CLASSIFICATION AND INVENTORY OF WETLANDS IN THE SOUTHERN APPALACHIAN REGION

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ABSTRACT

The National Wetlands Inventory of the U.S. Fish and Wildlife Service has prepared large scale (1:24,000) wetland maps for nearly all of the Southern Appalachian Region. Traditional and digital cartographic products are available from the Earth Science Information Centers of the United States Geological Survey and from State-run distribution outlets. Most of the materials prepared by the NWI within the region were cooperatively funded by the States and other Federal Agencies.

NWI maps describe wetlands in terms of the life form of the dominant vegetation, substrata where vegetation is sparse or lacking, water chemistry, relative duration of inundation or saturation, and special modifiers. The maps display wetland polygons as small as 0.5 hectares in size and linear wetlands as narrow as 8 meters, showing the size, type of wetland, and relative position of the wetland on the landscape. The wetland inventory process is principally a remote sensing task, relying on the interpretation of high altitude color infrared aerial photography, supported with ground truth data and collateral information. The procedure has limitations related to scale, quality, and timing of the aerial photography; experience and training of the photo interpreters; and the wetland types which are to be classified and delineated. Since wetland maps provide a static depiction of a dynamic resource, the NWI conducts periodic wetland status and trends studies to evaluate wetland change in areal extent and the reasons for the change. Although trend surveys are routinely conducted nationally and selectively for regional and local areas, no study to specifically address the wetlands of the Southern Appalachian Region has been developed.

1. INTRODUCTION

The National Wetlands Inventory (NWI) of the U.S. Fish and Wildlife Service (Service) has been mapping and classifying wetlands, and analyzing wetland trends since the late 1970's. The information collected and disseminated by the NWI is intended as a tool to foster wise management of wetland resources.

The NWI is the fourth wetland inventory carried out by the Federal Government. The first two inventories, conducted in 1906 and 1922 by the Department of Agriculture, were intended to identify lands that could be improved by drainage and converted to productive croplands. The Service's previous wetland inventory was conducted in 1954 to identify important wetland habitat for wildlife, especially waterfowl. In the southern United States, the Service concentrated inventory efforts in the most important waterfowl wintering habitats of the Gulf of Mexico and Atlantic Coastal Plains and the Lower Mississippi Alluvial Valley. Consequently the wetlands of the Southern Appalachians were virtually ignored. Nevertheless, the release of the findings in Wetlands of the United States, usually referred to as Circular 39 (Shaw and Fredine, 1956), marked a major turning point in wetland conservation.

Since that survey, wetlands have undergone many alterations, both natural and man-induced. The recognition of these changes, coupled with our increased understanding of wetland values, led the Service to establish the NWI. During its 17 year history, the NWI has developed a variety of cartographic and narrative products. The project's principal focus has been the preparation of detailed large-scale wetland maps and periodic reports of the status and trends of the nation's wetlands. Wetland maps are in wide use for impact assessment of site-specific projects including facility and corridor siting, oil spill contingency plans, natural resource inventories, habitat surveys and other studies. National estimates of the current status and trends (i.e., losses and gains) of wetlands have been used to evaluate the effectiveness of existing Federal wetland programs and policies, and to identify national or regional problem areas. The first status and trends study by the NWI (Frayer et al. 1983) increased public awareness of wetlands and was instrumental in stimulating important wetland legislation, including the Emergency Wetlands Resources Act of 1986 (P.L. 99-645).

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2. WETLAND CLASSIFICATION

At the inception of the NWI, a variety of regional wetlands classification schemes were in use. However, no single classification fully met the needs of a nationwide project. Therefore, a new classification system (Cowardin et al. 1979) was developed by a team of wetland ecologists, with the assistance of local, State, and Federal agencies, as well as many private groups and individuals. After extensive field testing and four major revisions, the classification was officially adopted by the Service in 1980.

The Service's wetland classification defines wetlands in the following manner: "Wetlands are lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. For purposes of this classification, wetlands must have one or more of the following three attributes: (1) at least periodically, the land supports predominantly hydrophytes, (2) the substrate is predominantly undrained hydric soil, and (3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season of each year" (Cowardin et al. 1979). This definition predates recent Federal efforts to define jurisdictional limits of wetlands under the purview of Section 404 of the Clean Water Act and is more comprehensive in scope. Lists of wetland plants (Reed, 1988), and hydric soils (U.S.D.A. Soil Conservation Service, 1991), have been developed in support of the Service's definition and have become integral to the Federal methodology for identifying jurisdictional wetlands.

