Detection of Saline Seeps in North Dakota by Remote Sensing

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Introduction

Research has been conducted in North Dakota and in the northern Great Plains on many aspects of the problems of saline seeps. Much of this work has been directed towards gaining an understanding of the mechanisms of formation (Halvorson and Black, 1974; Doering and Sandoval, 1976). Much of this basic information has been made available to farm operators through various publications (Worcester et al., 1975; Vasey, 1976) and county extension service offices. Work has also been done on characteristics of saline seeps which could provide easier identification in the field. Saline seeps have characteristic vegetation which related to the salt content of the affected soils (Worcester and Seelig, 1976). Hand operated seismographs have also been used in the characterization of seeps (Worcester et al., 1976) as have electrical resistivity survey methods (Rhoades and Ingvalson, 1971; Halvorson and Rhoades, 1974).

Based on field observation, seeps can be placed into three categories or stages of development. These stages are: 1) incipient, indicated by wetness and luxuriant growth of normal vegetation; 2) intermediate, indicated by a growth of salt tolerant vegetative species; and 3) mature, indicated by a whitish salt crust. Although these stages are designated using chronologic terms, they are determined solely by the flux and accumulation of water and salts in the crop-soil system. The stages of development may occur in combination as a seep grows or as a single stage. The center of a seep may be mature, surrounded by a ring or a partial ring with intermediate characteristics and new areas of expansion appearing as an incipient seep.

In spite of all the information now available concerning saline seeps, problems still remain in identifying and locating seeps on the landscape. The use of vegetative indicators and wetness of soil are helpful for locating seeps. Then resistivity, seismic methods and probing can be used in delineating and characterizing their properties. However, these methods are slow since they require considerable field work and are therefore expensive.

A need exists for a method of rapidly locating saline seeps on large tracts of land. Ideally, this method should permit location of not only existing seeps but also those which are about to appear, i.e., incipient seeps. A project was conducted in Stark County, North Dakota (Figure 1) to evaluate remote sensing as a tool to fulfill these needs. This project was part of a three-state endeavor (North Dakota, South Dakota, and Montana) funded in part by the Old West Regional Commission.

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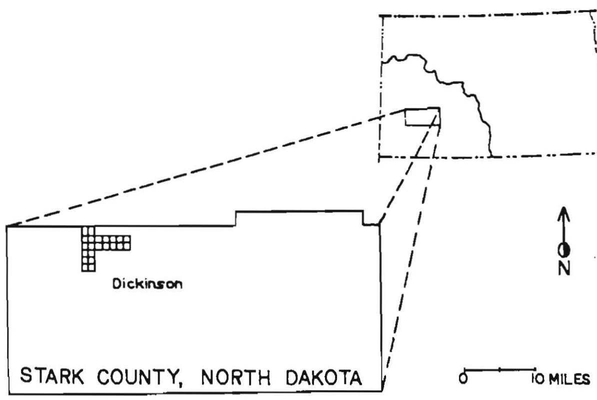

Figure 1. Study area in Stark County.

Approach

In the broadest sense, remote sensing is the measurement of some property of an object by a device which is not in direct contact with that object (Reeves et al., 1975). In this project we employed two such "devices" to detect saline seeps: color infrared (CIR) photography with spectral sensitivity of 0.51 to 0.90 micrometer and thermal infrared or thermography having spectral sensitivity of 8.7 to 11.5 micrometer. The Stark County test site was overflown to collect CIR and thermography on May 19, 1976 at an above-ground altitude of 3500 ft. The Remote Sensing Institute located at South Dakota State University supplied the aircraft and flight crew for this data collection. The CIR photography was acquired with a standard 70 mm camera. On this film, growing vegetation shows as red and salts as white. The thermography was recorded with a Daedalus thermal scanner. This scanner measures the apparent surface temperature of objects on the earth. Salinity and soil moisture were measured in the field by NDSU personnel at the time of the aircraft overflight. On the thermogram a photographic representation of thermography results, dark areas are coolest and light areas are warmest.

Results

The CIR aerial photograph in Figure 2 reveals many interesting features of the study site. It may be compared with the thermogram of the same area in Figure 3. Some of the most prominent and useful features are the salt crusted areas "S". These areas in this example occur low on the landscape along the Y shaped drainageway. The highly reflective nature of these areas and their sharp edges make them relatively easy to identify. Problems in identification often occur when seeps are confused with highly reflective, barren hilltops "HI". The diffuse edges of the hilltops as seen on the CIR photograph are an identifying characteristic. Three hilltops can be seen "H2" as areas where the sweetclover is planted in strips "SC". Between the hills the crops are much more vigorous in growth because of the increased availability of water in the valleys; therefore, in these areas the crops appear redder. This is due to their higher reflectivity in the infrared portion of the spectrum. Considerable information about topography can be deduced from such simple observations. A stock pond "W" is easily recognized through its shape and dark color.

