J. Scott Seher
Paul T. Tueller
University of Nevada
Reno, Nevada 89507

Color Aerial Photos for Marshland

Color and color-infrared aerial photographs were used to evaluate Nevada's marshlands.

Abstract: *Color and color-infrared aerial photographs of waterfowl habitats was studied to determine its usefulness for marsh vegetation evaluation. Attempts were made to determine the optimum film type, scale, time of day, and time of year for best results. Both color and color-infrared films proved to be valuable for marsh evaluation. The larger scales (1:1,000) showed interpretation results with more accuracy than did smaller scales (1:10,000); however, coverage was limited with large-scale photographs. Early-morning photographs were found to be the most interpretable as sun-spot and wave effects were not prominent. The best time of year to photograph marsh vegetation was found to be late summer (Aug.-Sept.) when the submerged and floating plants were at a stage of maximum vegetative development.*

Introduction

The large expanse of wetland habitats and the extreme inaccessibility of the interior of these areas makes proper ground inventory and evaluation difficult, time consuming, expensive and, many times, quite inaccurate. Many records of seasonal and yearly marsh changes are recorded only in the memory of the manager. As time goes on, the manager is likely to forget certain past vegetation situations or possibly be moved to a new management area. Therefore, large and intermediate scale 70-mm color aerial photographs have been tested as an inexpensive, accurate, fast, and easy-to-use supplement for ground inventory and evaluation of aquatic vegetation. Aerial photographs can be used to record permanently seasonal and yearly marsh changes and to supplement evaluation of treatments and management practices.

Only recently have aerial photographs been used to any large extent for aquatic vegetation evaluation. Schneider (1966) used panchromatic and color aerial photographs at scales of 1:20,000 to 1:57,000 taken of the Florida Everglades to aid inventory of this vast area. A clear delineation of fresh-water marsh could be made from brackish marsh types at these small scales. He concluded that aerial photographs were useful for making generalizations about hydrologic conditions of the Everglades. Schneider (1968) later found that the color-film types were better adapted for water resource studies than were panchromatic types. This study used larger scales of 1:18,000 to 1:12,000 and found color film to have good water penetration qualities. He was able to discriminate marsh vegetation communities quite easily. Kolipinski *et al.* (1969) were successful in identifying broad vegetation types and two water depths from multispectral aerial photographs.

Olson (1964) completed a study of coastal marsh vegetation using aerial photographs for species identification. Eleven vegetation types of Merrymeeting Bay, Maine, were photographed with four film types (two panchromatic and two color types) and three scales (1:5,000, 1:12,000, and 1:20,000). A photo interpretation test was designed and employed using 8 interpretation areas and 7 interpreters with 4 separate levels of experience. No significant difference was found between film types; however, the color films used in this study (1957) were inferior to the newer aerial color film. As the scale increased, the accuracy of interpretation also increased. A much larger increase in accuracy was realized with a change from a scale of 1:20,000 to one of 1:12,000 than a change from 1:12,000 to 1:5,000.

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Olson (1954) also attempted to determine marsh plant density from aerial photographs. He was unsuccessful in using aerial photographs to assign broad density categories to marsh vegetation.

METHODS

Four Nevada marsh areas managed for waterfowl production were selected for this study. The four areas were the Ruby Lake National Wildlife Refuge, the Stillwater Wildlife Management Area, the Mason Valley Wildlife Management Area, and the Kirch Wildlife Management Area. An attempt was made to obtain a good cross section of all the major marshland species and associations occurring in Nevada.

Seven large-scale photo transects were selected on the four management areas. Detailed vegetation maps were made on transects varying in length from 200 to 700 ft. Field maps were later compared to 1:1,000-scale color and color-infrared photographs to obtain accurate photographic maps of each transect.

Individual frames of intermediate scale (1:10,000) color and color-infrared positive transparencies were taken into the field for ground interpretation. Field vegetation notes were written on thin acetate transparency protectors. A variable 4.5×9-power hand lens was used for magnification of the photo transparencies; however, no field stereoscopic viewing was attempted. The vegetation notes were later used in the laboratory to map vegetation accurately at a scale of 1:10,000. Identifiable vegetation types or plant communities were outlined on acetate overlays using several sizes of Rapidograph pens. These vegetation maps were later transferred from acetate to drawing paper.

