Remote Sensing as a Vegetation Mapping Tool in the Proposed Charleston Dam Site Area

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Introduction

The demand is increasing for better and more timely information to aid the resource manager, as shortages of important resources emphasize the need to survey large areas to determine the wisest possible management. Recent developments in remote sensing facilitate the survey tasks which must be performed by resource managers.

Remote sensing is acquiring information through the use of cameras and related devices, such as radar and thermal sensors, operated from aircraft and spacecraft. In the fast-growing field of remote sensing, several useful developments are taking place. Most are designed to aid in the acquisition of better and more timely resource information. Several of these developments are centered around the remote sensing vehicle known as ERTS (the Earth Resources Technology Satellite) and supporting high-altitude underflights beneath ERTS to supply a multi-level "look" at the earth resources below.

In order to explore the utility of the multi-level approach, a vegetation survey of the proposed Charleston Dam Site Area, San Pedro Valley, was conducted using both ERTS multispectral imagery and high-altitude color infrared photography. An approximate 120,000 acre area surrounding the proposed Bureau of Reclamation Charleston Dam Site served as the test area.

The study area is bounded on the west by Sierra Vista, the east by U.S. 80 connecting Tombstone and Bisbee, the north by an imaginary east-west line five miles south of Fairbanks, and on the south by an imaginary east-west line four miles south of Lewis Springs. The area is located within the Chihuahuan Desert and consists predominantly of the desert scrub community.

Discussion

High-altitude color infrared photography, dated August 1, 1972, was first used to delineate vegetation boundaries. Extensive use was made of the vegetation-soil-topography correlation prevalent in this area, shown as the distinct boundary color variations in Figure 1. The dominant species present in the area are white thorn (*Acacia vernicosa*), tarbush (*Flourensia cernua*), and creosotebush (*Larrea tridentata*); however, the relative proportions of these species within specific plant communities and the presence or absence of mesquite (*Prosopis juliflora*) proved strongly dependent on soil and topography variation.

An initial vegetation map (Figure 2) was developed in the lab as a mylar overlay on a transparency of the scene shown in Figure 1. Eleven vegetation classifications, as given in Table I, were derived from the photography on the premise of surficial color variation which is a function of soil surface characteristics, topography, and vegetation.

Referring to Figure 1, an area eighteen miles square is seen on the color infrared frame. The image varies appreciably in color from what might be expected in color photography. Unlike color film, the color infrared has the three emulsion layers sensitized to green, red, and reflected infrared radiation instead of the blue, green, and red reflected radiation. A yellow filter is used on the camera to withhold blue, to which these layers are also sensitive. Upon processing, a yellow positive image records in the green-sensitive layer and positive images of magenta and cyan appear in the red and infrared sensitive layers, respectively. Blue can be formed in the print, even though blue has been excluded from the image by the yellow filter. When the yellow image in the green-sensitized layer is bright, magenta and cyan will predominate and combine to form blue. Numerous other colors are formed as seen in Figure 1, depending on the proportions of green, red, and infrared reflected by the scene. Healthy vegetation records red because of a high infrared reflectance.

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Once an understanding of the color infrared characteristics are known, the interpreter can then apply this knowledge as a tool to delineate and map earth resources, such as vegetation.

As seen on the photography, a variety of surficial color variation and boundaries occur. The light brown alluvial fans extending northeast from the City of Sierra Vista are classified as deep, well-drained, and fine-textured soil (General Soil Map, Cochise County, Arizona). This soil type consistently correlated well with the vegetation category mesquite with upland grass. Thus, once this fact is established by ground checks in an area, an extrapolation to other areas that have similar surficial characteristics on the photography is possible. A close observation of the photography in the same area reveals narrow fingers of a soil-vegetation complex that images blue in comparison to the areas of light brown. These are generally eroded areas near stream channels, with steep slopes and coarse soils, that trend toward the San Pedro River. As shown on the vegetation map, these areas correlate well with the shrub classification.

