THREE EXAMPLES OF APPLIED REMOTE SENSING OF VEGETATION*

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SUMMARY

This paper describes three very different cases in which remote sensing techniques were adapted to assist in the solution of particular problem situations in Texas involving vegetation. In each case, the final sensing technique developed for operational use by the concerned organizations employed photographic sensors which were optimized through studies of the spectral reflectance characteristics of the vegetation species and background conditions unique to the problem being considered. The three examples described are: (1) Assisting Aquatic Plant Monitoring and Control; (2) Improving Vegetation Utilization in Urban Planning; and (3) Enforcing the Quarantine of Diseased Crops.

ASSISTING AQUATIC PLANT MONITORING AND CONTROL

Concept

The infestation and rapid growth of aquatic plants in Texas reservoirs has become a serious state problem.

*Supported by NASA Grant NGL 44-001-001.

These plants have adverse effects on navigation, flood control and drainage, fish and wildlife, recreation, public health, and water quality. The growth and spread of these plants is so dynamic that it has been impossible to monitor and control the infestation by conventional means. The Texas Parks and Wildlife Department, with major funding assistance from the Corps of Engineers, has initiated systematic chemical spray programs costing over $50,000 annually in an effort to eliminate the problem (over $300,000 total expenditure in Texas to date), but the program has been only marginally successful and the aquatic infestation is still spreading each year within affected lakes and into new lakes. It was hypothesized that use of remote sensing techniques could aid in monitoring the species type and growth rate, and in determining more optimum periods and locations for application of chemical sprays.

Procedure

Color and color infrared photography was selected as the basic sensing technique. It was determined that processing control for the films had to be far more stringent than in most work with this approach to assure acquisition of reliable temporal measurements. Repeated flights over an extensive aquatic plant region of Lake Livingston in east

AQUATIC PLANT MONITORING - Lake Livingston, Texas; east end of Jungle area, showing old river channel at right. Area to right of channel is land; area to left is water covered by water hyacinth and duckweed. (Black and white reduction of color infrared transparency).

AQUATIC PLANT MONITORING - Entrance to Beacon Bay Marina. Cloudy patches offshore are areas of hydrilla infestation. (Enlargement of color infrared transparency).

Texas were performed, with supporting ground observations, to develop acceptable flight parameters, exposure settings, film processing procedures, and interpretation guides. Signatures of surface species were shown to provide adequate differentiation, however species such as hydrilla, coontail, and myriphyllum, which have both submersed and emersed states, often require temporal data to insure discrimination when submersed. The procedure established requires careful control of the sensing technique and use of sequential photography throughout the growing season.

Results

The sequential photography showed that there is no single period of youth, maturity, or senescence in the aquatic plants in Texas lakes. Newly emergent areas continually appear, even in mid-to-late season, both on the fringes of mature patches and in completely new areas of the lake. In the case of water hyacinth, new areas of youthful activity reoccur in areas where the mature plants have been sprayed with chemical herbicide. These findings account for the lack of success often experienced with the present herbicide application program.

Sequential imaging showing the effects of herbicide stress indicated repeated patterns of distinct stress bands, dieback, occasional disappearance of the vegetation mat, reemergence of the youthful plants, and steady and vigorous regrowth in the sprayed areas.

The findings included the following:

- Aquatic plants in Texas lakes are very dynamic systems.
- The seasonal evolution of aquatic plants can be monitored by remote sensing techniques. An estimate of aquatic plant biomass may be feasible.
- The maximum value of the remote sensing approach may be in the accurate monitoring of the effects of chemical herbicide treatments (and probably biological control agents as well) on plant status and regrowth.
- Evidence was found that application of the herbicide 2,4-D in the concentrations presently used may be counterproductive for long-range plant control.
- LANDSAT imagery is useful in monitoring seasonal growth of hyacinth and duckweed in large lakes with known infestations.
- Hydrilla, a particularly noxious aquatic plant species, has been identified on color and color infrared photography and is now known to exist in Lake Livingston.

Payoff

The imagery collected as part of this project has been presented to the Trinity River Authority, Texas Parks Department, Texas Water Quality Board, and EPA. Representatives of these agencies were advised of the documented dynamic proportions of the aquatic plant problem in Texas lakes and of the evidence found that the current control program was inadequate to eliminate the spread of these plants. One of the agencies responsible for the control program in Lake Livingston, the Trinity River Authority (TRA), reevaluated their approach and have adopted a systematic remote sensing survey of the lake for their 1975 season plant control program. The technique developed in this project will be employed during 1975 by Texas A&M University under contract to the Trinity River Authority. These data will also be employed by the Texas Parks and Wildlife Department as part of their chemical spray program. The 1975 work is a pilot project for subsequent application of the approach to other lakes in Texas.

