AN INTEGRATED LANDSAT/ANCILLARY DATA CLASSIFICATION OF DESERT RANGELAND

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BIOGRAPHICAL SKETCHES

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ABSTRACT

The federal government manages millions of acres of desert rangeland in the western United States. To efficiently protect and manage this natural resource, a knowledge of present range condition is essential. The objective of this study was to improve range inventorying methods using Landsat MSS data, coupled with ancillary data. The study area encompassed nearly 20,000 acres in Rush Valley, Utah. The vegetation is predominately desert shrub and annual grasses, with some annual forbs.

Three Landsat scenes were evaluated using a Kauth-Thomas brightness/greenness data transformation (May, June, and August dates). The evaluation revealed the June date to have the greatest amount and variability of infrared reflectance while containing a relatively low reflectance in the green band. This suggested plant biomass production and phenological stages in June were optimal for differentiation of plant communities. The data was classified using a four-band maximum-likelihood classifier. A print map was taken into the field to determine the relationship between print symbols and vegetation. It was determined that classification confusion could be greatly reduced by incorporating geomorphic units and soil texture (coarse vs. fine) into the classification. The geomorphic units include

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playa, lake bottom deposits, young and old alluvium, and deltas. Soil texture classes were extracted from SCS soil survey information. Spectral data, geomorphic units, and soil texture were combined in a GIS format to produce a final vegetation map identifying 12 vegetation types. A preliminary accuracy assessment is quite promising.

INTRODUCTION

Much of western Utah is referred to as the west desert. This cold desert is part of the Great Basin Province taking in approximately 544,000 square kilometers (210,000 miles) of mountains, desert valleys, dry lake beds, and a few terminal lakes, including the Great Salt Lake. The dominant land use is extensive grazing for cattle and sheep, with a scattering of irrigated farmland where perennial water is available. The land is owned or managed by a mixture of private, state and federal entities with the great majority being under the jurisdiction of the Bureau of Land Management (BLM). With vast tracts of land to be protected and managed, along with continuing budget restrictions, it appears that modern remote sensing technology will be of increasing value to resource managers in the evaluation of rangelands. To test this idea, a study plan was designed and a study site selected.

The study area is located in Rush Valley, Utah, immediately south of the Tooele Army Depot, approximately 110 kilometers (70 miles) southwest of Salt Lake City. The cold desert environment in Rush Valley is representative of western Utah and contains a good variety of plant communities. The predominant plant species found in Rush Valley are big sagebrush (<u>Artemesia tridentata</u>), shadscale (<u>Atriplex confertifolia</u>), little rabbitbrush (<u>Chrysothamnus viscidiflorus</u>), and greasewood (<u>Sarcobatus vermiculatus</u>). The predominant grass type is cheatgrass (<u>Bromus tectorum</u>). Lands within the study area are managed almost exclusively by the BLM. In recent years the land has primarily been used as rangeland pasture for early spring grazing by sheep. One small grazing allotment has been used in the past for cattle, but it has remained unused over the last nine or ten years. Since the site is adjacent to an ungrazed Army Depot, it may be possible to have control areas for studying vegetative trend at later dates.

OBJECTIVE

The objective of this study is to test the utility of using Landsat MSS digital data in the mapping of large acreages of vegetation in the west desert. If this technique is determined useful, the processes could eventually be used in vegetative condition analysis, and with continued research, may lead to the development of new methods to objectively assess vegetative trends in cold desert environments.

METHODS

Landsat Digital Data Analysis

Landsat multispectral scanner (MSS) data represents light reflecting characteristics for the combined vegetative land cover and terrain features within each pixel (1.1 acres) of ground area. Three separate dates of MSS data were evaluated to select the best date for use in this study: August 14, 1982; June 17, 1980; and May 18, 1979. A Kauth-Thomas (Kauth and Thomas 1976) data transformation was applied to each set of Landsat data. The Kauth-Thomas transformation is a vegetative index that converts the four bands of Landsat MSS data into two components; brightness and greenness. For example, data displaying relatively low brightness and high greenness values are interpreted as representing dense, vigorous vegetative cover. When the three Landsat scenes were compared using this method, the June 17, 1980 data was considered optimal due to its lower mean brightness and higher mean greenness values.

The June data was classified using both Kauth-Thomas transformed data and four band raw data. (For this study area, the four band raw data appears to give the most accurate results.) Landsat MSS data was analyzed statistically to detect light reflectance patterns which were sufficiently unique to make different ground cover types of interest consistently distinguishable (Hutchinson 1982). This unsupervised classification method began by examining the recorded MSS reflectance values for each pixel in the entire study area. From this search of individual pixels, statistics were generated which characterize pixel groups with similar spectral features. A maximum likelihood classification routine was then used to associate each pixel in the study area with one of the 58 spectral groups generated. The analysis then focused on detecting similarities and differences between spectral groups. A common means of evaluating spectral characteristics is to plot each spectral group's mean reflectance value for the four MSS bands and create a signature plot.