Sequential color-infrared photographs were taken during the growing season to aid species identification and vegetation mapping. Different plant species tend to reflect differently in the infrared region of the electromagnetic spectrum during various phenological stages (Sayn-Wittgenstein, 1961; Haefner, 1967). Sequential photographs, therefore, should show different infrared tones for the different plant species, thereby enhancing species identification seasonally.

Transect ground markers were designed and constructed to direct the aircraft over seven large scale transects, to mark the beginning and end points of each transect, and to make scale determinations possible. The ground markers used were constructed of white 2x4-ft. plywood sheets attached to an 8-ft. *T*-type fence post leaning 45 degrees down the flight path (Figure 1). Three white plywood markers (2×0.5 ft.) were placed at one end of each transect and spaced 10 ft. apart for scale determinations.

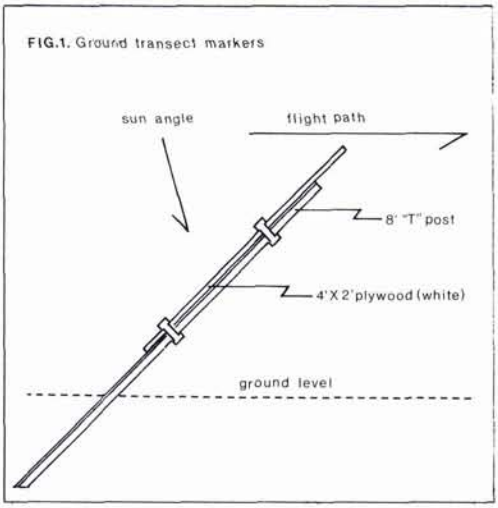

FIG. 1. Ground transect markers.

Vegetation cover was determined on the seven large-scale transects by both field and photographic methods. A three-step method for measuring range condition and trend has been described by Parker (1951). One step of this method employs the use of a ¾-inch loop for vegetation cover at 1-ft. intervals along a 100-ft. transect. Percent of vegetation cover is tallied along the 100-ft. transect to give a vegetation cover percentage for each plant species.

One step of the Parker method was used with gross modification to adapt it to both ground and photo analysis. The first modification was that the loop size was increased to 6 inches. The 6-inch loop size was selected because (1) it approximates the photo resolution unit at the scale of 1:1,000, (2) it is about the smallest size vegetation unit that can be identified at a scale of 1:1,000, and (3) it is the ground size of a point made by a 00-size Rapidograph pen (the smallest available for this study) on the 1:1,000 scale photographs.

Each of the seven large-scale transects were divided into several 100-ft. subtransects. A vegetation sample of 50 loop points was taken on each of these subtransects, which were spaced 46.9 ft. apart. This spacing provided three equally spaced lines on each 70-mm frame. A total of 93 100-ft. subtransects were analyzed with 4650 loop points checked.

Ground *hits* were recorded by the name of the feature most abundant within the area of the 6-inch loop. Floating or submerged vegetation was recorded as a *hit* only if it comprised the major portion of the area of the loop from the surface to 1 inch below the surface. Loop points were located at 2-ft. intervals. Percent cover of marsh species was determined by multiplying the number of *hits* in each 100-ft. line by 2.

Vegetation cover was also determined from large-scale aerial photographs using similar methods. Acetate overlays were placed on the photo transparencies, and individual subtransect lines were measured and drawn. The 100-ft., 50-ft., and 10-ft. marks were drawn onto the subtransect lines. Templates were constructed with 2-ft. tick marks (representing the 6-inch loop points) and were moved along the major transect lines. All measurements were adjusted to the exact scale of the transect. Both color and color-infrared film types were analyzed. All ground data (maps, personal familiarity, and photo notes) except actual ground transect data were used to identify the marsh vegetation.

