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Vegetation Mapping with Seasonal Color Infrared Photographs

Winter photographs were necessary for determination of understory and evergreen/deciduous boundaries while fall photographs were essential for separation of deciduous canopy classes in the Great Dismal Swamp.

ABSTRACT: *The Great Dismal Swamp of Virginia-North Carolina is a forested wetland which has been extensively altered by fire, timbering, and ditching. Seasonal high- and low-altitude color infrared photographs of the swamp have been used to identify and map specific swamp vegetative communities. These photographs provided the capability to distinguish among deciduous species, to separate broad-leaved evergreen and deciduous species, to evaluate understory, and to locate several special community types. Comparisons made of data from different seasons frequently helped to distinguish between otherwise obscure classes.*

Vegetative cover classes for the Great Dismal Swamp were defined to provide maximum habitat information for management of the swamp by the U.S. Fish and Wildlife Service. These classes were based on dominant canopy species and type and extent of understory. Forty-three separate canopy designations and 243 specific vegetative communities were distinguished. Class combinations in the map units were ranked by relative dominance as observed on the color infrared photographs.

Evaluation of class accuracy was accomplished by helicopter overflight using sample sites selected by two methods. A canopy or understory map unit was considered correct if at least one of the classes was identified in the field sample. Using this criterion, canopy accuracy was 93.8 percent and understory accuracy was 90.5 percent. A vegetation map was prepared at a scale of 1:100,000 using a U.S. Geological Survey 7.5-minute orthophotomosaic as the base map.

THE GREAT DISMAL SWAMP is an 84,890 ha (210,000 acre) forested wetland located on the Virginia-North Carolina border on the Mid-Atlantic coastal plain. The origin of the swamp, represented by the beginning of organic soil accumulation, has been dated at 9,000 years B.P. (before present) by palynological and radiocarbon methods (Whitehead, 1972). Today, the soils of the Great Dismal Swamp are composed of organic deposits (histosols) varying from a few cm (inches) to 3.7 m (12 feet) in depth in the interior, and of poorly-drained to very poorly-drained mineral soils at the periphery (Reber, oral comm. 1977; Oaks and Coch, 1973). The gradient within the swamp is

PHOTOGRAMMETRIC ENGINEERING AND REMOTE SENSING,
Vol. 45, No. 1, January 1979, pp. 87-97.

slightly less than 19 cm/km (one foot/mile) from west to east. The major surface water inflow is from the west; the surface outflows are to the north, east, and south. The Suffolk escarpment forms the western boundary of the swamp; the Dismal Swamp Canal, a 35.4 km (22 mile) north-south waterway (excavation begun in 1802), forms an effective barrier to eastward drainage and is consequently considered the eastern boundary of the present swamp area. Lake Drummond, approximately 4 km (2.5 miles) in diameter, is almost centrally located within the swamp.

Generally described as a forested wetland, the Great Dismal Swamp contains within its boundaries a remarkable diversity of vegetative communities. Because the swamp lies near the northern or southern limit of many plant species (Meanley, 1973; Carter *et al.*, 1977), the vegetative composition includes a variety of both deciduous and evergreen, broad-leaved and needle-leaved tree species, and evergreen and deciduous shrubs, vines; and herbaceous plants. Tables 1 and 2 list the scientific and common names of the major canopy and understory species in the Great Dismal Swamp (Musselman *et al.*, 1977). Scientific nomenclature follows Radford *et al.*, 1968. The geographically-induced community diversity has been modified by the effects of fire, timbering, ditching, road building, and changes in water availability. The long-term impact of these imposed changes upon the vegetative composition has not yet been determined; however, at present, the traditional southern swamp species such as cypress, water tupelo, and Atlantic white cedar have been largely replaced as canopy dominants by red maple, sweetgum, and pine (Whitehead, 1972).

