PROCEEDINGS

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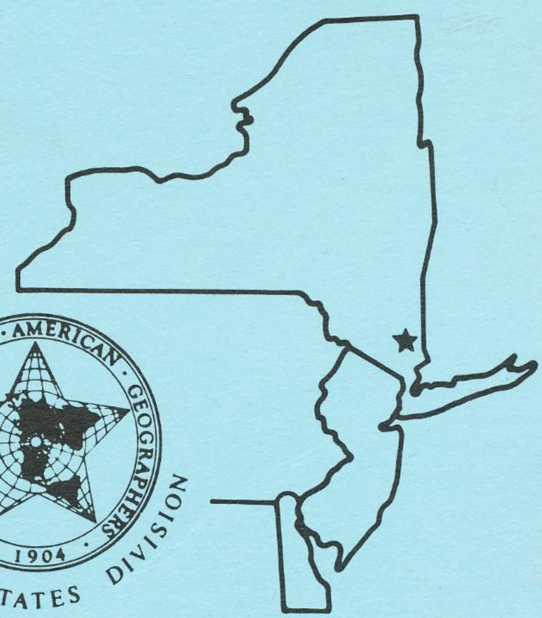

LANDSAT GENERATED 'LUNR' MAPS

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This study was undertaken to explore the potential use of Landsat for updating the New York State Land Use and Natural Resources (LUNR) maps. The results of this study could help pave the path for regular use of Landsat products at the county and local level in New York State. Schoharie County, situated in the Catskills, was the study area. The bulk of the analysis and production work was done by the Oneonta Laboratory for Computer Graphics and Spatial Analysis (OLCGSA), Department of Geography, SUNY College at Oneonta. NASA's Eastern Regional Remote Sensing Applications Center (ERRSAC) provided the necessary financial support for this study and developed the final color products.

BACKGROUND

In 1966, Governor Nelson Rockefeller directed the New York State Office of Planning Coordination to develop a comprehensive land use and natural resource inventory of the entire state. This inventory, referred to as LUNR, was based on aerial photography taken in 1967 and 1968 of upstate New York and in 1969 and 1970 of Long Island and New York City. From these photographs, land uses were mapped on mylar film overlays, using the standard U.S. Geological Survey 7.5 minute quadrangle as the base.

Land use data for the inventory were divided into two types: area and point data. Two overlay maps, one for area and the other for point data, were made to correspond in coverage and scale to each of the 7.5 minute USGS maps within the state. The area maps delineated all the land within the state according to 51 land use classes. Point maps designated by symbol the specific location of 68 different types of land use. At the county level, the area land use maps have proved to be much more valuable than the point maps because they contain needed information not readily available from other sources. Point information, generally human-made features on the landscape, has been easily obtainable from various public and semi-public agencies at the state level. From the information on these maps, a computerized geodata base was constructed. The data base was structured on the Universal Transverse Mercator (UTM) grid with a cell resolution size on one square kilometer or 247.1 acres.

In 1972, the Temporary State Commission to Study the Catskills was established by the state legislature. One of the charges given to this commission was to analyze land use conditions in the seven-county area designated as the Catskills. Schoharie County was one of the seven counties. Based on aerial photographs taken in 1973, updated LUNR maps were made of the region. Thus, the Commission was able to compare the 1968 and 1973 maps, a five-year interval. The geodata base was not updated. In 1976, the Commission was dissolved with no plans for updating LUNR maps in the future.

Even though many local governments have expressed a desire to have new, up-to-date LUNR maps and many state agencies have stated a strong need for an updated geodata base, the high costs of acquiring aerial imagery for the entire state, of interpreting the photography, and of manually drafting the maps and entering information into the geodata base make it impossible to maintain the LUNR system. Consequently, a need exists but funds are not available to accomplish the task using traditional methods.