The mottled appearance of the land surface at "N1" results from the influence of sodium affected soil in pastureland. This pattern is very characteristic and is caused by irregular barren "scab spots" intermixed with growing vegetation. The same pattern can be seen at "N2" in the cropped land. In this location, the sodium levels were either: 1) lower than at "N1" such that the land could be cropped or 2) the physical mixing during tillage ameliorated the effect of the sodium.

Two significant areas are marked "I". These were found to be incipient saline seeps. The slightly higher moisture levels in the soil resulted in greater vegetative growth and therefore show as reddish areas on the infrared photograph. At this stage of development, management practices to use water in the upslope recharge areas could be implemented to prevent further development and thus save this cropland from salinity development.

The thermogram (Figure 3) provides many of the same observations from a different remote sensing medium. The cooler areas (dark) result from higher soil moisture in the seep areas and from the cooling effects of plant transpiration in the cropped strips. One additional cool area is the north side (15-25% slope) of a prominent hill "HS". This does not show on the color infrared photograph except as an area of grassland. The cooling effect of higher soil moisture at the incipient seeps "I" is readily visible on the thermogram. This confirms the suspicion initially gathered from the CIR imagery.

After training interpreters in basic techniques, color infrared photography and thermograms of the surrounding 22 sections of land were analyzed visually for saline seep occurrence. Interpreters were able to correctly locate 86 to 93 per cent of the existing seeps and to map their areal extent with 68 to 92 per cent accuracy. Inadequate ground data was collected to locate most incipient seeps. Location of incipient seeps during the ground data collection would have been enhanced by having the thermograms 'in-hand'.

Conclusions

Low altitude aerial color infrared photography and thermography can be developed into a viable tool for detection and monitoring of mature or intermediate saline seeps. The procedure is rapid, and, with trained interpreters sufficiently accurate to be very useful. If such a technique were developed into an operational program, most seeps could be located easily and their growth or recession monitored on a county or farm basis. A program of this nature could be extremely valuable to land owners where saline seeps are a problem and where others are concerned with the loss of productive land to saline seeps.