In this study, every effort was made to objectively evaluate spectral signatures. This involved statistical analysis to determine how each signature relates spectrally to the others. The sequence of statistical routines that were used are: principal components analysis; cluster analysis; and discriminant analysis. A two-dimensional scatter plot produced in the discriminant analysis allows one to graphically view the spectral context in which a particular signature is found. The use of discriminant analysis, in combination with examination of spectral signature plots and ground information, was a key element in achieving good results from an unsupervised approach to Landsat data analysis (Merola 1984).

Another vital dimension to the process of digital data analysis is the calibration of spectral signatures with ground characteristics. This was accomplished by assigning print symbols to each signature or signature group and preparing print maps which were registered to standard base maps and referenced to photographs and field study sites. In this study, a digital print map overlay was prepared to match the USGS 7½-minute quadrangles (scale 1:24,000) of the study area.

Field Methods

Prior to the field work, hand-held aerial photography covering much of the study area was taken using 35mm ektachrome film. The photographs were taken at altitudes of 500', 1,500', and 5,000'. This data, along with 1:24,000 scale orthophotoquads, were invaluable in determining the ground location of field sites.

Preliminary field sites were selected from the digital print map before entering the field. Several field sites were selected for each print symbol class. Trips to the study area to collect ground data were made in mid-summer 1984. At each site ocular estimates of vegetative cover were recorded, along with general descriptions of the soil type, slope, aspect, and on-the-site photographs of representative vegetation. The field data was used to group spectral signatures representing similar cover types. Vegetation within the study area was surprisingly diverse. Field observations detected 12 separate vegetative communities in the study area that would be considered important cover types to land managers.

Ancillary Data

After several trips to the field, it became apparent that spectral data alone would be insufficient to accurately classify vegetative communities in the desert environment. In an attempt to improve mapping accuracy, two forms of ancillary information were added: general soil texture; and geomorphic terrain units.

Using Soil Conservation Service (SCS) maps and reports, soils within the study area were divided into coarse and fine textured soils. The coarse vs. fine soil map was digitized and entered into a data base to be used in stratifying Landsat spectral data. By using the texture data in classifying, it became possible to separate several important cover classes that could not be separated by spectral data alone. Still there were vegetative communities that were not adequately separated.

Within the study area, it was noted there were five relatively distinct geomorphic terrain units. Through the use of 1:20,000 scale black and white photographs, and USGS quadrangles, these five units were delineated and mapped. These terrain units include: pleistocene lake deposits, deltaic deposits, playa, new alluvial deposits, and older alluvial deposits. These units were digitized and entered into the data base, along with the file of soil textures.

Digital Data Base Analysis

Landsat spectral data, soil texture, and geomorphic units were used in combination to generate a final classification map of the west desert vegetative communities (Figure 1). An algorithm was written to assign corrected symbols to areas where spectral signatures had previously been confused. The algorithm systematically uses a sequence of condition statements to properly classify each cell on the print map. For example, spectral signature number 8, when found on pleistocene lake deposits and coarse textured soils, is symbolized on the print map as the letter 'T,' which is the symbol assigned to the big sagebrush community. When signature number 8 is found on deltaic deposits and fine textured soils, it is assigned the print symbol 'S,' representing the shadscale vegetative community. Thus, the vegetative communities may be uniquely stratified using soil texture and geomorphic terrain units.

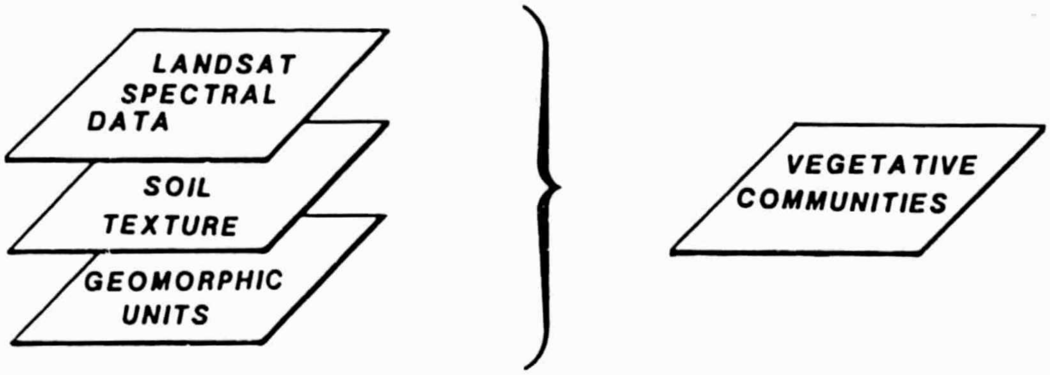

Figure 1. Use of satellite spectral data, soil texture, and geomorphic units to map the west desert vegetative communities.

