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Mapping Land Cover From Satellite Images: A Basic, Low Cost Approach

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BIOGRAPHICAL SKETCHES

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I. INTRODUCTION

Demands being placed on limited land resources increase daily, necessitating better land management. Better management, at all levels of responsibility, can be accomplished only through adequate collection of data which identifies present land resources and provides a basis for evaluation of land resource capabilities with respect to future needs.

An effective program for evaluation of land resources should include mapping methodologies which combine accuracy, universality, and cost effectiveness, while being simple and easily updated. Remote sensor imagery and satellite imagery, in particular, provides a means for supplying data which is current, synoptic, readily obtainable, and relatively inexpensive.

The launching of the Earth Resources Technology Satellite (formerly called ERTS but now called Landsat) initiated a new era in the application of remote sensing technology to land resource inventory. Results of numerous experimental applications of machine processed Landsat data and images indicate a strong potential for the technology as a primary data source for generalized land use and land cover mapping.

This report outlines a visual interpretation approach for interpreting and mapping general land cover types (called Level I) from Landsat images. Emphasis is placed upon the use of Landsat false color composites at a scale of 1:250 000. This approach is designed for users who (a) have little or no experience with satellite imagery, (b) want to minimize their expenditures of time and financial resources, and (c) have limited or essentially no access to equipment normally used in image interpretation.

II. IMAGERY, MATERIALS, AND EQUIPMENT

A. Imagery

Landsat imagery in the form of 9 in. × 9 in. single band and false color composite transparencies scaled at 1:1 000 000 and 36 in. × 36 in. false color composite paper prints scaled at 1:250 000 constitute the needed satellite imagery. Low to medium altitude, panchromatic, 9 in. × 9 in. ASCS or USGS mapping photography, and index sheets or orthophoto quads are used as interpretation aids. It is most helpful if this coverage is the most recent available, but older coverage can be substituted.

B. Materials

Basic materials consist of clear acetate that will accept pencil and ink, pencils, technical fountain pen,and USGS 1:250 000 scaled topographic map sheets. If additional image enhancement or enlargement is elected, photographic film, paper, chemicals, a camera, and diazo materials would be required.

C. Equipment

A simple office desk or drafting table is adequate for the construction of a basic Level I land cover map from 1:250 000 false color composite images. For improved interpretation the user might need a light table, dark room facilities, microviewer, and/or diazo process equipment.

III. MAPPING METHODOLOGIES

The direct tracing approach consists of the following basic steps:

a. The user gathers background information about the area to be mapped and becomes familiar with the geography of that area.

b. The user becomes acquainted with the Landsat image.

c. The user selects a classification system or scheme to assist in an organized approach to interpreting the image.

d. Overlays of the study area indicating major identifiable cultural or natural features are prepared from USGS 1:250 000 scale maps and registered on the Landsat image.

e. Land cover categories are interpreted according to the classification system used and boundaries are mapped on the overlay utilizing the Landsat image as the mapping base.

The 1:250 000 scaled false color composite paper print image format is recommended for the following reasons:

a. It does not require the user to prepare additional photographic enlargements.

b. No special equipment is needed for interpretation purposes.

c. It is the largest scaled standard Landsat product available.

d. It is readily understood by persons not familiar with satellite imagery. Color is the most interpretable feature on a photograph. This is especially true for satellite images which cover large areas at small scales with relatively low resolution. The human eye is more sensitive to the range of colors in the color image than it is to the range of gray shades seen in a single band image.

e. Each Landsat scene is imaged in four spectral wavelength bands. The color composite, a combination of three of the four bands, offers the user a somewhat balanced blend of the unique contrasts brought out by the individual bands. This eliminates the need to purchase four separate images.

f. At a scale of 1:250 000 the image can function as the plotting base and as a map base for the mapping procedure. Although the images are by no means distortion free, their use as a base provides an acceptable degree of positional accuracy relative to a scale of 1:250 000 and the generalized uses to which maps of this scale are often put.

The spectral sensing characteristics of Landsat are presented in Table 1.

An expanded description of each step in the methodology follows. The procedure is simple, straightforward and can be easily modified depending upon the skills and resources of the user.

A. Step 1 – Area Familiarization

The user begins by determining the location of the area to be mapped on an appropriately scaled base map. This is helpful in becoming familiar with the extent of the geographical area to be mapped and also in locating the defined study area on a Landsat image. The user will find that familiarity with the coordinate locations of longitude and latitude for the area are helpful in ordering the correct Landsat image.

