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# ANNUAL PROGRESS REPORT

JULY 1973-JUNE 1974

# USE OF REMOTE SENSING TECHNIQUES FOR INVENTORYING AND PLANNING UTILIZATION OF LAND RESOURCES IN SOUTH DAKOTA

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Remote Sensing Institute
South Dakota State University
Brookings, South Dakota 57006

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# Use of Remote Sensing Techniques for Inventorying and Planning Utilization of Land Resources in South Dakota

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## ABSTRACT

General land use and soils data collected by remote sensing techniques are being used in South Dakota for land use planning and land evaluation. The basic procedures for interpreting remote sensing imagery to rapidly develop general soils and land use inventories were developed and utilized in Pennington County, South Dakota. These procedures and remote sensing data products have been illustrated and explained to many user groups, some of whom are interested in obtaining similar data.

The general soils data were integrated with land soils data supplied by the county director of equalization to prepare a land value map. A computer print-out of this map indicating a land value for each quarter section is being used in the tax reappraisal of Pennington County. The land use data have provided the land use planners with the present use of land in Pennington County.

Additional uses of remote sensing applications are also discussed including tornado damage assessment, hail damage evaluation, and presentation of soil and land value information on base maps assembled from ERTS-1 imagery.

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## ACKNOWLEDGEMENTS

1. The NASA technical Officer for this grant is J.A. Vitale, NASA Headquarters, Office of University Affairs, Room 6125, 400 Maryland Avenue, S.W. Washington, D.C. 20546.

2. The photographic work was processed by Jack Smith, Head-Photo Lab, Remote Sensing Institute, South Dakota State University, Brookings, South Dakota.

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INTRODUCTION

Efficient management of the earth's resources is of paramount importance. The application of remote sensing techniques to many phases of natural resource management has been proven but the use of these data by action agencies is presently very limited. Therefore, the present activities of the Remote Sensing Institute NASA University Affairs Grant have been directed toward the utilization of remote sensing techniques by action groups.

The area selected for application of remote sensing techniques was Pennington County, South Dakota. This county was selected as the study area because the variety of soils and land uses are representative of Western South Dakota. The land area of the county is 711,500 hectares (1,778,700 acres) of which the Black Hills National Forest, Buffalo Gap National Grassland, and Badlands National Monument comprise most of the 280,100 hectares (700,300 acres) of public land. In addition, the second largest city in South Dakota, Rapid City (population 55,000), is located in the county.

Once the study area was selected, a meeting with the county resource planners and managers was held to accomplish the following objectives:

1. Explain remote sensing technology
2. Describe proposed remote sensing activities in Pennington County
3. Obtain a response from meeting participants as to the desirability of conducting the study in Pennington County
4. Determine specific action agencies that could use remote sensing data for their decision making processes.

As a result of this meeting the following agencies were deemed most likely to provide input and to use the output of the remote sensing applications:

1. South Dakota Sixth Model Rural Development and Planning District (Sixth District Council of Goverment)
2. Black Hills Conservancy Sub-District
3. Pennington County Planning and Zoning Commission
4. USDA Soil Conservation Service
5. Pennington County Director of Equalization
6. USDA Forest Service
7. USDA Agricultural Stabilization and Conservation Service

These agencies were contacted individually and possible applications of remote sensing technology to their problems were discussed in detail.

This report contains the progress to date in the various application areas which are being pursued. The major effort in Pennington County, South Dakota, involving soils inventory and land evaluation will be discussed first. Then, additional studies of remote sensing applications will be discussed. These efforts are being funded in part by the State of South Dakota, the specific action agency, and the NASA University Affairs Grant. It is estimated that a minimum of 40 percent of the total support required for the efforts described herein are coming from the involved action agencies.

## General Soils Inventory

The 1970 South Dakota legislature enacted a law which required that agricultural land be assessed for taxation purposes according to the potential of the land to produce agricultural crops or native grasses. Subsequent to the 1970 legislative directive, guides for land evaluation were developed for each county in South Dakota (Westin et al., 1974). These guides utilize yield estimates, soil inventory information, and sales data to develop a dollar value for each kind of soil limitation for the county directors of equalization.

Adequate soil surveys necessary to use the county land evaluation guides are not available for 41 of the 67 counties in South Dakota. Pennington County is one of the counties which does not have adequate soils information to comply with the directives of the 1970 legislature.

The present methods of surveying soils are too time consuming and expensive to fulfill the need in the required time period. The time required to collect soils data by remote sensing techniques becomes greater as the soils information becomes more detailed. For general soils data, ERTS-1 imagery was interpreted since it was available and could be provided quickly for almost immediate use.

## Procedures

The ERTS-1 imagery available for Pennington County was evaluated and transparencies from three dates were selected for further analysis (Table 1). Color transparency composites at 1:1,000,000 scale were made from bands 4, 5, and 7, and enlargement negative prints at scales of 1:500,000 and 1:250,000 were made from bands 5 and 7 from the September 6 and October 12 imagery. A band-7 transparency for December 5, 1973, was enlarged to 1:250,000. The area was snow covered at this time.

Table 1. ERTS-1 imagery of Pennington County, South Dakota used for interpretation of soils.

| Date | Frame Identification | Color Composite | Positive Transparencies, Bands 4,5,6 & 7 | Enlargement Prints of Bands 5 & 7 | |
|---|---|---|---|---|---|
| | | | | 1/500,000 | 1/250,000 |
| September 6, 1972 | 1045-17063 | X | X | X | X |
| October 12, 1972 | 1081-17064 | X | X | X | X |
| December 5, 1972 | 1135-17078 | | X | | X |
| December 5, 1972 | 1135-17074 | | X | | X |

The ERTS-1 imagery was interpreted using a light table and a three power magnifying glass. Areas with similar image characteristics were delineated on mylar on imagery from September 6, 1972. This overlay was then placed over the other color composite and positive black and white transparencies for additional interpretation using the data from the other dates.

For field checking, the ERTS-1 interpretation was transferred to a 1:250,000 USGS topographic map and a 1:60,000 ASCS photo index map of

Pennington County. The field checking consisted of a reconnaissance survey by a resource team consisting of a geologist, range scientist, and soil scientist, which described th. soils, vegetation, and geology for each mapping unit. The general soils map interpreted from ERTS-1 imagery is shown in Figure 1. Table 2 provides the map legend which includes a description of soils, geology, and lan. use along with suitability ratings for rangeland, cropland, and groundwater development.

## Usefulness of ERTS-1 Imagery

The color composite transparencies of the ERTS-1 imagery were most useful for interpretation of boundaries among the soilscape areas. The interactions among the individual bands provided an additional characteristic for interpretation (Figure 1). Most of the boundaries of the soilscape areas were delineated very well on the ERTS-1 imagery (Figure 2). The thick lines in Figure 2 mark those boundaries located on ' ground which were not detected from the ERTS-1 imagery. The de' ons were either too small or too similar to adjoining areas. The ...aries between the soilscape areas were as easily interpreted from transparencies at a scale of 1:1,000,000 as from enlargement prints at a scale of 1:250,000. Areas such as flood plains however, which were too small to delineate using the color composite transparency at a scale of 1:1,000,000, could be mapped using the 1:250,000 enlargement prints.

The image features or characteristics of the E..TS-1 color composite transparency used for interpreting the soilscape boundaries were tone, color, land use patterns, and drainage patterns. Figure 3 provides an illustration of the use of drainage pattern, color, and land use patterns to delineate soilscapes in northern Pennington County. Drainage pattern was used in conjunction with color patterns to interpret the boundary between the steep shale breaks (B1) and hilly to steep sandstone breaks (C1). The steep shale breaks have yellowish-red hues and a dendritic drainage pattern (Figure 3). Difference. in color were utilized to draw the boundary between the undulating shale plains (B4) and the undulating to gently rolling sandstone uplands (C3).


Figure 1. Soilscapes of eastern Pennington County. Scale = 1:1,000,000

Table 2. Soilscapes of Eastern Pennington County

| Unit | Land Form | Geologic Material | Soil | Range Site | Land Use | LCS* | Ground Water** |
|---|---|---|---|---|---|---|---|
| A | Soilscapes from White River Sediments | | | | | | |
| A1 | Hilly to very steep barren badlands | Siltstone and shale | None | None | Non-Agricultural | 8s | None to Poor |
| A2 | Undulating to gently rolling uplands | 0-5' of terrace alluvium over White River Sediments | Shallow to Moderately Deep Clayey Soils | Clayey-Shallow | Rangeland | 4e-6s | Poor |
| A3 | Nearly level to undulating badland basins | Clayey alluvial sediments | Shallow to Moderately Deep Clayey Soils | Clayey-Shallow | Rangeland | 4e-6s | Poor |
| A4 | Nearly level to undulating | 5-20' of terrace alluvium and aeolian deposits over White River Sediments | Deep Silty and Loamy | Silty-Sandy | Cropland-Rangeland | 3c-3e-4e | Fair |
| B | Soilscapes from Pierre Shale | | | | | | |
| B1 | Steep shale breaks | Pierre Shale | Shallow to Moderately Deep Clayey Soils and Shaleland | Shallow | Rangeland | 7s-7e-8s | None to Poor |
| B2 | Undulating to rolling sideslopes | Colluvium from Pierre Shale | Shallow, Moderately Deep to Deep Clayey Soils | Clayey | Rangeland | 6e-4e-6s | Poor |
| B3 | Undulating to gently rolling plains | Colluvium from Fox Hills Sandstone and Pierre Shale | Deep Clayey and Thin Claypan Soils | Clayey-Claypan | Rangeland | 4e-6s | Fair to Good |

Table 2. Continued

| Unit | Land Form | Geologic Material | Soil | Range Site | Land Use | LCS* | Ground Water** |
|---|---|---|---|---|---|---|---|
| B4 | Undulating plains | Thick colluvium from Pierre Shale | Moderately Deep to Deep Clayey Soils | Clayey | Cropland | 4e | Fair |
| B5 | Undulating to rolling dissected terraces | 5-10' of terrace alluvium over Pierre Shale | Moderately Deep to Deep Loamy Soils | Clayey-Thin Upland | Rangeland | 4e-6e | Fair |
| B6 | Undulating to gently rolling terrace remnants | 5-10' of terrace alluvium over Pierre Shale or White River Sediments | Deep Loamy Soils | Clayey | Rangeland-Cropland | 3e-4e | Fair |
| B7 | Nearly level to undulating terrace remnants | 5-50' of terrace alluvium over Pierre Shale | Deep Loamy Soils | Clayey | Cropland | 3c-3e | Fair |
| B8 | Nearly level terraces | 5-20' of terrace alluvium over Pierre Shale | Deep Silty and Loamy Soils | Silty-Clayey | Cropland | 3c | Fair to Good |
| B9 | Nearly level terraces | 0-5' of terrace alluvium over Pierre Shale | Moderately Deep Loamy Soils | Silty | Rangeland | 4s | Fair to Good |
| C | Soilscapes from Fox Hills Formation | | | | | | |
| C1 | Hilly to steep breaks | Fox Hills Sandstone and Shale | Shallow to Moderately Deep Loamy Soils | Shallow | Rangeland | 7s | Fair |
| C2 | Rolling uplands | Colluvium from Fox Hills Sandstone and Shale | Shallow, Moderately Deep to Deep Silty Soils | Silty-Shallow | Rangeland | 6e-6s | Fair to Good |

Table 2. Continued

| Unit | Land Form | Geologic Material | Soil | Range Site | Land Use | LCS* | Ground Water** |
|---|---|---|---|---|---|---|---|
| C3 | Undulating to gently rolling uplands | Colluvium from Fox Hills Sandstone and Shale | Deep Silty Soils | Silty | Cropland | 3e-4e | Fair to Good |
| C4 | Nearly level to undulating uplands | Colluvium from Fox Hills Sandstone and Shale | Deep Silty Soils | Silty | Cropland | 3e-3c | Fair to Good |
| D | Flood Plains | | | | | | |
| D1 | Flood plains of Cheyenne and White Rivers | Sands and fine textured alluvium | Deep Clayey and Thin Sandy Soils | Clayey Overflow | Rangeland Hayland | 4s-4e 6w | Excellent |
| D2 | Flood plains of Rapid, Box Elder, and Spring Creeks | Medium textured alluvium | Deep Silty Clay Loam Soils | Overflow | Hayland | 3c-6w | Excellent |
| E | Soilscapes from Black Hills Footslopes | | | | | | |
| E1 | Rolling uplands | Colluvium from Carlisle, Greenhorn and Niobrara Formations | Moderately Deep Clayey and Loamy Soils | Thin Upland-Clayey | Rangeland | 6e-4e | Fair to Poor |
| E2 | Rolling uplands | Clayey colluvium and bedrock from Graneros Group | Shallow to Moderately Deep Clayey Soils | Shallow-Clayey | Rangeland | 6s-6e | Fair to Poor |

* LCS Land Capability Subclass
** Potential for development of household wells

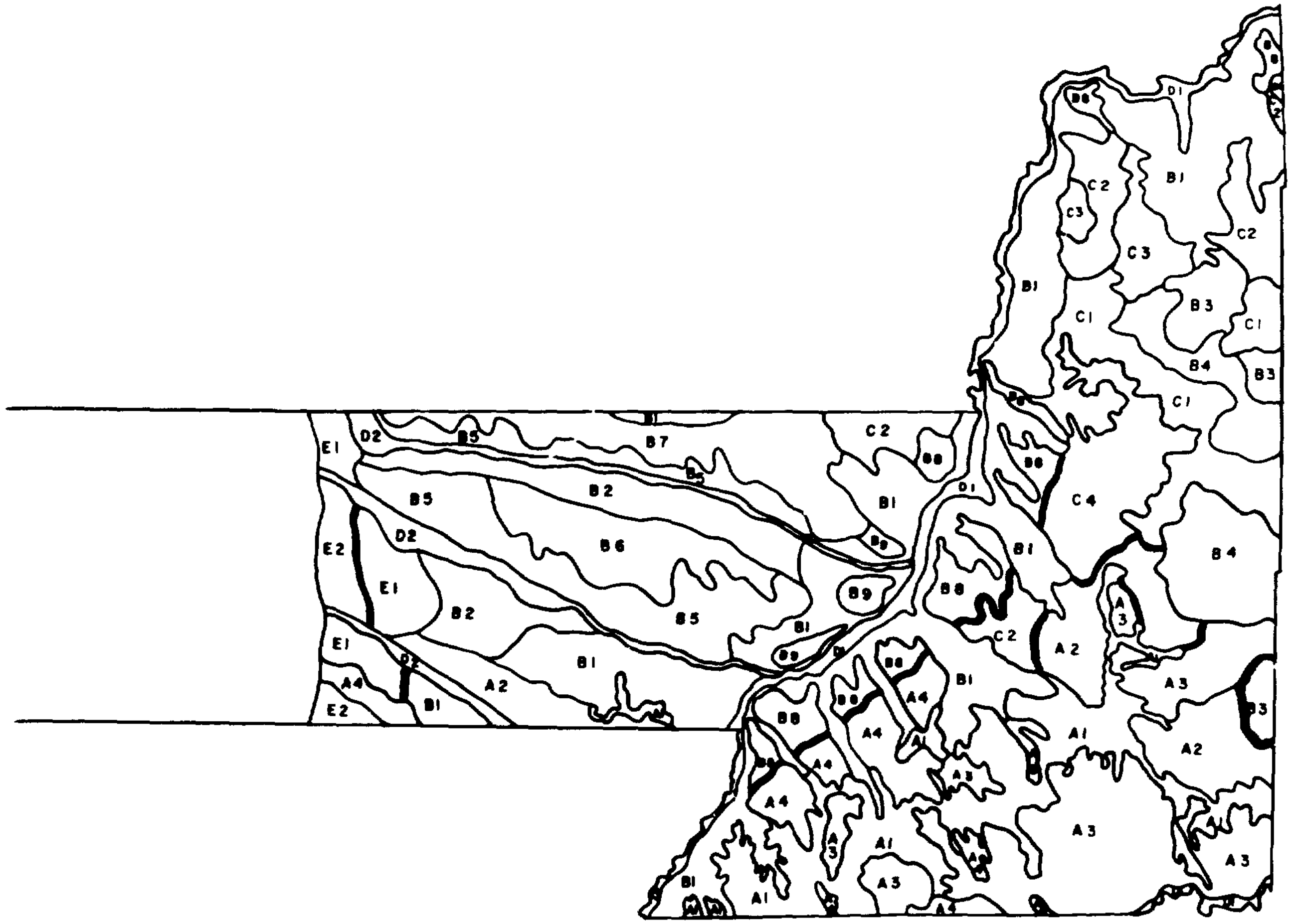


Figure 2. Usefulness of ERTS-1 imagery to delineate soilscape boundaries. Thick lines indicate boundaries not detected on ERTS-1 imagery. See Table 2 for legend.


Drainage Pattern--C1 was separated from B1 by change in drainage pattern and color. C1 has reddish colors and a dendritic drainage pattern. B1 has yellowish-green colors and a pinnate drainage pattern.

Color--The boundary between B4 and C3 was delineated by a color change. The fields in the B4 have lower reflectance.

Land Use--The B3 areas have a rangeland land use pattern. The B4 areas have a cropland pattern.

Figure 3. Use of drainage pattern, color and land use pattern features of ERTS-1 imagery to delineate soilscapes of northern Pennington County. Enlargement print of color composite. July 9, 1973. 1351-17064. Scale = 1:250,000.

These two areas have similar land use patterns, but the reflectance from the soils developed from the olive-gray Pierre Shale is less than that from the soils developed from the grayish-brown Fox Hills Formation (Figure 3).