Small catchments of deep soil which support tobosa grass (*Hilaria mutica*) and sacaton (*Sporobolus wrightii*) are seen throughout the area as the small red patches. These are small, closed basins which have slowly filled with fine silt and now maintain a moisture content sufficient to support the grasses previously mentioned. The vegetation of these areas is identifiable, in this case, not by soil variation, but by the unique signature of the dense vegetation which images bright red in August at the peak of vegetative activity of these grasses, and by its occurrence in small often roughly circular patches on the uplands.

Various types of riparian vegetation are identified on the map. The capability to map such vegetation and estimate acreages of riparian vegetation becomes extremely important where proposed inundation may destroy such habitat. Conversely, the technique can also be applied to determine types and acreages of riparian vegetation present in other reaches of the channel where inundation does not occur.

Along the eastern boundary of the study area, U.S. 90 intersects a well defined bajada that originates in the Mule Mountains immediately east of the study area. The bajada is shown in Figure 1 as the reddish-brown area surrounded by the dark blue tones. This soil is a red fine-textured material and correlates well with the mesquite-shrub classification.

Shown in Figures 3a, 3b, and 3c is the study area as imaged by the ERTS satellite from an altitude of approximately 570 miles on November 19, 1972. The three pictures of the same geographic area are an example of the multiband imagery received from ERTS. Each picture is produced from reflected radiation in three distinct wavelength bands in the visible and photographic infrared region. These are the .5 - .6 microns (green), .6 - .7 microns (red), and .7 - .8 microns (reflected solar infrared) bands as respectively shown in Figures 3a, 3b, and 3c. A comparison of the photos reveals a different reflectance response from the vegetation-soil-topography complex for the three bands.

Shown in Figure 4 is a "false" color infrared rendition of the area as derived from the three multispectral photos shown in Figure 3. A transparency of each photo in Figure 3 was overlain on top of each other and projected onto a screen through different color filters to produce the "false" color infrared. For example, the green band was projected through a blue filter, the red band was projected through a green filter, and the infrared band was projected through a red filter. A comparison of Figure 1 and Figure 4 reveals similar surficial characteristics. Although no vegetation species are visible on the ERTS imagery as contrasted to the high-altitude photography, the surficial color variation as a function of soil and vegetation is evident. Utilizing the same criteria, then, that was used on the high-altitude photography, ERTS false color infrared imagery can be utilized to delineate broad vegetation boundaries as related to soil and topography variation. For example, the light brown alluvial fans seen extending northeast of Sierra Vista on the high altitude photography are visible on the ERTS false color infrared imagery as the light yellow vegetation-soil complex. The narrow fingers of shrub image blue on the ERTS imagery as well as the high altitude color infrared photography. The bajada originating in the Mule Mountains is plainly visible; however, no difference between the fans northeast of Sierra Vista and West of Mule Mountains is evident. Thus, no discrimination would be possible between the mesquite-upland grass and mesquite-shrub classification from ERTS.

When comparing Figure 1 and Figure 4, the complex boundaries visible in Figure 1 cannot be delineated in Figure 4; however, broad catagorizations are possible. ERTS then serves an important role as a regional information source.

Table I
Vegetation Legend

	Grassland (upland species such as gramas, *Bouteloua*, spp.)
	Converted to grassland (usually lovegrass, *Eragrostis*, spp.)
	Mesquite (Prosopis juliflora) with upland grass species (e.g. *Bouteloua*, spp.)
	Mesquite with shrubs [whitethorn (*Acacia vernicosa*), creosote bush (*Larrea tridentata*), and tarbush (*Flourensia cernua*)]
	Shrubs (*Acacia, Larrea, Flourensia*)
	Mesquite
	Mesquite and sacaton (*Sporobolus wrightii*), and tobosa (*Hilaria mutica*)
	Sacaton and tobosa
	Riparian trees [cottonwood (*Populus fremontii*), willow (*Salix*, spp.), walnut (*Jugians nigra*), and others]
L	Limestone scrub [(*Aloysia wrightii*), ocotillo (*Fouquieria splendens*), mortonia *scabrella*), and whitethorn (*Acacia vernicosa*]
MS	Mesquite, shrubs with *Rhus microphylla*

Conclusions

Vegetation mapping using high-altitude color infrared photography relies heavily on the vegetation-soil-topography correlation concept in a desert area. Where desert vegetation is sparse, the sensor actually "sees" bare soil and rock, therefore, the vegetation - soil - topography interrelation becomes increasingly important.

