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ERTS-1 APPLICATIONS TO MINNESOTA LAND USE MAPPING

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ABSTRACT

Land use class definitions that can be operationally employed with ERTS-1 imagery are being developed with the cooperation of personnel from several state, regional, and federal agencies with land management responsibilities within the state and the University of Minnesota. Investigations of urban, extractive, forest, and wetlands areas indicate that it is feasible to subdivide each of these classes into several subclasses with the use of ERTS-1 images from one or more time periods.

INTRODUCTION

A spate of recent and pending state legislation has broadened and will greatly expand the powers of various state and local government agencies in the field of land use management in Minnesota. Land management agencies, charged with policy development and implementation, will require current land use data classified in a way that allows them to be employed in day to day operations. Cooperative efforts involving personnel from the State Planning Agency (SPA), several departments at the University of Minnesota, and state and federal agencies with land management responsibilities within the state are aimed at defining appropriate classes of land use information for incorporation into the Minnesota Land Management Information System (MLMIS). The system currently contains a ninefold land use classification for the nearly 1,400,000 forty-acre data cells in the state. These data are now four to five years old and will require continual updating. Furthermore, the classes are general and do not fully satisfy the land management agencies' needs for detailed land use information.

ERTS-1 imagery is being examined as a broad-scale, seasonally repeated data collection system in order to determine the suitability of this kind of imaging system for solving some of the land use data needs of the state. The questions we are specifically asking are: 1) What classification schemes are most useful to data users and how can they be met with ERTS type data? 2) What are the appropriate times of year to collect information for these various classes of land use? 3) What is the appropriate mapping unit or data cell size for mapping land use from ERTS? 4) What methods of interpretation, spectral band(s), and data processing will extract the maximum information from the ERTS-1 system?

Cooperative involvement of data users is the key to developing a successful classification scheme. The present MLMIS land use classification includes forested, urban residential, urban non-residential or mixed residential, cultivated, pasture or open, transportation, water, marsh, and extractive. The user agencies, almost exclusively, require more detail within one of these broad classes of land use. Once classes are established, the suitability of ERTS-1 for providing appropriate data can be determined. Timing, cell size, appropriate spectral bands, and data processing procedures can then be determined.

This paper will focus on four broad areas of land use: urban, extractive, forested, and wetlands. To achieve optimum classification schemes within these categories personnel from the State Planning Agency, the State Department of Natural Resources, the Metropolitan Council, the National Forest Service, the USDI Bureau of Sport Fisheries and Wildlife, County Land Commissioners, the Department of Iron Range Resources and Rehabilitation, private forest management firms, and the Soil Conservation Service are cooperating in the development and evaluation of land use classes. It is already evident that needs of data users vary greatly, and that information needs of individual data users are not always well defined. This project is bringing the land and resource management people together to better define and make more compatible, their information needs.

INTERPRETATION

PROCEDURES. Test areas for each broad class of land use were selected on the basis of the quality of ERTS-1 imagery received to date (Fig. 1). Interpretation procedures for the work reported here are largely based on the use of bulk MSS 70 mm positive transparencies. These are either projected for interpretation of individual bands or color combined in the Institute of Agriculture Remote Sensing Laboratory's I^2S Mini-Addcol color combiner. These color combined scenes are then photographed and projected for interpretation at scales ranging from 1:30,000 to 1:250,000. Nine-inch bulk positive and negative transparencies of these ground scenes have been obtained on retrospective requests, and are now being analyzed by density level slicing with an Interpretation Systems VP-8 image analyzer.

Ground truth to support these investigations is based on field investigations and a variety of aerial photography provided by the State Planning Agency, the College of Forestry, and NASA. Preliminary interpretation results based on these materials will be discussed individually for the four broad classes of land use.

URBAN. In MLMIS, urban land is divided into two classes--urban residential and urban non-residential or mixed residential. The very low threshold of detection (five dwellings or one commercial structure per forty-acre cell), although suitable for interpretation from high altitude photography, is neither operable from high quality ERTS-1 MSS images nor does it produce a useful data set for metropolitan Twin Cities land use analysis and planning. The scheme being tested for use with ERTS imagery is a more detailed land use classification designed to maximize compatibility with the land use system developed by the Metropolitan Council. Results are very encouraging for the development of a much more useable and detailed data base.

