Attempting to Detect and Record Brushland in the Northeastern United States Using MSS Data: Schoharie County, N. Y., as a Case Study

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ABSTRACT: Before county and local governments will utilize satellite data extensively for landcover inventories, digital image processing techniques must be developed to identify transitional land-use conditions and create large-scale, readable land-cover maps. This study examines a satellite-based land-cover inventory done for Schoharie County, New York and reviews the problems encountered in identifying and mapping brushland – a significant transitional land use – within the county and region. Brushland throughout the Northeast represents a barometer for measuring the shift away from agricultural land use to second-home property. Detecting and locating brushland on a regular basis can greatly assist county and local government officials in planning and managing a county's future.

INTRODUCTION

SCHOHARIE COUNTY, a rural county situated on the northern edge of the Catskills, is experiencing, as are many areas of the northeastern United States, a land-use shift away from dairy farming and a movement toward vacation/second-home property. In 1968, using traditional aerial photographic techniques, New York State developed a land-use inventory of its upstate region. Employing the same techniques, the inventory was updated in 1973, but only for the Catskill Region. Maintaining the five year interval, the inventory was again updated in 1978 for Schoharie County using Landsat MSS data and digital image processing techniques. One major land-use change noted in these inventories was the shift of marginal farmland to abandoned, brush covered land which eventually would become forests - the desired environment for second-home property. Brushland represents a significant intermediate stage in this land-use shift; however, it does not form a homogeneous surface condition in a manner similar to some other land covers, making it difficult to identify and display using conventional digital image processing techniques. Local government officials throughout the rural areas of the Northeast are quite concerned about the repercussions which this land-use change might have on local economies and governmental expenditures. Brushland forms a barometer for measuring land loss to active agriculture and potential land gain for second-home development. Using Schoharie County as a case study, this paper examines the issues associated with detecting and recording brushland using satellite imagery in comparison to aerial photography and the reaction of local governmental officials to a satellite based inventory featuring brushland.

BACKGROUND

In 1966, the New York State Office of Planning Coordination was directed by the late Governor Rockefeller to develop a comprehensive land-cover study of the entire state known as the Land Use and Natural Resources (LUNR) inventory. This inventory was based on aerial photography taken in 1967–68 for upstate New York and 1969–70 for Long Island and New York City (Swanson, 1969). From these photographs, land-use maps were produced on mylar film as overlays to the U.S. Geological Survey 7½-minute quadrangles. These maps were valuable planning and development tools used by local governments. From the information on these maps, a computerized geodata base was constructed which was structured on the Universal Transverse Mercator (UTM) grid with a cell resolution size of one square kilometre (Tomlinson, 1976).

In 1972, the Temporary State Commission to Study the Catskills (1975b) 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 detect and analyze land-use change over the five-year interval between the 1968 and 1973 LUNR inventories. In 1976, the Commission was dissolved with no plans made for updating LUNR maps in the future.

In 1975 a cooperative program was established between the State University of New York, College at Oneonta, and the Schoharie County Planning and Development Agency (SCPDA). Several projects were undertaken through this program, one of which was to develop a countywide automated geographic information system for environmental monitoring (Baumann, 1983a). This system contained land-use information from the 1968 and 1973 LUNR inventories. In the early 1980s, the land-use portion of this system was updated using 1978 Landsat MSS data. The year 1978 was selected in order to maintain a five-year interval. In addition to updating the geographic information system, a new set of mylar overlay maps showing land use was prepared based on the 1978 MSS data. SCPDA was particularly interested in having up-to-date maps because the planners had done considerable work with the 1968 and 1973 LUNR maps and found them to be an important resource for planning purposes.

