Paper L 5

EVALUATION OF ERTS-1 DATA FOR ACQUIRING LAND USE DATA OF NORTHERN MEGALOPOLIS

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ABSTRACT

State planners are increasingly becoming interested in ERTS as a possible method for acquiring land use data. An important consideration to them is whether ERTS can provide such data at a savings in both time and money over alternative systems. The following is a preliminary evaluation of ERTS as a planning tool.

INTRODUCTION

Among the investigations funded by NASA under the ERTS-1 Program was one for the investigation of the land use of northern Megalopolis by the Dartmouth College Project in Remote Sensing. Specifically the objectives of this investigation were (1) to map and digitize the land use of the northern third of Megalopolis, and (2) to evaluate ERTS as a planning tool. At present we have completed the mapping and digitizing phase of the project; the evaluation of ERTS as a planning tool is in progress.

For aid in orientation, a map showing the Boston-Washington Megalopolis among the urban concentrations of the United States has been included (Fig. 1), as well as a map displaying the location and boundaries of the test area (Fig. 2).

Mapping the Land Use of Northern Megalopolis

The Color-Coded Version. Good weather over New England in mid-October 1972 provided the first fully useful imagery of our test area. Nine-by-nine transparencies of the four necessary scenes became available from the NDPFC on 18 December 1972, and the General Electric Photo Laboratory in Beltsville, Maryland, provided the essential unenhanced 1:250,000 CIR transparencies of those scenes on 3 January 1973. Working from the CIR transparencies a single photointerpreter completed the three-state land use map in draft form within three months (1 April 1973). However, it took another two months (1 June 1973) to complete the final color-coded map (Fig. 3). Thus, it took five months to complete the map by conventional photointerpretation techniques. Furthermore, because of a variety of constraints we did not use multi-seasonal coverage, we relied exclusively on MSS bulk-processed products, and we made infrequent use of the individual bands.

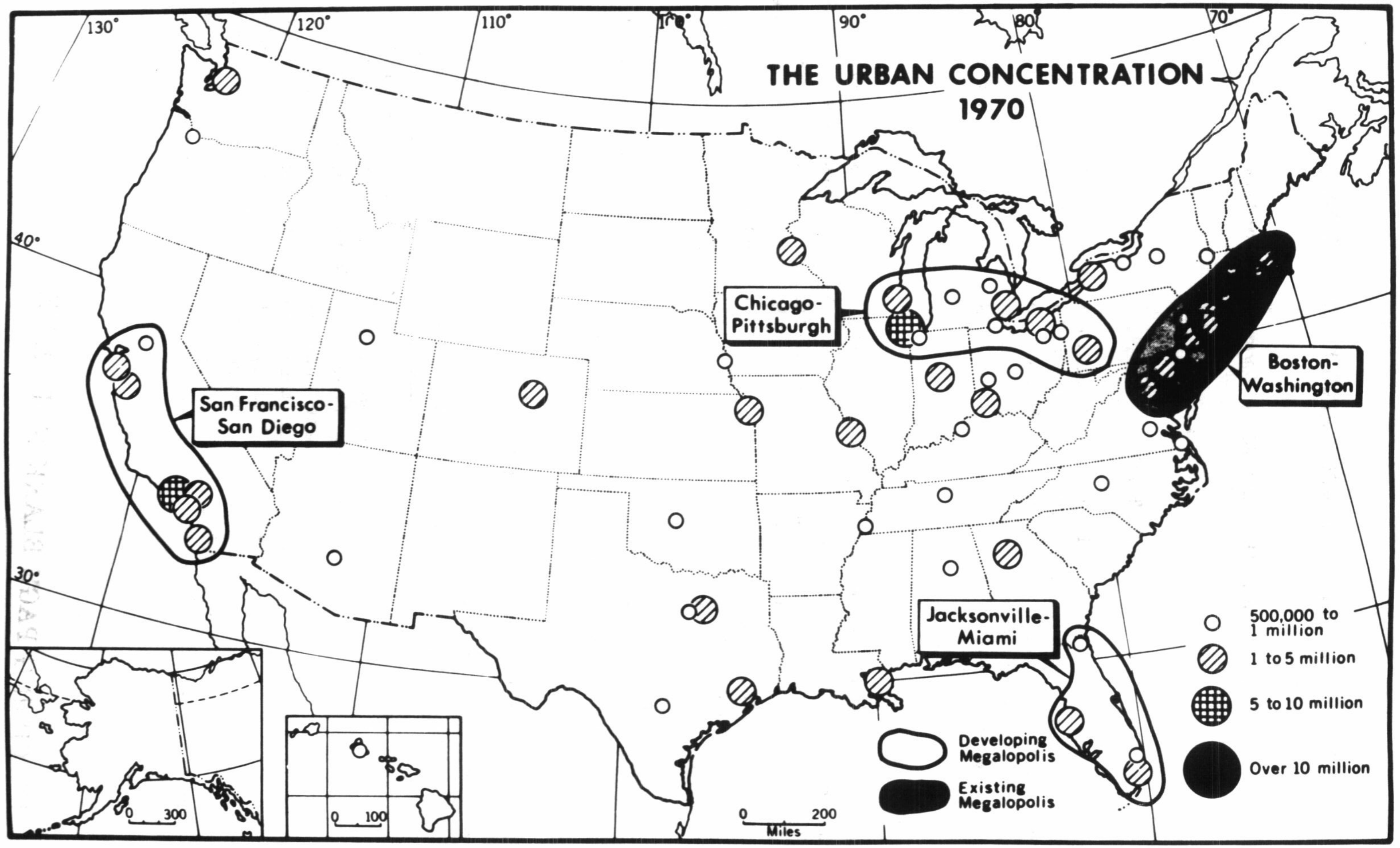

Figure 1. The Boston-Washington Megalopolis.

