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THREE APPROACHES TO THE CLASSIFICATION AND MAPPING OF INLAND WETLANDS

Patricia T. Gammon [1]
Donald Malone [2]
Paul D. Brooks [3]
Virginia Carter [3]

ABSTRACT

Three projects representing three approaches to the classification and mapping of inland wetlands are discussed. In the Dismal Swamp project, seasonal, color-infrared aerial photographs and Landsat digital data were interpreted for a detailed analysis of the vegetative communities in a large, highly altered wetland. In western Tennessee, seasonal high-altitude color-infrared aerial photographs provided the hydrologic and vegetative information needed to map inland wetlands using a classification system developed for the Tennessee Valley Region. In Florida, color-infrared aerial photographs were analyzed to produce wetland maps using three existing classification systems to evaluate the information content and mappability of each system. The methods used in each of the three projects can be extended or modified for use in the mapping of inland wetlands in other parts of the United States.

INTRODUCTION

As awareness of the economic and environmental value of wetlands has increased, the classification and mapping of inland wetlands has become a matter of great concern to local, State and Federal agencies. Inland (nontidal) wetlands make up approximately 87 percent of the total wetland acreage of the conterminous United States. Their size ranges from potholes less than one-half hectare in the northern prairies to thousands of hectares in the Great Dismal Swamp, the Okefenokee Swamp, and the Lake Agassiz Peatlands Natural Area. The three projects discussed in this report concern the development of remote sensing techniques to classify and map inland wetlands in Virginia-North Carolina, Tennessee, and Florida, using three different approaches.

Wetlands are dynamic ecosystems definable in terms of hydrology, vegetation, and soils, but difficult to map because of water level (boundary) fluctuations. A photograph, or a field visit, results in a record of the location of the water's edge at one isolated instant in time. Vegetative composition, soils, or abrupt topographic changes may serve to indicate the boundary of a wetland or wetland class. Often, however, the change in vegetation, soil, or topography is gradual and it is difficult, therefore, to place a meaningful boundary within the continuum from permanently wet to permanently dry.

Recent research and published scientific reports have shown that color-infrared (IR) aerial photographs can be used for detailed mapping of inland wetland vegetation cover types (Seher and Tueller, 1973; Neilsen and Wightman, 1971; DeSteiguer, 1975; Carter and Stewart, 1975; Carter and others, 1976). The use of high-altitude color IR photographs to document surface-water boundaries in wetlands has been discussed by Carter and Stewart, 1975, and by Moore and North, 1974.

U.S. Geological Survey (USGS) topographic quadrangles are often used as a base map on which to transfer information interpreted from aerial photographs. The most commonly used scale is 1:24,000, but maps of the 1:250,000-scale and the new 1:100,000-scale series are also used for this purpose. Orthophotoquads, interim map products made by rectification of black-and-white (B/W) aerial photographs, also provide an extremely useful and up-to-date base map. The natural photographic detail is preserved and there is minimal cartographic treatment (place names and a grid reference system) to obscure the mapped detail. In all the projects discussed below, USGS base maps were used to present wetland information.

[1] U.S. Geological Survey, Suffolk, Virginia
[2] Tennessee Valley Authority, Chattanooga, Tennessee
[3] U.S. Geological Survey, Reston, Virginia

THE GREAT DISMAL SWAMP

Background and objectives

The USGS and the U.S. Fish and Wildlife Service (FWS) have a continuing cooperative project in the Great Dismal Swamp, Virginia-North Carolina. The FWS has the responsibility for evaluating and developing management priorities for the 56,630 ha primary area of the swamp. Management decisions must be based in part upon an understanding of the vegetative communities and their relationship to the hydrologic regime of the Great Dismal Swamp. The objectives of the project include using remotely-sensed data to map the vegetative cover and to study the hydrology of the swamp.

Test site

The Great Dismal Swamp is an 84,000 ha forested wetland located on the Virginia-North Carolina border on the mid-Atlantic coastal plain. It is developed on organic soils ranging in depth from 4 m in ancient drainage channels to less than 0.3 m along the outer edges and on poorly drained mineral soils. Lake Drummond, approximately 4 km in diameter, is almost centrally located within the gently sloping west-east gradient of water flow.

