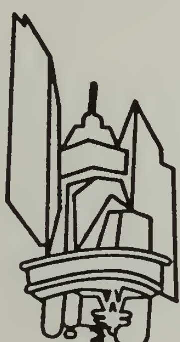
# TECHNICAL NOTE 361

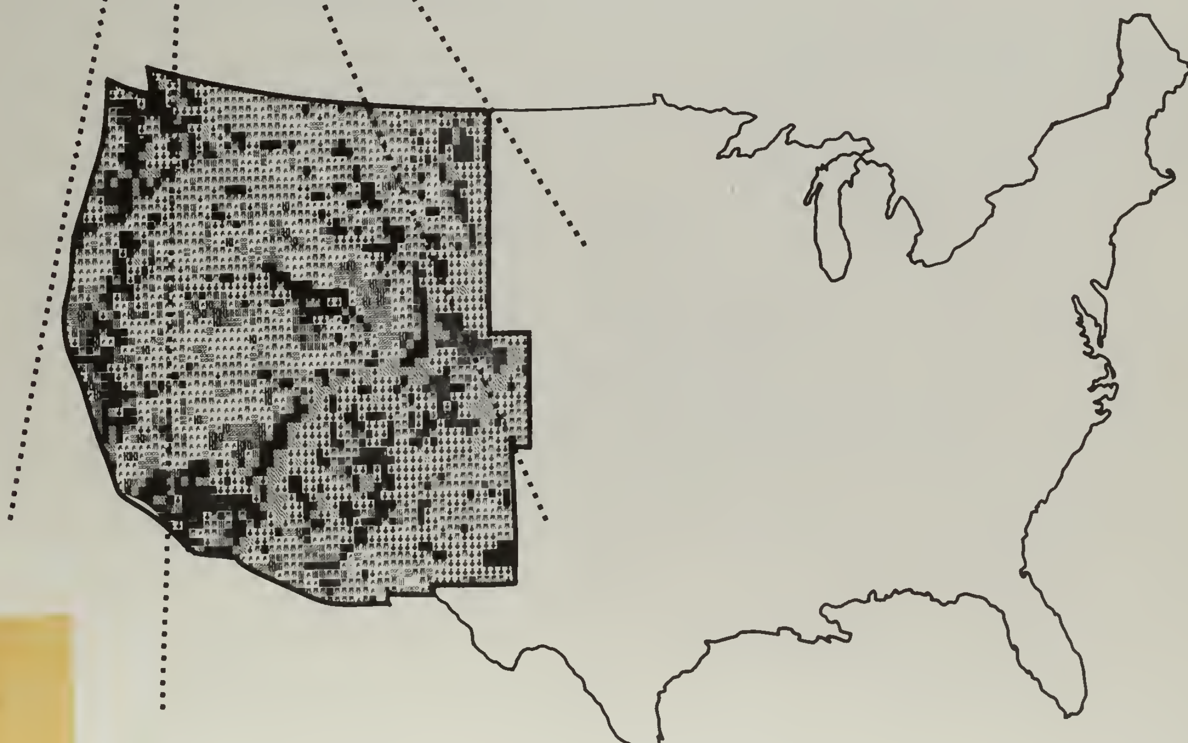
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT



## THE USE OF REMOTE SENSING FOR SOILS INVESTIGATIONS ON BLM LANDS

by

William D. Di Paolo and Laura B. Hall



Technical Note

# THE USE OF REMOTE SENSING FOR SOILS INVESTIGATIONS ON BLM LANDS

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF FIGURES

LIST OF TABLES

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# Preface

This report primarily concerns the use of Landsat digital data as an aid in the soil survey mapping efforts taking place on Federal, particularly BLM, lands in the western United States. Its purpose is to help BLM personnel become more familiar with the use and potential of Landsat data for soil survey work. The procedures and ideas presented in this report are those being used at the time of this writing (Fall, 1982). Changing technology and experience may warrant updates of this methodology in the future.

In order to better understand how Landsat data can be used in resource investigations, a brief description must be given of the Landsat system and the electromagnetic spectrum. Therefore, this report contains several appendices which describe Landsat, the electromagnetic spectrum, the types of image analysis equipment used by the BLM's Branch of Scientific Systems Applications at the Denver Service Center, a general outline of the steps taken in a BLM remote sensing project, and the procedures and forms required for those interested in ordering Landsat imagery.

The body of the report describes a project in southwestern Idaho where Landsat digital data were used as an aid in an Order 3 soil survey. Laboratory procedures, field observations, and results are given. This is followed by a discussion of the use of Landsat data in the soil survey process. Also, procedural recommendations for future soils remote sensing projects are given.

It should be stated that the use of product brand names in this report does not necessarily indicate BLM endorsement of those particular brands.

# INTRODUCTION

The Bureau of Land Management (BLM) of the U.S. Department of the Interior has the responsibility for the management of 192 million hectares (474 million acres) of public lands in 11 western states and Alaska. Management of these lands entails multiple use decision-making. The Bureau considers soils information an integral part of this decision-making process. Therefore, it is important to have timely and accurate soils data. The long range goal of the Bureau is to complete a once-over soil survey of the public rangelands under its management by 1989. As of 1981, approximately 88 million acres remained to be mapped.

Soil surveys in the western United States currently are being mapped by BLM and Soil Conservation Service (SCS) at an Order 3 on rangeland and at an Order 2 on potentially irrigable areas. Information from these surveys will be used in BLM's planning system, grazing environmental impact statements, and as a basis for other land use activity on public lands. SCS currently estimates that a person can map, at an Order 3 level, about 48,500 hectares (120,000 acres) per year in these arid and semiarid areas. This figure varies depending upon weather, terrain, field season, and so forth.

To carry out the variety of programs on the lands under its management, BLM has had to collect and handle large quantities of information. Within BLM, there have been many efforts toward an automated information system and the use of remote sensing data to satisfy some of these information needs.

One such effort analyzed the use of remotely sensed data as an aid to the current soil survey effort on Federal rangelands in southwestern Idaho [2/]. While Landsat imagery can be enhanced and used as a photo interpretation tool, this report will discuss the use of digital classification techniques and the merging of ancillary digital data sets.

Some elements which can be obtained using Landsat data and that may contribute to the Order 3 soil survey include:

1. Scale - Maps can be generated directly at a scale of 1:24,000.

2. Premapping Stratification - The synoptic view provided by Landsat imagery and compatible ancillary data can result in useful premapping products at a common scale. This could prove helpful both in the initial stratification of the survey area and in developing a field sampling strategy.

3. Boundary Delineation - Subtle contrasts, not visible on aerial photographs, can often be seen on the Landsat products because of the additional portions of the electromagnetic spectrum sensed by the satellite scanners. To the extent that these contrasts can be correlated with soil properties, soil map unit boundaries can be located and perhaps refined.

4. Map Unit Quantifications - Tabulating acreages and determining the proportional composition of soil map units is traditionally a time-consuming process. A digital data format could save time. Principal applications will likely occur on (a) relatively homogeneous areas such as rock outcrops or severely eroded lands with clearly discernible spectral signatures, and (b) multicomponent map units (e.g., associations) where major components are spectrally separable.

5. Soil-Vegetation Correlation - Much of the value of soil information to BLM rests on the correlation between soil properties and vegetation. Landsat imagery may denote relationships not readily apparent on the ground or through visual interpretation of aerial photographs.

## OBJECTIVES

The major objective of this work was to determine what information could be obtained from Landsat data which would aid or could be incorporated into an Order 3 soil survey for multiple use management with emphasis on livestock grazing management. Part of this objective was to determine the spectral nature of these arid lands, along with understanding the factors that contributed to the spectral response of the classes within this area. Another objective was to determine the analysis techniques needed to produce a map containing representative and distinct spectral classes. Once these spectral classes were established, they were to be related to informational classes. Therefore, it was not the intent of this project to produce an Order 3 map, but rather to demonstrate the potential of this technology as a tool which might increase the efficiency, productivity, and accuracy of the soil survey, especially where large acreages were invovled.

## STUDY AREA

The location of the study area is shown in Figure 1. It is located about 113 kilometers (70 miles) south of Boise, Idaho, and south of the Snake River. It encompasses an area of approximately 135,000 hectares (300,000 acres). This general location was selected by the soils staff at the BLM Boise District Office because of the diversity of soil types recognized within this area.

Elevations range from 700 meters (2,300 feet) to over 2,100 meters (7,000 feet). Precipitation varies from 15 to 36 centimeters (6 to 14 inches) at the lower elevations, to over 51 centimeters (20 inches) in the mountains.

Physiograhic elements consist of dissected granitic mountainous terrain, elevated volcanic plateaus, an old pediment surface, and young alluvial fans. At the north end of the study area is the Snake River flood plain. The geology of this area has been mapped, and published at a scale of 1:125,000 [3/]. A generalized county soils report covering this area was published at a scale of 1:126,720 [1/]. Most of the soils within the study site were generally formed in an arid and semiarid environment.


Figure 1. Index map showing the approximate location of the study area described in this paper.

Vegetation associations within the study site include salt-desert shrub, big sagebrush-grassland, low sagebrush-grassland, grassland, juniper-sagebrush, and mountain brush. Fire and overgrazing have affected the natural plant communities in some areas.

## ANALYSIS METHODS AND PROCEDURES

Data from a June 5, 1976, Landsat-2 scene were selected for this study. The reasons for selection of this data were: (1) absence of cloud cover, (2) channel quality, (3) time period most favorable for resource enhancement, and (4) date of ancillary aerial photography. Climatological data indicated that very little rain occurred during this period so conditions were dry. The ancillary data available consisted of color resource aerial photographs taken in mid-July 1976 at a scale of 1:31,680, topographic maps (scale of 1:24,000 and 1:250,000), a geologic map, a county soil map, and ecological site descriptions and vegetation information.

The computer compatible tape containing data from this Landsat scene was analyzed at Purdue University's Laboratory for the Applications of Remote Sensing (LARS). The computer system used was an IBM 370 Model 148 central processing unit.

Data were also analyzed from a July 10, 1978, scene using BLM's Interactive Digital Image Manipulation System (IDIMS) which is implemented on a HP-3000 minicomputer with an array processor. Digitial terrain data, land ownership, and geology were also merged into this data set using the BLM's Geographic Information System.

The Landsat multispectral scanner data were geometrically corrected. This included rotating and deskewing, and rescaling output data to approximately 1:24,000. That portion of the scene containing the study site was selected for further preprocessing. For the June data, this entailed defining the exact study site boundaries. The July data were registered to a Universal Transverse Mercator (UTM) map projection through the use of ground control points selected from U.S. Geological Survey 7.5 minute topographic quadrangles.

Several analysis techniques were used during the study in attempting to convert the Landsat data into distinct spectral classes. Because of the heterogeneous nature of the study area, an unsupervised classification method was used. Basically, the analysis process involved clustering, or using an algorithm to divide the four channel Landsat data into groups of points having similar spectral characteristics; deleting, retaining, or combining cluster groups based upon statistical separability; and then using the statistics developed from the resulting classes in a classification algorithm to assign each of the data points in the study area to one of the resulting classes.

The June 5, 1976, data were clustered using a modified cluster block approach [4/]. This involved selecting areas representing many different cover types or classes so that the complete spectral nature of this area would be represented. The size of the blocks ranged from 720 hectares (1,776 acres) to 2,877 hectares (7,104 acres). This resulted in about 16 percent of the study area being sampled. Figure 2 shows the location of these cluster blocks.

A systematic sampling method was used to generate cluster statistics for the July 10, 1978, data resulting in 25 percent of the area being sampled. These clusters, or training statistics, were then used in an algorithm to classify all the data elements or pixels within the study site.

Subsequent classification of sample areas revealed some class confusion. It appeared that classes in the highlands were being confused with certain classes in the lower areas. For example, bare granitic rocks appeared spectrally similar to barren lacustrine sediments. In order to avoid this confusion and better refine the spectral classes, the study site was divided into three distinct areas. A natural physiographic break occurred separating the mountain and plateau areas from the alluvial fan area. This boundary was digitized and incorporated into the June 5, 1976, data set. Since this physiographic break coincided quite closely to the 1,220 meter (4,000 feet) contour line, all data greater than this elevation could easily be stratified using digital terrain data which were merged with the July 10, 1978, data. Figure 3 shows band 5 of the spectral data greater than 1,220 meters (4,000 feet) in elevation.

The agricultural areas around the Snake River were not included in the BLM soil surveys, and therefore it was necessary to separate these areas from the alluvial fan. On the June 5, 1976, scene, this was done by digitizing around the outline of the agricultural fields observed on spectral band 5. The agricultural area was separated from the fan area on the July 10, 1978,

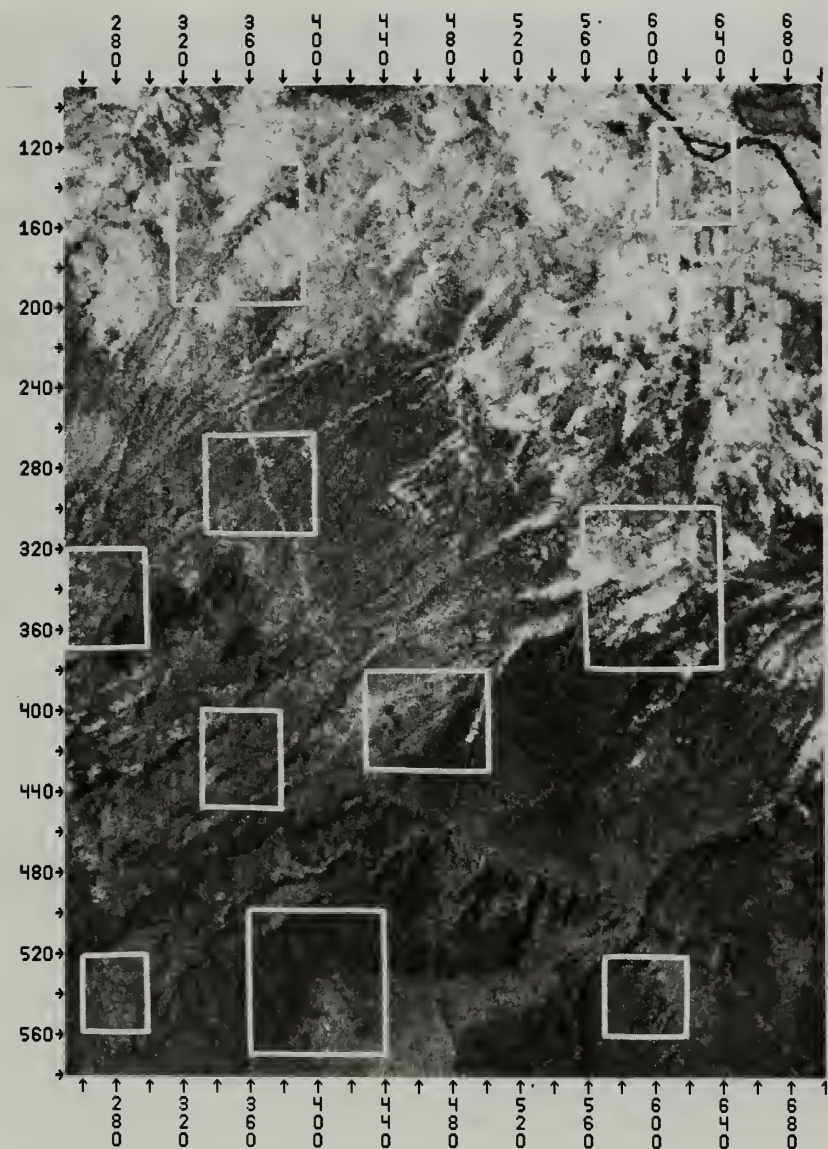


Figure 2. Location of cluster blocks used to generate training statistics. (From Di Paolo, 1979)

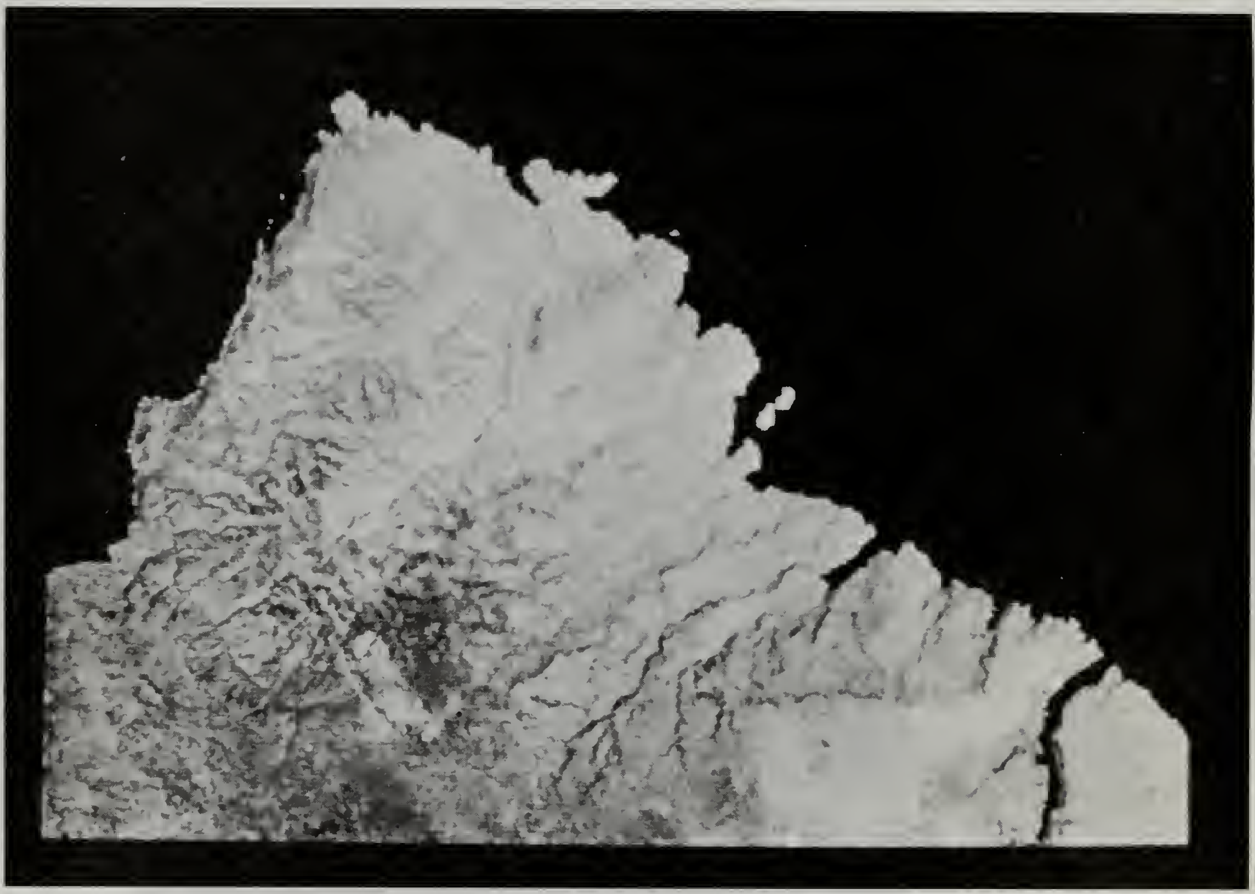

Figure 3. Band 5 data showing the area greater than 1,220 meters in elevation which was generated using digital terrain data.

data set by using land ownership data which had been digitized and merged with this Landsat scene. Therefore, Federal land could be separated from non-Federal (agricultural) land occurring at less than 1,220 meters (4,000 feet) in elevation. From this, separate statistics could be generated for each area. Figure 4 shows the boundary of the agricultural land superimposed on one band of spectral data. It also shows the other boundaries which were drawn manually based upon physiography or the location of agricultural fields, and then digitized.


