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Early Warning and Crop Condition Assessment

USE OF LANDSAT 2 DATA TECHNIQUE TO ESTIMATE SILVERLEAF SUNFLOWER INFESTATION

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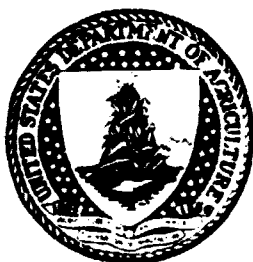
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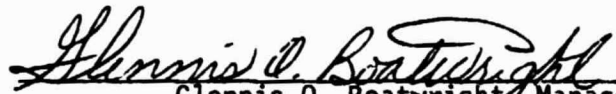
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USE OF LANDSAT-2 DATA TECHNIQUE TO ESTIMATE
SILVERLEAF SUNFLOWER INFESTATION

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USE OF LANDSAT-2 DATA TECHNIQUE TO ESTIMATE SILVERLEAF
SUNFLOWER INFESTATION*

ABSTRACT: We conducted this study to test the feasibility of the technique using the Earth Resources Technology Satellite (LANDSAT-2) multi-spectral scanner (MSS) data, collected on June 2, 1977, to distinguish silverleaf sunflowers (Helianthus argophyllus Torr. and Gray) from other plant species and for estimating the hectareage percent of its infestation. Sunflowers gave high mean digital counts in all four LANDSAT MSS bands that were manifested as a "pinkish" image response on the LANDSAT color composite imagery. Photo- and LANDSAT-estimated hectare percentages for silverleaf sunflower within a 23,467-ha study area were 9.1 and 9.5%, respectively. The geographic occurrence of sunflower areas on the line-printer recognition map was in good agreement with their known aerial photographic locations. Thus, we believe that the technique using LANDSAT MSS data might be used to estimate silverleaf sunflower infestation.

* Contribution from the Soil and Water Conservation Research, Agricultural Research, Science and Education Administration, USDA, Weslaco, Texas 78596.

INTRODUCTION

Plant leaf pubescence affects both visible and near-infrared spectral light reflectance (Shull, 1929; Billings and Morris, 1951; Gausman and Cardenas, 1969). Gausman et al. (1977) found that the densely white pubescence of silverleaf sunflower (Helianthus argophyllus Torr. and Gray) increased light reflectance and, thus, enabled it to be distinguished from other plant species using color-infrared aerial photography. They reported that ground-truth reconnaissance for 24 sporadic sites, selected from color-infrared positive transparencies, gave 100% correct recognition of the sunflower plants.

We conducted this study to ascertain if the technique using Earth Resources Technology Satellite (LANDSAT-2) multispectral scanner (MSS) data could be used to estimate silverleaf sunflower infestation.

MATERIALS AND METHODS

Silverleaf sunflower is a tap-rooted annual weed that grows in sandy soils of south and southeast Texas. It germinates in April or May, usually reaching its leaf pubescence peak in July. It may grow 3 to 4 m high under ideal growing conditions. It flowers in late summer or fall.

In June and July 1977, a ground reconnaissance and color infrared (CIR) aerial photography were conducted on silverleaf sunflower in Kleberg and Kenedy Counties located about 6.6 km southwest of Riviera (25.7 km south of Kingsville, TX) along Texas highway 285 and on an area located about 10 km southwest of Sarita, Texas (52 km south of Kingsville, TX).

Photographic equipment included: (a) Zeiss* wide-angle survey camera (RMK-A 15/23, 22.9- x 22.9-cm format); (b) filter packet made up with Zeiss CF yellow, 40 magenta, and 40 cyan filters; and (c) Eastman Kodak Aerochrome* color infrared, type-2443, film. The camera setting used was f/5.6 at 1/150 sec. Photographs were taken at 793-m altitude on July 11, 1977.

* Mention of a company or trademark is included for the readers' benefit and does not constitute endorsement of a particular product listed by the U.S. Department of Agriculture over others that may be commercially available.

The two areas in which the silverleaf sunflower were located are primarily native rangeland consisting of open grassland with scattered brush, scattered small motts, or singly distributed large mature mesquite trees (Prosopis glandulosa Torr.), and large motts of live oak trees (Quercus virginiana Mill.) (Everitt et al., 1979). Dominant grasses are fringed signalgrass (Brachiaria ciliatissima (Buck.) Chase), fringe-leaf paspalum (Paspalum setaceum Michx.), knotgrass (Setaria firmula (Hitchc. & Chase) Pilger), and Roemer threeawn (Aristida roemeriana Scheele). Major forbs include ground cherry (Physalis viscosa L.), American snout bean Rhynchosia americana (Mill.) C. Metz.), and three-seeded mercury (Acalypha radians Torr.).