Man-induced alterations such as fire, timbering and ditching, as well as geographic location, have created a remarkable diversity of vegetative communities in the Great Dismal Swamp. The vegetative composition includes a variety of deciduous and evergreen, broad-leaved and needle-leaved tree species, and deciduous and evergreen shrubs, vines and herbaceous plants. Because of this diversity and the inaccessibility of interior parts of the swamp, the traditional methods of ground sampling have proven to be too costly and time-consuming to successfully identify and describe the present vegetation.

Materials and methods

National Aeronautics and Space Administration (NASA) seasonal high- and low-altitude color IR photographs were used to identify and map specific swamp vegetative communities at scales of 1:100,000 and 1:24,000. On winter, leaves-off photographs, peripheral land-use or land cover can be identified, dendritic drainage patterns can be seen extending from the upland into the swamp, and evergreen species, both broad-leaved and needle-leaved can be identified. Using these winter photographs supplemented with growing season photographs, evergreen and deciduous canopy and understory can be separated and several deciduous classes identified.

Early black-and-white (B/W) aerial photographs, in combination with timber records and state fire reports, were used to prepare maps showing approximate dates and extent of timbering and fires. These historical maps for 1937-38, 1952 and 1971 were designed to overlay the vegetation maps.

USGS prepared a 1:100,000-scale mosaic of the 16 USGS 7.5-minute orthophotoquads containing the Great Dismal Swamp. Classes were interpreted from the color IR photographs and historical B/W photographs, and delineated on stable base mylar registered either to the mosaic or to the individual orthophotoquads.

Geometrically corrected and temporally registered Landsat digital data from April and February 1974 have also been used to classify and map the vegetative cover in the Great Dismal Swamp. Vegetative cover classes were grouped into dominance types and subclasses according to the new FWS wetland classification system (Cowardin and others, 1976). Four Landsat data sets were analyzed on the Interactive Digital Image Manipulation System (IDIMS) at the Earth Resources Observation Systems (EROS) Data Center in Sioux Falls, S. D.: (1) April data all multispectral scanner (MSS) bands (2) February data all MSS bands (3) MSS bands 5 and 7 from April and February and (4) all 8 MSS bands from April and February. Classifications have also been made with Landsat digital data from the same data sets and from different dates using the General Electric 1/ Image-100 (Carter and others, 1977), and the Purdue University Laboratory for Applications of Remote Sensing System (LARSYS). We are using sample plots and IDIMS algorithms to measure the accuracy of these classes and previous classifications.

1/ The use of brand names in this report is for identification purposes only and does not imply endorsement by the U.S. Geological Survey.

Winter Landsat images clearly show the extent of surface water in areas with deciduous cover. This information helps to understand the damming and diversionary effects of roads and ditches. It is also important as an aid in site selection for vegetation and hydrology studies.

Map products

The 1:100,000- and 1:24,000-scale vegetative cover maps show classes based on dominant canopy species and type and extent of understory (Fig. 1). Ten canopy classes, the deciduous classes ranked in order of water tolerance, and three associated understory classes were designated. Due to the complex mixtures of species throughout the swamp, classes were frequently combined in order of dominance. These class combinations have resulted in over 40 separate canopy designations and 240 specific community delineations. The maps provide up-to-date information which can be used directly in making management decisions and for selecting sites for intensive study. The historical maps show patterns of regeneration following disruptive events. By combining the information from the historical and present-day vegetative cover maps with biological and climatic data, it is possible to interpret the responses of vegetation to various environmental influences and to establish successional trends, thus providing additional data on which to make management decisions.

For the Landsat classification with IDIMS, 18 dominance types were established for the swamp on the basis of season, dominant canopy species and, in some deciduous classes, on type of understory. The subclasses and dominance types vary in number and composition according to season of data acquisition. Percentage estimates for the swamp subclasses were as follows: shallow water/benthos, 2.2 percent, broad-leaved evergreen forested wetland, 6.5 percent, needle-leaved evergreen forested wetland, 16.0 percent, broad-leaved deciduous forested wetland, 67.7 percent, narrow-leaved deciduous forested wetland, 1.0 percent, broad-leaved evergreen shrub wetland, 5.0 percent, and altered, 1.6 percent.

