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REMOTE SENSING OF PHYSIOGRAPHIC SOIL UNITS OF BENNETT COUNTY, SOUTH DAKOTA

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Remote Sensing Institute
South Dakota State University
Brookings, South Dakota

February, 1973

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Interim Technical Report

REMOTE SENSING OF PHYSIOGRAPHIC SOIL UNITS OF BENNETT COUNTY, SOUTH DAKOTA

BY

C. J. FRAZEE, J. L. GROPPER AND F. C. WESTIN

TO

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ABSTRACT

A study was conducted in Bennett County, South Dakota, to establish a rangeland test site for evaluating the usefulness of ERTS data for mapping soil resources in rangeland areas. Photographic imagery obtained in October, 1970, was analyzed to determine which type of imagery is best for mapping drainage and land use patterns. The Plus-X film with 25A filter was best for mapping drainage and land use patterns.

Imagery of scales ranging from 1:1M to 1:20,000 was used to delineate soil-vegetative physiographic units. The photo characteristics used to define physiographic units were texture, drainage pattern, tone pattern, land use pattern and tone. These units will be used as test data for evaluating ERTS data. The physiographic units were categorized into a land classification system. The various categories which were delineated at the different scales of imagery were designed to be useful for different levels of land use planning. The land systems are adequate only for planning of large areas for general uses. The lowest category separated was the facet. The facets have a definite soil composition and represent different soil landscapes. These units are thought to be useful for providing natural resource information needed for local planning.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

REMOTE SENSING OF PHYSIOGRAPHIC SOIL UNITS OF BENNETT COUNTY, SOUTH DAKOTA[1]

by

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INTRODUCTION

With the ERTS-1 satellite a reality, research is needed to establish remote sensing techniques for mapping soils and soil limitations in rangeland areas from small scale imagery. Procedures must be developed for rapid semi-automatic and/or visual interpretation of space imagery. For spacecraft data the investigator or resource manager will probably remain as the decision maker in man-machine interactive data processing systems.

A definite need exists to establish data requirements for evaluating different soil and vegetative conditions. The type of data obtainable from different image scales must be tested in relation to the soils and range information needed for solving management problems concerning

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land use.

There are approximately 32,000,000 hectares of rangeland in the Northern Great Plains of which 10,400,000 hectares are in South Dakota. Soil and range inventories of these areas are limited because of the relatively high cost of obtaining ground-based information. Hopefully, information from the ERTS satellite will be of suitable quality for this purpose, providing the necessary research is conducted to establish correlations between the imagery and ground situations.

The capability and suitability of an area for different land uses are determined from information about soil limitations. The various types of soil limitation, according to the Soil Conservation Service (Klingebiel and Montgomery, 1961), are erosion, wetness, soil rooting zone, and climate. The land capability rating is used by members of the National Cooperative Soil Survey which is composed of agencies, both state and federal, who compile and use soil survey information for land use planning. Range conservationists subdivide the range into sites or landscape positions, based upon vegetation associated with climatic and soil characteristics. These range sites indicate the potential of the area for producing grass.

The present concept for using remote sensing to collect data about soil and range conditions encompasses using multispectral and temporal data from spacecraft and aircraft. Multistage sampling of basic soil physiographic units will be utilized. Satellite imagery will be interpreted by standard techniques of photo interpretation for delineation of general soil areas. Aircraft imagery will be used to identify and map the component parts of the general soil areas. With these concepts in mind, the objectives of this study were:

1. To establish a rangeland test site for determining the usefulness of ERTS imagery for mapping soil resources in rangeland areas.
2. To define soil-vegetative physiographic mapping units for various scales of imagery.

LOCATION AND DESCRIPTION OF STUDY AREA

The study area located in Bennett County is part of the Pine Ridge Reservation in southwestern South Dakota (Figure 1). Approximately 300,000 of the 761,000 acres of land in the county are Indian owned. The major uses of the land are ranching (75%) and winter wheat farming (23%).

Bennett County lies in the Missouri Plateau subdivision of the Great Plains physiographic province which is covered by Tertiary sediments (Fenneman, 1931). The climate is semiarid and continental with large variation in seasonal temperatures and precipitation. Approximately three-fourths of the county is covered with native mid to short range grasses. The three major soil associations of the study area are the rolling to hilly sandy soils of the Nebraska Sandhills in the south, the nearly level to gently sloping silty soils of the Martin Tableland, and the rolling to hilly loamy soils of the Arickaree Uplands (Chamberlain and Radeke, 1971).

The major soil limitations of the soils in the study area are:

1. Erosion of sloping upland soils
2. Wetness of depressional or alluvial areas
3. Soil rooting zone limitations
    a. claypans of varying depths and thickness
    b. shallow depth to gravel
    c. shallow sandy and silty soils
    d. shallow depth to bedrock
    e. salinity