Figure 4. Digitized major stratum breaks used in the analysis, based upon a manual interpretation. (From Di Paolo, 1979)

After land ownership was digitized and merged with the Landsat data set (Fig. 5), the location of private land could be displayed more accurately and then stratified (Fig. 6). Figure 7 shows the area below 1,220 meters (4,000 feet) which is non-private land. Thus, stratification of data was greatly facilitated when land ownership, resource management boundaries, and terrain data were merged digitally with Landsat spectral data. Accurate acreage tabulations could also be made.

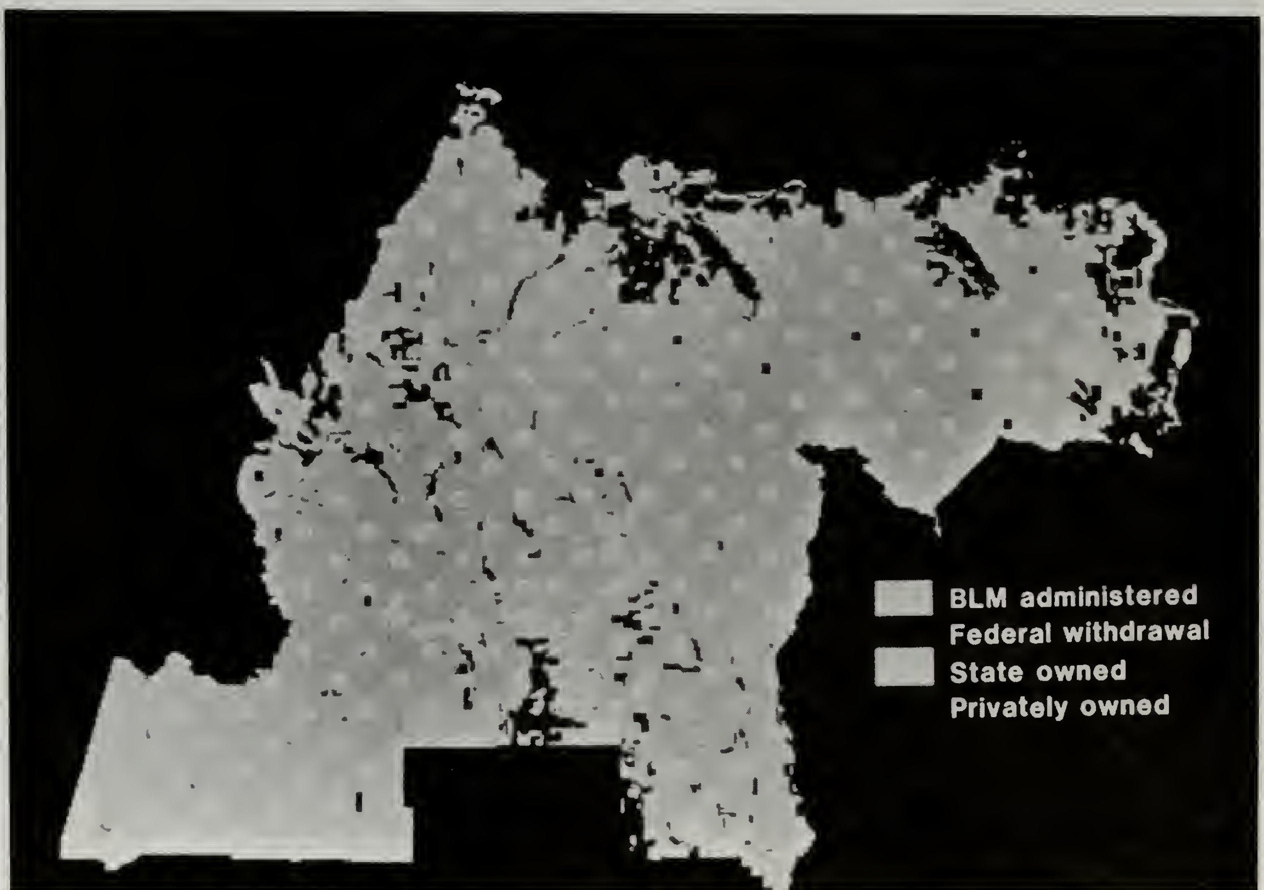


Figure 5. Digitized land ownership data.

Figure 6. Classified Landsat data merged with digitized land ownership to show the location of private land.

Figure 7. Band 5 data showing Federal and state lands below 1,220 meters in elevation.

Each stratum of the June 5, 1976, data was clustered separately using the modified block approach. An attempt was made to identify the resulting cluster classes within each stratum. Resource aerial photography and a Zoom Transfer Scope aided in this process. A pooling algorithm was then used to combine classes having similar spectral responses and statistics. This was done within each stratified area. Classes with low separability or transformed divergence were pooled while those with high variance, uncertain identification, or redundancy with others were eliminated. This process was repeated several times until classes were found to be as separable, or spectrally distinct, as possible while still maintaining the level of detail needed by the resource specialist.

A visual representation of these classes in each stratum can be made by plotting their values in the visible bands against their values in the infrared bands. Figures 8 and 9 show the locations of the spectral classes for the fan and mountain areas respectively. The plotting of these spectral classes in this manner facilitates grouping of the spectral classes into informational classes and permits other relationships to be observed. For example, the distribution of spectral classes in relationship to parent material may be observed. Also, those classes falling in the vegetative or nonvegetative regions of the plots are discernable.

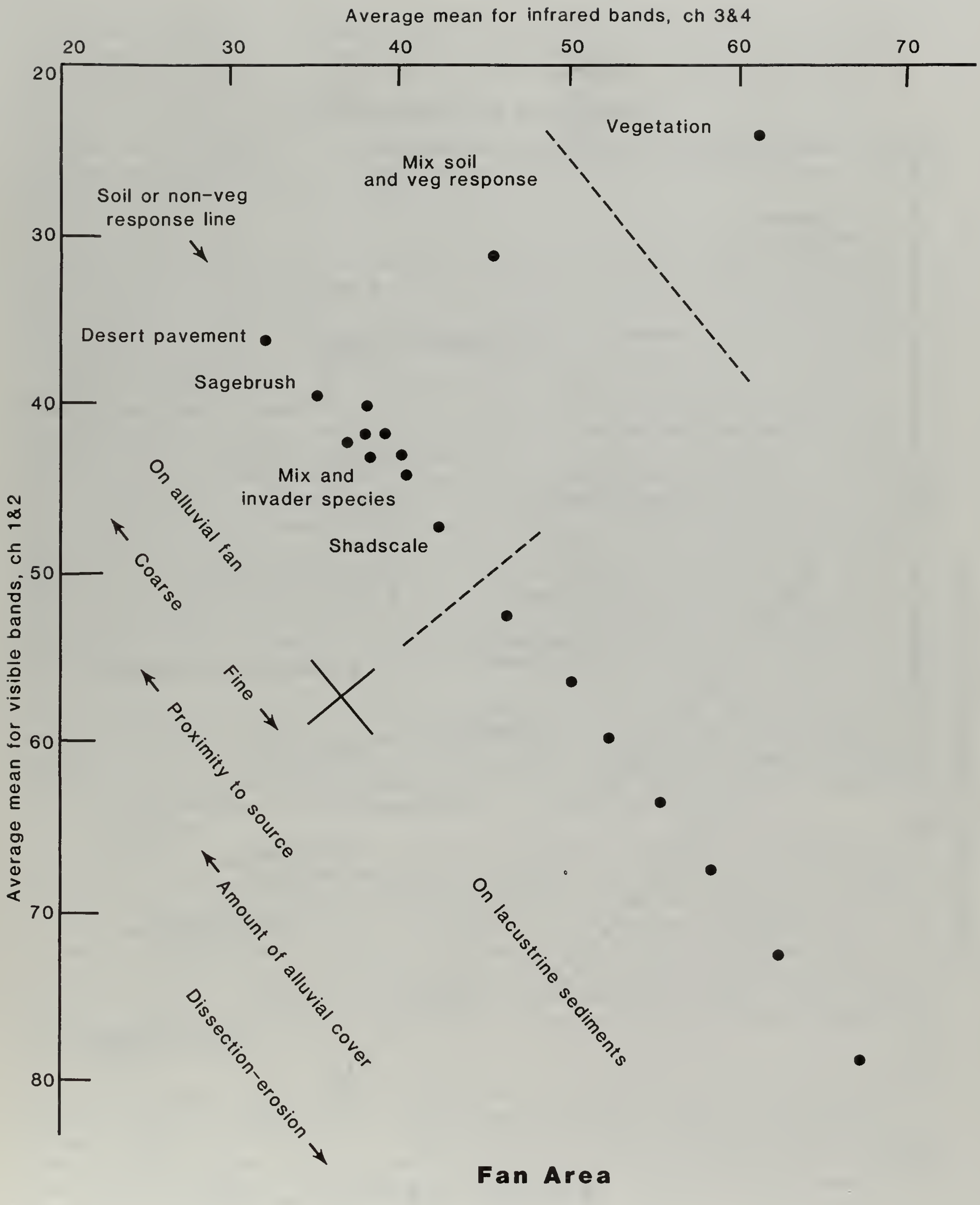


Figure 8. Plot showing the location of the spectral classes for the fan area. (From Di Paolo, 1979)

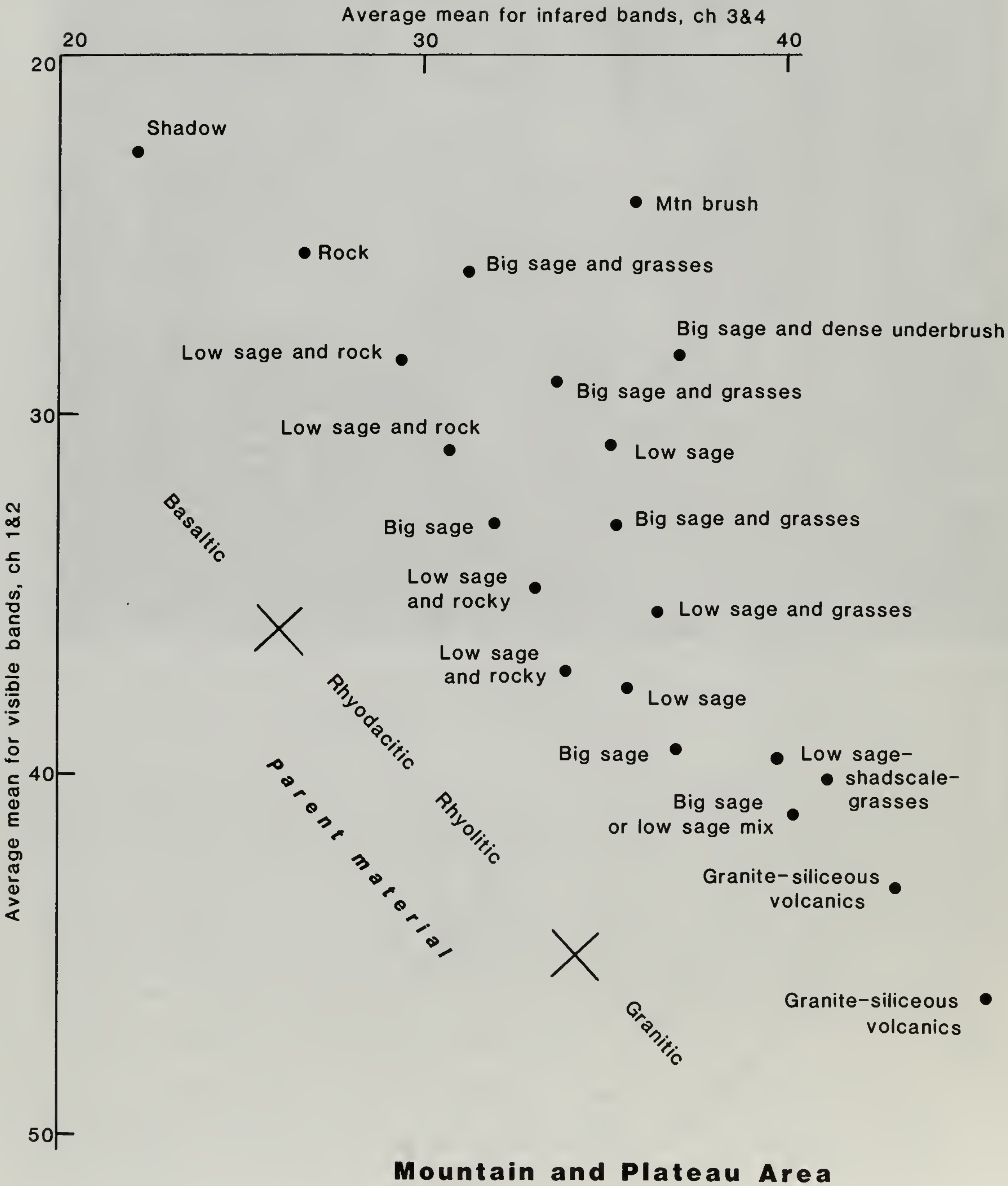


Figure 9. Plot showing the location of the spectral classes for the mountain and plateau area. (From Di Paolo, 1979)

On the BLM system, no attempt was made to identify the cluster classes before classification. Instead, each stratum was classified and the resulting spectral classes were grouped into informational classes by District resource specialists familiar with the area. This could be done using the BLM's color display system by alternately displaying individual spectral classes and two bands of the Landsat data encompassing the same area. The success of this process was dependent upon the familiarity of the resource specialist with the study area.

Classification involved using a decision rule or classification algorithm to group Landsat data into a smaller and more meaningful number of classes. This classification decision procedure assigned a Landsat data element to one of the known spectral classes generated during the clustering or pooling process. Several different classification algorithms were used including minimum distance to the mean [9/], a spatial algorithm classifier [6/], a maximum likelihood Gaussian classifier [7/], and a layered type algorithm classifier using decision tree logic [8/]. Minimum distance was the algorithm used on the June 5, 1976, data set processed on the IBM 370/148. Classification results were very similar to the maximum likelihood classifier, but minimum distance was found to run about three times faster on the IBM. The spatial algorithm classifier was found to give the data an artificial blocky appearance. Proper class groupings should eliminate the need for using smoothing algorithms, and care should be taken when attempting to use any type of smoothing algoritm in soils analysis. The maximum likelihood classifier was used in the analysis of the July 10, 1978, data set on the BLM's IDIMS system because this function runs on the array processor. Calculations on the array processor run ten to forty times faster than those performed on the HP-3000.

Next, an algorithm was used which divided the entire study site into 7.5 minute quandrangle size areas. All intermediate and field products were produced on a 7.5 minute quadrangle sheet basis at a 1:24,000 scale. This output was generated on the BLM's electrostatic plotter, and then transparent overlays of these sheets were made to facilitate field use.

Examination of the preliminary classification maps generally revealed more detail than was required in the Order 3 survey. The .45 hectare (1.1 acre) resolution of Landsat data was greater than the 4 hectare (10 acre) range survey mapping minimum. After a reexamination of aerial photography and classified Landsat data, another class grouping was made resulting in a smaller number of classes within each stratum. In this case, the original statistics were retained and only symbols were combined. Thus, after field work, different groupings could be made if needed without having to generate new statistics.

Finally, geologic units were digitized and subsequently registered to, and merged with, the Landsat data. The classified Landsat data and merged geology, combined with digital terrain data, served to refine spectral class descriptions. Figures 10, 11, and 12 show the digitized geology along with the classified image. A generalized flowchart of laboratory procedures is shown in Figure 13.