This project was sponsored by NASA's Eastern Regional Remote Sensing Applications Center (ERRSAC) to demonstrate the utility of operational applications of satellite data at the local government level (Baumann, 1981). The total cost of the project, including computer time and data acquisition, was $11,600, considerably less than the estimated $25,000 needed to produce the 1973 LUNR maps which were based on aerial photography. However, for several reasons the project was not repeated. First, with the commercialization of the Landsat program, satellite data sets have increased in price form several hundred dollars to several thousand dollars per set. For a project of this type,

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this price increase might be partially offset by the decrease in the cost of computer time. Second, the maps generated through this project were difficult for the local planners and decision-makers to read. This problem is discussed in greater detail later in the paper. Third, both LUNR projects as well as this project were supported mainly by state and federal funds. The county does not have a record of financing work of this type from local funds. This same problem has plagued the development and use of the geographic information system prepared by the college for the county. Finally, the lack of time and funds by both the college and county has made it difficult to train local officials on how to use remote sensing and GIS techniques to address the county's planning problems.

STUDY AREA

Schoharie County, situated in east-central New York State, covers an area of 1616 square kilometres (see Figure 1). Based on the 1980 Census, the county has a population of 29,710 with its largest community accounting for 5272 people. In 1970 the county had 24,750 people; thus, during the ten-year interval it experienced about a 20 percent increase in population. The State during this same time period faced a 3.7 percent decrease in population. Schoharie's growth reflects mainly an internal shift in the State's population from the urban centers to the rural areas. These population figures for the county do not include the large non-resident population.

Dairy farming is the county's principal occupation, followed by service activities and a few small industries. A growing number of people commute to Albany and Schenectady to work aided by the construction of an interstate highway through the county. The county faces several major land-use problems, two of which are the continued loss of agricultural land and the increase of land owned by non-county residents. From 1969 to 1978, during the period that the county experienced a 20 percent increase in population, it lost 105 farms and 9880 hectares of farm land. However, the average size of a lost farm was 93.8 hectares, which would indicate that most of these farms were working under marginal conditions. This loss of farmland represents an on-going process which started mainly after World War II and peaked during the 1950s and 1960s when a number of large, marginal farms in hill regions of the county were abandoned. In 1980, the county had 10,889 year-round housing units and 1,762 seasonal or vacant units. Of this latter group, 433 were designed for occasional use such as weekend visits, summer vacations, or hunting trips, and 338 were in varying stages of abandonment.

FIG. 1. Location of Schoharie County in New York State and the Catskill Region as defined by the Temporary State Commission to Study the Catskills.

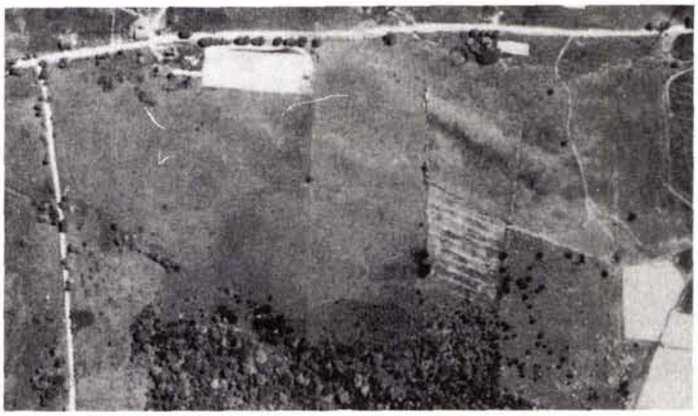
The county possesses considerable topographic variation ranging from low rolling hills above the Mohawk Valley in the north to the Catskill Mountains in the south. The northern third of the county averages around 425 metres in elevation with a local relief of approximately 45 metres. In general, this rolling land produces good crops such as hay, corn, and oats. A relatively high, heavily dissected plateau condition exists throughout the center of the county. With poor soils and steep slopes, the land is mainly in forest, brushland, and pasture. In the southern part of the county the Catskills rise to elevations of over 765 metres, 150 to 185 metres above the general level of the upland plateau. These glaciated mountains, with rounded slopes, are heavily wooded. Overall, the county corresponds closely in area to the drainage basin of the Schoharie River which flows northward from the mountains to the Mohawk River. This river meanders through a wide, fertile valley setting from 150 to 245 metres below the surrounding uplands. Endowed with rich soil, the valley contains excellent farmland and forms the historical heart of the county. Figure 2 shows the Schoharie River flowing northward through the county's hill region in the south out onto its rolling topography area in the north, eventually linking with the east flowing Mohawk River.

