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CHANGE IN LAND USE IN THE PHOENIX (1:250,000) QUADRANGLE, ARIZONA BETWEEN 1970 AND 1972: SUCCESSFUL USE OF A PROPOSED LAND USE CLASSIFICATION SYSTEM

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ABSTRACT

Changes in land use in the Phoenix (1:250,000 scale) Quadrangle in Arizona have been mapped using only the images from ERTS-1, tending to verify the utility of a land use classification system proposed for use with ERTS images. The period of change investigated was from November 1970 to late summer or early fall, 1972. Seasonal changes also were studied using successive ERTS images. Types of equipment used to aid interpretation included a color additive viewer, a twenty-power magnifier, a density slicer, and a diazo copy machine for making ERTS color composites in hard copy. Types of changes detected have been: a) cropland or rangeland developed for new residential areas; b) rangeland converted to new cropland; and c) possibly new areas of industrial or commercial development. A map of land use previously compiled from air photos was updated in this manner.

This information on changes can be of value to planners and resource managers at Federal, state, and regional levels, in monitoring environmental change in developing resources in broad regions of the United States. Planners need land use maps as an early step in planning both in the Governmental and private sectors. Managers utilize successive maps of land use to monitor change in the natural and man-made environment. The ERTS images focussed attention on those areas of greatest change requiring more intensive study.

1. INTRODUCTION

Attempts have been made in the past to map the current land use of all or most of the United States, but it took so long to compile the necessary information that some of it was obsolete before it was finally published. With the advent of earth resources satellites of the ERTS type, the potential now exists for mapping land use in very large areas of the United States and for keeping these maps relatively current. In order to utilize as much as possible of the detail available from satellite images, an intermediate scale of 1:250,000 was selected for the mapping. This is the largest standard scale for which we have nationwide coverage. Prior to the launch of ERTS, an investigation had been conducted within the USGS Geographic Applications Program with NASA and EROS sponsorship to develop procedures for mapping land use in a sample 1:250,000 quadrangle, specifically the Phoenix Quadrangle in Arizona. The land use data were read off into a computer where they were combined with information on other environmental and politico-economic factors. It was hoped that contiguous blocks of such maps and data banks could be created to cover large regions, such as the Colorado River drainage basin.

The mapping of the Phoenix Quadrangle was done primarily with the aid of high-altitude aerial photography taken by NASA in 1970. Our ERTS experiment is to determine the value of ERTS images in the updating of that 1970 map and for consequent updating of the computer data bank for the Phoenix Quadrangle. In the past few months, we have successfully mapped the changes in generalized land use between 1970 and 1972 in the test quadrangle using only the images from ERTS. We believe now that we can use the frequent passage of ERTS-type satellites to complement our map revision procedures, providing us with a capability to monitor trends in land utilization on a nearly real-time basis. Admittedly, this is still highly-generalized mapping because of the 100-meter resolution limit on the images. However, better resolution should be forthcoming from Skylab and future unmanned satellites beyond the ERTS-B era, and we are already close to the threshold for another level of detailed classification using only the ERTS-1 images. In any event, our present capabilities allow us to monitor general trends and to focus in on areas of most rapid change requiring more intensive study.

2. PROCEDURES

However, our immediate goal is to draw the most information possible from the existing ERTS images. During the past summer with the launch of ERTS-A imminent, experimentation commenced using ERTS-simulation photographs. This procedure gave us experience in using the several spectral bands to create enhanced images on an I^2S Color Additive Viewer and for making land use interpretations from them. Multiband 70 mm frames were mounted in the viewer to determine the best combination of colored filters and light intensities.

With the arrival of the first ERTS images during the past five months, interpretation has been attempted using every image enhancement technique at our disposal. Experimentation has been primarily with 70 mm chips cut out of the 9 x 9 transparencies of each of the ERTS MSS bands 4, 5, and 6. The primary equipment used was (1) an I^2S Color Additive Viewer; (2) a Richardson Film Projection Viewer at 10-power and 20-power magnification, (3) a microfiche viewer at 12-power and 18-power magnification, and (4) a Spectral Data Systems Data Color density slicer. We have found the MSS images to be superior to the RBV images for purposes of interpreting land use.

Since it had been found previously that color infrared transparencies are generally the most useful images for land use interpretation, a search was made for the best method of creating hard copy composites from the ERTS MSS bands. Copies of color composite transparencies are being ordered retrospectively from NASA Goddard by special order form. One composite has been made by conventional photographic procedure, but this is very expensive. Diazo copying of individual bands has been done with the Diazo transparencies being overlain to form a composite. This is quite inexpensive and the quality is almost as good as the photographic product. The method demonstrated here to create briefing slides and report illustrations is the simple photographing of the display screen of the Color Additive Viewer. An example is shown in Figure 1 which is a color infrared composite of ERTS MSS bands 4, 5, and 6 taken of the eastern part of the Phoenix Quadrangle in November. Some degradation in quality occurred from the photographic step, yet this can be compared favorably with the famous Apollo-9 photo of the Phoenix area.