Color and color-infrared photographic keys (Tables 1 and 2) were constructed to aid the

TABLE 1. VEGETATION KEY CONSTRUCTED FOR USE WITH COLOR FILMS

- *A*. Vegetation emergent or upland; if growing in water, height over six inches . . . . *B*
  - *B*. Texture coarse to very coarse on large-scale photography, medium on intermediate scale . . . . *C*
    - *C*. Color dark olive (108) to dark olive green (126); texture coarse, medium at intermediate scale; height medium, shadow distinct only at large scale; pattern normally broken; plants rooted on dry land and normally away from water; spikelets slightly visible at the larger scales . . . . 1. *Scirpus páludosus*
    - *CC*. Color dark-gray green (151) to very dark green (147); texture coarse at all scales; height tall; shadow distinct; pattern continuous in irregular shaped stands or radiating in clumps; brown spikelets visible at large scale; plants normally rooted in or very near the water . . . . 2. *Scirpus acutus*
  - *BB*. Texture medium or fine . . . . *C*
    - *C*. Color Greenish Yellow, Olive, or Yellow Green . . . . *D*
      - *D*. Color solid yellow green (117) to medium olive green (125); texture fine; height short; shadow not distinct; pattern continuous in pure stands, normally near water . . . . 3. *Eleocharis macrostachya* 3. . . .
      - *DD*. Color light yellow green (119) to medium yellow green (120); texture medium; height medium; shadow slightly distinct; pattern more or less continuous . . . . 4. *Distichlis stricta*
      - *DDD*. Color dark olive (108) to dark gray olive (111); texture normally medium; height medium; shadow not distinct; pattern continuous or broken, normally forming a band of vegetation along water bodies . . 5. *Juncus balticus*
    - *CC*. Color Green or Yellowish Green . . *D*
      - *D*. Plants forming large solid stands on dry land; texture medium or fine; color light greenish gray (154) to medium green (145); height medium or short; pattern continuous; shadow not distinct. . 4. *Distichlis stricta*
      - *DD*. Plants forming bands near water; color brilliant green (140); height medium; texture fine to medium; shadow not distinct; pattern continuous in a strip of vegetation. . 6. *Scirpus americanus*
- *AA*. Vegetation submerged or floating, if floating height less than six inches and areas of water visible between mats . . . . *B*
  - *B*. Color Greenish-yellow, Yellow Green, or Yellowish Green; plants with floating leaves . . . . *C*
    - *C*. Color deep yellow green (118) to solid yellow green (117); plants forming coarse textured mats; pattern usually broken . . . . 7. *Polygonum natans*
    - *CC*. Color gray greenish yellow (105) at large scale, light yellow green (119) at intermediate scale; plants forming very large floating mats of continuous vegetation; water only slightly visible between mats; texture fine to medium . . . . . 8. *Potamogeton natans*
  - *BB*. Color Green to Brown; plants floating or submerged . . . . *C*
    - *C*. Color dark gray green (151) when floating, very dark green (147) when submerged; texture medium; pattern broken (floating) or continuous (submerged . . 9. *Potamogeton pectinatus**
    - *CC*. Color medium brown (58) to medium olive brown (95); plants always submerged; texture coarse to medium; pattern broken and clumpy 10.*Myriophyllum evalbescens*

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* At the Stillwater area, this plant is either *Potamogeton pectinatus* or *Potamogeton latifolius*.

TABLE 2. VEGETATION KEY CONSTRUCTED FOR USE WITH COLOR INFRARED FILMS

A. Vegetation emergent or upland; if growing in water, height over six inches ....*B*

B. Texture coarse to very coarse on large scale, medium on intermediate scale ..*C*

C. Texture coarse to medium coarse; color deep red (13) at large scale, dark red (16) to very deep red (14) at intermediate scale; pattern normally broken; plants rooted on dry land and usually away from water; spikelets slightly visible at large scale 1. *Scirpus paludosus*

CC. Texture very coarse at large scales, coarse or very coarse at intermediate scales; color deep red (13), grayish red (19), or sometimes approaching solid reddish brown (40) at large scale; pinkish gray (10), dark reddish orange (38), or dark gray green (151) at intermediate scale; height tall; shadow distinct; pattern continuous in irregular shaped stands or radiating in clumps; large spikelets visible at large scale; plants normally rooted in or very near water ...... 2. *Scirpus acutus*

BB. Texture medium or fine ....*C*

C. Color Red or Reddish Brown ....*D*

D. Color deep red (13) and sometimes approaching solid reddish brown (40); texture normally medium; shadow not distinct; pattern continuous or broken; vegetation normally forming a band along water body .... 3. *Juncus balticus*

DD. Color solid red (12) to medium red (15); texture medium; pattern broken; shadow not distinct; height medium .... 4. *Eleocharis macrostachya*

CC. Color Purplish Pink, Purplish Red, or Pink (including pinkish gray) ...*D*

D. Color pinkish white (9) to pinkish gray (10); texture medium to fine; height medium or short; pattern continuous; shadow not distinct .....5. *Distichlis stricta*