BRUSHLAND

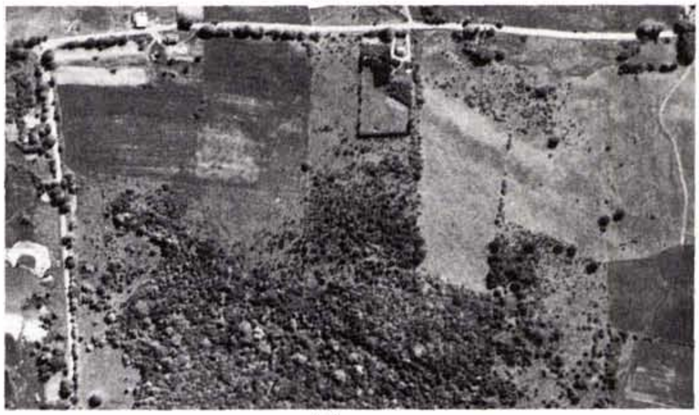
Brushland represents a transitional stage of pasture and cultivated land reverting back to forest. Around the turn of the century much of the hill land and slopes as well as valleys in Schoharie County were cleared of forest and used for pasture and cropland. As farmers in the region found it harder to compete with the development of new technologies and economic approaches to farming, they started to supplement their income with non-farm jobs, and concentrated their farming endeavors on their best land, mainly the valley bottoms and low slope areas (Temporary State Commission to Study the Catskills, 1975a). With smaller dairy herds developing due to increased milk production per cow and tractors replacing horse-drawn equipment, which was more suited for steeper slope areas, much of the pasture and cropland reverted back to forest. Pasture would start first by showing clusters of low brush generally near the edge of the field next to existing forest. Next, white pine trees would intrude, forcing the low brush to move further into the field. Hardwoods (mainly maple and oak) would follow by mixing with the pine and eventually replacing the pine except on steep and north-facing slopes. Cropland went through these same stages, but farmers frequently allowed this type of land to convert initially to pasture. Figures 3a through 3c show a series of aerial photographs taken in 1937, 1960, and 1973, respectively, for the same area. These photographs illustrate such historic changes, as cropland and pasture gave way to brushland and finally to forest.

Brushland provides little income to farmers who face increased property taxes as the county is pushed toward offering more services for the growing non-farm population. In 1971, the State required each county to produce a tax map for each parcel of land. Because much of the land was originally laid out by the metes and bounds system, property lines were frequently in question, but with the aid of aerial photographs, these tax maps were made showing property lines. With better defined parcels, many farmers found that they owned more land than originally indicated and, as a consequence, had to pay more taxes. With an increase in non-productive land and more taxes, farmers have felt the pressure to dispose of their farms. Sometimes if they are not able to sell their land, they lose it to delinquent taxes. Urbanites from the nearby cities, especially New York City, find land prices in places like Scho-

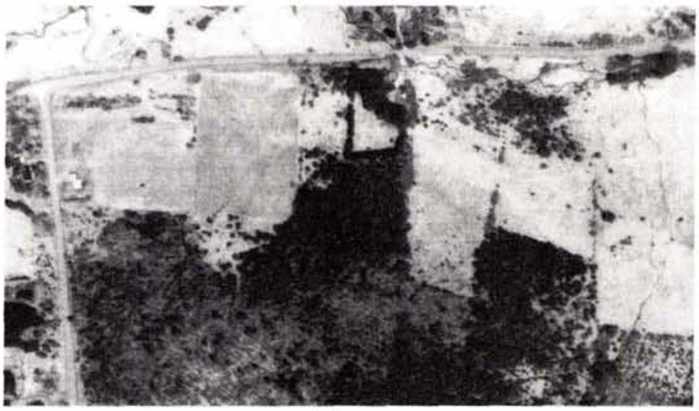
FIG. 2. Landsat MSS Band 6 image of the Schoharie Region. The Schoharie River flows northward through the center of the image linking with the Mohawk River which is located outside the country.