In 1975 the Schoharie County Planning and Development Agency and OLCGSA entered into a cooperative arrangement called the Schoharie County Cooperative Program (SCCP). Under this program several major projects have been undertaken by OLCGSA for the county. One major project was the development of a county-wide automated geographic information system. This information system contains terrain, soil, cultural, and land use data. When this information system was developed, land use data were extrapolated manually from the 1973 LUNR maps and entered into the system's geodata base -- a long, tedious task. This geodata base is similar in structure to the State LUNR data base but it has a smaller cell size and additional variables. The land cover information produced under this project was also entered into the Schoharie County geodata base; thus, the data base now possesses both 1973 and 1978 land use data. Because this information was generated from Landsat digital data, entering it into the data base was an easy procedure.

Based on this long term working relationship between OLCGSA and Schoharie County and the type of products developed by OLCGSA for the county, Schoharie County makes an ideal case study area for this project. In addition, the county possesses a good variety of land uses, typical of many sections of upstate New York.

PROCEDURE

The initial step was to select an appropriate Landsat scene. Since the LUNR inventories were conducted in 1968 and 1973, county officials expressed a desire to maintain the five year interval between inventories which made it necessary to acquire a 1978 scene. Like much of the northeast United States, Schoharie County is located in a hilly region usually covered with heavy haze and clouds. This condition made it extremely difficult to find a workable scene. A November 2nd scene was selected initially because it was the only cloud-free data set with high quality rating in all four multi-spectral scanner (MSS) channels. However, as a result of the low sun angle at that time of the year, shadows darkened the west facing slopes and bright reflecting surfaces appeared on east facing slopes. A variety of ratioing techniques were employed in an attempt to rectify this situation, but with little success. In addition, the time of year was not the best for detecting various vegetation patterns. Later, an August 22 scene was acquired. This scene had high ratings in all four channels but some small clouds existed in the upland areas of the county. Due to its good reflectance patterns showing different types of vegetation and the high sun angle during the summer, this August scene became the data base for the study.

After selecting a scene, the next step was the pre-processing and analysis of the data. OLCGSA has developed a computer system known as LAP (Landsat Analysis Package) for handling multispectral data. Using the LAP system the scene was initially rectified to eliminate some of the errors resulting from unbalanced radiometric responses from the scanner and reformatted to make the data easier to handle during analysis. Channel 1 (MSS band 4) contained some unusual data irregularities making it undesirable for the study, but since channels 1 and 2 are highly correlated, the loss of channel 1 should not have significantly altered classification results.

Once the scene was rectified and reorganized, a modified version of the technique known as SEARCH was used to obtain training fields, and thereby, spectral classes (groups of similar training fields). Originally developed by NASA's Earth Resources Laboratory, SEARCH is an unsupervised method to the extent that training fields are automatically selected and a supervised method with respect to how class statistics are generated. The SEARCH algorithm is based on moving a window of prescribed size through the data set searching for areas which are spectrally homogeneous. Such areas are called training fields. In this study a window size of 3 rows by 3 columns (9 pixels) was used. To establish the level of spectral homogeneity desired for selecting training fields, and to stress certain general land cover conditions, an investigator must define a set of parameter values within the SEARCH program. By varying these values, different groups of pixels within the scene will become training fields resulting in various land cover patterns being observed. After investigating numerous combinations of parameter values, an acceptable set was obtained in terms of the specific objectives of this study. Thirty five spectral classes were produced based on these values.

These spectral classes were processed through the maximum likelihood classification technique to classify each pixel within the study area. Each spectral class was then assigned a land cover class by the analyst, who compared, using photointerpretative methods, the spatial and land surface patterns on the aerial photography with similar patterns on the Landsat alphanumeric computer generated maps. Generally, several spectral classes were grouped together to form a single land cover class. The defined land cover classes are listed in Table 1.

