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USE OF SATELLITE IMAGERY FOR CLASSIFYING AND MONITORING RANGELANDS IN SOUTHERN IDAHO[1]

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INTRODUCTION

Inventory of range lands to determine their current cover and actual potential is a basic requirement for management. The problem of obtaining adequate range inventories and periodically updating them has been a critical one since the earliest days of range management. Difficulties have resulted from a number of factors, including the large size of the areas involved, their diversity, and the severe limitations of funds available for inventory purposes. In addition, subsequent changes in land use often render parts of an inventory obsolete soon after it has been made. All of these conditions exist in Idaho where a 30 million acre (12 million ha) area south of the Idaho batholith contains some 25 million acres (10 million ha) of rangeland. Most of this range is in the sagebrush-grass zone, and despite superficial uniformity, contains many different types of range vegetation.

Much of the vegetation has been drastically altered by fire and past abusive grazing use. To further complicate the situation, exotic annuals from the Mediterranean region presently dominate the landscape over extensive areas, and vegetation cover types not present in presettlement periods are widespread. Moreover, nearly 2.0 million acres (0.8 million ha) of depleted ranges have been artificially seeded to crested wheatgrass and other introduced forage species, thus producing additional range types. In addition to these sources of range variability rapid changes in land use are now occurring, especially in the conversion of range to irrigated crop lands. As a result of all these factors, classification of range lands in southern Idaho and monitoring of changes in their use has not been carried out in a comprehensive and continuing program, but has remained spotty and incomplete.

One of the more promising methods for supplementing ground procedures for the inventory of range or other natural resources is by means of remote sensing. This term refers to acquiring information about objects from a distance, whether from a satellite vehicle, an aircraft or a platform a few feet from the ground. Aerial photographs taken from elevations of 5,000-25,000 ft (1,500-7,500 m) represent a common type of remote sensing, and until recently were the only form available for range inventories. Photos of this type have been used in range inventory during the past 25 years, but they have certain limitations for this purpose. First, the area covered by each photo is relatively small, so that many photos are needed for a sizable range area. Also, there is significant distortion on the edges of photos taken from such elevations, and a large degree of overlap is required in order to provide accurate mosaics which must be made from the central portions of the photos. Another adverse factor is the time required to cover a large range area, making it difficult to obtain uniformity of lighting over the entire area. Finally, photos of this type were usually made with a standard black and white film, sensitive only to a portion of the visible spectrum. Recently color film has received increased use for forestry purposes, but its use increases the photographic costs considerably.

Improvements in techniques, equipment and films made during and since World War II have greatly extended the utility of remote sensing for inventory of natural resources. Improved lenses and other equipment have made it possible to obtain images of great clarity and definition from much higher elevations than was possible in earlier years. The development of improved films and filters sensitive to different parts of the visible and the infrared spectrum has also greatly increased the amount of information available by remote sensing.

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Cover: ERTS-1 (now called LANDSAT-1) photograph of Craters of the Moon National Monument in southeastern Idaho. Shades of greyness of lava are indicative of different kinds and ages of lava flows. The communities in the lower center are Burley-Rupert, and American Falls in the lower right corner.

Fig. 1. Black and white print of band 5 ERTS-1 (now called LANDSAT-1) imagery of southwest Idaho, October 1972. Portions of Treasure Valley (Boise) and Magic Valley (Twin Falls) are located in the upper left and center right, respectively, with the Snake River traversing east to west across the mid portion of the photograph. Other than the major drainage systems, dark images were identified as areas supporting actively growing vegetation (coniferous forest at top of photograph) or irrigated crops. Various shades of grey were areas of dormant or sparse range vegetation and harvested croplands.

The most spectacular recent advance in remote sensing has been the development of the Earth Resources Technology Satellite by the National Aeronautics and Space Administration (NASA). This satellite was put into orbit in July 1972, and functioned for over two years before reaching the end of its working life. During this period it produced an extraordinary amount of information regarding the natural resources of earth.

ERTS-1 revolved in a circular orbit 570 miles (917 km) above the earth. Fourteen orbits were made each day, obtaining imagery of strips 115 miles (185 km) wide, with a 14 percent overlap between orbit paths to provide limited stereo coverage. Any one location of the earth's surface was covered every 18 days in a continuing sequence. Earth resources data were collected by a multispectral scanning device (MSS system) which operates in two wave bands of the visible spectrum (green and red), and two in the near infrared. This information was actually obtained as impulses of reflected light energy impinging on filtered detectors and transmitted to earth as electrical impulses where they were reproduced as photographs, or as digital tapes for computer analysis. Each photoframe covered an area of 8.5 million acres (3.4 million ha) and an image was obtained simultaneously on each of the four bands.