(a)



(b)



(c)

FIG. 3. Photographs taken in (a) 1937, (b) 1960, and (c) 1973, respectively, showing the normal land-use shift of cropland to brushland and brushland to forest.

harie County extremely low. They are seeking property for rural retreats and as a means of lowering both their federal and state income taxes by having a second home. To some of these urbanites, especially those interested in hunting, brushland areas are quite attractive, because wild game such as deer and turkey concentrate in brush environments. These urbanites also like forested areas because they provide more privacy and epitomize the "back to nature" experience.

Brushland represents an important barometer of land-use changes in the county and associated changes in social and economic patterns. A farmer generally takes note when another farmer does not work a field and allows it to begin the process of reverting back to the natural environment. It reflects how the second farmer is thinking and problems which he may be facing. County and town planners and decision-makers try to take note of the same conditions but at a different scale. By identifying which areas are experiencing a shift from agricultural land to brush conditions, planners and decision-makers can attempt to take appropriate action at an early stage. Their problem lies in obtaining accurate information about brushland for large areas within a reasonable time period, so that decisions based on general observations and speculations are minimized; thus, the need for satellite based remote sensing techniques to detect brushland.

1978 STUDY

A 9 August 1978 Landsat MSS scene was acquired for the 1978 updating of the 1968 and 1974 LUNR inventories of Schoharie County. In addition to maintaining the five-year interval, the scene was selected for its near cloud free conditions, high ratings in all four channels, and summer coverage. Using NASA/Earth Resources Laboratory's SEARCH program, an unsupervised technique, 35 spectral classes were generated using channels 2, 3, and 4. Channel 1 was dropped due to its high correlation with channel 2. The spectral classes were processed through the maximum likelihood classifier to assign each pixel to a class. Using field methods, limited 1975 aerial photographic coverage, and topographic maps, the 35 classes were grouped to form 11 land-cover classes which are identified in Table 1. The accuracy level for these classes ranged from approximately 70 percent for the settlement patterns to 97.5 percent for water, with most classes falling between 85 and 92 percent. The classified data set was geometrically rectified and scaled to conform to the USGS 7½-minute topographic maps. Employing a digital pen plotter, the corrected data set was used to produce maps similar in format to the LUNR maps (Baumann, 1983b).

Table 2 shows, by township, the percentage of total area for each land-cover class based on this 1978 study. The northern townships average approximately 60 percent of their land cover in agriculture, whereas the southern townships have between 60 and 70 percent of their land in forest. Also, the southern townships possess a relatively higher amount of land in coniferous forests than do the northern townships. Such forests generally exist at higher elevations and on steep, north facing slopes, matching topographic conditions associated with the southern half of the county. The northern townships contain more of a land class identified as "brushwood," an advanced

