Inventory of a Nature Preserve Area in Lake County, Indiana Using Satellite MSS Data[1]

S. J. KRISTOF, F. R. KIRSCHNER, R. A. WEISMILLER, and S. A. KAMINSKY[2]
Laboratory for Applications of Remote Sensing, Purdue University

Abstract

Computer-aided techniques were used to classify Landsat data in order to distinguish terrestrial features within the Hoosier Prairie tract near the city of Griffith, Lake County, Indiana. Data within the study area were divided into distinct spectral classes by a clustering procedure. A statistics algorithm was used to compute the mean and covariance for each cluster class. Terrestrial ecosystems were classified using a maximum likelihood algorithm. The output consisted of a spectral map with each class represented by a different alphanumeric symbol. The descriptions of the spectral classes were based upon their mean vector ratios and data collected at the ground site.

Computer-aided analysis of Landsat data was successful in distinguishing eight informational classes within the highly complex plant regime of the Hoosier Prairie Nature Preserve Area.

Introduction

The objective of this research was to investigate the application of computer-implemented analysis (2, 5) of Landsat data to recognize major vegetative cover and important physiognomic characteristics of species in a 121 hectare area of Lake County, Indiana. This area is characterized by a mixture of wetland prairie, dry prairie and oak savannas with over 300 different plant species (4).

Description of the Area

The study area, known as the Hoosier Prairie Nature Preserve, is a part of the remaining prairie in the northwestern part of Lake County, Indiana. It is situated in the former glacial Lake Chicago and the soil parent materials are primarily glacial till, lacustrine deposits, beach sands and gravels. Most of the soils are poorly drained with a relatively high water table such as Maumee fine sand or moderately well drained such as Brems fine sand. There are also some excessively drained soils such as the Plainfield fine sand with 0 to 6 slopes.

Data Analysis Procedure

September 7, 1975 Landsat multispectral scanner (MSS) data obtained over the Hoosier Prairie tract located in the Griffith-Highland-Schererville area was used for analysis.

A nonsupervised clustering algorithm was used to analyze and group individual remote sensing units or pixels into clusters of similar

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[2] Research Agronomist, Agronomy Department; Soil Scientist, USDA/Soil Conservation Service; Research Agronomist, Agronomy Department; Graduate Student, Agronomy Department, respectively. Purdue University/Laboratory for Applications of Remote Sensing.

spectral response. Although the Hoosier Prairie tract consists of only 121 hectares, a much larger area, 2172 hectares, was used for clustering to increase the spectral contrast so as to represent adequately all of the spectrally distinct features in the Hoosier Prairie tract. A statistics processor calculated the mean vector and covariance matrices for each cluster class in each of four wavelength bands. Using the statistics developed, a nonsupervised maximum likelihood classification algorithm was used to classify the area into 17 spectrally separable classes. Cover types were identified using a mean vector ratioing technique. This is a heuristic ratio:

$$A = \frac{V}{IR}$$

where V is the relative intensity of the visible wavelengths [(0.5 to 0.6μm) + (0.6 to 0.7μm)] and IR is the relative intensity of the reflective infrared wavelengths [(0.7 to 0.8μm) + (0.8 to 1.1μm)].

By summing the relative intensity values of all four bands the magnitude of relative spectral responses can be obtained as shown in the following equation:

$$\text{Summed response} = (0.50 \text{ to } 0.60\mu\text{m}) + (0.60 \text{ to } 0.70\mu\text{m}) + (0.70 \text{ to } 0.80\mu\text{m}) + (0.80 \text{ to } 1.10\mu\text{m}).$$

By observing the ratio A and the summed response, the analyst delineated major vegetation and land use categories within the Hoosier Prairie tract. Topographic, soil survey and geologic maps, aerial photography and limited ground observations also aided in determining the associations existing between spectral classes and ground features.

