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UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

Interpretation--Apollo 9 Photography of Parts of Southern Arizona and Southern New Mexico

by

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Open-file report 73-215

Denver, Colorado
February 1973

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ILLUSTRATIONS

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ABSTRACT

Examination of small-scale (approximately 1:650,000) multispectral photographs obtained on the Apollo 9 mission in March 1969 revealed that in semiarid regions features due to differences in soils or quantity of vegetation could most easily be discriminated on the color infrared photographs. Where there is sufficient ground truth, it is possible to delineate regional wildland plant communities on the basis of tone, however, the precision of the method may be improved by using photographs obtained two or more times during the year. Sites where vegetation-improvement practices have been completed are not always discernible. For example, where waterspreaders have been constructed, there was sufficient change in the density of vegetation to be readily detected on the photographs; however, pinyon-juniper to grass conversions or contour furrowing did not always produce a sufficient change in the vegetation to be detected on the photographs.

INTRODUCTION

The Apollo 9 Manned-Spacecraft mission flown in March 1969 provided multispectral photographic coverage of several regions in the southern United States. One such region for which relatively cloud-free coverage was obtained was part of the arid and semiarid areas of southern Arizona and southern New Mexico. The authors' main objectives were to determine if regional wildland plant communities and soil differences could be discriminated on small-scale photography obtained from orbiting platforms. Another objective was to determine if tracts where vegetation modification or improvement practices that altered the kind or quantity of vegetation could be discriminated from the surrounding vegetation. Associated with these objectives we wanted to determine which spectral band or bands enabled these features to most readily be discriminated. Interpretations in this report are primarily for the Tularosa Basin area in New Mexico; however, several specific sites also were investigated in the Separ, New Mexico area and in southeastern Arizona. The Arizona interpretations were primarily of the Tombstone area and the San Simon Valley.

The authors have not worked extensively in these areas so a ground reconnaissance through the area was necessary. Prior to the trip we consulted with personnel of the U.S. Geological Survey who had investigated and evaluated contour furrowing, rangeland ripping, and waterspreader construction in southern Arizona and New Mexico. C. E. Sloan, a geologist who had worked in New Mexico on the Mescalero Apache Indian Reservation and in the Tularosa Basin, provided general information about that area. State geologic and 1:250,000 U.S. Geological Survey maps helped delineate many features. Range-survey maps of New Mexico provided by the Bureau of Land Management were most helpful in interpreting the photographs.

INTERPRETATION OF THE SPECTRAL BANDS

The Apollo 9 multispectral photographic experiment consisted of four different cameras, each with its own film, filter combination, exposure, speed, and focus. For each scene, the four films were exposed simultaneously.

The photographs designated "A" were false-color infrared photographs sensitive in the wavelength band from 510 to 900 nanometers. The black and white photographs designated "B," "C," and "D" represent three wavelength ranges within the electromagnetic spectrum. The "B" photographs were sensitive in the green band from 460 to 610 nanometers. The "C" photographs were sensitive in the near-infrared band from 700 to 890 nanometers. The "D" photographs were sensitive in the red band from 580 to 700 nanometers.

Overall, the false-color infrared photographs showed the greatest tonal contrasts, and were the easiest to interpret of the four bands. Vegetation that was actively growing could be distinguished from dormant vegetation only on the false-color infrared photographs. On native rangeland, infrared reflectance was apparent primarily on the foothills northeast of Phoenix (photographs 3801-3802) and on the mountain tops of southern Arizona and New Mexico (photographs 3752-3756) where oakbrush predominates. Examples are shown in figure 1A (photograph 3801) and in figure 1B (photograph 3755).

The variable quality of the black and white photographs made their interpretation more difficult. When only the black and white photographs were considered, tonal differences due to vegetation, soil, and other land features were most easily interpreted on the 590-715 nanometer band (D). This is probably due to the better haze penetration provided by the Photar 25A filter used on the red band.

The black and white infrared phtographs in the 700 to 900 nanometer band (C) are best used for identifying land-water interfaces. As there were no water bodies visible on any of the photographs examined, this band was of little use in our interpretations.

