

Evaluation of Airborne Video Imagery for Distinguishing Black Mangrove (*Avicennia germinans*) on the Lower Texas Gulf Coast

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ABSTRACT



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Airborne color-infrared (CIR) video imagery was evaluated for mapping black mangrove [*Avicennia germinans* (L.) L.] populations on the lower Texas gulf coast. Video imagery of black mangrove sites was obtained in December 1989. Results showed that black mangrove populations had a distinct red signature on the CIR video imagery that could be separated from other vegetation, soil, and water. Computer-based image analyses of the imagery showed that black mangrove populations could be quantified. Airborne video data provides a near-real-time tool for distinguishing and delineating black mangrove communities and should be useful for assessing damage to populations following catastrophic weather events such as freezes and tropical storms. Aerial surveys are also less costly to conduct with video than with photography.

ADDITIONAL INDEX WORDS: *Color-infrared photography, remote sensing, Texas gulf coast, computer image analyses.*

INTRODUCTION

Mangrove communities are widely distributed in the tropics and subtropics (CHAPMAN, 1975). Because mangrove communities are often inaccessible, it is difficult to determine their distribution and abundance by ground surveys. Remote sensing techniques provide a timely, cost-effective means to obtain reliable data over inaccessible areas (TUELLER, 1982). Color-infrared (CIR) aerial photography has been used to document the distribution and extent of mangrove in several areas of the world (REARK, 1975; ROSS, 1975; SAENGER and HOPKINS, 1975; SHERROD and McMILLAN, 1981). EVERITT and JUDD (1989) demonstrated that CIR aerial photography coupled with computer-based image analyses could be used to monitor the distribution and abundance of black mangrove on the lower Texas gulf coast.

More recently, airborne video imaging systems have been used as remote sensing tools for natural resource assessment (VLCEK and KING,

1985; MEISNER and LINDSTROM, 1985; NIXON *et al.*, 1987; EVERITT *et al.*, 1991). Video has many attributes that make it attractive for remote sensing, but the most prominent is the near-real-time availability of imagery. Video data is relatively inexpensive to acquire and the time between acquisition, availability, and utilization can be hours instead of weeks, or even months, with other remote sensing multispectral systems. This is particularly important in highly time sensitive applications such as disaster assessment (MEISNER and LINDSTROM, 1985). These systems have been used successfully to characterize or assess vegetation in both agricultural (EDWARDS *et al.*, 1984; NIXON *et al.*, 1985, 1987) and natural environments (MACKAY *et al.*, 1987; EVERITT *et al.*, 1990).

The objective of this study was to determine the potential of airborne video imagery for distinguishing and quantifying black mangrove communities along the lower Texas gulf coast. In addition, the costs versus benefits of using CIR aerial photography and airborne video imagery are compared.

METHODS AND MATERIALS

The study site was on the lower Texas gulf coast in the Port Isabel-South Bay area of Cameron County. This area has a major concentration of black mangrove (SHERROD and McMILLAN, 1981; EVERITT and JUDD, 1989). Aerial CIR photography was obtained of black mangrove at scattered locations along the gulf coast on April 13, 1988 at an altitude of 1500 m (1:5000 scale). Kodak* Aerochrome CIR (0.50–0.90 μm) type 2443 film was used with a Fairchild camera (305-mm lens, 23-by 23-cm format) that was equipped with Kodak Wratten 15 and Kodak Wratten 50 blue filters. The aperture setting was $f9.6$ at $\frac{1}{100}$ s. Photos were acquired with a fixed-wing aircraft.

Airborne CIR video imagery was also obtained of these black mangrove study sites on December 12, 1989 using a high resolution multispectral video system (EVERITT *et al.*, 1991) mounted vertically in the floor of a fixed-wing aircraft. The imagery was acquired at an altitude of 3050 m with the camera lenses set at 20 mm focal length. This provided a width coverage of 1.3 km and a recorded ground resolution of approximately 3.2 m per horizontal scan line. The lenses of the three cameras were equipped with narrowband filters, one having a yellow-green filter (YG, 0.543–0.552 μm), the second a red filter (R, 0.644–0.656 μm) and the third a near-infrared filter (NIR, 0.815–0.827 μm). The signals from these cameras were subjected to the red, green, and blue inputs of the color encoder, respectively, producing the CIR composite imagery. Video data was stored on $\frac{1}{2}$ -inch tape format Super-VHS video cassette recorders. Video imagery of black mangrove was selected from two locations, one for comparison purposes with photography and the other for quantification of mangrove.

Due to the altitude at which the video imagery was acquired, ground coverage of the system was somewhat limited. Hence, two scenes of the area used to demonstrate the quantification of mangrove were merged to give a larger area. The IR, R, and YG video images of the scenes were digitized with a PC-AT clone computer, having a MATROX MVP/AT board. These images were transferred to a 386 AT com-

puter that contained PCI image processing software which was utilized to warp each respective scene, using the R band image as the common geometric base. Warped images were then transferred (using "Lap Link" software) to an ERDAS image processing computer which was used to merge the two scenes by utilizing the "Subset" function of the image processor. A false color composite image was made from the warped IR, R and YG images of the scene by using the red, green, and blue color channels, respectively, of the image processor.