The classification is hierarchical. At the most general level, wetlands and deepwater habitats are separated into five systems - Marine, Estuarine, Riverine, Lacustrine, and Palustrine. Each system groups wetlands and deepwater habitats according to hydrologic, geomorphologic, chemical and biological similarities. In the southern Appalachians, most wetlands are associated with the Palustrine system. Small acreages of wetlands are associated with the Riverine and Lacustrine systems, although these systems principally include deepwater habitats.

At the next level of the hierarchy, subsystems subdivide the systems on the basis of water depth and other hydrologic characteristics. At the taxonomic level below the subsystems are the classes, followed by subclasses. The 11 classes are based on either vegetative life form or substrate and flooding regime. Classes describing vegetated wetlands include Aquatic Bed, Moss-Lichen Wetland, Emergent Wetland, Scrub-Shrub Wetland, and Forested Wetland. Classes describing nonvegetated wetlands include Rock Bottom, Unconsolidated Bottom, Unconsolidated Shore, Rocky Shore, Streambed, and Reef. Subclasses provide additional life form detail (e.g. needle-leaved evergreen), or substrate information (e.g. sand). The classes and subclasses are easily recognized and can normally be identified by using remote sensing techniques.

At the most precise and detailed level of the classification are dominance types. These are named for the dominant plant species in vegetated wetlands or the predominant sedentary or sessile macroinvertebrate species in nonvegetated wetlands. At this point, the classification is open-ended and dominance types can be identified and named as required. For example, a western North Carolina bog vegetated primarily by rhododendron would be classified: SYSTEM: Palustrine; SUBSYSTEM: none; CLASS: Scrub-Shrub; SUBCLASS: Broad-leaved Evergreen; DOMINANCE TYPE: Rhododendron maximum.

To complete the wetland description, the classification includes modifiers which describe hydrology, water chemistry, soil type, and the impact of beavers or man. Modifiers can be applied at the class, subclass, and dominance type levels. The "saturated" water regime modifier is added to the bog classification example to indicate that the water table is at the surface of the substrate for much of the growing season.

3. WETLAND MAPPING

Due to the magnitude of this effort, wetland mapping by the NWI is primarily a remote sensing task. High altitude aerial photography is the basic information source. Since 1980, the NWI has regularly utilized 1:58,000 scale color infrared photography acquired for the U.S. Geological Survey's National High Altitude Photography Program. The use of satellite images is periodically investigated by the NWI and others and may eventually prove useful for monitoring wetland changes, updating NWI maps, and for producing maps in unmapped areas (Wilen and Pywell, 1992). At present, aerial photographs are the preferred tool for wetland mapping (Federal Geographic Data Committee, 1992).

The interpretation of the aerial photographs is performed by skilled photointerpreters following detailed guidance (conventions) developed by the NWI (U.S. Fish and Wildlife Service, 1990). The interpreters look at stereo-paired photographs through 4 to 6 power mirror stereoscopes. Viewing the images in stereo provides a 3 dimensional image that enables the interpreters to distinguish vegetation heights and to discern topographic relief to facilitate delineation of wetlands. Colors, textures, tones, and topographic position are among the characteristics of wetland signatures recognized by the interpreters. The delineations are made using 4X0 to 6X0 pen tips in waterproof black ink on clear stabalene overlays attached directly to the photographs. Field-checks and quality control reviews are conducted at specific intervals throughout the interpretation process. Tiner (1990) lists eleven steps performed in every NWI mapping project. Careful attention is paid to collateral information, especially county soil surveys and topographic maps.

When delineations are complete and have received a satisfactory review by NWI project personnel, the linework and classifications are transferred from the 1:58,000-scale aerial photographs to 1:24,000 scale base maps using zoom transfer scopes. Wetland delineations are superimposed over and composited with the corresponding topographic quadrangle (Figure 1.). The composited maps are distributed to a variety of Federal and State agencies for review and field checking. Editorial comments are compiled, maps are corrected, and final maps are prepared. The entire process takes 2 to 3 years from photo acquisition to final map production.

