

APPLICATION OF ERTS-1 IMAGERY IN MAPPING AND MANAGING SOIL AND RANGE RESOURCES IN THE SAND HILLS REGION OF NEBRASKA

Paul M. Seevers, David T. Lewis and James V. Drew, *Department of Agronomy, University of Nebraska-Lincoln, Lincoln, Nebraska 68503*

ABSTRACT

Maximum sustained beef production within the 32,000 square kilometers of the Sand Hills region of Nebraska is directly related to range management decisions based on range sites and interpretations of range condition classes. Interpretations of imagery from the Earth Resources Technology Satellite (ERTS-1) indicate that soil associations and attendant range sites can be identified on the basis of vegetation and topography using multi-temporal imagery. Optical density measurements of imagery from the visible red band of the multispectral scanner (MSS band 5) obtained during the growing season were related to field measurements of vegetative biomass, a factor that closely parallels range condition class on specific range sites. ERTS-1 imagery also permitted inventory and assessment of center-pivot irrigation systems in the Sand Hills region in relation to soil and topographic conditions and energy requirements. The following resource maps of the Upper Loup Natural Resource District located entirely within the Sand Hills region were prepared from ERTS-1 imagery: (1) Location of subirrigated range sites and lakes, (2) Frequency of blowouts and areas affected by severe wind erosion, (3) Areas with less than 10% vegetative cover and severe wind erosion hazard, (4) Distribution of center-pivot irrigation systems identified according to production of perennial forage crops or annual crops.

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INTRODUCTION

The objective of this investigation is to evaluate the use of MSS imagery acquired by ERTS-1 as a tool in mapping and managing soil and range resources in the Sand Hills region of Nebraska. This region occupies the north-central one-third of Nebraska, is composed of approximately 32,000 square kilometers of eolian sand dunes interspersed with nearly level valleys, and is stabilized by grass and grass-like plants. The dominant economic enterprise within the region is the production of beef cattle and centers on cow-calf operations involving the utilization of rangeland forage. In 1972 there were 518,300 beef cows and 606,700 calves and yearlings within the Sand Hills region, representing an aggregate value of \$263,820,000.

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Beef animals raised within the Sand Hills region obtain virtually all of their feed units from forage. Consequently, domestic and foreign demands for beef translate into demands for efficient use of existing forage as well as for more forage. Maximum sustained beef production within the Sand Hills region is directly related to the optimum use of rangeland according to management practices determined on the basis of range sites and range condition classes. In addition, the development of center-pivot irrigation systems has considerable potential for increasing and stabilizing forage yields under the erratic climatic conditions of the Great Plains.

The model tested in this study is that shadow patterns from the dune topography of the sandhills and the spectral reflectance of the rangeland vegetation will permit interpretations of soil associations and attendant range sites, range condition and degree of forage utilization from reflectance measured by sensors aboard ERTS-1. A major goal in developing this model was to determine the optimum level of generalization suitable for consistent and accurate interpretations using the scale and resolution of ERTS-1 imagery.

SOIL ASSOCIATIONS AND RANGE SITES

Multi-temporal ERTS-1 imagery of McPherson, Hooker and Thomas Counties within the Sand Hills region of Nebraska permitted human image interpretation of soil

Table 1. Relationships of Topographic Features, Soil Associations and Range Sites Within the Sand Hills Region of Nebraska

<u>TOPOGRAPHIC FEATURES</u>	<u>SOIL ASSOCIATIONS</u>	<u>RANGE SITES</u>
1. Rolling and steeply sloping (choppy) uplands with dry valleys	Valentine-Dunday	Sands, Choppy Sands and Sandy
2. Rolling uplands with dry valleys	Valentine-Anselmo	Sands and Sandy
3. Steeply sloping (choppy) uplands	Valentine, hilly	Choppy Sands
4. Rolling uplands with subirrigated valleys	Valentine-Elsmere-Gannett	Sands and Subirrigated
5. Rolling uplands, dry valleys and subirrigated valleys	Valentine-Dunday-Loup	Sands, Sandy, Subirrigated
6. Rolling uplands	Valentine, rolling	Sands
7. Rolling uplands with dry valleys of sand hills - loess border	Anselmo-Valentine-Dunday	Sands, Sandy

associations comparable with recently published soil association maps for these counties. Specific soil associations and range sites defined in terms of soil and topographic features are shown in Table 1.

Color composites generated from spring imagery (MSS bands 4, 5 and 6 of image 1295-16564) obtained on May 14, 1973 prior to summer haying operations were used to identify the Valentine-Elsmere-Gennett soil association consisting of dunes and subirrigated valleys. Within this association, Elsmere and Gannett soils (Subirrigated range sites) exhibited relatively dense and physiologically active vegetation and provided strong reflectance in MSS band 6 in comparison with Valentine soil (Sands range site) that is not subirrigated. Moreover, standard management practices involving mowing or grazing of the Subirrigated sites prevent the annual accumulation of dead vegetation and permit near-infrared reflectance from vegetative growth produced during the spring. In contrast, the relatively low density of vegetation on the choppy, steeply sloping uplands permitted tentative identification of the Valentine, hilly, soil association.