In summary, the advantages of ERTS-1 imagery most useful to this study were the synoptic view and multispectral imagery. The synoptic view provided by ERTS-1 imagery allowed large areas to be viewed and studied from the same perspective. Therefore, differences in reflectance patterns of noncontiguous areas are meaningful and can be used to delineate general soil areas (soilscapes). The multispectral feature of ERTS-1 imagery provides a new tool for studying soil differences.

## Comparison With Existing Soil Association Map

More areas were delineated on the soilscape map using ERTS-1 imagery as described above than on the existing soil association map (Figures 1 and 4). Three reasons may be cited to explain this. The soilscape map is at a scale of 1:250,000 whereas the existing soil association map is at a scale of 1:500,000. More and smaller areas may be delineated on the larger scale map. Secondly, the field work provided additional information which was used to distinguish more areas. The existing soil association map was based upon previous field information, and no field checking was performed in its preparation. Thirdly, the use of the ERTS-1 imagery allows further delineations within some of the large soil associations on the existing map. These separations are obvious when the existing map is plotted on the photographic-like background of the ERTS-1 imagery rather than a line map.

The major differences between the two maps are in the areas with soils formed on the Fox Hills Formation, White River Sediments, and terraces overlying the Pierre Shale. The Badlands association (69) of the ex sting map was split into two soilscapes (A1, barren badlands and A3, badland basins). This separation was made possible by the use of a photographic image background. The barren badlands have a very high reflectance (light

5 Nevee-Spearfish
6 Spearfish-Nevee
7 Butche-Canyon
8 Canyon-Butche
32 Ralph-Cabbart-Regent
36 Caputa-Satanta
37 Ree
39 Satanta
43 Penrose-Minnequa
44 Pierre-Kyle
47 Pierre-Samsil
48 Grummit
50 Samsil-Lismas-Pierre
57 Valentine-Anselmo
60 Wanblee
62 Glenburg-Haverson
63 Haverson
64 Loamy alluvial land
65 Bankard-Kyle
69 Badlands

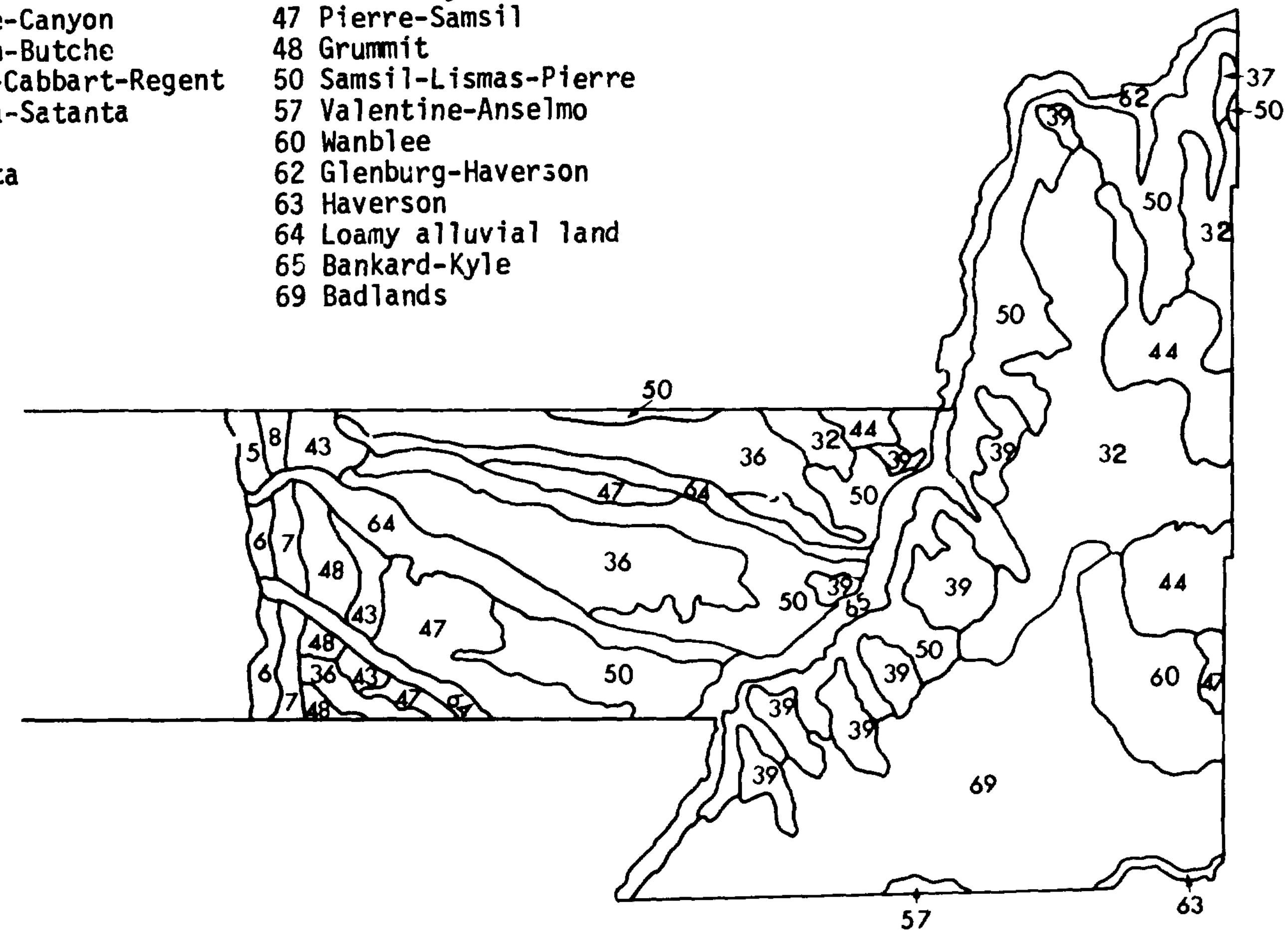



Figure 4. Current soil association map of eastern Pennington County (Westin and Bannister, 1971). Original scale = 1:500,000.

photographic tone) which can be used to distinguish the areas from other soilscapes (Figures 1 and 4). The Ralph-Cabbart-Regent area (32) on the existing map was divided into four parts using color and color pattern interpretations (Figures 1, 3, and 4). The rangeland soilscapes C1 and C2 were separated from the cropland soilscapes C3 and C4 by the difference in the color pattern of the ERTS-1 image which is due to the difference in land use (Figure 1 and Table 2). The area denoted by C1 is distinguished from C2 by a more distinct drainage pattern (Figure 1). C3 is located physically separate from C4. The Caputa soil association (36) was separated into three parts utilizing differences in color patterns related to land use (Figure 1). The B5 soilscape is dominantly rangeland; whereas, the B7 soilscape is mostly cropland.

Recommendations for Use of ERTS-1 Imagery to Interpret General Soil Maps

The ERTS-1 imagery gives soil scientists a new tool for interpreting general soil areas. The use of ERTS-1 imagery for preparing a general soils map has been discussed in this paper. Based upon this work, the following recommendations are intended to provide guidelines for use of ERTS-1 imagery to obtain soil information for areas where soils data are lacking.

The following materials are needed:

1. ERTS-1 imagery -- single band transparencies, color composite transparencies, preferably for more than one season
2. Enlargement prints of ERTS-1 imagery -- scale to base maps, the 1:250,000 USGS topographic map series covers the entire U.S.
3. Existing soil and geologic information
4. Topographic or other existing base maps
5. Photo index maps for existing aircraft coverage -- useful for plotting boundaries interpreted on ERTS-1 imagery.

ERTS-1 imagery can be enlarged to 1:125,000 without a serious loss of detail.

The production of a general soils map using ERTS-1 imagery can be separated into three major parts. The first part involves the following items:

1. Locating and evaluating existing ERTS-1 imagery
2. Summarizing existing soils information
3. Interpreting ERTS-1 imagery
4. Drafting initial legend and map
5. Transferring map to 1:250,000 topographic map for field checking.

This part involves from 1 to 1½ weeks time.

The second part is the field checking of the interpreted map. Boundaries interpreted in the office are verified. The soils, geologic material, and vegetation are described for each mapping unit. The time needed to complete this part is dependent upon the size of the area. For an area similar in size to eastern Pennington County (400,000 hectares or 1,000,000 acres) which had some soils information available, 2 to 3 weeks time was necessary for the field work.

The final part includes drafting the final map and legend and writing the report. One to two weeks are required for this work.

## Land Evaluation

The soilscape map was used along with dollar values from land sales supplied by the director of equalization to prepare a land value map (Figure 5). This map has been provided to the Pennington County Director of Equalization for evaluation and use.

The general soils data are being used by the Director of Equalization in comparing the average value of general soil areas in the county for equalization among areas.

I. This map was prepared by:

1. Calculating a productivity index for each soilscape area. The yields for both agricultural crops and native grass were used. The yields are summarized by land capability subclass and range site (Westin et al., 1974).

2. Relating the land sales in the county to the soil areas. A value is determined for each kind of soil in the county based upon the productivity index.

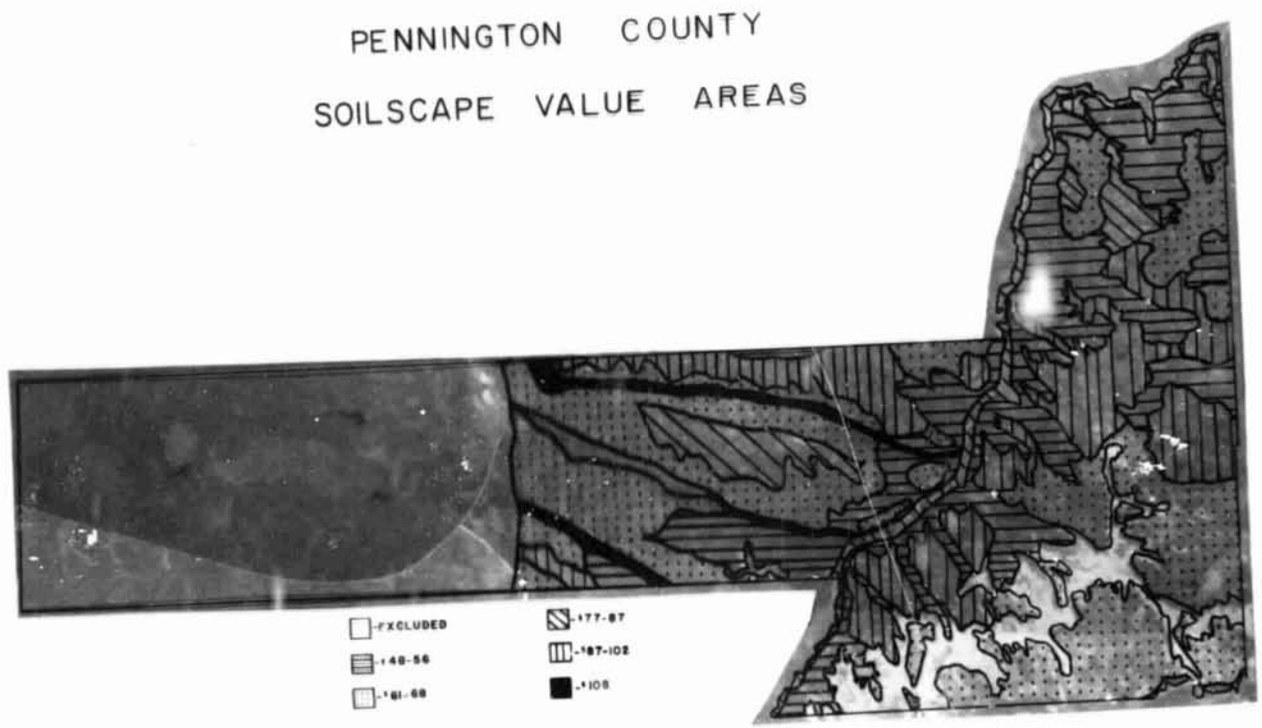



Figure 5. Land value map of eastern Pennington County.

3. Utilizing this relationship along with the soil data, the land value for each soilscape area is computed.

After several meetings with the State Department of Revenue, it was decided that a computer print out indicating a land value for each quarter section (160 acres) would be useful for appraising land value for taxation. The general soils map of Pennington County, was coded into the computer on a quarter section basis. A computer program was written to relate the procedures for determining land value to the soils data. The resulting computer print-out is shown in Figure 6. This information is being used by the appraisers of the consulting firm which is reappraising Pennington County. If this approach proves useful, the other counties in western South Dakota which need soils data for land evaluation will be interested in securing similar data. It should be noted that this level of information is not suitable for evaluating individual parcels of land but it can be used as an equalization guide among various soil units.

This work was reported at the Ninth International Symposium on Remote Sensing of the Environment held April 15-19, 1974, at Ann Arbor, Michigan (Frazee et al., 1974). In addition, a newspaper release on the work has been sent to the major newspapers in South Dakota and a half-hour television program on the South Dakota Educational Network was presented.

This work has been reviewed by the Bureau of Indian Affairs for use in providing soils data for water rights determination on the Rosebud Reservation. Based upon this review, they have funded a contract to provide general soils data for the Rosebud Reservation and surrounding areas utilizing the remote sensing methods and techniques developed in the Pennington County study. The soils data will provide basic information for a reservation-wide hydrologic study. The area being studied under this contract is over 5,000,000 acres (2,000,000 hectares).

The soil map and land evaluation map of Pennington County have generated considerable interest in other counties. To date, cost estimates for three other counties have been prepared and sent to the local county directors of equalization (see Appendix A). Other agencies which have been contacted and which have shown interest are the U.S. Forest Service, Planning Bureau, and the United Sioux Tribes.

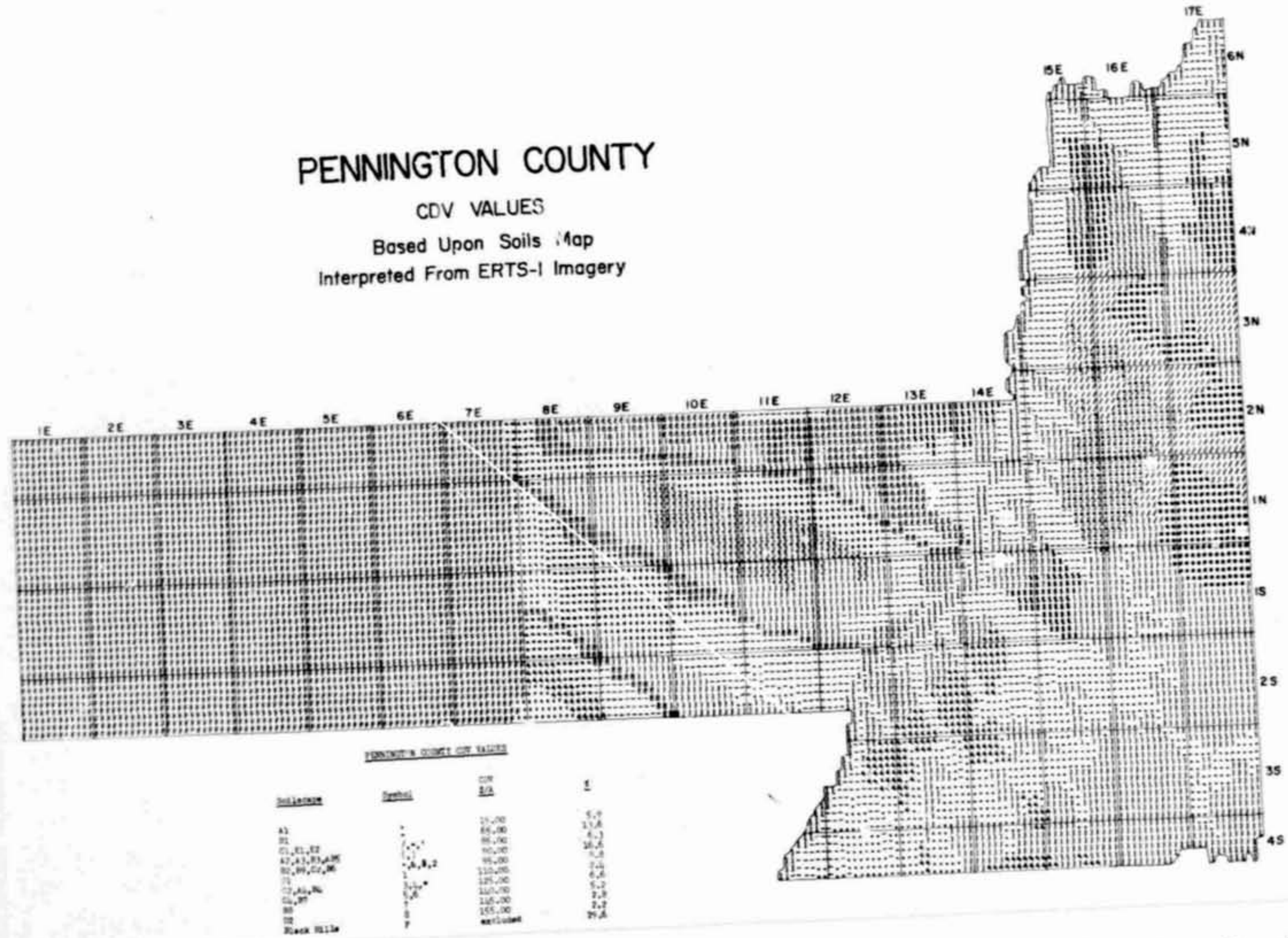



Figure 6. Computer print-out illustrating land value for each quarter section of eastern Pennington County.

## Detailed Soils Inventory

Aircraft imagery is being used to extract detailed soils information. Because of the time required, interpretation is being limited to a seven township area using the aircraft data. Black and white Agricultural Stabilization and Conservation Service (ASCS) photographs of the area have been procured at a scale of 1:20,000. High-altitude NASA RB-57 imagery at a scale of 1:125,000 is also available for interpretation. Preliminary interpretation of the area is almost complete. Field checking and evaluation in cooperation with the USDA Soil Conservation Service will be scheduled.