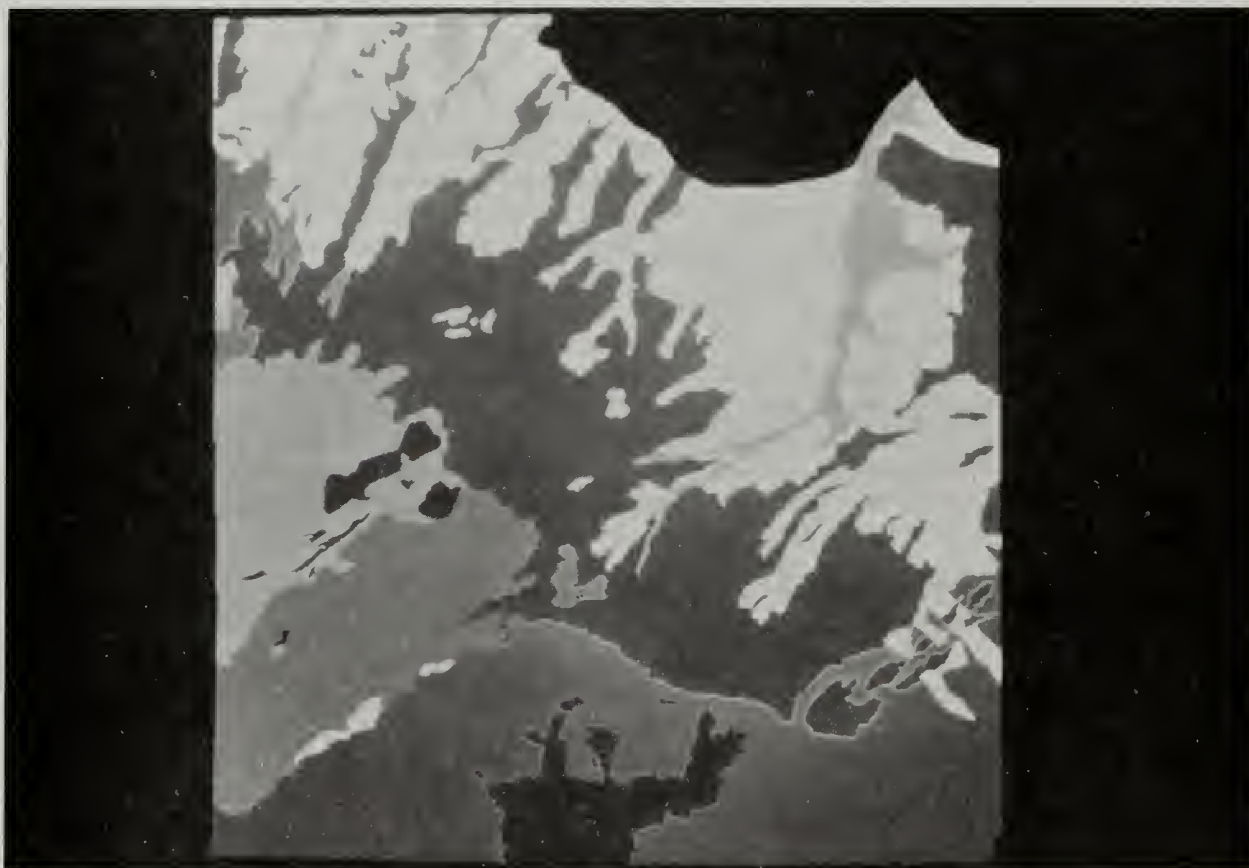

Figure 10. Digitized geologic units modified from a published map of the area.

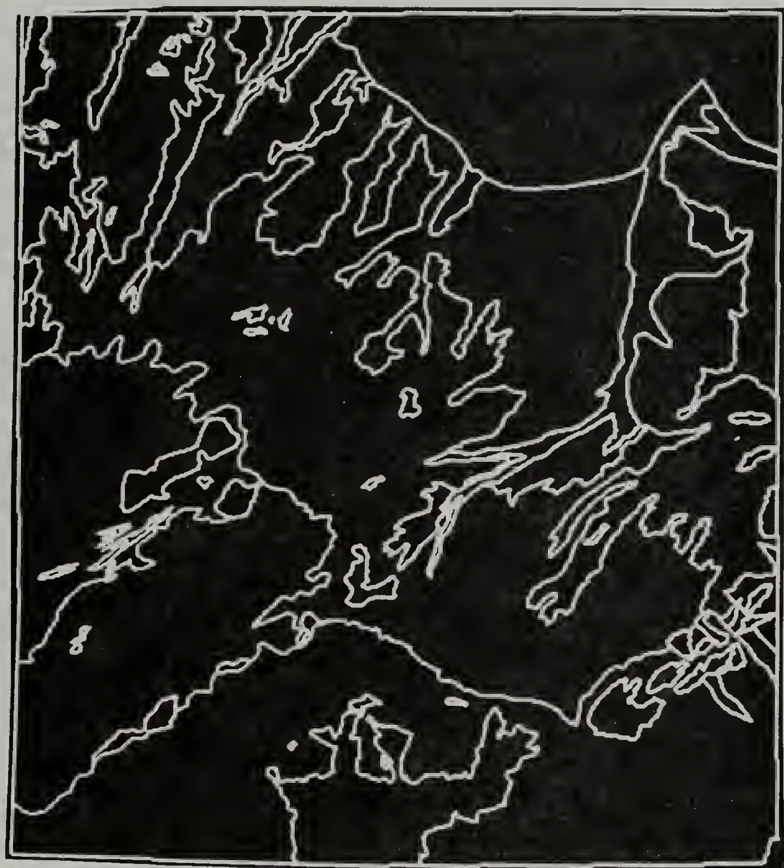

Figure 11. Image showing the outline of the geologic units.

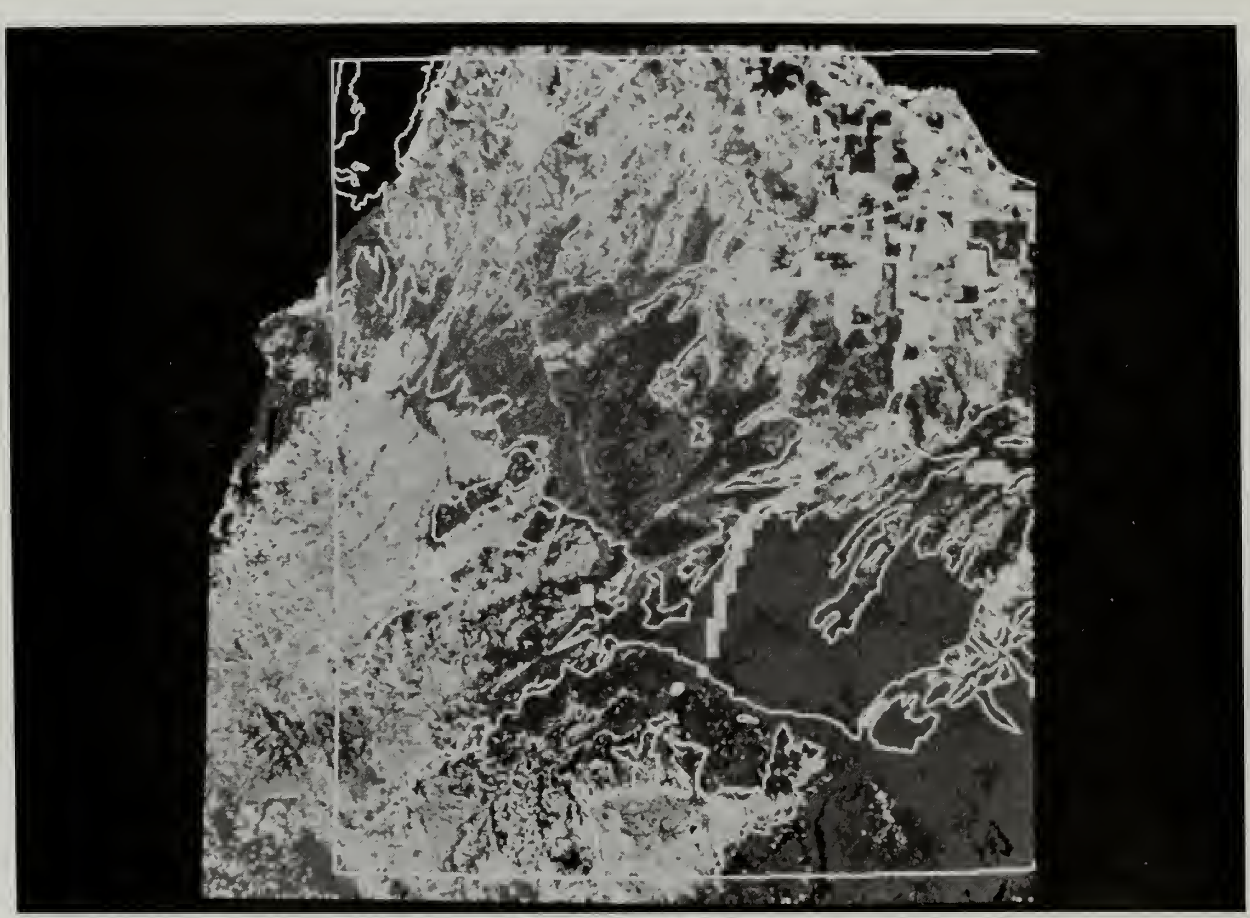

Figure 12. Geologic data digitally merged with the classified data.

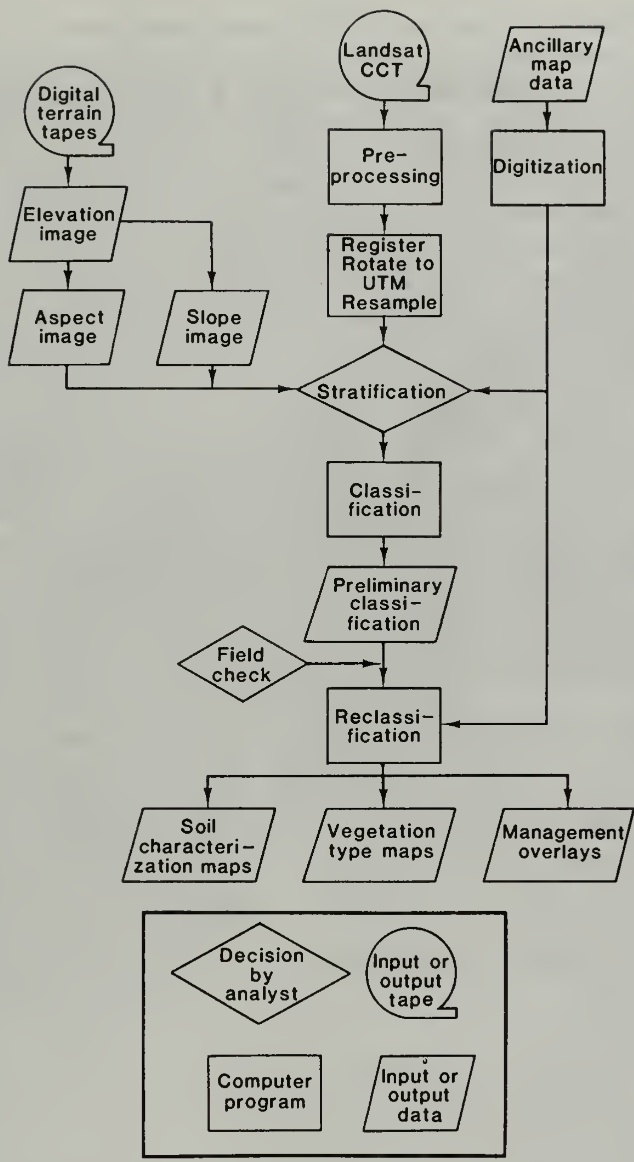


Figure 13. Generalized flow chart of the laboratory procedures performed on the BLM analysis system.

## FIELD OBSERVATIONS AND PROCEDURES

When Landsat multispectral scanner (MSS) data are used in a remote sensing project for soils, some basic considerations must be made. These are: (1) the human eye is limited to the number of tonal and textural subtleties it can differentiate from an image, and the MSS data can increase this range of view; (2) digital mapping of soils is based solely upon the surface reflectance properties of the exposed rock, soil, vegetation or combination of these, and therefore characteristics below the surface such as profile development cannot be detected directly; and (3) the remote sensing analyst is generally limited to delineation and description of soil units rather than classification and naming, which differs from the vegetation analyst who can identify certain plants and then formulate unit identifications at a specific level.

With these considerations in mind, the objectives of the field work for this study were: (1) to relate spectral classes with cover types on the ground; (2) to determine the factors that contributed to the spectral response in this environment; and most important, (3) to determine how these spectral classes and associated cover types would aid in defining soil characteristics which would facilitate the field work and increase the accuracy of the soil scientist in the preparation of an Order 3 soil survey for large acreages of western Federal lands.

Field investigations should be made around the date (month-day) of the Landsat data being used. Ancillary aerial photography should also correspond to this date if possible. This greatly facilitates the identification of information classes during the analysis process and also during field work. In this way, resources would be at the same state on the ground as reflected on the imagery and in the data.

The field procedure involved enlarging the 1:31,680 resource photos to 1:24,000 scale which was compatible with the digital computer output. A mylar sheet was placed on the enlarged photos, and the features which could be discerned on the computer output such as roads, agricultural fields, canyons, and so forth were drawn on the mylar. Thus, information classes or cover types which were identified and plotted on the air photo could be located on the computer output by overlaying the mylar on the output. This served to adequately locate pixels and correlate them to cover types. The soils were described and their locations were plotted and cross-referenced to field notes.

On the BLM system, classification maps were produced on a 7.5 minute quadrangle basis at a 1:24,000 scale. Symbols were created for each spectral class and this output was generated on the electrostatic plotter. These sheets were then photographically made into transparent overlays. These transparencies proved to be extremely useful as they could be overlaid directly onto the topographic quadrangle sheets (Fig. 14) or aerial photographs.

Figure 14. Classification map being overlaid onto the corresponding 7.5 minute topographic quadrangle sheet.

## Spectral Classes and Ground Cover Types

Concerning the first field objective of relating spectral classes to ground cover types, it was found that, in the areas visited, the relationship between a spectral class and cover type was consistent within classification strata. In most cases, no pure classes of any one cover type were found to contribute to a spectral response. Instead, mixtures determined the spectral signature such as different vegetation types, shrub-undercover ratios, non-vegetative ground cover types (alluvium, desert pavement, silt, rock, etc.) and slope. One of the problems, in both the field and the lab, was to determine which classes or symbols needed to be combined in order to avoid confusion and aid in user interpretation. Yet, care was taken not to combine classes which alone would indicate a distinct soil characteristic.

In arid and semiarid environments, precipitation amounts and the history of land use influence the kind, amount, and proportion of vegetation. As the age of the soils increases and where soils less likely are disturbed by nature or man, a soil/natural plant community relationship becomes very significant. Areas that have been disturbed tend to show less of a soil/natural plant relationship. Thus, in some instances the vegetative distribution may correlate to soil changes while other vegetative patterns may not be indicative of changing soil conditions.

In this study area, the higher or older pediment surfaces, mountains, and plateaus exhibited the best soil/vegetation relationship. In these areas, where disturbance had not occurred, the landforms were older with more stable soil development and had a better established natural vegetation community. Thus, the spectral response from changing plant communities accurately reflected changing soil conditions.

In the mountain and plateau area, such factors as elevation, slope, and aspect also contributed to soil and plant communities. Certain plant species were good indicators of soil depth. In these areas, the green underbrush and the density of vegetation dominated the spectral response. Green forbs or grasses underlying sagebrush caused more of a vegetative response than just the sagebrush itself. Where the vegetation was less dense, the outcropping bedrock or bare soil usually dominated the response.

## Factors Contributing to Spectral Classes

The next objective of the field work was to determine which factors contributed to the spectral response in this environment. Assuming that spectral classes within the study area were as separable or spectrally distinct as possible and that these spectral classes represented certain cover types or combinations of cover types, knowledge must be gained of the factors influencing these spectral signatures. Only through this understanding of the environment and its spectral response can an accurate and intelligent interpretation be made of the classification product. Table 1 lists the key elements that influenced the spectral response in this area.

Table 1. Key elements influencing spectral response. (From Di Paolo, 1979)

Plant Communities
- Type
- Density
- Underbrush

Landforms and Topography
- Elevation
  - Slope
  - Aspect
- Type and Age
  - Branches and terraces
  - Alluvial Fans
  - Pediment and desert pavement
  - Highlands, canyons, plateaus

Bedrock Type and Geology
- Stratigraphy or Composition of the Rocks (igneous, metamorphic, sedimentary)
- Weathering Products
  - Light or dark
  - Weathered in place
  - Eroded, transported, or resistant
  - Rounding and size

The order of importance of these elements changes depending upon the area being analyzed. In the mountain and high plateau areas (higher rainfall areas), the plant communities may have played the dominant role in affecting the spectral signatures. In the fan or dissected lake sediment areas (lower rainfall areas), landforms, topography or bedrock type and geology may have been most significant.

Besides density, plant types are also an important factor. In this study, sagebrush generally was nonreflective in the infrared spectral region at the resolution of Landsat. The spectral properites of this plant and others warrant further study. Certain plants may have greater leaf area, a broader canopy, or contain more moisture or chlorophyll, which also may affect the spectral response.

Landforms and topography are found to be factors in determining the spectral response. Elevation, slope and aspect are interrelated with the distribution of vegetative communities. Northerly aspects exhibit denser and different vegetative species than southerly aspects. Vegetation also changes with changing elevation. Areas of steep slopes may be more susceptible to erosion, and windswept slopes may exhibit less dense vegetation and more rocks at the surface.

Finally, the bedrock type and geology contribute to the observed spectral response. Sedimentary, igneous and metamorphic rocks weather differently producing different landforms. Igneous rocks weather to different textures and different degrees depending upon the composition. Generally, rocks high in quartz and feldspar will be more resistant while those containing a greater amount of ferromagnesium minerals will weather more rapidly. Where a regolith forms, a direct correlation can be found with soil types and phases. If this material is transported, the more resistant and finer components will travel farthest and thus influence the spectral response. Such areas may be at the foot of alluvial fans. If this area is interfingered with sediments deposited along the flanks of ancestral streams or dry washes, the resulting soil forming at this location may be high in silt and easily eroded. This would form a class having a distinctive spectral response. The composition of rocks contributing to the soil profile will definitely be a prime factor influencing the response. Certain limestones may cause local soils to be highly calcareous while minerals eroding from metamorphic rocks promote the formation of clays. Soils forming on granites are generally found to be sandy in nature.

The factors just discussed are thought to be important in causing the types of spectral response observed within this study area. It is felt that a good understanding of the elements contributing to the spectral response is important where inferences must be made in the determination of soil characteristics. It will most likely be found in future work that as the understanding of the spectral nature of these types of arid and semiarid environments increases, the accuracy and reproducibility of spectral maps for soils studies within this and similar regions will also increase.

Classified data may be refined further by digitally merging other data sets with the Landsat data. This digital data base can be easily updated. Figure 15 shows the types of data (several of which were incorpoarated in this project) that are merged and then used in current BLM remote sensing efforts.

Some selected spectral curves of various cover types within the study area are shown in Figures 16 and 17. In the alluvial fan classification area, spectral curves of soils developed on the lacustrine and fluvial sediment areas (sparse vegetation cover) are distinctly brighter than those formed on the alluvial fans. Also, materials deposited closer to the mountain fronts are generally coarser than those transported further, so possibly a relationship may also be seen between texture and spectral response. The variation seen in the two Wyoming big sagebrush (Artemisia tridentata var. wyomingensis) curves, shown in Figure 16, may either be caused by plant density difference or the presence of a grass undercover. The non-vegetative surface materials appear to dominate the spectral response in the alluvial fan and lowland areas. Even in fairly dense sagebrush stands, the spectral response is still dominantly from the non-infrared channels (channels 1 and 2 or Landsat bands 4 and 5). Figures 16 and 17 also illustrate the spectral separability of the classes. The spectral signatures for some representative classes found in the mountain and plateau area reveal more of an overall vegetative response. In this area, around early June, various growth forms of vegetation will influence the spectral response. Figure 17 also shows the different signatures for the big sagebrush class and the mountain big sagebrush (A. tridenta var. vaseyana) with green underbrush class.*

* Also referred to as alpine big sagebrush in Idaho.