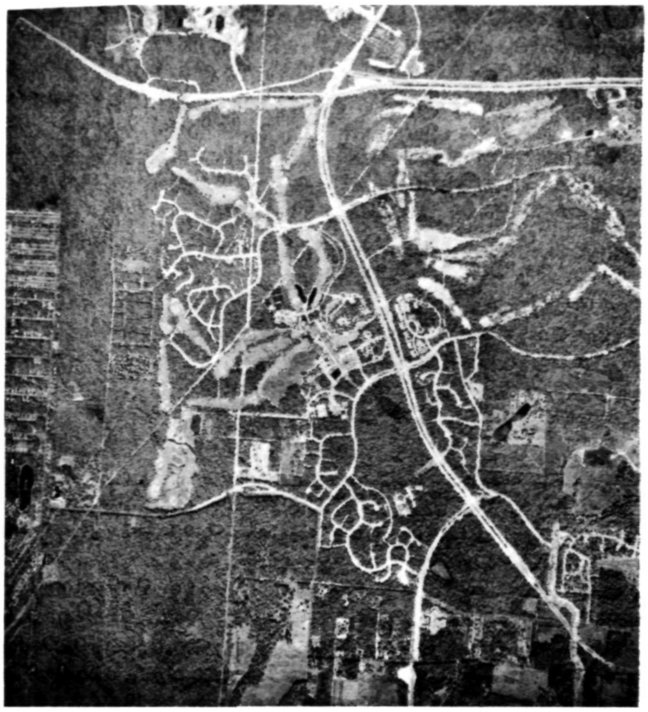
IMPROVING VEGETATION UTILIZATION IN URBAN PLANNING

Concept

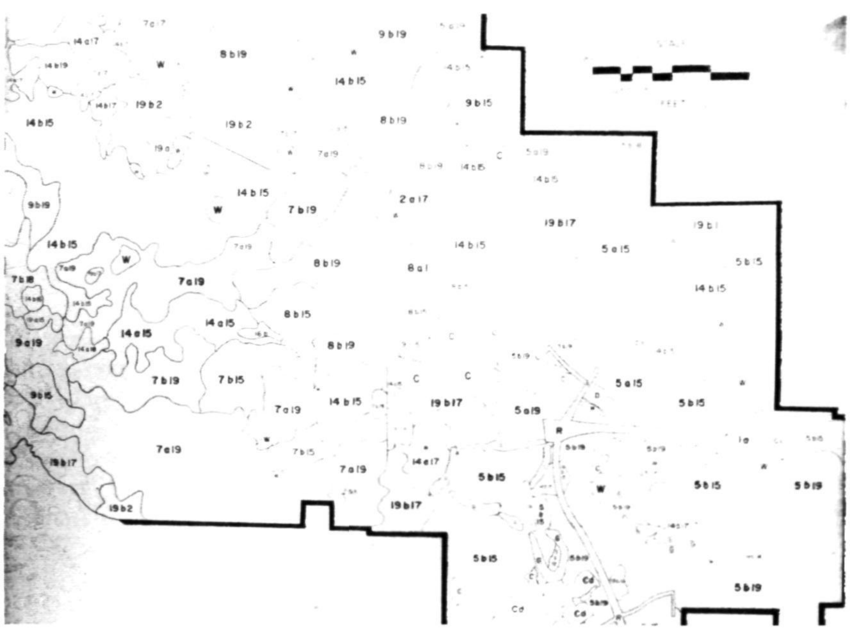
The Federal Government has authorized the development of certain entirely new planned communities as an experiment in urban planning with minimum environmental impact. The Woodlands is one of these Title VII communities located 28 miles north of Houston, Texas in Montgomery County. In preparation for this development, Mitchell Associates began compiling extensive background information on the 17,776 acre construction site. This included geologic, topographic, water resources, and soil maps and surveys of wildlife resources. These data were formatted as a series of thematic maps and overlays. An attempt was made to acquire sufficient vegetation information using ground survey techniques in order to supplement these maps. However, it was found that because of the quantity and quality of vegetation information required to support the project planning activities, the ground survey methods were inadequate. It was hypothesized that aerial remote sensing techniques could be used to provide satisfactory vegetation species identification and vegetation distribution maps more rapidly and at less cost than existing methods.

Procedure

The nature of the information required dictated that a ground survey approach must be employed during the initial stages. The objective of the remote sensing procedure developed was to optimize the ground survey and considerably reduce the intensity of the ground sampling.



THE WOODLANDS - Initial development area, showing vegetation types, recreational facilities and cultural features. (Black and white reduction from color infrared transparency).



THE WOODLANDS - Section of vegetation - cultural map made from color infrared photos.