The detailed soils data will be used by the County Director of Equalization in the following manner:

1. For each tract of agricultural land, the acres of each soil mapping unit are measured

2. The value of each land tract is determined by the dollar value for each soil type multiplied by the acreage of that soil

3. The summation of the values of each soil area within the parcel is the total value of bare agricultural land.

The USDA Soil Conservation Service (SCS) will assist in the evaluation of the detailed soils data obtained by utilizing remote sensing methods and in the determination of whether or not present methods of surveying soils can be improved with remote sensing data. Once the detailed soil survey has been evaluated and studied for usefulness, the county commissioners will be asked to provide money support for surveying the soils of the remainder of Pennington County.

## USDA-SCS COOPERATION

### Soil Mapping Unit Composition

A soil survey report includes the description of soil composition (kind and amount of each soil) for each soil mapping unit (area). The development of this information requires an experienced soil surveyor and is very time consuming. Previous work has suggested that density slicing techniques may be useful to the soil surveyor for determining the composition of soil mapping units (Frazee, Myers, and Westin, 1972). This study consisted of comparing a remote sensing technique (density slicing) with the standard methods of determining soil composition (transect method) using a detailed map for control. This work is being accomplished cooperatively with the soil surveyors[1] who are in the process of preparing a detailed soil survey for Beadle County, South Dakota.

Four different areas of the same soil mapping unit in Beadle County were selected for study. These fields were selected randomly from the Agricultural Stabilization and Conservation Service (ASCS) photographs which were used in the mapping of Beadle County. These black and white ASCS field sheets (photographs) were used due to their availability and scale (1:15,840). They were taken in July 1957. The contrast on the photographs was poor in comparison to more recent remote sensing images.

The density slicing was accomplished by placing the black and white photographs over the light source on the density slicing device. The tone density was divided into eight levels. The eight density levels were interpreted by the soil surveyors as to the soils they represented. Three major categories of soils were assumed: Hand soil, Bonilla soils, and other soils. The percent composition of these categories was determined using the automatic planimeter associated with the densing slicing machine.

Line transects were conducted in all four fields by transecting the field twice diagonally. The line transect method is routinely used by soil surveyors and assumes the soil mapper can recognize the soil without boring.

[1] (D. Heil, USDA-SCS, Beadle County Survey Party Chief and D. Bannister, USDA-SCS, State Soil Scientist.

The pacer recorded the number of paces between soil breaks while the other two members of the party observed the soil. The paces for each soil series were subsequently summed for the whole field and converted to percentages. Percent composition was determined for three groupings of the soils: Hand, Bonilla, and Others (included soils).

The detailed mapping was considered the control and was conducted after the transects were completed. Individual phases of soil series large enough to delineate at the scale of the field sheet (1:15,840) were separated. The fields were broken down into the same soil categories as the transect data: Hand, Bonilla, and Others. Overlays were constructed for each soil category and measured with the automatic planimeter of the density slicing machine to determine the percent of each. The percent of each category was determined, and the display was photographed for comparison with the density sliced output. Figure 7 illustrates the comparison of the results for each method.

Upon comparison with the detailed map, the light tones or lighter colors frequently corresponded to Ethan, Davison, Tetonka, and Dudley soils (Others). The dark tones or darker colors generally corresponded to the Bonilla soils and the medium tones to the Hand soils (Figure 7). However, composition was difficult to determine as the same tones did not always correspond to any one soil. For example, some Hand soils occurred within both the encoded dark tones and also within the encoded light tones. When the percentages of the encoded composites from the density slicing analysis were averaged, the average composition of the four fields was 39% Hand, 44% Bonilla, and 17% other soils (Table 3).

The line transect method required approximately 1.5 hours for an (80 acre) field whereas the density slicing method required 30 to 40 minutes. An average composition of 42.5% Hand, 37% Bonilla, and 20.5% other soils was determined for the four fields by the line transect method (Table 3).

The detailed mapping of the four fields provided a check and was used as a basis for comparing the results of the transect method and the density slicing. Average composition of the four fields was 36.5% Hand, 35% Bonilla, and 28.5% other soils (Table 3).

a b c

Figure 7. Illustration showing (a) sample area with (b) density slicing compared with (c) detailed soil map.

Table 3. Percent composition of the Hand-Bonilla soil mapping unit obtained with the density slicing lines transect, and detailed survey methods.

| Field No. | Density slicing | | | Line transect | | | Detailed survey | | |
|---|---|---|---|---|---|---|---|---|---|
| | Hand | Bonilla | Others | Hand | Bonilla | Others | Hand | Bonilla | Others |
| 1 | 48 | 23 | 29 | 37 | 38 | 25 | 48 | 28 | 24 |
| 2 | 36 | 46 | 18 | 52 | 36 | 12 | 39 | 30 | 31 |
| 3 | 39 | 50 | 11 | 36 | 41 | 23 | 35 | 42 | 23 |
| 4 | 33 | 57 | 10 | 45 | 34 | 21 | 24 | 48 | 18 |
| Ave. | 39 | 44 | 17 | 42.5 | 37 | 20.5 | 36.5 | 35 | 28.5 |

The soils composition of the soil mapping unit as estimated by both the density slicing analyses and transect methods was similar (Table 3). The density slicing method was not successful in mapping the individual soils which comprise the mapping unit because the density contrasts, timing, and film-filter combinations of the photography were far from ideal. If more contrasting photography had been available, better results may have been achieved. A report entitled "Density Slicing for Determining the Composition of a Soil Mapping Unit" has been written and is in the final stages of review.

The density slicing techniques employed in this work will be evaluated in other situations. A proposal entitled "Use of Remote Sensing Data to Delineate Claypan Soils Requiring Deep Plowing in the Oahe Project" has been submitted to the U.S. Bureau of Reclamation. This proposal suggests studying density slicing analyses as a tool for better delineation or mapping of claypan soils requiring deep plowing for reclamation before irrigation in the Oahe project area.

## Evaluation of ERTS-1 Imagery for Soil Survey

ERTS-1 interpretation techniques to permit delineation of general soil areas is a fairly recent development. Most soil scientists have not even seen ERTS-1 imagery and consequently are not familiar with its capabilities or the required interpretation.

Ten South Dakota USDA-SCS soil scientists who are soil survey party chiefs have been provided with ERTS-1 contact prints and prints at a scale of 1:250,000 from 2 seasons of the year. In addition, color composite transparencies were sent to three county soil surveyors. Remote Sensing Institute soil scientists are working with the agency personnel providing training and assistance in interpreting the imagery. Additional ERTS-1 imagery will be provided to the soil scientists as it becomes available. The soil scientists comments evaluating the ERTS-1 imagery for their use are included in Appendix B.

This effort is providing the opportunity for soil scientists to become knowledgeable about ERTS-1 imagery and to actually evaluate how useful the imagery is for purposes of soil surveying. It is hoped that the use of imagery in the soil survey program will be established through this program. The USDA-SCS is providing all the support for the USDA-SCS soil scientists cooperating on this effort.

## LAND USE

Current land use information is practically non-existent in South Dakota. The data that are available are commonly in tabular form and not presented in a form suitable for evaluation in terms of geographic distribution. South Dakota is being encouraged, both by pressure within the state and by pending federal legislation, to develop land use plans at various levels. Although the utility of remote sensing techniques for certain aspects of land use planning has been established, its use by local, county, and state land use planning groups in South Dakota is very limited.

Pennington County, South Dakota, was selected as a test site to illustrate the use of ERTS-1 data for level I land use inventorying (Anderson et al., 1972) in Western South Dakota. The level I land use categories were interpreted from ERTS-1 color composite prints at a scale of 1:250,000. An overlay map showing the location and amount of each land use category of level I has been prepared (Figure 8). The inventory has been computer encoded using a 64 hectares (160 acre) cell size. The data may be either printed out or displayed on a color television monitor (Figure 9). A township boundary overlay has been prepared for use in locating the areas in the county. The South Dakota Sixth Model Rural Development and Planning District has the preliminary land use data and is utilizing it for their planning purposes. The primary use of the level I land use data is to establish current land use and to indicate areas needing more detailed data.

This land use inventory was reviewed by the Bureau of Indian Affairs soil and range scientists, and a subsequent contract was entered into to obtain similar level I land use data for the Rosebud Reservation and surrounding areas. This inventory, plus an inventory delineating irrigated land, was provided for an area of over 2,000,000 hectares (5-million acres) on May 15, 1974.

The level I land use data have been described and discussed with many agencies and groups in South Dakota. Cost estimates have been submitted to the State Planning Bureau of inventorying level I land use for the entire state of South Dakota plus computer encoding of the data. Other agencies which have shown considerable interest in obtaining land use data for selected

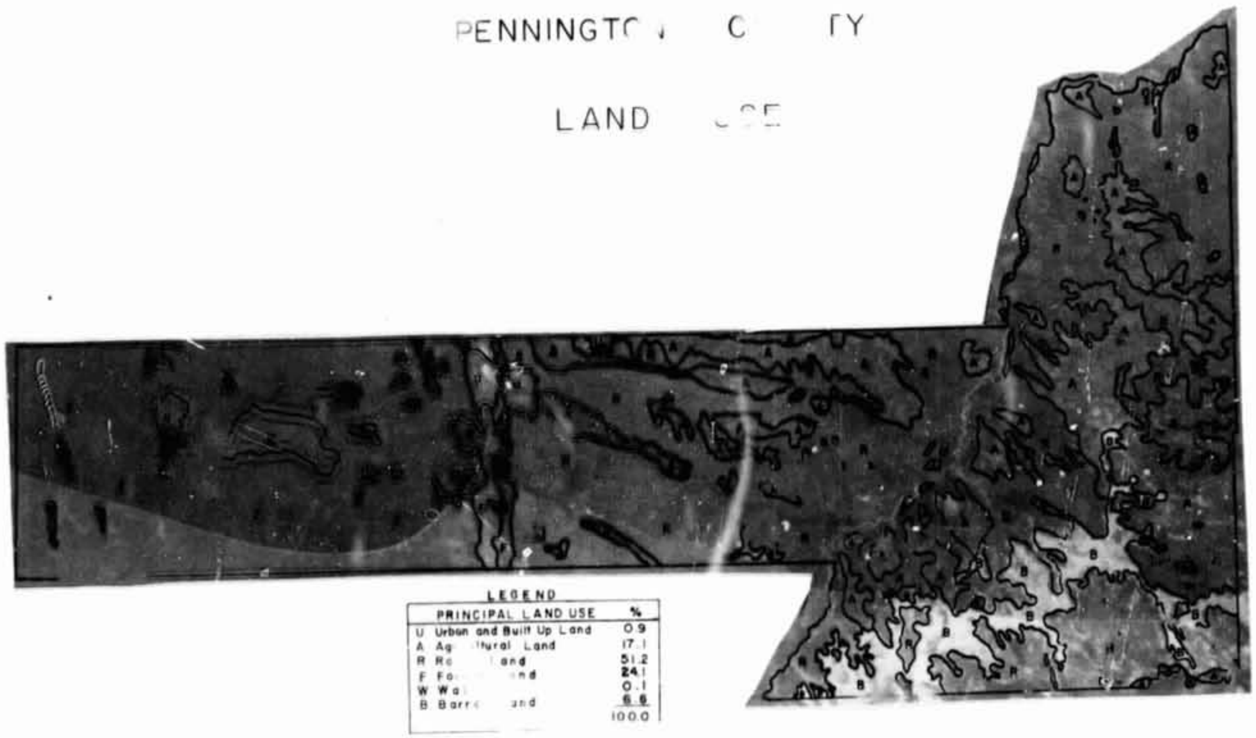
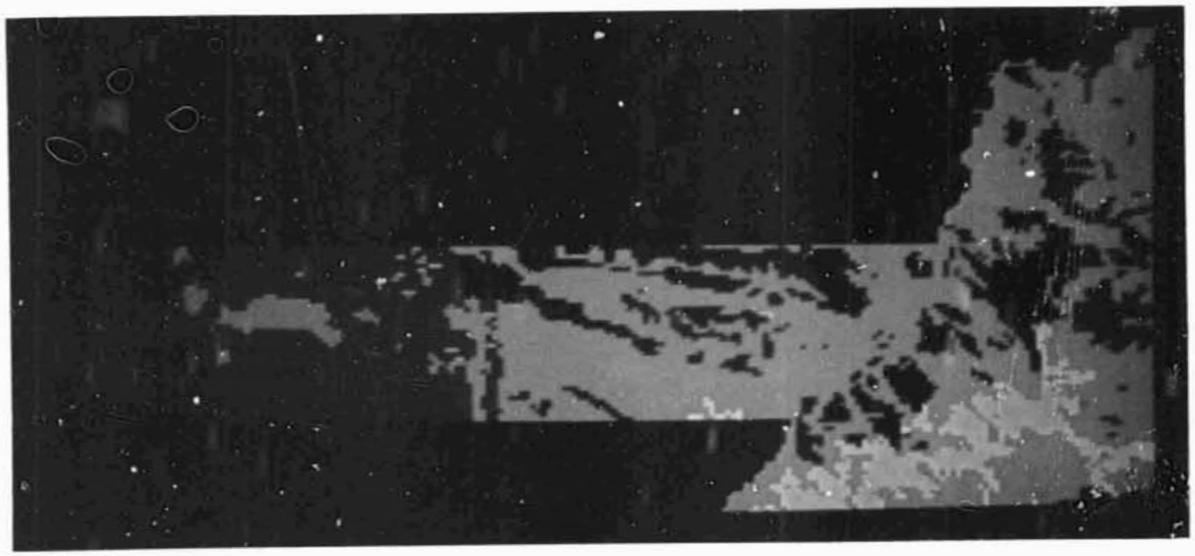



Figure 8. Land use map of Pennington County.



Black - Urban and Built Up Land
Dark Green - Agricultural Land
Tan - Range Land

Reddish Brown - Forest Land
Blue - Water
Light Grey - Barren Land

Figure 9. Color display of land use map of Pennington County.

portions of the state are the USDA Forest Service for the Black Hills, USDA Soil Conservation Service for western South Dakota, and United Sioux Tribes for the Lower Brule Reservation. A popular type publication, which will explain level I land use data and how to use these data, is in preparation.

## BIA COOPERATION

### Resource Inventories

The Bureau of Indian Affairs has the responsibility for the resource management of vast acreages. In South Dakota alone, Indian lands comprise approximately 2,000,000 hectares (5-million acres). Some reservations have detailed soil data while others have very limited soils information. In all cases, general resource maps required for broad reservation-based planning are not available. Interpreted ERTS-1 imagery can provide much of the broad based information required by BIA resource managers. This effort, funded primarily by BIA but utilizing NASA acquired imagery, was designed to illustrate the utility of ERTS-1 data for resource management of Indian lands in South Dakota.

A general soil map of Indian lands in Shannon County, South Dakota, has been prepared by interpretation of an ERTS-1 color transparency (Figure 10). This map was prepared in cooperation with BIA personnel[2]. The Pine Ridge Indian Reservation had completed a standard soil survey and this information is being used to evaluate the usefulness and accuracy of the ERTS-1 interpretation. The soil units mapped from the ERTS-1 image (Figure 10) were characterized according to land capability subclass and range site, using the standard soil survey maps published in the Soil Survey of Shannon County (Radeke, 1971). The photo map units interpreted from the ERTS-1 imagery had different compositions of range sites and soil capability classes and subclasses (Tables 4 and 5). The data contained in Tables 4 and 5 indicate that areas related to soils can be interpreted from ERTS-1 imagery. Each of the photo-mapped units interpreted from ERTS-1 imagery had an unique range site and land capability subclass composition. Therefore, the photo interpreted units were general soil resource areas. The preliminary indications are that the information provided by ERTS-1 interpretations are superior to other available information for reservation wide planning.

[2] R. Carey, Area Soil Scientist

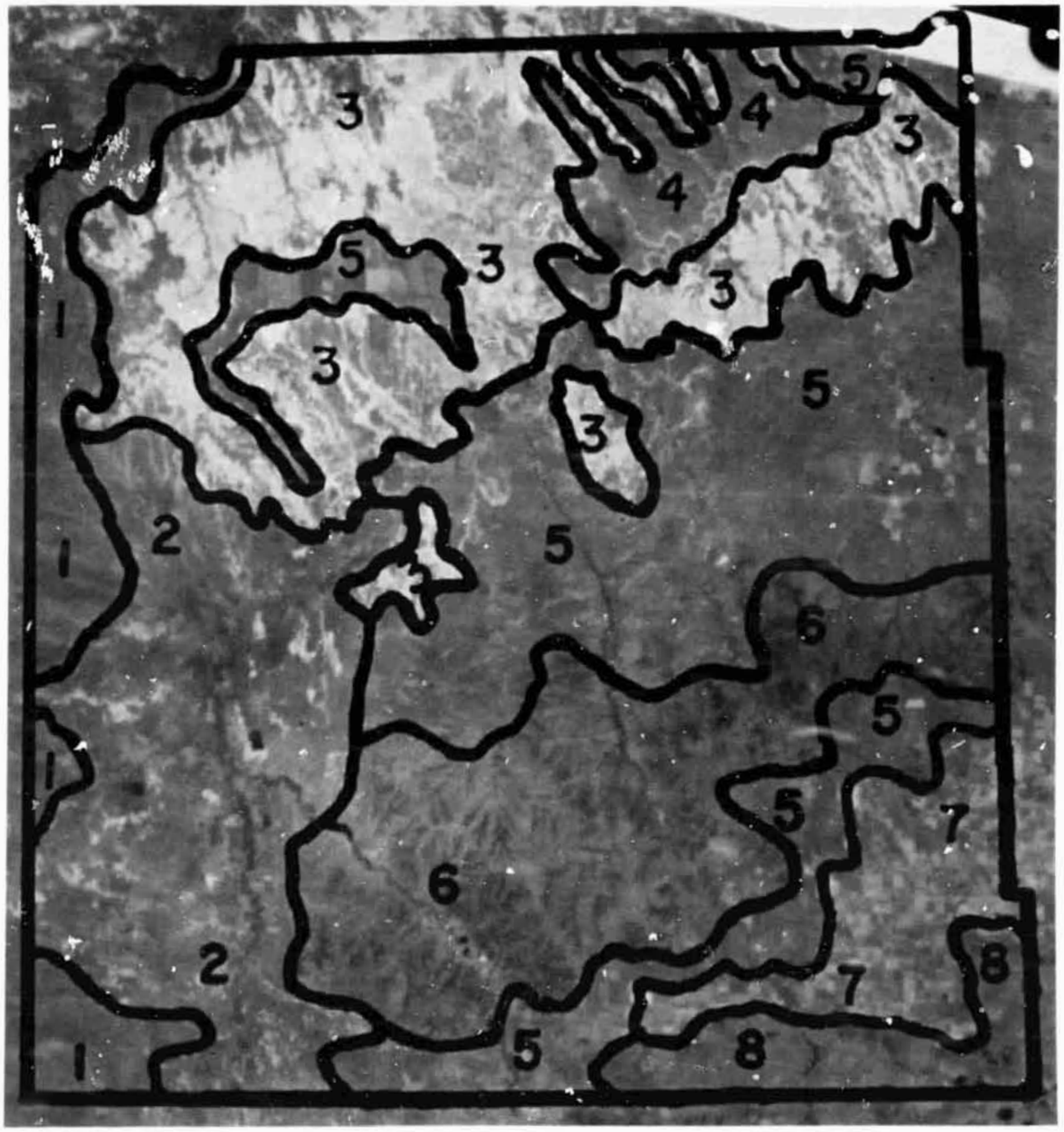



Figure 10. Photo-interpreted units of Shannon County on ERTS-1 composite. Scale = 1:500,000. August 19, 1972. 1027-17065.