WESTERN TENNESSEE

Background and objectives

The USGS and the Tennessee Valley Authority (TVA) are presently conducting a cooperative wetland mapping project in western Tennessee. This experimental project was initiated in response to local, State and Federal management needs and concern over the loss of wetland habitat in the area. The wetland maps were designed to provide baseline information for resource management, including the information needed for:

(1) legislative or regulatory requirements,
(2) location of seasonally inundated and permanently flooded areas,
(3) decisions on sites for agricultural, residential, or industrial development,
(4) wildlife management and habitat acquisition,
(5) development of recreational opportunities,
(6) monitoring change.

The three major objectives of the project were: one, to develop and test a wetland classification system for the Tennessee Valley Region, two, to test the utility of seasonal high-altitude color IR photography for mapping the proposed wetland classes and subclasses as well as surrounding land-use, and three, to use seasonal data to study wetland boundary dynamics (hydrologic fluctuations) and to relate boundaries to stage (water level). The primary emphasis in this paper is to describe the preparation of wetland maps for four sites in western Tennessee using the wetland classification system developed during the study.

Development of the classification system

The classification system developed is based primarily on vegetation and on the frequency and duration of inundation (Virginia Carter and J. H. Burbank, unpub. data 1977). Several modifications were made in the initial system as the mappability of the classes was tested. The final system is thus designed to derive the optimum blend of interpretable and mappable wetland information from the data source, in this case high-altitude, color IR photography.

Test sites

Four test sites, Reelfoot Lake, Hatchie River Bottoms, White Oak Swamp, and Duck River dewatering area, were selected for classification and mapping. These sites, all located in western Tennessee, were considered to be representative of the diversity of wetlands encountered in the Tennessee Valley Region. Reelfoot Lake is a tectonic feature created on the Mississippi

River flood plain by the New Madrid Earthquakes of 1811 and 1812. This relatively shallow and heavily vegetated lake, surrounded primarily by agriculture and upland forest, has the most diversity in wetland types of any site mapped. Hatchie River Bottoms is an extensive and classic example of Bottomland Hardwood extending along both sides of the Hatchie River. During much of the year, including the growing season, the water is contained within the river channel, but in the late winter and spring and for short periods following very heavy rain in the drainage basin, a wide area of forested flood plain and some surrounding agricultural land is flooded.

The two remaining sites are located in Tennessee River basin and are more or less affected by controlled water levels in the Tennessee River. The Duck River dewatering area, located where the Duck River enters the Tennessee River, is surrounded by a levee, and the water level is controlled by TVA. The area contains many acres of agricultural land that are flooded annually and, until recently, a program for control of vegetation was carried on by TVA. The White Oak Swamp is located along White Oak Creek which has been channelized and the dredge spoil piled on the channel banks. Very few connections were retained between the main channel and the low areas behind the spoil banks and beavers have now dammed most of these. The impounded water has created many acres of Dead Woody Swamp, partially regenerated to Shrub Swamp and surrounded by Forested Swamp or Bottomland Hardwood.

Materials and general methods

The primary data source for mapping the land-use and wetland classes and subclasses was high-altitude color IR photography obtained by NASA. The scale of the aerial photographs is approximately 1:130,000. Natural water-level fluctuations, seasonal growth of emergent aquatic vegetation and continuous tree cover in many areas necessitated the use of seasonal photography. Photographic coverage was therefore obtained in February (high water, leaves-off), October (late growing season), and November (low water, leaves-off) of 1975.

A mapping scale of 1:24,000 was selected for several reasons. The small size of some wetland classes necessitated a large mapping scale. The 1:24,000-scale USGS topographic map series covers all of the sample test sites and provides additional data for evaluating wetlands; e.g., topography, cultural features, and surrounding drainage patterns. A published map, which meets the National Map Accuracy Standard (NMAS), also provides reliable planimetric control for locating wetland classes.

