A LANDSAT MSS LAND COVER CLASSIFICATION OF THE EASTERN FINGER LAKES REGION, NEW YORK: ISSUES

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Certain spatial patterns associated with the spectral classes were observed while developing a general land cover map of the Eastern Finger Lake Region of New York. This map is based on Landsat Multispectral Scannar (MSS) data. In this paper, the procedures used to construct the land cover map of the Eastern Finger Lake Region and the related results are examined. The issues encountered with the spatial nature of the spectral classes used to create the land cover map are identified.

STUDY AREA AND DATA SOURCE

The landscape around the Eastern Finger Lake Region, which lies slightly southwest of Syracuse and just northwest of Cortland, is in many respects similar to other rural areas in the Northeastern United States. Two lakes, Lake Skaneateles and Lake Otisco, form the core of this region. These lakes are surrounded by rounded hills covered with crop, pasture, fallow, and wooded lands. In the glacial cut valleys of this region, rich crop land and wetlands predominate. Also present is a rolling plateau which is covered with wooded, crop, pasture, fallow, and idle lands. Existing between the plateau and the valley bottoms are steep slopes which are occupied by more woodlands. Although no urban centers exist within the study area, several small settlements ranging in size from thirty to one hundred establishments ring the lakes. Other smaller settlements are scattered throughout the study area.

The multispectral data for this scene were taken from October 11, 1972 imagery recorded by Landsat 1. The imagery is cloud free and each of the four bands received a rating of eight which indicates that they are all of excellent quality. The imagery for this area consists of 90,000 pixels (picture elements) and encompasses approximately 155 square miles.

Precipitation data for late summer and early fall of 1972 were gathered to see if any significant wet or dry spells occurred in the lake region. A considerable deviation from the normal amount of rainfall could have caused reflectances which would be atypical of the land cover (land use) for this time of year. The data revealed that no significant wet or dry spells occurred in the months of August, September, and October. Therefore, normal ground conditions should have existed when the imagery was taken.

METHODOLOGY

A standard technique developed by NASA, known as Search, was used to generate thirty-three spectral classes. Search is designed to send a 3 x 3 (9 pixels) window across the scene looking for spectrally homogeneous surfaces as determined by certain input parameters. The scene was next classified by employing the maximum likelihood classifier with the thirty-three spectral classes.

After assigning each pixel to a spectral class based on its statistical composition, the spectral classes were grouped together to form land cover classes. This grouping process followed two unsupervised approaches. The first utilized line printer images and involved finding spectral classes which were spatially related. Two classes were considered related if pixels from those classes were situated adjacent to each other consistently throughout the imagery. Once the number of classes was reduced to a workable level for observation purposes, high altitude, color infrared photography was used to identify the assign land cover classes. In addition, spectral classes which consisted of pixels that existed in a known land cover were joined with classes which constituted that land cover.

A second approach employed involved examining and comparing the statistical signatures of spectral classes. This was employed only when a spectral class could not be spatially related to other classes (Figure 1). Similar to the first approach, once a class of this nature was joined with others and identified, it was then placed in a land cover category.

RESULTS

The imagery which initially had thirty three spectral classes was narrowed down to five land cover map categories. These include: water bodies, wetlands, woodlands, agriculture 1, agriculture 2. For purposes of this project, agriculture 1 was defined as all crops which had not been