TABLE 1. SPECTRAL SENSING CHARACTERISTICS OF LANDSAT

Band	Spectral Range (Wavelength)	Spectral Range (Color)	General Land Use Applications
4	0.5 to 0.6 micrometers	Green	Greatest potential for water penetration. Some contrast between vegetation and soil.
5	0.6 to 0.7 micrometers	Lower red	Best for showing topographic and overall land use recognition, especially cultural features, such as roads and cities. Geologic and surficial sand features enhanced.
6	0.7 to 0.8 micrometers	Upper red to lower infrared	Tonal contrasts reflect various land use practices; also gives good land-water contrast.
7	0.8 to 1.1 micrometers	Near infrared	Best for land-water discrimination.

The base map should be large enough in scale to provide an adequate overview of the study area. USGS 1:250 000 scale maps are recommended because the detail of these maps include major highways, towns, civil boundaries, primary drainage, and contours, as well as a grid of the longitude and latitude. Another advantage of the USGS maps is that they can be used in developing the overlays upon which the land cover category boundaries can be mapped. For study areas that consist of 10 or more average sized counties, the user should consider using a smaller scale state base map. USGS 7.5 minute and 15 minute quadrangle sheets and State Highway Department county road maps are helpful for providing additional details. All of these maps are standard products and readily obtained.

As part of the detailed orientation to the study area, the user should collect as much background information as possible. The more a user knows about the area to be mapped, the better that user will be able to interpret from the image. Background information is especially helpful in strengthening the user's interpretation abilities in those areas where he lacks familiarity or experience. Helpful sources of background information are described as follows:

1. Topographic, geologic, and hydrologic maps will provide an insight to the drainage patterns of an area as well as the lay of the land. Areas of steep slopes which readily affect cover type and land use are more readily delineated. Sometimes sharp demarkations between geologic parent materials can be seen on satellite images.

2. County road maps are helpful for scale adjustment purposes and for orientation to specific locations. Roads have a tendency to be distinguished on the image because the reflectance of the road is usually much higher than that of the cover types around it. The verification of drainage features such as lakes and rivers as to their specific location are helpful through the use of county road maps. The road maps will also be helpful for later ground verification and determining the route of travel.

3. Previously compiled land use maps may exist due to the efforts of rural development groups for community development studies. These maps give a better indication of the cover types for which to look. Land use changes are quite noticeable, especially when image responses appear different than shown on the land use maps. An example would be a recently cleared timber area that is now in pasture.

4. Aerial photographic coverage consisting of individual frames, mosaics, or indexes of low to medium altitude photography or high altitude photography help verify cover types. One can readily determine the locations of timbered areas and assess the density of these areas from the photography. This is extremely helpful when interpreting the intensity or color tones seen on the satellite images. In addition to helping one to become familiar with the area, photography can also serve as a useful ground truth instrument.

5. Knowledge of the crop calendar is important. The user should be familiar with the expected stages of maturity of different crops at the time the image was taken. A crop calendar would show the stages of maturity of the different crops and an estimate of the percent of fields that have reached a specific maturity by a certain date. Crop maturity may be the only way that one can separate small grains from row crops. It is also helpful to know information about specific cultural practices as applied to a crop. For example, the image of ground that has been prepared for row crop planting would appear different than an area that has crop residues at the soil surface.

6. Weather data should be considered. Many unusual patterns on Landsat images can be explained by weather; primarily precipitation variations. One should check the rainfall and temperature information for all weather

stations in the area for at least a month prior to the time that the image was taken. For example, one might check a crop calendar and determine what fields farmers are unlikely to begin plowing early because these areas might be mistaken for wetland areas. This would be especially true if a rain has been received 24 to 48 hours prior to the time that the image was obtained.

7. The general soil map prepared for a county soil survey is most helpful for familiarizing the user with basic soil differences in an area or county. The soils will have an effect on the type of crop grown, cultural practices performed, and date that these practices are initiated. It was noticed in one of the study sites that the timber appeared different in the central region of the county. Checking with a soil survey map it was found that this area of poor timber response had an abundance of fragipan soils. The poor timber growth on the fragipan soils became very evident on the satellite images. Many times one needs to compare the soil differences and the weather information to explain differences on the images.