The delineation of the 6 wetland classes, 12 wetland subclasses and the surrounding land-use was done manually by an experienced photointerpreter. The photointerpreter also took part in the preliminary field checking and assisted in modifying the subclasses to maximize the information derived from the aerial photographs. Table 1 shows the classification system and the photographic criteria for mapping the wetlands. The interpreted data were transferred to stable base drafting film overlayed on the appropriate 1:24,000-scale map. The registration of wetland data was accomplished by the use of a Bausch and Lomb Zoom Transfer Scope. For less detailed mapping of the surrounding land-use, a Kelsh stereoplotter was used.

Records from gages on Reelfoot Lake (USGS and FWS) and Hatchie River (USGS and U.S. Army Corps of Engineers) were used to determine the water stage on the dates of the overflights. A stage-duration curve was developed from five years of stage record on Reelfoot Lake.

In addition to the preliminary field checking, the final map products were extensively checked in the field at the Reelfoot Lake site, with somewhat less intensive checking for the other three sites. At Reelfoot Lake, the field checking included running transects to determine both accuracy of wetland classification and boundary placement.

Map products

Wetlands and adjacent land-use were mapped in the four sites on a total of 15, USGS 7.5-minute quadrangles: Reelfoot Lake (5), Hatchie River Bottoms (5), Duck River dewatering area (2), and White Oak Swamp (3). The final map product is a clear positive overlay keyed to the appropriate 1:24,000 sheet. The overlay is on stable base material and can be reproduced in several forms, including a clear positive, matte finish positive, or a blueline paper print. Wetlands for the Tiptonville quadrangle (part of the Reelfoot Lake site) were color separated and printed using the 7.5-minute topographic map for base information to produce a 5-color lithographic product. The stage-duration curve for Reelfoot Lake was placed on the map collar. Copies of this map are available through TVA Mapping Services Branch, Map Information Records Unit, 100 Haney Building, Chattanooga, Tenn. 37401.

AUBURNDALE, FLORIDA

Background and objectives

USGS 1:24,000-scale topographic maps have shown wetlands as a hydrologic feature for many years, and are the primary cartographic base for the Nation's wetlands. They are produced according to NMAS, and the relative internal accuracy of the map is likely to be better than NMAS. The various wetlands are shown on USGS maps as follows:

1. Marsh --- marsh or swamp symbol without a color overprint
2. Submerged marsh --- marsh or swamp symbol overprinted with solid blue tint
3. Swamp --- marsh or swamp symbol overprinted with green tint
4. Submerged swamp --- marsh or swamp symbol overprinted with both solid blue and green tint
5. Mangrove swamp --- mangrove symbol overprinted with green tint

While reasonably accurate and acceptable in the main the marsh or swamp symbol bears little or no relation to the vegetation species; the criteria are unreliable at the marsh or swamp boundary; and at publication the definitive outline is lost by nature of the marsh or swamp symbol. Since the maps do not show a well-defined wetland boundary (except where it coincides with a shoreline), the map accuracy standards cannot be applied in the area between wetlands and upland.

USGS has been experimenting with new compilation methods and map products using three different wetland classification systems. The objectives of this research project were: (1) to test the feasibility of mapping and classifying inland wetlands on USGS 7.5-minute quads in more detail than is presently shown; (2) to develop or identify a standard definition and classification system for use by USGS; and (3) to prepare sample products for user evaluation. The following discussion focusses on the Auburndale, Fla., 7.5-minute quadrangle, for which sample map products have been prepared for evaluation by selected users.

Wetland classification systems

The three classification systems (Figure 2) tested on the Auburndale, Fla., quadrangle are the Martin (Martin and others, 1953), Anderson (Anderson and others, 1976), and Cowardin (Cowardin and others, 1976). Two of these classification systems were available at the beginning of this project; the third, Cowardin, was obtained in draft form in March 1976. These three classification systems were developed for nationwide usage. However, they differ in scope, terminology, and criteria, and provide varied approaches to the mapping of wetlands on USGS 7.5-minute quads. Many excellent classification systems have been written for local or regional conditions, but they cannot usually be applied to different regions of the country. Thus, they are not applicable to a national wetland mapping program nor to standard treatment on USGS topographic quadrangles. These local classifications were not considered in this research.