The process of preparing wetland maps through the interpretation of high altitude aerial photography has inherent limitations related to 1) the skill and experience of the photointerpreters, 2) the scale, quality, and acquisition date of the photography, and 3) the specific types of wetlands being classified and delineated. The NWI strives to train and employ individuals with a special aptitude for photointerpretation and an interest in wetland ecology. Remote sensing specialists and biologists from the Tennessee Valley Authority assisted the NWI with wetland photointerpretations for large areas in Tennessee, Kentucky, Alabama, and Georgia. However, most of the photointerpretations along with the cartographic tasks required in map preparation have been provided by a service support contractor associated with the NWI Central Control Group in St. Petersburg, Florida. The photointerpreters have degrees in the natural or biological sciences and are specifically trained in wetland classification and delineation. They perform wetland photointerpretation exclusively on a full time basis thereby continually maintaining and improving their skill. Service personnel from the Central Control Group and Regional Offices accompany the photointer- preters on ground-truthing field trips and provide feedback on the delineations, further fine-tuning the contractor's abilities.

Even though high altitude aerial photography has proven to be a useful and cost effective remote sensing tool for mapping wetlands, it is not without limitations. The scale of the photography determines the size of wetlands which can be delineated. Color infrared photography at a scale of 1:58,000 permits the NWI to delineate wetlands as small as 0.5 hectares and linear wetlands as narrow as 8 meters. Color infrared photography of optimum quality can record thousands of colors, shades, hues, and textures which can be interpreted as wetlands or other land cover. However, color infrared film is sensitive and requires careful handling, processing, and duplication. Photographs which are darker, lighter, bluer, or redder than normal can obscure standard wetland signatures. Poor quality imagery necessitates increased field checking and greater reliance on collateral information.

The aerial photography utilized by the NWI is usually taken during the period from late fall to early spring when deciduous trees are without leaves. This permits the interpreters to see beneath the forest canopy. Observations of moist to flooded substrates provide visual clues to the extent of wetlands. However, photographs inadvertently taken during periods of extreme drought or unusual flooding can be misleading. Compensation is again achieved by additional field checking and reliance on collateral information.

Some types of wetlands are inherently difficult to recognize and delineate regardless of the technology selected. Wetlands that are flooded or saturated for relatively short periods, wetlands that are vegetated by species common to the adjacent upland, and wetlands that have had alterations to the hydrology are especially difficult to photointerpret. For example, floodplain and riparian wetland habitats associated with small watersheds flood regularly but briefly during periods of heavy precipitation. Because flooding is of short duration, the probability is high that the photography will be obtained when the wetlands show no sign of flooding or saturation. Furthermore, floodplain and riparian wetlands are usually vegetated by species common to the surrounding uplands. For instance, the alluvial wetland forests of western North Carolina are vegetated by species with wide ecological tolerances, such as Tsuga canadensis, Liriodendron tulipifera, Platanus

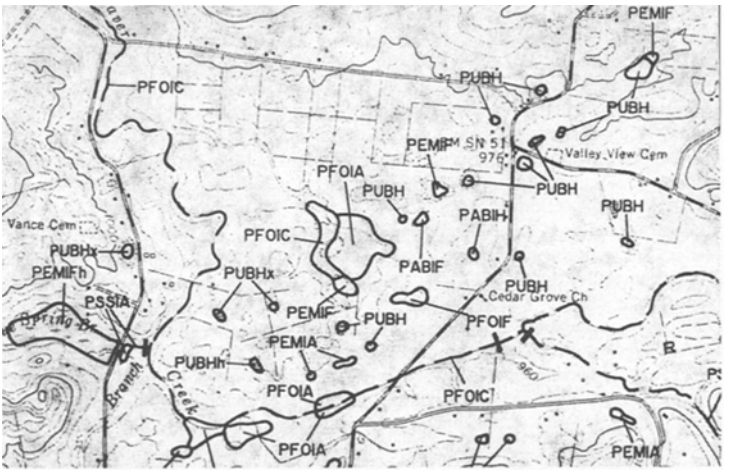

Fig. 1. West-central section of the New Market, Tennessee, National Wetlands Inventory Map (1:24,000 scale).

occidentalis, Betula alleghaniensis, Quercus alba, and Acer rubrum (Schafale and Weakley 1990). Even the edges of mountain bogs can be dominated by broadly tolerant tree species, such as Acer rubrum, T. canadensis, Pinus strobus, P. rigida and Picea rubens, which obscure the wetland perimeter. In cases when hydrologic indicators are not visible or when the wetlands grade nearly imperceptibly into upland habitats, the reliance on the aerial photography is augmented by the use of collateral information, intensified fieldwork, use of topographic maps, and whenever possible, the opinions of local experts.

