LAND USE MAPPING AND MODELLING FOR THE PHOENIX QUADRANGLE

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16. Abstract

The land use of the Phoenix (1:250,000 scale) Quadrangle in Arizona had been mapped previously from aerial photographs and recorded in a computer data bank. During the ERTS experiment, changes in land use were detected using only the ERTS-1 images. The I^2S Color Additive Viewer was used as the principal image enhancement tool, operated in a multi-spectral mode. Hard copy color composite images of the best multi-band combinations from ERTS were made by photographic and diazo processes. The I^2S viewer was also used to enhance changes between successive images by "quick flip" techniques or by registering with different color filters. More recently, a Bausch and Lomb Zoom Transferscope has been used for the same purpose. Improved interpretation of land-use change resulted, and a map of changes within the Phoenix Quadrangle was compiled. The first level of a proposed standard land use classification system was successfully used. ERTS-underflight photography was used to check the accuracy of the ERTS image interpretation. It was found that the total areas of change detected in the photos were comparable with the total areas of change detected in the ERTS images. Although the air photos allowed more detailed interpretation, the ERTS images were more up-to-date than the November ERTS underflight photography.

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Figure 2A. Technical Report Standard Title Page. This page provides the data elements required by DoD Form DD-1473, HEW Form OE-6000 (ERIC), and similar forms.

Type II Progress Report

ERTS-1
1 January 1973 - 30 June 1973

a. Land Use Mapping and Modelling for the Phoenix Quadrangle.
(ERTS-A Proposal SR-186)

b. IN-057

c. Statement and explanation of any impedance:

Nearly all of the impedances have cleared up during May and June. Black and white aerial photography of the test site has arrived from NASA Ames, however, the southern 10% of the Phoenix Quadrangle was not covered. Color photography for the Phoenix quadrangle was not provided, but has been back-ordered. Nevertheless adequate black and white coverage was provided to allow an accuracy check to be made of our ERTS interpretations. MSS Band 7 images have been arriving during June, but for most of the earlier passes, we still have only bands 4, 5, and 6.

d. Accomplishments during the reporting period and those planned for the next period:

During the first four months, January through April, examination of the imagery which became available early in the reporting period allowed improvement in the accuracy of the map of land use change previously compiled from ERTS imagery in the Phoenix Quadrangle. MSS 9 x 9 imagery was examined on an I^2S Color Additive Viewer, a Richardson Film Projection Viewer at 10X magnification, and in microfische viewers at 12X and 18X magnification. Images of the Phoenix area covering a ten week period from August to November were examined to establish possible relationships between seasonal changes in vegetated areas and detection of changes in land use.

Portions of MSS images were examined on a Spatial Data Systems Data Color System 703-32 color density slicer. Urban, agricultural, and rangeland areas were examined separately and in combination to determine to what extent density patterns aid in determining land use or detecting changes in land use. The equipment allowed up to thirty-two equally-spaced density levels to be detected from MSS 9 x 9 black and white transparencies and displayed in color on the television unit. Transparencies were also examined over restricted density ranges to eliminate undesired low and high densities and to provide greater detail over the desired density range of the transparency.

An MSS 9 x 9 image, which became available during the middle of the reporting period, has been examined on a Bausch and Lomb Zoom Transferscope. Using an optional 4x magnification lens to view the backlighted image on the horizontal viewing surface of the Zoom Transferscope and zoom enlarging of the backlighted image on the vertical viewing surface to 4x magnification, a composite image has been formed at a scale of approximately 1:250,000. Initial investigation suggests that setting up two images in the same spectral band from different time periods in this manner and then using a "quick flip" technique to view alternately identical areas on the frames allows changes to be detected quickly in complex urban fringe areas. Illumination limitations of the Zoom Transferscope tend to limit the effectiveness of these techniques with denser ERTS images.