DD. Color Purplish Pink or Purplish Red ....*E*

E. Texture medium to medium coarse; color medium purplish pink (250) to solid purplish pink (247); height medium; shadow slightly distinct; pattern more or less continuous . 5. *Distichlis stricta*

EE. Texture fine ....*F*

F. Color solid purplish pink (247) to deep purplish pink (248) at large scale, solid red (12) at small scale; height medium; shadow not distinct; pattern continuous in a narrow band next to water .. 4. *Eleocharis macrostachya*

FF. Color deep purplish pink (248) to solid purplish red (255); height medium; shadow not distinct; pattern continuous in a wide strip around islands and near water .... 6. *Scirpus americanus*

AA. Vegetation submerged or floating, if floating height less than six inches and small areas of water visible between mats ....*B*

B. Color Red, Brown, or Gray ....*C*

C. Color solid brown (55); plants definitely submerged; texture medium; pattern broken and clumpy .... 7. *Myriophyllum exalbescens*

CC. Color dark red (16), grayish red (19), or dark reddish gray (23); plants either submerged or floating; texture medium; pattern fairly continuous .... 8. *Potamogeton pectinatus**

BB. Color Pink or Purplish Pink ....*C*

C. Color light pink (4) at large scales, pinkish white (9) at intermediate scales; plants obviously floating and forming very large mats of continuous vegetation; texture medium to fine; very little water visible within the mats ....9. *Potamogeton natans*

CC. Color solid purplish pink (247) to deep purplish pink (248); plants forming coarse textured mats of floating vegetation; pattern usually broken ......10. *Polygonum natans*

CCC. Color dark pink (6) to medium pink (5); plants floating in scattered mats; pattern very broken; texture medium to coarse; water visible within mats 8. *Potamogeton pectinatus*

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* At the Stillwater area this plant is either *Potamogeton pectinatus* or *Potamogeton latifolius.*

photo interpreter in the identification of 10 major types of marsh vegetation. The identification parameters height, color, texture, shadow and pattern were used for key characteristics. Color determinations were aligned with the ISCC-NBS color chips. Height was a subjective measurement using the stereoscopic characters of the photographs, and the categories were: very tall (10 ft. or greater), tall (3 to 10 ft.), medium (0.5 to 3 ft.), short (1 to 6 inches) and flat (less than 1 inch. Texture classification was a subjective determination using the general categories fine, medium, coarse, and very coarse. Shadow characteritsics used were simply distinct shadow or indistinct shadow, and pattern characteristics included three categories: continuous, broken, and radiating (Figure 2).

A photo interpretation test was designed to assess (1) the value of experience (both photo interpretation and vegetation familiarity), (2) the interpretive difference of the two film types, and (3) the influence of scale on interpretive accuracy. A total of 36 field-checked points of vegetation were selected on both color and color-infrared photographs of intermediate (approximately 1:10,000) and large (approximately 1:1,000) scale. Six interpreters of varied experience were chosen to attempt to identify the 36 points on both film types using the prepared keys for the color and color-infrared photographs. Examples of texture, color, pattern, height, and shadow were made available for the interpreters to study before and during the text. Bais was reduced by having three interpreters work with the color transparencies first and the other three interpreters study the color-infrared transparencies first. Bias was further reduced by having the names of the vegetation types excluded from the key and the key plants identified only by random numbers. A short training period was given to all interpreters on the use of stereoscopes, color chips, and to standardize the subjective texture and pattern classifications. All interpretation was accomplished from positive transparencies using a light table.

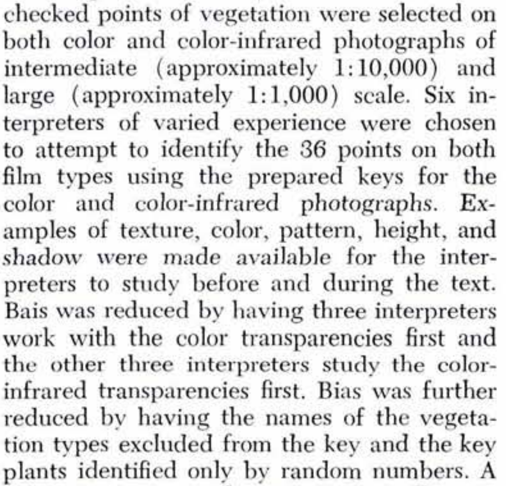

FIG. 2. Examples of the pattern categories used for interpretation testing. *A* (left), *Continuous*—Vegetation unit with no obvious breaks within the stand. The vegetation seems to be a solid, continuous mass. *B* (center), *Broken*—Vegetation unit with an obviously clumpy plant distribution. The vegetation shows breaks and irregularities within the stand. *C* (right), *Radiating*—The vegetation shows obvious rays from the center of the stand to the outer edges.