RESULTS AND DISCUSSION

Vegetation Types

The 12 major vegetation types in this study are: mixed shrub (high species diversity), mixed shrub (low species diversity), winterfat (*Eurotia lanata*), shadscale (*Atriplex confertifolia*), big sagebrush (*Artemesia tridentata*), little rabbitbrush (*Chrysothamnus viscidiflorus*), greasewood (*Sarcobatus vermiculatus*), saltbush (*Atriplex tridentata*, and *A. Falcata*), cheatgrass and shrub mix (*Bromus tectorum* and various mixes of shrubs), cheatgrass (*Bromus tectorum*), summer cypress (*Kochia scoparia*), halogeton (*Halogeton glomerata*).

The mixed shrub (high diversity) type is excellent for sheep range due to the high forage quality of the shrub mixes. The mixed shrub (low diversity) site contains fewer shrub species and less desirable shrub types for sheep rangeland. Winterfat is often referred to as an "ice cream" plant because of its palatability to browsing animals. Shadscale is also a highly desirable forage plant and is above average in essential nutrients. Big sagebrush has moderate forage value to sheep and very little value to cattle. Little rabbitbrush has marginal to very little forage value and occupies sites having little ground cover. Greasewood, a salt tolerant shrub, is found predominantly on the playa and does have a little forage value in the spring.

The saltbush types are very desirable in terms of sheep and cattle forage. Atriplex tridentata is found on the playa bottom and A. falcata resides on sites which are fine textured, but have better water drainage. Cheatgrass is an introduced annual grass with very little forage value except in the spring when it is green and occasionally in the late fall, if sufficient rain is received to initiate regermination. Cheatgrass sites with interspersed shrubs were classed separate from pure cheatgrass because the shrubs improve the site forage value. Summer cypress is an introduced annual forb which is relatively high in nutrients and desirable to both cattle and sheep. Halogeton is also an introduced annual which is highly associated with soil disturbance. This plant is very poisonous to sheep, yet cattle seem to suffer no ill effects.

Mapping Results

A map of the 12 vegetation types within the study area was produced using Landsat spectral data, stratified by soil texture and geomorphic units. The resulting acreage estimates are listed in Table 1.

Table 1. The 12 vegetation types and their acreage estimates.

	Hectares	Acres
Mixed shrub (high diversity)	397	980
Mixed shrub (low diversity)	349	862
Winterfat	314	778
Shadscale	585	1,445
Big sagebrush	1,088	2,688
Little rabbitbrush	768	1,898
Greasewood	1,002	2,477
Saltbush	338	836
Cheatgrass mix	2,226	5,501
Cheatgrass	638	1,576
Summer cypress	351	867
Halogeton	468	1,156
	8,524	21,064

Due to adverse weather conditions, the final field verification of the map has been delayed until spring of 1985. A preliminary assessment of accuracy using random sites and 35mm aerial photography has been very encouraging.

Individuals who have worked within the study area for many years examined the map and are impressed with the classification accuracy.

CONCLUSION

It is generally not feasible to compare the results of conventional range inventories with satellite gathered results due to differences in the types of data that are collected using the two techniques. Ranchers, however, will often express their opinion that conventional inventory methods are unfair. Many are concerned that data collected in he past is misleading, since information from very few sites is interpolated over large tracts of rangeland. Other ranchers feel that conventional data collecting methods are subject to individual bias.

Use of satellite information can help alleviate some of these problems. At different points in this study, vegetative maps produced in the conventional way by the BLM were compared to Landsat classification maps. The maps generated from satellite data were consistently more detailed. Upon examination of aerial photography similar to what the BLM used in mapping vegetation, it became apparent that the Landsat sensors are much more sensitive to subtle vegetative changes than are photointerpreters. In some instances, areas that were photointerpreted as vegetatively homogeneous, were mapped by satellite as being quite diverse. Field observations found the Landsat classification to be correct. This increased detail is often vital for making proper land management decisions.

Since Landsat coverage and data quality are very uniform, studies using MSS data are often viewed as being less biased than conventional range inventorying methods. In addition, the digital nature of satellite data is ideal for ecological modeling through the incorporation of digital terrain data or map data which may be easily digitized. For an example, the digital information gathered in this study made it possible to produce maps showing areas of optimal sheep forage for spring vs. fall grazing. This is but one example of many questions land managers could answer using an interactive satellite and ancillary data base. The future of Landsat in solving problems associated with the field of range management looks bright. As the number of individuals using this technology increases, methods for solving the more complex problems are being developed.

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