A hierarchical land use classification scheme similar to that developed by the U.S. Geological Survey (1) was followed (Table 1). Two broad

Table 1. Classification Hierarchy

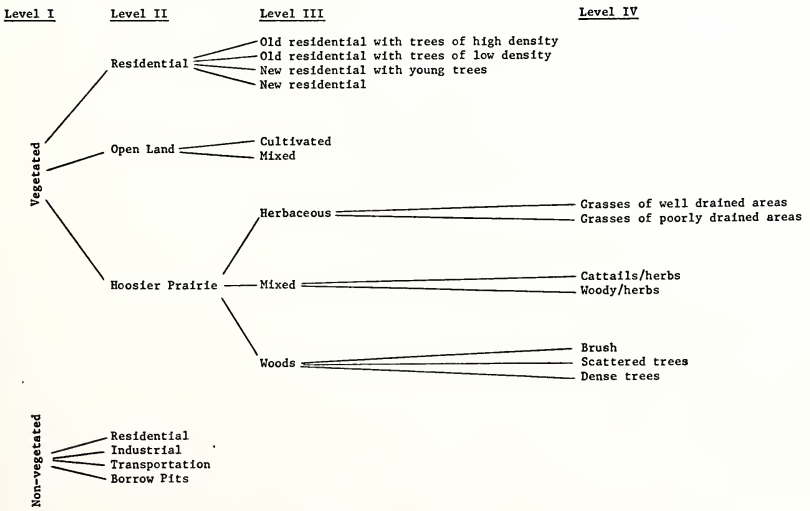

Table 1. *Classification Hierarchy.*

Level I categories, vegetated and nonvegetated, were separated solely on the basis of their spectral responses. The mean vector ratios of the vegetated and non-vegetated areas were 1.00 or less and 1.10 to 1.30, respectively. The mean vector ratio statistics in conjunction with conventional photointerpretation of aerial photography were used to determine the Level II categories. At this stage the vegetated category was divided into vegetated residential, open land and Hoosier Prairie while the non-vegetated category was split into non-vegetated residential, industrial, and borrow pits.

Ground observations were used to further differentiate the Hoosier Prairie area into the Level III land cover categories of (a) herbaceous, (b) mixed herbaceous with woody plants and (c) woods and Level IV categories of (a) grasses on well drained areas, (b) grasses on poorly drained areas, (c) marsh-cattails and herbs, (d) marsh-shrubs and herbs, (e) brush, (f) scattered trees, (g) dense trees and (h) other.

Results and Discussion

The main effort of this study involved an assessment of the utility of the Landsat data to detect, identify, locate and measure features of the area of approximately 121 hectares known as the Hoosier Prairie Nature Preserve which has remained relatively undisturbed. Because of the complexity of the location and in order to obtain greater spectral contrast within the area the investigation was expanded to include the metropolitan area of Griffith and open land to the north and cultivated land to the west of the Hoosier Prairie.

Within the entire study area two broad classes, vegetated and non-vegetated, were classified, their identification based upon their mean vector ratios. Non-vegetated terrestrial features exhibited high ratios due to high responses in the visible and much lower responses in the reflective infrared portion of the spectrum. Green vegetation exhibited lower ratio values due to high responses in the reflective infrared and low responses in the visible region of the spectrum.

Since the vegetative cover of the Hoosier Prairie represents a highly complex regime of native herbaceous, annual and perennial plants situated in colonies many times smaller than 0.5 hectare, the spectral resolution of Landsat, it is readily apparent that it would not be possible to delineate individual plant species using Landsat data. However, it was possible to classify the Hoosier Prairie area into 9 spectrally separable classes (Figure 1). These classes were separable due to differences in the type of vegetative cover, the density of vegetation and the wetness in the terrestrial ecosystems. By comparing the spectral classification to aerial photographs and field observations these nine spectral classes were interpreted to represent eight informational classes (Table 2). Figure 2 shows the relative spectral responses of the seven vegetative covers identified within the Hoosier Prairie tract. As the density of the vegetation increases (i.e., scattered trees vs. dense trees) the ratios decrease in value. Also it can be shown that vegetation on wet terrestrial ecosystems exhibit lower relative magnitude values than vegetation on dry ecosystems.