The similar spectral reflectance of the numerous lava flows and patches of dense vegetation in the southwestern United States made interpretation of the vegetation in the southwestern United States difficult. Specific examples are cited later in the report.

Tularosa Basin, New Mexico Photograph

Each of the Apollo 9 photographs covers an area of approximately 100 miles by 100 miles. The Tularosa Basin photograph (fig. 2, photograph 3805A) is dominated by the 45-mile long Malpais lava flow near the center of the photograph. West of the Malpais is a light-colored circular feature which is the Trinity atomic test site. At the bottom of the photograph, the northern end of the White Sands area is visible. The Sierra Blanca Range trends north and is east of the Malpais. The Capitan Mountain Range, which trends east, is located in the right center of the photograph. U.S. Highway 54 runs from north to south across the photograph, while U.S. 380 crosses it from east to west. Tularosa and Carrizozo are the main towns on the photograph. All of these features, which aid in orienting one in the Tularosa Basin area, are indicated on the overlay for figure 2.

The season of the Apollo 9 flight appears to be too early for optimum infrared reflectance of the vegetation. The blue-green shades at Three Rivers and east of Carrizozo appear to be a function of the quantity rather than the types of vegetation at the time the photographs were taken. For example, the area along U.S. Highway 54 near Three Rivers is dominated by creosote bush (a list of common and scientific plant names occurs at the end of this report) with very little understory vegetation, but through the darker area where soil moisture is probably greater as a result of drainage from the Sierra Blancas, there is substantial grass cover between and under the creosote bush plants. The area along U.S. Highway 380 east of Carrizozo has a sparse juniper overstory, but again a substantial grass cover which seems to account for the blue-green color.

Light-colored patches south of Three Rivers and the rather large area surrounding the Trinity atomic test site are dominated by four-wing saltbush and alkali sacaton. Both of these species are indicators of saline soil into which moisture penetrates rather deeply. North of Tularosa an orange-tan patch lies across the highway. The soil in this area is reddish. Several similar patches appear as alluvial outwash between the Sierra Oscura Mountains and the Malpais lava flow. These soils probably are red also, as are the soils just west of the Sierra Oscura along U.S. Highway 380.

The Broken Back lava flow, immediately west of the north end of the Malpais was investigated on the ground. Light patches on the photograph occurring in the northern part of the lava flow were sites that we thought had been cleared of juniper and seeded to grass. Ground inspection revealed that no juniper occurred in the area. Instead, the light patches are swales covered with vigorous stands of alkali sacaton grass which indicate fine-textured, saline soil. These swales probably receive runoff from the adjacent uplands. Several tracts north of the Malpais have been cleared of juniper. However, these sites could not be discriminated on the photographs.

A small, crescent-shaped feature is visible on a grassy terrace just south of Indian Creek. This feature is the abaondoned channel of Indian Creek. The old gully is approximately 600 feet wide and 200 feet deep, according to C. E. Sloan (oral commun., 1969).

A rough regional vegetation map (fig. 2B) was prepared for the Tularosa Basin area from the color infrared photograph using Bureau of Land Management (BLM) range-survey maps, prepared at a scale of 1:62,500, as the basic ground truth data. The scale of a 1:500,000 geologic map of New Mexico was equated to the photograph's scale of approximately 1:650,000 using an overhead projector. Township and range lines were traced on a clear overlay from the geologic map and matched to the photograph. No scale adjustment was made toward the edges of the photograph. The plant species occupying the largest area in each township on the Bureau of Land Management range-survey map was transferred to the corresponding township on the overlay. Vegetation type lines were drawn to correspond to color and tonal differences on the photograph.