Figure 2 shows examples of the classification scheme on color combined MSS bands 5, and 7 of October 6, 1972 ERTS coverage of the Twin Cities. This date of coverage has the maximum contrast of the four periods of coverage received to date. The threshold of detection of residential land seems to be about twenty dwellings per forty acres.

EXTRACTIVE. A 288 square mile test area in the Mesabi Range was selected to develop a classification scheme for extractive industries. A portion of this area is shown in Figure 3. Interpretation of July 6, 1972 NASA underflights provides the basis for comparison with ERTS-1 images and ground truth is supported by published maps of mining features. Bands 4, 5, and 7 are projected individually for interpretation and classification of extractive features into tailings and mine pits. ERTS-1 imagery compares very favorably with the 1:120,000 scale photography in terms of area measurements; however, accuracy is directly related to size. Class assignment was difficult for shallow pits and low tailings piles from the September 18, 1972 images. However, January 4, 1973 images (Band 7) provide sufficient snow enhancement of shadows at low sun angles to allow seperation of positive and negative mine features.

Age of abandoned pits and tailings is also a factor affecting the ease of detection. Some features not readily identified as old tailings piles on individual bands are detectable on color combined images (Fig. 3). Older, water-filled pits and active tailings ponds can also be identified. Furthermore, gravel quarries in the test area show up only on Band 5 and are thus separable from the iron extraction facilities.

FORESTED. The diversity and importance of forests in Minnesota has dictated the use of several test sites. August 12, 1972 color combined images of the Superior National Forest allow the separation of conifers and hardwoods (Fig. 4). Also evident are the logging patterns and wildfire burn. Better color contrasts are obtained on the October 7, 1972 color combined image of the Chippewa National Forest area (Fig. 7). Conifer-hardwood distinctions are easily made and in some areas lowland conifers can be separated from upland conifers.

The optimal color combinations for enhancing forest classification and interpretation is with a green filter with Band 5 and a red filter

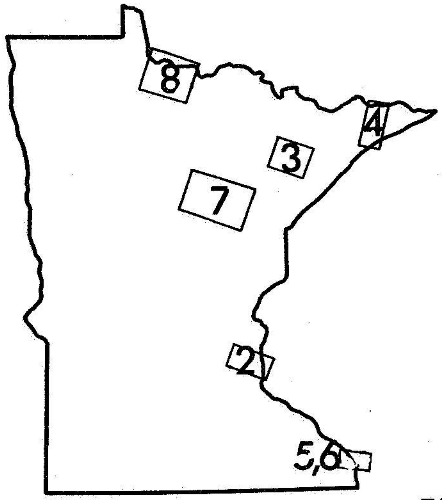

Figure 1. Location of Figures 2 through 8.

Figure 2. Color combined image, Twin Cities Metropolitan Area. Letters denote classes of urban use: A=Commercial Core; B=Industrial Core; C-Commercial/Industrial Strip; D=Multiple Dwellings; F=Older, Single Family Dwellings; G=Newer, Single Family Dwellings; H=Recreational/Open Space; I=Transportation; J=Water.

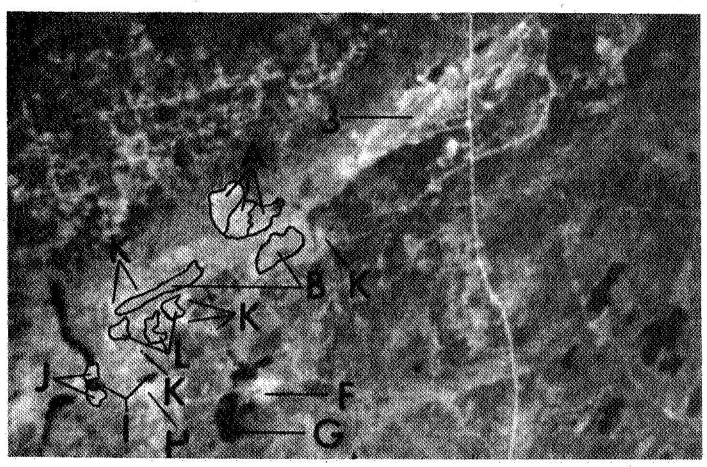

Figure 3. Color combined image, Mesabi Range. Letters represent extractive land use classes. A=Tailing Ponds; B=Deep Open Pit Mines (Iron Ore); L=Shallow Open Pit Mines (Taconite); K= Tailings Piles or Stripping; F=Hoyt Lakes (population 3,634); G=Reservoir; H=Aurora (population 2,531); I=Water filled, abandoned Iron Ore Pits; J=Old Tailings Piles.