The Martin system was developed for the first FWS Wetland Inventory in 1954 (Shaw and Fredine, 1956). Its single primary purpose was the assessment of the amount and types of valuable waterfowl habitat. The wetland classes are based on vegetation and presence of water or wet soil. Only the eight wetland types in the Inland Fresh Areas category were considered in the current research project.

The Anderson system is a complete land-use and land cover classification system based almost entirely on the use of remote sensor data. The system, hierarchical in nature, proceeds from the very general at Level I to the more specific at the lower levels. Wetland, one of the nine Level I categories, is divided into Forest and Non-Forested at Level II. For this project, the Level II wetland classes were subdivided into Levels III and IV for mapping at 1:24,000 scale.

The Cowardin system, which will replace the earlier Martin system, by FWS for a new national inventory of wetlands. It is a hierarchical, descriptive system based upon vegetation, soils, and hydrology and is intended to facilitate inventory and comparison of wetland types on a national basis. The system is intentionally left open-ended to allow wetland data to be added which has been gathered through the acquisition of additional source material and (or) field inventory. Ultimately, this would complete the definition of wetland parameters that could be identified using remote sensing techniques.

Test site

The Auburndale, Fla., 7.5-minute quadrangle, located approximately midway between Tampa and Orlando, was selected as a test site for two reasons: one, geology within the area covered by the map is complex; and two, a variety of wetland types are present. The eastern third of the quadrangle is covered by the Central Florida Highlands which is underlain by limestone with many sink-hole lakes interconnected by canals with control dams. The central and western portions of the quadrangle are relatively flat lowland covered by marine shore deposits, and extensive areas of strip mining located in the western edge. The higher, well-drained ground of the limestone terrain is occupied by large citrus groves. The rest of the highland area is urban, and urban development is spreading into the lower elevations west of the limestone ridge, sparing the citrus plantations.

Materials and methods

Existing superwide B/W aerial photographs at 1:20,000 scale acquired on November 30, 1971, and quad-centered 1:76,000-scale color IR aerial photographs taken on December 1, 1972, were used to interpret and delineate the wetland boundaries and classes. The photo-image bases at 1:24,000-scale were made from the color IR photographs by overprinting on yellow scribecoat from a rectified B/W film transparency. The three wetland classification systems were then stereo-compiled from the aerial photographs on the photo-image bases.

Map products

Three inland wetland classification maps were prepared at 1:24,000 scale on an orthophoto base of the Auburndale, Fla., 7.5-minute quadrangle using the Martin, Anderson and Cowardin wetland classification systems respectively. Each map contains a geographic reference system, major geographic names (cities and lakes), and appropriate standard map collar information. In addition, an explanation (legend) depicting the map symbols for the categories of the appropriate wetland classification system is contained in the collar on each map.

Wetland classification and mapping proved very difficult using the Martin system definition. The Martin system does not appear to be suited for large scale wetland mapping on an operational basis. The Anderson system in the expanded form (Levels III and IV) is limited in its utility by geographic considerations and by the difficulty of applying uniform map symbolization. The Anderson system is designed as a complete land-use and land-cover system, so wetland can potentially be classified as agricultural land, water or one of the other Level I categories.

The Cowardin definitions, of the three classification systems tested, were the easiest to apply in the photointerpretation and delineation of the wetland categories. Using remote sensing techniques and the Cowardin system, the USGS was able to compile a greater density of wetland classes than could be compiled with either the Martin or Anderson systems. We concluded, however, that neither a classification system nor a map need contain all of the information gathered during a complete wetland inventory. With the modified Cowardin system, we have produced a generalized wetland map using remote sensing techniques, and of the three systems tested, it is the preferred system.