As previously mentioned the density of the blue-green color on the color infrared photograph apparently is more a function of quantity than type of vegetation at the time the photographs were taken in early March. The blue-green color becomes more intense from the valley floor to the tops of the mountains owing to an increasing quantity of vegetation. On arid and semiarid lands the kinds of plants (grasses, shrubs, and trees) as well as the quantity of vegetation change, due to differences in available soil moisture resulting from differences in soil texture, soil depth, temperature, and precipitation. Where color intensity changes occurred, it was presumed that there was a change in the quantity of vegetation that corresponded to a change in the type of vegetation. The correlation was surprisingly good between the vegetal type boundaries drawn from the Apollo 9 photographs and the vegetal type boundaries on the BLM range-survey map.

Following this example, small-scale photographs may be used to prepare regional vegetal thematic maps. One may detect various classes of vegetation such as grasses, shrubs, and trees with reasonable accuracy by first being generally familiar with field conditions. Repetitive false-color infrared photographs taken during the principal growing season of the different plant communities in a region could be a refinement of the technique. Color-additive and density-slicing techniques may be used to aid the interpretative analysis by providing information that is recorded on the film but not detectable by the human eye.

Southeastern Arizona Photograph

The main objectives of the interpretations of the southeastern corner of Arizona, photograph number 3752 (fig. 3), were to investigate a waterspreader system and several areas where contour furrowing and ripping practices were done by the Bureau of Land Management. Several interesting geomorphic, vegetation, and cultural features can also be identified on this photograph.

Wilcox Playa is located in the center of the photograph. Tombstone and Benson, Arizona are located in the lower left corner, while the San Simon Valley area is located in the upper right corner of the photograph, and is north of Interstate Highway 10.

Several waterspreaders were investigated in the San Simon Valley. These structures consist of a series of dikes perpendicular to the channels designed to spread flood flows across the valley bottom and thus reduce erosion and promote vegetal growth. These flooded areas support vigorous stands of grass which appear as elongated blue-green areas within the buff-colored area in the upper right hand part of photograph 3752A (fig. 3). The buff-colored area is a broad valley bottom with a sparse to moderate cover of creosote bush and tarbush growing on a light gray, calcareous soil.

Another waterspreader at Centennial Wash, Arizona located in the northeast corner of photograph 3800 (not shown) is also easily distinguished from the surrounding, less dense vegetation. However, this spreader was not field checked. The vegetation from both of these waterspreaders should have strong infrared reflectance when photographed during the growing season of the plant species involved which is July through September. Two tracts adjacent to the San Simon waterspreaders were furrowed and seeded to grass in 1967 and 1968, and are identifiable on photographs 3752A.

Regional geomorphic, vegetational, and cultural features are apparent in the San Pedro Valley, between the Tombstone and Benson areas. The alluvium and soils are very light colored there. Raw ephemeral channels, eroding slopes, recently cleared highway right-of-ways, and unpaved roads, where vegetation is sparse or absent, are the lightest areas.

The color contrast on the two sides of the Southern Pacific Railroad on the west side of the San Pedro Valley is apparently due to both a break in relief and to vegetation change. A dissected pediment lies west of the railroad and there are eroding breaks east of the railroad. The vegetation west of the railroad probably is mixed brush and grass type while the vegetation east of the railroad is moderately sparse creosote bush and tarbush. A similar change in vegetation occurs on the east flank of the San Pedro Valley, but the sharp, straight contrast lines indicate that brush has been cleared below the lines (not field checked).

Separ, New Mexico Photograph

Photograph number 3755A (fig. 4) is the southwestern corner of New Mexico. Interstate Highway 10 is visible in the upper center of the photograph. Separ, New Mexico is located adjacent to the major bend in the highway. The Little Hatchet Mountains and Playas Lake are near the center of the photograph.

The major plant communities indicated on the overlay for figure 4 were determined from Bureau of Land Management range-survey maps. Tobosa grass occurs over most of the lowland areas, while creosote bush occurs on the intermediate slopes of the mountain ranges. Juniper and (or) oakbrush dominate the higher parts of the mountain ranges. The infrared reflectance from the higher elevations of the mountains is from areas that are covered primarily with oakbrush.

