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Mapping Wetlands Using Orthophotoquads and 35-mm Aerial Photographs

Wetland types were identified on large scale 35-mm aerial photographs of North Carolina and then were plotted on the orthophotoquads.

Introduction

Considerable effort is being put forth by several agencies to develop systems for classifying and mapping wetlands nationwide (Anderson *et al.*, 1976; Cowardin *et al.*, 1978). Most research efforts have evaluated the potential use of Landsat images or high altitude, small scale, color-infrared aerial photographs for wetland mapping, for example, Brown (1978), Carter and Stewart (1978), and Carter *et al.* (1977). However, very little work with low-altitude, large scale, 35-millimetre (mm) photography specifically for wetland mapping has been reported.

Abstract: *A U.S. Geological Survey 7.5-minute orthophotoquad is used in combination with 35-mm color-infrared aerial transparencies to inventory and map North Carolina wetland areas of interest to regional or local land managers. Orthophotoquads are rectified black-and-white aerial photographs produced in the 7.5-minute, 1:24,000 scale standard map series. These orthophotoquads provide a mapping base of uniform scale upon which many vegetation and land-use boundaries may be delineated. The 35-mm aerial photographs, flown at a larger scale, for example, 1:6,000, along selected transects within the orthophotoquad afford identification of different wetland types. The vegetation types identified on the 35-mm infrared photographs thus assist the interpreter in identifying the desired wetland types on the total wetland area within the quad. In areas where orthophotoquads are available, this method permits resource managers to map wetlands without the need for expensive large format photography.*

Meyer and Grumstrup (1978) have shown that small format photography has several advantages which justify its use: (1) Photographs can be acquired inexpensively by using a small rental aircraft and a standard 35-mm camera; (2) no special expertise in remote sensing is required, and sophisticated, expensive equipment is not needed in the interpretation process; and (3) the photography can be acquired to coincide with specific phenological conditions within a narrow time frame. Also, Spencer (1978) reported that maps can be intensified economically and accurately using small format aerial photographs. In short, the resource manager can complete the entire project himself in a timely manner and, most importantly, for very little expense.

Mapping with small format photographs, however, has major limitations which must be considered: (1) Many photographs are required to cover large areas, particularly at large scales; (2) the geometric accuracy of 35-mm photographs is less than that of standard 22.5 by 22.5 centimetre (9 by 9 inch) format photographs, resulting in scale variation among the photographs, even in areas where the elevation is fairly constant (Clegg and Scherz, 1975); (3) long, perfectly parallel flight lines are necessary to cover large areas and are difficult or nearly impossible to execute, espe-

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cially if the pilot is inexperienced; and (4) correction for displacement and the transfer of photo detail would usually preclude practical use of small-format photographs for mapping because of the large number of frames and the necessary equipment, supplies, and expertise required.

This study was initiated to establish if 35-mm aerial photographs could provide field level resource managers with an inexpensive technique for mapping wetlands. Specifically, the objectives were (1) to develop an inexpensive, practical methodology for mapping relatively small wetlands, and (2) to identify its capabilities and limitations.

Study Methods

The Chowan River swamp in the coastal plain of northeastern North Carolina was used as the study site for developing the methodology discussed in this paper. A recent (1974) U.S. Geological Survey (USGS) 7.5-minute orthophotoquad (quad) was acquired for the study area. Orthophotoquads are prepared from black-and-white aerial photographs which have been rectified to alleviate image displacement due to camera tilt and ground relief. They are produced in the 7.5-minute, 1:24,000-scale map series and contain little or no cartographic information (Southard, 1975). The quad provides an excellent base map upon which many different vegetation communities can be discerned due to changes in gray tone or texture, although the species composition may not be identifiable. Wetland/upland boundaries are frequently apparent due to different species composition and the degree of surface flooding. In addition, the quad is a geometrically correct base upon which mapping may be done directly. Key wetland areas exhibiting tonal/textural differences are identified by examination of the quad. Subsequently, flight lines of 35-mm photographs are then planned to cross these key wetland areas.

The flight plan must specify the scale of the photographs, flight altitude, aircraft direction and speed, the interval between exposures, and film type. Procedures for preparing flight plans for 35-mm photography are detailed by Meyer and Grumstrup (1978). Ideally, the areas covered by the flight lines should be easily accessible to facilitate field checking. If the test areas are long and narrow, preferably near or over easily identifiable landmarks, flight planning will not be complex.

Thirty-five mm color-infrared aerial photography for the Chowan River study area was obtained on a series of flight lines designed to provide complete coverage of a representative sample (approximately five percent) of the wetland types to be mapped in the entire orthophotoquad. In practice, the flight lines should cover as many of the wetland vegetation types as possible and include all of the wetland tone/texture combinations depicted on the quad. In this study it was necessary to compensate for not covering all wetland vegetation types by adding an additional observation flight which facilitated identification of the remaining types.

A Canon AT-1 35-mm camera* with a 50-mm lens and an automatic film advancer was used. A DeHavilland Beaver aircraft with a belly hole was used in this study; however, smaller aircraft are available for less expense and may be used with a side window mount. A side mount can be built or purchased for approximately \$300 (Meyer and Grumstrup, 1978).