All aerial photographs taken of the four marsh areas were taken with a Hulcher 102, 70-mm, rapid sequence, aerial camera equipped with a 150 mm Schneider-Xenotar lens. Aldrich *et al.* (1959) reported the Hulcher 70-mm camera to be well suited for aerial sampling of forest types at large scales. This camera used an external 12 volt battery source and was equipped with an intervalometer built by Charles A. Hulcher Co., Inc., with capabilities for camera sequence rates of from 5 frames per second to 1 frame every 5 seconds.

The 1:1,000-scale photographs were taken at 2 frames per second and 90 miles per hour ground speed. Shutter speed depended on individual light conditions, but attempts were made for maximum shutter speeds (normally 1/1500 second). The intermediate-scale photographs (1:6,000 and 1:10,000) was taken sequencing the camera manually at approximately 110-miles-per-hour ground speed. Attempts were made to achieve 60 percent overlap on all photographs to enable stereoscopic viewing. The pilot obtained the nearest altimeter setting and adjusted flight altitude according to the scales desired. Perfect control of scale was not possible with this method; however, altitudes rarely were off by over 40 ft.

Color (Kodak Ektachrome ER, type 5257) and color-infrared (Kodak Ektachrome Infrared Film, type SO-117 and Kodak Aerochrome Infrared Film, type 2443) were used in this study. Both color infrared types were used with a Wratten No. 12 (minus blue) filter. No black-and-white film types were used.

RESULTS AND DISCUSSION

The marsh vegetation photographed within the four study areas consisted primarily of: sago pondweed (*Potamogeton pectinatus* L.), broad-leaved pondweed (*P. natans* L.), western pondweed (*P. latifolius* (Robbins) *Morong*), floating knotweed (*Polygonum natans* (Michx.)*Eat.*), aquatic buttercup (*Ranunculus aquatilis* L.), American milfoil (*Myriophyllum exalbescens* Fern.), common bladderwort (*Utricularia vulgaris* L.) widgeon grass (*Ruppia maritima* L.), tule or hard-stem bulrush (*Scirpus acutus* Muhl. ex Bigel.), alkali bulrush (*S. americanus* Pers.), common cat-tail (*Typha latifolia* L.), narrow-leaved cat-tail (*T. angustifolia* L.), spike-rush (*Eleocharis* sp.) Baltic rush (*Juncus balticus* Willd.), sedge (*Carex* sp.) and saltgrass (*Distichlis stricta* (Torr.) Rydb.),

Subjective comparisons between ground vegetation maps and maps from aerial photographs of the seven large scale transects showed that vegetation may be photomapped extremely accurately at large-scale (1:1,000). Ground checks of intermediate-scale (1:10,000) photo vegetation maps (Plate 1) revealed that these maps are quite accurate, although not as detailed as those derived from the large scale photographs. Field checking was necessary before marsh vegetation was mapped from either the large or intermediate-scale photographs. Once several field points were checked (10 to 20), the interpreter was able to map large areas of marsh vegetation without ground data. The value of this procedure is that considerable time may be saved, and inaccessible areas may still be mapped if the data from ground checked points is extrapolated to these areas.

In most of the marsh communities the vegetation was mapped accurately with either film type; however, the best maps were accomplished using the two films simultaneously to aid in plant identification. The differences in scale, resolution, and exposure were more important for marsh vegetation mapping at small scale than any film type differences.

The best scale used for vegetation mapping depended entirely on the amount of detail required. The 1:1,000-scale photographs resulted in very accurate and detailed maps, but photographic coverage was small, making a map of a large area extremely costly (approximately 10 to 15 times that at a scale of 1:10,000). For most management problems it seems that a scale of approximately 1:10,000 would be adequate. At this scale most large plant communities (25 or more square feet) may be identified and mapped with accuracy, and one frame of 70-mm photography covers approximately 81 acres.