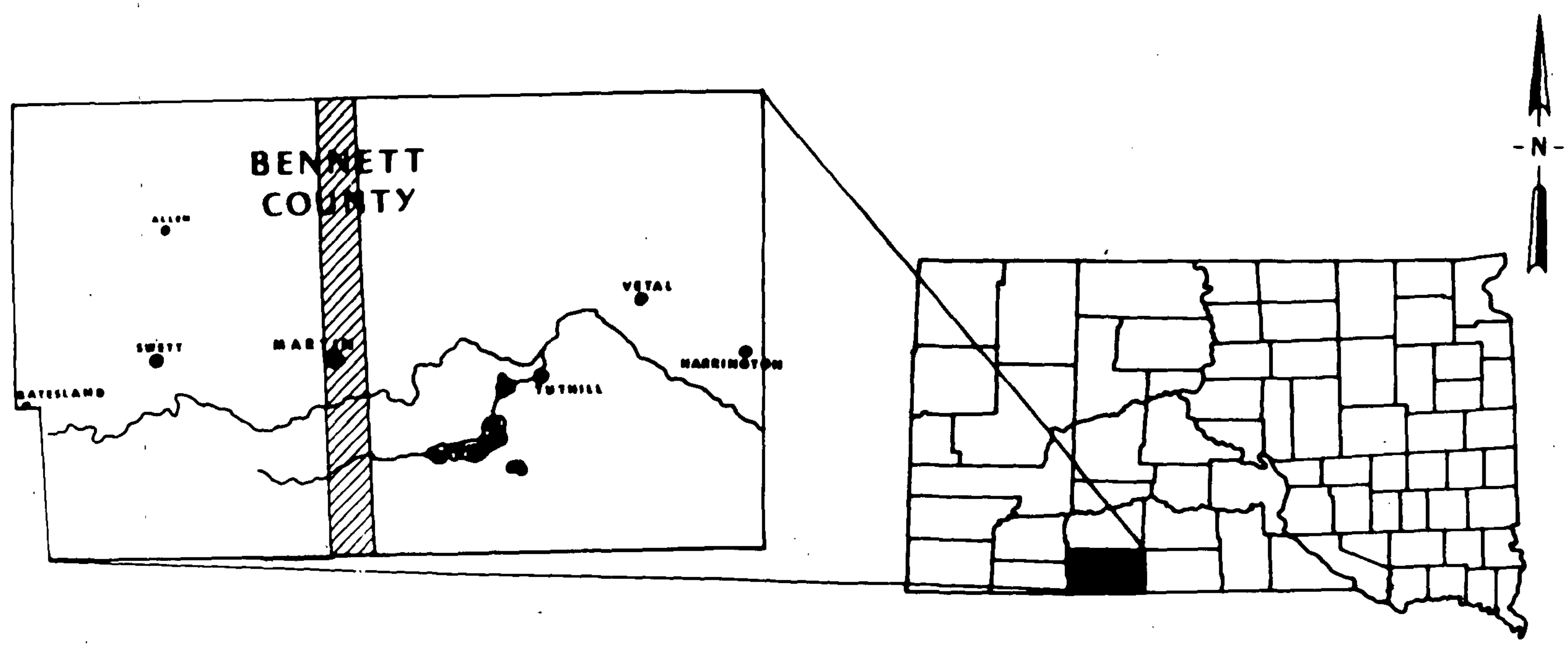


Figure 1. - Location of flight line in Bennett County, South Dakota.

Additional information about Bennett County and the study area can be found in Chamberlin and Radeke (1971) and Collins (1959, 1960).

EXPERIMENTAL METHODS AND PROCEDURES

The study area, which is twenty-eight miles long and two miles wide, is located in the central part of Bennett County (Figure 1). The legal description is as follows:

Bennett County, T39N, R37W, Sec. 4 and 5 to

T35N, R37W, Sec. 17 and 18.

Photographic and thermal infrared data were acquired for the study area, using the South Dakota State University Remote Sensing Institute's aircraft at an altitude of 3485 meters above ground level on October 15, 1970. The following sensors were flown: (1) 70 mm Hasselblad camera with black and white film filtered to study the green portion of the visible spectrum (Kodak 2402 with Wratten filter No. 58), (2) 70 mm Hasselblad camera with black and white film filtered to study the red portion of the visible spectrum (Kodak 2402 with Wratten filter No. 25A), (3) 70 mm Hasselblad camera with color infrared film (Kodak 2443 with filters 15G and 30M), (4) 70 mm Hasselblad camera with black and white infrared film (Kodak 2424 with Wratten filter No. 89B) and (5) a thermal infrared scanner, 4.5-5.5 μm wavelength. Ground truth information on the various land uses and soil and range conditions was recorded at the time of the overflights. Prints were made of the selected areas for laboratory and field study.

The major effort during the reporting period consisted of locating areas to be used as test sites for research using ERTS data and interpreting the imagery collected for features expected to be identifiable on ERTS imagery. The best film and filter combination was determined for photo analysis of drainage patterns and land use along the flight line. These analyses will be used as ground data for studying the potential of ERTS data for detecting soil limitations, identifying landforms, and determining proper land use.

A controlled analysis was conducted to establish the best photographic image for defining drainage and land use patterns. Two study areas were randomly picked and enlargement prints made to a scale of 1:20,000. A specific print was randomly selected, and then the order of the image type to be analyzed was randomly determined. By using this method for selecting the order of the images to be analyzed, an unbiased average for the overall analysis was obtained. The analyses were made on a mylar overlay attached to the print.

Photographs from earlier flights over the study area were used in addition to the imagery acquired for this project to develop the soil physiographic units (Table 1). A simulated ERTS scale photograph was made from the 1:322,500 mosaic.

The basic soil physiographic units were designed, utilizing the principles outlined by Vink (1968), Webster and Beckett (1970), Buringh (1960), and Christian and Stewart (1968). The nomenclature of Webster and Beckett (1970) was used to name the categories of the land classification system.

Table 1. Imagery Available for Bennett County, South Dakota

Year of Flight	Scale	Source
1937	1:60,000	National Archives & Records Services
1954	1:322,500	USGS
1954	1:60,000	ASCS
1961	1:60,000	ASCS
1967	1:63,000	ASCS
1970	1:63,000	RSI

RESULTS AND DISCUSSION

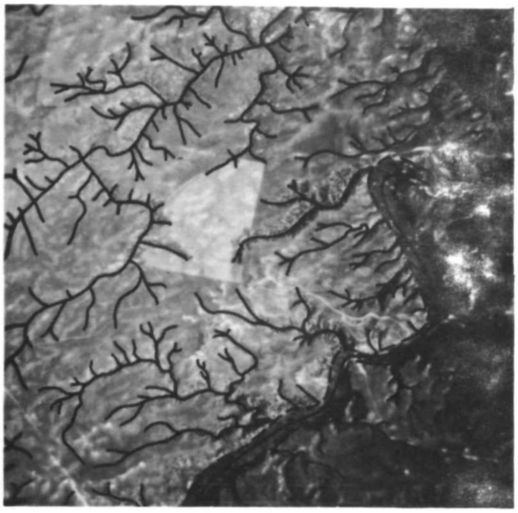
SPECTRAL ANALYSIS FOR DRAINAGE PATTERNS

A controlled analysis was conducted to establish the best type of imagery for defining drainage patterns in the Bennett County area. Four different types of imagery were analyzed in the experiment (Figure 2).

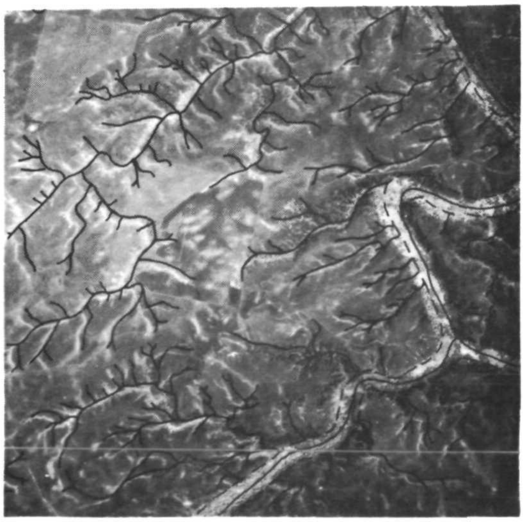
1. Plus-X film with red 25A filter
2. Ektachrome infrared film with G15/30M filters
3. Black and white infrared film with 89B film
4. Plus-X film with green 58 filter

Of the four types of imagery used, the Plus-X film with the red 25A filter proved to be the quickest and most efficient for detecting drainage patterns. More contrast was obtained through this film and filter combination than with any of the other imagery available. The drainage patterns showed up significantly darker on much lighter backgrounds. The IK-IR film with the G15/30M flights was placed second of the four types of imagery. Although the analysis with the EK-IR was much slower than the analyses using the BW-IR film or the Plus-X film with the green 58 filter, it was placed second in importance because many of the smaller drains showed up more clearly on the EK-IR film. At first glance, the BW-IR film with the 89B filter seemed to show the drainage pattern clearly. However, after further study many of the drainage features blended in with many of the lighter toned areas such as roads, trails, and eroded areas. The Plus-X film with the green 58 filter was the most inferior of the four. Utilizing this film and filter