A 9.5 inch color infrared composite transparency has been prepared from 9.5 inch MSS band 4, 5, and 7 imagery by diazo copying methods. The frame covers the eastern portion of the test site, including metropolitan Phoenix, during mid-February. Diazo color film transparencies have been prepared from each MSS band (yellow from band 4, magenta from band 5, and cyan from band 7) and registered to create a color infrared composite. 70mm chips have been cut from 9.5 inch transparencies of MSS band 4, 5, and 6 imagery for viewing in an I^2S Color Additive Viewer. The MSS color composites have been most useful for discriminating cropland from either rangeland or urbanized areas in the test site.

During the last two months of the reporting period, MSS imagery acquired over the test site from late winter through late spring has been received. Submission of a revised Product Order Form has resulted in the most recent images being received in all MSS bands in both 9 x 9 inch and 70mm positive transparency formats. ERTS Data Request Forms which have been submitted have resulted in some MSS 7 band imagery being received to complete earlier ERTS coverage over the test site.

Diazo-transparency color composites have been prepared from late spring MSS imagery (bands 4, 5, and 7) for areas covering the entire test site. Color composite transparencies have also been prepared from ERTS images which covered the eastern section of the test site in October, February, and May, by photographic processes. Color print enlargements at a scale of 1:100,000 covering that portion of the Phoenix metropolitan area within the test site have been prepared from the previously mentioned color composite transparencies.

ERTS data acquired up to this point have been examined to detect land use changes in the test site. These latest changes in use have been mapped at 1:250,000 scale. Land use changes have also been mapped from recently received NASA high-altitude aerial photography taken over the test site in November, 1972. The two land use change mapping efforts were done independently and the results from the photo interpretation have been compared with the ERTS results to measure the accuracy and completeness of the ERTS results, and to determine what

advantages, if any, the ERTS image interpretation might have over the air photo interpretation. Using the ERTS results, an initial approximation of the number of square kilometers of land which has changed uses has been made and the net gain or loss in area by land use category has been calculated. Area measurements of land use change have also been conducted using the November, 1972 ERTS underflight photography.

During the next reporting period, imagery should be received which will give complete coverage over the test site for an entire year. Further investigation of these data will be made to refine land use change-detection techniques utilizing seasonal changes to improve accuracy and completeness. The existing computer data bank for the Phoenix Quadrangle will be updated to reflect the newly-detected changes in land use, and a new land use tabulation will be printed out automatically. An experimental map of land use change will be prepared.

e. Scientific results and practical applications:

Comparisons which have been made during the early and middle portions of the reporting period of 9 x 9 MSS band images and color composites made from bands 4, 5, and 6 showing vegetated areas near Phoenix during the summer, fall, and winter seasons aided in verifying that certain land areas were being used as agricultural land and not as rangeland. Agricultural land which appeared to be fallow, idle, or not irrigated, often become more readily identifiable as agricultural land when comparing different images of identical land areas which have been affected by seasonal vegetation changes. Examination of these MSS transparencies and color composites allowed further updating of a map of land use change in the Phoenix Quadrangle.

Experimentation with color density slicing portions of a 9 x 9 MSS band 7 transparency showing the central urban core of Phoenix conducted during the early portion of the reporting period enabled dense commercial and industrial areas to be discriminated from less dense urbanized land uses; however, loss of resolution produced results of limited usefulness. The best results in agricultural areas near Sun City were obtained using MSS band 5 imagery. Discrimination of different land uses in both urban and agricultural areas which were color density sliced was not possible to the degree of accuracy necessary to make mapping feasible. Color density slicing techniques may be useful in identifying areas which merit further study with more definitive methods such as the LARS-Purdue type of processing of computer compatible tapes.

During the middle portion of the reporting period experimentation with the Bausch and Lomb Zoom Transferscope using 9 x 9 MSS images of identical areas in the same spectral band from different time periods, with a "quick flip" method of alternately viewing the frame areas, enabled rapid detection of a major land use change from agricultural to urban use on the northwest fringe of the metropolitan Phoenix area. The best results in this case were obtained when comparing MSS band 5 images.