There are many dispersed lagunas of various sizes and several large blocks of cultivated land located along the Los Olmos Creek near the Riviera sunflower site.

The climate is mild with short winters and relatively warm temperature throughout the year. The average growing season exceeds 325 days (Texas Almanac, 1975). The average annual rainfall is 70 cm. Heaviest rains occur normally in May and September.

This study used LANDSAT computer compatible tapes (CCT) and corresponding color images (1:1,000,000 scale) from a LANDSAT-2 overpass on June 2, 1977, (scene I.D. 2862-16000). The MSS bands used were 4, 5, 6, and 7, covering the 0.5- to 1.1- μ m spectral region. This overpass provided digital counts for a 185- by 185-km area, which included the two silverleaf sunflower study areas near Riviera and Sarita, Texas.

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We traced a seven-class ground truth map of a 23,467-ha study area, that included the silverleaf sunflower near Riviera and Sarita, on a transparent overlay over a scale photo, made from a 1:1,000,000 scale, 9.5-inch LANDSAT, color-composite, transparency. The photo-estimate process, used to produce the ground truth map, resembled that described by Hardy and Hunt (1975) and Elifrits et al. (1977). The percentage of the study area, occupied by each landuse category, was determined by cutting the tracing paper overlay, on which the boundary lines between landuse categories had been traced, into areas corresponding to each category. Then, we weighed these portions of tracing paper on an analytical balance and determined their ratio to that of the total weight of the paper for the study area.

The seven landuse classes were composed of rangeland (native grass, silverleaf sunflower, honey mesquite-mixed brush, and live oak), and agricultural cropland. Idle cropland, water, and unknown areas were called threshold areas.

We used a training-field classification approach for the LANDSAT digital data, wherein we classified every picture element (pixel) in the 23,467-ha study area. (The LANDSAT digital data has a resolution of 0.467-ha/pixel.) This approach consisted of obtaining over 540 training pixels from 22 training sites which air photo-reconnaissance had indicated were representative of the seven landuse categories to be studied within the 23,467-ha study area (1.1% of total area). The entire study area was classified using a maximum-likelihood classifier (Fu et al., 1969); implemented in a table look-up procedure, described by Eppler et al. (1971). Training sites were identified on gray maps of the study area, from which record and pixel coordinates were determined.

A LANDSAT-2 color positive print composite (MSS bands 4, 5, and 7) and a classification map of the study area were developed to visually assess the identification and mapping accuracy of the silverleaf sunflower among the other plant species.

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RESULTS AND DISCUSSION

A LANDSAT-2 color positive print composite (MSS bands 4, 5, and 7) of the 23,487-ha study area, and a CIR aerial photo of a dense silverleaf sunflower site near Riviera are presented in Figs. 1A and 1B, respectively. Figure 1B shows the silverleaf sunflower's characteristic "pinkish" image response on the CIR film that distinguished it from the scattered brush, grass, and woody plant species. Gausman et al. (1977) indicated that the "pinkish" image on CIR photography was associated with the high visible (0.5- to 0.7- μ m waveband) and near-infrared (0.7- to 0.9- μ m waveband) spectral light reflectance of the sunflower's dense leaf pubescence.

The "pinkish" image of the sunflower site (Fig. 1B) was also evident on the LANDSAT color composite (Fig. 1A). Figure 2 shows the plotted mean digital counts from the four MSS bands for the seven land-use categories in the study area. Generally, silverleaf sunflower had high mean digital counts for all four MSS bands. Cropland had higher digital counts from bands 6 and 7 as compared with that of sunflower, but the digital counts for cropland for bands 4 and 5 were considerably lower than those for sunflower. Digital counts for native grass were relatively close to those for sunflower from bands 4 and 5, but for bands 6 and 7 the sunflower's digital counts were distinctively higher than those of the native grass. Mean digital counts of the other land-use categories were lower than those of sunflower, except for idle cropland's mean digital count at band 5. Therefore, the sunflower's high mean digital counts for all four MSS bands were manifested as a "pinkish" image response on the LANDSAT color composite.

The photo- and LANDSAT-estimated percentages for silverleaf sunflower, all other plant species, and threshold within the 23,467-ha study area were generally in close agreement (Table 1). The photo- and LANDSAT-estimated hectare percentages for the sunflower were 9.1% (2136 ha) and 9.5% (2261 ha), respectively. This particularly good agreement for sunflower may be attributable to its characteristic "pinkish" response on the LANDSAT-2 color composite imagery (Fig. 1B) and its high spectral reflectance at all four MSS bands (Fig. 2).