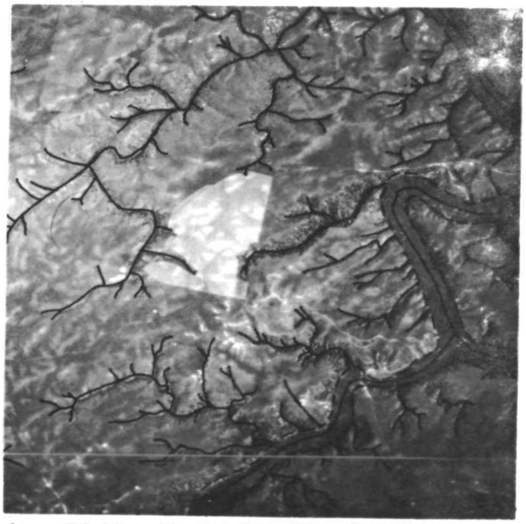
1. PLUS-X WITH 25A FILTER



2. EKIR WITH G15/30M FILTERS



3. B/W-IR WITH 89B FILTER



4. PLUS-X WITH 58 FILTER

Figure 2. - Comparison of film-filter combinations for drainage pattern analysis of Bennett County site.

combination, the least contrast was found between the drainage patterns and adjacent topography.

SPECTRAL ANALYSIS FOR LAND USE PATTERNS

An analysis was also conducted to determine the best imagery for defining land use patterns along the flight line. The same types of imagery analyzed for drainage patterns were analyzed in this experiment. Cropland, rangeland, and settlement patterns were the land use features evaluated on the imagery. Cropland field boundaries were found to show up best on the Plus-X film with the 25A red filter, although the crop species were easier to differentiate on the color infrared EK-IR film. Also, Plus-X film with the 25A filter proved to be the best for detecting rangeland differences. In analyzing settlement patterns such as towns and farms, the Plus-X film with the 25A filter again proved to be superior because of resolution and high contrast. On the basis of these analyses, the Plus-X film with the red 25A filter is best for identifying and mapping drainage and land use patterns.

PHYSIOGRAPHIC SOIL UNITS OF BENNETT COUNTY

Physiographic units of the landscapes in Bennett County were delineated using various scales of imagery. The map units were designed according to the various characteristics of the photographs. The photo characteristics used were: texture, drainage pattern, shape, tone patterns, and tone. Selective and elimination photo interpretation keys were constructed to demonstrate the usefulness of photo keys for delineation of physiographically similar areas of the Bennett County study area. An elimination key is a step-by-step process which enables the interpreter to proceed through a series of possible identifications, eliminating the incorrect categories. The elimination key in Table 2 allows the interpreter to proceed through a series of general categories to the specific category. A selective key consists of illustrations and descriptions from which the interpreter chooses the example which best represents the unknown area. These keys are guides which may be used by other people in similar areas.

Using the simulated ERTS imagery (scale - 1:1M), two broad physiographic areas were delineated (Figure 3). These units were differentiated on the basis of pattern and texture (Tables 2 and 3). The photographic image of the Sandhills Land Region (I) is characterized by an irregular texture and no drainage network. The medium sands allow the precipitation to infiltrate rapidly with little runoff to develop a drainage system. Ranching is the best use to which the land in this area is adapted. The sand dunes are used for grazing of the native range grasses, while the poorly drained valleys provide hay.

TABLE 2 - PHOTO INTERPRETATION KEY FOR PHYSIOGRAPHIC UNITS OF BENNETT CO. STUDY AREA

I. Irregular and smooth texture with little or no drainage patterns. Sandhills Land Region. 1:000,000.

   A. Light toned areas with irregular texture. Hilly to Rolling Sand Dunes. 1:60,000.

      1. Coarse irregular texture. Hilly to Rolling Dune Ridges and Knolls. 1:20,000.

      2. Moderately-coarse irregular texture interspersed with small areas of smooth texture. Undulating to Nearly Level Dunes. 1:20,000.

   B. Dark tones associated with smooth texture. Level Valleys and Basins with Shallow Water Table.

      1. Moderately dark tones. Level Valleys and Basins. 1:20,000.

      2. Dark Toned areas often with a dotted or striped pattern. Subirrigated Basins and Wetlands. 1:20,000.

II. Dense to moderate dendritic drainage patterns. Level areas often associated with geometric shapes and patterns. Arickaree Plain Land Region. 1:1,000,000.

   A. Well developed drainage pattern and absence of geometric shapes and patterns. Steep to Rolling Uplands with Steep Valleys and Canyons. 1:60,000.

1. Areas with well integrated drainage pattern around major drainage networks, often containing small linear lighter toned areas. Steep and Hilly Sloping Valleys and Canyons. 1:20,000.
2. Areas lacking major drains and linear features. Undulating to Rolling Uplands. 1:20,000.

B. Geometric shapes and patterns with absence of major drainage patterns. Nearly Level and Undulating Tablelands. 1:60,000.

1. Minor drains associated with lighter toned linear features. Undulating Tablelands. 1:20,000.
2. Absence of drainage patterns and lighter toned linear features. Nearly Level to Flat Tablelands. 1:20,000.
3. Mottled texture. Nearly Level Tablelands with Claypans. 1:20,000.

TABLE 3. MAJOR LANDSCAPES OF BENNETT COUNTY STUDY AREA

Sandhills

I. Unconsolidated sand dunes consisting of fine sand derived from the underlying formation. Dunes have a relief of 25 to 35 meters with interspersed dry valleys, subirrigated basins, and lakes.

FORM	SOILS, HYDROLOGY	LAND USE	LIMITATIONS
A. Hilly to rolling sand dunes.			
1. Dune ridges, hilly,15-35% slope.	Light colored, very thin sandy soil, excessively drained, rapid permeability.	Native range	Very severe wind erosion, low moisture holding capacity, low fertility.
2. Rounded dune ridges and knolls, undulating to rolling, 3-18% slope.	Light colored, thin sandy soil, excessively drained, rapid permeability.	Native range	Very severe wind erosion, low moisture holding capacity, low fertility.
B. Level to gentle sloping valleys and basins.			
1. Nearly level valleys, 0-3% slope.	Moderately dark and dark colored sandy soils, somewhat poorly drained, rapid permeability, seasonally high water table.	Native range and hayland	Seasonally high water table, severe wind erosion, low moisture holding capacity.

TABLE 3. CONTINUED

2. Level to concave basins	Dark colored loamy soils, poorly drained, moderately rapid permeability, water table near surface.	Native range and hayland	Severe wind erosion high water table near surface year around.

Arickaree Plain

II. Silty and loamy sedimentary formations dissected by deeply entrenched streams in northern part. Southern part is a nearly level to gently rolling loess covered tableland with a few deeply incised drainageways. Elevation around 900 meters with local relief of 6-60 meters.