The Valentine, hilly association (Choppy Sands range site) as well as the other soil associations differing in topographic expression were readily identified from winter imagery (MSS band 6 of image 1170-17020) obtained on January 9, 1973 showing topographic features enhanced by continuous snow cover and low sun angle. Shadow patterns allowed the delineation of the Valentine-Dunday soil association (Sands, Choppy Sands and Sandy range sites) consisting of large dunes separated by rolling valleys, the Valentine-Anselmo soil association (Sands and Sandy range sites) consisting of rolling dunes and swales, the Valentine, rolling soil association (Sands range site) consisting of rolling uplands, and the Valentine, hilly soil association (Choppy Sands range site) consisting of choppy sandhills with no major intervening valleys.

Color composites generated from summer imagery in MSS bands 5, 6 and 7 permitted the identification of patterns of cultivated cropland and the delineation of the Anselmo-Valentine-Dunday soil association (Sands and Sandy range sites) in the sandhills-loess border.

Relationships established through comparisons of ERTS-1 imagery with published soil association maps of McPherson, Hooker and Thomas Counties permitted construction of a soil association map for Cherry County, Nebraska, an adjacent sandhills county for which no comparable soil association map was available. Comparisons of the soil association map constructed for Cherry County with data obtained from field observations and from high altitude color-infrared aerial photography indicate a high degree of accuracy for the soil association map interpreted directly from ERTS-1 imagery (MSS bands 4, 5 and 6 of image 1295-16562 and MSS band 6 of image 1170-17013). Because of unique combinations of vegetation and land surface configuration within the Sand Hills region, ERTS-1 imagery is suitable for interpreting soil units and range sites at a level of generalization intermediate between county soil association maps and standard soil surveys made by observations of soil profiles and landscapes on the ground.

RELATIONSHIPS OF VEGETATIVE BIOMASS AND OPTICAL DENSITY

Identification of soil associations and attendant range sites within the Sand Hills region provides a basis for the measurement and interpretation of total vegetative biomass from ERTS-1 imagery. Because of the total spectral response of the sandy soils, differences in image density in relation to vegetative biomass are more distinct in the Sand Hills region than in other rangeland areas of Nebraska.

Field studies in Cherry County, Nebraska, completed within one day of the ERTS-1 overpass on July 26, 1973 indicate relationships between total vegetative biomass and the optical density of imagery from MSS band 5 (image 1386-17011) measured at specific study sites (Table 2). The optical density measurements reported fall within the upper one-half of the gray scale, the optimum range for image evaluation.

Numerous field observations within the Sand Hills region suggest that range condition classes based on field estimates of climax vegetation for a given range site are also closely related to vegetative biomass. Nevertheless, comparison of values for optical density and range condition between different range sites (e.g., Sandy v.s. Subirrigated) is not feasible because variations in range condition on similar range sites result in overlapping values for optical density.

Table 2. Relationships of total vegetative biomass to optical density of ERTS-1 image, MSS band 5, for selected range sites within the Sand Hills region of Nebraska.

<u>RANGE SITE</u>	<u>RANGE CONDITION</u>	<u>VEGETATIVE BIOMASS</u> ¹ kg/ha dry wt.	<u>OPTICAL</u> ² <u>DENSITY</u>
Sandy	Poor	367	0.49
Choppy Sands	Fair	598	0.58
Subirrigated	Fair	1428	0.64
Sandy	Good	1418	0.67
Sands	Good	1288	0.64

¹Field data obtained July 25, 1973

²ERTS-1 overpass July 26, 1973

When the soil association and attendant range site are known, however, range condition class can be estimated from optical density measurements of imagery from MSS band 5 obtained during the growing season. Range condition class is a major factor in determining animal stocking rates for Sand Hills rangeland.

APPLICATIONS

The Sand Hills region includes all or part of several Natural Resources Districts within Nebraska. Each district is governed by a local board of directors and is authorized to develop a variety of resource programs including range management. In addition, the Soil Conservation Service, USDA, is responsible for soil surveys and range site interpretations and for developing conservation ranch plans within the Sand Hills region. ERTS-1 imagery has substantial potential for use by these organizations in planning and monitoring operational programs in range management.