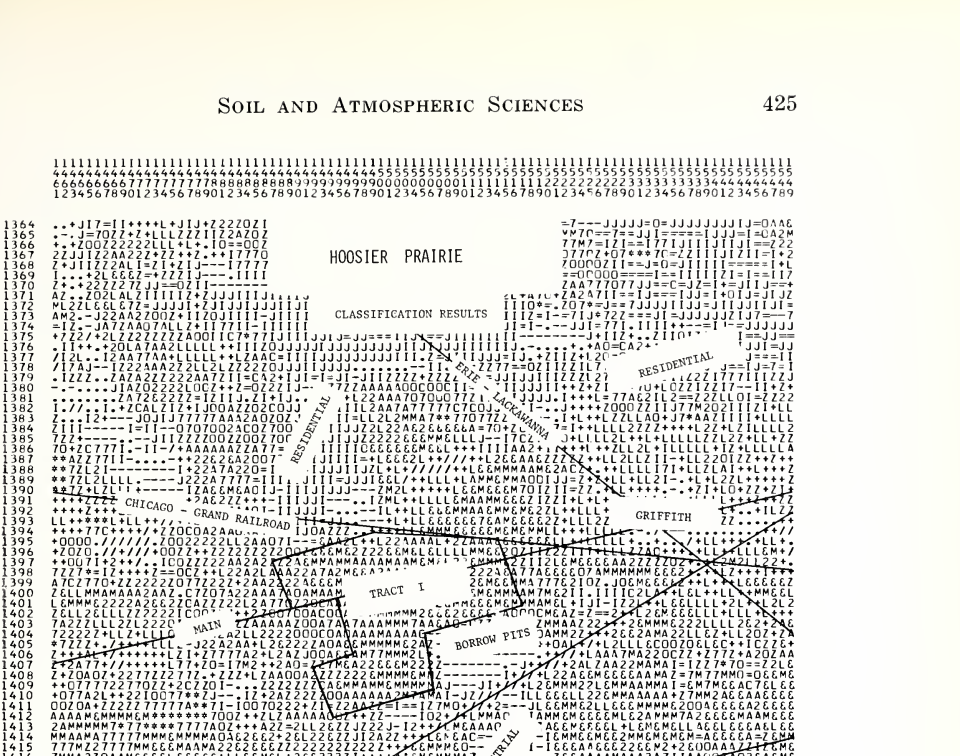

FIGURE 1. *Spectral classification of the terrestrial environment of the Hoosier Prairie and surrounding area.*

TABLE 2. *Distribution of informational classes as determined from Landsat data.*

	Spectral Symbols	Pixels	Percent	Hectares
Grass well drained areas	M	77	25.91	31.46
Grass of poorly drained areas	A	77	25.91	31.46
Marsh-shrubs/herbs	&	66	22.24	27.00
Marsh-cattails/herbs	Z	7	2.36	2.86
Brush	7	9	3.03	3.68
Scattered tree groups	2	41	13.80	16.76
Dense trees	L	11	3.72	4.50
Other	0, +	9	3.03	3.68
TOTAL		297	100.00	121.40

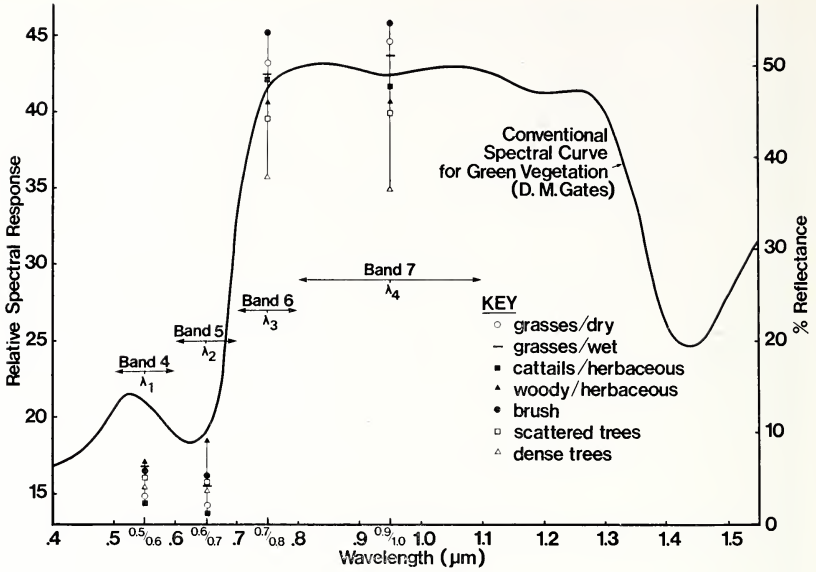

FIGURE 2. *Relative spectral response obtained from seven different vegetative covers.*

Conclusions

Nonsupervised computer-aided classification techniques employed to classify the Hoosier Prairie features with Landsat MSS data showed:

(1) Level I land use categories could be readily identified from Landsat data without the aid of supplemental reference material.

(2) All Level II categories could also be readily identified from Landsat data without the aid of reference material except for the residential classes occurring in vegetated areas. Photointerpretation of aerial photography was required to distinguish this class accurately.

(3) Identification of Level III and IV categories was possible by using ground observations to facilitate interpretation of the classification derived from Landsat data.

Acknowledgment

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