FORM	SOILS, HYDROLOGY	LAND USE	LIMITATIONS
A. Rolling uplands with steep valleys and canyons.			
1. Side slopes of buttes, valleys, canyons, hilly, 18-40% slope.	Shallow loamy soils, somewhat excessively drained, moderately rapid permeability	Native range	Shallow depth to bedrock, low fertility, low moisture holding capacity, severe wind erosion.
2. Rolling uplands, 9-18% slope.	Deep and moderately deep silty and loamy soils, well drained, moderate permeability.	Native range	Moderate fertility, moderate water holding capacity, severe wind and water erosion.

TABLE 3. CONTINUED

B. Nearly level to undulating tablelands and uplands.			
1. Upland, gently sloping, 2-6% slope.	Deep silty soils, well drained, moderate permeability.	Winter wheat	Moderate water and wind erosion.
2. Upland, nearly level to level, 0-2% slope.	Deep silty soils, moderately well drained, slow permeability.	Winter wheat and alfalfa	Slight wind erosion.
3. Upland, level, 0-2% slope.	Deep silty claypan soils, somewhat poorly drained, very slow permeability.	Cropland or hayland	Wetness, salinity, restricted root growth and moisture penetration due to claypan.

BENNETT COUNTY, SOUTH DAKOTA

SIMULATED ERTS IMAGERY

I=SANDHILLS

II=ARICKAREE PLAIN

SCALE

0 30 MILES

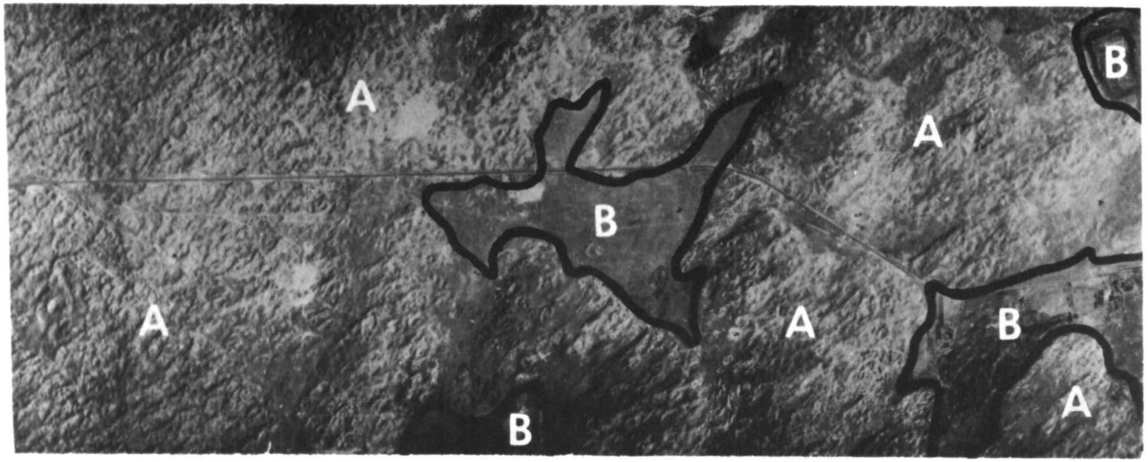
Figure 3. - Simulated ERTS imagery of the Bennett County area in southwestern South Dakota. Scale = 1:1,000,000.

The Arickaree Plain Land Region (II) was delineated by the well developed dendritic drainage pattern in the northern part and the geometric shapes of the cultivated fields in the southern part (Figure 3, Tables 2 and 3). The landforms in the area are developed from medium textured Tertiary sediments. The use of the land for agricultural purposes is dictated by slope. The nearly level and undulating areas are suitable for cultivation. The boundary between these two land regions also serves as a boundary for the lower categories which were separated on imagery of larger scales.

Imagery with a scale of 1:60,000 was used to distinguish the subdivisions of the land regions. The Sandhills land region was subdivided into two land systems (Tables 2 and 3, Figure 4). Texture is the primary characteristic of the photograph utilized for the separation of the two units. Within the Sandhills land region, the hilly to rolling sand dunes (A) appear on the photographs as areas with light tones and irregular texture (Figure 4). These areas are well adapted for grazing of the native grasses. The areas which have smooth texture and dark tones on the imagery are the valleys and basins with high water tables (Figure 4). These tracts are excellent for the production of hay if water table is not at the surface.

The Arickaree Plain Land Region was separated into two land systems on the basis of the drainage pattern and geometric shapes of the fields (Tables 2 and 3, Figure 5). The steep to rolling loamy uplands (A) are dissected by a well developed dendritic drainage system. These areas are best suited for grazing of the native grasses (Figure 5). The

I. SANDHILLS



A.=ROLLING SAND DUNES

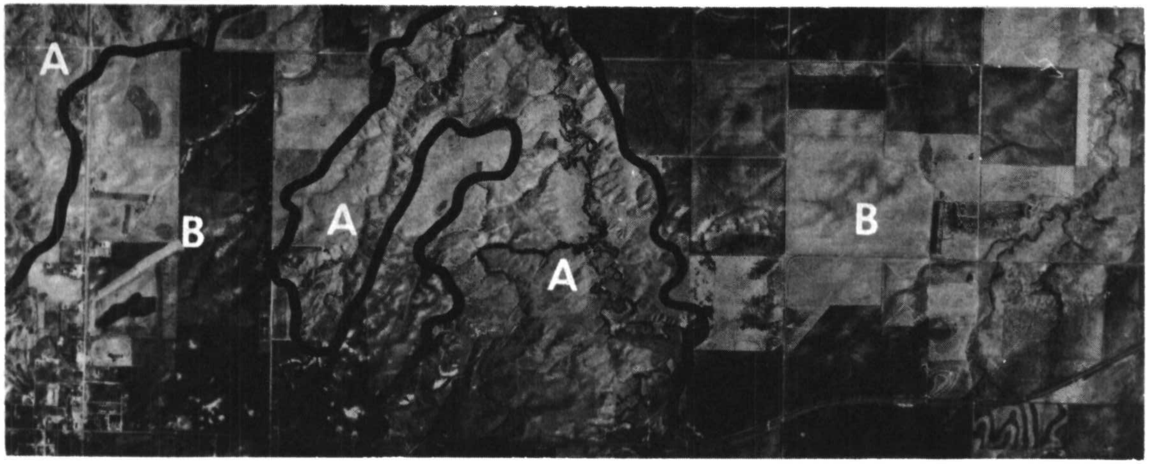
B.=NEARLY LEVEL VALLEYS AND BASINS

SCALE

0 5 MILES

Figure 4. - Subdivisions of Sandhills Land Region on figure 3. Scale = 1:60,000.