Table 1

LAND COVER CLASSES

AG	Agriculture
DF	Deciduous Forest
CF	Coniferous Forest
BW	Brushwood
WW	Wooded Wetlands
UR	Urban
SB	Suburban
HA	Hamlet
SM	Surface Mining
WT	Water
RE	Reservoir

Once the scene was statistically classified, it was necessary to redefine the land cover for some pixels. As previously indicated a few small clouds existed over the study area in the August scene. These clouds and their respective shadows were cosmetically removed from the classified scene and replaced by the land cover patterns indicated on 1975 high altitude color IR photography. Each of these cosmetically altered areas related to a mature forest environment, and no noticeable land cover change occurred in any of these areas between 1975 and 1981, when they were field checked. Also, in order to show on the land cover maps a continuous water pattern for the Schoharie River, it was necessary to link sections of the river together where overhanging vegetation blocked or modified potential water reflectances, and to insert water pixels on the river's bends where the rectangular shaped pixels did not display well formed curves. Finally, certain spectral classes could not be easily assigned to any one land cover. In certain sections of the scene they related to one land cover; whereas, in other sections they were best grouped into another land cover. Rather than grouping one of these classes completely under one land cover throughout the entire scene, they were assigned to different land covers in different sections of the scene. This procedure was done cosmetically by an analyst using an interactive computer system, a component of LAP, to change the classified values of selected pixels. None of these spectral classes was extensive in their areal coverage, and none of them was split between more than two land cover classes.

VALIDATION

Two different methods were employed to validate the accuracy of the land cover classes generated. First, by overlaying the mylar based 1968 and 1973 LUNR maps on the 1978 Landsat computer line printer maps produced at the same scale, visual comparisons were made for general compatibility between land surface features over the three different years. This method allowed the investigators to determine if the Landsat land cover classes corresponded spatially with the land use classes of the earlier inventories. In general, a high degree of spatial correlation existed between the classified maps and the LUNR maps. The noticeable differences were due to either landscape alterations not in existence in either 1968 or 1973, or to variations in land cover definitions between inventories.

The second method, a more rigorous test of accuracy, involved the statistical sampling of individual classified pixels. The classified scene was organized in a grid pattern with scan lines and elements sequentially numbered. Using random numbers in correspondence with the numbered lines and elements, forty randomly selected pixels were obtained for each land cover class. The selected pixels were compared to the 1975 color IR photography to determine their relative accuracy. Next, a grid was superimposed on the aerial photography covering the classified scene. Employing, again, random numbers in relationship to the lines and elements of the gridded photography, forty pixels were compared to the classified scene. This cross-checking procedure of photography to scene reduces the possibility that certain land cover locations within the study area will be overlooked as might be the case when comparing only the scene to photography. None of the areas altered cosmetically were used for sample points.

Table 2 illustrates the results of this second accuracy test. Overall, the land cover classes recorded

Table 2

Comparative Accuracy Results Between the Landsat Classified Land Cover Map and the Photographically Interpreted Infrared Aerial Photography

Land Cover	Scene to Photo (Percent)	Photo to Scene (Percent)	Combined (Percent)
Agriculture	92.50	90.00	91.13
Deciduous Forest	95.00	90.00	92.50
Coniferous Forest	87.50	92.50	90.00
Brushwood	85.00	90.00	87.50
Wooded Wetland	87.50	82.50	85.00
Urban	90.00	92.50	91.13
Suburban	85.00	85.00	85.00
Hamlet	70.00	72.50	71.13
Surface Mining	92.50	90.00	91.13
Water	97.50	95.00	96.13
Reservoir	100.50	97.50	98.63

percent marks in the high 80's and low 90's, an accuracy level comparable to most large land use inventories produced under traditional methodologies. The two water classes have very high marks; however, some problems existed in separating water from wooded wetlands. The lowest marks relate to the class entitled "Hamlet." Some hamlets were not detected due to the size of the community and the density of tall, full-crown trees which hid them from the satellite's sensors. Although the accuracy results for this study are good, they must be considered with respect to the investigator's interpretation of the landscape on the aerial photography.