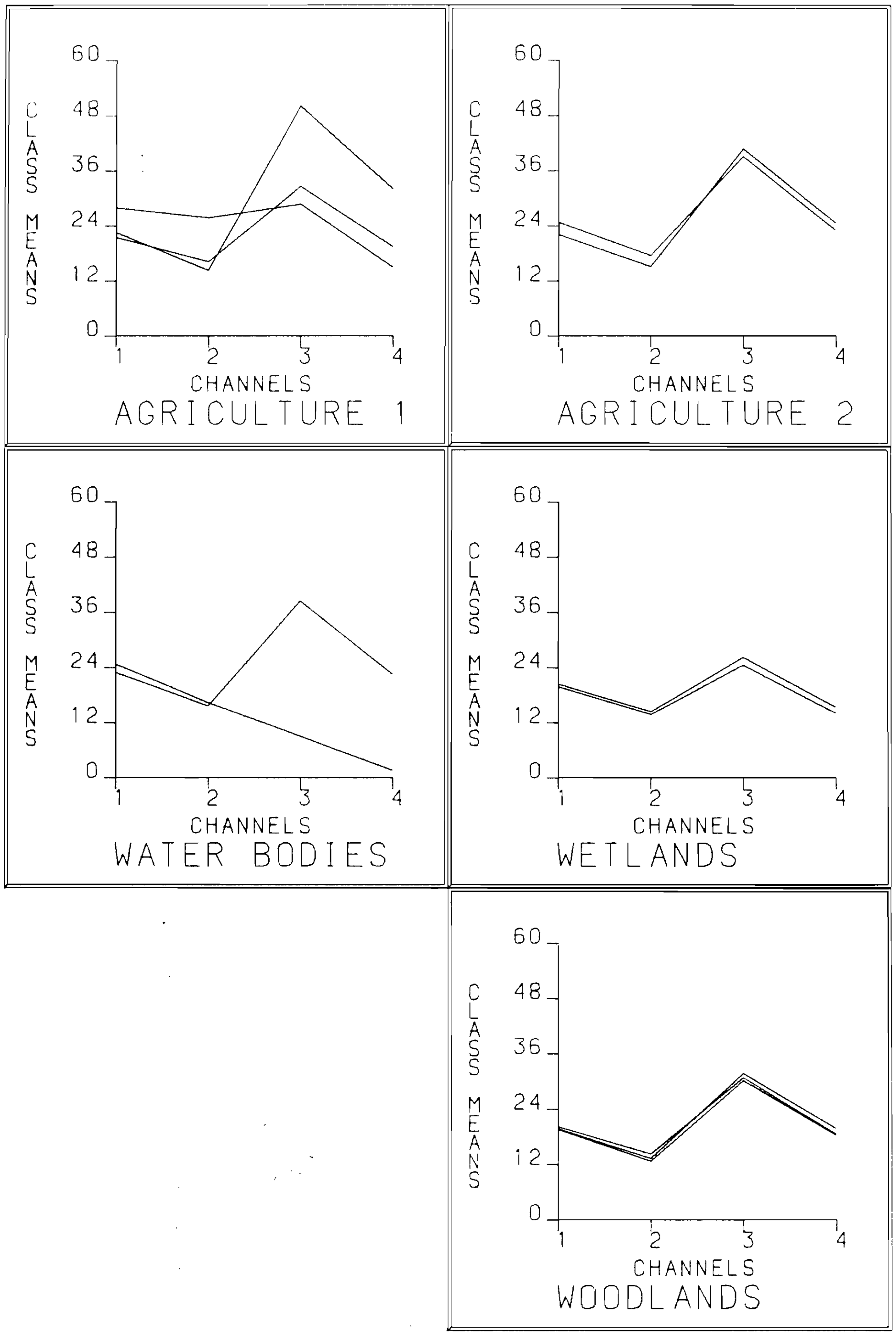


Figure 1: Selected Stectral Signatures

harvested as of October 11, the date of the imagery. Agriculture 2 was defined as all crops which had been harvested as of October 11 plus fields left fallow, idle, or used for pasture.

After creating the map, an accuracy test was performed on the data. A statistical approach was used in which a threshold of three standard deviations was assigned to each spectral class. This put a restriction on the classification of all pixels which had a value more than three standard deviations away from the mean in any of the four channels. The test revealed that approximately 55% of the pixels were not classified. Therefore, the final product may have many pixels which are incorrectly categorized.

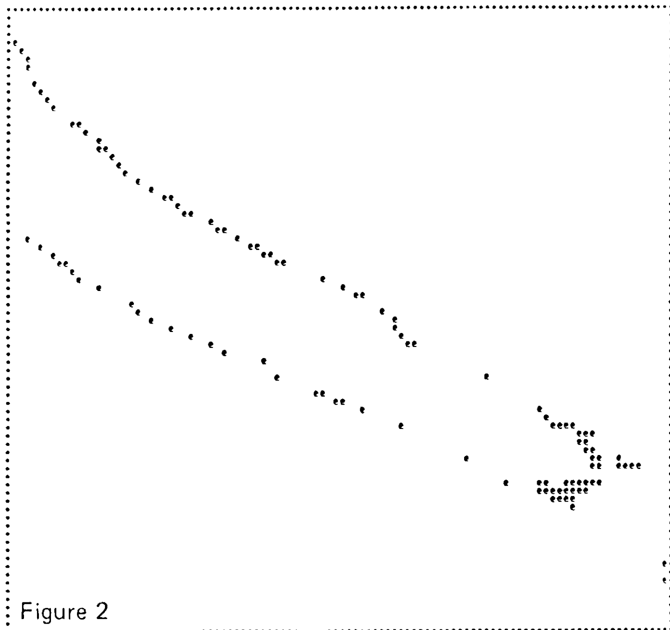
SPATIAL PATTERNS: ISSUES

After completing the final product, the spectral classes were reexamined. It was concluded that each class was characteristic of one of the following spatial patterns: the "edge pattern", "solid pattern", "pepper pattern", or "mixed pattern". Although each pattern was recognized when initially identifying the spectral classes, not much thought was given to associating each class with a pattern. In the process of creating the land cover map, unique issues were encountered that can be related to each class and its pattern.