Among the most difficult wetland delineation problems is the accurate determination of the extent of wetlands in areas where natural riparian overbank flooding has been controlled or altered as the result of channel modifications or run-of-the-river dams. These conditions are prevalent throughout the Appalachians and adjoining piedmont. Intensive site specific hydrologic studies beyond the scope of the NWI are required to accurately map wetlands in these situations. Therefore, the NWI should be used as only an approximation of wetland locations when extensive hydrologic modifications have occurred.

The employment of skilled full-time photointerpreters dedicated exclusively to wetland delineation assisted with collateral information and ground-truth data normally results in the preparation of good quality draft wetland maps. Constant oversight by Service biologists and reviewers from outside agencies, enable the NWI to produce high quality finished map products. Studies in New England by Swartout et al. (1981) and Crowley et al. (1988) determined the maps to be extremely accurate for their study areas. However, these results reveal little regarding the quality of the NWI elsewhere. A subjective gauge of NWI map reliability and utility is the willingness of outside agencies to sponsor NWI mapping activities. In the Southern Appalachian Region, nearly all work by the NWI has been accomplished cooperatively. Major contributions of State funds enabled Tennessee and Kentucky to be among the first States in the Nation to be mapped by the NWI. The Army Corps of Engineers provided cooperative funding for mapping major portions of Alabama, Georgia, South Carolina, and North Carolina. The State of South Carolina is currently providing funding to the NWI to prepare digital maps which include not only wetland classification and delineation but also upland land cover and land use information. West Virginia, Virginia, and North Carolina have sponsored the conversion of NWI maps from traditional cartographic products to digital data. Since 1983, North Carolina has had a formal agreement with the NWI to supply logistical support and local expertise for ground-truth acquisitions, as well as provide editorial review of draft maps.

4. MAPPING STATUS AND AVAILABILITY

The NWI had prepared maps, draft or final, for nearly 90% of the Southern Appalachian Region by early 1994. Final wetlands inventory maps are available for all of West Virginia, Virginia, Kentucky, and Tennessee. Nearly all of Georgia has been mapped, although most NWI maps are in the draft stage of preparation. Maps are available for most of North Carolina and Alabama. Complete coverage for these States will be available by the end of 1994. Wetland mapping has lagged in South Carolina, with only about half of the State having been completed. This is due in part to the State's desire to develop a database which includes both wetland and upland coverage, which is now underway.

An important strength of the NWI is the accessibility of its products. Maps are routinely distributed to the U.S. Army Corps of Engineers, the U.S. Environmental Protection Agency, and the U.S.D.A. Soil Conservation Service, as well as State agencies which have cooperated in their preparation. The Service alone distributes about 150,000 copies of NWI maps annually throughout the 50 States.

Maps are available for purchase from several sources. The Earth Science Information Centers (ESIC) of the U.S. Geological Survey (USGS) cooperate with the Service in the distribution of NWI maps. Mylar map copies can be purchased for $5.25 and paper copies for $3.50 from USGS. Details regarding the ordering process and information on product availability can be obtained by calling USGS/ESIC toll free at 1-800-USA-MAPS. The NWI has also established State-run distribution centers across the country. Locations and telephone numbers of distribution centers in the Southern Appalachian States are found on Table 1.

The NWI is mandated by the Emergency Wetlands Resources Act of 1986 (P.L. 99-645) as amended by the Wild Exotic Bird Conservation Act of 1992 (P.L. 102-440) to convert traditional cartographic products to digital data by September 30, 2004. Approximately 10,000 maps nationwide have been digitized and incorporated into the georeferenced NWI digital database. Complete Statewide digital wetlands databases will be available for Virginia and West Virginia in 1994. The digital database for North Carolina and South Carolina are also in progress but are several years away from completion. NWI digital data files can be purchased through USGS/ESIC. The data are stored on magnetic tape in MOSS export, DLG3 optional, or GRASS formats, written to 9 track tape, 1/4 inch or 8 mm cartridge in ASCII or UNIX-TAR. Tennessee and Kentucky are independently digitizing wetlands maps. The NWI is working with the States in order that the data might be shared and eventually made available for distribution.