Table 4. Percentage of Land Capability Classes and Subclasses within Photo Mapped Units

| Shannon County Capability Classes and Subclasses | Photo Mapped Unit 1 | 2 | 3 | 4 | 5 | 6 | 7 | 3 |
|---|---|---|---|---|---|---|---|---|
| VIII s | 3 | 5 | 48 | 8 | 1 | | | |
| VII s | 8 | 2 | 3 | | 27 | 53 | | |
| VI e | 61 | 25 | 23 | 80 | 26 | 37 | 23 | 67 |
| VI S | 8 | 20 | 10 | | 14 | | 6 | |
| VI w | | 4 | 2 | | | | | |
| V w | | | | | | | | 9 |
| IV e | 11 | 20 | 5 | 1 | 12 | 3 | | 19 |
| IV s | | 13 | 3 | 8 | 5 | | 5 | |
| III c | | 1 | 2 | | 1 | | | |
| III e | 9 | 5 | 1 | | 6 | 1 | 14 | 5 |
| III w | | 3 | 1 | | | 2 | | |
| II c | | 2 | 1 | | 5 | 4 | 22 | |
| II e | | | 1 | | 3 | | 30 | |

Table 5. Percentage of Range Sites Within Photo Mapped Units

| Range Sites in Shannon County | Photo Mapped Unit 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| Sb | | | | | | | | 9 |
| Ov | | 7 | 3 | | 1 | 2 | | |
| CD | | | | | | | | |
| SL | | 3 | | | | | 3 | |
| Sa | 3 | | 2 | 38 | | | | 67 |
| Sy | 17 | | 5 | 21 | 3 | | 3 | 24 |
| Si | 3 | 26 | 19 | 25 | 52 | 45 | 86 | |
| CS | | | | | | | | |
| Cy | 55 | 37 | 13 | | 3 | | | |
| Cp | | 2 | 3 | 8 | 3 | | 5 | |
| Sw | 6 | 16 | 3 | | 37 | 53 | 3 | |
| TU | 3 | | | | | | | |
| DC | 5 | 1 | 2 | | | | | |
| TCp | 5 | 3 | 2 | | | | | |
| NONE | 3 | 5 | 48 | 8 | 1 | | | |

## Conservation

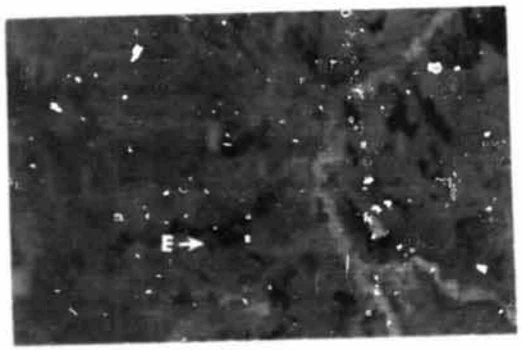
On all Indian lands, certain conservation practices such as strip-cropping, contour farming, and terracing are required of farmers and ranchers leasing Indian lands. The certification and monitoring of Indian lands to assure that adequate conservation practices are being adhered to is a sizable task. In fact, present techniques, coupled with limited personnel, are not effectively monitoring the Indian lands.

Contact prints of single band transparencies, color composites, and prints of ERTS-1 imagery at scales of 1:500,000, 1:250,000, 1:125,000 and 1:60,000 for two different overpasses were evaluated for identifying fields which were wind stripcropped, contour stripcropped, or gully eroded. Features such as reservoirs, stockponds, wells, land use boundaries, and blow-outs, were also studied for ease of identification from ERTS-1 imagery. Certain agricultural conservation features such as wind stripcropping, contour stripcropping, reservoirs, and stockponds can be visually identified on ERTS-1 imagery (Figure 11, Table 6). Other features like wells, blow outs, areas burned by fire, prairie dog towns, and hay cutting areas can only be identified with ground control (Table 6).

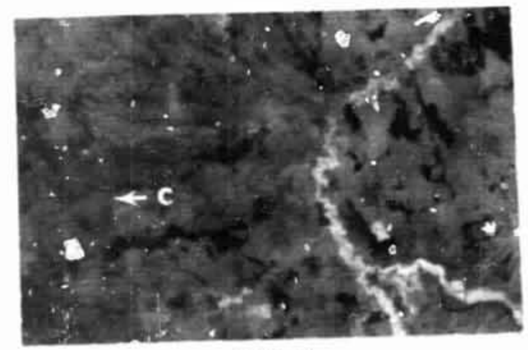
There is considerable potential for using ERTS-1 imagery for making general soil maps and for monitoring certain conservation farming practices and related agricultural features. This type of information is useful to agencies, such as the Bureau of Indian Affairs, in areas where detailed soils information is not available.

## Range Inventory

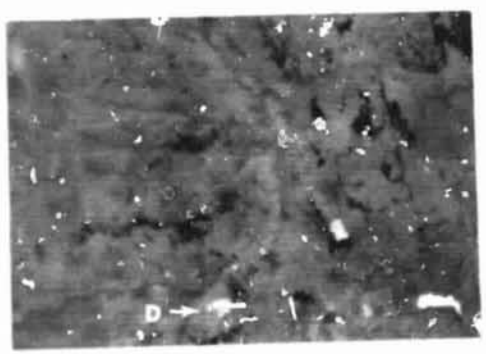
Range inventories of most of the Indian lands in South Dakota are completed. These inventories provide basic resource data for land use and management decisions on Indian lands. These inventories provide detailed information on range site, range condition, watering points, and several other categories of information obtained during a field survey. Coupled with information on climate, the data in these surveys permit estimates of



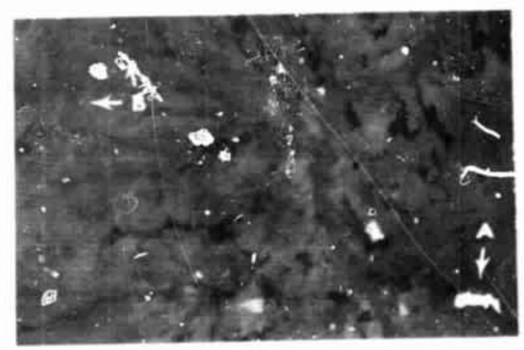

MSS-4




MSS-5




MSS-6




MSS-7

Figure 11. Appearance of reservoirs, stockponds, rangeland boundaries, and other features on four MSS bands of ERTS-1 imagery. August 19, 1972. 1027-17065.

Table 6. Ratings of ERTS-1 Imagery for Visual Identification of Selected Ground Features in Shannon County, South Dakota

| | | August 1972 | | | | | May 1973 | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Feature | Scale | Band 4 (Green) | Band 5 (Red) | Band 6 (Infrared) | Band 7 (Infrared) | Color Composite | Scale | Band 5 (Red) | Band 7 (Infrared) | Color Composite Enlargements |
| Wind Strip-cropping | 1:1,000,000 | 0 | 1 | 1 | 1 | 1 | 1:500,000 | 1 | 2 | 1 |
| | 1:500,000 | 1 | 2 | 3 | 3 | - | 1:250,000 | 1 | 3 | 3 |
| | 1:250,000 | 1 | 3 | 3 | 4 | - | 1:125,000 | 1 | 3 | 2 |
| | | | | | | | 1:60,000 | 1 | 1 | 1 |
| Contour Strip-cropping | 1:1,000,000 | 0 | 0 | 0 | 0 | 0 | 1:500,000 | 1 | 0 | 1 |
| | 1:500,000 | 0 | 0 | 1 | 1 | - | 1:250,000 | 1 | 0 | 2 |
| | 1:250,000 | 0 | 1 | 1 | 1 | - | 1:125,000 | 1 | 0 | 2 |
| | | | | | | | 1:60,000 | 1 | 0 | 1 |
| Reservoirs | 1:1,000,000 | 1 | 1 | 4 | 4 | 3 | 1:500,000 | 2 | 4 | 3 |
| | 1:500,000 | 2 | 2 | 4 | 4 | - | 1:250,000 | 2 | 4 | 3 |
| | 1:125,000 | 2 | 2 | 4 | 4 | - | 1:125,000 | 2 | 4 | 3 |
| | | | | | | | 1:60,000 | 1 | 4 | 3 |
| Stock Ponds | 1:1,000,000 | 0 | 0 | 1 | 3 | 2 | 1:500,000 | 1 | 4 | 2 |
| | 1:500,000 | 1 | 2 | 3 | 4 | - | 1:250,000 | 1 | 4 | 2 |
| | 1:250,000 | 1 | 1 | 3 | 4 | - | 1:125,000 | 1 | 4 | 2 |
| | | | | | | | 1:60,000 | 1 | 3 | 2 |
| Wells | 1:1,000,000 | 0 | 0 | 0 | 0 | 0 | 1:500,000 | 0 | 0 | 0 |
| | 1.500,000 | 0 | 0 | 0 | 0 | - | 1:250,000 | 0 | 0 | 0 |
| | 1:250,000 | 0 | 0 | 0 | 0 | - | 1:125,000 | 0 | 0 | 0 |
| | | | | | | | 1:60,000 | 0 | 0 | [illegible] |

Table 6. Continued

| | | August 1972 | | | | | May 1973 | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Feature | Scale | Band 4 (Green) | Band 5 (Red) | Band 6 (Infrared) | Band 7 (Infrared) | Color Composite | Scale | Band 5 (Red) | Band 7 (Infrared) | Color Composite Enlargements |
| Cropland Boundary | 1:1,000,000 | 2 | 3 | 2 | 4 | 1 | 1:500,000 | 2 | 4 | 3 |
| | 1:500,000 | 3 | 4 | 3 | 3 | - | 1:250,000 | 2 | 4 | 3 |
| | 1:250,000 | 3 | 4 | 3 | 3 | - | 1:125,000 | 1 | 4 | 2 |
| | | | | | | | 1:60,000 | 1 | 3 | 1 |
| Rangeland Boundary | 1:1,000,000 | 2 | 3 | 2 | 1 | 1 | 1:500,000 | 0 | 0 | 0 |
| | 1:500,000 | 3 | 3 | 2 | 2 | - | 1:250,000 | 0 | 0 | 0 |
| | 1:250,000 | 2 | 2 | 2 | 1 | - | 1:125,000 | 0 | 0 | 0 |
| | | | | | | | 1:60,000 | 0 | 0 | 0 |
| Gully Erosion (Cultivated fields) | 1:1,000,000 | 0 | 0 | 0 | 0 | 0 | 1:500,000 | 1 | 0 | 1 |
| | 1:500,000 | 1 | 1 | 1 | 1 | - | 1:250,000 | 1 | 0 | 1 |
| | 1:250,000 | 1 | 1 | 1 | 1 | - | 1:125,000 | 1 | 0 | 1 |
| | | | | | | | 1:60,000 | 0 | 0 | 0 |
| Blow-outs (Wind) erosion | 1:1,000,000 | 1 | 1 | 1 | 1 | 1 | 1:500,000 | 3 | 3 | 3 |
| | 1:500,000 | 2 | 3 | 2 | 3 | 0 | 1:250,000 | 3 | 3 | 3 |
| | 1:250,000 | 2 | 3 | 3 | 2 | 0 | 1:125,000 | 3 | 3 | 3 |
| | | | | | | | 1:60,000 | 3 | 3 | - |

CODE:

0 Can't Identify
1 Poor
2 Fair
3 Good
4 Excellent
- No imagery available

stocking rates, crop yields, and suitability for a variety of land use alternatives. Because of use changes, a need exists for techniques to periodically update and improve existing inventories. At present, the Bureau of Indian Affairs does not have sufficient personnel to accomplish the updating work by conventional techniques.

Previous work at the Remote Sensing Institute in cooperation with the Bureau of Indian Affairs has demonstrated that much of the soil and range information obtained by field surveys can be interpreted from photographs (Frazee and Carey, 1972). Techniques to extrapolate remote sensing range and soil information from detailed test sites to other similar areas have not been developed. The problem studied was that of predicting or estimating range production (herbage yield) using remote sensing technology. Vegetative and soil data were collected for rangeland test sites utilizing a 100 meter grid sampling pattern. The following 70-mm aircraft imagery was collected at the time of the ground sampling:

| Camera # | Film | Filter |
|---|---|---|
| 1 | B/W Plus-X (2402) | 25A |
| 2 | B/W Plus-X (2402) | 58 |
| 3 | Color Infrared (2443) | 15 + 30 m |
| 4 | B/W Infrared (2424) | 89B |

The imagery collected on July 23, 1972, was digitized utilizing the Signal Analysis and Dissemination Equipment (SADE) at the Remote Sensing Institute (Figure 12). Seven sets of digital data were obtained. One set each for the black and white films and 4 sets from the color infrared film. The digital data were related to the ground data by correlation and regression analysis. Both density slicing and pattern recognition approaches were used for extrapolation from the test site to an adjoining similar pasture. A ratio of ERTS-1 imagery (MSS 5 and 7) was utilized to search for a vegetative index or estimate of herbage yields.

The linear correlation coefficients between the film data and ground data are shown in Table 7. Herbage yield (lbs. of dry matter per acre) was significantly related to film density for the color infrared film and

SADE was designed as a state of the art data analysis system with a highly flexible modular design. In the independent off-line mode the system provides monitor display of digital film or analog tape data and transmission of analog information to the film printer. When on-line with the computer, the system provides transmission of digitized image data and analog tape data to the computer and transmission of data stored or transformed in the computer back to the display monitor or the film printer. The system is composed of the following components:

1. Image digitizer (image dissector tube)
2. Data control and conversion unit
3. Lockheed 417 seven track analog tape recorder
4. Daedalus film printer
5. Band pass filters
   Red - .59 - .70μm
   Green - .47 - .62μm
   Blue - .36 - .50μm

Figure 12. Signal Analysis and Dissemination Equipment.

Table 7. Correlation Coefficients from Analysis of Field and Film Data for Pasture #1

| | EK-IR | | | | B/W | | |
|---|---|---|---|---|---|---|---|
| | N | R | G | B | 58 | 25A | 89B |
| Depth of A Horizon | -.36** | -.22 | -.42** | -.41** | .46** | .23 | .16 |
| Slope | .63** | .53** | .67** | .60** | -.44** | -.24 | -.07 |
| Organic Matter | -.09 | .01 | -.10 | -.20 | -.01 | .04 | -.18 |
| Reflectivity | .32* | .26 | .30* | .40** | -.28* | -.19 | .13 |
| Condition | -.27 | -.22 | -.19 | -.15 | .30* | .38** | .28 |
| Yield | -.52** | -.37** | -.48** | -.36* | .52** | .53** | .18 |

* Significant at .05 level (>.279)

** Significant at .01 level (>.362)

black and white films with 58 or 25A filter but not with the black and white infrared film. The relationships between film density and herbage yield were not improved by multiple correlation analysis or by the use of transformations of the digital data.

The classification of range site is illustrated in Figure 13. The k-class technique is based upon pattern recognition analysis of training samples for each class. The interactive classification is based upon a visual evaluation of the digital printout. One band or set of digital data was adequate for classification. Results were displayed on the color television monitor of the SAI system (Figure 13). The best equation for estimating yield was yield = 9931.3 - 62.5 (output code of EK-IR film - no filter). Utilizing this equation based upon the detailed test site, the mean yield was 1744 lbs/acre which compare favorably with the estimated mean yield from ground observations of (1830 lbs/acre). This type of extrapolation is limited by sun angle and vignetting effects inherent with low-altitude photography.

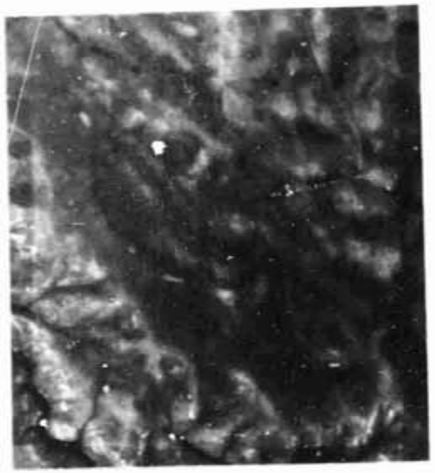
ERTS-1 data (bands 5 and 7) were digitized from 9½-inch transparencies and ratioed. The ratioed (5/7) data were most sensitive to vegetative differences and demonstrated a strong inverse relationship to ground cover (Figure 14). Within a general area of similar soils and range sites, this index is a good measurement of vegetative cover.