Use of small scale photography from both aircraft and satellite permits detailed mapping of large areas in a short period of time. Approximately four man-days were required to produce the map shown in Figure 2. Excellent resolution allows for detailed mapping of objects as small as three meters (m) in diameter when using high-altitude photography, however, vegetation boundaries are usually gradation boundaries rather than distinct boundaries. ERTS represents resource information on a regional basis. The resolution element is approximately one hundred m versus three m for the high altitude photography; thus, loss of information can be expected, however, the large areas encompassed by one ERTS image make it an excellent data collection instrument over large areas.

References

General Soil Map, Cochise County, Arizona, 1971, U.S. Department of Agriculture, 42 pages Soil Conservation Service, Tucson, Arizona.

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Figure 3a. ERTS Multispectral Scanner Image of Study Area (MSS 4) .5 - .6 microns (green).

Figure 3b. ERTS Multispectral Scanner Image of Study Area (MSS 5) .6 - .7 (red).

Figure 3c. ERTS Multispectral Scanner Image of Study Area (MSS 6) .7 - .8 (reflected infrared).

Figure 4. ERTS False Color Infrared Image of Study Area.

Figure 1. An aerial infrared color photograph showing areas along an arroyo where peach trees have been killed by the soil-borne fungus, Phymatotrichum omnivorum. **Mesquite and paloverde trees in the foothills, upper right, harbor the fungus on their roots. The fungus moves through soil approximately 50 feet per year following the moisture and runoff water along the arroyos.**

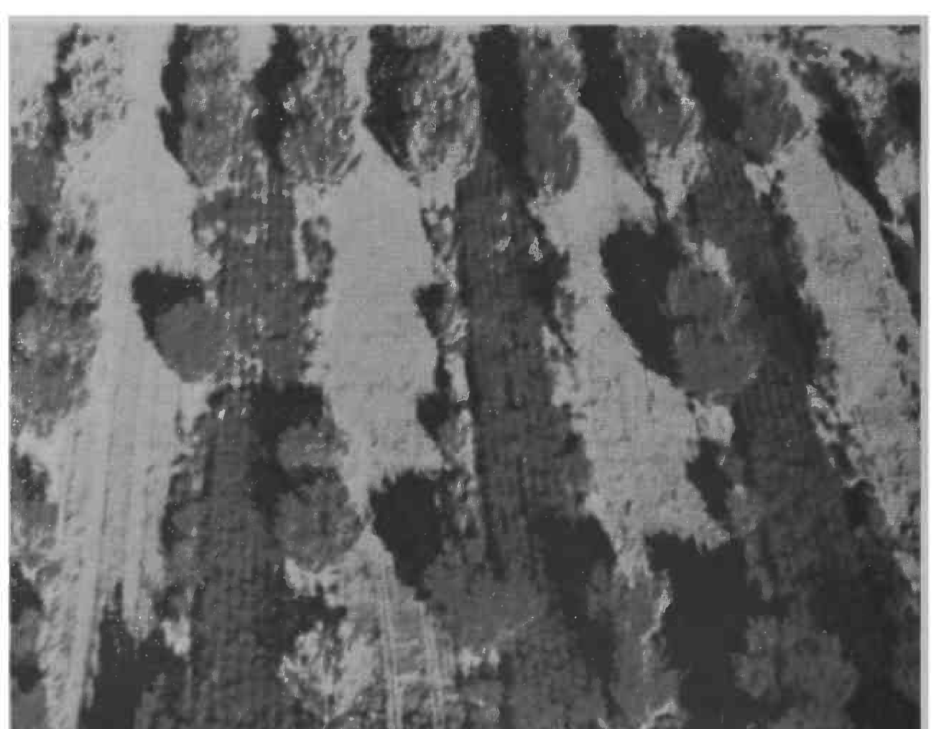

Figure 2. Color infrared aids in the detection of trees infected by Phymatotrichum omivorum. **Almond trees whose roots have been penetrated by the fungus, appear whitish to pale yellow in contrast to the deep red color of healthy trees.**

(NOTE: Please lineup this overlay by superimposing registery marks X at right with corresponding marks on photo below.)