II. ARICKAREE PLAIN



A.=ROLLING AND STEEP UPLANDS

B.=NEARLY LEVEL AND UNDULATING TABLELANDS

SCALE

0 5 MILES

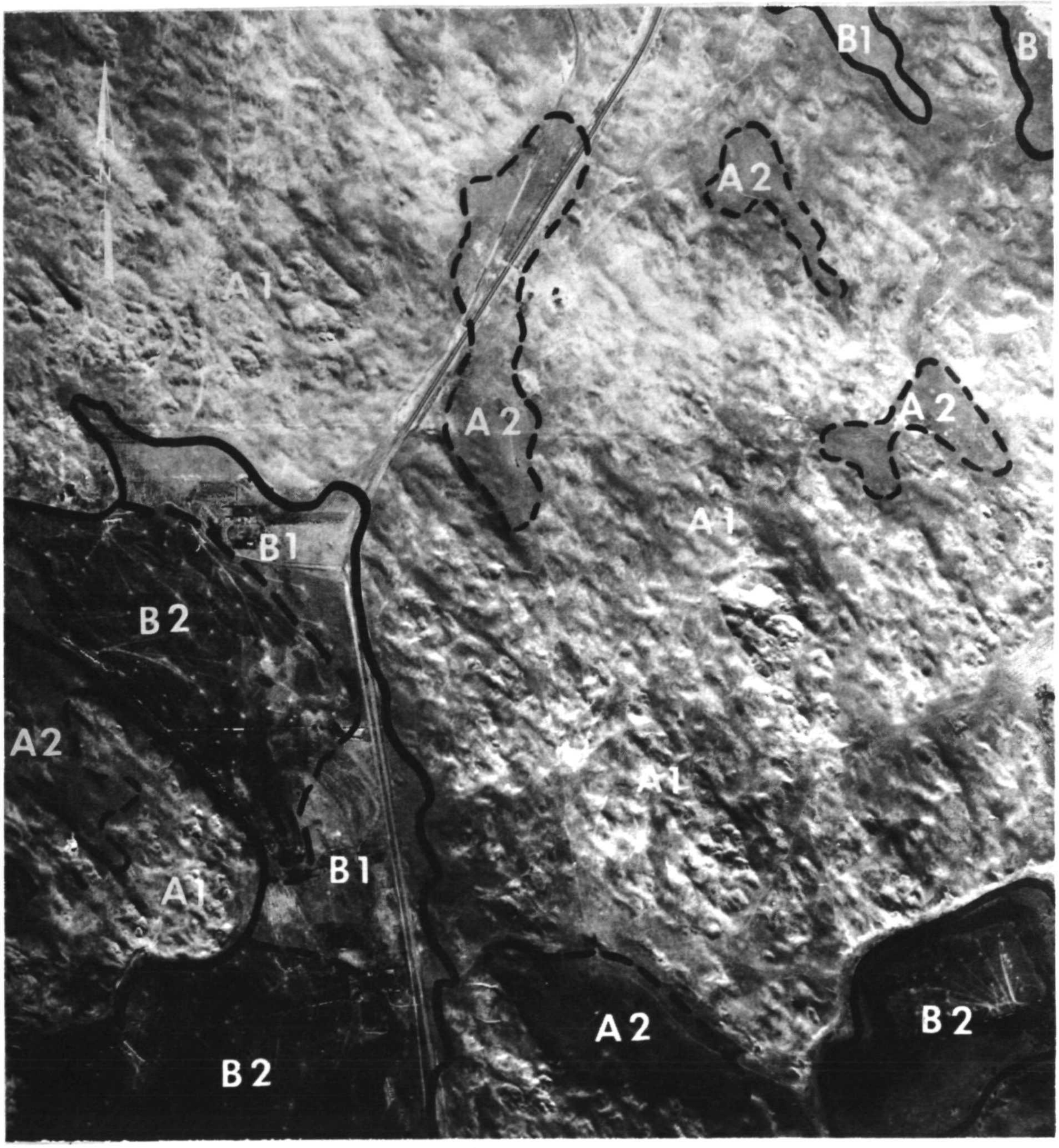
Figure 5. - Subdivisions of Arickaree Plain Land Region on figure 3. Scale = 1:60,000.

portion of the photographs where the drainageways are absent are the nearly level to rolling silty uplands (B) which are suited for cultivation. The boundary between the land systems is also the boundary of the subdivisions of the land systems.

The imagery used to delineate the subdivisions of the land systems had a scale of 1:20,000. The hilly to rolling sand dunes land system of the Sandhills land region was separated into two parts based upon the degree of irregular texture on the photography (Tables 2 and 3, Figure 6). The dune ridges and knolls (A1) correspond with the portion of the imagery having irregular texture (Figure 6). The undulating to rolling sand dunes are correlated with the areas on the photographs which have a smoother texture (Figure 6). Both of these units are best used as rangeland.

The level valleys and basins with high water tables land system of the Sandhills land region were separated into two parts according to tone (Tables 2 and 3, Figure 6). The areas of moderately dark tones on the photographs correlated with the dryer portion of the valleys and basins (Figure 6). These areas (B1) are used primarily for grazing. The portions of the photograph which have dark tones are the subirrigated parts of the valleys and basins (Figure 6). The subirrigated areas (B2) are used where possible for production of hay.

The subdivisions of the steep to rolling uplands land systems of the Arickaree Plain land region were based upon the density and type of drainageways (Tables 2 and 3, Figure 7). The areas which have the well developed dendritic drainage pattern are the steep valleys and