Several miles south of Separ, New Mexico, we visited a tract that was ripped in 1962 in order to increase the vegetal cover. This tract was not discernible on the Apollo 9 photograph (fig. 4). Apparently the ripping practice did not create a sufficient difference in the density or type of vegetation to be detected from the space photographs even though difference was observed on the ground.

CONCLUSIONS

1. The false-color infrared photographs had greatest contrast and were easier to interpret than the black and white photographs which were sensitive to the green, red, and infrared spectral bands.

2. The intensity of the blue-green color that results from vegetation is more a function of quantity of vegetation than class, such as grass, shrubs, and trees.

3. The highly absorbtive characteristics of the lava flows make interpretation of the plant cover growing on them difficult, if not impossible and illustrates the need for good ground-truth information.

4. On the photographs that we examined, light-colored calcareous soils appeared as light colored areas, while red soils appeared orange-tan on color infrared photographs. Basalt flows and soils derived from basalt were dark blue to black on the color infrared.

5. Ripped and furrowed areas near Separ, New Mexico were not discernible on the photographs even though the grass on the treated areas was denser than on adjacent untreated areas. However, in the San Simon Valley, areas that had been cleared, furrowed, and seeded to lovegrass were discernible from adjacent creosote bush and tarbush areas. Vegetation conversions of juniper to grass northwest of Carrizozo could not be detected.

6. Waterspreaders can be detected due to greater soil moisture which results in vegetation densities much greater in the spread areas than the surrounding areas.

7. No infrared reflectance from native vegetation was detectable in the Tularosa Basin. This is believed to be due in part to the time of year in which the Apollo photographs were taken. Photography taken during two or more different seasons may be more beneficial in determining regional plant types and moisture differences.

8. The use of the color-additive technique should be investigated to see if it will enhance the differences between coniferous trees, grass, and shrub communities for the preparation of regional vegetation maps.

9. Regional geomorphic expression is easily seen on photographs obtained from space and may be useful in determining regional differences in land forms, infiltration, and soil texture as expressed by drainage patterns, upland and channel erosion, and areas of recent deposition.

LIST OF COMMON AND SCIENTIFIC PLANT

NAMES USED IN THIS REPORT

Common	Scientific
Grasses	
Grama grass	*Bouteloua* spp.
Tobosa grass	*Hilaria mutica*
Vine mesquite	*Panicum obtusum*
Alkali sacaton	*Sporobolus airoides*
Fluffgrass (annual)	*Trioda pulchella*
Shrubs and trees	
Sand sage	*Artemisia filifolia*
Fourwing saltbush	*Atriplex canescans*
Mountain mahogany	*Cercocarpus* spp.
Tarbush	*Flourensia cernua*
Juniper	*Juniperous* spp.
Creosote bush	*Larrea tridentata*
Oakbrush	*Quercus* spp.
Soapweed	*Yucca* spp.