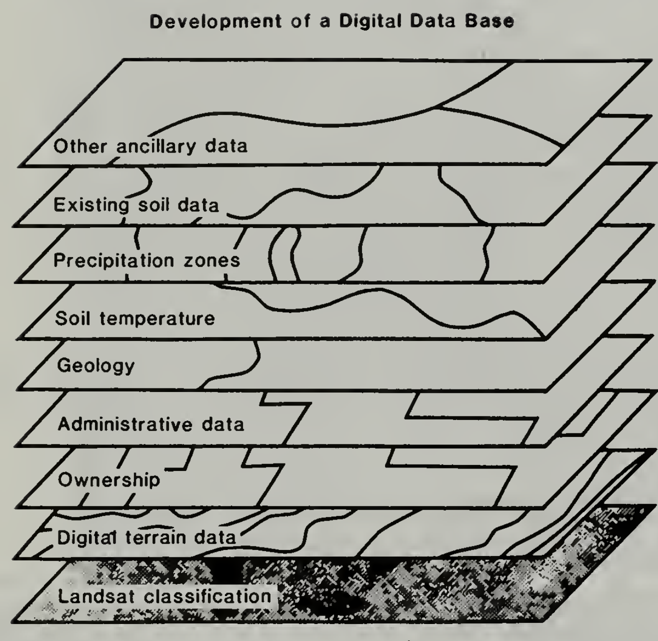


Figure 15. Classification refinement and specialized resource products through the use of ancillary data sets.

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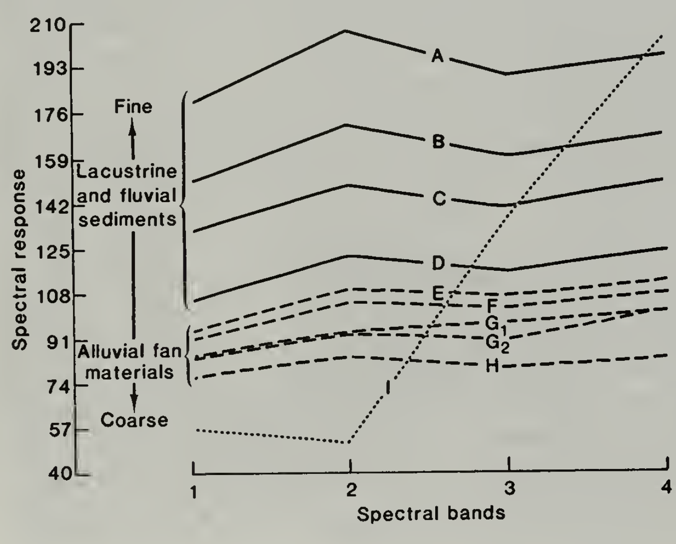


Figure 16. Spectral curves of selected classes within the fan area. A - bare lake sediments; B - slight vegetation on lake sediments; C - level lake sediments covered by some loess and grasses; D - shadscale on disturbed lake sediments; E - shadscale on alluvial fan material; F - shadscale complex on fan material; $G_1$ and $G_2$ - sagebrush on fan material; H - desert pavement on fan material; I - crops (alfalfa). (From Di Paolo, 1979).

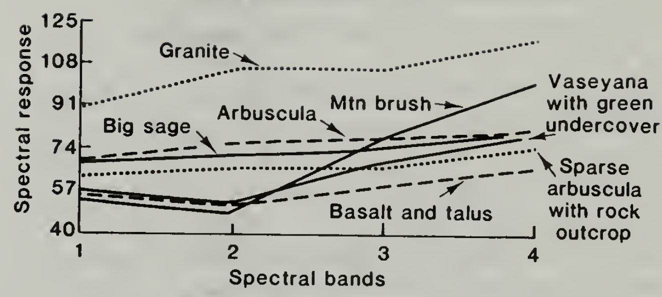


Figure 17. Spectral curves of selected classes within the mountainous area. (From Di Paolo, 1979)

## Spectral Classes and Soil Survey Work

The final objective of the field work in this area was to determine how these spectral classes, and their associated cover types, could aid in defining soil characteristics; how that might reduce the manpower and time needed in the field by soil scientists; and how that possibly might increase the accuracy of an Order 3 soil survey. Again, it was not intended to directly produce an Order 3 soil survey map from Landsat data. Instead, the intent was to produce a tool to facilitate and aid in the construction of a soils map by the soil scientist.

In this area, it was found that changing vegetative communities, landforms, and geologic materials and processes signaled changing soil characteristics. Some of the soil characteristics indicated by certain plant species were depth; restrictive layers of rock, clay or carbonate; leaching; pH; and loam. When these areas could be identified spectrally or inferred based on terrain or land form data, then more accurate unit descriptions could be made. Figures 18 and 19 and Tables 2 and 3 show classification map examples along with acreage tabulations of the corresponding classes.

## IMAGERY SELECTION

The date of the Landsat imagery is also an important consideration. In semiarid areas, where the native vegetation is largely unaltered, mid- to late-spring Landsat scenes seem to be the most useful. Where native vegetation has been severely altered by range treatments, fire, or heavy grazing, vegetation patterns can be deceiving. In such cases, a midsummer scene may be advantageous.

Multitemporal Landsat data could prove to be useful, particularly in arid areas, to accentuate variable vegetation patterns. A multitemporal classification approach is being applied on a 400,000-hectare (1,000,000 acres) project near Lake Havasu City, Arizona.[5/] In this project, data from April 1979 and July 1979 Landsat scenes were geometrically registered to each other and then compressed into a single, four-band data set using principle components analysis. The SCS crew doing the mapping reports that the classification is picking up very subtle features that are not visible on the aerial photography, or in some instances, on the ground.

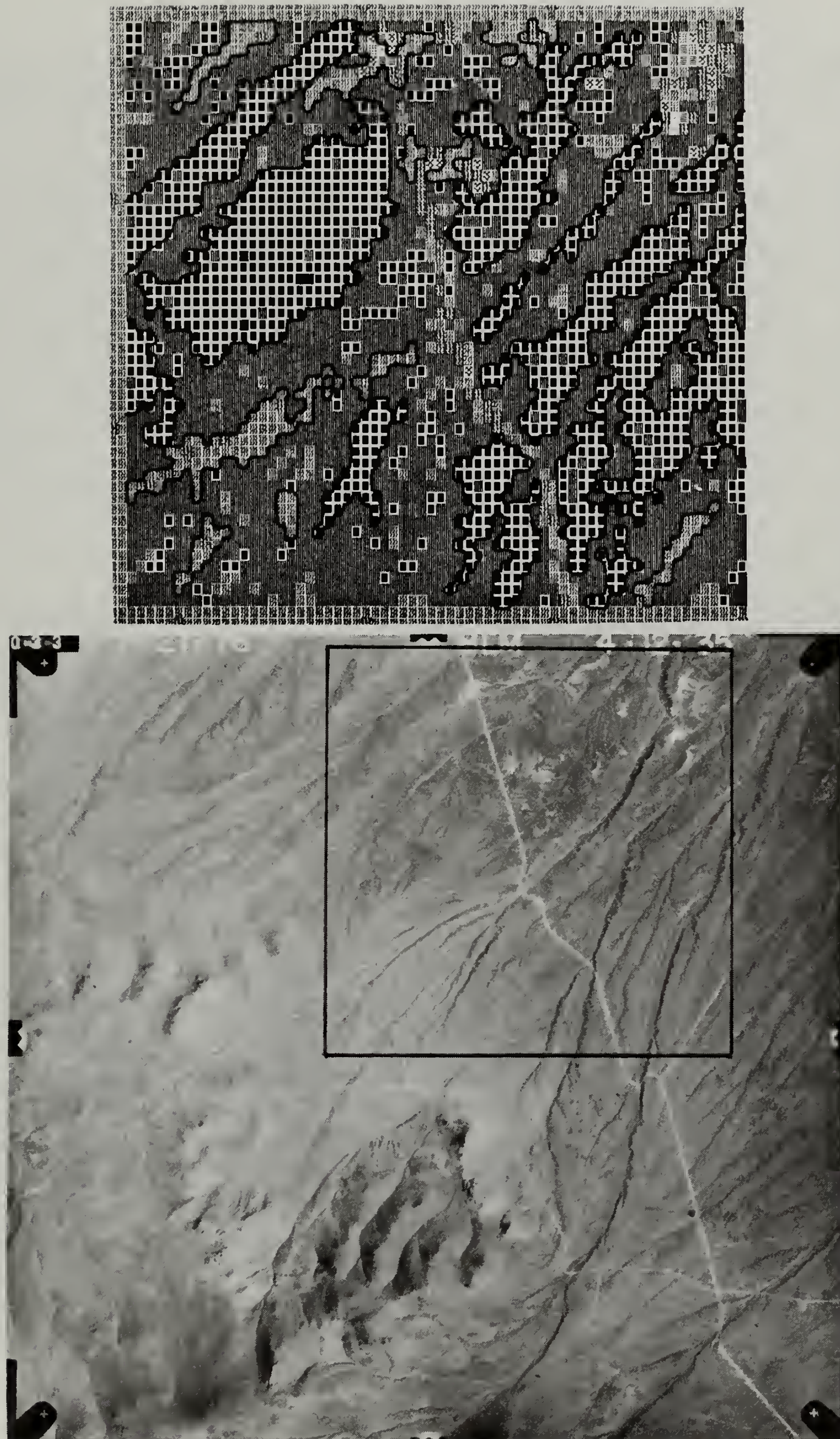

Figure 18. A classification map, corresponding aerial photograph, and ground photograph of a loamy sage site found in depressions alternating with a shadscale (calcareous restrictive) and transition area. The location of the sample classification block is marked on the aerial photograph and the road appearing in the photo can also be seen in the classification map. These classes are lying on alluvial fan material. See Table 2 for distribution of classes. (From Di Paolo, 1979)

Figure 18 (Continued)

Table 2. Distribution of classes found within the sample classification block shown in Figure 18. (From Di Paolo, 1979)

| | Group | Points | Acres | Hectares | Percent |
|---|---|---|---|---|---|
| 1. | Desert pavement | 4 | 4.6 | 1.9 | 0.1 |
| 2. | Disturbed area, calcareous, invader species | 77 | 88.5 | 35.9 | 2.3 |
| 3. | Calcareous restrictive, shadscale | 315 | 362.2 | 146.7 | 9.6 |
| 4. | Transition, mix | 1645 | 1891.6 | 765.9 | 50.0 |
| 5. | Crops | 0 | 0.0 | 0.0 | 0.0 |
| 6. | Loamy, wyomingensis | 1211 | 1392.6 | 563.9 | 36.8 |
| 7. | Badlands | 3 | 3.4 | 1.4 | 0.1 |
| 8. | Badlands, shadscale | 4 | 4.5 | 1.9 | 0.1 |
| 9. | Lake sediments, grasses | 7 | 8.0 | 3.2 | 0.3 |
| 10. | Loamy, wyomingensis, mix | 22 | 25.3 | 10.3 | 0.6 |

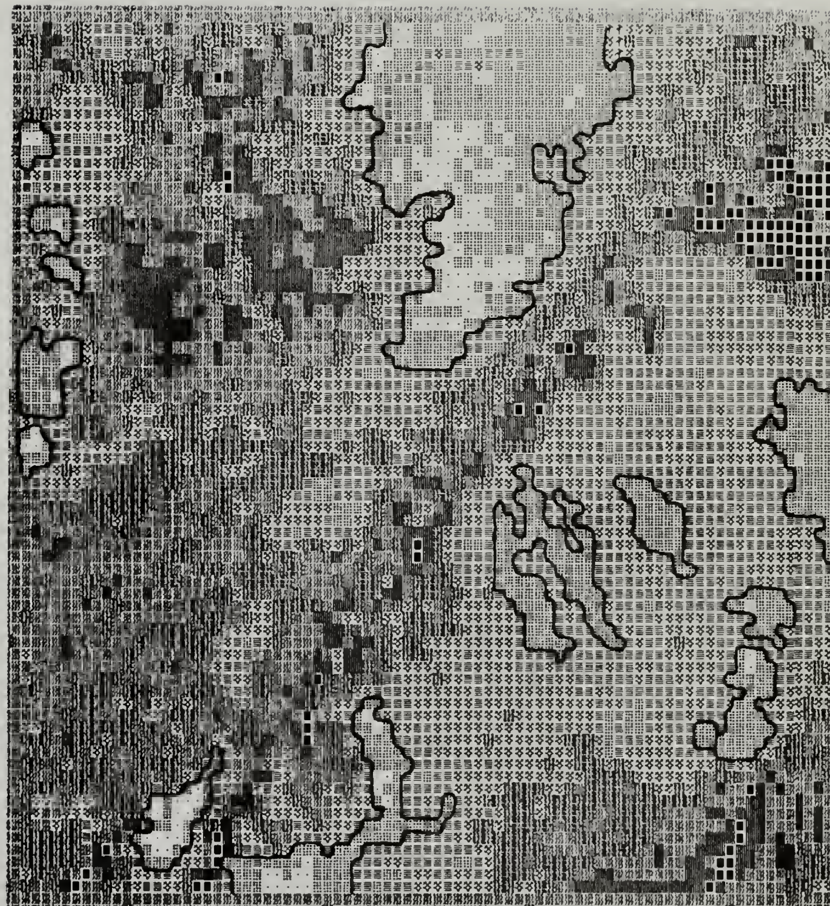

Figure 19. The classification map, corresponding air photo, and ground photo show an area with classes formed mainly on lake sediments some loess and alluvial fan material, and also on alluvium deposited along the creek drainage. This creek can be seen running on a diagonal from the lower left to the upper right. The areas outlined on the classification map represent exposed lacustrine and fluvial sediments, and have been classified as dissected lake and fluvial sediments or badlands. (From Di Paolo, 1979)

Figure 19 (Continued)

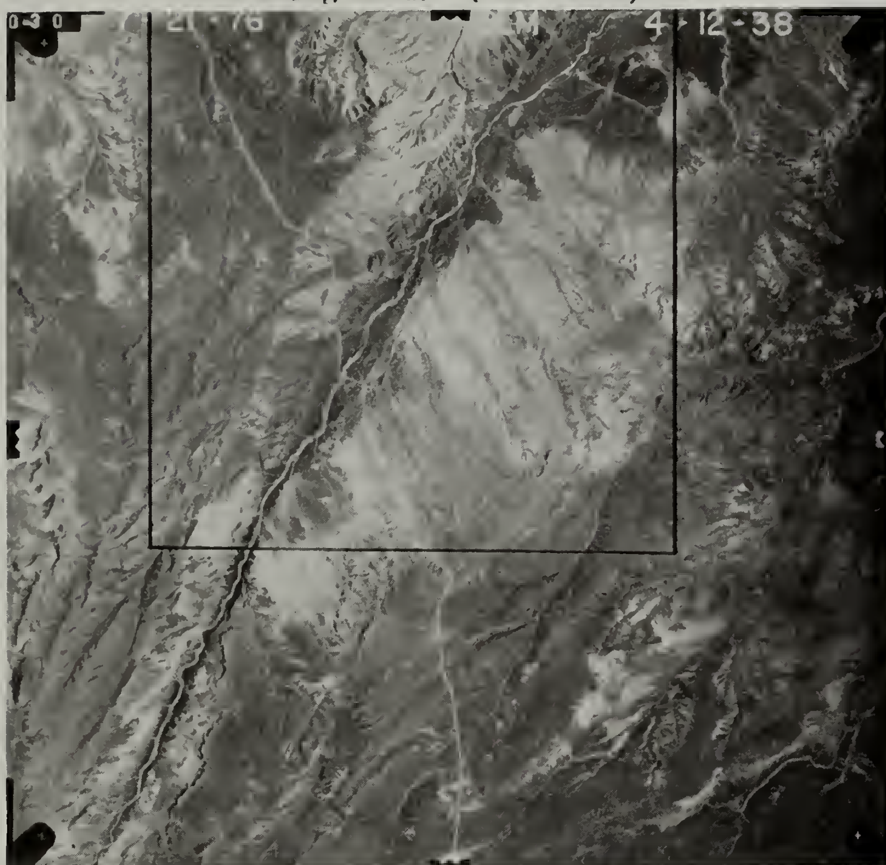


Table 3. Distribution of classes found within the sample block shown in Figure 19. (From Di Paolo, 1979)

| | Group | Points | Acres | Hectares | Percent |
|---|---|---|---|---|---|
| 1. | Desert pavement | 2 | 2.3 | 0.9 | 0.0 |
| 2. | Disturbed area, calcareous, invader species | 1068 | 1228.2 | 497.2 | 18.6 |
| 3. | Calcareous restrictive, shadscale | 1076 | 1237.4 | 501.0 | 18.7 |
| 4. | Transition, mix | 424 | 487.6 | 197.4 | 7.3 |
| 5. | Crops | 5 | 5.7 | 2.4 | 0.1 |
| 6. | Loamy, wyomingensis | 91 | 104.6 | 42.4 | 5.2 |
| *7. | Badlands | 151 | 173.6 | 70.3 | 2.6 |
| *8. | Badlands, shadscale | 765 | 879.7 | 356.2 | 13.3 |
| 9. | Lake sediments, grasses | 1041 | 1197.1 | 484.7 | 18.1 |
| 10. | Loamy, wyomingensis, mix | 1128 | 1297.2 | 525.2 | 19.6 |

*Classes 7 and 8 represent the exposed lake sediments outlined in Figure 18.

## ANALYSIS COSTS AND SAVINGS

### Costs

Cost of such classification procedures vary with the type and speed of the computer system used and the complexity of the project and study area. The laboratory cost at LARS on the IBM 370/148 system were estimated to be 2.5 cents per hectare (1 cent per acre). This assumes $200 per hour on the IBM 370/148 and represents the total cost for all processing functions and output products. This also allows for some iterations. If analyst salary and field time are included, the total cost would be about 12 cents per hectare (2 cents per acre). This assumes $2,200 per workmonth for five months, including one month of field work. Current costs on the IDIMS system are approximately 14 to 17 cents per hectare (6 to 7 cents per acre). This figure includes analyst salary, field time, and all ancillary data costs. The size of the study site could have been increased without additional generation of training samples or statistics, and this would have decreased the cost per hectare.