The photographically-prepared color composite of the eastern half of the test site and the 1:100,000 print enlargements of the Phoenix area covering the fall, winter, and spring seasons, and the diazo color composites of the western section of the test site prepared from spring imagery that were examined during the latter portion of the reporting period allowed the most accurate update so far of the map of land use change to be accomplished. Land changing from agricultural or rangeland to urban residential use usually can be accurately identified only when landscaping vegetation is established to the point that a distinctive pink color is visible on the color composite. Due to size, location, and rapidly changing shape, one area adjacent to the northern edge of Sun City undergoing change from agricultural to urban use was readily detectable without relying on the color change previously mentioned One case of change from agricultural to urban use was detected from the appearance of white and blue-black patterns which correspond to large buildings and parking areas. Land areas which had been inundated in the Salt and Gila River valleys were evident in the late winter and spring imagery. The large land area inundated with the sudden filling of the Painted Rock Reservoir in the extreme south central section of the test site resulted in a significant amount of land use change in relation to the entire test site. Rapid detection and measurement of land use change caused by sudden natural and man-made situations may be quickly detected and measured using ERTS data.

The amount of water area within the test site increased by about 72 square kilometers, which resulted in a loss of about 16 1/2 square kilometers of agricultural land and 55 1/2 square kilometers of rangeland to the new use. Urban land area increased by about 19 1/4 square kilometers, with about 18 1/4 square kilometers changing from agricultural and about only 1 square kilometer changing from rangeland. Agricultural land increased by about 27 3/4 square kilometers by change from rangeland, but changes of 18 1/4 square kilometers and 16 1/2. square kilometers to urban and water uses respectively resulted in an overall decrease of about 7 square kilometers for land in agricultural use. Rangeland decreased about 84 1/4 square kilometers with losses of 55 1/2 square kilometers, 27 3/4 square kilometers, and 1 square kilometer to water, agricultural, and urban uses respectively. ERTS results indicate that agricultural land is being urbanized, but that new agricultural land is being developed from rangeland at a greater rate. Cleared land was more easily detectable from surrounding naturally-vegetated rangeland at certain times of the year on ERTS imagery.

Total areas of change detected in the ERTS underflight photos were comparable with the total areas of change detected in the ERTS images. The photos allowed more detailed interpretation, but the ERTS images were more up-to-date and covered the entire quadrangle. A strip about 7 kilometers wide along the bottom of the quadrangle was not covered on the underflight photos.

f. Published reports and talks:

"Change in Land Use in Phoenix (1:250,000) Quadrangle, Arizona, between 1970 and 1972: Successful Use of a Proposed Land Use Classification System," by John L. Place, U.S. Geological Survey, Geographic Applications Program, was presented at the Symposium on Significant Results Obtained from ERTS-1 at New Carrollton, Maryland on March 6, 1973.

g. Recommendations for improvement:

The color infrared composite transparencies have proven to be most valuable for interpreting land use. Many such composites have been prepared at NASA expense. An index or catalog of existing color composites could be very useful if distributed widely, similar to the EROS Data Center's publication entitled, "Color Composite Pictures Available from EROS Data Center", dated March 1973.

h. Changes in Standing Order Forms:

The revised ERTS Product Order Form submitted to Arthur W. Fihelly, ERTS Technical Monitor, on April 17, 1973, has been implimented and the requested imagery is being recieved. Imagery was requested for every pass that qualifies on the basis of a maximum acceptable cloud cover of 20%. MSS bands 4, 5, 6 and 7 were requested in bulk black and white transparencies, both 9.5 inch and 70mm for use in color additive viewers. This revised Product Order Form is enabling us to receive the data required to make a more complete and comprehensive analysis of land use change in the test site than has been possible with the imagery previously recieved.

i. ERTS Image Descriptor Forms:

No new descriptors have been detected.

j. Changed Data Request Forms submitted to Goddard Space Flight Center/NDPF:

The ERTS Data Request Form that was submitted to Goddard Space Flight Center/NDPF on April 9, 1973 has been processed and the imagery has been received.

Two ERTS Data Request Forms were submitted to Goddard Space Flight Center/NDPF on June 21, 1973. MSS imagery in several different product formats was ordered retrospectively. The imagery requested has not yet been received.