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APPLICATION OF ERTS-1 IMAGERY TO STATE-WIDE LAND INFORMATION SYSTEM IN MINNESOTA

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16. Abstract

To update and refine existing state-wide land resource information systems, the Minnesota State Planning Agency is assessing the feasibility of extracting resource information from ERTS-1 imagery. Work has centered on a comparative analysis of Minnesota Land Management Information System (MLMIS) and ERTS-1 land use classes. The associated problems of determining appropriate data cell size and optimal seasonal timing have also been addressed.

Using ERTS-1 images, dominant land use is classified as follows: urban, forest, agriculture, extractive, transportation, water, and wetlands. Preliminary analysis suggests that with appropriate changes in operational definitions these general classes can be further refined for the benefit of MLMIS users. Additional detail appears most feasible in urban, forest, wetland, water and extractive classes.

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Figure 2. Technical Report Standard Title Page

PREFACE

The objective of the work effort described in this progress report is to evaluate the potential contribution of ERTS-1 imagery to updating and improving a state-wide land resource information file. The scope of work reported here covers the progress of interpretating land use and resource information for urban, forest, agriculture, extractive, transportation, water, wetlands and soil classes as well as cooperating with various State, Federal, University and private working groups with responsibilities in the land management and information fields.

Although it is necessary to develop special operational definitions for some land use classes, considerable detail can be added to existing urban, forest and wetland classes. In order to discriminate pasture and open land from cultivated land it appears necessary to use either late spring imagery or to accumulate the cultivated class by monitoring bare ground throughout the cultivation season.

Delays in receipt of imagery have presented the greatest problems for planning work scheduling and progress in several areas.

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INTRODUCTION

In cooperation with the University of Minnesota Center for Urban and Regional Affairs and staff personnel from the Departments of Forest Resources Management, Geography, and Soil Science, the Minnesota State Planning Agency is examining and evaluating the potential contribution of ERTS-1 imagery to updating, supplementing, and enriching a state-wide land information base, the Minnesota Land Management Information System (MLMIS). This report covers the first six months progress of investigation of land information classification and interpretation. The work effort can be broken down into nine classes or areas of concern: forests, urban, wetlands, water, transportation, extractive areas, cultivation, pasture and open lands, and soil classification.

Within each area of concern questions of optimum data cell size, seasonal timing, operational definition of information classes, accuracy, and costs are being addressed. Further, the involvement of various data-using state agencies is being effected so the potential and limitations are not only understood by them, but they may also guide improvement of the classification system to better meet their data needs.

Beyond the above level of involvement, the purpose of this cooperative effort is to assist appropriate resource people in various state agencies to develop capabilities for implementing or expanding their use of remote sensing data to meet their specialized information needs.

WORK PROGRESS AND PROGRAM FOR NEXT REPORTING INTERVAL

Interpretation of land use was to be based on several product types from NDPF: 1) Nine inch scene-corrected color transparencies of product 6 and 7 viewed simultaneously under old delft scanning stereoscopes, 2) Black and

white nine inch film negatives and positives for electronic level slicing, 3) Bulk 70mm black and white for optical color combining and projection enlargement. Originally, RBV products were desired because of better geometry; however, scene-corrected MSS imagery was considered acceptable.

To date no color products have been received, production of color product six has been canceled, and the black and white scene-corrected imagery has an unexpected checkerboard of dynamic ranges making it unsuitable for electronic level slicing.

It is clear, in light of current delays in data receipt for standing and retrospective requests, that we must first shift our reliance on NDPF color to locally produced color combined images received on standing order. Secondly, that we must utilize nine inch bulk transparencies for electronic level slicing analysis. Retrospective requests are now being filed with these changes in mind.

Arrangements have been made with the Institute of Agriculture Remote Sensing Laboratory to assist our needs for optical color combining and reduce reliance on NDPF-produced color products.

To date we have received 1003 bulk images for 126 ground scenes, filed retrospective requests for 560 images of 48 scenes, and received 101 images of 30 scenes. June 6, 1972 RB-57F overflights have provided considerable support for the necessary ground truth. The development of a ground truth base and progress in imagery analysis will be discussed under individual areas of concern. The program for the next reporting interval is also included in each of these work areas.

Urban Land Use

Urban Land use is divided into two classes in MLMIS. Any forty-acre data cell occupied by five or more residential dwellings is classified as urban residential. Forties having one or more commercial establishment are classified as urban mixed. These operational definitions were based on a desire for a low threshold of detection of urban development and were based on 1:90,000 aerial photography. It was clear in the beginning that individual dwellings could not be detected on ERTS-1 imagery; thus, operational definitions must necessarily be redefined.