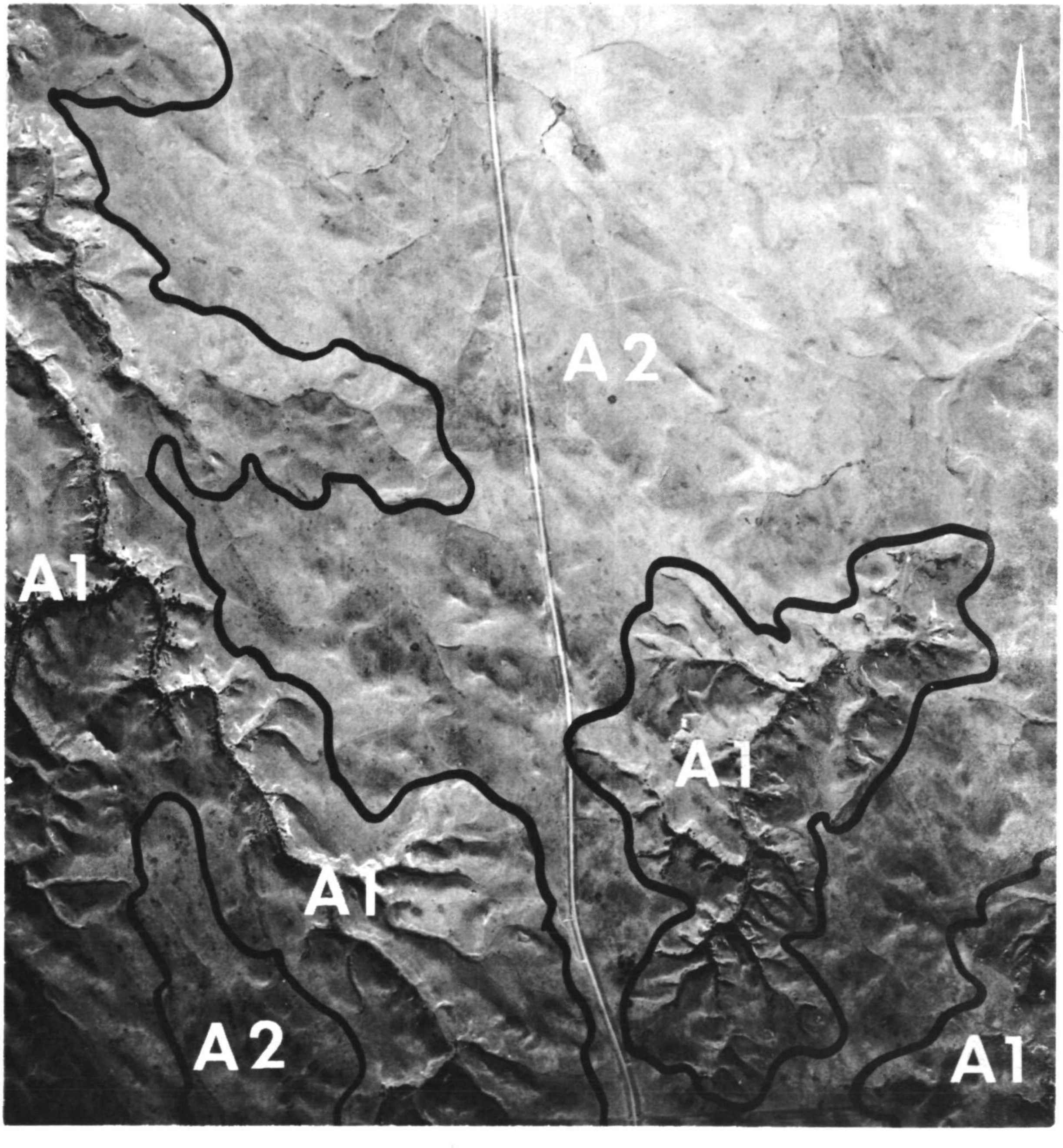
A1.=DUNE RIDGES AND KNOLLS

A2.=UNDULATING TO ROLLING DUNES

B1.=DRY VALLEYS AND BASINS

B2.=SUBIRRIGATED BASINS AND WETLANDS

Figure 6. - Subdivisions of A and B on figure 4. Scale = 1:20,000.



A1.=STEEP VALLEYS AND CANYONS

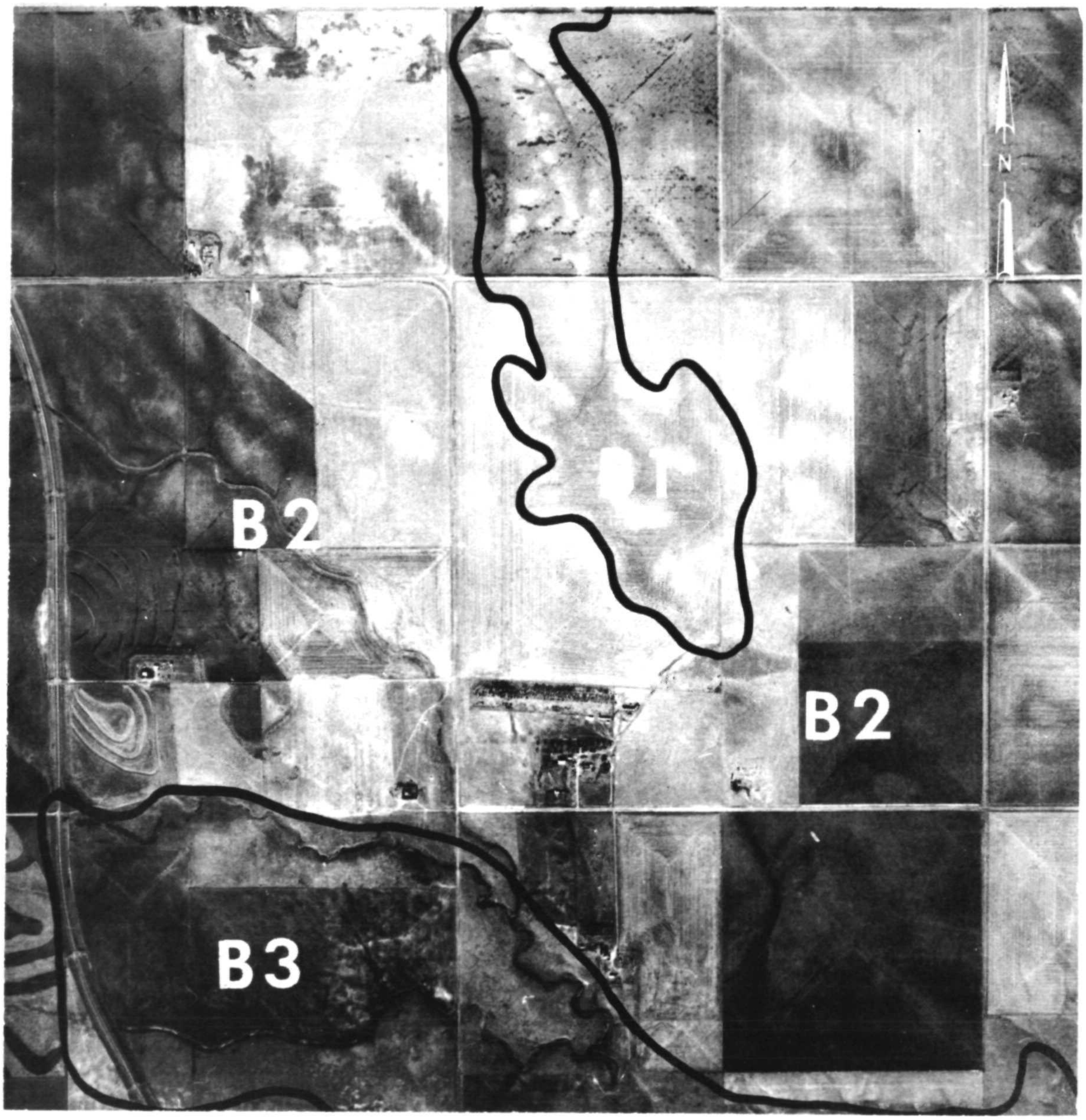
A2.=UNDULATING TO ROLLING UPLANDS

Figure 7. - Subdivisions of A on figure 5. Scale = 1:20,000.

canyons (Figure 7). These areas are not suited for range improvement practices because tillage implements can not traverse the landscape. The A2 subdivisions are characterized on the photographs as lacking major drainageways (Figure 7). These undulating to rolling uplands are best utilized as rangeland.

The nearly level and undulating tablelands land system of the Arickaree Plain land region was separated into three parts (Figure 8). Subdivision B1 (undulating tablelands) appears on the photograph as having a tonal pattern of lighter toned circular or linear features. These features are usually next to a minor drainageway. The areas have wind and erosion hazards which must be controlled when these areas are farmed (Tables 2 and 3, Figure 8). The areas with the least contrast in tones on the photographs are the best land in the region. These nearly level to flat tablelands (B2) have only a slight erosion hazard (Tables 2 and 3, Figure 8). The portions of the photograph which have a mottled texture correlate with areas having claypan limitations (Tables 2 and 3, Figure 8). The soils in these areas have claypans at varying depths in the profile which hinder downward movement of water and root penetration. A selective photo key aerial and ground view of the subdivisions of the land systems are illustrated in Figures 9-16.