The U.S. Fish and Wildlife Service (USFWS) has acquired 21,450 ha (53,000 acres) of the Great Dismal Swamp for incorporation into the National Wildlife Refuge System and has recommended an additional

TABLE 1. LIST OF MAJOR TREE SPECIES IN THE GREAT DISMAL SWAMP

Needle-leaved Deciduous

Taxodium distichum (L.) Richard—bald cypress

Broad-leaved Deciduous

Nyssa aquatica L.—water tupelo
N. sylvatica Marshall—black tupelo
Acer rubrum L.—red maple
Fraxinus pennsylvanica Marshall—red ash
F. caroliniana Miller—water ash
Liquidambar styraciflua L.—sweetgum
Liriodendron tulipifera L.—yellow poplar
Quercus nigra L.—water oak
Q. laurifolia Michaux—laurel oak
Q. michauxii Nuttall—swamp chestnut oak
Fagus grandifolia Ehrhart—American beech

Needle-leaved Evergreen

Pinus taeda L.—loblolly pine
P. serotina Michaux—pond pine
Chamaecyparis thyoides (L.) BSP.—Atlantic white cedar

Broad-leaved Evergreen

Magnolia virginiana L.—sweet bay, swamp magnolia
Persea borbonia (L.) Sprengel.—red bay

TABLE 2. LIST OF MAJOR UNDERSTORY SPECIES IN THE GREAT DISMAL SWAMP

Deciduous Shrubs

Clethra alnifolia L.—sweet pepperbush
Vaccinium corymbosum L.—high bush blueberry
Leucothoe racemosa (L.) Gray—fetter-bush
Itea virginica L.—virginia willow
Lyonia ligustrina (L.) DC.—male-berry

Evergreen Shrubs

Magnolia virginiana L.—sweet bay, swamp magnolia
Persea borbonia (L.) Sprengel.—red bay
Ilex opaca Aiton—American holly
I. glabra (L.) Gray—inkberry
I. coriacea (Pursh) Chapman—sweet gallberry
Leucothoe axillaris (Lam.) D. Don—leucothoe
Lyonia lucida (Lam.) K. Koch—fetter-bush

Deciduous Vines

Smilax walteri Pursh.—greenbrier
S. rotundifolia L.—greenbrier
Lonicera japonica Thunberg—Japanese honeysuckle (semi-evergreen)
Anisostichus capreolata (L.) Bureau—cross vine (semi-evergreen)
Campsis radicans (L.) Seemann—trumpet vine
Mikania scandens (L.) Willd.—climbing hempweed
Decumaria barbara L.—climbing hydrangea

Evergreen Vines

Gelsemium sempervirens (L.) Aiton f.—yellow jessamine
Smilax laurifolia L.—greenbrier
S. glauca Walter.—catbrier (semi-deciduous)

Grasses

Arundinaria gigantea (Walter) Muhl.—switch cane
Calamagrostis cinnoides (Muhl.) Barton—reed grass

28,350 ha (70,000 acres) for public ownership. The USFWS has the responsibility for evaluating this wetland ecosystem and developing management priorities for the primary 49,815 ha (123,000 acre) unit. Management plans must be based in part upon an understanding of the vegetative communities, i.e., their origins, their successional trends, their interrelationships, and their response to outside pressures and manipulation. The initial step toward this understanding is documentation of the present vegetative composition of the Dismal Swamp.

The concept of vegetation mapping is not a new one. Prior to the turn of the century, maps depicting the vegetation of an area were being produced in Europe and the United States (Kuchler, 1967). These early maps were prepared by a variety of ground sampling methods; rapid advances in the field of vegetation mapping have resulted from the development of aerial photographic techniques.

Research and improvements in aerial cameras, films, and filters have made it possible to produce detailed vegetation maps of large or inaccessible areas with a great reduction in field checking time. Vegetation patterns, boundaries, and the areal extent of vegetation types can often be more accurately assessed with aerial perspective than with traditional ground sampling methods (Kuchler, 1967). The development of color infrared (IR) film with high resolution and good atmospheric haze penetration has made the use of small-scale, high-altitude photographs practical and economical. Recent studies have demonstrated the utility of color IR photographs for mapping forested wetlands (DeSteiger, 1975; Carter and Stewart, 1977; Nielsen and Wightman, 1971).

Because the Great Dismal Swamp is large, inaccessible, and possesses a complex vegetation, color IR photographs were used for identifying and mapping its vegetation. The objectives of this study were to (1) identify and map the vegetative communities of the Great Dismal Swamp by using seasonal color IR photographs, and (2) document the procedures and methods utilized in the process.

Identification of Vegetation Classes

DATA SOURCE

Color IR photographs were the primary data source for vegetation mapping. Table 3 lists the date of acquisition, scale, and quality of available photographs, all of which were in the form of 22.5 by 22.5 cm (9 by 9″) positive film transparencies. Some color prints were made for field use from selected transparencies.