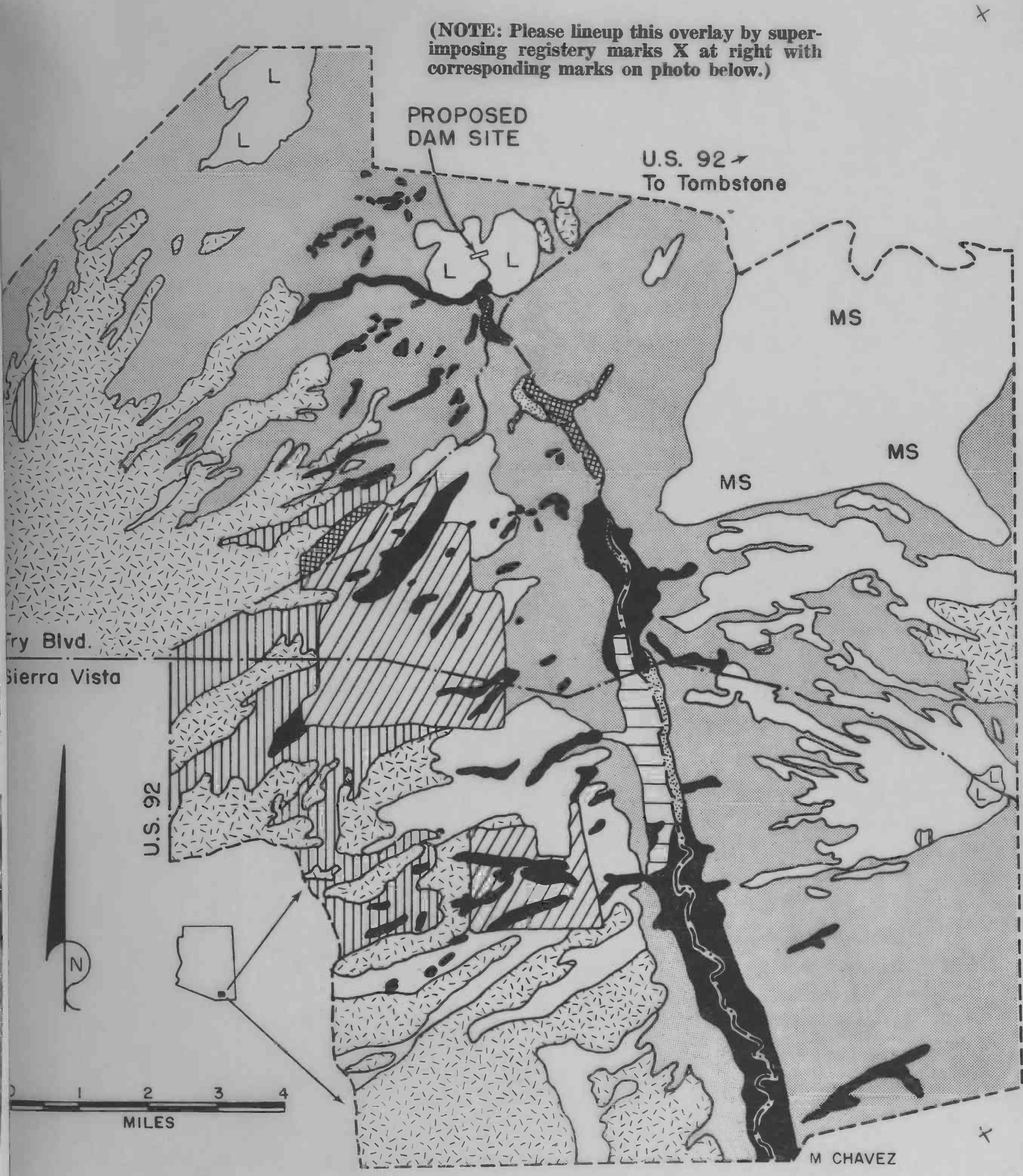

Figure 2. Vegetation Map of proposed Dam Site Area, San Pedro Valley, Cochise County, Arizona.

altitude color infrared photography, August 1, 1972. (Photo courtesy of Arizona Ece-
Test Site Data Center, Office of Arid Lands Studies, University of Arizona.)