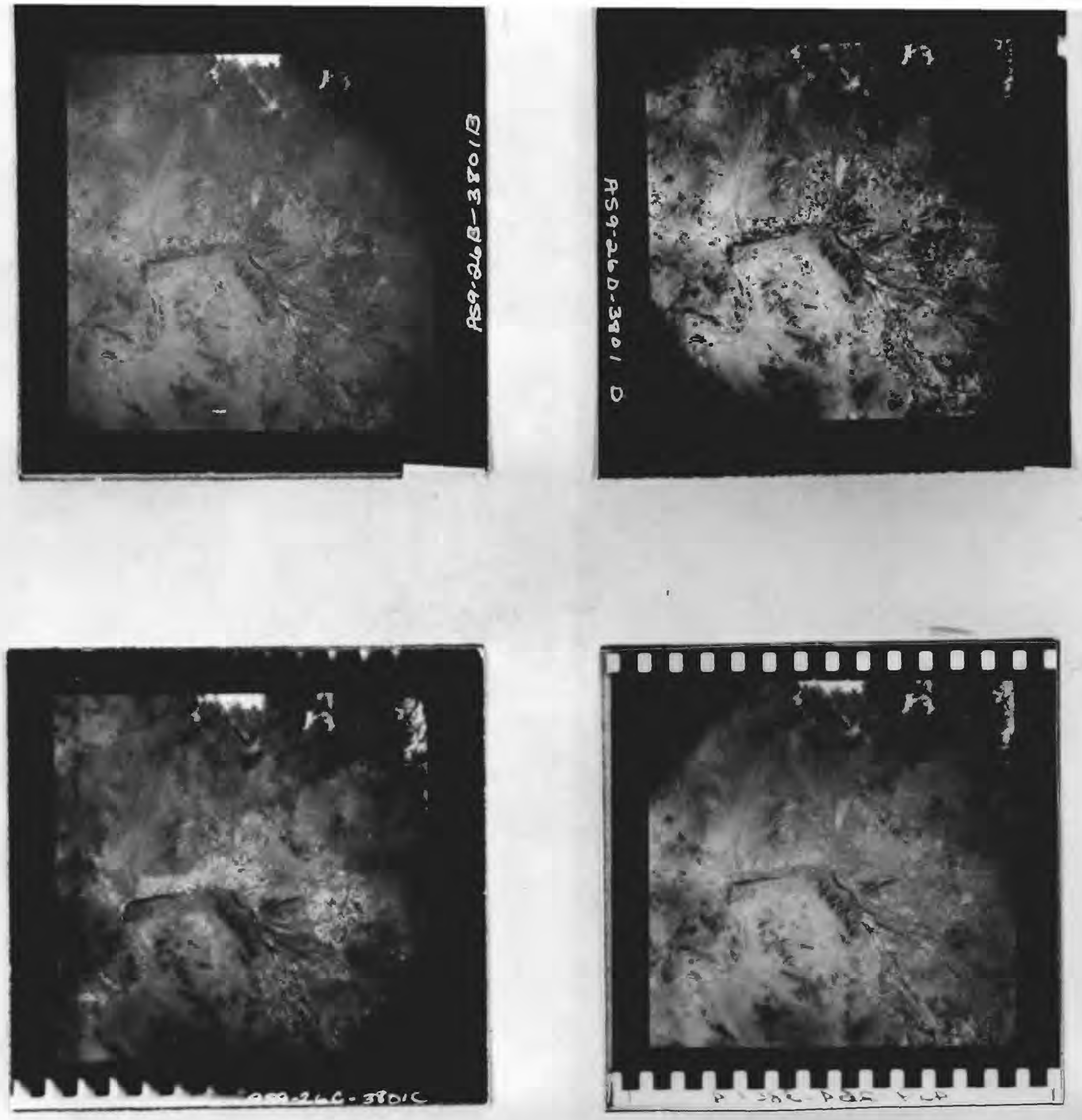

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Figure 1A.--Comparison of the spectral bands of the Phoenix, Arizona area. The upper left is the 470-610 nanometer (green) band; upper right is the 590-715 nanometer (red) band; lower left is the 700-900 nanometer (infrared) band; and the lower right is false color infrared, which covers a spectral band from 510-890 nanometers.