SUMMARY AND CONCLUSIONS

The three studies presented in this paper differ significantly in their approach to a common problem, the classification and mapping of inland wetlands. In the Great Dismal Swamp, 56,630 hectares of forested wetland have been subdivided on the basis of dominant canopy and understory species. Information from seasonal color IR aerial photographs was transferred to orthophoto base maps at 1:100,000- and 1:24,000-scales. Geometrically-corrected and temporally-registered Landsat digital data was also used to classify vegetative cover. It has been concluded from the Great Dismal Swamp project that:

1) Color IR photography from both the winter (leaves-off) and growing season (leaves-on) is essential for detailed vegetative cover (habitat) mapping.

2) Transfer of information to a planimetrically correct orthophotomap base results in a product which may be reproduced at any convenient size, can aid in directing intensive field studies, and can be used to illustrate vegetative relationships, succession, and trends.

3) The winter data give information on surface-water drainage patterns and concentration within the swamp, thus giving some needed perspective on the damming effects of roads and the diversionary effects of ditches. These data are particularly useful in selecting sites for ground-water observations.

4) B/W historical aerial photographs can be interpreted to produce maps that illustrate successional trends in altered areas.

5) Landsat temporal digital data can be used to classify vegetative cover and thus are a strong potential tool for future monitoring of vegetative trends.

In Tennessee, seasonal high-altitude color infrared photographs were used to map wetland classes using a classification system specifically designed for the Tennessee Valley Region as part of the project. Fifteen maps were compiled on U.S. Geological Survey 7.5-minute quadrangle base maps, and one map was made into a color lithograph product. Stage information was placed on the map collars of 9 of the 15 maps. The conclusions reached from this project are the following:

1) A new classification system was developed for inland wetlands in the Tennessee Valley Region.

2) Seasonal color IR photographs provide sufficiently detailed information to map wetland areas as small as 0.43 ha in area and 20 m in the smallest linear dimension. A minimum of field observations is required, although field checking of final or interim products is always advisable.

   The critical periods for aerial photography were determined to be the leaves-off, high-water season, the growing season, and the leaves-off, low-water season. This combination provided a maximum of information for identification and delineation of wetland classes.

3) Dates of aerial photographs can be related to stage records to give an idea of range in water-level fluctuation and placement of wetland boundaries within this range.

In Florida, wetlands on the Auburndale 7.5-minute quadrangle were mapped to test three different wetland classification systems. It was concluded from this study that:

1) Inland wetland boundaries interpreted from quad-centered, color IR aerial photographs supplemented with low-altitude B/W aerial photographs have positional accuracies of about 40 feet (within NMAS).

2) Orthophotographic products provide an excellent base map for the mapping of inland wetlands.

3) Of the three systems tested, Martin, Anderson, and Cowardin, respectively, the Cowardin system best fitted the needs of USGS for a national system that uses remote sensing data as a primary source of wetlands information. The definitions of the Cowardin system are easier to apply in the photointerpretation and delineation of the wetland categories, and a greater density of wetland classes can be compiled with this system.