Most of the subdivisions of the land systems are complexes of soil mapping units as defined in standard detail soil surveys. To map the individual soil mapping units is normally impractical and impossible at scales of 1:20,000. Imagery at a scale of 1:7,920 would be needed to



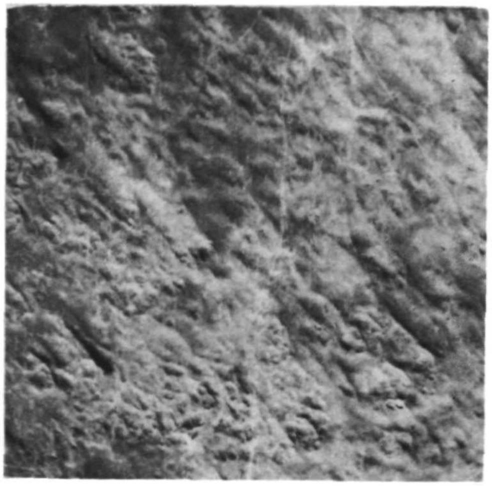
B1.=UNDULATING TABLELANDS

B2.=NEARLY LEVEL TO FLAT TABLELANDS

B3.=NEARLY LEVEL TABLELANDS WITH CLAYPAN LIMITATIONS

Figure 8. - Subdivisions of B on figure 5. Scale = 1:20,000.

IA1. HILLY TO ROLLING DUNE RIDGES AND KNOLLS

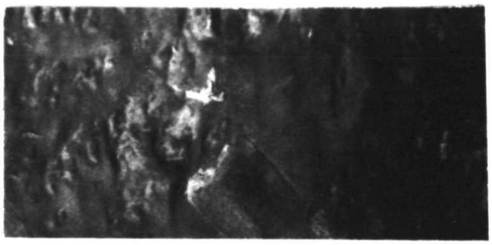


AIR PHOTO
scale = 1:20,000

GROUND VIEW

Figure 9. - The hilly to rolling dune ridges and knolls are identified by the coarse irregular texture.

IA2. UNDULATING TO GENTLY SLOPING DUNES

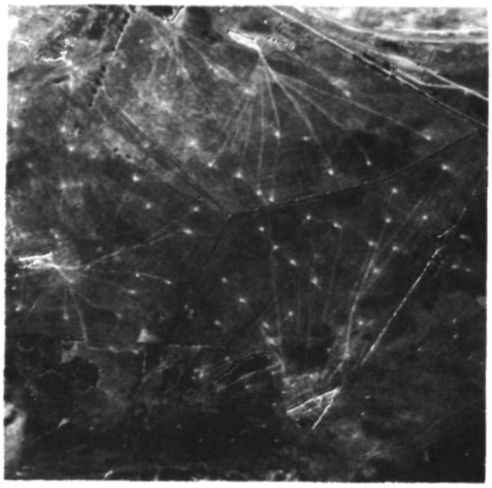


AIR PHOTO
scale = 1:20,000

GROUND VIEW

Figure 10. - The undulating to gently sloping dunes are identified by a moderately coarse texture interspersed with small areas of smooth texture.

IB2. LEVEL VALLEYS AND BASINS

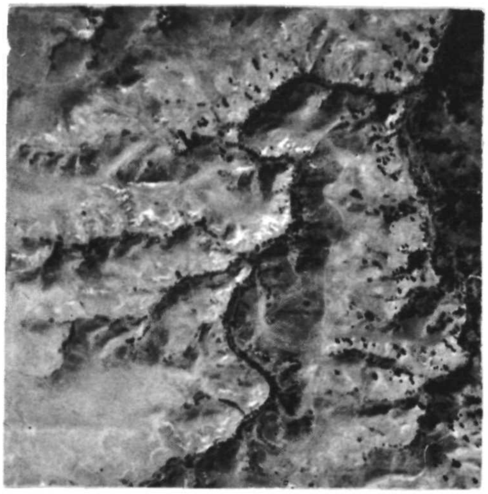


AIR PHOTO
scale = 1:20,000

GROUND VIEW

Figure 11. - Level valleys and basins are identified by a smooth texture and moderately dark tones.

IIA1. STEEP TO ROLLING UPLANDS WITH STEEP VALLEYS AND CANYONS

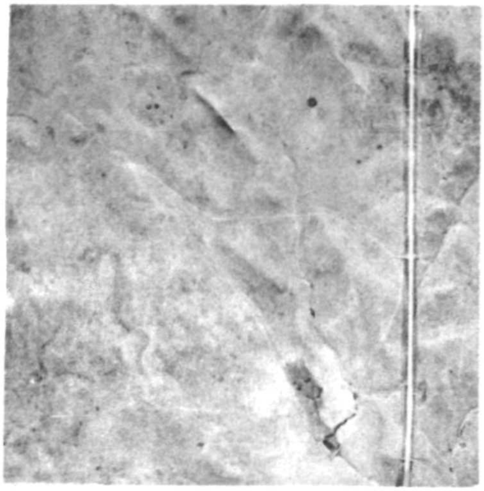


AIR PHOTO
scale = 1:20,000

GROUND VIEW

Figure 12. - Steep to rolling uplands with steep valleys and canyons are identified by a well integrated drainage network often associated with small linear lighter toned areas.

IIA2. UNDULATING TO ROLLING UPLAND

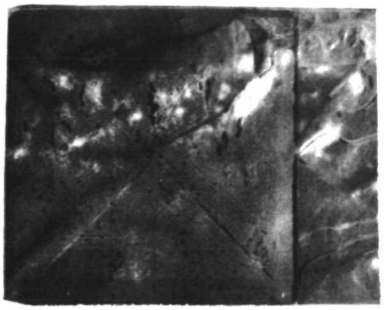


AIR PHOTO
scale = 1:20,000

GROUND VIEW

Figure 13. - The undulating to rolling uplands lack major drains and linear features.

IIB1. UNDULATING TABLELANDS

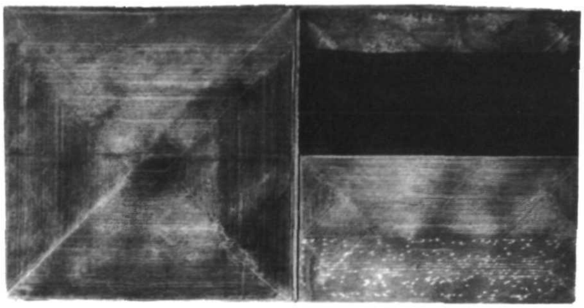


AIR PHOTO
scale = 1:20,000

GROUND VIEW

Figure 14. - The undulating tablelands are identified by minor drains associated with lighter toned linear features

IIB2. NEARLY LEVEL TO FLAT TABLELANDS



AIR PHOTO
scale = 1:20,000

GROUND VIEW

Figure 15. - Nearly level to flat tablelands lack drainage patterns and lighter toned linear features.