TABLE 1. LAND-COVER CLASSES DERIVED FROM MSS DIGITAL DATA

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

TABLE 2. PERCENT OF TOTAL LAND COVER BY TOWNSHIP

	AG.	MF.	CF.	BW.	WL.	ST.*	SM.	WT.**
Northern Townships								
Carlisle	57.54	28.25	0.12	11.41	1.92	0.00	0.00	0.88
Cobleskill	61.76	25.97	2.66	6.35	0.55	1.05	1.08	0.57
Esperance	52.11	26.47	0.07	17.51	0.99	0.38	0.00	2.47
Richmondville	60.38	33.68	2.12	3.10	0.01	0.13	0.00	0.22
Schoharie	58.50	29.15	4.52	4.28	1.29	0.61	0.09	1.54
Seward	64.22	32.00	2.22	0.87	0.31	0.03	0.00	0.34
Sharon	71.47	24.39	0.42	2.53	0.62	0.00	0.00	0.56
Wright	56.05	36.56	3.94	2.35	0.69	0.08	0.09	0.23
Southern Townships								
Blenhein	16.59	67.15	12.86	0.89	0.06	0.00	0.00	2.43
Broome	28.95	57.50	12.04	0.71	0.43	0.00	0.00	0.36
Conesville	30.57	56.96	10.17	0.96	0.00	0.00	0.00	1.33
Fulton	23.44	63.29	11.40	0.97	0.25	0.00	0.00	0.65
Gilboa	34.00	52.04	9.08	1.53	0.38	0.00	0.00	2.97
Jefferson	46.67	51.32	5.13	0.48	0.06	0.06	0.00	0.28
Middleburg	35.71	51.43	9.94	1.47	0.37	0.42	0.08	0.91
Summit	46.46	41.37	9.83	1.17	0.20	0.00	0.00	0.97
COUNTY	43.60	45.04	6.84	2.80	0.46	0.13	0.07	1.05

* Settlement (ST.) includes the land cover classes of urban, suburban, and hamlet.

** Water (WT.) includes reservoirs as well as other water bodies.

stage of brushland having more tree coverage. The southern half of the county experienced the shift from farm abandonment to brushland to forest at an earlier period, resulting in the higher percentage of land in forest. The county's northern towns are more at the brushland stage of this process because farm abondonment has proceeded in these areas at a slower rate. Throughout the Catskills the most significant land-use change observed between the 1968 and 1973 LUNR inventories was the decrease in brushland and the corresponding increase in forest land, indicating that the brushland of 1968 had become forest in 1973 and that farm land abandonment to brushland had slowed down.

FINDINGS

In general, the 1978 study provided evidence in support of the known land-use patterns and changes within Schoharie County and showed for the first time the significant increase in brush conditions in the northern townships. The study also demonstrated the problems associated with identifying and displaying brushland, particularly in comparison to the 1968 and 1973 aerial photo interpretation inventories. Brushland is a mosaic composed of small patches of grass, shrub, and/or trees, making it a heterogeneous type land cover. Under traditional aerial photo interpretation techniques, an investigator would identify a brushland area by grouping these mixed patches together as one land cover and show the area as a single, contiguous pattern on a map. However, conventional digital image processing methodology is based upon classifying each pixel. With an MSS pixel approximately 2.7 hectares in size, nearly every patch within the brushland mosaic can be identified according to its basic land cover. No suitable image processing procedures exist to group these contiguous but heterogeneous patches of land cover together as one class. Consequently, individual pixels within a brushland area were classified as being either deciduous forest, coniferous forest, brushwood, or agriculture. The percentage values associated with these four classes in Table 2 are inflated because they include counts in brushland areas as well as areas normally classified under these categories. A class identified as brushwood was developed but should not be confused with brushland. Brushwood represents a later stage in the brushland transition from active agricultural land to forest and is associated with more contiguous tree cover and less open land conditions. In general, brushland as a land-cover category was not detectable using digital image processing techniques.

The 7½-minute land cover maps derived from this study display areas of brushland as clusters of single pixels and/or small groups of pixels classified as brushwood, agriculture, and forest. Figure 4, which shows a representative section from one of these land-cover maps, illustrates this situation of mixed pixels. The deciduous forest (D) and agriculture (A) areas are represented as large, contiguous surfaces, whereas brushland is inferred through the pixel clusters of brushwood (B), coniferous forest (C), deciduous forest, and agriculture. Collectively, these distinct pixels or groups of pixels form a brushland condition. In comparison Figure 5 shows an example of brushland (Fc) as presented on a LUNR map. The brushland pattern is illustrated as a solid surface representing a transition zone between cropland/pasture (Ac) or inactive agriculture (Ai) and forest land (Fn). To the local government officials of Schoharie County the satellite derived maps were difficult to read due to the level of detail on the maps and the box-shaped representation of land-cover patterns. The level of detail was not due to the number of different land-cover classes but to the mixture of individual land-cover pixels found in areas throughout the maps. Even though it was explained that these mixtures represented transitional conditions, and in most cases brushland areas, the maps were still difficult to read and relate to the actual landscape. To filter out individual land-cover pixels by grouping them with neighboring pixels to form larger clusters might make the maps less complex in appearance and, thereby, more readable, but this process might also eliminate many of the transitional areas. In most cases local rural planners want good land cover maps down to the 7½-minute level. Small scale, satellite derived maps are generally attractive and colorful, but they do not provide information down to the level at which local planners frequently need to work.