8. Natural resource inventories may provide helpful information about specific resources in the area. Crop acreages will tell the user the percent of the area to expect in row crop versus small grain. The total number of livestock can be equated with pasture acreages. Population figures will give an indication of urban density to expect in an area. The population growth figures are also helpful for interpreting new residential areas.

9. All of Missouri's regions have regional profiles which were prepared by the Office of Regional and Community Affairs. These publications show specific information on transportation, institutions, occupations, agriculture, economics, and many other factors. This information is extremely helpful for understanding an area and for interpreting responses seen on a satellite image.

B. Step 2 — Image Orientation

The large regional coverage by each satellite image and the high altitude (910 km) from which the landscape is imaged combine to give the Landsat imagery a dynamic quality which is often lacking in larger scaled aircraft photography and conventional maps. This step is designed to allow the user to adjust to this unique perspective of the Earth's surface. It also gives the user an opportunity to become familiar with the general layout of the image before any attempt is made at serious interpretation or mapping.

In looking at the layout of the image, the user should note such things as the orientation of the scene, scale, product size, latitude and longitude grid ticks, registration marks, and the annotation block printed under the scene. This block contains specific information about the location and identification of the scene. The first and most important notation of the block is the date the image was taken. The date is the user's most important clue to understanding the various color tones and patterns found on the image. One needs to consider the climatic and growing variables during a season as they can vary dramatically from year to year. This would result in different color tones for scenes taken at approximately the same time of year.

The user makes an initial assessment of scene content during this step. Upon first seeing the image, the user scans the entire frame looking for familiar cultural and physical landmarks. This will help put the entire geographical area of the scene into proper perspective. Using the base map selected in Step 1, or a state highway map, the user locates the larger towns, rivers, lakes, reservoirs, and highways on the image.

It is often helpful to construct a clear acetate overlay showing all the county boundaries of the area encompassed by the scene. This overlay can then be registered to the scene, and the user's attention can be focused on a particular county or group of counties where specific landmarks can more easily be recognized.

The user is not concerned about the meaning of each color tone or pattern visible on the image during this orientation step. However, to become more familiar with the general association of a specific color to cover types, the user should locate several land cover types on photo index sheets or on black and white conventional photographs. It is a useful exercise to place a clear acetate overlay on the aerial photo and map out some of the general land cover categories such as forest, urban, agriculture, and water. The user should then attempt to recognize the same land cover categories at the same locations on the satellite image.

C. Step 3 – Classification System

A classification system provides a means for the user to group the different land uses or cover types that one wants to recognize. This system in essence becomes the legend or key to the map produced. The system may be designed by the user or the user can select an existing classification system which might be modified to meet specific needs. The USGS has proposed a

Level I and II land use and land cover classification system for use with remotely sensed data [1]. The Level I categories established for this system can be accurately interpreted from Landsat images.

This system (Table 2) is designed as a standardized approach for nationwide land use data collection efforts. The categories are defined so that a minimum level of interpretation accuracy is required. The user should be aware that categories and accuracy levels of this system can be altered to meet the needs and interpretation capabilities which the user possesses.

The classification system used by most of the students for this project is shown in Table 3.

D. Step 4 – Preparation of Overlays

Using 1:250 000 scale USGS map sheets as a base, the user delineates the boundaries of the study area on clear acetate. Major highways are also delineated. The highways are a good positional guide and helpful in registering the overlay to the satellite image. If the user desires to have more detail on the acetate, consideration should be given to developing individual overlays showing hydrology, State and Federal roads networks, cultural features, and topography as drafted from the USGS base maps. Copies of overlay plates for the individual USGS 1:250 000 series can also be purchased. These overlays can then be placed between the color composite image and the primary overlay to assist the interpretation process.

The overlays will never register perfectly to the Landsat image. Although the loss in positional accuracy is not a serious problem for Level I interpretation, the user should be aware of the factors causing the discrepancies. The Landsat image, in standard product form, is not geometrically rectified. There are geometric errors in the image due to the Earth's rotation, orbit pattern, and navigational variances of the spacecraft.

E. Step 5 – Mapping

The mapping step is divided into two stages: development of a generalized map (Stage 1) and developing detailed maps (Stage 2), which depend upon such factors as the clarity of the image, season of the year the image was obtained, the interpreter's ability, and other factors.