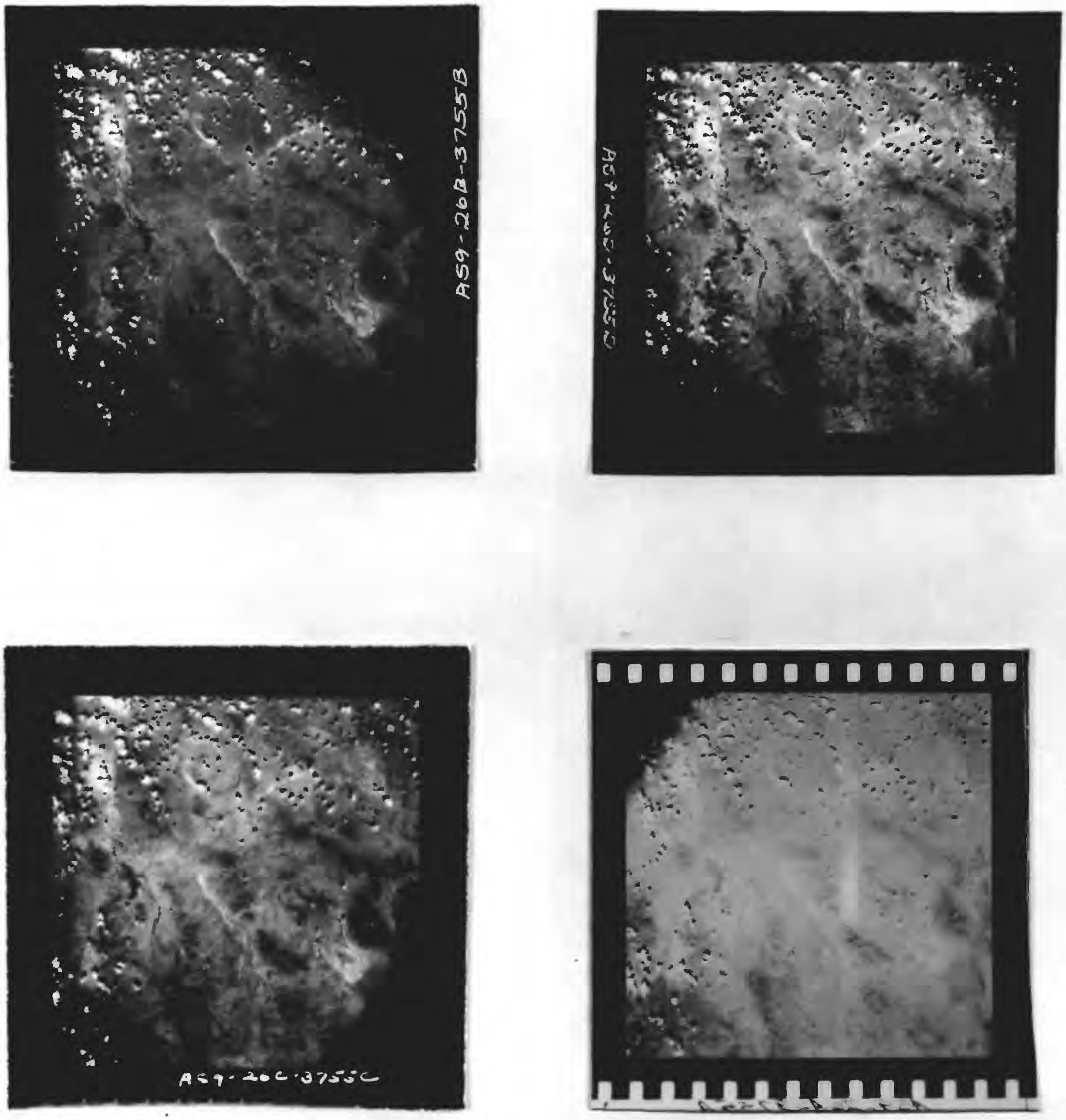

Figure 1B.--Comparison of the spectral bands of the southwestern New Mexico area. The upper left is the 470-610 nanometer (green) band; upper right is the 590 to 715 nanometer (red) band; lower left is the 700-900 nanometer (infrared) band; and lower right is false-color infrared, which covers a spectral band from 510-890 nanometers.

Figure
Figure 2
Grama grass
Juniper ?
Rio Grande
Sand sage
Fluff grass
Alkali sacaton
U.S. Highway
Black grama.
Sand sage
Fourwing saltbush
Trinity Site
Creosote bush
Alkali sacaton
Creosote bush
Creosote bush
Flow
Fourwing saltbush
Alkali sacaton
Three Rivers
U.S. Highway

Arizona
Photo
igure 3
tobosa
cover
Drop structure
Naturally
area with tobosa
and
delineated
areas
Bowie
San Simon
10
High
Playa
River
clearing
Ephemeral
Tombstone