### Savings

In the above mentioned Havasu Resource Area project, SCS reports a savings of 12 workmonths and a 30 percent higher yield per person. The SCS found the product to be extremely useful in mapping approximately 35 percent of the area. The total cost for the Order 3 survey was 20 cents per acre (13 cents for the SCS effort and 7 cents for the Landsat product, as described above). This represents a considerable savings over the 30+ cents per acre cost usually cited for an Order 3 survey.

## DISCUSSION AND CONCLUSIONS

The Landsat products generated in this study were compared with the generalized county soils map of the area. This soil map was made at a lower intensity than Order 3, however, and would not suffice for multiple-use purposes, particularly for livestock grazing management. Nevertheless, in the areas compared, spectral class boundaries generally conformed to the soil map unit boundaries. In all cases, more than one spectral class was found within the generalized soil boundaries, implying the capability for additional detail. When the same spectral class was found within different soil units, or across soil unit lines, geology was found to be the determining factor in the delineation of soil units. This emphasizes the importance of merging available geologic data with the Landsat data.

The results of this work show that Landsat data can be used as a tool for stratifying large areas into smaller units that can be sampled more efficiently in the field. The basic assumption, throughout this process, is that the cover types of interest are spectrally separable. For soils, this separability may result from different vegetative cover types or density, or a difference in the spectral response of the soil itself. Factors causing these spectral differences must be analyzed so that their relationship to soil characteristics may be understood. Texture, color, drainage (or wetness), composition, and depth are just a few factors that may determine different spectral signatures. Knowing these factors, along with a knowledge of the parent materials, soil forming processes, landform effects, and soil moisture and temperature regime breaks, contribute to the identification of various soil units in a given area. Then, assuming the spectral classes that indicate certain characteristics in one area also indicate similar characteristics in a different area, onsite sampling and field transects may be reduced, thereby increasing the productivity and efficiency of field survey parties.

The subleties observed in the Landsat spectral data and not observed visually on aerial photographs, along with the synoptic view offered by Landsat, increases the accuracy of the Order 3 soil survey. Therefore, knowledge and understanding of the spectral nature of the environment being analyzed and the factors contributing to the spectral response of the cover types will be most important in accurately relating spectral information to useful resource information.

While remote sensing projects in different regions should be considered unique, and analyzed based upon the different characteristics of each region, the following general procedure is recommended for using digital Landsat data as a tool for soil survey work:

1. Stratifying the area on the basis of soil temperature, moisture regime breaks, and/or landform.

2. Classifying the Landsat digital data within each of these regimes separately.

3. Digitally merging parent material or geologic data.

4. Grouping spectral classes separately within each geologic unit specified.

Information names then can be given to the classes based upon soil moisutre and temperature regime, parent material and landform, and cover type, in that order.

SCS and the BLM soil scientists are currently using the digital classification maps and output products produced from this and similar projects. Only through the use of this information in the field by soil survey parties can its value be fully assessed. The field soil scientist will never be replaced, but it is hoped that these and future space-age tools will allow man to look at his environment more efficiently and accurately.

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# APPENDIX A - GLOSSARY OF TERMS

Ancillary data - Secondary data used to define the area or classes of interest, such as topographic, administrative, climatologic or geologic data. Ancillary data may be digitized and merged with the primary set as part of the analysis.

Classification - The process of assigning individual pixels of a multispectral image to categories, or classes, generally on the basis of spectral-reflectance characteristics.

Digitization - The process of converting data, recorded originally on photographic material or a map base, into numerical format.

Electromagnetic spectrum - The array of all electromagnetic radiation that moves with the velocity of light and is characterized by wavelength or frequency. The wavelengths 0.3 to 15.0 µm are the ones most frequently used in remote sensing.

Pixel - A data element having both spatial and spectral characteristics. The spatial variable defines the apparent size of the resolution cell (i.e., the area on the ground represented by the data values, approximately 1.1 acre for Landsat), and the spectral variable defines the intensity of the spectral response for that cell in a particular channel, or band.

Reflectance - A measure of the ability of a surface to reflect energy in the various regions of the electromagnetic spectrum. Reflectance is affected not only by the nature of the surface itself, but also by the angle of incidence and the viewing angle.

Signature - A characteristic, or combination of characteristics, by which a material or object may be identified on an image or photograph.

Synoptic view - The ability to see or measure large areas at the same time and under the same conditions (i.e., the overall view of a large portion of the earth's surface which can be obtained from satellite altitudes).

## APPENDIX B - LANDSAT AND THE ELECTROMAGNETIC SPECTRUM

Remote sensing may be defined as the collection of information about an object without being in physical contact with the object. Aircraft and satellites are the common platforms from which remote sensing observations are made 4/. This discussion deals with that portion of the electromagnetic spectrum in which reflected sunlight is sensed by the Landsat multispectral scanner (MSS) system.

The major objective of remote sensing is to detect, measure, record, and analyze energy in selected portions of the electromagetic spectrum. The physical basis for remote sensing is the distinctive character of electromagnetic radiance from natural and man-made objects. A material can often be identified by its spectral characteristics if the energy that it is reflecting and emitting is broken down into carefully chosen wavelength bands. Figure B-1 shows the various regions of the electromagnetic energy spectrum. For a given object or ground resolution element (pixel), which is about 1.1 acres in size with Landsat, energy levels at specific wavelength bands are unique. A repeatable set of reflected energy levels at specific wavelengths may be defined as the spectral signature of an object. This is shown in Figure B-2.

There have been four Landsat satellites launched since 1972. ERTS-1 (Earth Resource Technology Satellite) was launched on July 23, 1972, and operated until January 6, 1978. It represented the first unmanned satellite specifically designed to acquire data about earth resources on a systematic, repetitive, medium resolution, multispectral basis. The results from the initial experiments on the data from ERTS-1 probably exceeded most of the expectations of the scientific community. Just prior to the launch of ERTS-B on January 22, 1975, NASA officially renamed the ERTS program the "Landsat" program (to distinguish it from the planned Seasat oceanographic satellite program). Thus, ERTS-1 was retroactively name Landsat-1 and ERTS-B became Landsat-2 at launch. Landsat-3 was launched on March 5, 1978 2/. Landsat-4 was launched July 16, 1982 5/. In addition to carrying a four-banded multispectral scanner system similar to the previous Landsat satellites, Landsat-4 carries a seven-banded scanner called Thematic Mapper which has twice the resolution of the previous Landsats, and the ability to sample additional regions of the electromagnetic spectrum.

Although Landsats -1, -2, and -3 produced pictures of Earth, the principal viewing instrument of all Landsats is not a camera but a sensor known as a multispectral scanner system (MSS). Figure B-3 shows the configuration of the scanning system. The MSS records information in two visible (green and red) wavelengths of the spectrum and in two infrared portions not visible to the human eye (Fig. B-4). These portions of the spectrum, known as bands, each provide slightly different information about the Earth's surface. For example, band 4 (the green band) emphasizes sediment-laden water and band 5 (the red band) emphasizes cultural features and terrain, while bands 6 and 7 (the near infrared bands), provide the best penetration of atmospheric haze and give valuable information about the health and vigor of vegetation as well as land-water contrast.

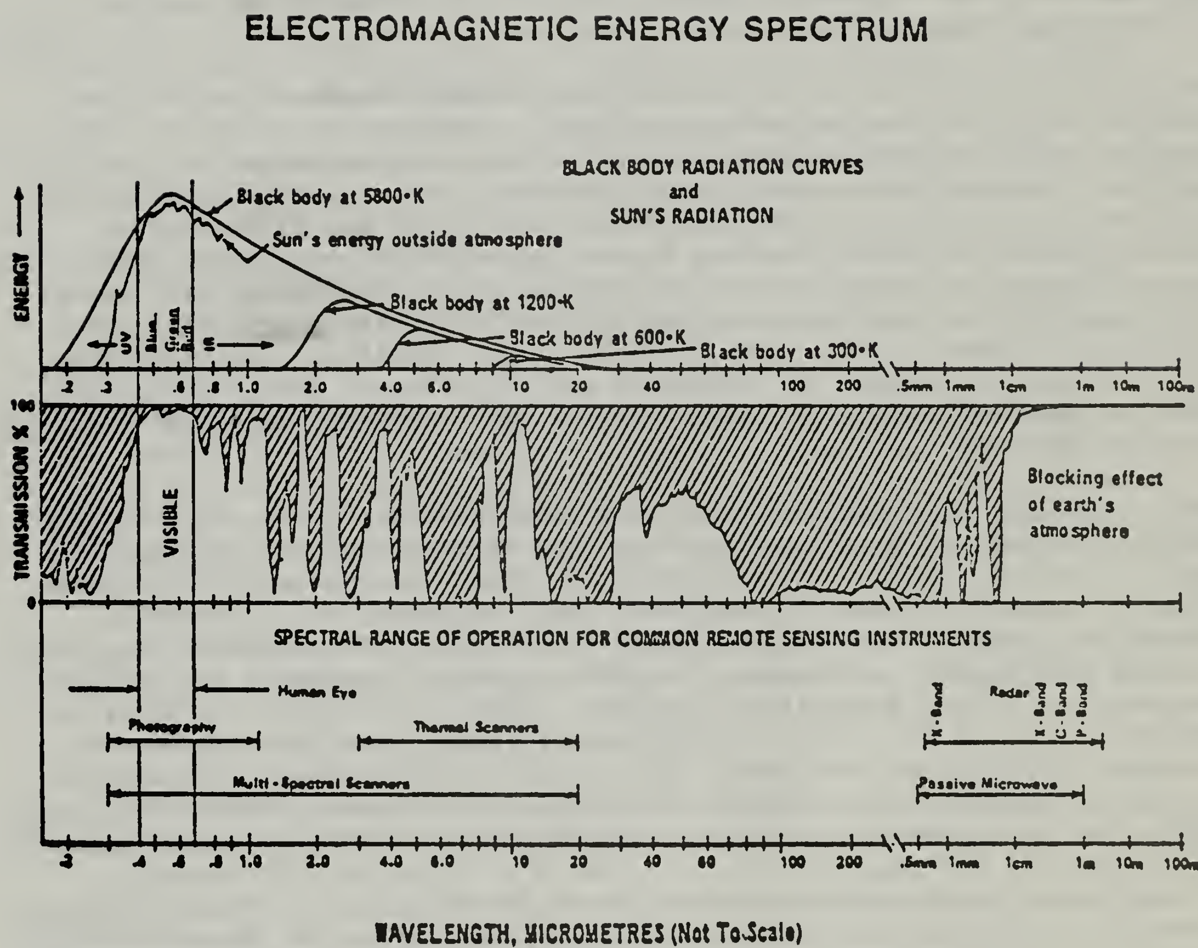


Figure B-1. Regions of the electromagnetic energy spectrum. (From EROS Data Center)

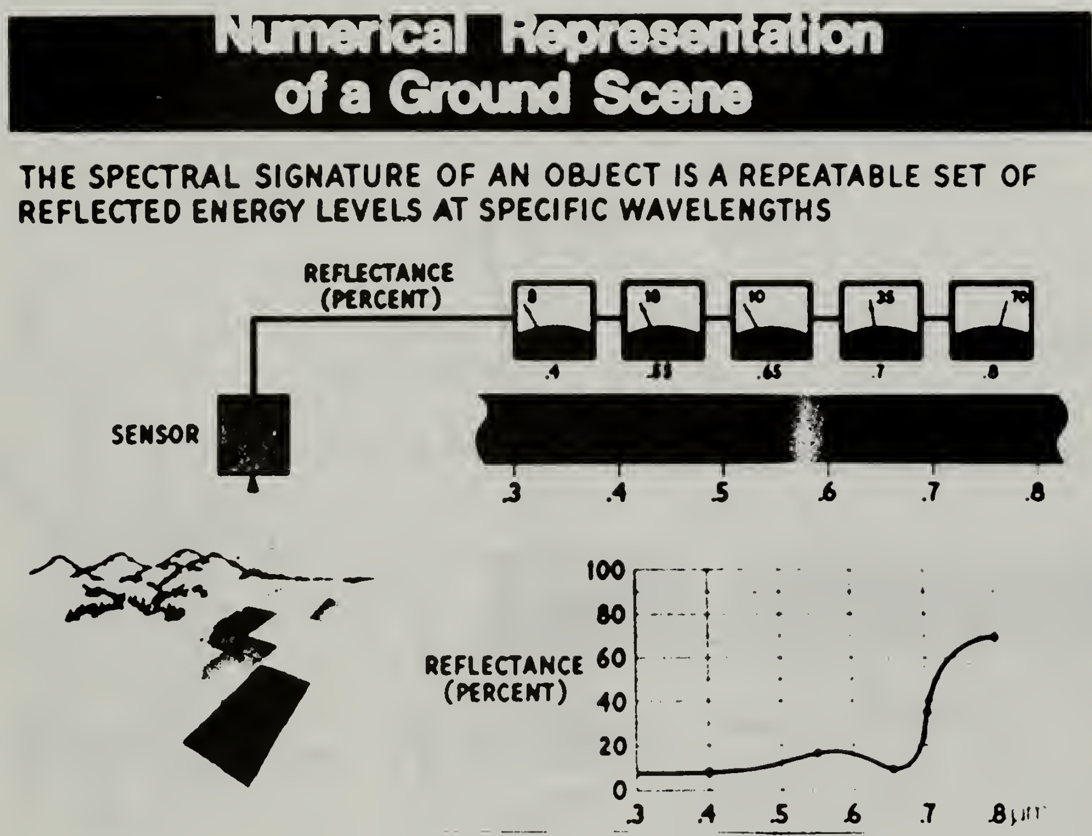


Figure B-2. The generation of a spectral signature. (From Purdue University - LARS Minicourse Series)

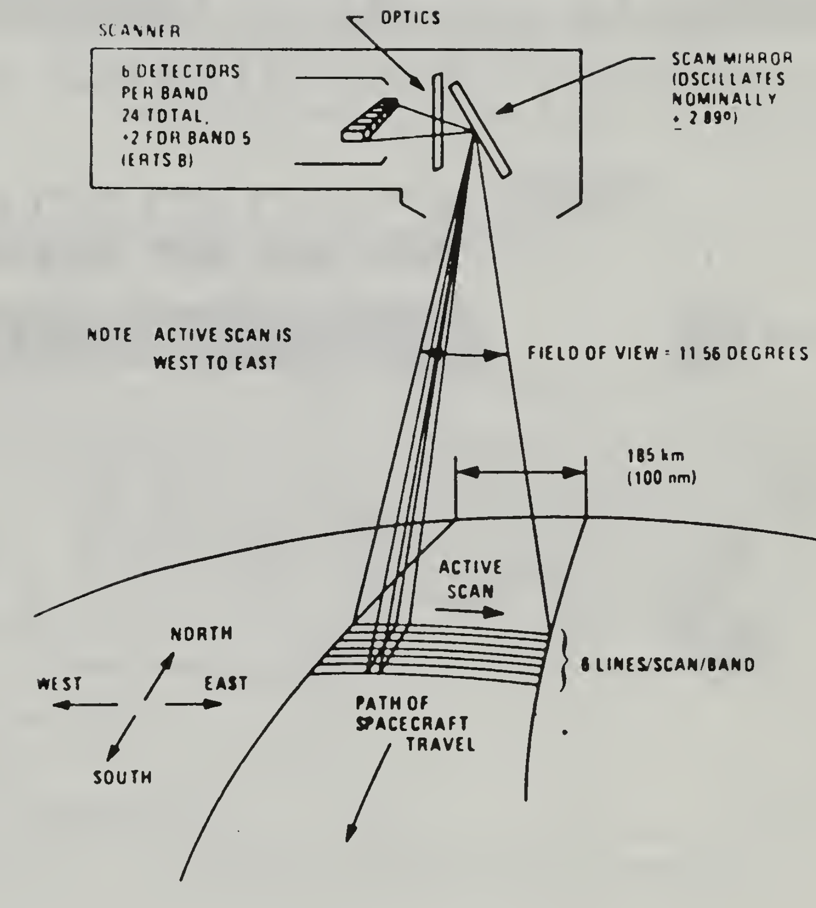


Figure B-3. MSS scanning arrangement. (From EROS Data Center)

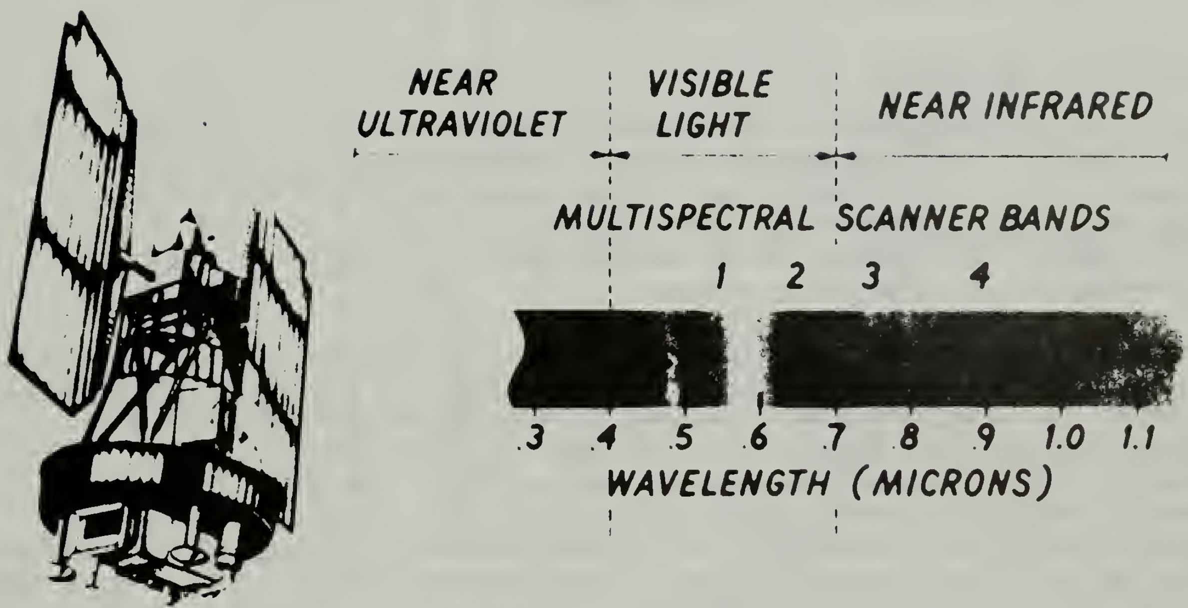


Figure B-4. Four regions of the electromagnetic spectrum detected by Landsat. (From Purdue University - LARS Minicourse Series)

Landsat collects data in a digital form than can be processed into computer-compatible tapes for detailed analysis. The data also can be converted to black-and-white images for each spectral band. Using two or three of the four black-and-white images, a false-color composite of a scene can be created by exposing the bands through a color filter onto color film. These images are called false-color composites because they do not portray the world in "natural" tones. This is similar to a color infrared photo. Important features of the earth's surface can best be studied by analyzing photographs made through a unique combination of bands and filters. On these images, growing healthy vegetation appears bright red, clear water appears black, sediment-laden or shallow water appears light blue, and urban areas appear blue-gray [5/,3/].