TABLE 2. LAND USE AND LAND COVER CLASSIFICATION SYSTEM FOR USE WITH REMOTE SENSOR DATA [1]

Level I	Level II
1 Urban or built-up land	11 Residential 12 Commercial and services 13 Industrial 14 Transportation, communications, and utilities 15 Industrial and commercial complexes 16 Mixed urban or built-up land 17 Other urban or built-up land
2 Agricultural land	21 Cropland and pasture 22 Orchards, groves, vineyards, nurseries, and ornamental horticultural areas 23 Confined feeding operations 24 Other agricultural land
3 Rangeland	31 Herbaceous rangeland 32 Shrub and brush rangeland 33 Mixed rangeland
4 Forest land	41 Deciduous forest land 42 Evergreen forest land 43 Mixed forest land
5 Water	51 Streams and canals 52 Lakes 53 Reservoirs 54 Bays and estuaries
6 Wetland	61 Forested wetland 62 Nonforested wetland
7 Barren land	71 Dry salt flats 72 Beaches 73 Sandy areas other than beaches 74 Bare exposed rock 75 Strip mines, quarries, and gravel pits 76 Transitional areas 77 Mixed barren land
8 Tundra	81 Shrub and brush tundra 82 Herbaceous tundra 83 Bare ground tundra 84 Wet tundra 85 Mixed tundra
9 Perennial snow or ice	91 Perennial snowfields 92 Glaciers

TABLE 3. LEVEL I LAND USE AND LAND COVER CLASSIFICATION SYSTEM FOR USE WITH VISUALLY INTERPRETED LANDSAT IMAGES

1. Urban or built-up land
2. Cropland
3. Hay and pasture lands
4. Forest land
5. Disturbed lands
6. Water

1. Stage 1 — Generalized Mapping. A very generalized map can be compiled that outlines each major land use category. The user should simply draw lines around areas that appear similar, utilizing the knowledge gained from reviewing previous maps and data of the area being mapped. Categories can be combined if the user has difficulty in making immediate distinctions between certain categories. It is important that the user gain confidence in combining the gross categories and have a feel for the type of cover types or land uses that have been combined or are included within the category.

There are several ways to check the accuracy of the generalized map. One can compare it with a recently acquired aerial photograph of a portion of the study area. High altitude photography at a scale of 1:120 000 is excellent for this purpose since one would have a minimum of scale confusion. The interpreter can also determine the location of specific categories in relation to a county road map and check the categories by driving the roadway in an automobile. It is useful to transfer the generalized map onto a county road map when actually checking in the field. One can use USGS 1:250 000 scale maps as a guide in making the transfer. When making a field check, take the satellite image to make visual comparisons between what is seen on the image and actually found on the landscape. This will help in establishing the association between color tones and patterns seen on the image and their corresponding land cover category. Field inspections are most effective if they are made at a time comparable to the date (season and month) that the image was acquired.

2. Stage 2 — Detailed Mapping. In this stage the user attempts to remap the study area utilizing the information gained from inspection of aerial photography and/or field inspection. It is important at this time to determine the categories of a classification system to be used. The user delineates the smallest areas that the eye can see and that the pen can be drawn around and still distinguish the category. A fairly large area should be mapped before consulting the ground truth techniques used in Stage 1.

F. Image Interpretation

Image interpretation requires a complex mixture of artistic, scientific, and physical abilities. Some basic techniques can be learned from textbooks and lectures, but interpretation is learned primarily through experience. The following suggestions on how to approach the interpretation task stem directly from experiences in developing this direct tracing methodology.

The successful interpretation of Landsat imagery requires that the user make accurate associations between a particular land cover type and its representative color tone, pattern, shape, areal extent, and location on the image. Several key factors determine the user's ability to see, comprehend, and synthesize the previously mentioned variables and then make inferences about them that are accurate and consistent.

These key factors include the following:

1. The user's knowledge base is the most critical determinant in what the user can or cannot see on the image. One literally "sees what one knows." A previous study revealed that geologists and foresters were better at interpreting physical landscape features than agronomists who were more competent in interpreting agricultural features such as cropping and soil patterns. Geographers were best at interpreting cultural features and seeing the overall land cover relationships.

2. The user must develop the ability to consistently separate color tones with his eyes and keep them separated in his mind. This ability is further refined through practice in the mapping task.

3. The interpreter very seldom has to identify objects because of the low resolution of satellite images. The interpreter must infer a land use or a land cover type from clues even less specific than those relied upon in the interpretation of aerial photography. An ability to interpret on aerial photography does not guarantee that one will be successful in interpreting categories on a satellite image.