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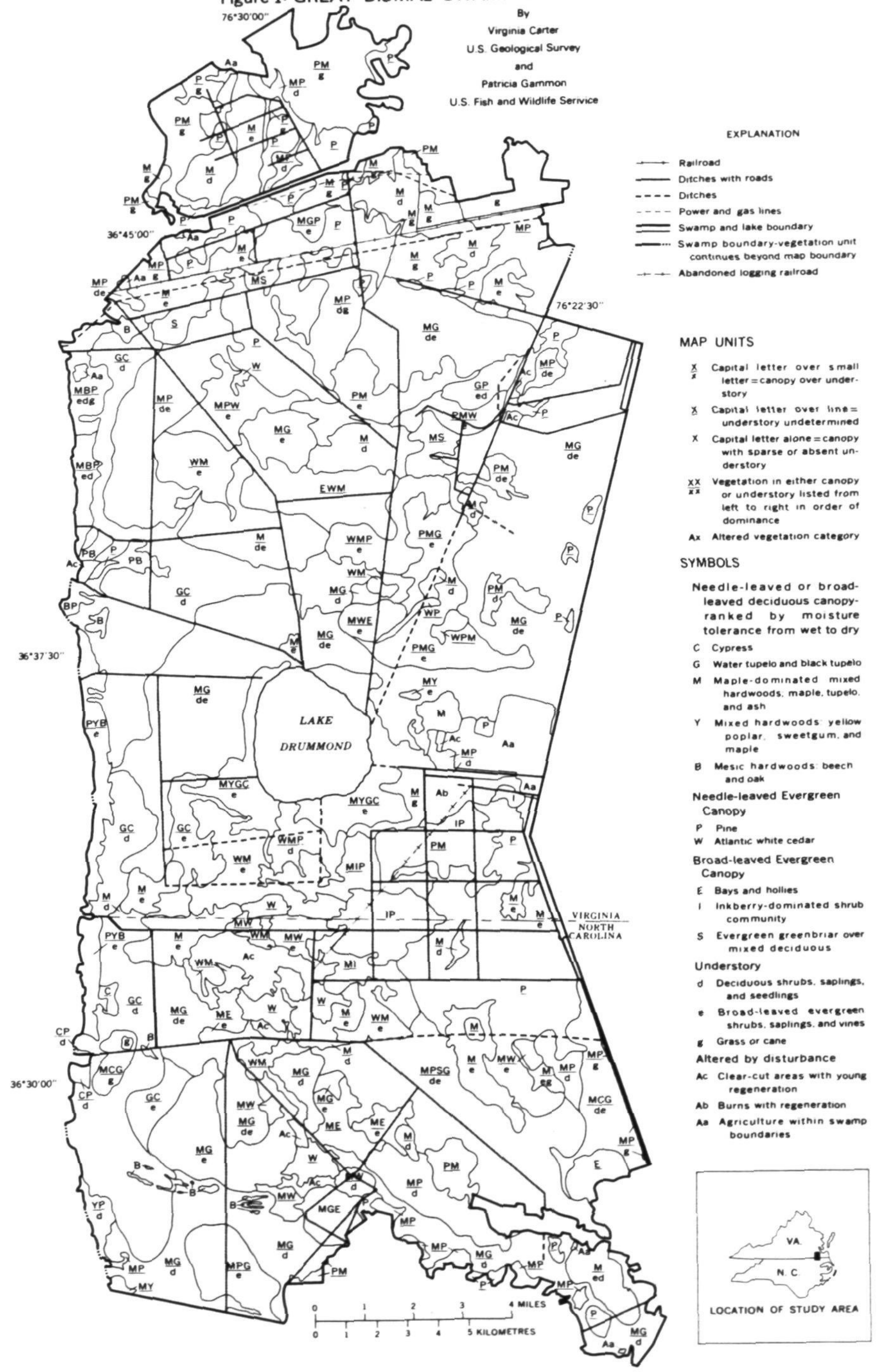
Figure 1: GREAT DISMAL SWAMP VEGETATIVE COVER MAP



From U.S. GEOLOGICAL SURVEY OPEN-FILE MAP 76-615
Produced by The U.S. Fish and Wildlife Service and The U.S. Geological Survey from National Aeronautics and Space Administration Color Infrared Photography—1976

TABLE 1: Photographic criteria for mapping wetland classes and selected subclasses