The merged video R band image of the scene was subjected to the PCI's "Thresholding and Encoding Bitmap" function which selected pixels that represented black mangrove in the scene. This technique produced a classified image that highlighted the mangrove with green pixels and everything else with its original pixel color. The "Count Pix" function, an in-house developed software, was used to determine the mangrove percentage in the video image. Video images shown here were photographed from an image display monitor.

A photointerpretive procedure was used on the print of the merged video images to compare differences in classified percentages between the two methods. A "mask" was made of the video image print by tracing areas in black where mangrove was thought to occur onto the transparent paper overlay of the prints. The "masked" tracings were digitized and subjected to the "Count Pix" function to obtain the classified percentage of mangrove on the masked tracings (EVERITT *et al.*, 1988).

RESULTS AND DISCUSSION

Figures 1A and 1B show a CIR composite video image and a CIR photograph, respectively, of a black mangrove community in the South Bay area of Cameron County, Texas. Black mangrove has a distinct red signature in both images. Although the video image does not have the detailed resolution of the photography, the major portions of the mangrove community were as distinguishable in the video image as in the photograph. The poorer resolution of the video image was partially contributed to being acquired at a higher altitude than the photograph. The photograph was obtained at low tide, whereas the video image was acquired at high tide. Hence, the exposed tidal

*Trade names are included for the benefit of the reader and do not imply an endorsement of or a preference for the product listed by the U.S. Department of Agriculture.

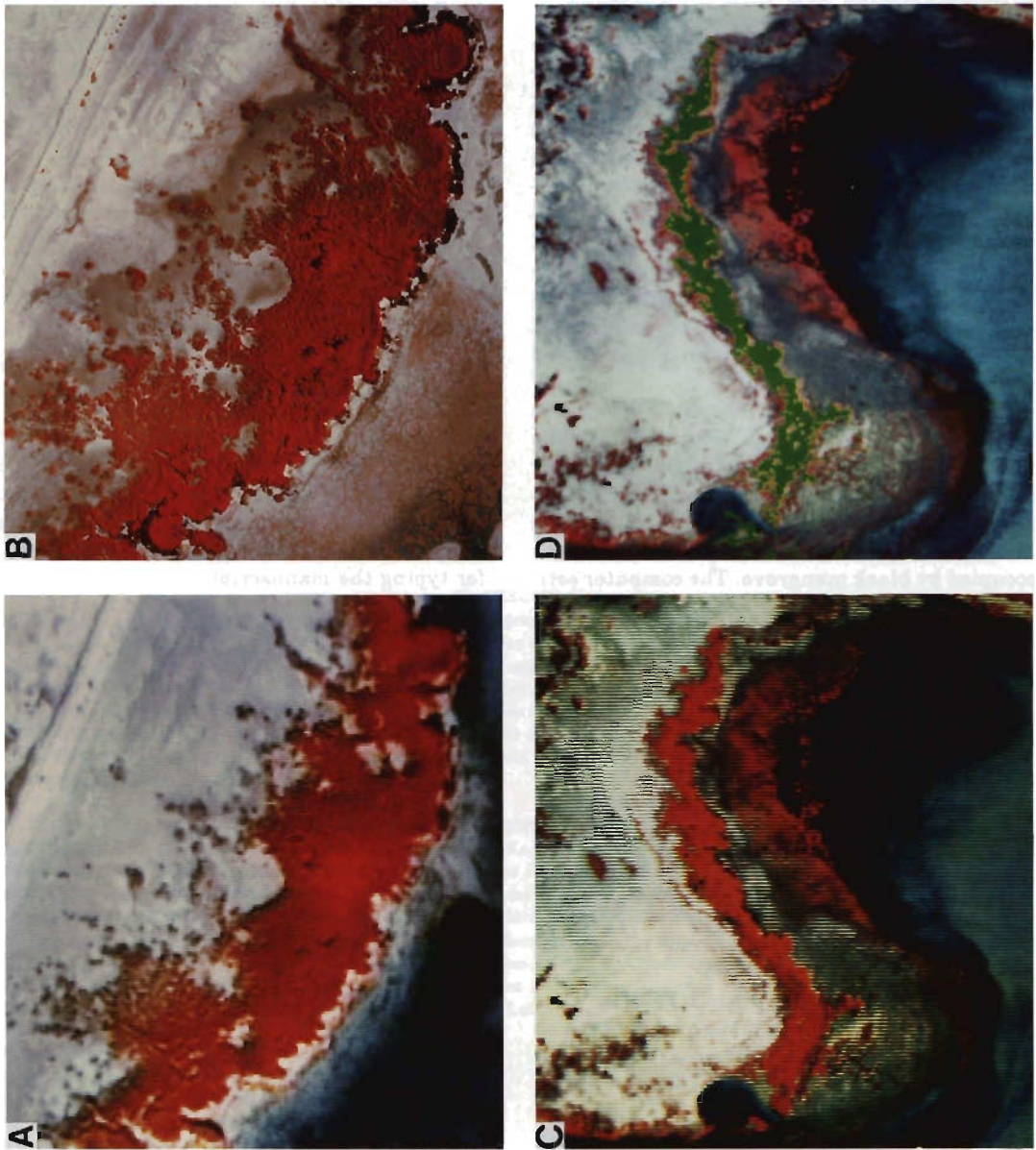


Figure 1. Color-infrared video image (A) and color-infrared photograph (B) of a black mangrove community in the South Bay area of Cameron County, Texas. Print C shows another color-infrared video scene of black mangrove in a different area of South Bay. Print D is the computer classification of the color-infrared video scene (C). Areas classified as black mangrove are coded green.

flat between the mangrove and water in the photograph was under water in the video image.