To date we have received three scenes of the Twin Cities Metropolitan Area: Sept. 18, 72; Oct. 6, 72; Nov. 29, 1972. Atmospheric interference and missing scan lines in bands 4 and 6 make some coverage unsuitable in the urban area. The best image set to date is the Oct. 6 scene. Analysis of potential is confined to this scene based on a projection of the image at a scale of 1:220,000 and on slides of experimental color-combining projected at scales ranging from 1:125,000 to 1:250,000.

The considerable variations in tone on this image do not correspond to the two level classification in MLMIS. Preliminary analysis indicates that the threshold for detection of residential areas is on the order of twenty dwelling units per forty-acre cell. This is in keeping with the detection threshold for some small towns in Minnesota which have populations of approximately one hundred.

Though commercial areas stand out on the image, comparative analysis using the 1:120,000 scale aerial photography indicates that 5 to 10 rather closely spaced commercial structures in a small (about ten acres) data cell are necessary before the area can be identified as commercial. The most distinctive land use on the image is the Metropolitan area golf courses which

stand out on bands 6 and 7 because of the sharp contrast between well-watered grass and surrounding urban tree cover that has begun to turn and lose leaves.

Placement of a data cell grid for interpretation of the Metropolitan area presents more difficulty for repeated accurate locational descriptions than has been found in areas of well-defined agricultural field patterns. It is doubtful that early October is the optimal seasonal timing for discrimination of all classes of urban land use. Low sun-angle snow-covered images (such conditions occurred Jan. 1, 1973 during satellite overpass) that will allow intensity level slicing may allow sharper discrimination of structure densities than October images. The shadow intensity may also prove to bear an important relationship to the urban heat island due to the cavity radiator effect. October imagery displays a roughly radial tonal change away from the Minneapolis C.B.D. This type of analysis should allow accurate definition of the detectability thresholds for various classes of urban land use.

Forest Land Use

NASA RB-57 photography and 1:90,000 black and white photography have been analyzed for comparison with ERTS-1 imagery for forest land use classification in Southeast Minnesota and Northern Minnesota from the Chippewa National Forest to the Mesabi Range. Products of optical color combining of ERTS-1 imagery of both of these areas have been compared with field-checked interpretations of the aerial photography. Analysis indicates that black spruce can be distinguished from aspen-birch on Oct. 7th ERTS-1 imagery.

Analysis of small wood lots in agricultural areas indicates that the threshold of detectability of woodlots on ERTS-1 imagery is approximately five acres where there is a high tonal contrast between the wood lots and their surroundings. Work is continuing using density level slicing techniques to provide a definite statement about the threshold of detectability under different contrast and environmental conditions.

Work in the next reporting period will continue along three lines: 1) interpretation of RB-57 1:60,000 IR color imagery for 15 selected study areas using a revised classification of forest lands; 2) combining, color enhancing and photocopying ERTS-1 imagery of the above areas for comparison of data from the two systems; and 3) image density level analysis to more accurately define land use boundaries. Supporting photographic coverage and ground truth were obtained in June and October respectively.

Interpretation of color-combined slides of ERTS-1 imagery will be done at a scale of 1:60,000 by projecting square format super slides on a table top direct projection screen.

Agricultural Land Use

Two classes of land use in commercial agricultural areas are found in MLMIS, Cultivated land and Pasture/Open land. Seventy-two sample townships throughout the major agricultural areas of Minnesota were selected for analysis. Manuscript MLMIS maps were taken to the field for updating a ground truth base. Field work was done from late July through September. Using June 6, 1972, RB-57 1:60,000 and 1:120,000 color infrared photography analysis of those townships that were covered by the aircraft support program were interpreted as a second check and as an aid in translation from the ground to the ERTS-1 imagery.

Relatively few of the sample townships were covered or cloud free during the growing season. Discrimination of cultivated land from the pasture and open land category for sample townships in Northwestern and South Central Minnesota on enlarged 70mm bulk-bands 5 and 7 was very difficult. Difficulty seems to increase toward the end of the growing season. However, fall plowed fields which absorb energy in all four bands begin to look like very dark on bands 6 and 7 and are difficult to distinguish from water surfaces on the basis of tone on early October images. Fields of cultivated dry forage crops and other unharvested crops are very difficult to separate from open uncultivated grasslands.

A 1:250,000 scale color composite print of pre-mission (July 29) coverage has just been obtained from the EROS data Center. This is the earliest coverage available and interpretation of groundtruth sites for which ground truth was updated on July 26-30. This image probably contains the largest number of sample townships of any of the ground scenes received to date. Exhausting analysis of this product will provide data from the only mid to late growing season coverage we will be able to obtain.