Study of sequential photographs revealed that only limited utility could be made of these for vegetation mapping. With the exception of one marsh species (*polygonum natans*) on intermediate-scale photographs, all plant species and communities that could be identified and mapped from sequential photographs were identified and mapped with at least as much ease on the later photos (August and September dates). Only at these late summer dates were the floating leafed species at a stage of maximum vegetative development which enabled proper quantification.

The plywood transect markers were extremely well suited for marking marsh plant communities. No problems were encountered finding the transects by air at either high or low altitude. All transect markers (2 × 4 ft.) were of adequate size to be clearly visible to the pilot at altitudes as high as 5,000 ft. The markers were also clearly visible on both color and infrared transparencies. The white marker color was particularly well adapted to aerial photographs and appeared white on both film types. The transect markers remained in place throughout two winters with only minor maintenance required in the spring before photographs were taken. They probably could be used for many years to permanently mark vegetation transects. Markers were placed leaning 45 degrees away from the sun at the time of photography (early morning) and down the flight path. This insured that the sun would shine on the side of the marker visible to the aircraft. If the pilot had to look at the shaded side of the transect marker, an unsuccessful overflight resulted.

Statistical analysis (analysis of variance, randomized complete block design) of percent cover of open water (as a check on methodology and analysis) revealed no significant differences between field gathered and photo gathered data (Table 3). Nine of 13 vegetation communities analyzed showed no significant differences (0.05 level) between field and photographic cover data, and none showed highly significant differences (0.01 level). Only *Juncus balticus* and the filamentous algae showed significant differences between the field data and *both* color and color-infrared data. The floating nature of the filamentous algae accounted for some of the variability of the measurements of this community. Wind action may have blown the floating, mat-forming algae in or out of the transect between that date of photography and the date of field data collection. The significantly higher values of *Juncus balticus* on the photographic data indicates that this plant is much more obvious on the photographs than on ground examination. The *Scirpus acutus*/*Typha* sp. community was identified and quantified more accurately with color film than with color-infrared. The *Scirpus americanus* plant community was identified with more accuracy on the color-infrared rather than color film. Results of these analyses suggest that color and color-