It appeared that this high altitude, multiband, repetitive imagery might provide a valuable approach for classifying major range types and monitoring their use. The slowness and difficulty of studying a 25 million acre (10 million ha) area entirely by ground methods suggested the value of testing the ERTS imagery. The opportunity arose in September 1972, when the authors obtained a grant from NASA for this purpose. The research reported here was conducted during 18 months of the contract with NASA. Southern Idaho was chosen as the study area because of the extensive range resource it contains and because of the large amount of ground truth already obtained on the vegetation and soils of the area.

THE STUDY AREA

Most of the cultivated, irrigated lands of southwestern Idaho are restricted to a 10-20 mile (16-32 km) zone along the Snake River and the lower drainage of the Boise and Payette rivers. Outside of these areas, rangelands dominate the landscape, except where the precipitation exceeds 20 in (500 mm) annually and forest vegetation becomes important. Precipitation in this portion of the state ranges from less than 7 in (175 mm) to more than 30 in (760 mm) annually and the elevation varies from 2,100 ft (1,200 m) to more than 10,000 ft (3,000 m) above sea-level. Soils are highly varied and are derived from parent materials that include loess, basalt, welded tuffs, rhyolite, granite and alluvium, each occurring over extensive areas. The original vegetation, being the product of climate, soil, relief and time, varied from xeric salt-desert shrub vegetation to the mesic Douglas-fir and spruce/fir forests at the higher elevations. Man's manipulation of the landscape has affected all of the original vegetation through varying degrees of disturbance by grazing, cultivation, fire, and logging, and through the introduction of exotic plant and animal species. These influences have further increased the variability of the vegetation.

METHODS OF INVESTIGATION

The present study was conducted using only th photographic material from ERTS-1, in the form of 7 mm (2¼ x 2¼ in) transparencies and enlarged print made from these.

Sets of ERTS photos of the study area taken at fou different dates during 1972 and 1973 were used t determine seasonal differences in the imagery of rang types and to detect changes in land use.

The relative effectiveness of the different wave bands in delineating landscape features was first teste by viewing each one separately as a black and white image. Further information was then obtained by viewing the different band in combinations of 2, 3, or 4 by means of a color additive viewer and projector. The false color images produced by this procedure were helpful in further recognition of ground features, particularly vegetation.

Viewing of the ERTS films was followed by making enlarged prints in black and white, on a scale o 1:500,000. In addition, paper tracings were made on a scale of 1:250,000 from projected images. Color enhanced imagery was used for the latter, and all observed images were delineated. Both enlargements and tracings were used to check against ground truth in the field.

Field inspections were made primarily in areas where prior ground truth information was deficient. At each inspection site the vegetation was characterized by abundance ratings on a scale of 1 to 5 (rare to dominant). In addition to describing the present plant cover, the site was classified by its probable potential vegetation. A description of the soil profile was made in accordance with standard survey procedures, and the soil was classified according to current soil taxonomy. These ground truth observations were supplemented by a road log of vegetation which totaled 1,200 miles of vegetation traverse. These data helped in determining the distribution of vegetation types.

Due to the large size of the study area, it was decided early in the investigation to confine the most detailed work to rangelands in southwest Idaho. The area was chosen for the variability in range types and the amount of ground truth available.

Limited coverage by another kind of remote sensing imagery from high elevation aircraft was obtained through courtesy of the Ames Research Center of NASA, located at Moffett Field, CA. Coverage was made for one time only on pre-designated flight strips in several parts of the study area. This imagery, taken from an elevation of 65,000 ft (19,500 m) was used to aid in the interpretation of features not shown clearly by the ERTS imagery and photos.

RESULTS

The results obtained to date in this study are presented here in three main groups: image recognition vegetation mapping and monitoring land use.

Image Recognition and Interpretation

An ERTS image of the study area (Fig. 1) illustrates the kinds of information available from satellite imagery without color enhancement. Land features such as major drainages, mountainous areas, lava flows and playas are shown clearly. Man-made features including large reservoirs, urban areas and major highways can also be recognized. Land use patterns and natural vegetation types are also discernible, but with varying degrees of distinctness. It was for these features especially that further utilization of multiband, sequential imagery was necessary for recognition and interpretation.