When examining the classified data scene, it is evident that specific spectral classes form patterns around the perimeter of well defined land covers. These patterns are known as "edge patterns" and they can represent multiple landscape conditions (Figure 2). First, they can represent areas of transition on the landscape which are very heterogeneous in nature. For instance, between agricultural fields and woodlands a transitional zone may exist which includes high grass and shrubs intermixed with trees. Second, edge patterns may include conditions in which individual pixels from a spectral class take on reflectance values which are representative of many different land covers. For example, an edge pattern outlining the lakes may represent pixels with reflectance values that consist of both water and woodlands. In a wetland area, pixels from that same spectral class may represent values from wetland and wooded land.

In creating a general land cover map, a cartographer is responsible for drawing land cover boundaries and creating specific map categories.

Figure 2: Edge Pattern



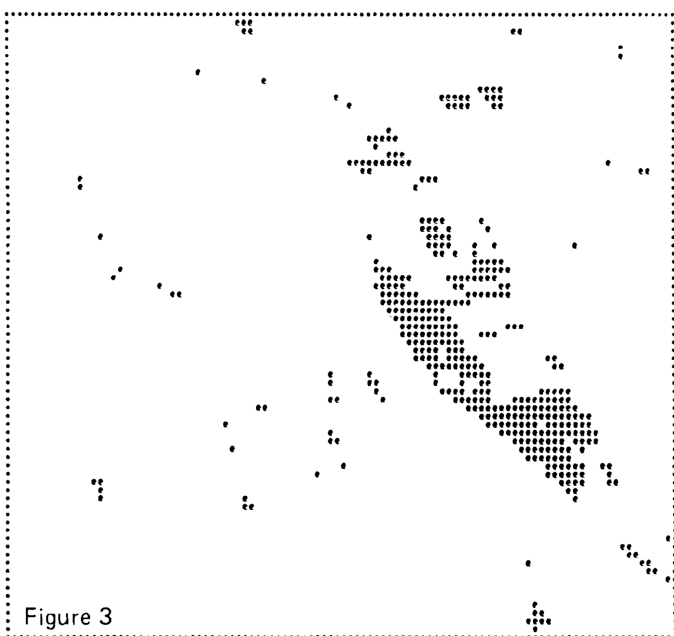
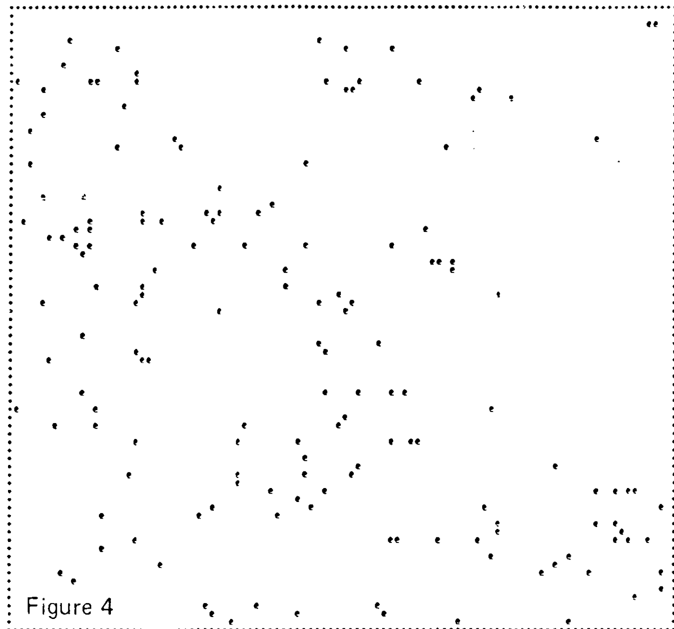