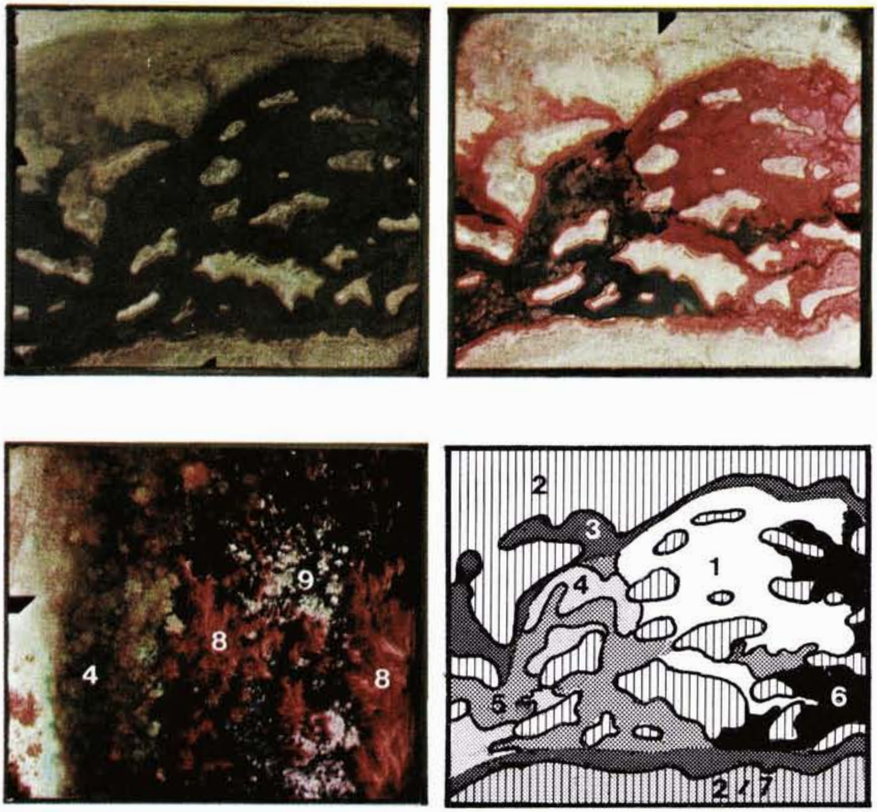

Plate 1. Color and color-infrared photographs of the Kirch Wildlife Area. *Upper left*–Color, approx. scale 1:10,000. *Upper right*—Color-infrared, approx. scale 1:10,000. *Lower left*—Color-infrared, approx. scale 1:1,000. *Lower right*—Legend: 1. *Hippuris vulgaris,* 2. *Distichlis stricta,* 3. *Scirpus americanus,* 4. *Potamogeton Pectinatus,* 5. Open water, 6. *Carex* sp., 7. *Sarcobatus vermiculatus,* 8. *Scirpus acutus,* 9. *Polygonum natans.*

TABLE 3. A COMPARISON OF PERCENT VEGETATION COVER ANALYZED BY FIELD TECHNIQUES AND LARGE SCALE AERIAL PHOTOS

Communities Analyzed	*No. Transects*	*Field Analysis*	*Photo Analyses*	
			Color	*Infrared*
Polygonum natans	11	6.9	6.9	22.9
Potamogeton pectinatus	13	18.1	19.2	18.5
Myriophyllum exalbescens	14	19.6	14.1	24.1
Distichlis stricta	22	29.9	28.6	31.2
Eleocharis macrostachya	14	12.0	12.4	9.6
Potamogeton latifolius	8	7.0	9.5	4.8
Scirpus paludosus	10	21.2	22.6	17.8
Scirpus acutus/Typha sp.	25	18.2	19.6	22.7*
Scirpus americanus	10	13.0	7.8*	8.2
filamentous algae	7	8.0	2.6*	2.0*
Juncus balticus	27	18.7	23.4*	24.4*
Potamogeton natans	5	30.8	35.6	10.8
Meadow complex	12	21.8	27.3	27.7
Open water	43	47.3	47.9	44.1

* Photo analysis significantly different from the field analysis at the 0.05 level.

infrared film types may be used equally well to identify and quantify marsh vegetation.

The interpreters correctly identified 84 percent of a total of 432 vegetation points (Tables 4 and 5). An average of 89 percent of the points on the large-scale (1:1,000) photographs were identified correctly (Table 4). These differences were significant at the 0.05 level. Interpretation testing showed that as scale increased from 1:10,000 to 1:1,000, the interpretability and accuracy of species identification was also increased.

An analysis of the interpretation differences on color and color-infrared film types determined that an average of 82 percent of the vegetation points were correctly identified on the color photographs, whereas 86 percent of the same points were correctly identified on the color-infrared film types (Table 3). These differences were not significant at the 0.05 level. Three of the six interpreters had higher percentage scores on the color photography, and the color-infrared interpretation scores were more variable.

Little advantage could be seen from interpretation tests of one film type over another. Most interpreters, however, had more confidence with the results from the color-infrared test. Field experience in areas photographed would probably have greatly increased interpretation scores.

The effect of interpretation experience levels (Table 6) was found not to be a significant factor in interpretation test scores. Probable reasons for this are: an extensive

TABLE 4. A COMPARISON OF INTERPRETATION SCORES OF 36 VEGETATION POINTS USING LARGE AND INTERMEDIATE-SCALE AERIAL PHOTOGRAPHS

Interpreter	*Large Scale*	*Intermediate Scale*
	(1:1,000)	(1:10,000)
A	93%	83%
B	93%	73%
C	81%	73%
D	81%	77%
E	95%	83%
F	88%	73%
Mean	89%	77% $t = 3.69$*

* Significantly different at the 0.05 level.

TABLE 5. A COMPARISON OF INTERPRETATION SCORES OF VEGETATION POINTS USING COLOR AND COLOR-INFRARED AERIAL PHOTOGRAPHS

Interpreter	*Color*	*Infrared*
A	83%	94%
B	86%	83%
C	67%	89%
D	86%	72%
E	92%	89%
F	78%	86%
Mean	82%	86% $t = .85$ N.S.

NOTE—Not significantly different at the 0.05 level.