The geographical occurrence of the silverleaf sunflower (*) within the 23,467-ha study area is depicted by a line printer recognition map in Fig. 3 (corresponding to Fig. 1A). The known ground and aerial photographic locations of sunflowers corresponded very closely to their locations on the recognition map. Sunflowers were most concentrated near Riviera along the Los Olmos Creek (Fig. 1A). Other sporadic areas of sunflower were in the midsection of the study area near Sarita. All other rangeland plant species (*) and threshold (blank space) areas were also geographically well identified on the map.

These results indicate that this technique using LANDSAT MSS data may be useful for estimating silverleaf sunflower infestation.

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Table 1. Comparison of photo- and LANDSAT-estimated percentages for the landuse categories for the study area using LANDSAT-2 MSS digital data (bands 5, 6, and 7) for June 2, 1977 overpass. The total photo- and LANDSAT-estimated hectarage of the study area was 23,467-ha and 23,801-ha, respectively.

Landuse categories	Photo %	Computer %
Silverleaf sunflower	9.1	9.5
Other rangeland vegetation	81.5	82.9
Threshold	9.4	7.6
Total	100.0	100.0

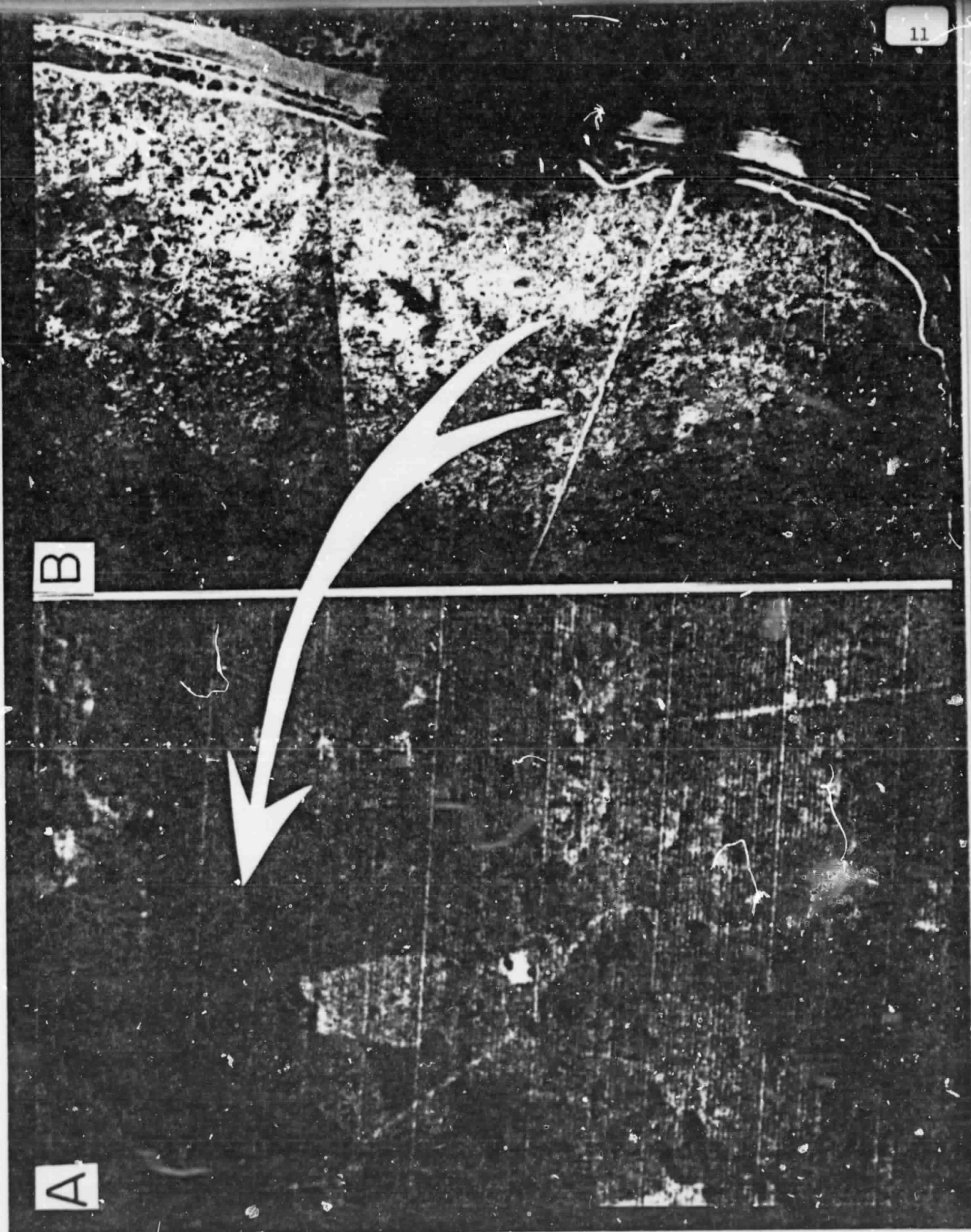


Figure 1. Landsat 2 color positive print composite (MSS 4, 5, and 7) of the study area (a), and a CIR aerial photo dense silverleaf sunflower site near Riviera from the study area (B). The black areas are cloud shadows.

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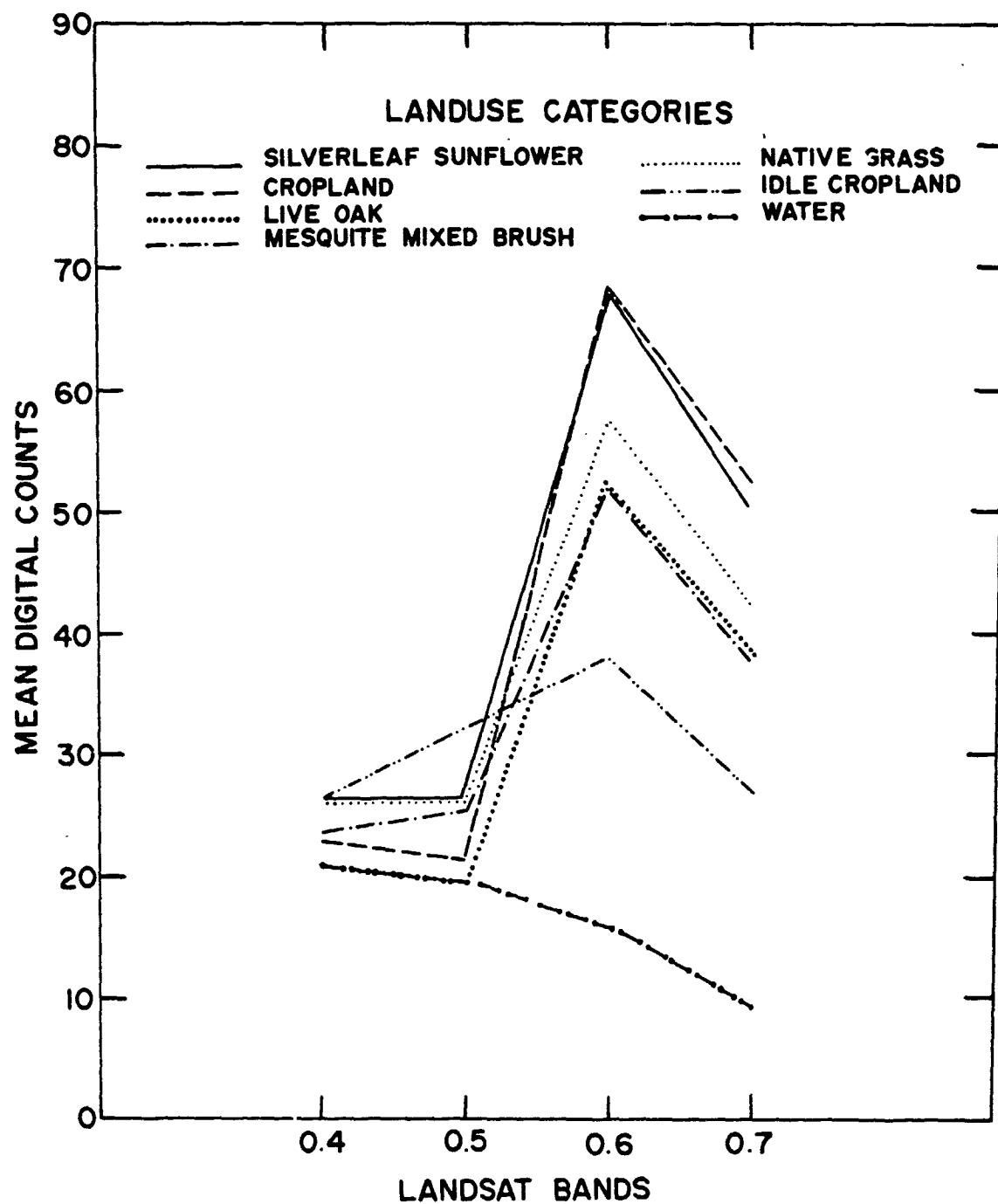


Figure 2. Mean digital counts from the four MSS band for the landust categories.