The Upper Loup Natural Resources District is located centrally within the Sand Hills region. Four resource maps have been prepared from ERTS-1 imagery for this District as follows:

Subirrigated Range Sites and Lakes

Forage production from Subirrigated range sites and the location of sandhills lakes are significant factors in planning range management within the Upper Loup Natural Resources District. Consequently, a map showing the distribution of these features (Fig. 1) was prepared from imagery obtained from MSS bands 5 and 7 on May 14 and 15, 1973 (images 1295-16564 and 1296-17023).

Wind Erosion Hazard

Overgrazing in the Sand Hills region is particularly critical in view of the fragile nature of the sandy rangeland and its potential for destruction by wind erosion. Continued overgrazing results in a sharp decrease in range condition class and increases wind erosion hazard.

ERTS-1 images from MSS band 5 obtained on August 17 and 18, 1972 (images 1025-16554 and 1026-17012) and May 14 and 15, 1973 (images 1295-16564 and 1296-17023) were used to map areas with less than 10% vegetative cover on these dates within the Upper Loup Natural Resources District (Figure 2). Areas that did not recover to more than 10% vegetative cover by mid-May, 1973 are potentially hazardous in terms of wind erosion.

Blowout Land

Within the Sand Hills region, areas from 2 to 50 hectares or more in size that have been stripped of vegetative cover by wind erosion and that are actively eroding are readily interpreted from ERTS-1 imagery obtained during the growing season. A map showing the number of blowouts per township within the Upper Loup Natural Resources District (Fig. 3) was prepared from ERTS-1 imagery from MSS band 5 obtained on May 14 and 15, 1973 (images 1295-16564 and 1296-17023). This map identifies areas where blowouts have severely reduced forage production and where erosion control is needed.

Center-Pivot Irrigation

The production of forage irrigated by center-pivot systems to supplement forage produced by native rangeland is a recently established procedure for increasing the production of beef cattle within the Sand Hills region. One

hectare of properly irrigated forage in the Sand Hills region provides an animal carrying capacity approximately equal to 20 hectares of dryland range. Imagery obtained from MSS band 5 on May 14 and 15, 1973 (images 1295-16564 and 1296-17023) was used to locate all center-pivot irrigation systems within the Upper Loup Natural Resources District and to identify these systems according to perennial forage crops or annual crops (Fig. 4).

ERTS-1 imagery permits an assessment of center-pivot irrigation systems in relation to soil and topographic conditions within the Sand Hills region. Primary problems in establishing irrigated crops on the sandy soils involve wind erosion following severe land leveling, and the accumulation of surface water in subirrigated locations. Image interpretation has potential for delineating areas unsuited for the installation of center-pivot irrigation. In addition, an accurate inventory of center-pivot systems permits an analysis of energy requirements necessary to maintain irrigated production.

SUMMARY

The synoptic view provided by imagery from ERTS-1 is of substantial value for inventorying and measuring rangeland resources across the 32,000 square kilometers of the Sand Hills region. Interpretations of multi-temporal imagery within the region identified associations of soils and attendant Sandy, Sands, Choppy Sands and Subirrigated range sites at a level of generalization intermediate between county soil association maps and standard soil surveys made by detailed observations on the ground. Recognition of seven established soil associations permitted the delineation of these units in a portion of the region where modern soil association maps do not exist.

Optical density measurements of imagery from MSS band 5 obtained during the growing season were related to field measurements of vegetative biomass, a factor that closely parallels range condition class on defined range sites within the Sand Hills region. Consequently, range condition classes defined according to determinations of climax vegetation in the field may be estimated from the optical density of ERTS-1 imagery when range sites are known. Refinement of these relationships will permit operational interpretations of range condition in the Sand Hills region for use in timing livestock grazing and in selecting stocking rates. Overgrazing in the Sand Hills is particularly critical in view of the fragile nature of the sandy rangeland and its potential for destruction by wind

The following resource maps for use in planning range management programs in the Upper Loup Natural Resources District within the Sand Hills region have been prepared from ERTS-1 imagery: (1) Location of Subirrigated range sites and lakes, (2) Areas of erosion hazard with less than 10% vegetative cover in August, 1972 and May, 1973, (3) Frequency of blowout land and areas affected by severe wind erosion, and (4) Distribution of center-pivot irrigation systems identified according to the production of perennial forage crops or annual crops

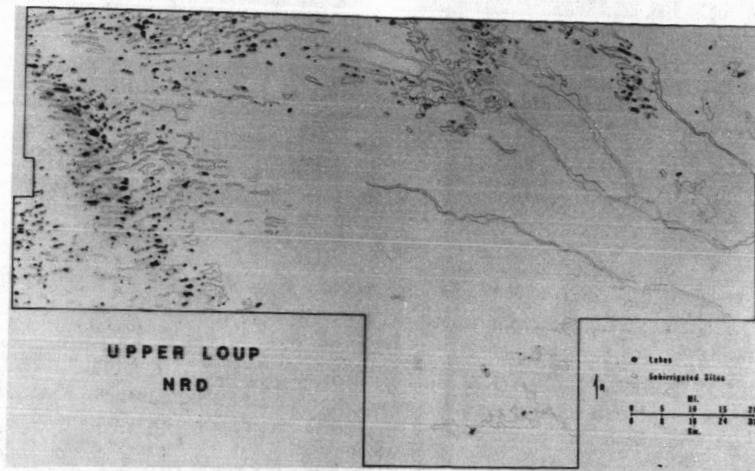


Figure 1. Distribution of Subirrigated range sites and lakes within the Upper Loup Natural Resources District, Nebraska.