In addition to Remote Sensing personnel, five specialists[3] from the Bureau of Indian Affairs are involved. The Bureau of Indian Affairs furnished approximately four man-months of work plus travel to this effort.

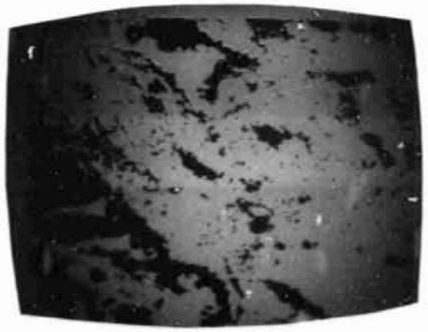
## Water Resources Planning

The Bureau of Indian Affairs is presently authorizing funding for comprehensive water resource planning on Indian reservations. The Rosebud Reservation is developing a comprehensive water resources plan and has enetered into a contract with a private consulting firm to update and

[3] R. Carey, Area Soil Scientist, C. Reed, Range Scientist, C. Owens, Range Conservationist, J. Warkentin, Soil Scientist, R. Williams, Soil Scientist.

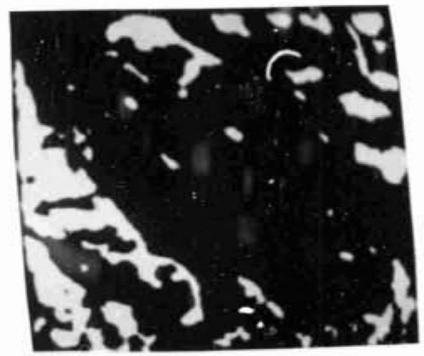


Plus X-film
with 25A filter
July, 1972



K-class

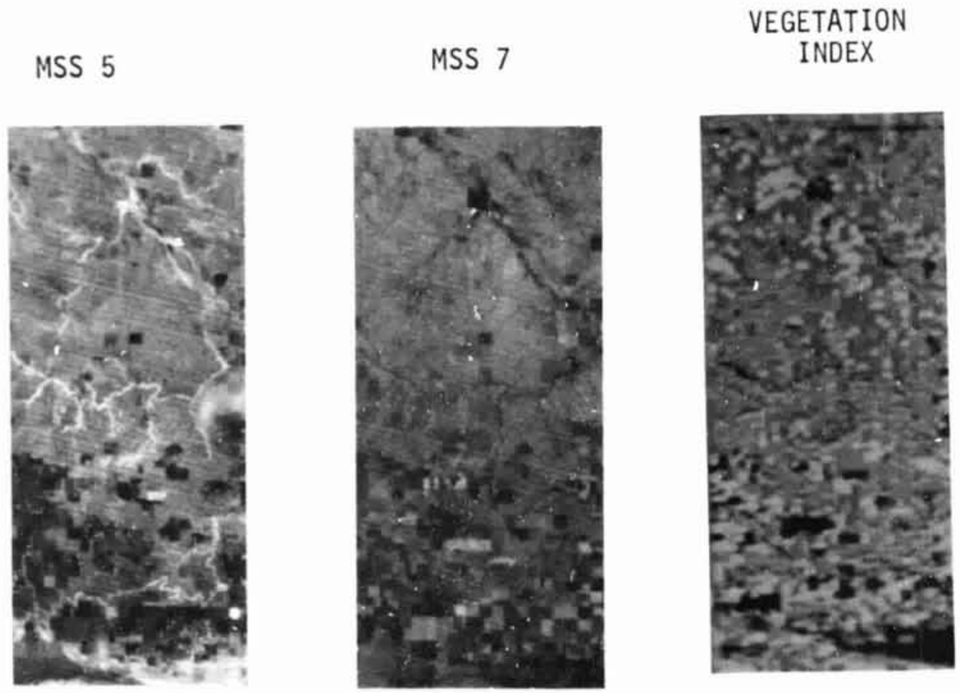
yellow-silty and
overflow
blue-shallow and
thin upland



Interactive

brown-silty and
overflow
yellow-shallow and
thin upland

Figure 13. Classification of range site for Pasture 1.




LEGEND

1 Dark → SubIrrigated
2 Overflow
3 Silty/Shallow
4 Sandhills/Thin Upland
5 Stubble
6 Light Fallow

Figure 14. Vegetation index with six classes derived from ratioed ERTS-1 data.

compile all basic resource data for the reservation. The Remote Sensing Institute has entered into a contract with the private consulting firm to provide ERTS-1 interpreted soils, land use, and irrigation development data. The techniques employed to prepare these inventories were developed under RSI's NASA grant.

Prints at a scale of 1:250,000 from color composite transparencies, band 5, and band 7 ERTS-1 imagery were mosaiced for interpretation. Soil, land use, and irrigation development (Figure 15) were interpreted from ERTS-1 imagery and transferred to the 1:250,000 USGS topographic map of the area.

The soils and land use data will be used to evaluate potential sites for water resources development on the reservation. The use of ERTS-1 imagery has allowed the extrapolation of resource data from known to unknown areas. This extrapolation approach is applicable to other Indian reservations which will be developing comprehensive water resources plans.

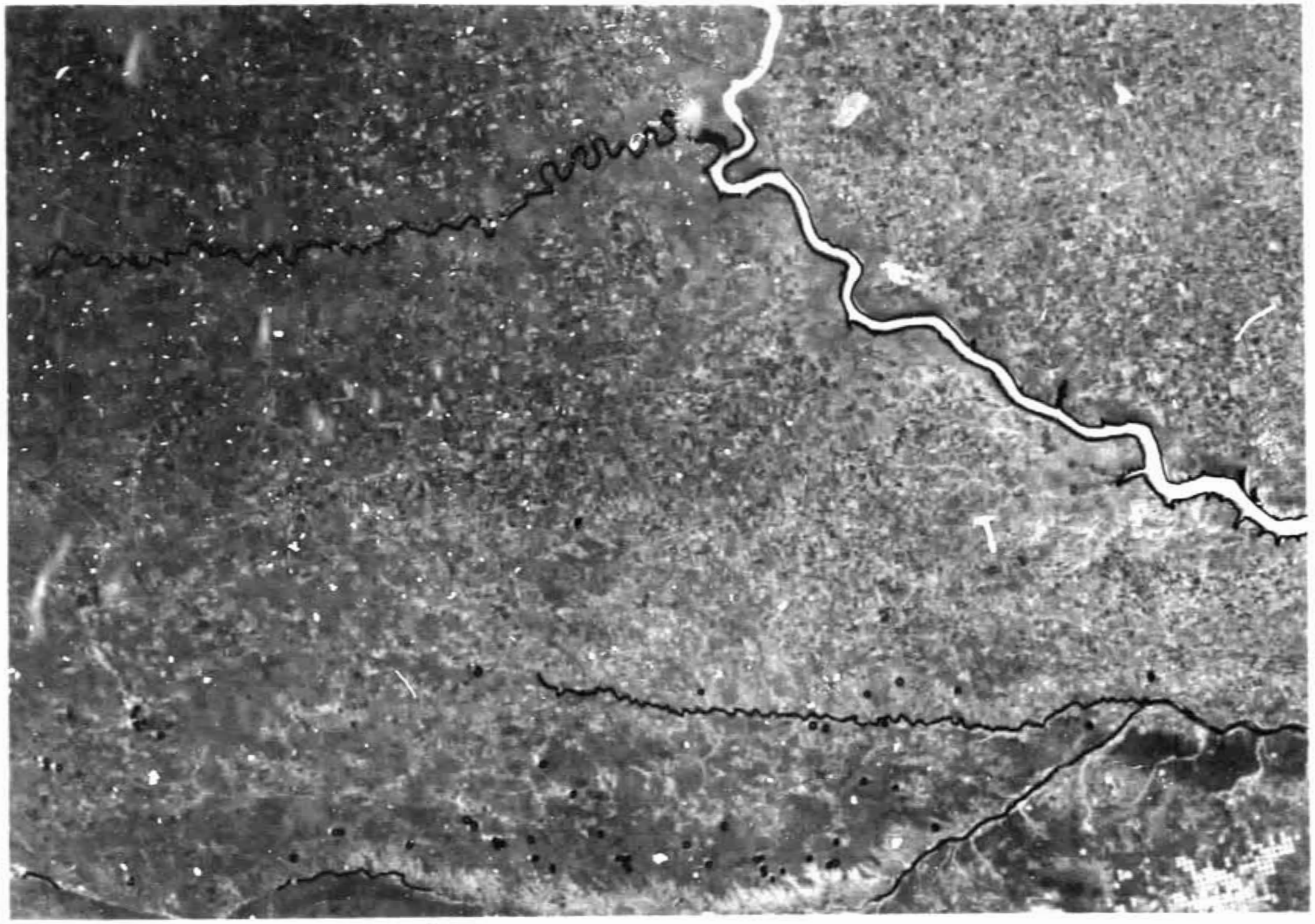


Figure 15. Irrigation development on Rosebud Reservation Area, South Dakota interpreted from ERTS-1 imagery.
Band 5 Scale 1:1,000,000 16551 August 17, 1972

## ADDITIONAL STUDIES OF REMOTE SENSING APPLICATIONS

### Tornado Damage Assessment

On July 23, 1973, a tornado severly damaged approximately 20 city blocks in Pierre, South Dakota. On the morning following the storm the Remote Sensing Institute aircraft was flown to Pierre to collect aerial vertical and oblique photography. Supplemental ground photography was also collected.

The photography was processed at the Remote Sensing Institute photo lab and provided to the Civil Defense Office in Pierre. Excellent photographic coverage was obtained. Storm damage is clearly evident as shown in Figure 16 which is an example of the aerial imagery obtained.

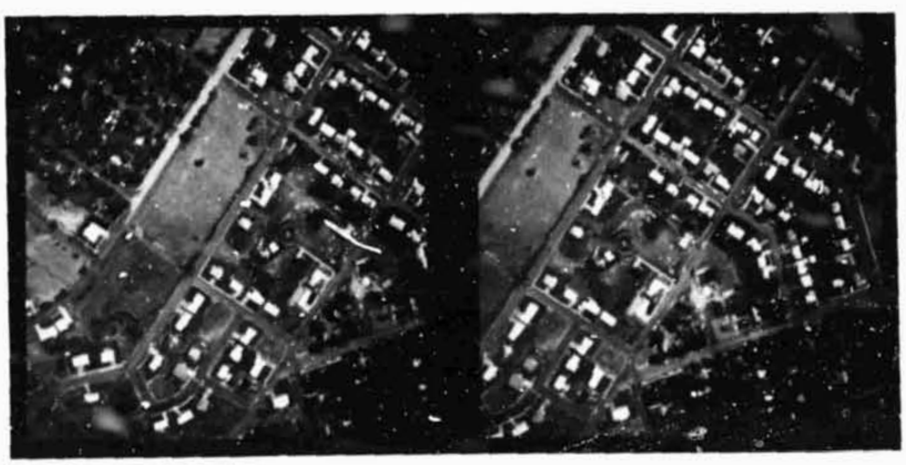


Figure 16. Color infrared aerial photography illustrating ability for assessing tornado damage. Film 2443, filters 15 and 40M, altitude 450 meters (1500 feet), Hasselblad camera with 50 mm lens.

The use of remote sensing data for assessing and scheduling storm cleanup operations includes the following:

a. determining extent of area damaged
b. directing debris clearance
c. routing traffic
d. determining damage to utilities
e. estimating damage to structures
f. determining temporary housing requirements
g. others.

The letters from the office of the South Dakota Civil Defense (Appendix C) indicate that remote sensing imagery is useful for planning and directing cleanup operations. It is expected that this remote sensing operation, along with the one covering the Rapid City flood in 1972 (SDSU-RSI report 72-11), will lead to formation of a contingency plan by the State Civil Defense Agency for calling on the Remote Sensing Institute for immediate remote sensing coverage of disasters for evaluation and planning purposes.

A field investigation report entitled Remote Sensing for Evaluating Post-Disaster Damage Conditions, SDSU-RSI-74-2, was completed on this subject and submitted to NASA in August 1974.

## Hail Damage Evaluation

During the 1973 growing season, the Plant Science Department at the South Dakota State University was engaged in a controlled study of simulated hail damage on oats. This study presented an opportunity to observe and record radiation changes as the crop matured and as simulated damage was imposed. Therefore, a cooperative effort was established between the Plant Science Department and the Remote Sensing Institute. The radiation change data were recorded on three different dates using an Exotech radiometer filtered in the same wavelength bands as that recorded by ERTS-1. A second Exotech radiometer was used to measure incoming radiation simultaneously with the reflected radiation so that net differences can be determined. These data have been partially analyzed with some indication of significant results.

In addition to the above studies, natural hail damage reports were carefully monitored to find an occurrence which coincided closely with an ERTS-1 overpass. On July 1, 1973, heavy hail caused extensive damage in an area near Pollock, South Dakota. Hail stones about an inch in diameter were reported. News reports said crops were completely destroyed in an area about 10 miles wide and 15 miles long east of Pollock, South Dakota.

Figure 17 is a photograph of an ERTS-1 (July 8, 1973) band 5 mosaic on which areal hail damage was interpreted. Band 5 presented the most contrast for interpretation; however, bands 4 and 6 also showed some reflectance changes. The reflectance changes were not as apparent on band 7. The broken line on Figure 17 outlines an apparent reflectance change which was interpreted as hail damage. The solid line represents the hail damage boundary line as determined by field personnel from the Weather Control Commission at Pierre, South Dakota. The field personnel established the damage boundary line by ground observation and interviews with the farmers. The severly hail-damaged areas appear to be visually interpretable on ERTS-1. Areas determined by ground evaluation to have medium to light damage were not visually interpretable. It is hoped that the results of the controlled experiment will lead to data analysis techniques that will improve the interpretability of ERTS-1 to include medium to light hail damage assessment.

Contact has been established with the Hail Insurance Adjustment and Research Association and a briefing of our work has been presented to them. They have shown a considerable interest in what has been done since a gross quick estimate of extensive crop damage would be valuable to them. Present delays in receipt of ERTS-1 imagery would make a quick assessment of damage infeasible; however, continuation of the development of such a capability is important for use when satellite imagery closer to real time does become available.

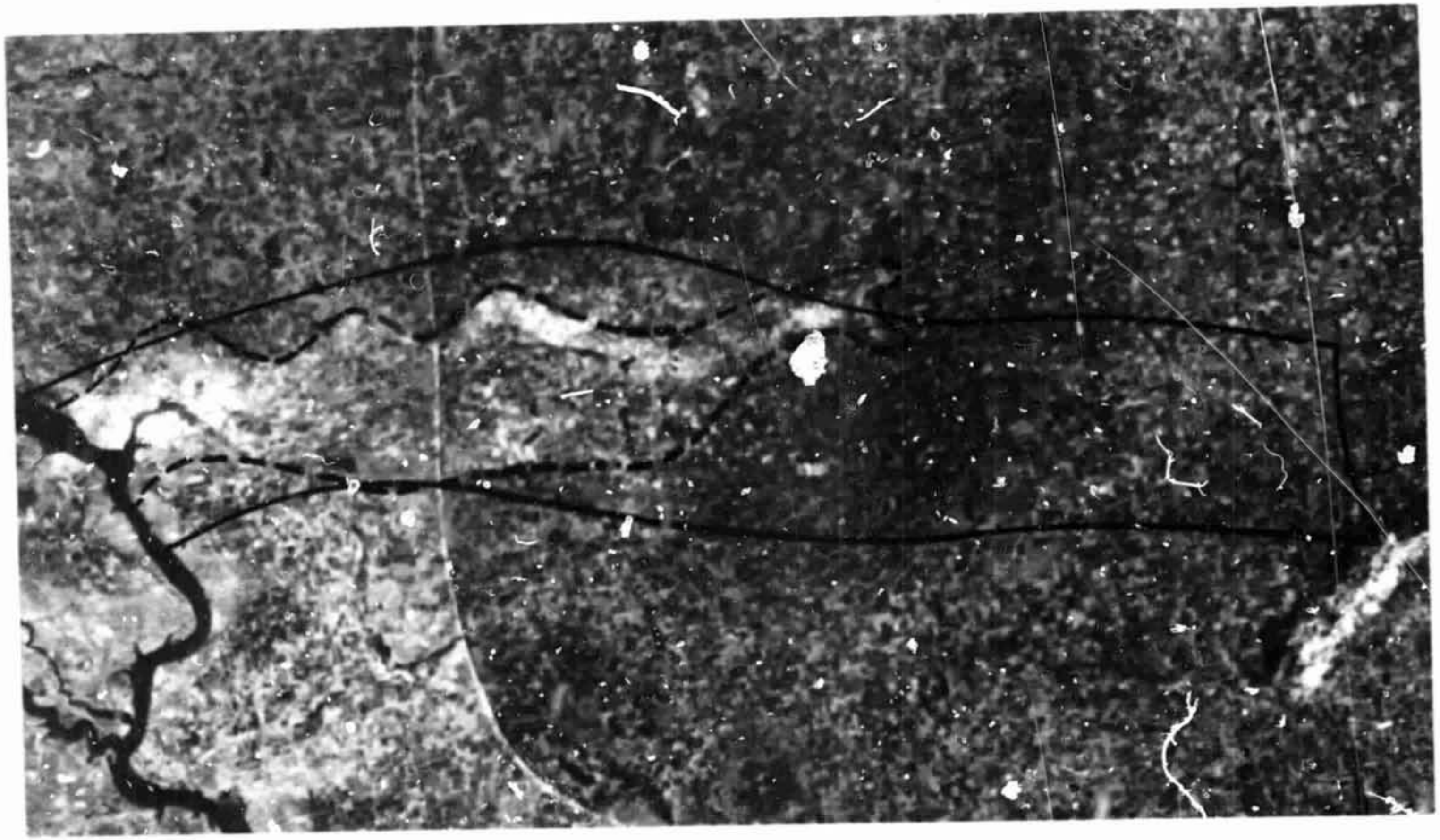


Figure 17. Photograph of band 5 ERTS-1 mosaic with illustrated hail damaged area. Broken line encircles area visually interpreted from ERTS-1 and solid line encircles area determined by ground evaluation.

