—Have You Updated Yours Recently?*, *at* http://developers.evrsoft.com/article/business/business-tips/your-elevator-speech-have-you-updated-yours-recently.shtml (last visited Aug. 4, 2009).

8. Jack Carroll, *Ride an Elevator to Fame and Fortune*, *at* http://www.saleslinks.com/sideline/99c/11v1.htm (last visited Aug. 4, 2009).

9. Arvin Murch, *Who Cares About the Environment: The Nature and Origins of Environmental Concern, in* Environmental Concern: Personal Attitudes and Behavior Toward Environmental Problems 10 (MSS Information Corp. 1974).

10. *Id.* at 12.

11. Kotler & Lee, *supra*, note 2, at 142-46.

12. My colleague Lynn Setzer of the University of North Carolina at Chapel Hill Kenan-Flager School of Business used to consult with companies on communication questions. This is an actual example of her work, taken from the early 1990s.

13. Solid Waste Agency of Northern Cook County v. United States Army Corps of Engineers, 531 U.S. 159 (2001).

14. Matthew Kreuter et al., *One Size Does Not Fit All*, 21 Annals Behav. Med. (4) 276 (1999).

15. *Id.* at 277.

16. *Id.* at 278.

17. Celette Sugg Skinner et al., *How Effective Is Tailored Print Communication?* 21 Annals Behav. Med. (4) 296 (1999).

18. *Id.* at 296.

19. The asset map tool was created by John Kretzmann & John McKnight, Building Communities From the Inside Out (Northwestern Univ. Press 1993).