Usefulness of Different Wave Bands

Significant information was obtained from viewing individual wave bands of the black and white transparencies, but additional data were provided by multiband, color enhanced imagery. Band 5 (600-700 nanometer) covering the red part of the spectrum showed the distribution of the major vegetation types and distinguished these clearly from cultivated lands. Band 7 (800-1,100 nm) in the near infrared was useful for distinguishing bodies of water, drainage channels and most geological features, but was inferior to Band 5 for showing vegetation. Dry and dormant vegetation was rendered poorly in both bands. The other two bands, nos. 4 (500-600 nm) and 6 (700-800 nm), also showed many features, but were not as useful as bands 5 or 7.

Color enhanced, multispectral imagery composed of bands 5 and 7 with green and red filters proved to be the best combination for the purpose of this study. Vegetational features which were subdued or obscured in black and white single-band imagery showed well in these color-enhanced photos.

Value of Sequential Imagery

Although multispectral, color enhanced imagery from a single ERTS recording was highly useful in depicting vegetation, much additional information was obtained by viewing the same scene during different stages of vegetational growth and activity. For example, sagebrush stands could be separated from cheatgrass with imagery obtained in the spring due to high reflectance from the rapidly growing grass. Later in the season these two vegetation types were often indistinguishable, due mainly to the low infrared reflectance from both sagebrush and dried cheatgrass.

Recognition of Specific Features

Using the combined information provided by multiband, sequential ERTS imagery and the interpretive experience of the authors, supported with additional ground observations, many images of more subtle land features were recognized. Heavy reliance was placed on color, density, texture, shape, and pattern for image interpretation. Evaluation of the accuracy with which images were identified as compared with subsequent ground checks was biased because of the interpreters' previous familiarity with the area under investigation. Thus, no quantitative analysis of the expected accuracies when using ERTS data was undertaken.

Cultivated vs. Uncultivated Lands

One of the most clear-cut distinctions found on ERTS imagery was that between cultivated and uncultivated lands. The cultivated areas could also be subdivided into irrigated and dry land operations, as determined primarily by the amount of infrared reflectance from the crops produced. A further division of irrigated fields into annual row crops such as beans and sugar beets, versus perennial forage crops or pastures was also possible with the aid of sequential imagery. Dry farming areas with vigorous growth and relatively high productivity could likewise be distinguished from marginal areas with sparse production. Identification of specific cultivated crops was beyond the scope of this project, but preliminary examination of the color enhanced imagery and the results of remote sensing research in other parts of the country indicate that much can be done in this regard.

Another category of land treatment shown by the ERTS images was that of reseeded rangelands. These are common in southern Idaho where a major form of range improvement consists of conversion of depleted sagebrush-grass range areas to a more productive forage cover by reseeding to suitable species, mainly crested wheatgrass *(Agropyron desertorum)*. The procedure for conversion generally involves removal of most of the sagebrush and other existing vegetation by shallow disc plowing, spraying with herbicides or burning, followed by seeding of the forage species with a drill. Reseeding of sagebrush areas has attained a high degree of success, but attempts to reseed areas dominated by cheatgrass or other annual grasses have been less satisfactory due to difficulty in reducing competition from the existing plant cover.

Only qualified success was obtained in identifying reseeded ranges in the study area. Highly successful and relatively recent seedings were indicated by their distinct edges and difference in tone from adjacent vegetation. Crested wheatgrass stands, however, showed low infrared reflectance even during the period of lush growth in spring. This effect was contrary to the results of the closeup color infrared photography, and is believed to be due to the high percentage of bare ground present in most reseeded ranges. As a result, the majority of seedings could be identified only by sequential imagery which distinguished them from the high reflectance of cheatgrass stands in the spring, and from sagebrush stands by differences in tone on either black and white or color images. Older seedings or those containing a high percentage of annuals or sagebrush were difficult to identify or delineate.

Native Range Types

Much variation was found in the extent to which native range vegetation types would be identified on ERTS images and in the characteristics which proved useful for this purpose. For example, the shadscale zone, located in the driest part of the study area, with an average annual precipitation of about 6 in (150 mm) exhibits sparse plant cover and light colored soil surface. The high amount of reflectance from the soil tended to mask the effects of vegetation in ERTS imagery of this zone. The presence of other salt desert shrub communities within the shadscale zone could not


VEGETATION TYPE MAP
Mt. Home – Jarbidge Mt. Area
0 5 10 15 20 miles
N
Boise
Mt. Home
Twin Falls
Basin big sagebrush / Thurber needlegrass
Basin big sagebrush / Bluebunch wheatgrass
Range seedings
Irrigated cropland
Low sagebrush / Fescue
Forest (Douglas-fir/Aspen)
Recent lava
Dryland cropland
Juniper/sagebrush
Mt. big sagebrush / Fescue
Rivers and large water bodies
Playas
Meadow
Shadscale
Sand dune
Cheatgrass

be detected. The mountain big sagebrush/Idaho fescue type was differentiated from the basin big sagebrush-bluebunch wheatgrass type by the greater reflectance of the former shown in spring and summer imagery. At higher elevations, analysis of fall imagery separated the mountain shrub and aspen-dominated communities from adjacent sagebrush-grass vegetation.