Figure 3: Solid Pattern

Figure 4: Pepper Pattern



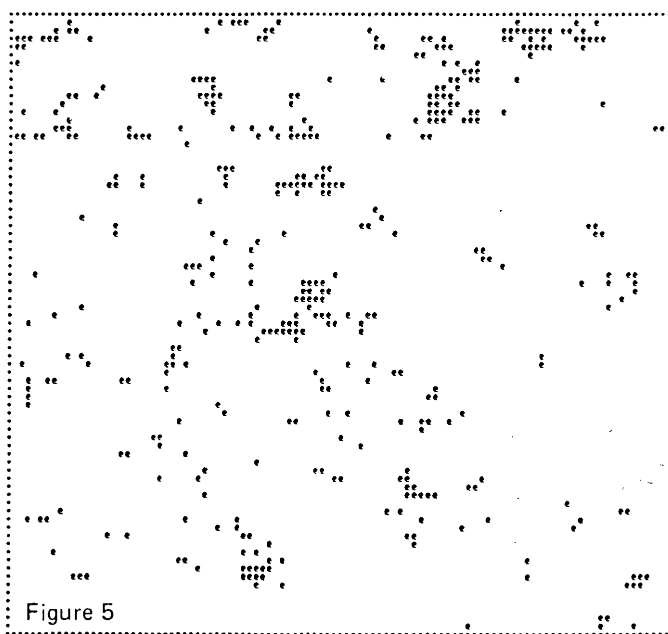


Figure 5: Mixed Pattern

However when examining an aerial photograph, it is apparent that distinct boundaries do not exist on the landscape. The cartographer is, therefore, faced with the issue of interpreting the landscape boundaries from the photography and transferring them to the map. A similar issue is encountered when identifying spectral classes that represent the edge pattern. As already mentioned, this pattern can take on various landscape conditions. Thus, how should spectral classes of this nature be identified?

In contrast to edge patterns, the "solid patterns" are associated with spectral classes showing spatial concentrations of land covers. In other words, solid patterns may be described as the distribution of pixels clustered together to create solid areas (Figure 3). When identifying these patterns on aerial photographs, their related land covers are quite evident. This procedure for identifying solid patterns is rather simple; however, a particular solid pattern-spectral class might relate to more than one land cover condition. This may be due to changes occurring in the landscape between the dates when the photography and the imagery were taken.

The most frequent patterns associated with spectral classes are the "pepper patterns". These patterns may be described as a scattering of pixels throughout the scene with no logical relationship to a particular land cover (Figure 4). Since few agglomerations of pixels exist, it is nearly impossible to identify these patterns, and thereby, their spectral classes on aerial photographs. From a geographic point of view, the preferred method of spatially associating spectral classes with land covers is no longer feasible. Thus, an issue is encountered as to how pepper pattern-spectral classes should be identified. The only other method available is to identify classes spectrally (i.e.: comparing the channel means as statistical signatures of the spectral classes). Although this is a statistical method, the geographer frequently examines the spatial aspects of signatures. The signatures which have similar configurations are joined and identified as the same land cover. See the wetlands, woodlands, and agriculture 2 classes in Figure 1.

In a few instances certain spectral classes display the description of two or more of the above mentioned spatial patterns. These patterns are referred to as "mixed patterns" (Figure 5). Spectral classes forming these patterns are the hardest to identify. First, they encompass a combination of the issues already discussed pertaining to the other spatial patterns. Second, they generally relate to several different land cover conditions making it difficult to decide in which land cover class to place them. For instance, if the pepper and solid patterns constitute the mixed pattern then which one should be chosen to identify the land cover. The decision must be carefully made because the two patterns represent totally different landscape conditions.

A SUGGESTED SOLUTION TO THE MIXED PATTERN PROBLEM

When dealing with landscapes similar to the Eastern Finger Lake Region, the patterns formed by spectral classes should not be overlooked. These patterns may provide clues as to what actually exists on the landscape without looking at support materials such as aerial photographs. Further, they may aid in determining which spectral classes should and should not be joined together.

In the 1950's, a study known as the nearest-neighbor analysis was conducted by two plant ecologists, Evans and Clark. This method quantitatively measures the departure of an observed spatial distribution from a theoretical random distribution (Clark and Evans, 1954). At one end of the nearest neighbor scale (R scale) the maximum departure is known as an absolute cluster pattern while at the other end the maximum departure is known as an absolute dispersal pattern. With the application of this statistical method, the R scale for spectral classes may be calculated, thus, providing a technique for measuring the classifying spatial patterns of spectral classes.

The method described above adds to the approaches available for classifying spectral classes. Similar to the techniques used in this paper, the nearest-neighbor analysis is interested in spatially relating a set of points (the degree of departure). Although this method is mathematical in nature, its spatial component makes it an acceptable approach from a geographic point of view.

ACKNOWLEDGEMENTS

The author would like to thank Professor Paul Baumann for providing his support and guidance and in helping make this paper possible.

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