## Landsat-1, -2, and -3

Each Landsat satellite circles the globe 14 times daily (at an altitude of 567 miles), scanning a particular scene every 18 days, or more than 20 times a year. Each image covers an area approximately 115 miles square. The resolution of Landsat is about 1.1 acres, or about the size of a football field. Each Landsat image contains about 7.5 million of these 1.1 acre resolution elements or pixels.

The satellites circle the earth from north to south once each 103 minutes. The inclination of orbit is shown in Figure B-5. At the 103-minute orbital period, the satellite always crosses the equator at precisely the same local sun time (the local clock time will vary with location within a time zone). This is known as a sun-synchronous orbit. Landsat-1, -2, and -3 were launched into orbits that cross the equator at 9:42 a.m. local sun time on each pass. This time was selected to take advantage of early morning skies that are generally clearer than later in the day. The lower sun angle also permits the enhancement of various terrain features. Because the system's orbital velocity is constant, all other points in its orbit will also be passed at a relatively constant local sun time, either slightly after 9:42 a.m. in the northern hemisphere, or slightly before in the southern. The important implication of the sun-synchronous orbit is that it ensures repeatable sun illumination conditions during specific seasons. Repeatable illumination conditions are desirable when mosaicking adjacent tracks of imagery and comparing annual changes in land cover [2/].

## Landsat-4

Landsat-4, like the three previous Landsats, carries a multispectral scanner (MSS) system with 1.1 acre (80 m) resolution. In addition, the satellite also carries the Thematic Mapper (TM) imaging system which has 30 m resolution.

Landsat-4 has a near-polar, sun-synchronous orbit similar to those of the previous satellites. To achieve the higher resolution of the TM, Landsat-4's orbit altitude is lower (431 miles) and the orbit period of 99 minutes (14.5 orbits per day) is shorter than in previous satellites. The satellite scans a particular location every 16 days at approximately 9:45 a.m. local sun time.

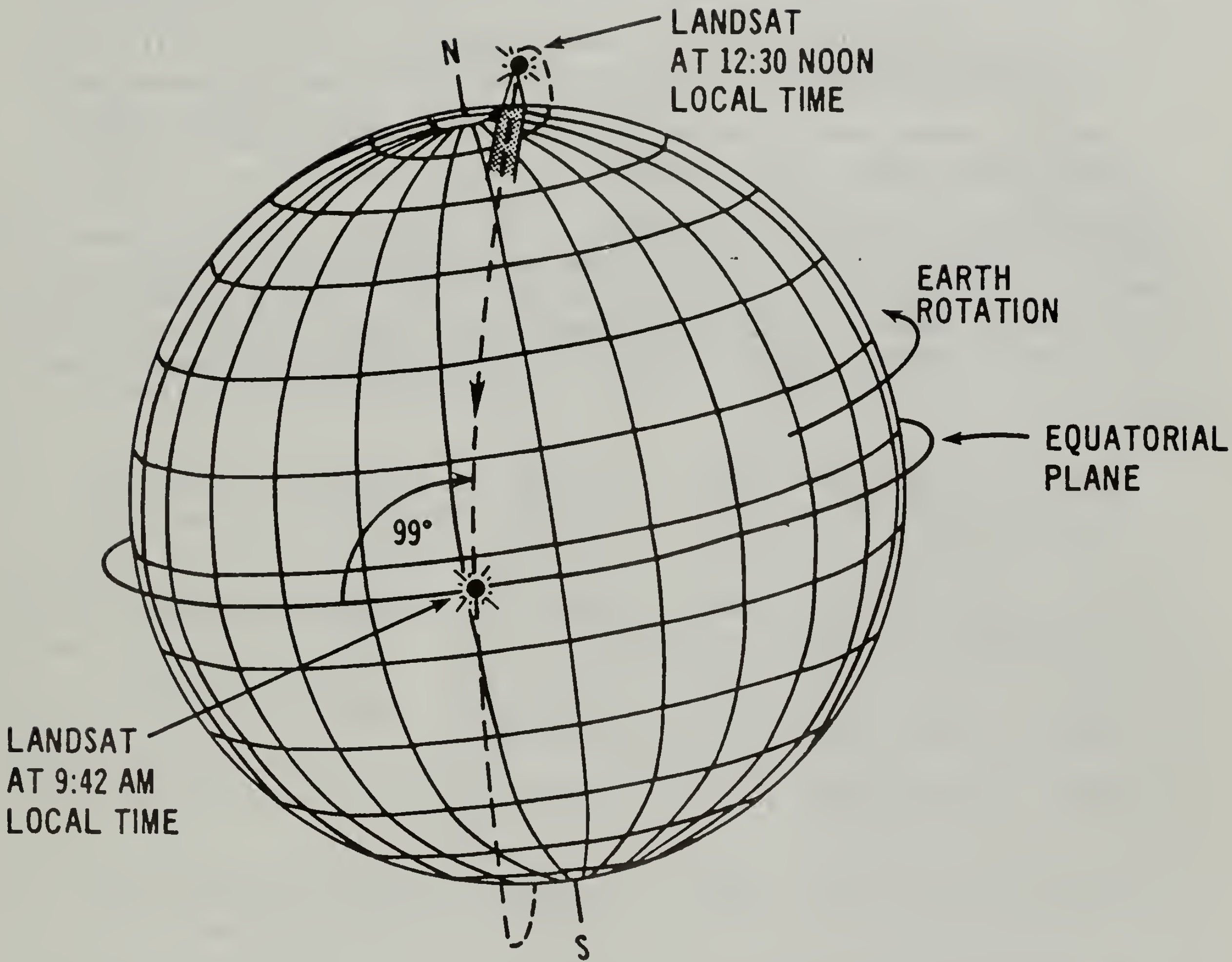


Figure B-5. Orbit of Landsat. (From EROS Data Center)

Because of its lower altitude, Landsat-4 images an adjacent track (path) to the west of a previous track every seven days instead of the next day, as previous satellites did. This change in the earth coverage cycle has major implications for the use of Landsat-4 data in projects where side-to-side mosaics are required. Some of them are:

1. Potential for resource change between adjacent tracks due to fires or rain (i.e., different degrees of greenness over the seven-day period).

2. Weather changes during the seven-day period between adjacent passes, i.e., snow, floods, cloud cover.

The TM scanner has seven spectral bands. The first four cover the same approximate region (0.45-0.90 μm) of the electromagnetic spectrum as the four spectral bands of the MSS system (0.50-1.1 μm). Band 6 is sensitive in the thermal infrared region while bands 5 and 7 are sensitive in the near infrared region. Below are listed the wavelengths at which each band is sensitive and the potential applications for information received by each band:

Band 1 0.45-0.52 μm: Band 1 is useful for water body penetration, soil/vegetation differentiation, and deciduous/coniferous vegetation differentiation.

Band 2 0.52-0.60 μm: Band 2 is useful for measuring the visible green reflectance of healthy vegetation.

Band 3 0.63-0.69 μm: Band 3, the chlorophyll absorption band, is useful for plant species differentiation.

Band 4 0.76-0.90 μm: Band 4 is useful for water body differentiation and biomass studies.

Band 5 1.55-1.75 μm: Band 5 is designed to measure vegetation and soil moisture, and to differentiate between clouds and snow.

Band 6 10.4-12.5 μm: Band 6, the thermal infrared band, is designed for use in plant heat stress measurements, soil moisture discrimination, and other types of thermal mapping. Resolution for this band is 120 m.

Band 7 2.08-2.35 μm: Band 7 is designed, primarily, for geologic applications and hydrothermal mapping. It will also be useful for soil surveys through the discrimination of clay types.

Thematic Mapper data will not be available to the general user community until sometime in early 1985. Landsat-4 MSS data is supposed to be available after January 1983.

Additional information on the Landsat system can be found in USGS Open File Report 78-187, "Characteristics of the Landsat Multispectral Data System." Data on Landsat-4 can be found in Landsat Data Users Notes, Issue 23, published by the USGS at the EROS Data Center.

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## APPENDIX C - EQUIPMENT AT DSC

The BLM, at the Denver Service Center (DSC), has two digital image manipulation computer systems: an ESL, Inc. Interactive Digital Image Manipulation System (IDIMS) and an International Imaging Systems ($I^2S$) System 500 Model 70. Both systems are designed for the manipulation, analysis, interpretation, and processing of a wide variety of image data. The heart of IDIMS is a Hewlett-Packard 3000 Minicomputer with a multi-programming operating system (MPE IV). Multiple users may interact by means of terminals, and batch jobs may be submitted to run in the background. Digital images are input to both systems by means of magnetic tape. Results of processing may be viewed and photographed from a high resolution color display, or they may be printed at the user's terminal or on the line printer. Final results may be transferred back to magnetic tape. In instances where rapid bulk throughput is required, an array processor (ASAP), enables the systems to meet heavy loads 1/. Figure C-1 shows one of the terminals and the IDIMS' Comtal color display.

Figure C-1. Terminal with color display at the BLM remote sensing lab, DSC.

The BLM also has a geographic input system (distinct and separate from ADS/MOSS) consisting of a Talos digitizer board, a Tektronix graphics terminal, and a Tektronix hard copy output unit. This equipment is used for the geographic registration of data and the digitization of ancillary data sets such as land ownership, allotments, geology, soils, water sources, etc. Figure C-2 shows the digitizer board and graphics terminal.

Figure C-2. Digitizer board and graphics terminal at the BLM remote sensing lab, DSC.

For hard copy output, in addition to the line printer, BLM has an electrostatic printer-plotter, an Applicon color ink-jet plotter, and a Dunn camera system for photo products taken directly from the display screen.

The Branch of Scientific Systems Applications at the DSC also has various types of photo image interpretation equipment, some of which are: two Bausch and Lomb stereo interpretation scopes, a stereo Zoom Transfer Scope, various mirror stereoscopes, and several light tables designed to accommodate roll film.

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## APPENDIX D - GENERALIZED PROCEDURAL OUTLINE

The following is a very generalized outline of the steps taken in a typical soil-vegetation type remote sensing project performed at DSC. These steps may vary depending upon the type and purpose of the project.

I. Project Planning

A. Meetings and discussions with State Office, District, and Resource Area personnel.

1. Discuss current field effort and information needs.
2. State project objectives, time frames, and desired final products.
3. Delineate study site.
4. Obtain resource information.
5. Preliminary field reconnaissance.

II. Acquistion of Ancillary Information and Landsat Imagery

A. Ancillary Data.

1. Land Status maps.
2. Pasture and allotment maps.
3. Resource aerial photography.
4. Topographic maps and orthophoto quadrangles.
5. Geology and soils reports.
6. Climatologic data.
7. Other resource information (i.e., URA, vegetation, MLRA data, etc.)
8. National Cartographic Information Center (NCIC) digital terrain data (DMA tapes) from which terrain elevation, slope, and aspect information is obtained.

B. Landsat Data.

1. Obtain computer search of available Landsat imagery.
2. Select favorable scene dates based upon:
   a. Percent cloud cover.
   b. Data quality.
   c. Time period most favorable to resource enhancement.
   d. Computer Compatible Tape (CCT) availability.
3. Order black and white images of selected spectral bands, and small scale color composite imagery for each date.
4. Select final scene or scenes (if using multitemporal data), and order CCT's and corresponding large scale images.

III. Define Project Methodology

A. Analyze resource area in separate phases.
B. Develop vegetation framework.
C. Decide upon stratification criteria.
D. Decide upon merged ancillary data.

IV. Landsat Data Processing

A. Unpack CCT and DMA tapes.
B. Examine data and fix any bad lines.
   1. Change areas of bad or altered data.
C. Create a terrain image.
D. Register Landsat data to a map base.
   1. Select ground control points.
   2. Digitize control points.
E. Digitize test site boundary.
F. Digitize land status.
G. Digitize geology.
H. Digitize allotments and pastures.
I. Digitize soils (if available).
J. Digitize environmental stratum (i.e., temperature, precipitation, landform, etc.)
K. Apply test site mask to Landsat data.
L. Apply strata mask (if necessary).
M. Develop training statistics.
   1. Within environmental stratum.
      a. Reduce sample size.
      b. Cluster (allow the computer to group similar spectral classes).
      c. Merge or delete statistics.
N. Classify.
O. Check classification.
P. Recluster and classify (if needed).
Q. Combine spectral class symbols.
   1. Use resource area personnel.
R. Combine classifed stratum into one image.
S. Create 1:24,000 scale Versatec intermediate output on a 7.5 minute quadrangle basis.
T. Allocate photo sample plots.*
   1. Plot flight lines and Primary Sample Units (PSU) on maps.

V. Award Photo Contract for Large Scale Photography (LSP)*

A. Acquire LSP.
B. Reproduce LSP.
C. Archive LSP.
D. Plot PSU's on maps.
E. Photo interpret (P.I.) PSU's.

IV. Ground Data Collection

A. Organize field work.
B. Collect field data.

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*These steps are dependent upon the purpose, time frame, and budget for a given project.

VII. Final Classification

A. Code and enter P.I. and ground data into ERIS (statistical package).
B. Generate contingency tables.
C. Develop final classification and class descriptions.
    1. Possible use of resource area personnel.

VIII. Produce Final Output Products

IX. Cost Determination

## APPENDIX E - ORDERING LANDSAT IMAGERY

Several Landsat products are available. A single black-and-white image or the complete set of four black-and-white images and a false-color composite for each scene can be ordered. The complete set will show how the same area appears differently in each of the four spectral bands. Computer-compatible tapes of scenes are also available.

All black-and-white products are available as film negatives, film positives, or paper prints. All false-color composites are available as film positives or paper prints.

These products can be ordered through the USGS's National Cartographic Information Center (NCIC) or its Earth Resources Observation System (EROS) Data Center. When ordering, it is important to describe the exact area of interest. Provide the geographic coordinates or a map marked with the specific area. When giving geographic coordinates, the Geographic Search for Landsat Data Inquiry Form can be used (Fig. E-1). Indicate on the form the preferred type of Landsat coverage (black-and-white or false-color), the minimum image quality acceptable, the maximum percent of cloud cover acceptable, and the preferred time of year. Figure E-2 shows an example of a computer printout search listing. Table E-1 explains the types of data provided by the search.

To order coverage over selected areas within the contiguous United States, you can use the form Preselected Landsats 1, 2, 3 Coverage, which provides a map of the Nation showing the path and row of individual scenes (Figs. E-3 and E-4). These scenes were selected for their clarity and lack of cloud cover. They are also available as 35 mm slides. A search can also be requested on the basis of path and row for a given time period.

The USGS and National Oceanic and Atmospheric Administration (NOAA) have also prepared a number of mosaics of Landsat images. A list of these mosaics is available from the USGS and NOAA. These mosaics retain the basic quality of Landsat imagery but cover larger areas and are available for a fraction of the cost of the separate images in photographic form.

It is important to note that all orders must be prepaid or sent on a company or Government purchase order. Costs for each type of image are included on the order forms. Figure E-5 shows an example of the order form for Landsats 1, 2, 3 Standard Products. It contains the prices for imagery as of October 1981. Table E-2 shows current and future prices (as of April 1, 1983) for Landsat and Thematic Mapper products and special acquisitions. Also the phone number and address for the EROS Data Center are given. If the latitude and longitude or the path and row of a particular area are known, this information can be phoned into EROS and they will generally send the computer search within a few days. The time frame for receiving imagery from the EROS Data Center varies between two and six weeks once the order is made. Image ordering can also be done over the phone if an account has been established. It should be noted that special discounts are available to BLM if data are ordered through State Offices or DSC.

Imagery acquired after February 1979 and processed through the EROS Digital Image Processing System (EDIPS) has had certain radiometric and geometric corrections and enhancements applied. It is recommended that EDIPS imagery be used for manual interpretation efforts.

# GEOGRAPHIC SEARCH FOR LANDSAT DATA
# INQUIRY FORM

**RETURN COMPLETED FORM TO:** NOAA/NESDIS Landsat Customer Services • EROS Data Center Sioux Falls, SD 57198 • Comm: 605/594-6151 FTS: 784-7151 • TWX: 910-668-0310

DATE ______

NAME ______ (FIRST) (INITIAL) (LAST) COMPANY ______

ADDRESS ______ CITY/STATE ______ ZIP ______

PHONE (HOME) ______ (BUSINESS) ______ EROS ACCOUNT NO. ______ REF. NO. ______

| POINT SEARCH<br>LAT.<br>LONG.<br>Imagery with any coverage over the selected point will be included. | POINT NO. 1<br>LAT. ____ ° ____ ' N<br>LONG. ____ ° ____ ' W | POINT NO. 2<br>LAT. ____ ° ____ ' N<br>LONG. ____ ° ____ ' W | POINT NO. 3<br>LAT. ____ ° ____ ' N<br>LONG. ____ ° ____ ' W |
|---|---|---|---|
| AREA RECTANGLE<br>LAT. LAT.<br>LONG. LONG.<br>Imagery with any coverage within the selected area will be included. | AREA NO. 1<br>LAT. ____ ° ____ ' N TO<br>LAT. ____ ° ____ ' N<br>LONG. ____ ° ____ ' W TO<br>LONG. ____ ° ____ ' W | AREA NO. 2<br>LAT. ____ ° ____ ' N TO<br>LAT. ____ ° ____ ' N<br>LONG. ____ ° ____ ' W TO<br>LONG. ____ ° ____ ' W | AREA NO. 3<br>LAT. ____ ° ____ ' N TO<br>LAT. ____ ° ____ ' N<br>LONG. ____ ° ____ ' W TO<br>LONG. ____ ° ____ ' W |

If any of the above geographic references cannot be provided, please specify areas of interest by GEOGRAPHIC NAME AND LOCATION (include a map if possible).