Class	Subclass	Mapping Criteria
FW-1 Bottomland Hardwood		≥ 30% tree cover; flooded on high-water, leaves-off photographs (Feb.): not flooded on low-water leaves-off photographs (Nov.). High-water leaves-off photographs needed to separate subclasses.
	FW-1a:	Upper Bottomland Hardwood: not flooded on normal high-water photographs (Feb.).
	FW-1b:	Lower Bottomland Hardwood: flooded on normal high-water photographs (Feb.).
FW-2 Swamp		≥ 30% woody vegetation cover: flooded on high- and low-water, leaves-off photographs (Feb., Nov.).
	FW-2a:	Forested Swamp: ≥ 30% live trees.
	FW-2b:	Shrub Swamp: ≥ 30% live shrubs - sometimes narrow fringe bordering Open Water and Forested Wetland.
	FW-2c:	Dead Woody Swamp: ≤ 30% live trees, ≥ 70% dead trees (impounded water).
M-1 Marsh		≤ 30% woody vegetation cover, ≥ 70% herbaceous vegetation cover: growing season and either Nov. or Feb. photographs needed to separate subclasses.
	M-1a:	Wet Meadow: flooded in high-water spring or winter photographs (Feb.): not obviously flooded in growing season or fall photographs (Oct., Nov.).
	M-1b:	Emergent Marsh: surface water present, but hidden by persistent vegetation except on high-water photographs (Feb.) when some water may be visible.
	M-1c:	Seasonally Emergent Marsh: ≥ 10% emergent cover: flooded in high-water winter or spring photographs (Feb.), mostly dead by fall low-water photographs (Nov.), visible in growing season photographs (Oct.).
M-2 Seasonally Dewatered Flats		Visible on late growing season photographs (Oct.) or fall (Nov.) photographs at low-water, flooded on high-water photographs (Feb.). Vegetated when cover exceeds 10%.
M-3 Agriculture subject to flooding		Flooded on high-water photographs (Feb.), agriculture in growing season (Oct.) or fall (Nov.) photographs.
OW-1 Open Water		≤ 30% live tree cover: separable at low-water (Nov.) if not vegetated or associated with Marsh. Growing season photographs needed to delineate if Marsh is present.
	OW-1a:	Open Water Vegetated: surface vegetation present in growing season photographs (Oct.): ≤ 10% emergents; minimum size 0.4 ha.
	OW-1b:	Open Water Non-vegetated: no surface vegetation.

MARTIN INLAND WETLAND CLASSIFICATION

1 Seasonally Flooded Flat
2 Wet Meadow
3 Shallow Marsh
4 Deep Marsh
5 Open Water
6 Shrub Swamp
7 Wooded Swamp
8 Bog

ANDERSON INLAND WETLAND CLASSIFICATION
(Expanded to Levels III & IV by USGS)

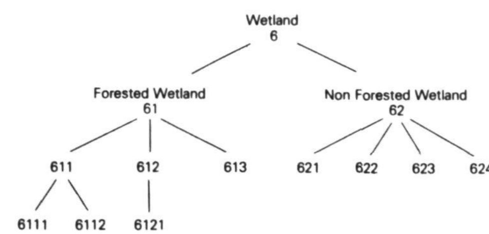
NOTE: D = Dugout

LEVEL I
6 Wetland

LEVEL II
61 Forested Wetland
62 Non Forested Wetland

LEVEL III
611 Deciduous
612 Evergreen
613 Mixed
621 Marsh
622 Meadow
623 Unvegetated Flat
624 *Vegetated Flat*

LEVEL IV
6111 Cypress
6112 Cypress/Gum
6121 Mangrove



COWARDIN INLAND WETLAND CLASSIFICATION (Modified by USGS)

ECOLOGICAL SYSTEM
R Riverine
L Lacustrine
D Palustrine

CLASS AND SUBCLASS
1 Pools
2 Riffles
3 Floating-Leaved Bed
4 Emergent Wetland
5 Moss/Lichen Wetland
6 Deciduous Shrub Wetland
7 Evergreen Shrub Wetland
8 Deciduous Forested Wetland
9 Evergreen Forested Wetland

WATER REGIME
Tidal { 1 Irregularly Flooded
2 Regularly Flooded
3 Subtidal }
4 Saturated
5 Temporarily Flooded
6 Seasonally Flooded
7 Semipermanently Flooded
8 Permanently Flooded
9 Intermittently Flooded

ORDER
M Mineral
O Organic

SPECIAL MODIFIERS
i Impoundment
d Dugout
c Canal
ch Channelized
ir *Irrigated*
f Farmed

Example:
Ecological System: Palustrine
Class/Subclass: Evergreen Shrub Wetland
Water Regime: Permanently Flooded
Order: Mineral
Special Modifier: Impoundment
D 7 8 M i

Map Code= $\frac{D\,7}{8\,M}$ i

Figure 2. Wetland Classification Systems and Map Symbols