## Data Analysis

The K-class report SDSU-RSI 73-08 was completed during this period of time. An appendix was also written which describes K-class. This appendix may be attached to and used to acquaint readers of reports in which K-class is used as the classifier to the decision processes.

An appendix was written to describe a mode-seeking procedure referred to as MODE1. The purpose of this appendix is similar to the K-class appendix. The MODE1 computer program and a procedure which uses the MODE1 results to train the K-class classifier is included in SDSU-RSI report 73-11. In addition a MODE2 computer program was corrected and made operational.

As an alternate approach to Robert's gradient for edge and line detection, and for low signal-to-noise ratios situations, the study of U. Montanari's article "On the Optimal Detection of Curves in Noisy Pictures" was pursued. It appears that the work done to detect lines and edges by Montanari could well provide a very useful tool to aid land use planners and others concerned with boundaries between different geologic, crop and soils boundaries.

The work that could be done to improve the recording of the image which contains lines and edges, and to evaluate Montanari's algorithm in low signal-to-noise environments is:

1) Generate line images with additive Rayleigh noise
2) Display these images on the SADE system monitor. This will provide a realistic human interpretation as to the signal-to-noise ratio which is detectable by the eye, and to compare the human results with the algorithm. This has not been done by Montanari in his paper. Only computer line printer outputs have been used
3) Program Montanari's algorithm on the IBM computer
4) Apply the algorithm to images currently under study by other investigators and evaluate the usefulness of Montanari's algorithm to aid these investigators in determining boundaries.

To improve the recognition accuracy of soil types, it was decided that spatial feature extraction techniques should be programmed for use on the IBM system. Computer programs of the two dimensional fast Fourier transform, the Binary Fourier Representation (BIFORE) and slant transforms were received from L. Kirvida of Honeywell Inc. N. Ahmed of Kansas State University also supplied his version of the two-dimensional BIFORE algorithm. Each of these algorithms has been useful to extract spatial features. Time did not permit the evaluation of these algorithms to see whether the use of spatial features improved the classification accuracy of soil types.

The use of the coherence function has been useful in communication systems and should be used to determine spatial frequency features in images. The computer program to extract the coherence function from one-dimensional fast Fourier transform frequency data was developed. Again the lack of time did not permit evaluation of the usefulness of the coherence function. This area of study should be pursued.

## A Map of Soil Textures and Land Forms on ERTS-1 Imagery

The Brookings County Map of "Soil Textures and Land Forms on ERTS-1 Imagery", (Appendix D) contains information pertaining to soil pH, organic matter content, and potassium and phosphorus in ten soil areas in the county. The general soil textures and land form areas are delineated on an ERTS-1 image.

The Brookings County map includes soil factors needed for determining herbicide application rates and the status of certain soil nutrients. The principal utility of the background soil information combined with the ERTS-1 image is in its use by farmers, county agents and other advisors, and by aerial or ground applicators, in their operations.

The soils information has been available previously but never in this unique form which makes it so convenient to interpret and use. Applicators, farmers, and others can pick out individual farms on the ERTS-1 imagery and quickly determine specific information pertaining to that farm and others in the same soil association area.

Information related to farming practices, to availability of ground water, to land sales values, to land use and land use planning, and other information can be inferred from the county ERTS-1 map.

Many environmental variables including soil factors affect the performance of soil applied herbicides. Soil texture, organic matter and pH are important criteria. Soil test results provide accurate indications of these factors.

The application rate for many soil-applied herbicides is based on soil texture and organic matter. Excessive rates result in needless expenditures of product, adding unnecessary amounts of pesticide to the environment, and can result in crop injury. Insufficient rates means "wasted" expenditure for product purchased if weed control is unsatisfactory. Many product labels and recommendations include a table as shown below. This indicates the importance of knowing soil texture and organic matter.

| | Lbs. "Lexone" Per Acre[1] | | |
|---|---|---|---|
| Soil Texture* | ½ to 2% Organic Matter | 2 to 4% Organic Matter | More than 4% Organic Matter |
| Loamy sand, sandy loam | Do Not Use | 3/4 | 1 |
| Loam, silt loam silt, sandy clay, sandy clay loam | 3/4 to 1 | 1 to 1¼ | 1¼ to 1½ |
| Silty clay, silty clay loam, clay, clay loam | 1 to 1¼ | 1¼ to 1½ | 1½ to 1 3/4 |
| Mississippi Delta Only | 1¼ | 1 3/4 | 2 |

* Do not use on sand nor on soils with less than ½% organic matter as crop injury may result.

[1] From "Lexone" label for metribuzin on soybeans

Soil pH is important in some situations. High pH is associated with crop injury with some herbicide treatments. A limited number of products should not be used on soils having pH's higher than specific stated values. These values may vary within fields, however, data from an area are helpful in predicting where problems may be more prevalent.

Growers can obtain the most precise soil information from individual field test results, however, more general information from larger areas is helpful to dealers, applicators and industry personnel. It is helpful in determining general use patterns within areas and in identifying areas where performance problems might be expected. Proper consideration of these factors can prevent problem occurrences, thereby eliminating crop losses due to poor performance or crop phytotoxicity.

In view of the above, it would appear that maps of this type, using ERTS-1 imagery as a base, could prove to be very helpful. Similar maps could be produced for other counties and could perhaps be modified to show other specialized information as required. The important aspect of this application of ERTS-1 imagery is that it is utilized to present available information, in an easily applicable manner, to users for practical purposes. An aerial applicator for example, may not take the time to look up soils information existing in tabular or narrative form, but he may very well make a direct application of the same information which is conveniently displayed on an ERTS-1 base map.

It is recommended that continuing efforts be made to adapt existing and newly discovered information to presentation on ERTS-1 base maps for convenient and practical use in operational situations.

The Soils Textures and Land Forms Map of Brookings County was sent to the South Dakota Congressional Representatives. The replies (Appendix E) indicate their interest in this usage of ERTS-1 imagery.

## A Map of Soil Association Value Areas

A Map of Soil Association value areas was completed in November, 1973. Three groups cooperated to prepare the map: (1) soil survey researchers from the South Dakota State University Agricultural Experiment Station and the USDA Soil Conservation Service who prepared the Soil Association separations; (2) the Directors of Assessment and the South Dakota Department of Revenue officers who compiled the land sales of unimproved agricultural land by Soil Associations; and (3) the South Dakota State University Remote Sensing Institute, and the National Aeronautic and Space Administration contract No. NASA-ERTS NAS5-21774, who furnished and prepared the ERTS Base Map from satellite imagery upon which Soil Association Value Areas are drafted.

The ERTS mosaic used for the base map was complied from scenes taken in May and June 1973. The imagery consists of negative prints from Band 7 of the multi-spectral scanner aboard the ERTS satellite. To prepare a base map of South Dakota using Conventional Aerial photographs, it is estimated that 30,000 separate photographs would be necessary, costing about $250,000. The ERTS base map used was complied using only 20 ERTS scenes at a far more reasonable cost.

The Soil Association Value Area Map is included in this report at Appendix E. The map legends included are such that the user can readily interpret the information displayed.

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APPENDIX A

Office of
Director of Equalization
POTTER COUNTY
Gettysburg, South Dakota 57442

19 November 1073

Mr. George Winkler CAE CSDA
Director, Property Tax Division
Pierre, South Dakota

Dear Mr Winkler;

Reference the EROS presentation by Doctor Weston and Doctor Frazee at our recent annual convention.

This County would like you to make the necessary contact with the proper Individual to determine Cost and procedure for us to obtain a colored print, and plastic overlays as displayed on the one county. Further we are also interested in having the same study accomplished on this County, as Doctor Frazee is doing on Pennington County. Please obtain this cost for us.

This letter coordinated with Mr. A. L. Rogers, Chairman Potter County Commissioners.

CC: County Commissioners

Sincerely,
Robert J. Borgish
Director of Equalization

OFFICE OF

# BROWN COUNTY
# DIRECTOR OF EQUALIZATION

ABERDEEN, SOUTH DAKOTA 57401

November 19, 1973

Mr. George Winckler
Director of Property Tax
Pierre, South Dakota 57501

Dear Mr. Winckler:

Brown County Commissioners, moved and passed motion, November 19, 1973 to find the cost of ERTS colored pictures and particularly of Brown County.

Sincerely yours,

Alberta Jacobson
Brown County
Director of Equalization

APPENDIX B

P. O. Box 1357, Huron, South Dakota 57350

July 10, 1974

Mr. Joe A. Vitale, Chief
Engineering Systems Design Branch
Office of University Affairs
NASA Code Y Room 6125
400 Maryland Ave. S. W.
Washington, D. C. 20546

Dear Mr. Vitale:

Dr Fred C. Westin suggested that you may be interested in some of the work initiated in South Dakota exploring methods in which ERTS imagery may improve or accelerate our soil survey program. In March, I forwarded black and white ERTS imagery at 1:1,000,000 and 1:250,000 scales, Band 5 and Band 7, to selected soil scientists. The purpose as outlined to them was to keep ourselves up to date on the type of data that is available, and to seriously review and study the imagery for any methods in which it may assist us in our soil survey program or land use interpretations. Some of the things we suggested for consideration were:

1. Refining or sharpening of our general soil association areas

2. Would it assist us in outlining general areas of different soils that do not seem to appear on our present photography; for example, would it help us separate some of our silty drift areas or geologic areas that may be reflected in our soil survey delineations?

3. Broader vegetative or land use patterns that may be indicative of soil patterns.

4. The possibility of using the ERTS background at a 1:250,000 scale for more impressive demonstration, educational, or informational uses.

The ERTS imagery was furnished us by the Remote Sensing Institute at Brookings. We hope to follow up this project with some 1974 ERTS imagery for study by field soil scientists. The Remote Sensing Institute also has furnished us a few selected color composites which will be evaluated.

I am attaching copies of the original comments received from our field soil scientists. Our soil survey staff has not yet appraised or followed up with our soil scientists on this project. This will be done this winter. In some cases, we plan for personnel of the Remote Sensing Institute to work with our people on interpretation of this imagery. I appreciate the excellent cooperation of the personnel of the Remote Sensing Institute and Plant Science Department at South Dakota State University in working with this data.

I believe it is evident that in some counties the imagery will assist us in more accurately delineating broad soil areas in addition to other features as geologic areas and land use patterns. Before drawing any conclusions for use in soil survey, it is necessary that we follow up with our soil scientists during FY 1975.

Sincerely,

D. L. Bannister
State Soil Scientist

Attachments

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

April 16, 1974

To: Don Bannister, State Soil Scientist
Soil Conservation Service
Huron, S. Dak.

From: Ken Miller, Soil Scientist KM
Soil Conservation Service
Milbank, S. Dak.

Subject: Soils - 16 - Techniques, ERTS Imagery

As requested, I have worked with the imagery coverage of Grant County, and have a few comments on this.

1. With prior knowledge of the area, a fairly accurate Soil Association map can be made, however, some areas are not well enough defined to use for sharpening up boundaries. Some of the gravel areas and the alluvial soil areas are not well enough defined to make accurate boundaries. Also, the boundary of the silty drift area is not well defined.

2. The imagery could be of some benefit in soil survey work as it shows the geologic areas, land use patterns, and in turn the kinds of soils one would expect to occur.

3. A soil association map developed on this background at 1:250,000 would be of some value for educational and informational uses.

4. The imagery could be of some value when starting a new survey area.



cc - A. Wayne Pope, A.C.
Soil Conservation Service
Watertown, S. Dak.

SOIL SURVEY

5/30/74

Don Bannister, State Soil Scientist, S C S
Huron, S.D.
Subject - Soil - 16 - Techniques, ERTS Imagery

I find these photos interesting but I can't use them for mapping but estimating the percent of cropland and rangeland in a particular soil delineation maybe with refinement in enlargement techniques other uses such as determining water areas / drainage systems (small), timber, gravel pits etc. could be made easily.

[illegible],
[illegible], S.D.

REPRODUCIBILITY OF THE
ORIGINAL PAGE IS POOR

UNITED STATES DEPARTMENT OF AGRICULTURE
[illegible]
Salem, South Dakota 57058

SUBJ: SOILS - ERTS Imagery DATE: March 22, 1974

TO: Donald L. Bannister, State Soil Scientist
Soil Conservation Service
Huron, South Dakota 57350

I have studied the ERTS imagery for McCook County and adjacent areas and have found it to be useful. In general the May imagery is sharper and has more detail than the October imagery for both bands and scales. I have the following comments on the imagery:

Band 7 (0.8 - 0.9 micron) 1:1,000,000 scale: This imagery is very useful for getting an overall perspective of the southeast corner of the state. The major drainage patterns are detectable along with cultural features such as Interstate 90 and 29 and Gavins Point Dam. This imagery is of little use for a single county except for comparing it to adjacent areas. It may be useful in Lincoln and Union counties where the loess areas are easily discernible and can be separated from the silty drift areas. There also seems to be a diffuse boundary between the silty drift and glacial till areas.

The May imagery is much clearer and shows more drainage detail than the October imagery. The major geologic areas, however, are prominent on both sets of imagery.

I am pleased with the detail on this imagery and would appreciate followup sets of it.

Band 7 (0.8 - 0.9 micron) 1:250,000 scale: This imagery is more useful on the county level. The drainage pattern and cultural features are visible but towns are not detectable. The Clarno-Ethan-Tetonka soil association is very prominent and can easily be delineated on this imagery. All other soil associations, except for the alluvial soils, have similar patterns or film contrasts. Perhaps if film densities were color encoded, the other soil associations may be discernible. The Hand-Clarno-Ethan association appears to be lighter in some areas but this is very abstract and impossible to separate on this imagery.

I would appreciate color composites of this imagery and also any followup sets that become available. I, too, believe this imagery makes a good background for the general soils map of the county.

Band 5 (0.6 – 0.7 microns) 1:250,000 scale: This imagery coupled with the Band 7 imagery is very useful on the county level. Drainage is more prominent on the Band 7 imagery, but cultural features are more prominent on the (May) Band 5 imagery. Towns appear as diffuse dark areas. The October imagery is unclear and seems to have some cloud cover.

The Clarno-Ethan-Betonka association is prominent and can be delineated on this imagery. The Hand-Clarno-Ethan association can be separated from the Clarno-Prosper association west of the Vermillion River, but cannot be separated elsewhere in the county. I believe a color composite of this imagery would be very helpful for delineating soil associations.

To summarize.

1. The 1:1,000,000 scale, Band 7 imagery shows the overall view of the drainage network and helps to delineate geologic areas of a section of the state. It helps in placing a particular county in perspective with the drainage network and geologic pattern.

2. The 1:250,000 scale, Band 7 imagery shows the drainage pattern better than Band 5 and may aid in delineating soil associations within a county.

3. The 1:250,000 scale, Band 5, imagery shows cultural features better than Band 7. It, too, may help in delineating soil associations within a county.

4. I believe color composites of the 1:250,000 scale would be helpful in making general soils maps. I would appreciate this imagery if it is available.

5. The May imagery is sharper and has more detail than the October imagery for both Bands. The October imagery, however, appears to have some cloud cover which may obscure the land pattern.

I would appreciate receiving any followup sets of imagery.

Maurice J. Mausbach

MAURICE J. MAUSBACH
Soil Scientist

cc–Robert D. Richter, Area Conservationist, SCS, Sioux Falls, South Dakota

| | | | |
|---|---|---|---|
| Ruehle | | | |
| Smalley | | | |
| Zavesky | | | |
| Radeke | | | |

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

SUBJECT: Soils - Techniques, ERTS Imagery

DATE: 3-25-74

TO: Don Bannister, State Soil Scientist
SCS, Huron

I have reviewed the copies of ERTS imagery that was sent covering Yankton and surrounding counties. In studying these I have observed the following:

Band 5 shows -
- Bottoms of James River
- Wet area along Turkey - Clay ditch
- Course textured soils along Missouri

Band 7 shows -
- Breaks along James Missouri, Turkey. Clay both grassed or wooded.
- Water areas - including where Missouri R. is stabilized.
- Alfalfa fields - very numerous in Missouri R. bottom.

If it is possible, would like copies of imagery from this season to compare with these and new Atlas Sheets we will be getting. I understand that band 5 is in the visible red and band 7 is near infrared which locates these photos in a different part of the spectrum from our normal photographs. Still would be interesting to compare even though patterns will be different.

[signature], Yankton.

cc: Robert Pielstick, AC

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

SUBJECT: Soils – Evaluation of ERTS Imagery

DATE: 5-20-74

TO: D.L. Bannister, State soil scientist
SCS
Huron, So. Dak. 57350

REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR

In studying the four ERTS photos which you sent, the most noticeable thing is that the photos taken in May, 1973 are much clearer and show more detail than the photos taken in Oct, 1972. Also, the scale of 1:250,000 is easier to use than the scale of 1:1,000,000.