**PREFERRED TYPE OF COVERAGE**

| | Black & White | False Color |
|---|---|---|
| ☐ Landsat 1-3 | ☐ | ☐ |
| ☐ Landsat 4 | ☐ | ☐ |

☐ MSS ☐ RBV

**PREFERRED TIME OF YEAR**
Check maximum of three

☐ JAN-MAR ☐ ALL COVERAGE
☐ APR-JUNE ☐ LATEST COVERAGE
☐ JULY-SEPT ☐ SPECIFIC DATES ______
☐ OCT-DEC

**MINIMUM QUALITY RATING ACCEPTABLE**

☐ (VERY POOR) ☐ (POOR) ☐ (FAIR) ☐ (GOOD)

**NOTE:**
Classification of percent of cloud cover is subjective and is relative to the amount of clouds appearing on the imagery and not on their location.

**MAXIMUM CLOUD COVER ACCEPTABLE**

☐ 10% ☐ 30% ☐ 50% ☐ 70% ☐ 90%

FOR ADDITIONAL SERVICES, PLEASE CONTACT: U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
USER AFFAIRS DIVISION, CODE Sx32, WASHINGTON, DC 20233

Comments: ______

Figure E-1



NOAA FORM 34-1202
October 1982

# HOW TO REQUEST A GEOGRAPHIC SEARCH

This form is used to request a geographic search for Landsat data over a point or area of interest.

Data from this inquiry form will be used to initiate a computer Geosearch. The results will be returned on a computer listing along with a decoding sheet, from which photography can be selected and ordered.

Complete the form as follows:

A. Enter your NAME, ADDRESS, and ZIP CODE clearly. Enter a PHONE number where you can be reached during business hours.

B. Complete the required information for either the POINT SEARCH, or AREA RECTANGLE inquiry. The preferred manner of inquiry is to identify the appropriate Landsat Worldwide Reference System (WRS) of PATH and ROW centers. However, if the WRS information is not available, a geographic reference of LATITUDE and LONGITUDE will suffice. It is beneficial that you minimize your area of interest, thereby allowing for a faster and more critical retrieval of information.

C. Complete all other information.

D. Complete the COMMENTS portion of the inquiry. Will it be used for interpretation, analysis, or will it be framed and placed on a wall? This information will assist our technicians in determining whether the products available will satisfy your requirements.

E. Return the completed form to the EROS DATA CENTER.

FOR INFORMATION OR ASSISTANCE PLEASE CONTACT
NOAA/NESDIS
LANDSAT CUSTOMER SERVICES
EROS DATA CENTER
SIOUX FALLS, SD 57198
COMM: 605/594-6151•FTS: 784-7151

INFORMATION OR ASSISTANCE MAY ALSO BE OBTAINED FROM THE FOLLOWING U.S. GEOLOGICAL SURVEY, NATIONAL CARTOGRAPHIC INFORMATION CENTER, OFFICES

Eastern Mapping Center
536 National Center
Reston, VA 22092
FTS: 928-6336
Comm: 703/860-6336

Mid-Continent Mapping Center
1400 Independence Road
Rolla, MO 65401
FTS: 277-0851
Comm: 314/341-0851

Rocky Mountain Mapping Center
Stop 504, Denver Federal Center
Denver, CO 80225
FTS: 234-2326
Comm: 303/234-2326

Western Mapping Center
345 Middlefield Road
Menlo Park, CA 94025
FTS: 467-2426
Comm: 415/323-8111

National Space Technology Laboratories
NSTL Station, MS 39529
FTS: 494-3541
Comm: 601/688-3544