IIB3. NEARLY LEVEL TABLELANDS WITH CLAYPAN LIMITATIONS

AIR PHOTO
scale = 1:20,000

GROUND VIEW

Figure 16. - Nearly level tablelands with claypan limitations are identified by mottled texture.

accomplish this task in most of the areas delineated in this study. To make interpretations for land use planning for the subdivision of the land systems, it is necessary to estimate the composition of the units. In the claypan areas the scale of the imagery would have to be larger than 1:7,920 because the individual soil units are smaller.

Previous work has shown that density slicing techniques should be helpful for providing information on soil composition of the physiographic units (Frazee et al., 1972).

The composition of the soil mapping units of the subdivisions of the land systems was estimated by measuring the percentage of each soil mapping unit occurring in the areas, using the published soil survey as a standard (Chamberlin and Radeke, 1971). The tabulation of this information is listed in Table 4. The average composition of the subdivisions of the land systems in Bennett County is listed in Table 5. These data indicate that the subdivisions have a definite composition and, except for IA1 and IA2, are composed of different kinds of soils.

TABLE 4
Soil Mapping Unit Composition of Subdivisions of Land Systems in Bennett Co.

Facet	Soil Mapping* Unit	%	Capability* Unit	Range* Site
IA1	VaC	78	VIe - 2	Sa
	VaD	21	VIIe - 1	Chs
	Bo	1	VIe - 2	Sa
IA2 & IB1	VaC	72	VIe - 2	Sa
	Du	16	IVe - 3, IVw - 1	Sy, Sb
	DvB	10	IVe - 3, VIe - 2	Sy, Sa
	Lo	1	Vw - 1	Sb
	Bo	1	VIe - 2	Sa
IB2	Lo	43	Vw - 1	Sb
	Ga	35	Vw - 1	WL
	Du	22	IVe - 3, IVw - 1	Sy, Sb
IIA1	CoF	46	VIIs - 1, VIe - 1	Sh, Si
	CnF	24	VIIs - 1, VIIIs - 1	Sh, **
	OcE	17	VIe - 1, VIIs - 1	Si, Sh
	AtE	6	VIe - 1, VIs - 2	Sy, Sh
	Cr	5	VIIs - 1, VIIIs - 1	Sh, **
	Aa	2	VIw - 1	Sb
IIA2	OcE	68	VIe - 1, VIIs - 1	Si, Sh
	KrB	14	IIe - 1	Si
	CoF	8	VIIs - 1, VIe - 1	Sh, Si
	RkB	5	IIe - 1	Si
	GoA	5	IIc - 1	Ov
IIB1	OcE	49	VIe - 1, VIIs - 1	Si, Sh
	KrB	19	IIe - 1	Si
	RkA	11	IIc - 1	Si
	RkB	9	IIe - 1	Si
	CyD2	5	VIs - 2, IIIe - 1	Sh, Si
	DrB	5	IIIs - 1, IIc - 1	Si
	Hv	2	VIs - 1	CD
IIB2	DrB	35	IIIs - 1, IIc - 1	Si
	RkB	23	IIe - 1	Si
	RkA	20	IIc - 1	Si
	KrB	15	IIe - 1	Si
	Hv	5	VIs - 1	CD
	GoA	1	IIc - 1	Si
	KeB	1	IIe - 1	Si

TABLE 4
(Continued)

Facet	Soil Mapping* Unit	%	Capability* Unit	Range* Site
IIB3	Mm	57	IVs - 1, VIs - 1	Cp, SL
	KrB	19	IIe - 1	Si
	DrB	15	IIIs - 1, IIc - 1	Si
	KrA	4	IIc - 1	Si
	Du	4	IVe - 3, IVw - 1	Sy, Sb
	RkB	1	IIe - 1	Si

* A complete description of the soil mapping unit, capability unit and range site designations may be found in the Bennett County soil survey (Chamberlin and Radeke, 1971).

** A portion of this unit is rock outcrop which has no range site designation.

TABLE 5. Average Composition of Facets in Bennett Co.

Facet	Soil Mapping Units	%	Capability Unit	%	Range Site	%
IA1	Valentine fine sand	99	VIe - 2	78	Sands	79
	Other	1	VIIe - 1	21	Choppy sands	21
IA2	Valentine fine sand	77	VIe - 2	78	Sands	77
&	Dunday loamy fine sand	17	IVe - 3	17	Sandy	17
IB1	Other	6	Other	5	Other	6
IB2	Loup fine sandy loam	43	Vw - 1	78	Subirrigated	50
	Gannett fine sandy loam	35	IVe - 3	15	Wetlands	35
	Dunday loamy fine sand	15	Other	7	Sandy	15
	Other	7				
IIA1	Canyon Loam	58	VIIs - 1	58	Shallow	60
	Oglala loam	29	VIe - 1	29	Silty	29
	Other	13	Other	13	Other	11
IIA2	Oglala loam	44	VIe - 1	44	Silty	63
	Canyon loam	32	VIIs - 1	32	Shallow	32
			IIe - 1	19	Other	5
	Other	24	Other	5		
IIB1	Oglala loam	29	IIe - 1	30		
	Canyon loam	24	VIe - 1	29	Silty	74
	Keith silt loam	20	VIIs - 1	24	Shallow	24
	Other	27	Other	17	Other	2
IIB2	Keith silt loam	35	IIc - 1	37	Silty	89
	Richfield silt loam	33	IIe - 1	35	Other	11
	Dawes silt loam	22	IIIs - 1	22		
	Other	10	Other	6		
IIB3	Mosher silt loam	40	IVs - 1	40	Claypan	40
	Minatare loam	17	IIe - 1	20	Silty	39
	Keith silt loam	12	VIs - 1	17	Saline lowland	17
	Other	31	Other	23	Other	4

SUMMARY AND CONCLUSIONS

A study was conducted in Bennett County, South Dakota, to establish a rangeland test site for evaluating the usefulness of ERTS data for mapping soil resources in rangeland areas. A controlled analysis of photographic imagery obtained in October, 1970, was conducted to determine the best type of imagery for mapping drainage and land use patterns. Selective and elimination photo interpretation keys were constructed for soil-vegetative physiographic units which were delineated on imagery of various scales.

The Plus-X film (Kodak 2402) with a 25A filter was best, when compared to the Plus-X film with a 58 filter, EK-IR film (Kodak 2443) with G15/30M filters and BW-IR (Kodak 2424) with a 89B filter, for mapping drainage and land use patterns. These patterns were used to delineate the land regions.

Imagery of scales ranging from 1:1,000,000 to 1:20,000 were used to delineate soil-vegetative physiographic units. Physiographic units were designed, based upon the characteristics of the photographs. The photographic characteristics used were texture, drainage pattern, slope, tone pattern, land use pattern, and tone. The physiographic units were categorized into a land classification system as described by Christian and Stewart (1968) and Webster and Beckett (1970). The lower categories of the system are subdivisions of the higher categories. The lowest categorical unit separated in this study was the facet. The soil composition of the facets was evaluated, using the published soil survey. The facets have a definite composition and represent different soil landscapes.

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