Using the spring flight at scale of 1:250,000 I was able to distinguish the areas of 7 of the 11 Gen. Soil Assoc. areas as I have separated them on a county highway map. The bottom land areas and the areas of the Crofton-Nora-Alcester Assoc. stand out the most. At an even larger scale the Gen. Soil Assoc. areas might show up even better and would make an impressive background for a Gen. Soil Map overlay.

The ERTS photos, I believe, could certainly help us in preparing Gen. soil maps in counties where there are no detailed soil surveys. However, the Gen. soil maps probably could be more accurately prepared using the soil survey field sheets where good detailed soil surveys are available.

James L. Driessen, soil scientist

cc: Robert D. [illegible], AC, Sioux Falls

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
CANTON, S.D. 57013

SUBJECT: Soils - ERTS Imagery, Union Co.

DATE: 5-21-74

TO: D. L. Bannister, State Soil Scientist
SCS, Huron, So. Dak. 57350

For your information I am sending a Gen. soil map overlay placed over an ERTS photo of Union County. Please return this material to me after you have reviewed it.

The overlay is a tracing of the soil Assoc. boundaries as presently drawn on the Highway map. The lines have not yet been refined to match the ERTS Imagery. This I will do at a later time.

Assuming the scales of the highway map and ERTS photo are the same, you will notice that the Missouri and Big Sioux River channels have changed considerably since the highway map was drafted, or the map is not accurate.

When the overlay is placed on the ERTS photo, most of the Gen. soil Associations can easily be seen on the ERTS image, and it is evident that some of the lines can be refined somewhat. With some more study of the ERTS photo, possibly the Gen. soil map can be improved considerably.

James L. Driessen
Soil Scientist

APPENDIX C

STATE OF SOUTH DAKOTA
OFFICE OF THE ADJUTANT GENERAL

**STATE CIVIL DEFENSE**

STATE EMERGENCY OPERATIONS CENTER
STATE CAPITOL BUILDING
PIERRE, SOUTH DAKOTA 57501

RICHARD F. KNEIP
*GOVERNOR*

MAJ. GEN. DUANE L. CORNING
*DIRECTOR*
*THE ADJUTANT GENERAL*

30 July 1973

Victor I. Myers, Director
Remote Sensing Institute
South Dakota State University
Brookings, South Dakota 57006

Dear Mr. Myers:

Thank you very much for the copies of photos taken by your Institute showing the damaged areas in Pierre on the July 24, 1973, tornado.

I am sorry that we did not advise you so that you had immediate knowledge of the tornado, however, we will certainly attempt to do this in all future incidents such as this and hopefully allow you more planning time for accomplishing such a mission.

These photos are very beneficial in determining the scope of damage and you can be assured that we appreciate it immensely.

Sincerely,

JOHN F. POWELL
Deputy Civil Defense Director
for South Dakota

JFP/st

STATE OF SOUTH DAKOTA

OFFICE OF THE ADJUTANT GENERAL

# STATE CIVIL DEFENSE

STATE EMERGENCY OPERATIONS CENTER

STATE CAPITOL BUILDING

PIERRE, SOUTH DAKOTA 57501

RICHARD F. KNEIP
*GOVERNOR*

MAJ. GEN. DUANE L. CORNING
*DIRECTOR*
*THE ADJUTANT GENERAL*



19 November 1973

Mr. Victor Myers
Remote Sensing Institute
Harding Hall
South Dakota State University
Brookings, South Dakota 57006

Dear Mr. Myers:

After the Black Hills flood of June 9, 1972, your Institute compiled a document of photos valuable in damage assessment immediately after the flood and important in delineating the flood plain area for long-range flood plain management.

Again as a result of a small tornado in Pierre this year the imagery provided assisted a great deal in identifying the path of and damage caused by this incident.

As a result of these two specific cases, and the uses to which the photos assisted in damage assessment, identification of the hazard areas and long-range planning, we would hope that your Institution could continue to provide this service in the event of future disasters.

Sincerely,

JOHN F. POWELL
Deputy Civil Defense Director
for South Dakota

JFP/st

APPENDIX D

# Soil Textures and Land Forms on ERTS-1 Imagery

AES Info Series 8
June 1974 (Revised)

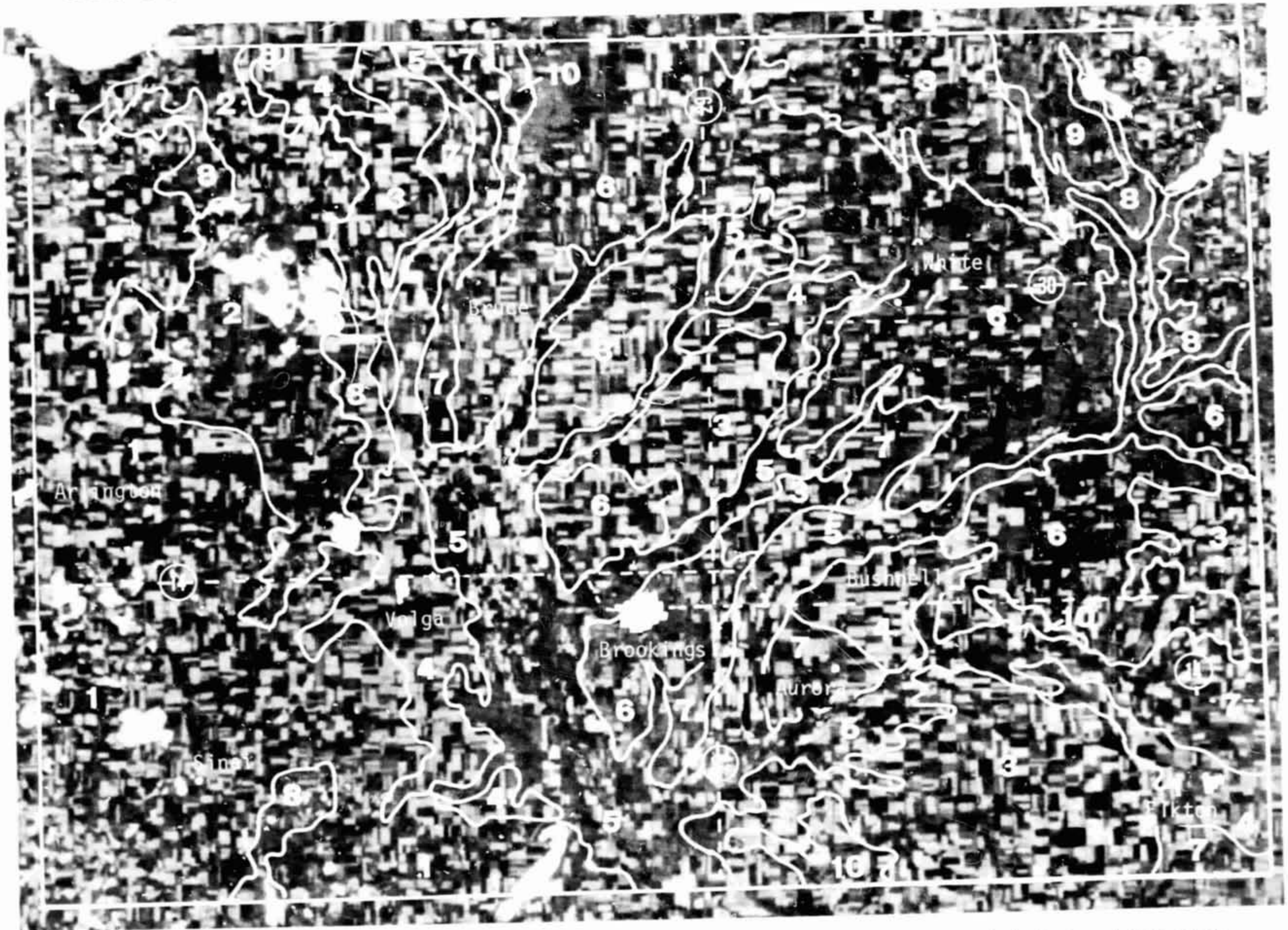
Plant Science Department, Agricultural Experiment Station, and Remote Sensing Institute, South Dakota State University, Brookings.

ERTS image of 17 June 73. Negative print of Band 7 Infrared. Water reflects white, bare soil very light gray, actively growing vegetation dark gray.

SCALE: 1:250,000 (1 inch = 4 miles)

——— - ——— Roads

Funded in part by the State of South Dakota and NASA University Affairs Office, Grant 42-003-007




## Brookings County, South Dakota

Use of this soil information discussed on reverse side.

1—Silty Clay Loams (undulating upland with marshes and lakes).
2—Silty Clay Loams and Loams (rolling upland with marshes and depressions).
3—Silty Clay Loams (sloping upland with stream drainage).
4—Silty Clay Loams (flat terrace, gravel substratum).
5—Silty Clay Loams and Clays (flat bottomlands, often wet, with variable depth to gravel).
6—Loams (sloping upland with stream drainage, may be stony).
7—Loams (flat terrace, gravel substratum).
8—Loams (hilly or steep uplands).
9—Loams (undulating upland with marshes and depressions).
10—Sandy Loams and Light Loams (sloping upland with stream drainage).

APPENDIX E

OFFICE ADDRESS:
1321 HOUSE OFFICE BUILDING
WASHINGTON, D.C. 20515
TELEPHONE: (202) 225-2801

DISTRICT FIELD OFFICES:
418 FOURTH STREET
BROOKINGS, SOUTH DAKOTA 57006
TELEPHONE (605) 692-4571

400 SOUTH PHILLIPS AVENUE
SIOUX FALLS, SOUTH DAKOTA 57102
TELEPHONE: (605) 336-2980

FRANK E. DENHOLM
1ST DISTRICT, SOUTH DAKOTA

Congress of the United States
House of Representatives
Washington, D.C. 20515

COMMITTEE ON AGRICULTURE
SUBCOMMITTEES:
LIVESTOCK AND GRAINS
DOMESTIC MARKETING AND CONSUMER RELATIONS
DEPARTMENT OPERATIONS

ADMINISTRATIVE ASSISTANT
MR. ARTHUR O. ANDERSON

September 19, 1974



Mr. Victor I. Myers, Director
Remote Sensing Institute
South Dakota State University
Brookings, South Dakota 57006

Reurlet 9/13/74

Dear Victor:

I acknowledge with gratitude the receipt of your above referenced letter together with a map of soil textures and land forms on Earth Resources Technology Satellite (ERTS-1) Imagery of the County of Brookings, South Dakota.

I have reviewed the enclosures with interest and I commend you and your associates on an excellent presentation of the vital services of ERTS-1 Imagery to the industry of Agriculture.

I am forwarding a copy of the enclosures to my good friend the Honorable W. R. "BOB" POAGE, Chairman of the House Committee on Agriculture for his information and evaluation of the essential services of ERTS to rural America.

It was thoughtful of you to write to me as you did and I welcome your advice and counsel on all future matters of mutual interest.

Thank you very much.

Sincerely,

Frank E. Denholm

FRANK E. DENHOLM, M.C.

FED/A/dc
(3)
74-9-475
cc: Honorable W. R. Poage, Chairman (info. w/encls.)
House Committee on Agriculture
1301 House Office Building
Washington, D.C. 20515

GEORGE McGOVERN
SOUTH DAKOTA

United States Senate
WASHINGTON, D.C. 20510



September 24, 1974

Dear Mr. Myers:

Thank you for your recent letter.

I agree that the technology of the Earth Resources Technology Satellite will prove to be extremely valuable in the management of our natural resources.

With every good wish, I am

Sincerely yours,

George McGovern

George McGovern

Victor I. Myers, Director
Remote Sensing Institute
South Dakota State University
Brookings, South Dakota 57006

JAMES ABDNOR
2D DISTRICT, SOUTH DAKOTA

WASHINGTON OFFICE:
1230 LONGWORTH BUILDING
WASHINGTON, D.C. 20515
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DISTRICT OFFICES:
439 FEDERAL BUILDING, PIERRE
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203 FARMERS AND
MERCHANTS BANK BUILDING, HURON
(605) 352-8117

307 NORTH MAIN, MITCHELL
(605) 996-3601

# Congress of the United States
## House of Representatives
### Washington, D.C. 20515

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EDUCATION AND TRAINING
HOSPITALS
INSURANCE

PHILIP N. HOGEN
ADMINISTRATIVE ASSISTANT

September 30, 1974

Dr. Victor I. Myers, Director
Remote Sensing Institute
South Dakota State University
Brookings, South Dakota 57006

Dear Dr. Myers:

Thank you very much for the ERTS-1 image of Brookings County and the explanatory information which relates to its application. I know that providing information on soils is but one of a multitude of potential practical applications of satellite imagery.

I look forward to being of any assistance possible in the further development of remote sensing technology, and I look forward to your continued interest in keeping me informed in this regard.

Sincerely,

Jim Abdnor

JAMES ABDNOR
Member of Congress

JA/adu

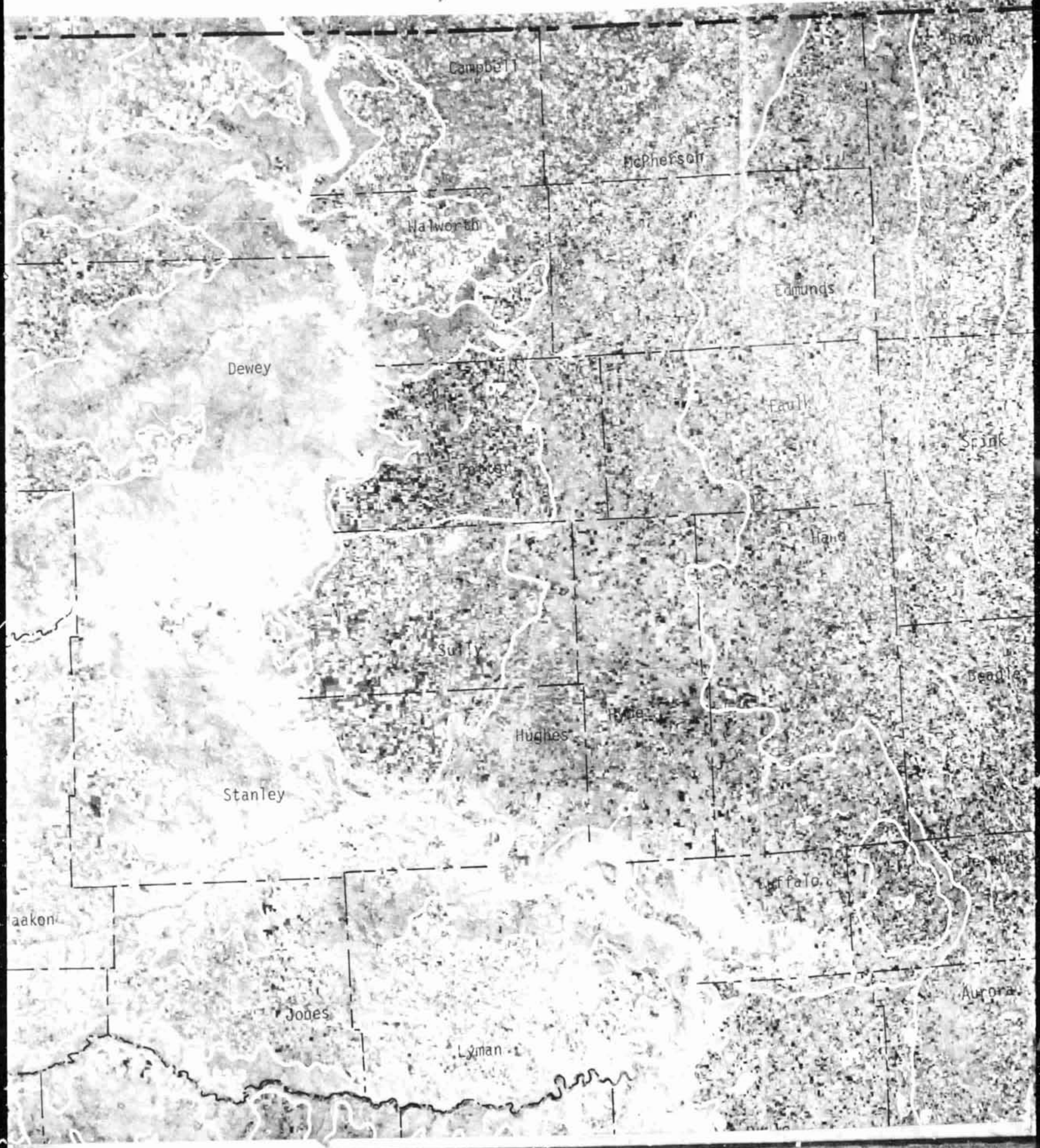
APPENDIX F

FOLDOUT FRAME

# ERTS Mosaic of South Dakota



2



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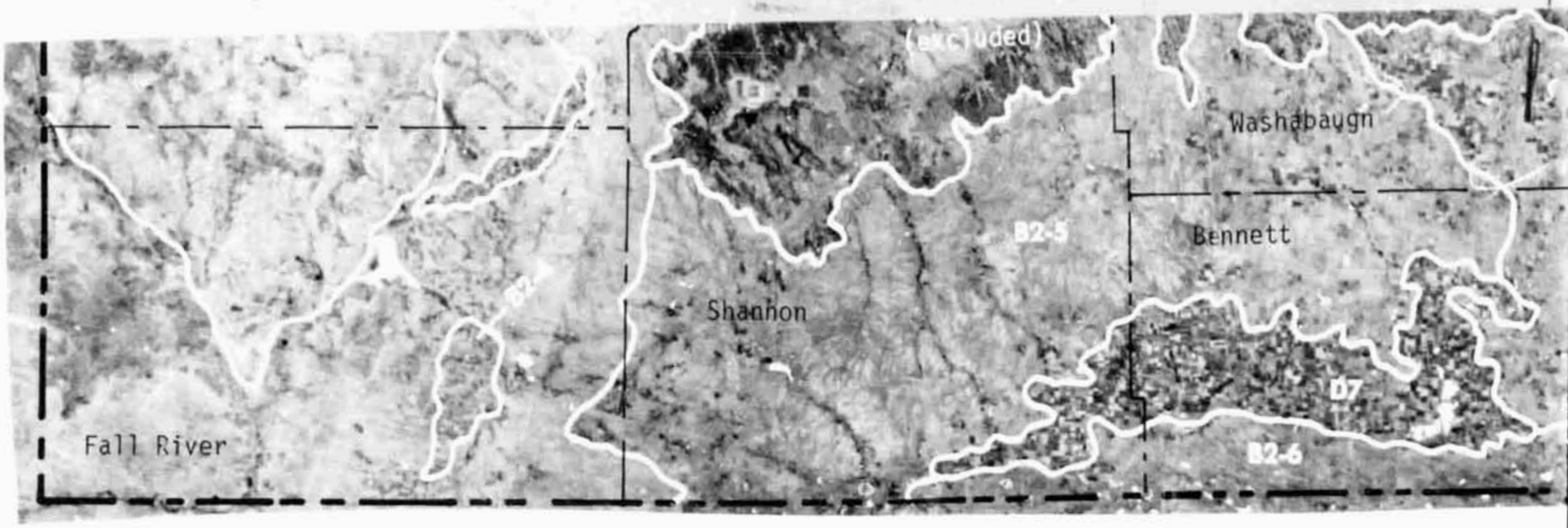



FOLDOUT FRAME 4

## SOIL ASSOCIATION VALUE AREAS

**Based on Major Land Use, 1967-72 Sale Prices of Unimproved Agricultural Land, (4,653 Sales), and Soils.**

A—Western Rangeland ($15-$20 average sale price per acre).
- A1 Undulating, dense clays from Cretaceous shale.
- A2 Undulating, sandy loams and sands from Cretaceous sedimentary rocks.