DEVELOPMENT OF VEGETATION CLASSES

The need for maximum habitat information dictated a detailed description of the vegetation, including both the canopy and the understory. The vegetation classes were defined at the most discrete level possible based upon the extent of separation on the color IR photographs. The following outline illustrates the separation of very general

TABLE 3. COLOR IR PHOTOGRAPHY OF THE GREAT DISMAL SWAMP*

Date of Acquisition	Scale	Remarks/Quality
September 23, 1970	1:20,000	Very poor color, little contrast.
July 19, 1972	1:130,000	Cloud cover over southern portion.
August 19, 1972	1:130,000	Extensive cloud cover; poor resolution.
December 2, 1972	1:130,000	Very good
November 1, 1973	1:130,000	Very good
September 10, 1974	1:65,000	Good quality, but only three frames in strip across lake.
October 22, 1974	1:21,000	SW ⅓ to ½ of each frame very dark; good coverage, overlap alleviates some frame darkness.
February 22, 1975	1:65,000 1:130,000	Excellent
March 26, 1975	1:23,000	Generally good; missed large strip of eastern side due to wandering flight lines.

*Additional information available through USGS Suffolk Field Unit, Great Dismal Swamp National Wildlife Refuge.

categories such as evergreen and deciduous into the final definite classes:

Vegetation	*Class Symbol*
I. Evergreen	
A. Needle-leaved	
1. Pine	(P)
2. Atlantic white cedar	(W)
B. Broad-leaved	
1. Trees	(E)
2. Shrubs	(I)
3. Vines	(S)
II. Deciduous	
A. Over standing water	
1. Cypress	(C)
2. Tupelo	(G)
B. Transition—wet to dry, Maple	(M)
C. Over dry ground	
1. Yellow poplar	(Y)
2. Beech	(B)
D. Understory (visible only under deciduous trees)	
1. Deciduous	(d)
2. Evergreen	(e)
3. Grass	(g)
III. Altered	
1. Agriculture	(Aa)
2. Burned	(Ab)
3. Cut-over	(Ac)

The final vegetative cover map (Figure 1) shows ten canopy classes, three understory classes, and three altered vegetation classes. The explanation lists the map symbols and species descriptions for each class.

Only the pine (P), Atlantic white cedar (W), and cypress (C) classes are limited to individual species. The remainder of the canopy classes are composed of two or more species which are frequently associated. The class symbol used for these associations reflects the indicator species as discernable on the photography. For example, yellow poplar is the indicator for the class Y which incorporates yellow poplar, sweetgum, and maple. Red maple is found throughout the swamp under all moisture conditions and is associated with all other species. Because of its frequent dominance, red maple is given the class designation M with tupelo and ash as subdominants. Maple is also listed as a subdominant in the Y class and has implied subdominance in all other classes (Fowells, 1965).

The understory classes are limited to evergreen, deciduous, and grass (e. d. g. respectively). Individual species could not be separated on the color IR photographs. The understory designation is further restricted to areas of predominantly deciduous canopy, since understory cannot be observed under the year-round evergreen cover. Altered vegetation classes were established to describe agricultural areas, burned areas, and clear-cut areas, (Aa, Ab, Ac, respectively) within the swamp boundaries. The clear-cut and burned sites are in various stages of regeneration, and often contain grasses or mixed evergreen shrubs and deciduous saplings.

Very few areas in the swamp consist of a single canopy and understory class; therefore, combination of classes to form a map unit was usually necessary. The map unit included the canopy and understory classes in order of relative dominance as interpreted from aerial photographs. For example, cypress, water tupelo, and black tupelo frequently occur together (GC-tupelo dominant); however, cypress and either species of tupelo may also be found with the maple class (MCG, GM, or MG). Similarly, Atlantic white cedar, although typically occurring in dense, pure stands (W), is also frequently mixed with maple (WM or MW) due to selective timbering practices or local environmental conditions. Using the classes in combination resulted in 43 separate canopy designations and 243 specific vegetative communities (map units).

PHOTOINTERPRETATION

Photointerpretation was based in part on the interpreter's prior knowledge of the Dismal Swamp vegetation and previous use of the photographs for other field work. During mapping, field checks were made to clarify points of confusion or identify unusual "signatures" by using fixed wing aircraft, helicopter, and ground survey.