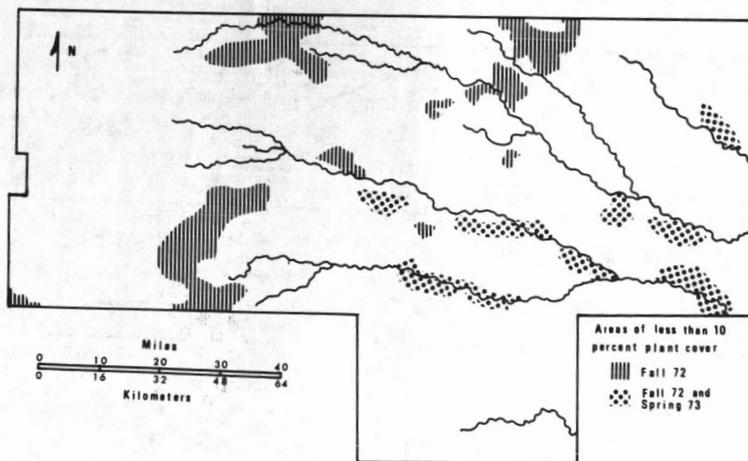


Figure 2. Distribution of areas with less than 10% vegetative cover on August 17 and 18, 1972 and May 14 and 15, 1973 within the Upper Loup Natural Resources District, Nebraska. Areas in which vegetative cover has not increased above 10% by mid-May, 1973 are susceptible to wind erosion.

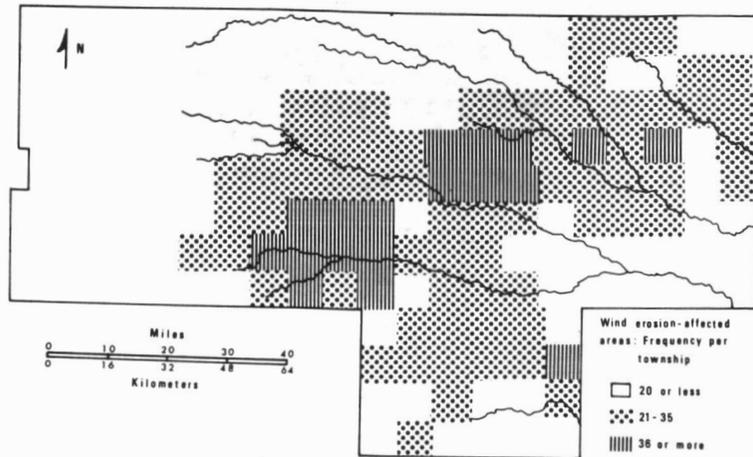


Figure 3. Frequency of blowouts 2 to 50 hectares in size within townships in the Upper Loup Natural Resources District on May 14 and 15, 1973.

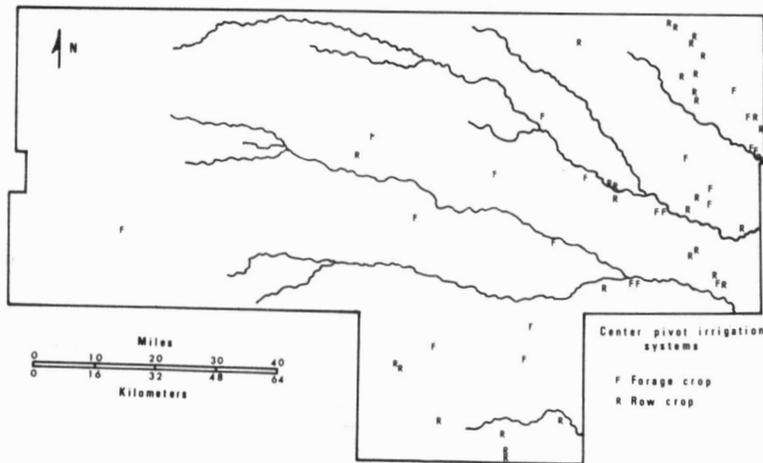


Figure 4. Distribution of center-pivot irrigation systems identified according to the production of perennial forage crops or annual crops within the Upper Loup Natural Resources District on May 14 and 15, 1973.