This was accomplished by employing a photo interpretation grid-sampling procedure with color and color infrared photography acquired at a scale of 1:6000. Tests with black and white film and with several grid-sampling methods were conducted prior to developing an acceptably reliable approach.

Results

Color and color infrared photography was used to prepare vegetation maps of critical portions of the Woodlands construction sites. The maps showed location, species, size, and relative health of the vegetation in the area. Ground sampling was substantially reduced, and it was found that an extension of the technique to new areas could be done reliably with virtually no ground verification. A series of vegetation maps were constructed using sequential photography.

The sequential photos proved to be useful in recording construction progress and the impact of construction activities on the vegetation. The definition obtainable from the 1:6000 scale photos allowed examination of individual trees and clumps of underbrush. This gave the developer insight into the undesirable environmental effects of common construction practices. To this end, the developer evolved a system of protective fences and barricades to prevent trees from being barked, shrubs from being overrun, and root systems from being overcompacted. In certain cases, subcontractors were taken off the project because of damage they had done to the vegetation.

Payoff

The vegetation maps prepared by the Remote Sensing Center were incorporated into the construction planning documents for the Woodlands. These data were used to select the locations of commercial buildings, homes, and roads within the site. The specific benefits obtained as a direct result of the use of these vegetation maps included:

- reduced landscaping costs due to the extensive utilization of the natural vegetation.
- reduced need for artificial drainage systems because of the maintenance of natural ground cover in select areas.
- increased land value and greater profit per acre of development due to limited construction-related environmental degradation.

The remote sensing procedure developed offers the additional advantage that environmental damage due to urbanization can be monitored in a rapid, cost-effective manner. The general methodology developed in this project has been adopted by the Woodlands developer for his future urban planning activities.

ENFORCING THE QUARANTINE OF DISEASED CROPS

Concept

St. Augustine grass is the primary turf used for lawns and pasture throughout the South. Ninety-six percent of the lawns along the Texas Gulf Coast are St. Augustine. This turf grass was attacked by a strain of Panicum Mosaic Virus, termed St. Augustine Decline (SAD), beginning in the mid-1960's. The damage caused by the virus has been extensive to both homeowners and commercial growers in Texas. Consequently, the Texas Department of Agriculture (TDA) has quarantined all commercial farms pending development of a SAD-resistant grass species. The quarantine has been costly and only partially successful. The TDA spends in excess of $10,000 each year just to survey the diseased crops. The manual survey process requires more than six weeks to complete. An improved survey technique and a more effective quarantine enforcement procedure was needed. It was hypothesized that remote sensing techniques could assist with this state problem.

Procedure

A project was initiated by the Remote Sensing Center in cooperation with the Johnson Space Center to determine a remote sensing technique for the early, reliable detection of SAD virus symptoms. Greenhouse samples, test plots, and commercial fields were measured. Initial results of both spectrophotometer and spectroradiometer readings indicated little spectral signature differences between healthy and diseased grasses in the infrared region and only slight differences in the green region. However, the use of light polarizers showed significant differences in light reflectance in both the red and blue portions of the spectrum.

The aerial detection method subsequently developed consisted of four Hasselblad cameras with polarizers using Plus-X film with red, green, and blue filters and black-and-white infrared film with an 89B IR filter.

Results

During the spring of 1974, the Texas Department of Agriculture requested that the Remote Sensing Center fly a SAD detection mission over commercial fields in south Texas. The area included farms that were known to have SAD infested crops. These farmers had been requested by TDA to plow under the diseased areas. However, the farmers had not been responsive

ST. AUGUSTINE DECLINE - Pan American University Campus, lawns infected with St. Augustine Decline. Diseased areas are detectable and intensities differentiable on the original color transparency.

ST. AUGUSTINE DECLINE - NASA truck-mounted spectroradiometer measuring control plantings of SAD-diseased and healthy turf.

to the request and the TDA Quarantine Division was aware of attempts to illegally harvest and ship some of the diseased turf. The farmers were notified by letter from the TDA that their farms would be overflown during March 1974 for the purpose of remote sensing SAD infected areas. On March 4, 1974, just prior to the scheduled flights, a visual inspection of the suspect commercial farms confirmed that all SAD infected grass areas had been voluntarily destroyed by the growers.

Payoff

Whereas the commercial turf grass growers in Texas realized that the existing manual inspection techniques of the TDA were inadequate to enable TDA to properly enforce the state-wide quarantine, the advent of an aerial remote sensing technique convinced the growers that the quarantine could be effectively enforced and, hence, they chose to comply with the TDA regulations.

As a result of this project activity, the Texas Department of Agriculture now has available a reliable, cost-effective remote sensing technique for surveying and enforcing quarantine restrictions on the Texas turf producers.