Many other types of sagebrush-grass vegetation known to exist in the study area could not be differentiated by ERTS imagery. The low reflectance from all major sagebrush species throughout the growing season made many of these types look alike in the ERTS imagery.

Range Burns

Recent burns in sagebrush-grass type areas were visable in detail for one to two years after the fire. It appeared that ERTS imagery could provide a rapid and accurate method of delineating and measuring burned areas. Burns in annual grass areas were more difficult to recognize after a few months.

VEGETATION MAPPING

The vegetation map of the Mountain Home-Jarbidge Mountain area shown in Fig. 2 was produced from ERTS imagery, supplemented by ground truth information. All divisions shown on the map could be seen in ERTS imagery. This is a second generation map, derived from the study and interpretation of images originally delineated at a scale of 1:250,000. The vegetation type lines shown on the map were based on interpretation of these images, and on the use of ERTS sequential imagery. In portions of the mapped area for which U-2 high flight coverage was available, this imagery was used to check the accuracy of the ERTS imagery. In cases where discrepancies were found between photos from the two sources, the U-2 imagery interpretation was accepted.

While this vegetation map does not show all possible separation of range types, it does include all the broader types, plus various forms of land use, range reseeding, etc. It is the most comprehensive and up to date land resource map available of the area, and was prepared at a small fraction of the cost that would have been required for a purely ground study approach. This map should be valuable to all agencies or individuals concerned with land use in the area.

MONITORING LAND USE

One of the more desirable features of ERTS imagery for land managers is the possible recurring coverage of the same site at relatively short intervals (18 days). Seldom does an investigation receive coverage this frequently, because of clouds or equipment malfunctions; however, even with imagery from only four to five passes during parts of two years we were able to monitor the following changes:

(a) Conversion of rangeland to cultivated and irrigated crops, particularly in areas adjacent to the Snake River where pump irrigation is feasible. In some cases the whole conversion process occurred in less than six months. Such changes would be difficult to monitor over so large an area by any other method. The type of irrigated crop, whether row crop or perennial hay or pasture could also be determined.

(b) The location, extent, and configuration of burns in sagebrush-grass range was also detected by the sequential ERTS imagery. Such quick and accurate information is basic for land managers in evaluating the impact of fire for a given year, and for planning rehabilitation measures.

Other examples of monitoring land use would undoubtedly be found if sequential coverage were continued for a longer period.

Fig. 2. Vegetation type map of southwest Idaho produced from color-enhanced ERTS-1 imagery and supported by ground truths. Original scale 1:250,000.

SUMMARY AND CONCLUSIONS

An initial evaluation of ERTS imagery as a tool for classification of range and associated lands and for monitoring and planning land use was made during an 18-month period in 1972-1973. While all of Idaho south of the central mountainous area was included, particular emphasis was placed on study of an area about 115 by 110 miles (185 by 177 km) in extent, which for the most part was included in the coverage of a single ERTS image.

ERTS imagery was used in the form of both single waveband black and white frames and color-enhanced imagery produced with a color additive viewer and projector. Repetitive coverage for four passes of ERTS was used, covering the fall of 1972 and spring and summer of 1973. Interpretation of the ERTS imagery was assisted by ground truth from previous research and by additional field work in 1973.

The results indicate the capability of ERTS imagery when combined with small-scale CIR photos and ground truth to provide timely information on a variety of physiographic and cultural features, differentiation of cultivated versus rangeland use, and classification of many major range types. Disturbance factors such as recent burns in sagebrush-grass ranges and many range reseeded areas were also identifiable.

Many physiographic and cultural features showed clearly on single-band, black and white ERTS photos. Better results for the interpretation of vegetation were usually obtained from color enhanced imagery produced by superimposing two or more of the four bands available for each scene. Bands 5 and 7, covering the red and near infrared portions of the spectrum respectively, were found to be the most useful of the four bands whether used singly or in combination.