☆U.S. GOVERNMENT PRINTING OFFICE: 1983—665-542

Figure E-1 (cont.)

```
                                    EROS DATA CENTER                                        REPORT NO. DL001-1
                              SIOUX FALLS, SOUTH DAKOTA  57198                              DATE       06/12/78
   PHONE 605-594-6511   FEDERAL TELECOMMUNICATIONS SYSTEM PHONES USE 784-7151                TIME       13:40
                                                                                            PAGE           1
                          CONTACT NUMBER 0004309121        TERMINAL T83A61

 9 ACCESSIONS                               POINT REFERENCE  RETRIEVAL

PATH  ROW   PATH  ROW      PATH  ROW   PATH  ROW          EXPOSURE-DATES QUALITY CLOUD-COVER  RECORDING-TECH
 016  033                                                  GE 770701         5        10%        VERTICAL

                                              DATA TYPE  LANDSAT

                                                                                                                    BIPP
  IMAGERY-TYPE         SCENE  ID       FILM-SOURCE QUALITY CLOUD EXPO-DATE   SCENE-CENTER-POINT    SCENE-SCALE   MICROFORM  COL CCT

PATH= 14  ROW= 33  LANDSAT
 LANDSAT-2 (MSS)       D2112014391X0    B&W-02.1"     8888=    10%  02/15/78  N38D46M00S W076D49M12S  1:3,369,000  =0000000000  P   N
  CORNER POINT COORDINATES=#1:N39D10M57S W075D37M40S,#2:N39D37M13S W077D31M48S,S3:N38D13M19S W077D59M39S,S4:N37D53M02S W076D07M37S

 LANDSAT-2 (MSS)       D2110214301X0    B&W-02.1"     8888=    10%  01/28/78  N38D46M00S W076D49M00S  1:3,369,000  =0000000000  P   N
  CORNER POINT COORDINATES=#1:N39D10M57S W075D37M36S,#2:N39D37M13S W077D31M44S,S3:N38D13M19S W077D59M35S,S4:N37D53M02S W076D07M33S

 LANDSAT-1 (MSS)       D5985134105O0    B&W-02.1"     M558=    10%  12/29/77  N38D37M00S W077D00M00S  1:3,369,000  =0000000000  P   N
  CORNER POINT COORDINATES=S1:N39D33M05S W075D42M02S,S2:N39D51M14S W077D44M03S,S3:N38D20M06D W078D14M42S,S4:N38D02M26S W076D15M13S

 LANDSAT-2 (MSS)       8601214394500    B&W-02.1"     5888=    00%  10/30/77  N38D52M00S W076D50M00S  1:3,369,000  =0000000000  7   N
  CORNER POINT COORDINATES=#1:N39D27M37S W075D39M44S,#2:N39D46M34S W077D43M25S,S3:N38D15M34S W078D15M01S,#4:N37D57M07S W076D13M49S

 LANDSAT-1 (MSS)       8591313490500    B&W-02.1"     M05D=    10%  10/18/77  N38D54M00S W077D05M00S  1:3,369,000  S1100640026  P   N
  CORNER POINT COORDINATES=S1:N39D30M20S W075D47M10S,#2:N39D48M11S W077D51M18S,S3:N38D14M32S W078D21M34S,#4:N37D59M30S W076D19M57S

 LANDSAT-1 (MSS)       8587713525500    B&W-02.1"     M580=    00%  09/12/77  N38D55M00S W077D04M00S  1:3,369,000  S1100620451  P   N
  CORNER POINT COORDINATES=#1:N39D31M06S W075D48M32S,S2:N39D48M56S W077D51M57S,S3:N38D18M08S W078D22M12S,S4:N38D00M47S W076D21M17S

 LANDSAT-1 (MSS)       D585913545500    B&W-02.1"     M883=    10%  08/25/77  N38D55M00S W077D08M00S  1:3,369,000  S11006202U8  P   N
  CORNER POINT COORDINATES=S1:N39D31M16S W075D50M21S,#2:N39D49M02S W077D56M16S,S3:N38D17M55S W078D24M22S,S4:N38D00M39S W076D23M01S

 LANDSAT-2 (MSS)       8290414435500    B&W-02.1"     8588=    10%  07/14/77  N38D48M00S W076D58M00S  1:3,369,000  D2100321205  P   N
  CORNER POINT COORDINATES=#1:N39D23M43S W075D38M49S,S2:N39D43M16S W077D43M33S,#3:N38D11M27S W078D15M53S,S4:N37D52M25S W076D13M43S

 LANDSAT-1 (MSS)       D580514003500    B&W-02.1"     M888=    10%  07/02/77  N38D53M00S W077D11M00S  1:3,369,000  S1100600340  P   N
  CORNER POINT COORDINATES=S1:N39D29M30S W075D52M41S,S2:N39D47M32S W077D57M32S,#3:N38D15M40S W078D28M02S,S4:N37D58M08S W076D25M43S

***************************************************************  DONE  *****************************************************************
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FIGURE E-2—*Example of a computer-printout listing of Landsat scenes.*

TABLE —*Type of data provided by the computer search*

| Image Parameter | Description |
|---|---|
| Type of coverage | Indicates whether Imagery was recorded by Landsat 1, 2, or 3 and the sensor used. |
| Film source | Indicates whether film is black and white (B/W) or color (C) and gives size of master reproducible. All black and white Landsat NDPF negatives will be 56 mm nominal image width; IPF/EDIPS MSS negatives and Landsat color composites have a nominal width of 185 mm (7.3 in.) and height of 170 mm (6.7 in.) Landsat 3 RBV negatives have a nominal image size of 198 mm (7.8 in.) on a side. |
| Photo ID | Indicates the unique control number assigned to the image. |
| Quality code | Black and White—Indicates a rating of poor (2), fair (5) or good (8) for each spectral band. Color—Indicates on a scale of 1 to 9, the overall quality. |
| Cloud cover | Indicates the portion of the image which is obscured by clouds (in tens of percent). |
| Date | Indicates the year, month, and day the scene was recorded. |
| Center point | Indicates the latitude and longitude of the center of the specific scene. |

TABLE —*Type of data provided by the computer search*—Continued

| Image Parameter | Description |
|---|---|
| Scale | Indicates the scale of the master reproducible. B/W imagery normally will be 1:3,369,000 for NDPF-processed Landsats 1, 2 & 3 MSS and Landsats 1 & 2 RBV images, 1:500,000 for Landsat 3 RBV images, and 1:1,000,000 for IPF/EDIPS-processed MSS images. Color will be 1:1,000,000. |
| Altitude | Indicates the altitude of the satellite in hundreds of meters when the image was recorded. |
| Microform | Indicates the microform, either microfilm (cassette and frame number) or microfiche (path and row number), for this accession. |
| Corner points | Indicates latitude and longitude of each of the four corner points of the scene. |
| CCT (computer compatible tape) | At right of listing, indicates that a BIP2 (byte interleaved by pixel pairs) NDPF format CCT is available for order. |

Table E-1

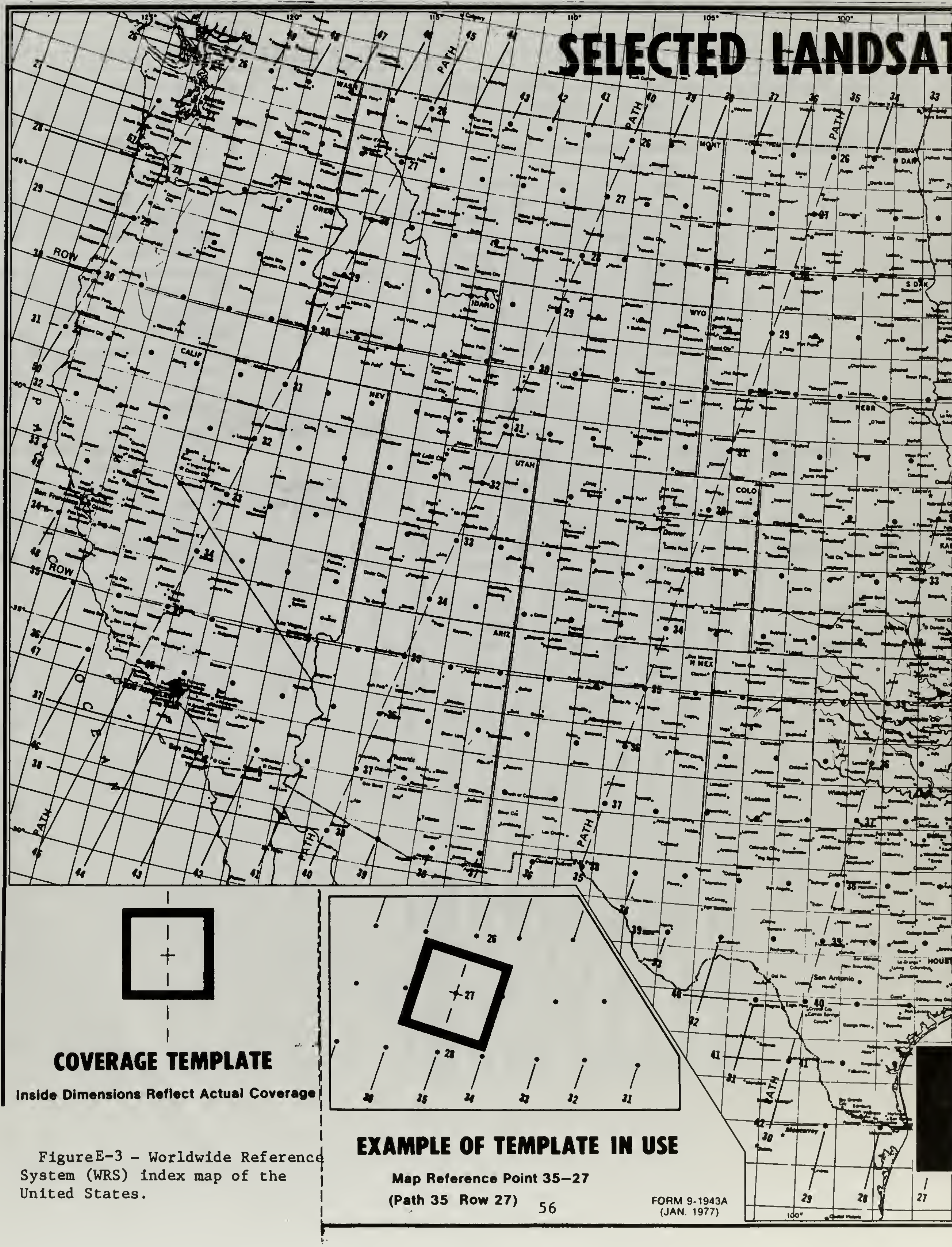


Figure E-3 - Worldwide Reference System (WRS) index map of the United States.

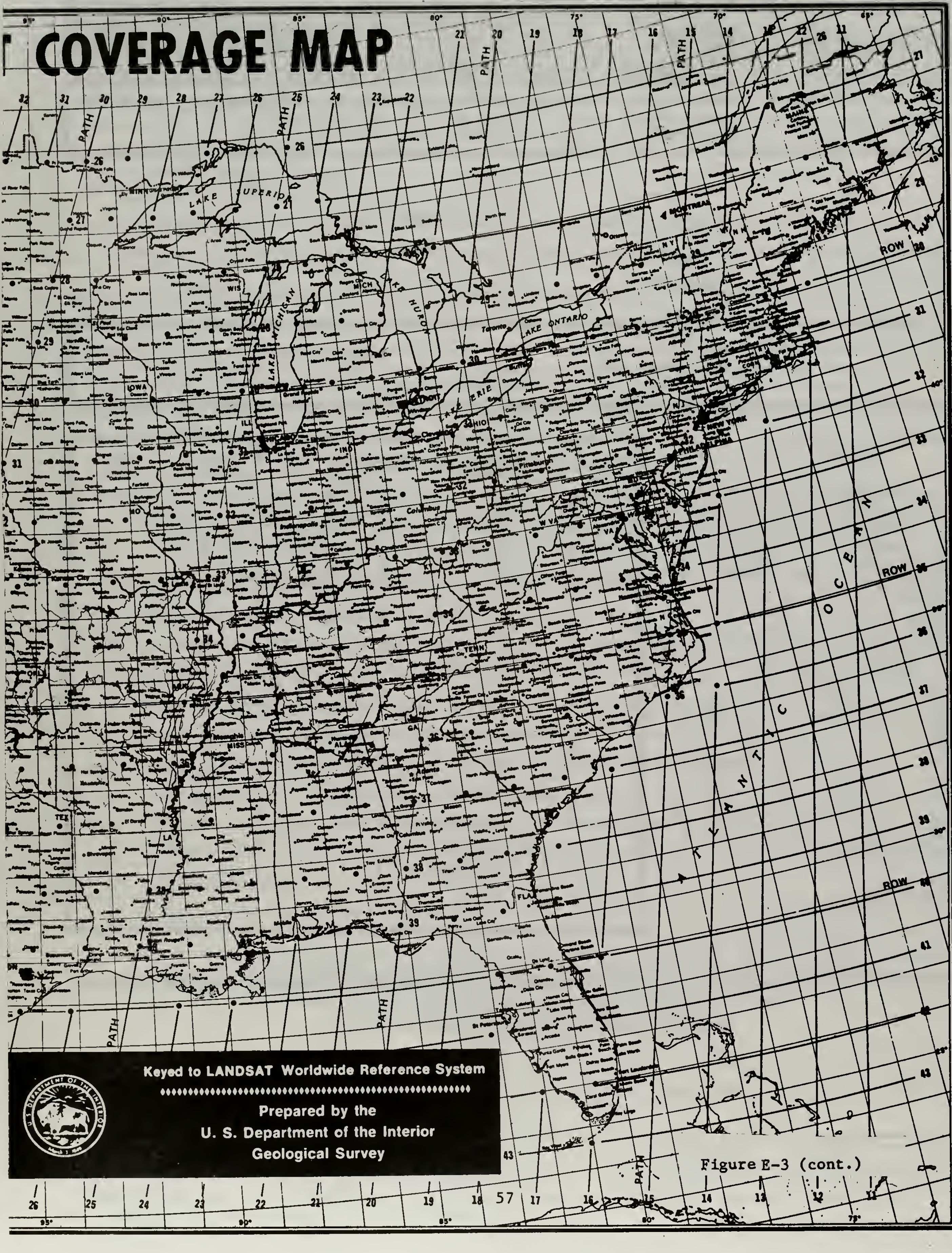


Figure E-3 (cont.)

# PRESELECTED LANDSATS 1,2,3 COVERAGE
# ORDER FORM

RETURN COMPLETED FORM TO: NOAA/NESDIS Landsat Customer Services • EROS Data Center Sioux Falls, SD 57198 • Comm: 605/594-6151 FTS: 784-7151 • TWX: 910-668-0310

DATE ________

NAME ________ (FIRST) (INITIAL) (LAST) COMPANY ________

ADDRESS ________ CITY/STATE ________ ZIP ________

PHONE (HOME) ________ (BUSINESS) ________ EROS ACCOUNT NO. ________ (IF KNOWN) REF. NO. ________ (P.O. GOV'T ACC'T., OR OTHER)

SHIP TO: ________

## STANDARD PRODUCTS TABLES

### BLACK AND WHITE

| IMAGE SIZE | PRODUCT MATERIAL | PRODUCT CODE | UNIT PRICE |
|---|---|---|---|
| 18.5cm (7.3 in.) | FILM NEGATIVE | 03 | $35.00 |
| 18.5cm (7.3 in.) | FILM POSITIVE | 13 | $30.00 |
| 18.5cm (7.3 in.) | PAPER | 23 | $30.00 |
| 37.1cm (14.8 in.) | PAPER | 24 | $58.00 |
| 74.2cm (29.2 in.) | PAPER | 26 | $95.00 |

### FALSE COLOR COMPOSITE

| IMAGE SIZE | PRODUCT MATERIAL | PRODUCT CODE | UNIT PRICE |
|---|---|---|---|
| * 35mm SLIDE | FILM POSITIVE | 50 | $ 4.00 |
| 18.5cm (7.3 in.) | PAPER | 63 | $ 45.00 |
| 18.5cm (7.3 in.) | FILM POSITIVE | 53 | $ 74.00 |
| 37.1cm (14.8 in.) | PAPER | 84 | $ 90.00 |
| 74.2cm (29.2 in.) | PAPER | 66 | $175.00 |

*Dupe slide of existing slide master intended for projection purposes only.

•PAYMENT MUST ACCOMPANY ORDER

CHECK, MONEY ORDER ☐

PURCHASE ORDER ☐ *Refer to item "O" on reverse side.

GOV'T ACCOUNT ☐

| WRS MAP REFERENCE PATH | ROW | PRODUCT CODE | MSS BANDS 4 | 5 | 6 | 7 | QTY | UNIT PRICE | TOTAL PRICE |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
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UNIT PRICES SUBJECT TO CHANGE

TOTAL ABOVE A ____

TOTAL FROM PREVIOUS SHEETS B ____

TOTAL COST C ____

FOR ADDITIONAL SERVICES, PLEASE CONTACT: U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
USER AFFAIRS DIVISION, CODE Sx32, WASHINGTON, DC 20233

Comments: ________

Figure E-4

NOAA FORM 34-1204
October 1982

# HOW TO ORDER PRESELECTED LANDSAT COVERAGE DATA

This order form is used to order only PRESELECTED LANDSAT COVERAGE DATA over the Conterminous United States. These scenes were pre-selected without any particular usage in mind except to demonstrate a typical good scene over a Path/Row point. Orders for Landsat data that require special consideration in printing such as a print for water detail, desert detail, etc. should be submitted using the Landsat Standard Products Order Form. (See Item N on Standard Products Order Forms)

Please provide the following information in the indicated areas of the order form:

A. List your complete NAME, ADDRESS, ZIP CODE, and name of your COMPANY if applicable.

B. If you desire to have the products mailed to an address or individual other than yourself, please complete the "SHIP TO" address.

C. List a PHONE NUMBER where you can be contacted during business hours.

D. If you have had previous business with the EROS DATA CENTER , please list your ACCOUNT NUMBER if known.

E. Enter the MAP REFERENCE NUMBER

Refer to the SELECTED LANDSAT COVERAGE MAP foldout.

Identify your area of interest on the map. It may require that you reference a road map or atlas in locating the area on the map.

Trace the small coverage outline from the lower left corner of the map onto a sheet of thin paper. This outline portrays the ground coverage of a LANDSAT image on that map.

Center the coverage trace over the numbered dot nearest your area of interest on the map, aligning the extended dashed line through the dots above and below. (See example of template in use - lower left on map). Dots should fall in sequence, i.e. if your center dot is 35-27 the dots to align with will be 35-26 and 35-28. You may find that a photo centered over adjoining dots will also cover your area of interest. Select the framing you most prefer.

Transcribe the PATH number from the map to the first column of the Map Reference Number. Transcribe the ROW number from the map to the second column of the Map Reference Number.

NOTE: ROW numbers are identified on every FIFTH PATH.

F. Enter the PRODUCT CODE of the type product being ordered from the STANDARD PRODUCTS TABLE. If your order is for Black and White imagery, check columns for bands desired for MSS Black and White products. Band 5 is recommended for a general use.

G. Enter the number of COPIES of that product which you desire in the QUANTITY column.

H. Enter the UNIT PRICE of the type product as reflected in the STANDARD PRODUCTS TABLE.

I. Multiply the figure in the QUANTITY column by the UNIT PRICE and enter the result in the TOTAL PRICE column.

J. Repeat the above for each product ordered.

K. TOTAL the costs of all products ordered on that order form and enter the net result in BLOCK A. (TOTAL ABOVE.)

L. If more than one order form is required, enter the sum of the figures in BLOCK A in BLOCK B on the last order form.

M. Enter the SUM of BLOCK A and BLOCK B in BLOCK C. (TOTAL COST.)

N. Indicate the TYPE of payment being made with a CHECK MARK. Make all drafts payable to EROS DATA CENTER. DO NOT SEND CASH.

O. Mail ORDER FORM(S) and PAYMENT to the EROS DATA CENTER. IF PRE-PAYMENT HAS BEEN PREVIOUSLY FORWARDED TO ANOTHER FACILITY, PLEASE FORWARD THIS ORDER TO THAT FACILITY FOR PROCESSING.

FOR INFORMATION OR ASSISTANCE PLEASE CONTACT
NOAA/NESDIS
LANDSAT CUSTOMER SERVICES
EROS DATA CENTER
SIOUX FALLS, SD 57198
COMM: 605/594-6151•FTS: 784-7151

INFORMATION OR ASSISTANCE MAY ALSO BE OBTAINED FROM THE FOLLOWING U.S. GEOLOGICAL SURVEY, NATIONAL CARTOGRAPHIC INFORMATION CENTER, OFFICES

Eastern Mapping Center
536 National Center
Reston, VA 22092
FTS: 928-6336
Comm: 703/860-6336

Mid-Continent Mapping Center
1400 Independence Road
Rolla, MO 65401
FTS: 277-0851
Comm: 314/341-0851

Rocky Mountain Mapping Center
Stop 504, Denver Federal Center
Denver, CO 80225
FTS: 234-2326
Comm: 303/234-2326

Western Mapping Center
345 Middlefield Road
Menlo Park, CA 94025
FTS: 467-2426
Comm: 415/323-8111

National Space Technology Laboratories
NSTL Station, MS 39529
FTS: 494-3541
Comm: 601/688-3544

☆U.S. GOVERNMENT PRINTING OFFICE: 1983—665-543

Figure E-4 (cont)

# LANDSATS 1,2,3 STANDARD PRODUCTS
# ORDER FORM

**RETURN COMPLETED FORM TO:** NOAA/NESS Landsat Customer Services • EROS Data Center Sioux Falls, SD 57198 • Comm: 605/594-6151 FTS: 784-7151 • TWX: 910-668-0310

DATE ____________

NAME ______________________________ (FIRST) (INITIAL) (LAST) COMPANY ______________________

ADDRESS ______________________________ CITY/STATE ______________________ ZIP ________

PHONE (HOME) ____________ (BUSINESS) ____________ EROS ACCOUNT NO. ____________ (IF KNOWN) REF. NO. ____________ (P.O., GOV'T ACCT., OR OTHER)

**SHIP TO:** ______________________________

______________________________

______________________________

## STANDARD PRODUCTS TABLES

BLACK AND WHITE PRODUCTS

| NOMINAL IMAGE SIZE | PRODUCT MATERIAL | PRODUCT CODE | PRICE |
|---|---|---|---|
| 18.5cm (7.3 in.) | Paper | 23 | $ 30.00 |
| 18.5cm (7.3 in.) | Film Positive | 13 | 30.00 |
| 18.5cm (7.3 in.) | Film Negative | 03 | 35.00 |
| 37.1cm (14.6 in.) | Paper | 24 | 58.00 |
| 74.2cm (29.2 in.) | Paper | 26 | 95.00 |

FALSE COLOR COMPOSITE PRODUCTS

| NOMINAL IMAGE SIZE | PRODUCT MATERIAL | PRODUCT CODE | PRICE |
|---|---|---|---|
| 18.5cm (7.3 in.) | Paper | 83 | $ 45.00 |
| 18.5cm (7.3 in.) | Film Positive | 53 | 74.00 |
| 37.1cm 14.8 in.) | Paper | 64 | 90.00 |
| 74.2cm (29.2 in.) | Paper | 68 | 175.00 |

COLOR COMPOSITE GENERATION*

| NOMINAL IMAGE SIZE | PRODUCT MATERIAL | PRODUCT CODE | PRICE |
|---|---|---|---|
| 18.5cm (7.3 in.) | Printing Master | 59 | $195.00 |

*Each MSS Color Composite Printing Master (generated from bands 4, 5, and 7) is retained by EDC. Color Composite product costs must be added to the generation fee.

| SCENE IDENTIFICATION | PRODUCT CODE | PHOTOGRAPHS ONLY: MSS BANDS 4 | 5 | 6 | 7 | NO. OF EACH | CCT | QTY. | UNIT PRICE | TOTAL PRICE |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | |
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| | | | | | | | | | TOTAL ABOVE | A |
| | | | | | | | | | TOTAL FROM PREVIOUS SHEETS | B |
| | | | | | | | | | TOTAL COST | C |

**PRICES SUBJECT TO CHANGE**

COMPUTER COMPATIBLE TAPES (CCT)

| TRACKS | BPI | FORMAT | MSS All Bands (Band Sequential) PRODUCT CODE | PRICE | MSS All Bands (Band Interleaved) PRODUCT CODE | PRICE | RBV Single Subscenes PRODUCT CODE | PRICE | Set of Four RBV Subscenes PRODUCT CODE | PRICE |
|---|---|---|---|---|---|---|---|---|---|---|
| 9 | 1600 | TAPE SET | 184-A | 650.00 | 184-B | 650.00 | 184-C | 650.00 | 184-D | 1300.00 |
| 9 | 6250 | TAPE SET | 185-A | 650.00 | 185-B | 650.00 | 185-C | 650.00 | 185-D | 1300.00 |

These tapes may be ordered either corrected or uncorrected (geometrically). Refer to reverse side.

PAYMENT MUST ACCOMPANY ORDER

- CHECK, MONEY ORDER ☐
- PURCHASE ORDER ☐
- GOV'T ACCOUNT ☐

FOR ADDITIONAL SERVICES, PLEASE CONTACT: U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
USER AFFAIRS DIVISION, CODE Sx32, WASHINGTON, DC 20233

Comments: ______________________________

______________________________

Figure E-5

NOAA FORM 34-1201
October 1982

# HOW TO ORDER LANDSATS 1,2,3 STANDARD PRODUCTS

This order form is used to order all standard Landsats 1,2,3 data. Necessary order information can normally be extracted from a computer listing of available data or from other Landsat references.

Please provide the following information in the indicated areas of the order form:

A. List your complete NAME, ADDRESS, ZIP CODE, and name of your COMPANY if applicable.

B. If you desire to have the products mailed to an address or individual other than yourself, please complete the "SHIP TO" address.

C. List a PHONE NUMBER where you can be contacted during business hours.

D. If you have had previous business with the EROS DATA CENTER, please list your EROS ACCOUNT NUMBER if known.

E. Enter the complete SCENE IDENTIFICATION NUMBER. This number can be transcribed directly from the COMPUTER LISTING or from a Landsat catalog.

F. Review the STANDARD PRODUCTS table on the front of the ORDER FORM and determine the type of product desired.

G. Enter the PRODUCT CODE of the type product being ordered from the STANDARD PRODUCTS table.

H. Check columns for bands you desire and also indicate the number of copies you desire of each band in the NUMBER OF EACH column. Check the CCT box only if a digital tape is being ordered. In selecting the tape format, make sure that you consider your equipment and usage. Uncorrected tapes are only available for data acquired after June 1981. If an uncorrected tape is desired, it should be noted in the comments portion. Please complete the QUANTITY column. Count the number of MSS bands checked, multiply by the figure in the NUMBER OF EACH column and enter the RESULT in the QUANTITY column.

I. Enter the UNIT PRICE of the type product as reflected in the STANDARD PRODUCTS table.

J. Multiply the figure in the QUANTITY column by the UNIT PRICE, and enter the result in the TOTAL PRICE column.

K. Repeat steps E through J for each product ordered.

L. TOTAL the costs of all products ordered on this order form and enter the net result in BLOCK A (TOTAL ABOVE).

M. For a single order form, enter the figure from BLOCK A in BLOCK C (TOTAL COST). If more than one order form is required, on the last order form enter the sum of the figures in all BLOCK A's in BLOCK B and then total BLOCK A and BLOCK B in BLOCK C (TOTAL COST).

N. The COMMENTS portion is completed only when special consideration is desired in printing, as in print for water detail, desert detail, etc. which does not necessarily fall in the CUSTOM PRODUCT category. If a CUSTOM PRODUCT is desired, the COMMENTS portion will also be used, and the cost determination will be normally based on three times the standard cost.

O. PHOTOGRAPHIC and DIGITAL TAPE products are available in other formats but require special ordering procedures. If interested, please call the EROS Data Center for further instructions.

P. Include type of payment (purchase order, check or money order). Make all drafts payable to EROS Data Center. DO NOT SEND CASH.

Q. Mail ORDER FORM(S) and PRE-PAYMENT to the EROS DATA CENTER. IF PAYMENT HAS BEEN PREVIOUSLY FORWARDED TO ANOTHER FACILITY, PLEASE FORWARD THIS ORDER TO THAT FACILITY FOR PROCESSING.

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FOR FURTHER INFORMATION OR ASSISTANCE PLEASE CONTACT
U.S. GEOLOGICAL SURVEY
NATIONAL CARTOGRAPHIC INFORMATION CENTER
507 NATIONAL CENTER•RESTON, VA 22092
FTS: 928-6045 COMM: 703/860-6045

INFORMATION OR ASSISTANCE MAY ALSO BE OBTAINED FROM THE FOLLOWING U.S. GEOLOGICAL SURVEY, NATIONAL CARTOGRAPHIC INFORMATION CENTER, OFFICES

Eastern Mapping Center
536 National Center
Reston, VA 22092
FTS: 928-6336
Comm: 703/860-6336

Mid-Continent Mapping Center
1400 Independence Road
Rolla, MO 65401
FTS: 277-0851
Comm: 314/341-0851

Rocky Mountain Mapping Center
Stop 504, Denver Federal Center
Denver, CO 80225
FTS: 234-2326
Comm: 303/234-2326

Western Mapping Center
345 Middlefield Road
Menlo Park, CA 94025
FTS: 467-2426
Comm: 415/323-8111

National Space Technology Laboratories
NSTL Station, MS 39529
FTS: 494-3541
Comm: 601/688-3544

Figure E-5 (cont)

TABLE E-2

# NOAA PRICES FOR LANDSAT PRODUCTS AND SERVICES
## NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
## WASHINGTON, D.C. 20233
## April 1, 1983

| TYPE OF PRODUCT/SERVICE | RETURN BEAM VIDICON & MULTI-SPECTRAL SCANNER | | THEMATIC MAPPER | | |
|---|---|---|---|---|---|
| | Present | Effective February 1, 1985 | Present | Effective October 1, 1983 | Effective February 1, 1985 |
| **Image Products** | | | | | |
| 70 mm film Pos (B&W) | $26 | $30 | — — — NOT OFFERED — — — — | | |
| 70 mm film Neg (B&W) | 32 | 35 | — — — NOT OFFERED — — — — | | |
| 10 in film (B&W; Pos) | 30 | 35 | $38 | $50 | $75 |
| 10 in film (B&W; Neg) | 35 | 40 | 42 | 60 | 80 |
| 10 in paper (B&W) | 30 | 35 | 33 | 50 | 75 |
| 20 in paper (B&W) | 58 | 65 | 70 | 95 | 140 |
| 40 in paper (B&W) | 95 | 105 | 115 | 150 | 200 |
| 10 in film (color; Pos) | 74 | 80 | 105 | 140 | 190 |
| 10 in paper (color) | 45 | 50 | 75 | 115 | 170 |
| 20 in paper (color) | 90 | 110 | 135 | 200 | 235 |
| 40 in paper (color) | 175 | 195 | 235 | 275 | 290 |
| **Digital Products** | | | | | |
| MSS Computer Compatible Tape (CCT), (full scene, 9 track, 1600 or 6250 BPI, 1 tape) | 650 | 730 | | | |
| RBV CCT single subscene (9 track, 1600 or 6250 BPI, 1 tape) | 650 | 730 | | | |
| RBV CCT full scene (9 track, 1600 or 6250 BPI, 4 tapes) | 1300 | 1460 | | | |
| TM CCT full scene (9 track, 6250 BPI, 4 tapes [A,B]) | | | 2800[C] | 3400 | 4400 |
| TM CCT, quarter-scene (9 track, 6250 BPI, 1 tape [A]) | | | 750[B] | 925[B] | 1350 |
| **Services** | | | | | |
| Color composite generation | 195 | 220 | 290 | 305 | 325 |
| Retrospective Orders to GSFC Archive | | | | D | D |
| **Special Acquisition** | | | | | |
| • Delivery of MSS HDT via Communications Satellite - per scene | 790 | 885 | | | |
| • Delivery of Standard MSS Imagery (not color composite) - per scene | 880 | 985 | | | |
| • Delivery of MSS CCT or HDT - per scene | 1000 | 1120 | | | |
| • Acquisition of customer specified TM scene | | | | 1200[E] | 1600[E] |
| • Surcharge for color composite generation for customer ordering acquisition -per scene | 150 | 170 | 250 | 250[E] | 275[E] |
| • Surcharge for specified minimum cloud cover -per scene | 250 | 275 | | 250[E] | 275[E] |

NOTES:

A 1600 BPI tapes will be available; number of tapes to be determined.
B Expected to be available in mid- or late - 1983.
C TM SCROUNGE data is available on 9 track, 6250 BPI, 3 tapes or 1600 BPI, 7 tapes.
D To be provided later.
E TM Special Acquisitions may be implemented earlier than February 1985.

☆ U.S. Government Printing Office 1984 - 680-241/381 Reg. 8

# ADDENDEM TO TECHNICAL NOTE 361

| | |
|---|---|
| Page 12 | "infared" at the top of the graph should read "infrared" |
| Page 21 | In Table 1, under Landforms and Topography, Type and Age: "Branches" should be "Benches" |
| Page 31 | Under ANALYSIS COSTS AND SAVINGS, Costs: "2 cents per acre" should be "5 cents per acre" |