LAND COVER CLASSES

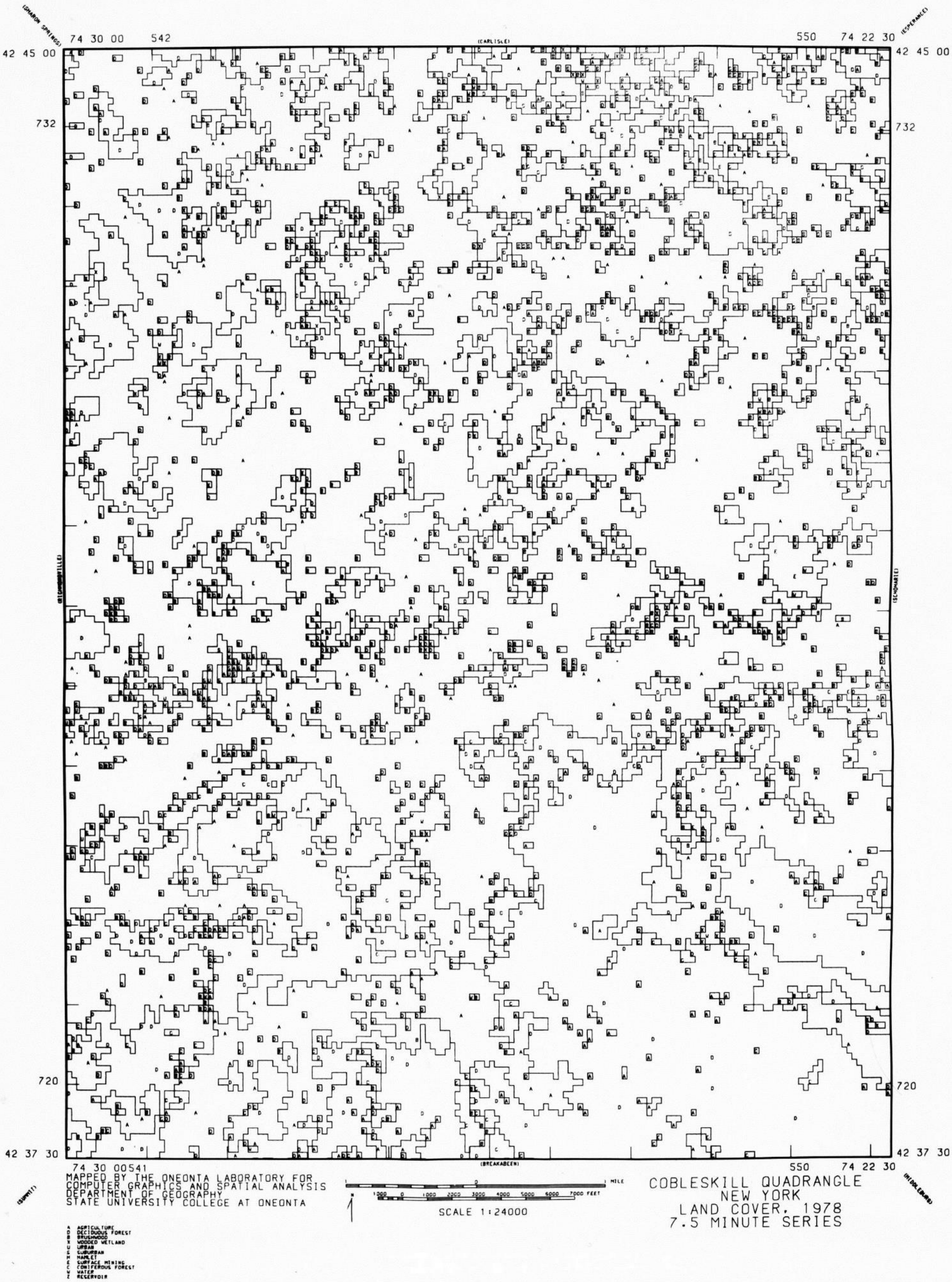
The specific goal of this project was to examine the feasibility of using Landsat data to update the New York LUNR information base. The ideal outcome would be to produce the identical land use classes created under the LUNR inventories. This outcome has been partially realized. In general, some of the derived land cover classes correspond to LUNR classes but others need to be refined. The forest classes relate well to LUNR forest classes but the single agricultural class does not provide the detail found in the LUNR system. An agricultural landscape is more dynamic than a forest environment; thus, the timing of the data becomes critical in order to detect certain land cover conditions. For example, to separate cropland from pasture, a late spring data set would be valuable because most cropland would be bare of any vegetation coverage.