Figure 4. Color combined image, Superior National Forest. Letters denote forest types: A=Conifer; B=Conifer/Conifer-Hardwood; C,D,F,G, & H=Logged areas; I=Conifers in logged area.

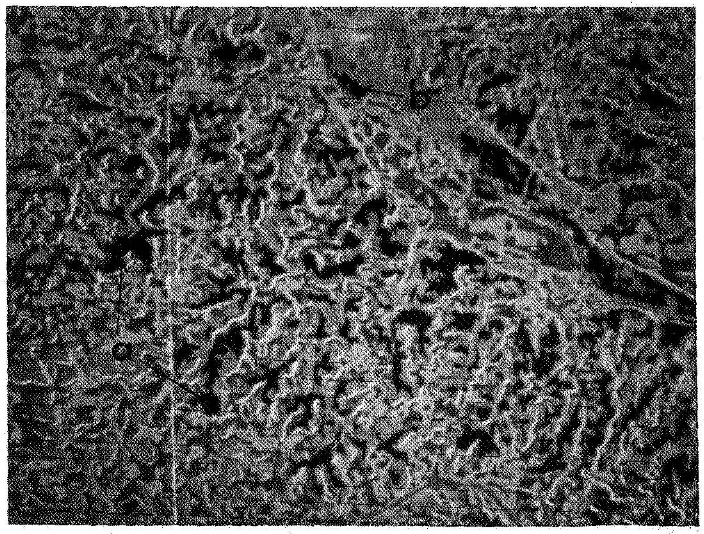

Figure 5. An image of band 7 for the area shown in Figure 6 which has been density sliced to emphasize forests: a=Upland Deciduous Forests; b=River Bottom Deciduous Forest.

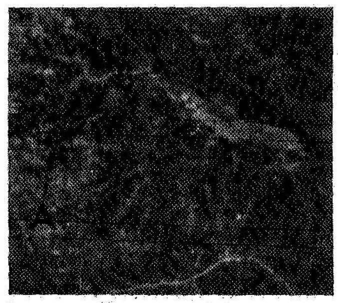

Figure 6. Color combined image of S.E. Minnesota. A and B are the same areas as on Figure 5.

Figure 7. Color combined image of the Chippewa National Forest. The letters indicate land use classes and forest types: A=Open/Pasture/Crops; B=Grand Rapids; C=Upland Conifers; D=Conifers-Hardwoods; F=Hardwoods-Open/Pasture/Crops; G=Lowland Conifers; H=Upland Hardwoods, with a narrow band of conifer and conifer-hardwood.

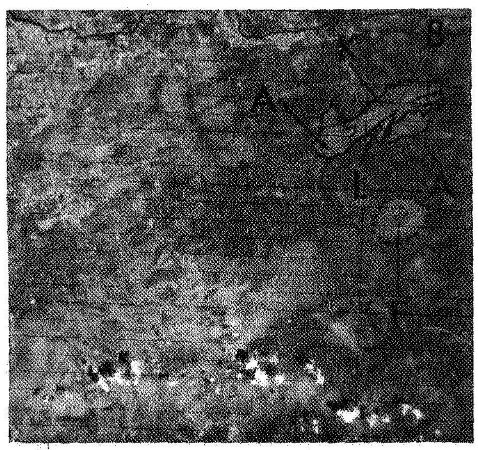

Figure 8. Color combined image of the Big Bog area of Northern Minnesota. A,B,K and L show different wetland types in a patterned bog area. F shows a similar bog that is not delineated but contains all of the features of A,B,K, and L. A=Raised Bog; B=String Bog and Patterned Fen; K=Poor Swamp Forest; L=Cedar or Larch String Bog and Fen.

with Band 6 or 7. Where tonal contrasts are high, forest vegetation types can be identified for plots as small as 5-10 acres. Further work holds some promise for the development of two density classes. The type, density, and site characteristics being developed are being evaluated by forest land managers for use in the field and office.