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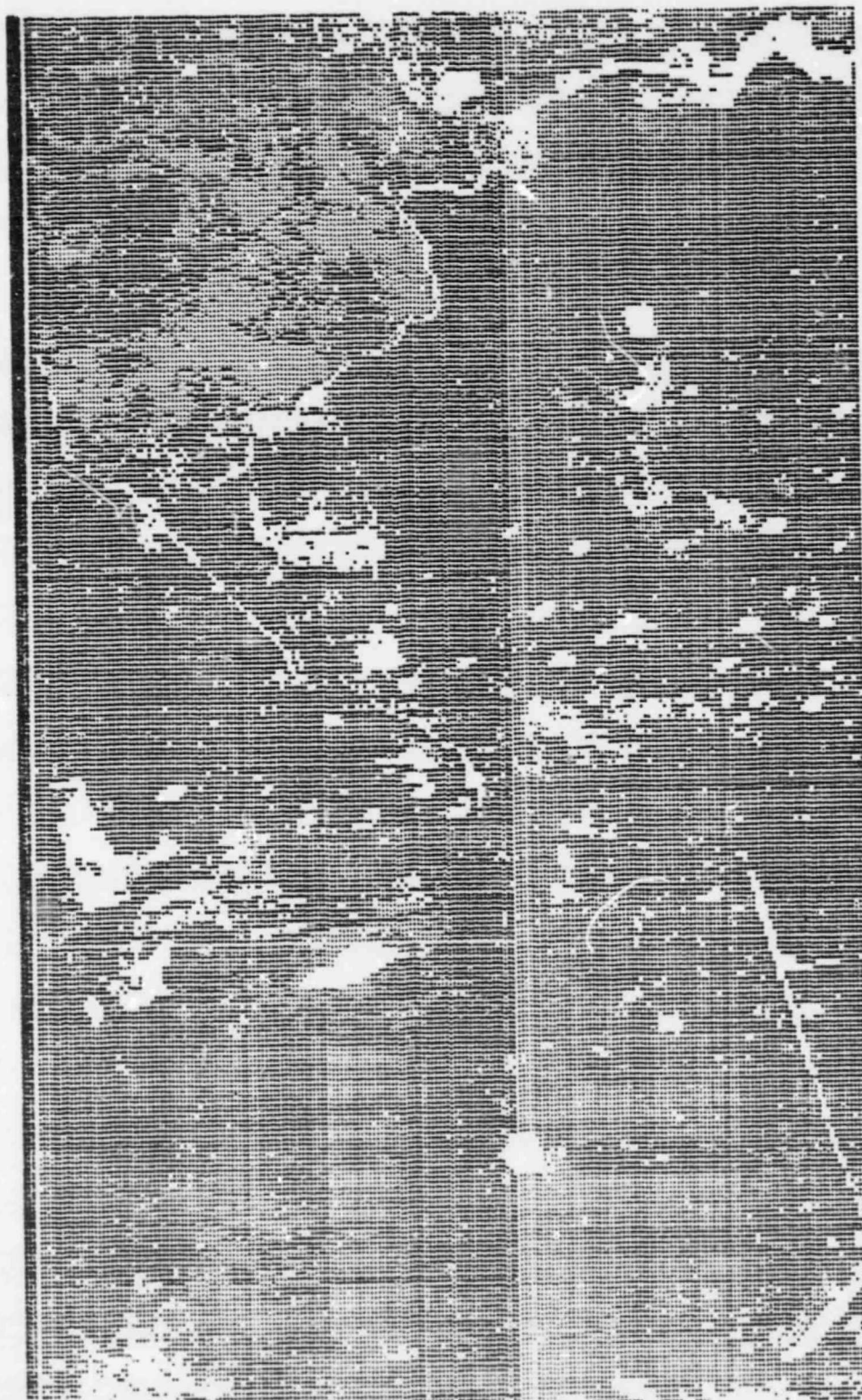


Figure 3. Classification map of the study area for June 2, 1978 Landsat 2 overpass. Resolution is 1.9 ha/symbol. Pixel, line-printer symbols (.), (*) and (blank space) represent silverleaf sunflower, all other plant species and threshold areas, respectively.