Photographs taken during different seasons facilitated class separation to the greatest detail possible. They were necessary for distinction among deciduous species, separation of broad-leaved evergreen from deciduous species, elucidation of understory types, and the location of several unusual communities. Seasonal comparisons frequently assisted in distinguishing otherwise obscure classes. Table 4 illustrates the season of photography most effective for specific class determinations and Table 5 privides a photographic color key for each vegetation class.

Winter and early spring photographs provided the best separation for all but one

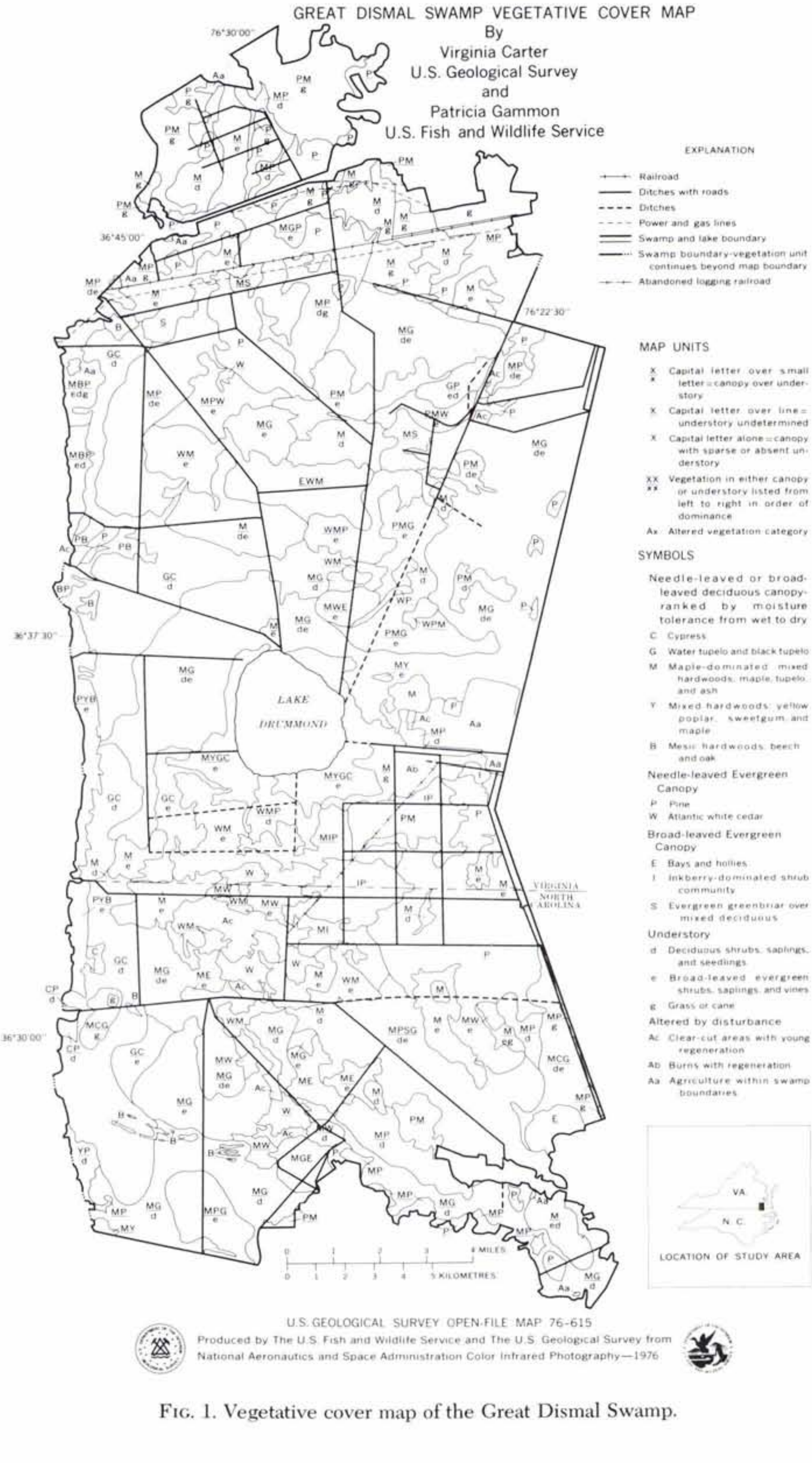

FIG. 1. Vegetative cover map of the Great Dismal Swamp.