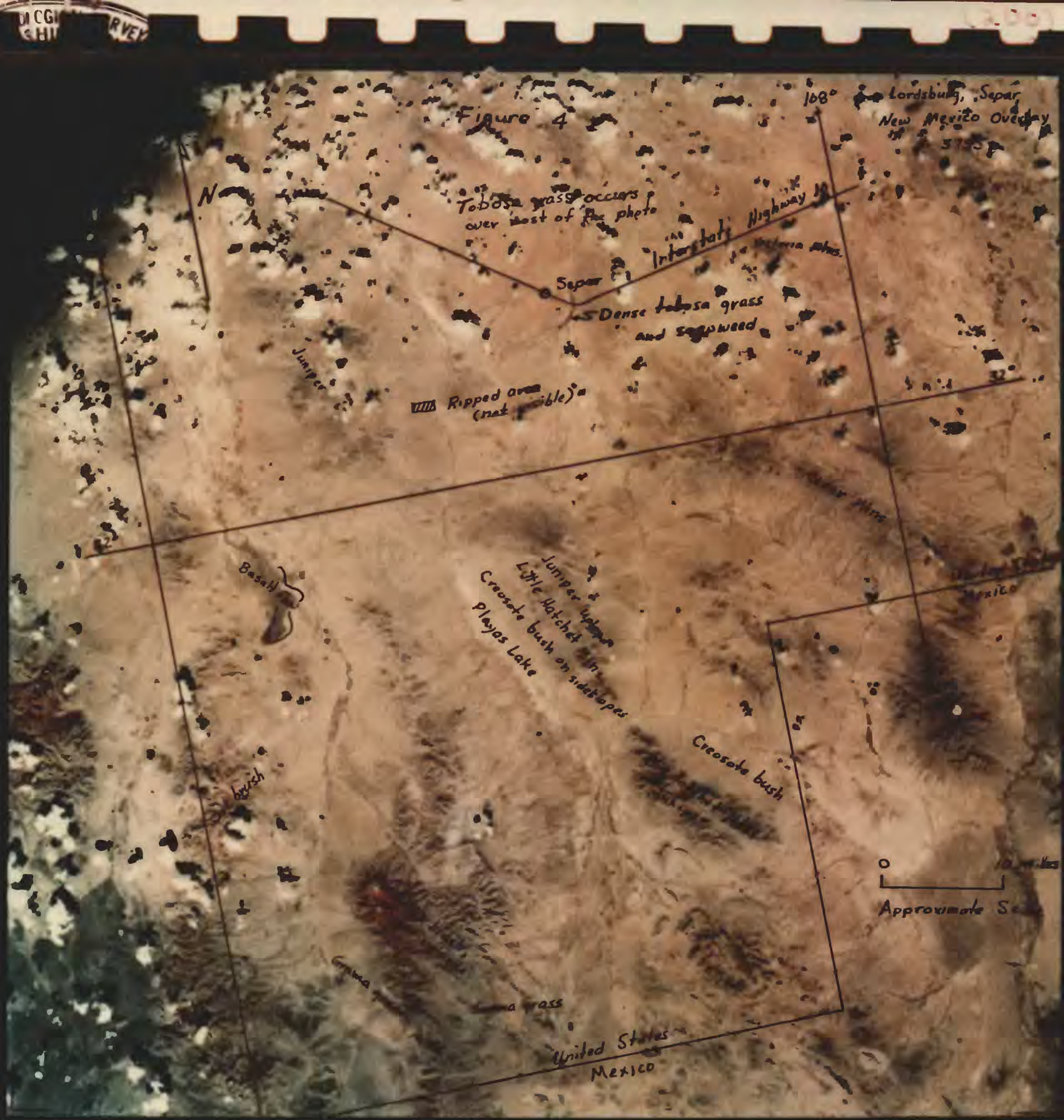

Figure 4
108°
Lordsburg, Separ
New Mexico Overlay
N
Tobosa grass occurs over most of the photo
Interstate Highway 10
Separ
Dense tobosa grass
Juniper
Ripped area
32°
Basalt
Juniper
Little Hatchet
Creosote bush on sideslopes
Playas Lake
Creosote bush
bush
grass
United States
Mexico
0
Approximate