Almost all of the interpretation of land use change in this project was done using the Color Additive Viewer with this type of display. The most useful setting that we found showed the MSS band 4 with a blue filter and light intensity of 4, the MSS band 5 with a green filter and full light intensity, and MSS band 6 with a red filter and light intensity of about 7. If the light intensity of the infrared band is changed rapidly up and down, it aids detection of subtle shades of red which indicate residential landscaping. The cropland with crops on it is easy to detect as bright red field plots. Fallow fields on the edge of the desert can barely be detected by the absence of faint brown brown desert shrub cover. Tree crops appeared brownish red, non-vegetated man-made features appeared bluish, and water surfaces stood out as dark blue. The 1970 map of land use was consulted and any changes discovered were plotted on an overlay upon it.

The EROS Program of the Department of the Interior has in its possession a Data Color density slicer made by Spectral Data Systems. It is housed at the Geological Survey's McLean, Virginia Office. This density slicer was tested with samples of ERTS MSS bands 5, 6, and 7. The next figure shows a photograph taken of the display screen of the density slicer which appear interesting. Although we have not yet been able to interpret these patterns to help in land use mapping, the potential is there and we seem to be getting close to something useful.

Figure 2 shows the Data Color density slicer enhancing certain gray tones of an ERTS image. Plots of land with lush, well-watered vegetation are enhanced compared to other types of surface cover, held as a duller gray background. This area is west of Phoenix in the vicinity of Sun City.

In general, of the 5, 6, and 7 bands tested, MSS band 7 gave the sharpest patterns in terms of contrast between vegetated and non-vegetated areas.

Basic to the entire investigation is the detection of change. The simplest approach was visual comparison of the 1970 map of land use with the 1972 ERTS image. An aid to this comparison would be the "quick flip" technique possible using a Bausch and Lomb Zoom Transfer Scope. Delivery of two of these instruments to our office is expected in the next few weeks. In the meantime, we have been experimenting with change detection using ERTS images taken three or more months apart. For example, field patterns in August are different from those in November. Use of the I^2S Color Additive Viewer allows both "quick flip" techniques and overlaying/registering of the August and November images.

3. FINDINGS

Nevertheless, a map of change in land use for the entire Phoenix Quadrangle was compiled by point by point visual comparison. A part of that map is shown in Figure 3, the portion around the City of Phoenix. Information already known, but recognized on the ERTS images is shown in red with solid line boundaries. New information detected by ERTS is in green with dotted boundaries. All of the changes shown here are new urban developments. New cropland was detected elsewhere in the quadrangle.

One of the goals of this experiment was to test the new standard land use classification designed for use with ERTS images and high-altitude air photos to see if it could be applied to arid areas. The proposed classification system for nationwide land use is shown in Figure 4. This classification system is described in USGS Circular 671. Basically, it consists of a first level of classification, designed for use with ERTS-type images, and a second level designed for use with high-altitude aerial photos. For the Phoenix Quadrangle, the proposed system was an apparent success. Because only satellite images were involved in the test, only the first level was used. Of the first level categories only Urban and Built-up, Agricultural Land, Rangeland, and Water existed in this quadrangle. We were particularly pleased that we came close to interpreting some of the second level categories as well, notably separating residential from other urban categories, separating out tree crops, and delimiting some mining/quarrying activities. In other areas, deciduous forests might be distinguished from evergreen forests, but surveillance over many seasons will probably be needed, and possibly use of more-advanced interpretation techniques presently being developed.

The most important test in this investigation is yet to come. When our ERTS underflight photography finally arrives--it was ordered by NASA MSC Form 192 in January 1972--we will calculate the accuracy of our ERTS interpretation. Until then, we cannot use the new discoveries to update the existing computer data bank for the Phoenix Quadrangle.

4. CONCLUSIONS

In conclusion, a map of land use change in the Phoenix 1:250,000 quadrangle has been compiled using ERTS images only. The proposed standard land use classification has been an apparent success in this test site, though not yet checked for accuracy.

Figure 1. A composite of ERTS MSS bands 4, 5, and 6 showing Phoenix and irrigated farmland November 1972, photographed from I^2S viewer.

Figure 2. Data Color density slicer enhancing an ERTS image. Plots of land west of Phoenix with lush, well-watered vegetation are enhanced compared to other types of surface cover.