Southeastern Minnesota hardwood forests are scattered along deeply entrenched dendritic drainage systems (Fig. 5, 6). Density level slicing is being tested as a means for separating and inventorying these very irregularly-shaped hardwood stands. With some ground truth in hand it seems feasible to separate these densely forested areas from the scattered trees or non-forested areas using Band 7 of the August 12, 1972 coverage.

WETLANDS. Minnesota has extensive areas of wetlands that are important for water storage and wildlife habitat. The wide variations in size, in permanence, and in location (relative to the major ecotones in the state) multiply the dimensions of the classification and data collection problems. Small seasonal wetlands which are of particular importance to waterfowl habitat management cannot be observed until spring. Lack of cloud free summer coverage also prevents analysis of large southern perennial wetlands until spring. Fall coverage of the Glacial Lake Agassiz plain does allow analysis of patterned bogs in Minnesota's most extensive wetlands area. This area can be subdivided into several wetland types that are based on vegetation/peatland relations. Two patterned bogs that are representative of the big bog landscape are shown in Figure 8. The patterned bog features which occupy much of this part of the state are surrounded by forest lands. The classification shown here also includes the lowland/coniferous forests category. Results of interpretation of several of these patterned bog areas compares very favorably with highly detailed ground truth based on in-depth ecological studies.

CONCLUSIONS AND FURTHER WORK

The potential of ERTS-1 as a tool for mapping land use information on a state wide basis is beyond the expectations of those persons involved. Interpretation of inhouse produced 2" x 2" slides of color combined images and projected 70mm bulk images is the simplest and most fruitful data extraction technique attempted to date. Using high quality ERTS images at appropriate season(s), these techniques can yield much more detailed land use information than now exists for a state that stands as a leader in the field of land management information.

Within the last three weeks the groups working daily with imagery have observed almost an exponential growth of applications and potentials for ERTS-1 data. There is considerable value in the use of multiple season data to increase the accuracy and detail of land use classification and further to identify those features whose presence in the landscape is transient in time.

We have begun to monitor the cultivation of land in a four township area because the identification of cultivated land from a single late summer image is virtually impossible. While this interpretation effort is time consuming it may have added benefits in the utility of the information. For example it will allow classification of cultivated land according to season; thus, making it possible for game managers to know the habitat conditions at any critical season. Further, these data will allow analysis of sediment availability and erosion potential by drainage basin by time period.

Preliminary studies on density of artifical surfaces of the Twin Cities indicate that with some training and ground truth it will be possible to make a map of impermeable surfaces from ERTS which can be coupled with storm sewer data to produce models for urban run-off management. Trained personnel are now achieving 90 percent or better accuracy of manual interpretation on training sets in the Twin Cities area.

Snow enhancement has also been of value in forest, cultivated, and extractive land use classification. It also provides a better basis for mapping urban housing densities and rural population distributions.

Results obtained thus far are very encouraging. The trade off between extent of coverage and detail is not as limiting as it originally appeared and repetitive coverage provides compensation. In summary, both cultural and vegetative landscape features have been classified and mapped from fall ERTS imagery. Urban land use reduces to nine classes; extractive land use to four. Six to twelve classes of forest vegetation can be identified, as well as five classes of northern wetlands.

IMAGE IDENTIFICATION

Figure	Image Type	Date	I. D.	Band
2	Color Combined	6 Oct. 72	1075-16321	5,7
3	Color Combined	18 Sept. 72	1057-16311	5,7
4	Color Combined	12 Aug. 72	1020-16252	5,7
5	Density Sliced	12 Aug. 72	1020-16252	7
6	Color Combined	12 Aug. 72	1020-16270	5,7
7	Color Combined	7 Oct. 72	1076-16370	5,6
8	Color Combined	2 Sept. 72	1041-16421	5,7