TABLE 6. EXPERIENCE LEVELS OF INTERPRETERS

	Experience Levels	
Interpreter	*Marsh Vegetation*	*Photo Interpretation*
A	Some	Extensive
B	None	Little
C	None	Extensive
D	Some	Some
E	None	Extensive
F	Little	Little

training period was given to all interpreters before the interpretation test; examples of color, texture, and pattern were readily available to the interpreters before and during the interpretation test; random numbers instead of vegetation names were used to identify vegetation; no time limit was placed on the interpretation test. It was, however, found that the interpreters with experience in photo interpretation completed the test much faster than those with little or no experience.

The best photographs were taken between 9:00 and 11:00 A.M. Aerial photographs taken over water at later hours presented the problem of having a sun spot in the frame. Winds normally increased after 11:00 A.M. which caused rough water and decreased interpretability. Shadow was not a problem on the marsh vegetation, and little interpretability was lost due to long shadows of the early morning photography.

The cost of 70-mm film and processing is a small portion of the total cost for aerial photography. Color and color-infrared positive films cost approximately $50 per 100-ft. roll. Processing of these types costs a maximum of $60 per 100-ft. roll. Assuming the proper 60 percent overlap and 10 percent sidelap at a scale of 1:10,000 and no waste of film, a 100-ft. roll of film costing approximately $110 covered approximately 11,000 acres. Unused film was saved for later photo missions. Aircraft rental and equipment costs were the greatest expense, and suitable aircraft normally rent for $30 to $40 per hour. Assuming a total of 4 hours to fly from home base to the target area, to photograph the area, and then return, the cost for aircraft rental would be $120 to $160. Actual flying time over the marsh was rarely over 1 hour.

TABLE 7. APPROXIMATE COSTS OF THE PHOTOGRAPHIC EQUIPMENT USED IN THIS STUDY

Equipment Used	*Approximate Cost*
Hulcher 70mm Model 103 Camera	$2,000
Schneider-Xenotar f2.8 Lens	$450
Hulcher 70 Intervalometer	$225
12 Volt Photographic Battery	$75
Battery Charger	$30
Kodak Wratten No. 12 Filter	$25
Accessories	$20
Total	$2,825

The cost of photographic equipment is variable. Equipment used in this study is listed in Table 7. A light table was needed because the photographs were processed to positive transparencies. The cost of light tables is variable and sometimes quite high, but many are available as government surplus items and they also may be constructed for very little expense (possibly as little as $100). No salary-cost figures have been analyzed in this study for pilot, photographer, or photo interpreter. The figures cited are only to give a prospective user a rough estimate of photographic costs.

SUMMARY AND CONCLUSIONS

Color and color-infrared photographs were taken at various scales of marsh vegetation communities in an attempt to evaluate photographic methods for marsh habitat inventory and quantification. Vegetation maps from large- and intermediate-scale photographs were found to be accurate and time saving. Best results were realized using a combination of color and color-infrared film types and field checking the vegetation communities before mapping. Marsh plant inventory was accomplished easily from the vegetation maps and the resultant data comprise a permanent record of the marsh community boundaries.

Ground transect markers (2 × 4 ft. white plywood) were found to be well suited for permanently marking vegetation transects. Best results were realized by leaning the marker 45 degrees down the flight path and away from the sun.

Quantification of marsh vegetation was accomplished by cover analysis on both ground and photographic transects. In most instances, both color and color-infrared film types were suitable for vegetation quantification at large scales.

Interpretation testing revealed very little difference in the species interpretability of the color and color-infrared film types. A change in scale from 1:10,000 to 1:1,000 realized a significant increase in interpretation accuracy. Interpretation tests also indicated that the experience level of photo interpreters did not greatly change the accuracy of interpretation scores. Interpreters with extensive photo experience took less time to complete the interpretation test. Field experience in the area photographed is desirable for accurate interpretation results.

Color-infrared films were found to be more difficult to expose properly than was the color film. Best results were realized by photographing in the early hours of the morning when wave action was at a minimum and overexposure due to a sun spot was no problem.

The best time found to photograph the study sites with either color or color-infrared film was late in the summer when the marsh plants were in a state of maximum vegetative development. Only at this time can the floating vegetation be properly inventoried. Sequential photographs taken during the plant growing season were found to add very little information to photographs taken in the later part of the summer.

Large- to intermediate-scale color aerial photography is a fast, accurate, and relatively inexpensive way to provide a permanent record of marsh vegetation boundaries, changes, and quantities. Due to the inaccessibility of the marsh habitats, ground techniques for results with similar accuracy are extremely time consuming and therefore quite costly.

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