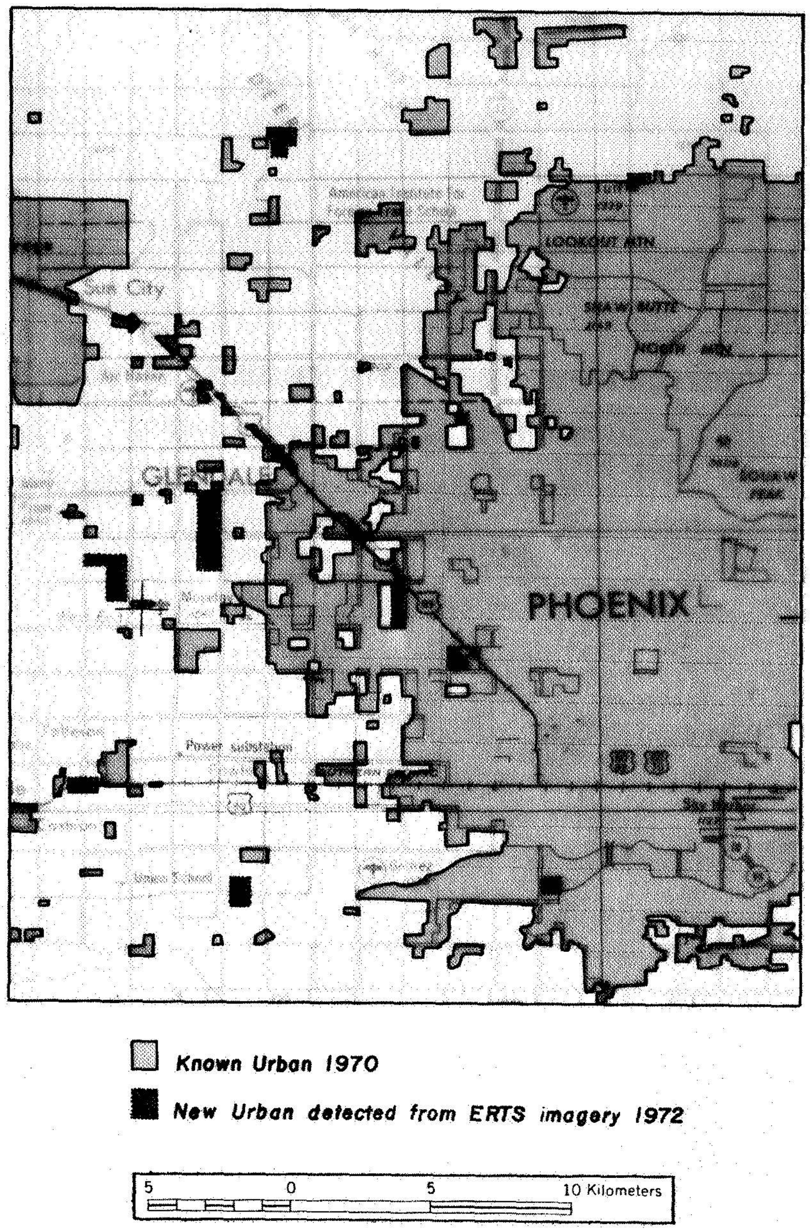

Figure 3. Map of urban and built-up land in the Phoenix metropolitan area. Areas with solid boundaries were detected in U-2 aerial photographs in 1970 and recognized in ERTS. Areas with dotted patterns are new urbanized areas detected in ERTS MSS composites. ERTS images were the only source of information used for this change detection.

LAND USE CLASSIFICATION SYSTEM FOR USE WITH REMOTE SENSOR DATA

LEVEL I CATEGORIES
LEVEL II CATEGORIES

01 URBAN AND BUILT-UP

- 01 RESIDENTIAL
- 02 COMMERCIAL & SERVICES
- 03 INDUSTRIAL
- 04 EXTRACTIVE
- 05 MAJOR TRANSPORT ROUTES & AREAS
- 06 INSTITUTIONAL
- 07 STRIP & CLUSTERED SETTLEMENT
- 08 MIXED
- 09 OPEN & OTHER

02 AGRICULTURAL

- 01 CROPLAND & PASTURE
- 02 ORCHARDS, GROVES, BUSH FRUITS, VINEYARDS & HORTICULTURAL AREAS
- 03 FEEDING OPERATIONS
- 04 OTHER

03 RANGELAND

- 01 GRASS
- 02 SAVANNAS (PALMETTO PRAIRIES)
- 03 CHAPARRAL
- 04 DESERT SHRUB

04 FORESTLAND

- 01 DECIDUOUS
- 02 EVERGREEN (CONIFEROUS & OTHER)
- 03 MIXED

LEVEL I CATEGORIES
LEVEL II CATEGORIES

05 WATER

- 01 STREAMS & WATERWAYS
- 02 LAKES
- 03 RESERVOIRS
- 04 BAYS & ESTUARIES
- 05 OTHER

06 NON-FORESTED WETLAND

- 01 VEGETATED
- 02 BARE

07 BARREN LAND

- 01 SALT FLATS
- 02 SAND (OTHER THAN BEACHES)
- 03 BARE EXPOSED ROCK
- 04 BEACHES
- 05 OTHER

08 TUNDRA

- 01 TUNDRA

09 PERMANENT SNOW AND ICE FIELDS

- 01 PERMANENT SNOW & ICE FIELDS

Figure 4. Proposed standard land use classification system. The first level of the classification system was designed for use with ERTS images.