TABLE 4. USE OF SEASONAL PHOTOGRAPHS TO SEPARATE VEGETATION CLASSES

Class	Fall Photographs (October, November)	Winter/Early Spring Photographs (December, February, March)	Summer Photographs (July, August, September)
C	Good separation	Not separable from other deciduous species; usually in areas with standing water	Cannot be separated from pine
G	Good separation; only leafless deciduous species	Not separable from other deciduous species; usually in areas with standing water	Cannot be separated from other deciduous species
M	Can be separated from G or C and from large homogeneous stands of other species; occurs throughout swamp mixed with all other classes	Not separable from other deciduous species; often identified by association with grass understory	Not separable from other deciduous species
Y	Can be separated from other deciduous species; compare with winter to separate mature age class from pine	Not separable from other deciduous species; not usually in areas with standing water	Not separable from other deciduous species
B	Can be identified by color and texture	Can be identified but sometimes confused with other deciduous with grass understory	Not separable from other deciduous species
P	Confused with broad-leaved evergreen; texture differences are useful for separation	Confused with broad-leaved evergreen; texture differences are useful for separation	Can be separated from all except C; boundaries are indistinct because stands are not homogeneous
W	Good separation	Good separation	Fair separation; boundaries are indistinct where stands are not homogeneous
E	Can be separated from *Ilex;* not easily separated from *Smilax* or other deciduous classes except G and C	Confused with evergreen understory	Not separable from other deciduous classes except C
I	Good separation by color and texture	Good separation by color and texture	Confused with class S
S	Not separable from class M or E	Not separable from pine	Separable from everything except class I
d	Only distinguishable under class G and C	Good separation	Not separable
e	Not separable	Good separation	Not separable
g	Not separable	Good separation	Not separable except where no canopy exists

evergreen class. These classes could be distinguished on the basis of red or pink hue, texture, height, and occasionally relative location. For example, Atlantic white cedar (W) has a distinctive maroon color which remains consistent even when mixed with other classes, permitting easy separation. The pine class (P), on the other hand, has a pink hue which is similar to the broad-leaved evergreen class (E). These two classes could be separated on the basis of textures and, on occasion, by height. The

TABLE 5. COLOR KEY FOR VEGETATION CLASSES FOR EACH DATE OF PHOTOGRAPHY*

Class	Oct. 22, 1974	Nov. 1, 1973	Dec. 2, 1972	Feb. 22, 1975	Mar. 26, 1975
C	yellowish-tan	blue to blue-green	deep blue	deep blue with gray-green tinge	deep blue
G	blue	blue	deep to medium blue	deep blue, grayish tinge	deep blue
M	bright red	red	blue to bluish-pink dependent upon understory	gray-blue to pink (understory)	blue, blue-gray, bluish-pink (understory)
Y	pale pink with scattered yellowish-tan	pale pink to red	blue to pink (understory)	light gray-blue, mottled with pink	medium blue to blue-gray heavily mottled with pink
B	brownish-yellow	mottled-pink, red, lavender	light blue-gray, not consistent	light gray to pinkish-tan	light blue-gray
P	pale pinkish-lavender	dark red	purplish-red	rose-pink to dull reddish-pink	dark rose-pink to dull red
W	maroon	maroon	maroon	maroon	maroon
I	bright pink	bright red	light bright pink	bright pink, smooth texture	bright pink, smooth texture
S	red	red, lumpy texture	bluish-pink, lumpy texture	pinkish-red, similar to pine but brighter	dull rose-pink
E	dull red	dull red, smooth texture	bluish-pink, smooth texture	bright pink	bright pink to dull rose-pink
Ac	red to gray-blue	dull red, blue or pink	red to blue	bright pink to blue	pinkish-purple
Ab	bright pink to blue	bright pink to blue	red to blue	dark gray-blue, smooth texture	not visible
Aa	gray-blue to blue-green	blue to gray	light gray-blue	light gray-blue to light pink	purple, blue or white
e	not visible	not visible	dull red	light pink to dull red	dull red
d	not visible	not visible	blue	blue to blue-gray	blue
g	not visible	not visible	blue to light gray-blue	pinkish-gray to bluish-gray	light blue-gray