Figure 1C shows a CIR composite video image of a black mangrove community at another location in South Bay. As in Figure 1A, black mangrove has a conspicuous red response that can be separated from the orange-red signature of *vidrillos* (*Batis maritima* L.) along the shoreline and the reddish-brown image of mixed herbaceous species scattered throughout the scene. EVERITT and JUDD (1989) reported that the distinct red signature of black mangrove was primarily due to its low visible (red band) light reflectance and its generally high near-infrared reflectance.

Black mangrove is coded with green pixels in the computer classification (Figure 1D) of the video image. A comparison of the computer classification of the video image with that of the conventional video image (Figure 1C) showed that the computer generally delineated areas occupied by black mangrove. The computer estimated that 5.8% of the video image was comprised of black mangrove. Conversely, the computer estimated that 7.2% of the photointerpreters overlay map of the video image was made up of black mangrove. These differences were thus judged to be minimal. The disagreement could be due to the training of the photointerpreter since subjective boundary lines are drawn due to the grading between black mangrove and soil. Other differences can be attributed to the computer classification technique that is based on discrete spectral classes, wherein a decision is made concerning each pixel (EVERITT *et al.*, 1988).

Selecting the optimum remote sensing technique for surveying black mangrove depends on the user's specific needs. Costs of a large format 23-cm mapping camera for CIR film would be approximately \$15,000, while a CIR video system would cost about \$12,000. The distribution of black mangrove on the lower Texas gulf coast is confined to an area of approximately 85 km². To map this area at an altitude of 3050 m, it would cost approximately \$325 using CIR film. However, CIR video imagery could be acquired of the same area for about \$175. The aircraft costs would be the same for both methods, but CIR film would cost approximately \$200 as compared to \$15 for a single Super-VHS tape. Video imagery can be viewed live on a monitor in the

airplane or assessed within minutes after landing. Conversely, CIR film processing usually requires a week or more. Thus, video imagery is particularly useful in applications requiring rapid turnaround time such as assessing damage following tropical storms or a rapid decrease in temperature. Considering the near-real-time availability of imagery and the omission of film processing, airborne video is a practical remote sensing tool for a variety of applications except those where precise mapping is required. Moreover, the electronic format of video makes it highly compatible for computer image processing and analyses.

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□ RÉSUMÉ □

On a testé une imagerie vidéo infrarouge aéroportée pour cartographier des populations de mangroves noire (*Avicennia germinans* (L.) L.) sur les côtes du golfe du Texas. L'imagerie vidéo des sites a été obtenue en décembre 1989. Les résultats montrent que les populations de mangroves ont une signature distincte dans le rouge, qu'on peut les distinguer des autres végétaux, des sols et de l'eau. Des analyses d'images ont montré qu'on pouvait quantifier ces populations. Les données fournissent donc un outil presque en temps réel pour différencier et délimiter les communautés de mangrove noire, elles devraient être des plus utiles pour l'estimation des dégradations de population suite à des événements climatiques catastrophiques comme des gelées ou des cyclones tropicaux. Il est également moins coûteux d'effectuer des survols vidéo que photo.—Catherine Bousquet-Bressolier, Géomorphologie EPHE, Montrouge, France.

□ ZUSAMMENFASSUNG □

Farb-Infrarot-Videoaufnahmen aus der Luft (CIR) wurden zur Kartierung der Verbreitung der schwarzen Mangroven [*Avicennia germinans* (L.) L.] an der Golfküste von Texas herangezogen. Diese Aufnahmen wurden im Dezember 1989 durchgeführt. Die Ergebnisse zeigen, daß die Areale von *Avicennia* auf den Infrarot-Videoaufnahmen eine deutlich rote Farbe aufweisen, was zur Unterscheidung von anderen Vegetationen, Boden und Wasser dient. Mit Hilfe Computer-gesteuerter Analysen dieser Aufnahmen konnten auch Quantifizierungen der Bestände erreicht werden. Videoaufnahmen aus der Luft sind ein gutes Instrument, um zeitlich unmittelbare Aufnahmen der Pflanzengesellschaften herzustellen, und sie sind besonders geeignet, um Schädigungen nach Katastrophen, Witterungserscheinungen wie Frösten oder tropischen Stürmen aufzuzeigen. Außerdem sind Luftaufnahmen mit der Videotechnik weniger kostenaufwendig als jene mit normaler Luftphotographie.—Dieter Kelleter, Essen, Germany.