1. Three Interpretation Approaches. Three methods for the interpretation task were used. Each technique or method relies upon the satellite image as the primary data source but will vary in the degree to which the approach depends upon aerial photography.

The first method requires the user to map solely from satellite imagery without referring to any type of supporting aerial photography. The user first establishes the basic relationships between color tones and land cover categories utilizing descriptive keys, ASCS index photos, and other supportive background information. The aerial photography is then put aside and interpretation done strictly from the satellite image.

This technique is the fastest and the cheapest approach. It produces a map with fewer categories and will likely have a higher accuracy than other techniques. This method is also easier for the user who is familiar with the area being mapped. An interpreter with a high degree of confidence in his interpretive ability will also do well with this method.

The second method utilizes aerial photography as a guide throughout the interpretation process. The user consults the supporting information to get an idea of what type of land cover should be recognized on the corresponding area of the satellite image. The support photography is consulted each time a new area is mapped, but the inferences are based primarily on what is seen on the imagery. This technique works best for the users who lack confidence in their interpretation abilities. As the user gains more experience, he will probably switch to one of the other approaches.

The third method relies heavily on supporting aerial photography as a reference for evaluating what is seen on the satellite image. The user interprets a portion of the study area and compares the interpretation to the same area of the support photography. The user must reevaluate the interpretation based on what is seen on the supporting photography and assign the area to a particular category. This technique is good for documenting changes in land use and cover type over time. An area categorized as pasture in either of two preceding techniques may be more accurately identified as an area recently converted from timber to pasture.

The third method is the most time consuming of the three approaches. Previous photo interpretation experience is helpful with this approach. The user must avoid simply transferring data from the supporting aerial photography to the satellite image since this would defeat the purpose of the interpretive task and would add to costs. One must note that the photography is consulted after the image has been interpreted.

2. Interpretation Tips. The following is a list of interpretation tips which may be useful to the user:

a. Use a "logical search" method of interpretation. Isolate the variables (color tone, pattern, etc.) that represent a particular land cover category and delineate all the areas with similar characteristics. Follow this procedure for each category in the classification system.

b. Always develop a generalized map first. An immediate attempt at mapping in detail usually leads to frustration and failure to accomplish the mapping task in a satisfactory manner.

c. Interpret only when full concentration can be given to the task. Interpreting on a regular schedule seems to give more consistent and reliable results. Select the time of day when you are most alert.

d. Limit the interpretation time to 1.5 to 2 hour sessions to avoid fatigue and loss of concentration.

e. If more than one image is required to cover the study area, try to obtain coverage of similar dates. One becomes accustomed to working with a particular set of color tones, and the transition is easier if the dates are similar. Be aware that images taken on the same date or two days apart may have different color tones due to differences in processing.

f. The season of the year is important when selecting a satellite image. The selection should be based upon the categories which the user wants to differentiate. Select the season when there is maximum contrast of these categories. Suggested time periods for most Level I categories are Spring and/or Fall.

IV. MAPPING ACCURACY

Assessing the accuracy of the final product is a complex and challenging job. The user must keep in mind the errors that can be introduced in the interpretation and mapping tasks as well as the statistical biases of the sampling procedures when attempting to evaluate the results either qualitatively or quantitatively [2]. Accuracy estimations are affected by many different variables. Significant variables are as follows: interpretation and cartographic skills, classification system used, complexity of area being mapped, image quality, image dates, timeliness of data, ground truth, and sampling procedures.

Table 4 lists the accuracy rates for Boone County as determined by the checking of 439 randomly selected points. Although no minimum mapping unit size was established for the mapping task, the smallest units mapped average approximately 40 acres in size. The sample points checked were roughly the same size. The sample points were checked for accuracy with NASA high altitude aircraft color infrared photography flown six months after the Landsat image interpreted was acquired, ASCS black and white photography flown in 1968, and some medium scaled black and white photography flown by Abrahms Aerial Survey in 1971. Additionally, road traverses were made of selected areas to verify the interpretation of both the satellite imagery and NASA aircraft photography.