Class	July 19, 1972	Aug. 19, 1972	Sept. 10, 1974	Sept. 23, 1970
C	purple	medium to dark lavender	pink to light purple	gray-blue, not distinct
G	purple to red, not consistent	pinkish-lavender, not very consistent	gray-blue mixed with pink	gray-blue, gray-pink or blue-green, not consistent
M	red	deep pink, not distinct	red	gray-pink
Y	pinkish-red, lumpy	purplish-pink	red	gray-pink
B	red	pink	red to pink	gray-pink
P	dark purple	medium to dark lavender	gray-pink to pale lavender	blue
W	purplish-black, blue-black in dense stands	very dark purple	almost black	dark blue

(continued on following page)

TABLE 5—*Continued*

Class	July 19, 1972	Aug. 19, 1972	Sept. 10, 1974	Sept. 23, 1970
I	bright pink, smooth texture	not visible on photography	red, smooth texture	grayish-blue to pink
S	bright pinkish-red, slightly lumpy texture	bright pink	not visible	grayish-pink
E	light reddish-purple	pinkish-purple, not very distinct	lavender, similar to pine, smooth texture	dull blue-green
Ac	bright pink	light pink	not visible	light blue to bluish-pink
Ab	bright pink to purple	bright pink	pink to bluish-pink	light blue to bluish-pink
Aa	pink to purple	not visible	blue to pink	blue-green or bright pink
e	not visible	not visible	not visible	not visible
d	not visible	not visible	not visible	not visible
g	not visible	not visible	not visible	not visible

* Texture included where useful for separation of classes.

Smilax class (S) was indistinguishable from pine (P) on the winter and fall photographs; however, on the summer photographs, it appears as a bright red-pink in an otherwise dull red signature. Although needle-leaved evergreen classes (P and W) could be determined on fall photographs, their boundaries were more difficult to define, especially in areas of mixed evergreen and deciduous classes.

Identification of deciduous classes was accomplished by comparing photographs of different dates. Initial examination of winter data allowed separation of deciduous areas which are inundated from those which are dry. Reviewing each of these areas on fall photographs often made species identification possible. For example, two distinct colors are visible on fall data in the areas where water stands during the winter. These can be identified as cypress (C) and tupelo (G), two classes which occur on very wet sites. These two classes also occur in areas of the swamp that are obviously wet on the winter photographs; however, once the "signature" has been established by comparing winter and fall data, these classes can be located based on their color on the fall photographs. Separation of the deciduous classes associated with drier (mesic) areas can be accomplished in the same manner.

Because maple occurs throughout the swamp in all environmental conditions (wet or dry), determination of the canopy class dominated by maple (M) presented special problems. Again, comparison of the winter and fall photographs located all deciduous areas (winter) and allowed separation of specific deciduous classes (fall). After identification of other deciduous classes, the maple class occupied the remaining deciduous areas.

Understory classes under predominantly deciduous canopy could be determined only on winter photographs. The evergreen canopy areas were too extensive to allow field checking for understory type, and it was not possible to field check sample areas and extrapolate color tone or texture as in the case of deciduous canopy areas. On the other hand, sparse or absent understory could be separated from deciduous understory with the aid of field checks. The most difficult distinction to make was whether broad-leaved evergreen classes were in the canopy (E) or understory (e), especially in areas containing class mixtures. This was partially resolved by noting differences in texture or height and by field checks.

MAP PREPARATION

MAP BASE AND SCALE

Recent (1974) U.S. Geological Survey (USGS) 7.5-minute orthophotoquads were available for the entire swamp. 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 standard map series and contain little or no cartographic treatment (Southland, 1975).

A 1:100,000-scale mosaic, prepared by the USGS from the 16 orthophotoquads containing the Dismal Swamp area, was utilized as the base map for the vegetation map. This mapping scale was selected primarily because of the size of the Dismal Swamp and the decision to reduce the final map for printing on legal size (21 by 35 cm [8½ by 14"]) paper. Maximum utility of the map dictated using a size which could be inexpensively reproduced in quantity and which was small enough for easy reference in the field. A scale larger than 1:100,000 would contain a greater degree of detail than could be reduced to legal paper size and still retain clarity. Vegetation patterns might also be obscured on a highly detailed, large-scale map.