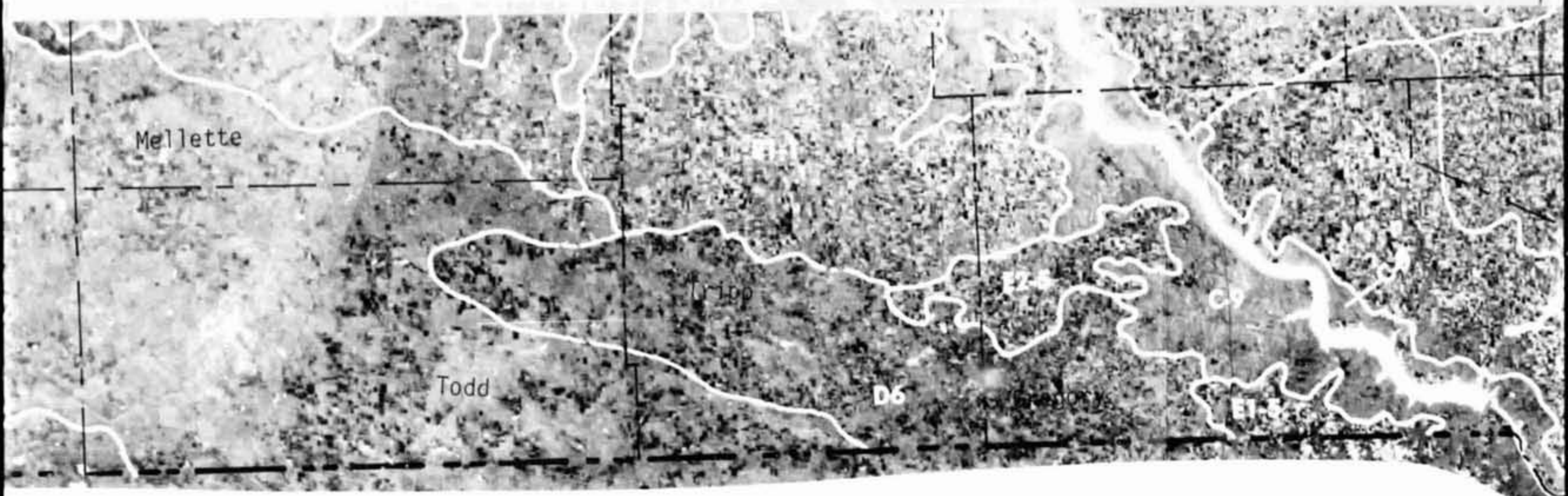
B1—Western Rangeland, with some Wheatland ($20-$25 average sale price per acre).
- B1-1 Rolling loams and clays, some with claypans from Upper Cretaceous materials.

B2—Western Rangeland and Wheatland ($26-$50 average sale price per acre).
- B2-1 Rolling loams and clays mainly along valley sides from Upper Cretaceous materials.
- B2-2 Strongly undulating clays on divides from Cretaceous shales.
- B2-3 Steep clays along valley sides from Cretaceous shales.
- B2-4 Undulating silty clays from Cretaceous shales and silts.
- B2-5 Rolling sandy loams and clays of the Pine Ridge from Tertiary materials.
- B2-6 Hummocky sands of the Sand Hills from Tertiary materials.

C—Wheatland, Rangeland or Pasture ($45-$76 average sale price per acre).
- C- 1 Undulating clay loams on western terraces
- C- 2 Undulating loams on tablelands from Fox Hills Cretaceous materials.
- C- 3 Undulating loams and sandy loams on broad stream divides from Cretaceous materials.
- C- 4 Strongly undulating clays from Cretaceous shales.
- C- 5 Strongly undulating silts and sandy loams from Tertiary materials.
- C- 6 Undulating clays from Cretaceous shales.
- C- 7 Strongly undulating glacial loams from stagnant ice materials.
- C- 8 Undulating silty clay loams from loess on residual plain.
- C- 9 Steep clays on valley sides from Cretaceous shales.
- C-10 Hilly clays from Cretace[...] moraines.
- C-11 Hilly loams from glacial [...]

D—Grain Crops, general agricult[...] average sale price per acre).
- D 1 Gently undulating silt[...] from stagnant ice materi[...]
- D 2 Gently undulating loa[...] loams from glacial till.
- D 3 Undulating silty clay lo[...] nant ice materials.
- D 4 Nearly level clay loams f[...]
- D 5 Undulating clays fro[...] shales.
- D 6 Undulating sandy loams [...] from Tertiary materials[...]
- D 7 Undulating silty clay l[...] lands from loess.
- D 8 Nearly level loams o[...] along Cheyenne River.
- D 9 Undulating silty clay l[...] nant ice materials.
- D10 Gently undulating silty [...] terraces along Missour[...]

E1—General Crops ($90-$115 av[...] per acre).
- E1-1 Undulating clays fr[...] shales.




FOLDOUT FRAME 5

...aceous shales.
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...al till on end
...ulture ($76-$100
...ilty clay loams
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E1-2 Flat silty clay loams and some undulating sands from Lacustrine sediments and outwash and till.
E1-3 Gently undulating silty clay loams from loess and stagnant ice deposits.
E1-4 Sloping silty clay loams from loess moderately deep over glacial till.
E1-5 Gently undulating loams on residual plain.
E1-6 Nearly level clay loams from glacial till.

E2—General Crops ($115-$150 average sale price per acre).
E2-1 Undulating silty clay loams from stagnant ice deposits.
E2-2 Nearly level loams from glacial till.
E2-3 Undulating silty clay loams from stagnant ice deposits.
E2-4 Nearly level silt loams from Lacustrine sediments.
E2-5 Undulating silty clay loams from loess.
E2-6 Sloping silty clay loams from loess.

F1—General crop, corn important ($140-$165 average sale price per acre).
F1-1 Nearly level loams from glacial till.
F1-2 Undulating silty clay loams from stagnant ice deposits.
F1-3 Nearly level silty clay loams from lacustrine deposits.

F2—Corn, soybeans and general crops ($160-$185 average sale price per acre).
F2-1 Sloping silty clay loams from loess.
F2-2 Strongly undulating silty clay loams from stagnant ice deposits.
F2-3 Gently undulating loams from glacial till.
F2-4 Strongly sloping silty clay loams from stagnant ice deposits.

G—Corn-Soybeans ($200-$275 average sale price per acre).
G1 Sloping clay loams from loess.
G2 Nearly level silty clay loams from loess moderately deep over glacial till.
G3 Strongly sloping silty clay loams from loess.

H—Corn, Soybeans and Alfalfa ($200-$425 average sale price per acre).
H1 Flat clays, silty clay loams, and sands from Alluvium

Imagery from Spring 1973 Negative Prints, Band 7 (IR). Plant Science Department and Remote Sensing Institute, South Dakota State University, Brookings; South Dakota Department of Revenue; and Soil Conservation Service, USDA.

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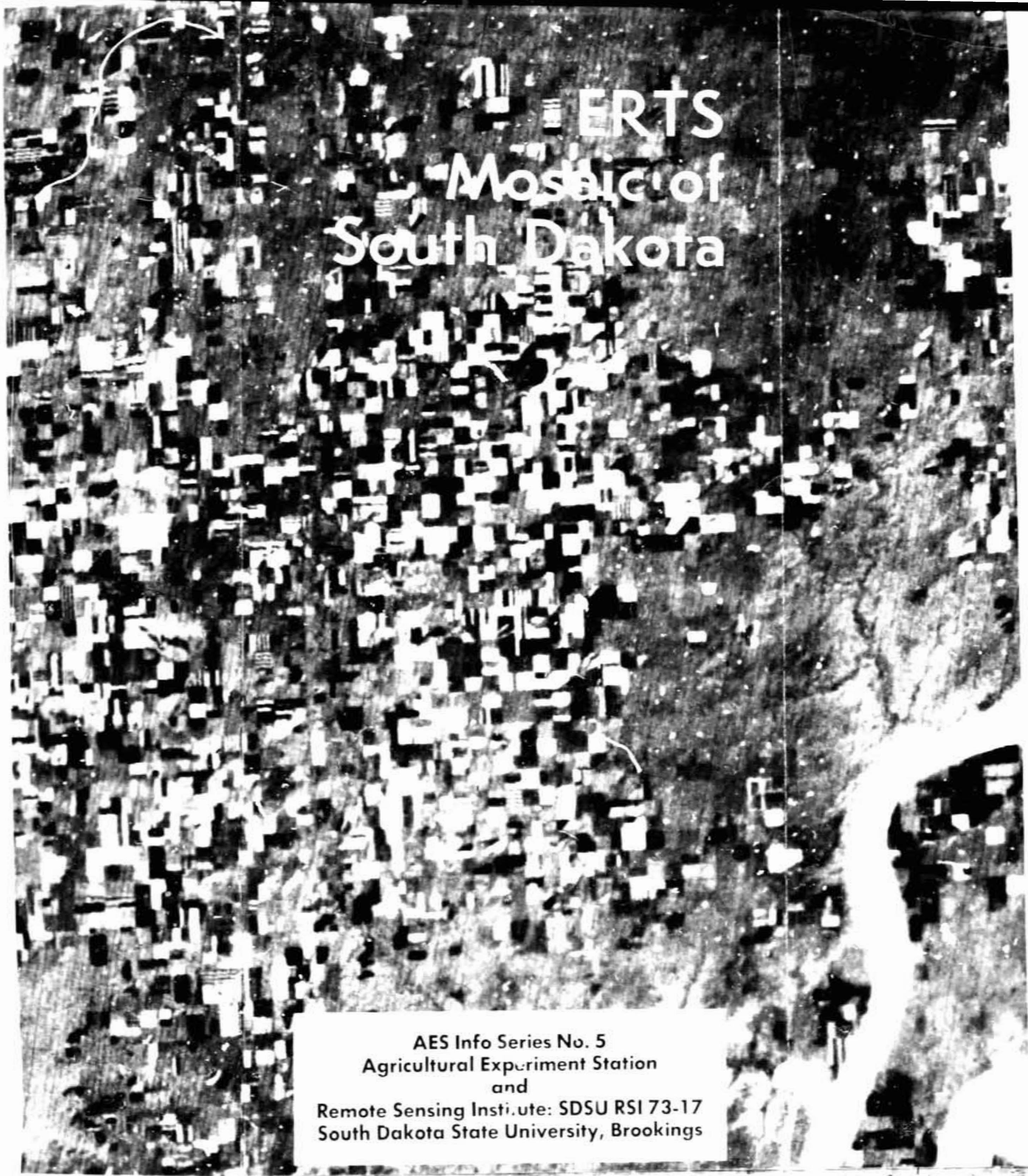
**ERTS Imagery Base Map. Scale about 1:1,000,000 (1" = about 16 miles)**

litional Information on Back of Map)

tation No. AES Info Series No. 5, Novem-
973, Agricultural Experiment Station and
Sensing Institute No. SDSU-RSI 73-17,
Dakota State University, Brookings, SD.
ed by Frederick C. Westin, professor,
Science Department, SDSU. ERTS mosaic
led by Jack Smith, photographic spe-
t, Remote Sensing Institute.
3M--11-73--1541

About this map: Three groups cooperated to prepare this map: (1) soil survey researchers from the South Dakota State University Agricultural Experiment Station and the USDA Soil Conservation Service who prepared the Soil Association separations; (2) the Directors of Assessment and the South Dakota Department of Revenue officers who compiled the land sales of unimproved agricultural land by Soil Associations; and (3) the South Dakota State University Remote Sensing Institute, and the National Aeronautic and Space Administration contract No. NASA-ERTS NAS5-21774, who furnished and prepared the ERTS Base Map from satellite imagery upon which Soil Association Value Areas are drafted.




The front cover of this publication shows an enlargement of an ERTS image using Band 7. Scale of the enlargement is 1:250,000. Most of the area showing on this negative print is in Lyman County, S. D. ERTS stands for Earth Resources Technology Satellite.

**Value of Map Areas Based on Sales 1967-1972 (4, 653 sales for state)**

| Map Area | Value in Dollars /Acre | No. of Sales | Map Area | Value in Dollars /Acre | No. of Sales |
|---|---|---|---|---|---|
| A1 | 15.24 | 24 | D8 | 78.00 | 2 |
| A2 | 17.13 | 7 | D9 | 89.20 | 85 |
| B1-1 | 23.90 | 134 | E1-1 | 97.92 | 93 |
| B2-1 | 37.77 | 158 | E1-2 | 115.88 | 170 |
| B2-2 | 45.77 | 101 | E1-3 | 105.74 | 107 |
| B2-3 | 25.84 | 238 | E1-4 | 90.49 | 117 |
| B2-5 | 42.06 | 27 | E1-6 | 125.36 | 22 |
| B2-6 | 43.45 | 11 | E2-1 | 117.59 | 193 |
| C1 | 45.41 | 19 | E2-2 | 121.81 | 193 |
| C3 | 53.65 | 70 | E2-3 | 119.98 | 108 |
| C4 | 58.72 | 91 | E2-4 | 149.24 | 8 |
| C5 | 64.05 | 36 | E2-5 | 130.66 | 3 |
| C6 | 55.19 | 20 | E2-6 | 127.58 | 64 |
| C7 | 68.99 | 568 | F1-1 | 164.59 | 390 |
| C9 | 66.50 | 38 | F1-2 | 142.59 | 74 |
| C10 | 64.18 | 42 | F1-3 | 140.47 | 29 |
| C11 | 76.47 | 146 | F2-1 | 164.07 | 14 |
| D1 | 86.66 | 51 | F2-2 | 180.03 | 55 |
| D2 | 96.42 | 573 | F2-3 | 171.54 | 25 |
| D3 | 91.00 | 71 | F2-4 | 183.50 | 32 |
| D4 | 93.05 | 57 | G1 | 253.09 | 81 |
| D5 | 82.05 | 38 | G2 | 238.20 | 133 |
| D6 | 93.15 | 32 | G3 | 226.82 | 29 |
| D7 | 88.46 | 24 | H1 | 281.33 | 50 |
| | | | | TOTAL | 4,653 |

Since land sale prices fluctuate, sometimes widely over short periods of time, the figures in this publication are valuable mainly in their relationship to each other. In other words, the relative values are more significant than the absolute values. In regard to absolute value data for a period 1967-1969 compared to 1970-1972 showed that for the state as a whole, values increased 13% over this period. But this varied among counties for a net loss of 7% for one county and a net gain of 71% for another county. Over 4,600 bona fide transactions of unimproved land were used in this compilation. Land sale prices have also increased since January 1973. Estimates of this average increase range from a few percentage points up to 20% or more.

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## Note about ERTS Imagery

The ERTS mosaic used for this base map was compiled from 20 ERTS scenes taken in May and June 1973. The imagery consists of negative prints from Band 7 of the Multispectral Scanner of the ERTS satellite orbiting the earth at a distance of about 550 miles. The MSS records energy reflected by the features of the earth in 4 bands, each in a different part of the spectrum. Band 4 is in the green, Band 5 in the visible red and Bands 6 and 7 in the near infrared.

On the negative prints of Band 7 used for this base map, water reflects white, fallow or bare soil very light gray, most grass medium to light gray, and vigorously growing vegetation dark gray. Thus, much can be deduced about soil use from the reflectances of just one of the ERTS bands. By comparing reflectances of all 4 ERTS MSS Bands "signatures" can be determined identifying virtually all uses of soils. ERTS mosaics as the one shown, provide a near orthographic view (very little distortion). The mosaic shown is at a scale of about 1:1,000,000 but the imagery can be enlarged to very useable maps at scales as large as 1:100,000. Also, false color composites of 2, 3, or 4 bands at different scales can be prepared to aid in identifying soil uses, and for hydrologic, geologic, geographic and other studies. To prepare a base map of South Dakota using conventional aerial photographs, it is estimated that 30,000 separate photographs would be necessary costing about $250,000. The ERTS base map used was compiled using 20 ERTS scenes. ERTS prints can be obtained at nominal cost from the EROS Data Center, Sioux Falls, S. D. The ERTS satellite provides complete coverage of the state every 18 days.