To measure the project's outcome based strictly on the direct correlation between the Landsat and LUNR land cover classes is not possible, so some indirect correlations must be considered. Some LUNR classes are inherent within the Landsat-derived maps although not specifically indicated on them. Classes associated with heterogeneous land surfaces frequently fall into this condition. Brushland, for example, is a mosaic composed of small patches of either grass, shrub, or forest. Under the traditional air photo interpretation methodology, an investigator would identify a brushland area by grouping these mixed patches together under one cateogry. However, the Landsat methodology is based upon classifying each pixel. With a pixel approximately an acre in size, nearly every patch within the mosaic can be identified according to its basic land cover. The Landsat-derived maps display areas consisting of clusters of single pixels and small groups of pixels classified as brushwood, agriculture, and deciduous forest. Collectively, these distinct pixels or groups of pixels form a brushland condition. Individuals working with these maps must recognize the existence of these inherent land cover classes and how these classes apply to the LUNR system or any other land use inventory.

In addition to the inherent land cover classes, another method exists for obtaining LUNR classes indirectly from the Landsat classes. As previously demonstrated in the section entitled "Procedure," different land cover information can be obtained by relating the generated land cover data to other data sets. Elevation and slope data might be used to subdivide the agricultural land cover class into grassland versus cropland. Schoharie County with its geographic information system could relate each pixel classified agriculture with the elevation and slope information available in its geodata base. Other counties without established geographic information systems could overlay Landsat-derived maps on topographic maps and accomplish the same basic outcome.

MAP PRODUCTS

Once an acceptable classification was developed, the scene was geometrically corrected and rescaled to relate to the 7.5 minute USGS quadrangel map size. Employing a digital plotter, land cover maps were plotted onto a mylar surface (Figure 1). These maps were similar to the LUNR maps in appearance. Mylar, a durable mapping surface, is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COMPUTER GRAPHICS AND SPATIAL ANALYSIS
DEPARTMENT OF GEOGRAPHY
STATE UNIVERSITY COLLEGE AT ONEONTA
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D DECIDUOUS FOREST
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X WOODED WETLAND
U URBAN
S SUBURBAN
H HAMLET
E SURFACE MINING
C CONIFEROUS FOREST
W WATER
Z RESERVOIR

a transparent film making it possible to overlay the land cover maps on the county's topographic and soil maps. This overlay ability will allow county officials to note spatial relationships between terrain, soil, and land cover. Also, the mylar will permit excellent blue print copies of the land cover maps to be made. The blue print copies can be used as work maps for a variety of purposes. These land cover maps are different from the LUNR maps in two ways. First, due to the size and shape of the pixels the land cover patterns on the maps are block-like in appearance. Second, because point data are impossible to detect with the Landsat resolution, only area data are being classified and mapped. Consequently, one land cover map was developed for each 7.5 minute USGS quad rather than two maps which was the case under the LUNR inventories. The elimination of the point data maps is not perceived as a major problem. As previously indicated, county government officials are much more interested in the area land use information.

These maps are best suited as work maps. They are designed to allow county officials to examine in relative detail various planning and development issues spatially. As work maps they fulfill a certain need.