BOUNDARY DETERMINATION

Abrupt changes in vegetative composition (vegetation boundaries) were visible on the black-and-white orthophoto base map, and these boundaries could be easily delineated on the overlay. Pure Atlantic white cedar stands or cedar mixed with deciduous trees were quite evident. Clear-cut areas, some boundaries between evergreen and deciduous canopy, and some very wet deciduous areas are discernable on the mosaic. In many cases, vegetation boundaries not immediately evident on the base map could be discerned on the color IR photographs. Once a boundary had been identified on the IR photograph, close examination of the base map would sometimes reveal a faint change in gray tone or texture which allowed for proper boundary placement.

In many areas the change in vegetation is gradual and it is difficult to establish a precise boundary. This is especially true where there is a change in degree of evergreen understory under deciduous canopy or where a different deciduous tree species becomes dominant. In areas where no clear boundary was evident on the base map or on the photographs, the interpreter placed the boundary according to best judgement.

METHODS OF TRANSFER TO BASE MAP

A sheet of stable-base drafting film was overlayed on and registered to the orthophotomosaic. Using a light table, classes were interpreted from the color IR photographs and delineated on the drafting film at the scale of the base map. Interpretation of the vegetation classes on the color IR photographs was facilitated by optical magnification up to 7× and by use of a mirror stereoscope. Roads, ditches, and other physical features were indicated on the map to serve as reference points both during map preparation and for later map utilization.

MINIMUM MAPPING UNIT

The minimum mapping unit, identified as the smallest area contained within a vegetation boundary, was approximately 9 ha (22 acres). Although the recognizable or interpretable limit of a 1:130,000-scale photograph is an area less than 1 acre in size (Carter *et al.*, 1977), this degree of detail would lose definition with reduction to legal size. For this reason, small blocks of different classes were grouped into one larger map unit or were incorporated into an adjoining map unit. This situation occurs most frequently in areas where cedar or pine have been cut and tree regeneration has resulted in a mixture of evergreen and deciduous species. For example, in an area south of Lake Drummond, numerous small stands of Atlantic white cedar were not cut during a logging operation in the 1930's. Deciduous species (primarily maple) and cedar have regenerated in the cut areas. The cedar stands are too small to be mapped individually but too frequent to be ignored; therefore, the area is assigned as a single map unit (WM).

The 9 ha (22 acre) minimum mapping unit was not applied to several very small areas which were recognized to be of special interest and worthy of being indicated on the map. These include small mesic areas (B) located in the swamp interior, the only marsh (g), and several small agricultural areas (Aa) within the swamp boundary.

CLASS ACCURACY EVALUATION

There appears to have been very little emphasis placed on class accuracy of vegetative cover maps until quite recently; therefore, development of methods and criteria for evaluation of accuracy are still in the experimental phase. Design of the sampling procedure for the Great Dismal Swamp Vegetative Cover Map was accomplished within the constraints of inaccessibility of many areas within the Swamp and the mixtures of species.

Accuracy evaluation was conducted in October, 1976 using a helicopter. A fall date was selected because class identification was facilitated by leaf color changes and variable leaf-drop of different species. Sampling sites were selected near interior swamp roads because these points could be precisely located by map measurement and ground measurement. Two methods were used for site selection:

(1) Points were selected at 2.4 km (1.5 mile) intervals along accessible roads in the southern half of the swamp. These points were marked by placing a large square of orange plastic in the center of the road. Evaluation of species composition inside a 8 ha (20 acre) plot on either side of the road at these points was accomplished by helicopter overflight.
(2) Because time limitations did not permit the northern roads to be marked prior to the flight, a second method was devised for point selection. Small paper bags were filled with lime powder and a weight tied with a long piece of orange flagging. Bags were dropped onto roads from the helicopter at points designated by a person unfamiliar with the vegetation map. The paper bag broke upon ground contact and the lime scattered in a large, easily visible pattern. The flagging provided a secondary location mark in the event adequate lime dispersal did not occur. Evaluation of species composition was carried out as in method 1. The day after the flight, the lime drop points were located on the ground and ground measure was made from a known point, either a road intersection or the preceeding lime mark on the same road.