While cultivated land seems to be difficult to identify accurately on any single image, future work will be directed toward identifying bare cultivated fields throughout the growing season. The prospects of building the data for this class by cumulating observations throughout the year seem quite good.

Extractive Land Use

The extractive industries of Minnesota that are of greatest importance to land use management are sand on gravel quarries utilizing fluvioglacial deposits, rock and stone quarries, and iron mining. All involve changes in the land surface leaving unreclaimed spoil piles, reclaimed spoil piles, dry pits and water filled pits. The MLMIS data file classifies all of these in one group.

NASA RB-57 overflights cover portions of the Mesabi Range, the largest area of extractive industry in the state. ERTS coverage of the area for several dates in fall 1972 has been received in bulk 70mm. A project, beginning January 15, is aimed at selecting a large test area to examine the accuracy of mapping extractive land use from ERTS and to determine the feasibility of setting up an operational classification that separates water filled pits, dry pits and spoil materials. The utility of the classification scheme will then be tested in granite, and gravel quarry areas to determine its transferability to smaller sites in different geological-environmental settings.

Wetlands

The category of wetlands in Minnesota ranges from including small seasonally wet prairie potholes of 10 acres or less to vast expanses of open heath and patterned bogs in Northern Minnesota Pleistocene Lake plains.

Preliminary analysis indicates the ability to discrimate different wetland types in the Big Bog area north of the Red Lakes. However, Federal and State agencies that manage wildlife habitat are deeply concerned with the very small seasonal wetlands of Minnesota's Wet Prairies.

Because of the seasonal nature of these wetlands and their size, analysis classification and mapping is scheduled to begin in early spring. Currently, discussion with personnel form the Minnesota Department of Natural Resources and U.S.D.I. Bureau of Sport Fisheries and Wildlife are underway in an effort to insure the classification and data extraction process maximize the utility of the data for these managing agencies.

The size and probable low contrast of these features with their surroundings, except when filled by water, dictate a very sensitive analysis. Density slicing procedures should provide the needed detail when film transparencies of small areas are scanned.

Water

Surface water resources of Minnesota presents one of the states most important resource management problems. Past history of illegal draining and lake level change, unregulated development of shore zones, increasing pressure on water surface use, disruption of wilderness lake environments by human activity, and pollution, have brought increasing pressure on regulatory and management agencies to regulate development and use of lakes, rivers, and their shorelines. Minnesota's over 14,000 lakes greater than 10 acres presents a management problem just in magnitude of numbers. No discrimination is made in MLMIS between regulated and unregulated lakes, or between lakes and rivers. This area of work is aimed at attempting to use

lake classifications used by water resource managers in state agencies and separation of rivers from lakes.

Actual interpretation in this area is not scheduled to begin until late winter. However, preliminary discussions with State Departemnt of Natural Resources personnel are being carried out in an effort to develop a workable and useable classification scheme.

Transportation Land Use

In the MLMIS data file any forty acre cell dominated by rail, highway, or aircraft faciliteis is considered as a separate land use. Cursory analysis of single hand bulk images and enlarged color composites indicates some distinct problems. Freeways and trunk highways that are nearly orthogonal to the scan lines of the MSS are fairly easily detected with some unusual and currently not understood exceptions. Those that closely parallel the scan lines are virtually undetectable on the same images.

Major airports such as Twin Cities International and Duluth are readily identified. However, small aircraft facilities are frequently very difficult to separate as being distinctly different from their surroundings.

Further effort will be made to separate this land use class using density slicing and optical color combining. If these efforts prove unsatisfactory, this class may be grouped with urban commercial mixed.

Soils

The inclusion of soils information in MLMIS is a necessary step toward understanding the adequacy of land resources for different uses. The reporting period was used to define study areas in Northwestern and Southeastern Minnesota, select ERTS scenes for processing, examination of RB-57 1:120,000 and 1:60,000 scale photography of the test areas.

The following observations have been made from preliminary analysis:

1) It seems feasible to measure the areal extent of Calciaquolls (soils of high carbonate content in surface horizons) in the landscape of the Agassiz plain (Red River Valley). This will be pursued, quantitatively, by image analysis.

2) It seems feasible to ascertain the area extent of soils having significant erosion in the landscape of southeastern Minnesota where soil parent materials are loess and glacial till. This hypothesis will also be studied, quantitatively, by image analysis.

3) The NASA Color IR imagery is probably more useful in identification of vegetative differences than soils, although at the time of flight (June 6) the proportion of non-vegetated soil surfaces was small. However, in southeastern Minnesota the character of vegetative grouwth, particularly in small grains as of June 6, seems to bear a relationship to degree of soil erosion.

4) The precision processed photography received to date (which is minimal) appears not to be very useful, because of tonal 'bands' which, apparently, are artifacts of processing.