The 35-mm photographs were obtained at a scale of 1:6,000 during the fall and winter seasons. Kodak Ektachrome infrared film and a Wratten No. 12 filter were used to provide good separation of the vegetation types (Gammon and Carter, 1979). Examination of the resulting photographs determined which of the vegetation categories were feasible to map. Due to the scale and resolution of the quad, a minimum mapping unit of 1.62 hectares (4 acres) was selected for this study. Photointerpretation of vegetation was supplemented by field checking, literature review, and consultation with colleagues.

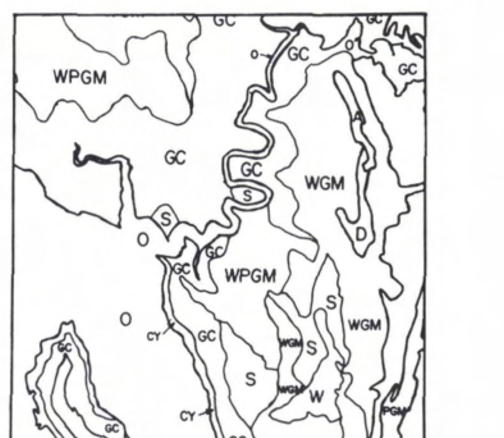

FIG. 1. Portion of final wetland map at 1:24,000 scale (reduced to 1:48,000 scale). (see Table 1 for map symbol explanation).

* The use of brand names in this report is for identification purposes only and does not imply endorsement by the U.S. Geological Survey or Virginia Polytechnic Institute and State University.

The sample photo strips were located and sketched on an acetate overlay placed over the quad. Then the cover types identified on the small format photographs were verified in the field. These sample photostrips were useful in assisting the interpreter in identifying each wetland cover type; however, the final wetland categories used in mapping were determined based upon the vegetation boundaries that were visible and distinct on the quad. Figure 1 shows a portion of the final wetland map delineated from the orthophotoquad. Table 1 gives the map symbols and descriptions of the vegetation categories mapped.

Discussion

The specific methods outlined above can be used to map many types of natural resources besides wetlands. They can be modified to suit particular resource information needs and the land-cover conditions of various areas. The experience gained in this study clearly shows definite advantages in using this method.

Color-infrared film has generally been found to provide good distinction among vegetation categories. Comparisons of photographs obtained during different seasons are useful for identification of some vegetation, particularly in wetlands (Gammon and Carter, 1979; Carter *et al.*, 1979). For the method presented here, the photo transects must cover areas which include all of the resource texture and tone combinations found on the quad. The classification system used must satisfy the resource information needs of the land manager, and the boundaries between the types must be identifiable on the quad. Map accuracy and level of category detail desired, as well as the distinctness of the cover type boundaries on the quad, determine the amount of field checking necessary.

The limitations of this method must also be considered. Orthophotoquads are available for North Carolina but may not be available for areas in other states. The land cover types desired may not be distinct on the black-and-white quad. Furthermore, the photos flown for producing the orthophoquad may not be at the optimum season. At a scale of 1:24,000, areas smaller than 1.01 hectares (2.5 acres) are too small to map and retain clarity; therefore, achieving greater detail may not be possible.

Table 1. Map Symbols and Descriptions of Vegetation Categories

Map Symbol	Vegetation Description
GS	Tupelo gum, Black Gum, Cypress
CY	Cypress
W	Atlantic White Cedar
S	Shrub
PS	Pine Shrub
CS	Grasses (Predominately Cane) Shrub
WGM	Atlantic White Cedar, Black Gum Maple
PGM	Pine, Black Gum, Maple
WPGM	Atlantic White Cedar, Pine, Black Gum Maple
O	open water
A	altered land
A	upland forest

Table 2. Selected Project Costs

Item	Cost
Film (12 rolls)	\$ 48.00
Film Processing	48.00
Aircraft rental and pilot	\$200.00
Supplies	40.00
Drafting	100.00
TOTAL	\$436.00

Finally, costs are often cited as the limiting factor. Table 2 lists the costs for film, film processing, purchase of quads (available from the U.S. Geological Survey), aircraft rental, supplies, and drafting. Salaries and transportation are not included in the cost for this study because, in practice, these costs are variable depending upon personnel involved. Less than five percent of the total area mapped (15,549.3 ha) was flown on the two dates for this study, at a cost of approximately 3¢ per hectare. In other areas, a larger percentage may need to be photographed. The amount of necessary field checking will vary according to the complexity of the area and the suitability of the orthophotoquad. Finally, additional field checking would be needed if an accuracy assessment is conducted. An accuracy evaluation was not conducted for this study.

Summary

A simple, easily implemented, and potentially less expensive method for mapping wetlands has been developed. This method can be modified to map other types of natural resources. Small format color-infrared aerial photographs obtained in key areas permit resource managers to interpret land-cover types directly from orthophotoquads which have uniform and standard scale. Proper flight planning and adequate field experience are essential. This method could potentially be very useful to resource managers where orthophotoquads are available.

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