Forty-nine points were established by these two methods and were plotted on the vegetation map. These points provided 97 sample plots for accuracy evaluation consisting of a 1.57 percent sample size (based on 49,815 ha [123,000 acres]). One sample plot had been timbered between map preparation and sampling; therefore, it was eliminated for the accuracy evaluation.

A canopy or understory map unit was considered correct if at least one of the classes was identified in the field sample. Using this criterion, the canopy accuracy was 93.8 percent and the understory accuracy was 90.5 percent. Because, in the mapping process, species were grouped into canopy classes and small blocks of a class were often included within a much larger map unit, it was considered unreasonable to assume or require that all classes in the map unit be found in an 8 ha (20 acre) test block. The sample plot might fall within one of the small blocks or might reflect the uneven distribution of classes within a photointerpreted map unit. Although sampling by low-altitude overflight allows the interpreter to assess the sample in the same perspective as used in photointerpretation (i.e., vertical perspective based on areal extent of cover), it involves subjective judgement of class dominance and the ability to identify species from a distance. This technique, however, permitted the sample plot size to be much larger (8 ha [20 acres]) than would have been possible using a ground-based method.

Occasionally a class was identified in the sample plot that in effect was of insignificant coverage to have been noted in the map unit. For example, at one sample site, the canopy map unit is M; however, the sampled map unit was called MP. Although pine is present in the area, it was not considered to be a significant amount to be included in the photointerpreted map unit.

The understory evaluation posed several problems. Evergreen understory is much more visible than deciduous understory and there was a tendency to over-emphasize the evergreen class during the sampling. In many cases, the ed or de designation on the vegetation map was called only e in the sampling. This error may also exist on the vegetation map, due to the same over-emphasis of evergreen understory during the photointerpretation. An occasional problem arose in the assignment of broad-leaved evergreen species to canopy (E) or understory (e). This was a consistent problem throughout the photointerpretation and remained so during the accuracy sampling.

Several additional observations were made during the overflight sampling. The M class contained a larger quantity of water tupelo or black tupelo than was expected. The frequent inclusion of G in the field sampling where it was not included on the map, usually in combination with M, suggests that the mixture of maple and tupelo gum is more frequent than previously realized. When the species are evenly interspersed, the presence of tupelo is difficult to determine on the color IR photographs. It was also observed during the evaluation that sweetgum is a major component of the M class as well as the Y class. Sweetgum, like maple, occurs throughout the swamp, although in lesser amounts, and is a species which has attained significance as a result of past alterations.

Summary and Conclusions

Vegetative cover classes for the Great Dismal Swamp were defined to provide maximum habitat information for management of the swamp by the U.S. Fish and Wildlife Service. Canopy and understory class assignments are based upon the extent of separation on color IR photographs. These classes were used in combination, resulting in 43 separate canopy designations and 243 vegetative communities (map units).

Seasonal photographs were essential for identification and mapping to the desired level. Winter and fall photographs provided the majority of information on the vegetation classes. Winter photographs were necessary for determination of understory and evergreen/deciduous boundaries. Fall photographs were essential for separation of deciduous canopy classes.

The Great Dismal Vegetative Cover Map has been published by the U.S. Geological Survey as Open-File Map 76-615 (Carter and Gammon, 1976). Copies of the map in legal size format are available at the Great Dismal Swamp National Wildlife Refuge office.

The Vegetation map was intended to serve several purposes: (1) to provide a basic information source for research projects conducted in the swamp, (2) to describe the present vegetation in order to assist in identification of management areas, and (3) to provide a record of present vegetation as a base for future monitoring of vegetation change. The 1:100,000-scale format permitted the availability of the map to any interested persons and assured that major vegetation patterns can be discerned for management purposes. To supplement this map and to provide additional detail, a series of 1:24,000-scale maps is being prepared. These will be retained in the original scale as overlays on orthophotoquads and will be available for reference.

As additional photography becomes available and as field checking continues, changes will be made in class assignment and class placement in a map unit. As a result of the accuracy evaluation, problem areas already have been identified and work will proceed to improve this map and future maps. A completed vegetation map should not be considered as a final statement of the vegetation of an area. The very nature of vegetation is one of change and progression from one stage to another. The vegetative cover map is, in actuality, a beginning, a base upon which new facts may be established and changes may be made in order to constantly expand our knowledge of the Great Dismal Swamp.

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(Received April 27, 1978; accepted August 2, 1978)