Color Aerial Photography For Aquatic Plant Monitoring

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ABSTRACT

Aerial photography, using color and color infrared film, was extensively tested during 1974 for its ability to differentiate between aquatic plant species, measure the size of infested areas, and monitor the changes taking place as the growing season progressed. Results were consistent and positive with respect to emersed species, somewhat less so with submersed species. It was discovered that the photography provides particularly valuable insight into the effectiveness of an ongoing aquatic plant control program. The cost of monitoring with color aerial photography is relatively low, possibly within the means of most control program managers.

INTRODUCTION

A successful aquatic plant control program requires that there be a means for detection and assessment of infested areas and also for monitoring areas under treatment to determine the effectiveness of the control method being used. The operational realities of the aquatic plant control problem often make both detection and monitoring by the usual means rather difficult. For one thing, new infestations frequently occur well off the beaten path. For another, the relative inaccessibility of a large part of these plant-clogged areas makes it next to impossible to measure how well or how poorly the chosen control method is doing in the total areal context.

Fortunately, aerial photography provides a viable and economical alternative to that which we call "the usual methods." Starting with the introduction of color infrared film (Kodak Type 8443) in the late 1960's, many investigators have looked into its use for differentiation between vegetation species. Since the improved version (Kodak Type 2443) arrived on the scene in the early 1970's, some rather good results have been obtained with aquatic vegetation. Recent work in tidal wetlands has pointed up the value of the latter film for salt marsh speciation (1, 4, 5). Good results have been obtained on freshwater aquatic vegetation in Nevada by Seher and Tueller (6) and in Wisconsin by Gustafson and Adams (3), also using Type 2443 film.

Spurred on by promising earlier results and by the apparent need for a remote sensing system to monitor aquatic plants, the Remote Sensing Center of Texas A&M University initiated aerial photographic tests in 1974. The initial purpose was to develop a low-cost procedure for detecting new infestation, determining the species present, and monitoring their spread by use of sequential photography over an entire growing season. As work progressed it became apparent that the system would be particularly useful for evaluating the effectiveness of ongoing plant control programs.

REMOTE SENSING TEST PROGRAM

The 1974 test of a potential monitoring system was carried out on Lake Livingston, a 36,000-ha reservoir lying 100 kilometers north of Houston, Texas. The dam was completed in early fall of 1968 and the reservoir filled by the fall of 1971. The aquatic plant population in 1971 consisted of 20 ha of waterhyacinth (*Eichhornia crassipes* (Mart.) Solms). By the fall of 1974 it had grown to nearly 800 ha of waterhyacinth, duckweed (both *Lemna minor* L. and *Wolffia columbiana* Karst), hydrilla (*Hydrilla verticillata* Royle) and coontail (*Ceratophyllum demersum* L.).

There is an ongoing aquatic plant control program in the lake, run by the Texas Parks and Wildlife Department (2). This program used spray boats in 1974 to periodically apply the butoxy ethanol ester of (2,4-dichlorophenoxyacetic) acid (2,4-D B.E.E.) on waterhyacinth.

Aerial photographs were taken at roughly 1-month intervals, depending on availability of clear weather, throughout the 1974 growing season. The first flight was in late April and the last in mid-January of 1975. Photography was taken over the same ground path on each sequential flight, concentrating on the waterhyacinth areas during the early months but later including in the flight itinerary several newly-discovered areas of hydrilla outbreak.

The aircraft used in the study was a DeHavilland Beaver operated by the Texas Forest Service. It is a relatively large, stable, single-engined, high-wing aircraft which has been specially modified for aerial photography.

Two 70mm electrically driven Hasselblad cameras were used, mounted with their optical axes parallel and triggered simultaneously to provide dual coverage of a single scene with two separate film and filter combinations. One camera held Kodak Aerial Infrared Film 2443 and used a yellow-orange filter to eliminate blue light; the other used Kodak Ektachrome MS Aerographic Film 2448, a standard aerial color film, without filter. Two different films were used to enhance the potential for accurate species differentiation.