A deliberate effort has been made by the NWI to make its products available to the greatest number of people possible. However, new NWI map users are sometimes deterred by the seemingly complex classifications displayed on the maps. To overcome this, NWI personnel located in each Regional Office of the Service are available to provide assistance in understanding the maps. In addition, formal training sessions in wetland classification and mapping procedures are regularly scheduled.

TABLE 1.

Sources of National Wetlands Inventory Products for the Southern Appalachian Region

Alabama	Alabama Geological Survey Post Office Box O Tuscaloosa, AL 35486	(205) 349-2852
Georgia	Georgia Geologic Survey Room 406A 19 Martin Luther King, Jr. Drive, S.W. Atlanta, GA 30334	(404) 656-3214
Kentucky	Natural Resources and Environmental Protection	(502) 564-5174

	Cabinet Division of Administrative Services Data Processing Branch 14th Floor, Capitol Plaza Tower Frankfort, KY 40601	
North Carolina	North Carolina Department of Environment, Health, and Natural Resources Division of Soil and Water Conservation Post Office Box 27687 512 North Salisbury Street Raleigh, NC 27611	(919) 733-2302
South Carolina	State of South Carolina Land Resources Conservation Commission Cartographic Information Center 2221 Devine Street Suite 222 Columbia, SC 29205	(803) 734-9100
Tennessee	ESIC/USGS* National Headquarters 507 National Center Reston, VA 22092	1-800-USA-MAPS (703) 648-6045
Virginia	ESIC/USGS* National Headquarters 507 National Center Reston, VA 22092	1-800-USA-MAPS (703) 648-6045
West Virginia	National Heritage Program of Wildlife Resources West Virginia Division of Natural Resources Post Office Box 67 Ward Road Elkins, W. VA 26241	(304) 637-0245

*Earth Science Information Center, United States Geological Survey

5. WETLANDS STATUS AND TRENDS REPORTS

Recognizing that maps are a static representation of wetland conditions, the Service conducts periodic studies to determine wetland gains and losses nationwide. The first wetland trends study was completed in the early 1980's and evaluated wetland changes from the mid-1950's to the mid-1970's (Frayer et al. 1983; Tiner, 1984). A second study (Dahl and Johnson, 1991) developed trend information for the mid-1970's to the mid-1980's. In

accordance with the Emergency Wetlands Resources Act, the NWI will continue these studies at 10-year intervals.

A stratified random sampling design was used. Aerial photographs taken at the start and the end of each study period were interpreted and wetland acreages measured for 3,629 four-square mile sample plots nationwide. Estimates of wetland acreages were then generated through statistical analysis of the data obtained from the plots.

The study design was such that sample plots were concentrated in areas recognized as having high wetland densities such as the Atlantic and Gulf of Mexico Coastal Plains, and the Lower Mississippi Valley. Conversely, samples were sparsely distributed in areas of anticipated low wetland densities. For example, only 50 sample plots were assigned to the combined area of Tennessee and Kentucky while Florida and Louisiana each were allocated over 600 plots. In some areas such as the Southeastern United States (Hefner and Brown, 1984) and Florida (Hefner, 1986; Frayer and Hefner, 1991) where sample sizes were large, it has been possible to employ the statistical procedures of the national studies to develop localized wetland status and trends information. Conversely, the subset of samples in the southern Appalachians is so small that statistical analyses would result in extremely large standard deviations in the estimates and little useful information would be obtained.

6. SUMMARY

The NWI is nearly completed with wetland mapping in the Southern Appalachian States. The maps represent the only uniform, accessible, and extensive source of cartographic information related to wetlands in the region. The NWI not only locates wetlands but also describes them in terms useful for a variety of evaluation purposes. Wetland maps have been prepared through the interpretation of high altitude aerial photography augmented by field checking, use of collateral information, and quality control reviews by the Service and NWI cooperators.

Wetland delineation from high altitude aerial photography has inherent limitations related to scale, quality, date, and type of photography; the types of wetlands to be delineated; and the skill and experience of the photointerpreters. Tiner (1990) described the special considerations for using high altitude aerial photography for inventorying forested wetlands, the predominant wetlands of the Southern Appalachians and adjoining piedmont. The NWI relies heavily on field checking and the use of collateral information to overcome photointerpretive limitations.

The NWI periodically conducts studies to determine wetland gains and losses. However, trend information has not been developed for the region. Therefore, follow-up studies should be designed not only to monitor changes in the areal extent of the wetlands but also to evaluate the functional health of the resource.

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