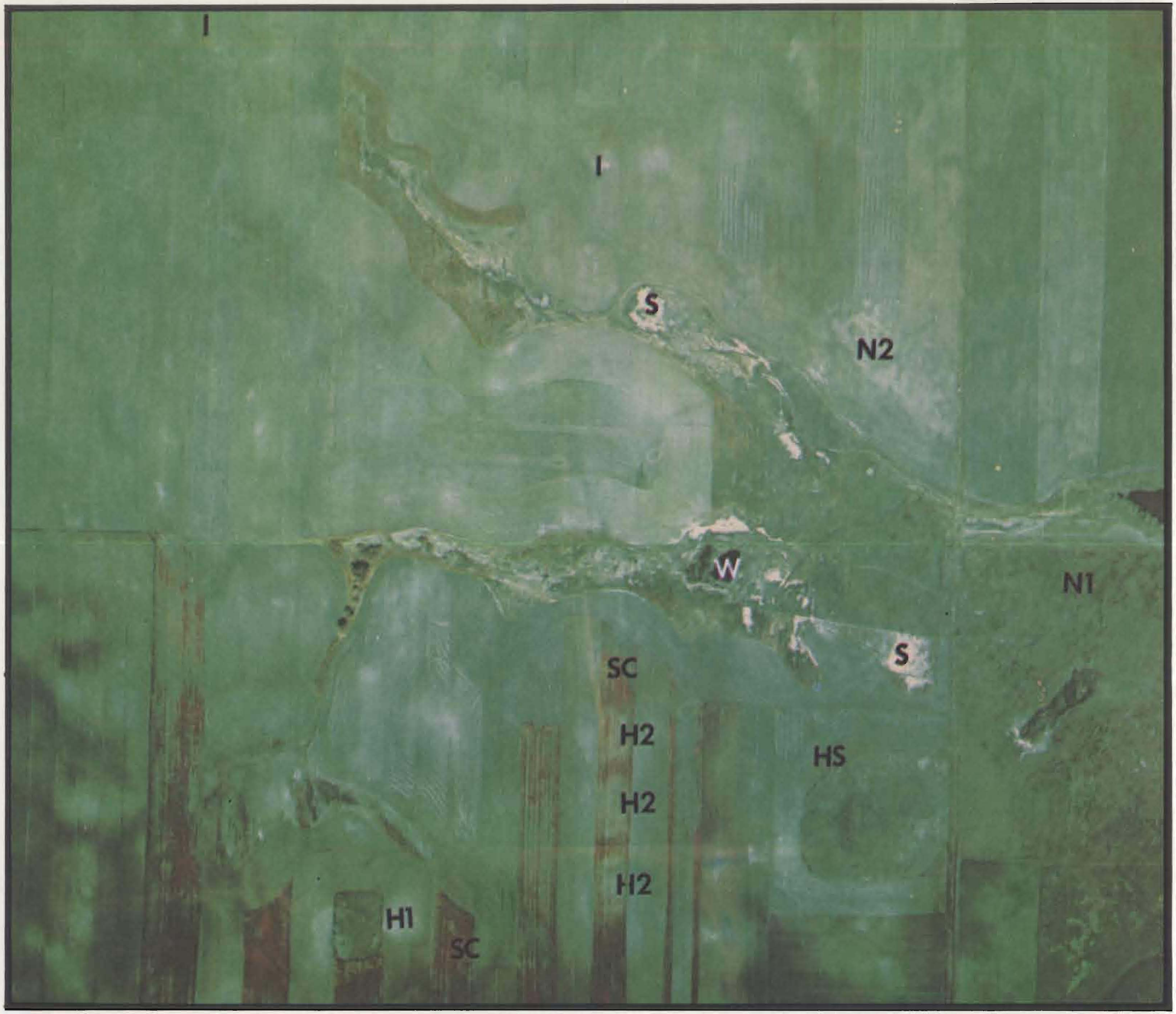

Figure 2. Color Infrared Photograph showing about 200 acres in study area.

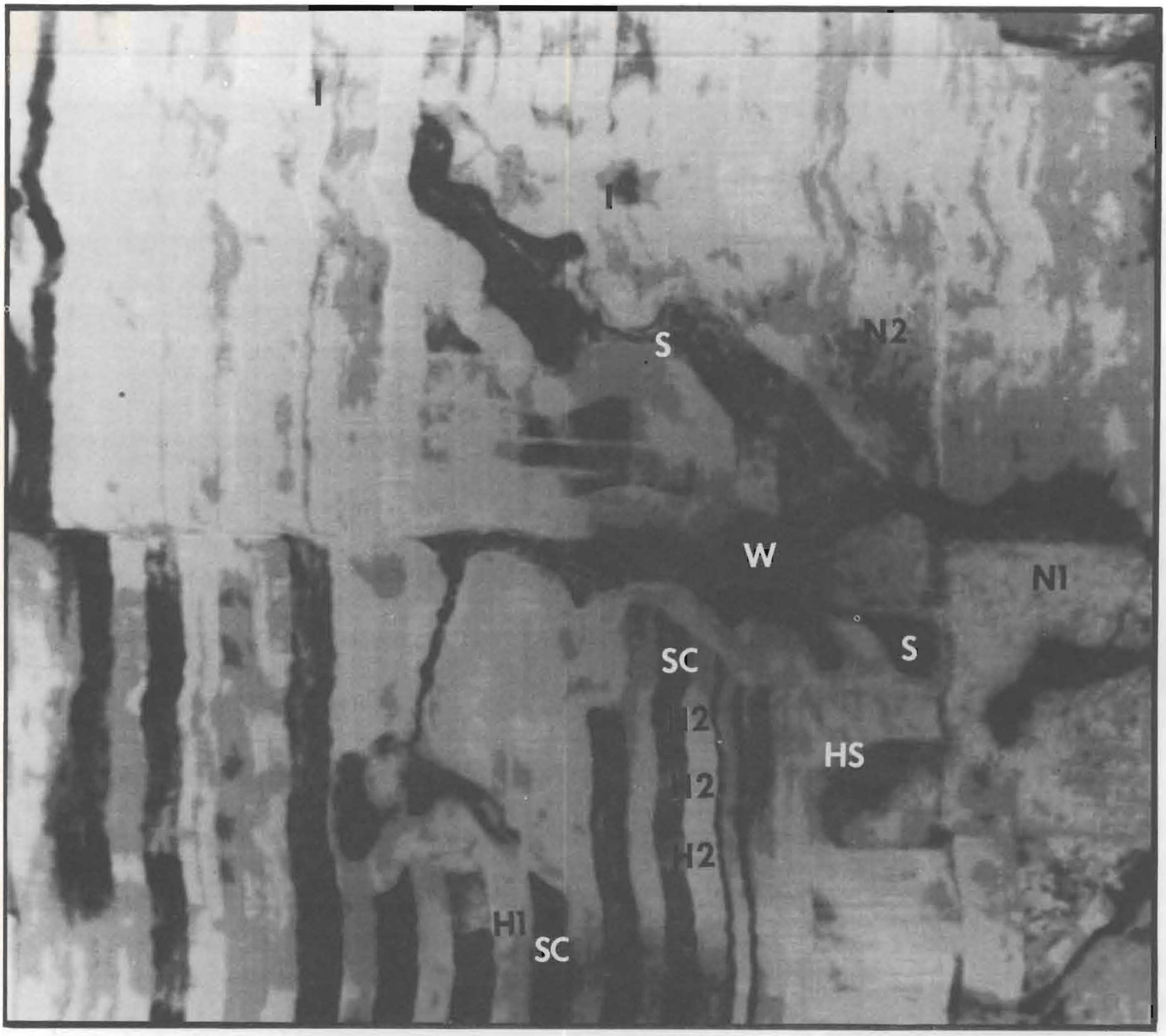

Figure 3. Thermogram of area shown in Figure 2.

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