The film was developed immediately after each flight with Kodak E-4 chemicals in accordance with the manufacturer's instructions. The reason for the in-house processing was two-fold. First, immediate processing under carefully controlled conditions minimizes spurious color shifts which often affect color infrared film. Second, quick processing enables the investigator to view the imagery prior to the ground-truth trip and still make it into the field before plant conditions change to an appreciable degree. The routine which evolved called for same-day processing and following-day photoanalysis, the ground-truth on the day after that being guided by the information obtained from the imagery.

RESULTS AND DISCUSSION

The 1974 season's photography produced over 300 images of aquatic plant concentrations on Lake Livingston. Most of this centered on two major areas of waterhyacinth infestation; the remainder was late season photography of two marinas and one popular fishing inlet where hydrilla had been introduced.

Waterhyacinth produces a color infrared image which is pale to medium lavender in youth, magenta in maturity, a deep red-brown in late season, and finally a rather bilious green-brown with the onset of senescence.

The impact of 2,4-D B.E.E. on waterhyacinth is clearly seen on color infrared film. The initial color shift is toward the green-brown of senescence, followed by lightening of the image to brown and tan prior to disintegration of the stressed mat. In the absence of continued herbicide treatment it was noted that regrowth almost invariably occurred, starting with the lavender of youth and darkening to magenta and rust-red as the regrown area matured.

This phenomenon became increasingly noticeable as the season wore on. By mid-November the entire palette of hues described above could be seen in a single color infrared photograph of an area in which multiple herbicide applications had been made over a period of time.

Normal color film proved to be of considerably less value for species identification. The differences between spectral signatures of the various aquatic plant species are far less pronounced in the visible range than in the near infrared, resulting in rather minor differences among shades of green in the color image. Herbicide effects can also be seen on normal color film, but with far less clarity than that available from color infrared. Part of the problem is caused by unfiltered atmospheric haze which blurs and deadens the normal color image. Color infrared film is only used with a yellow-orange filter (Wratten No. 12 or No. 15) which, by filtering out blue light, eliminates most of the effects of haze.

Normal color film is somewhat helpful when used for detection of the submersed species. Although it affords a smaller range of color differences between species than color infrared, it does provide superior delineation of the borders of submersed beds.

The images of the submersed species on color infrared film were somewhat less differentiable than was the case with emersed. The images of hydrilla and coontail both tend to appear deep maroon when the plants are still several centimeters below the surface. Photography of subsurface watermilfoil (*Myriophyllum* sp.), taken in mid-season over Lake Austin, Texas, showed about the same maroon color tendency. On the plants' arrival at the surface, a few more significant differences appear on the imagery.

Differentiation between submersed species is probably the biggest problem when monitoring aquatic plants with color photography. Follow-up work in 1975 is utilizing a modified color film and filter combination in order to enhance the rather minor spectral differences that exist between hydrilla, coontail and watermilfoil. Results to date are encouraging, particularly with respect to improved water penetration.

Areal coverage of aquatic plants is easily obtained with vertical aerial photography. Because of the fixed relationship between altitude, focal length and photo scale, ground distances can be readily determined from the formula:

$$\text{Ground distance} = \frac{\text{image distance X altitude}}{\text{focal length}}$$

Area coverage can be readily measured by using a transparent grid overlay of known line spacing (i.e., known image distance), counting squares on the overlain image and translating to acres or hectares, as required. By this method, with sequential vertical photography, the user can track seasonal changes in areal coverage and the quantitative effect of an ongoing control program.

The cost of aerial photographic monitoring can be quite low. A minimal system, which uses 35mm cameras, a rented aircraft and some inexpensive and readily available darkroom equipment and chemicals, can provide once-a-month monitoring at a cost about equal to that of 1 or 2 days' operation of a spray boat and crew. The information thus obtained can lead to a substantial improvement in the overall efficiency and effectiveness of chemical or biological control programs.

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