The box-shaped representation of patterns could be overcome by developing more sophisticated computer algorithms that could generalize the boundaries between land-cover classes and create cosmetically better looking maps. This process would require considerably more computer time. To draft a single map using the existing system took approximately 30 minutes of process time on a large mainframe computer and slightly more than two hours on a high speed digital plotter. To handle heterogeneous land-cover conditions, which are inferred through the mosaic clustering of other land covers, is a harder issue to overcome. A nearest-neighbor algorithm might be designed that could detect areas with clusters of individual pixels associated with certain land covers and group the pixels in these area together to form a single land-cover class. Such an algorithm would be extremely difficult to develop and would consume a great amount of computer time which could push the cost of producing maps of this type beyond what a local government could afford.

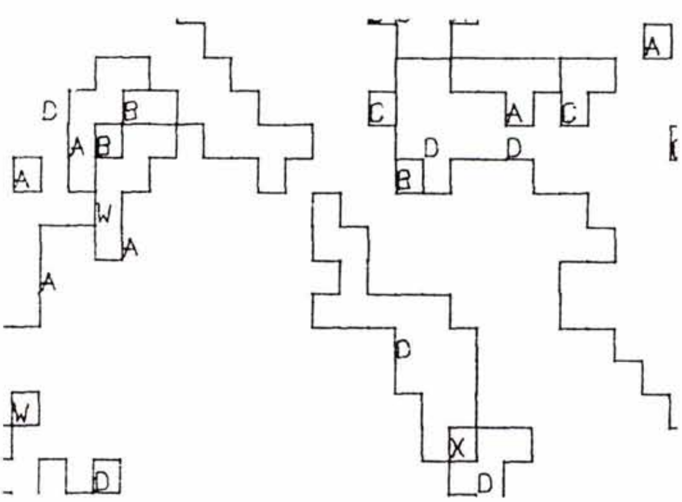


FIG. 4. Sample area from the land-cover map produced from the 1978 Landsat MSS data.

FIG. 5. Same sample area as shown in Figure 3, but from the LUNR map developed from the 1973 aerial photography.

Although the county has not provided any funds to continue this project using TM data sets for either 1983 or 1988, some work on brushland identification and mapping has been done at the college using TM data. This research has not produced any approach for detecting brushland as a separate land-cover class, and the mapping problem has been compounded by the smaller TM pixel resolution. Also, the computer time to produce a map has increased considerably.

SUMMARY

Local planners and policy makers are interested in identifying and locating brushland areas because they generally represent the early stage of the loss of farm land and the movement toward second-home property. Brushland is a major land-cover category throughout the Northeast, but, as a transitional land cover with apparent heterogeneous conditions, it is difficult to detect using normal digital image processing techniques. To display brushland conditions on maps as mosaics of pixels representing a variety of land covers results in maps which are difficult to read and use. Before local planners and other government officials begin to view digital remote sensing as a means to address their planning and resource management problems, image processing techniques need to be developed that detect heterogeneous surfaces (such as brushland in the Northeast) as separate entities and methods must be found to produce large-scale maps which are readable and comparable to conventional land-cover maps. Also, local government officials must receive the opportunity to learn more about the techniques used to classify satellite digital imagery. Workshops represent a possible way to handle this problem, but local officials must receive adequate release time to make workshops practical. Attempts were made to conduct workshops for the Schoharie County planners, but they could only attend for a one-half day presentation. Without some method of educating these officials, a certain reluctance will always exist about using a technology they do not understand.

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