TABLE 4. ACCURACY CHECK BY SAMPLE POINTS FOR LEVEL I LAND USE CATEGORIES IN BOONE COUNTY, MISSOURI

Category	Total Number of Points	Total Number Correct	Percent Correct
Urban/built-up	22	18	81
Cropland and pastures	282	187	66
Cropland (row crops and small grains)	156	95	61
Pasture	126	92	73
Forest	100	85	85
Water	20	20	100
Disturbed	15	13	86
Overall total	439	323	74

The cropland category had the lowest accuracy level of all categories. There are some definite reasons for misinterpretations. Eighteen of the areas mapped as cropland were actually forest. On the image these areas appeared identical to wet, plowed soil. More attention to landscape position and field patterns would have assisted in reducing these errors. There were 43 areas classified as cropland that were really pasture. The lush growth of well managed pastures made these areas look like winter wheat.

Table 5 compares acreage totals for three categories derived from the direct tracing method with three other sources of Level I land cover information for Boone County, Missouri. Both the Soil Conservation Service's (SCS) machine processed classification and the visual interpretation used the same April 14, 1974 data collected by Landsat-1. The conservation needs inventory data were collected by the SCS in 1970. The Forest Service data were collected in 1972.

TABLE 5. ACREAGE COMPARISONS

	SCS/Computer Classification	Direct Tracing Methodology	Conservation Needs Inventory	Forest Service
Cropland	90 000	105 000	94 000	—
Pasture	225 000	217 000	202 000	—
Forest	98 000	94 000	91 000	112 000

V. MAPPING COSTS

Table 6 gives a breakdown on the costs involved in implementing the visual interpretation approach outlined in the preceding pages. It is important to recognize that costs can be quite variable. In the case of Boone County, the cost of the entire image was charged to one county. Usually 5 to 10 complete counties are found on one Landsat image. The costs do not include any expenses involved in ground truthing the final product obtained for Boone County. The hours involved in the other activities will be variable depending on the skill of the interpreter and the amount of detail desired.

VI. CONCLUSIONS

A. Accuracy of Maps

Maps with an accuracy of 70 to 90 percent are easily produced. Studies at both University of Missouri-Columbia and Rolla have accomplished these levels of accuracy. Staff training reduces the time required to complete a map. However, accuracy does not necessarily improve with additional training.

TABLE 6. COST OF THE DIRECT TRACING VISUAL INTERPRETATION APPROACH FOR DEVELOPING LEVEL I LAND USE MAP FOR BOONE COUNTY, MISSOURI (AREA = 685 SQUARE MILES)

Activity	Hours	Cost/Square Mile
Premapping preparation		
a. Gathering support data	4	0.03
b. Image familiarization	5	0.04
Overlay preparation	2	0.01
Generalized map	4	0.03
Detailed map	10	0.07
Materials[a]	—	0.07
		$0.25

a. Materials include the cost of the image plus other mapping materials including acetates, pencils, etc. The labor rate is $ 5/hour.

B. Imagery Availability

Landsat images the entire Earth's surface every 18 days. This fact makes a frequently scheduled data base readily available. By taking advantage of this option and integrating it with seasonal changes, crop calendars, natural phenomenon, etc. A basis for updating maps and evaluating change in land resource is readily available.

C. Equipment, Supplies and Staff Requirements

The physical layout, cost of expendable supplies, and staff skills required make land use mapping from satellite imagery within the budget and scope of most any potential user. Hudson and Elifrits [2] report a time cost of 0.01 man hours per square mile when mapping on an overlay to a 1:250 000 false color composite. The area mapped was approximately 80 percent forest-agricultural lands, 20 percent urban.

D. Cost of Satellite Data

The cost of acquiring the satellite image from EROS, Souix Falls, South Dakota is very small with respect to the area which one frame covers. The cost as of January 1977 was $ 50 for one 36 in. × 36 in., 1:250 000 scale false color composite covering an area 115 miles × 115 miles. Transparencies and smaller hard prints at smaller scales are much less costly.

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16. ABSTRACT

Land resource inventories utilize a wide variety of interpretive and machine processed methodologies in extracting and mapping information provided by remotely sensed data. Quite often, even for generalized Level I land cover information, these methodologies are beyond the reach of potential users because they require special expertise, special equipment, and many times, large amounts of money.

This paper reports on some simple, inexpensive methodologies developed for mapping general land cover and land use categories from Landsat images. One methodology, a stepwise, interpretive, direct tracing technique was developed through working with university students from different disciplines with no previous experience in satellite image interpretation. The technique results in maps that are very accurate in relation to actual land cover and relative to the small investment in skill, time, and money needed to produce the products.

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