5) The inability to acquire image analysis or color additive equipment until the end of this period has precluded any use of this - which others have reported to be very helpful.

COOPERATION

Three specific aims of this project depend on mutual cooperation among several state, federal, private, and university groups. They are:

1) improving the utility of data collected from ERTS-1 for MLMIS so that it

can more closely relate to the information needs for policy development and implementation of various land resource management agencies within Minnesota; 2) transfer of both technical capability and understanding of the potential and problems of the remote sensing and data analysis techniques employed in this project; 3) cooperation with the Honeywell ERTS project for sharing of ground truth and results of analysis and discussions of problems.

Progress toward these aims has involved meeting with personnel from the Minnesota Department of Natural Resources, State Agricultural Statistician, U.S.D.A., North Central Forest Experiment Station, and U.S.D.I. Division of Fish, Game and Wildlife. During this reporting period numerous personal communications and more than ten meetings have been held with personnel from these various agencies in an effort to satisfy the first aim above. Thus far, suggested classification systems for wetlands and water have been discussed and will be tested in the next reporting period.

The second aim will be approached in the next reporting period in the framework of discussion seminars. To date only preliminary discussions have been held. Initiation of this phase has been delayed because of the slow production of proper material from NDPF that is necessary to demonstrate the information potential of ERTS-1 imagery.

In the third area of cooperation this project has supplied Honeywell with the ground truth obtained to date. Procedures for data and information sharing have been worked out. Mutually beneficial discussions of problems and ideas have been effected. Continued exchange of ground truth data and comparisons of interpretation results will be an intensified continuing effort in the next reporting period.

CONCLUSIONS

Preliminary analysis of ERTS-1 images, confined almost entirely to 70mm bulk black and white clips, indicate that a wide variety of additional detail can be added to the relatively simple "first cut" land use classification scheme in MLMIS. Redefinitions of urban land use classes is necessary because classifications based on counts of urban structures is not feasible with ERTS-1 images. Some mechanical problems in grid placement for repeated accurate locational description has been experienced in urban and forest areas. The forty acre cell size seems to be an operable size for most land use classes. However, delineations of some classes prior to their allocations to a data cell address will be necessary to avoid excessive grid placement errors.

Problems of separating cultivated from noncultivated pastures and open land may require continual monitoring in order to accumulate an accurate inventory of cultivated land. However, early to midgrowing season imagery (Mid June to Mid July) may be adequate. These images will not be available until late summer 1973.

Efforts toward cooperative involvement of state, federal, and university groups with land management and information responsibilities have yielded some suggestions for added detail in wetlands and surface water categories. Efforts to introduce various land management agencies to remote sensing data and data analysis have been delayed by lags in production of suitable imagery at NDPF.

RECOMMENDATIONS

Several areas of concern have emerged in the first six months of work. Prompt and realistic statements about data production capabilities and priorities would serve data users well. The exorbitant delays in the production of color and scene corrected products should have been forecast to facilitate the funded users' planning. The cancelation of color product 6 further compounds the time delay problem for investigators planning to use this product. While receipt of standing order lag times appeared to pick up it has again dropped to six weeks. Data products received since January 1 have a high percentage of defective emulsions which suggests a need for tighter quality control.

ERTS IMAGE DESCRIPTOR FORM

(See Instructions on Back)

NDPF USE ONLY
D _____
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ID _____

DATE December 1972

PRINCIPAL INVESTIGATOR Sizer, Minn. - S.P.A.

GSFC S 360

ORGANIZATION Minnesota State Planning Agency

PRODUCT ID (INCLUDE BAND AND PRODUCT)	FREQUENTLY USED DESCRIPTORS*			DESCRIPTORS
	agriclt.	forest	urban	
1020162615	x	x	x	
1020162617	x	x	x	SE Minnesota
1020162525		x		
1020162527		x	x	Lake Sup Central, Lake
1076163704	x	x	x	
1076163705	x	x	x	Iron Range Chip, mine
1076163706	x	x	x	
1095164315		x		
1095164316		x		Itasca State Park
10571624M	x	x	x	Twin Cities
107516321M	x	x	x	Twin Cities
102516540M	x	x	x	Red River Valley
102216375M	x	x	x	South Central Minnesota
1077164317	x	x		W. Central MN, Marsh
104116421M		x		Lake of Woods, Marsh

*FOR DESCRIPTORS WHICH WILL OCCUR FREQUENTLY, WRITE THE DESCRIPTOR TERMS IN THESE COLUMN HEADING SPACES NOW AND USE A CHECK (✓) MARK IN THE APPROPRIATE PRODUCT ID LINES. (FOR OTHER DESCRIPTORS, WRITE THE TERM UNDER THE DESCRIPTORS COLUMN).

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