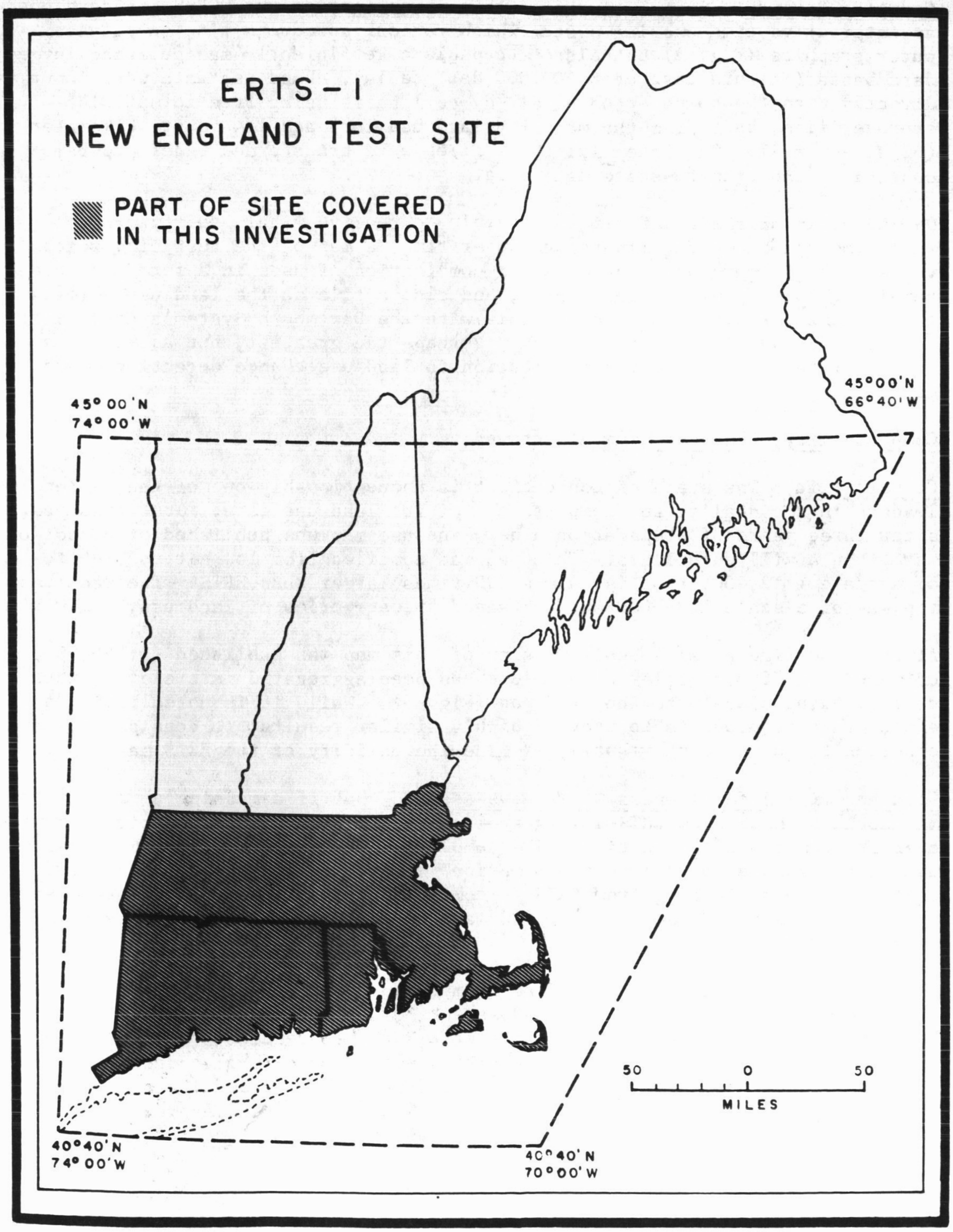

Figure 2. The Test Area.

Computer Version. In the course of this investigation the DCPRS has developed an interactive time-sharing system which not only produces fine quality computer graphics (Fig. 4) but also is capable of efficiently manipulating large data bases (in this case over 600,000 data cells). Land use data were input directly into the computer on a cell-by-cell basis using free-format disc-storage files, by typing the majority land use for each 1/4 square kilometer (62 acres) cell. Subsequently, these files were transformed under program control to the true-to-scale data base.

On the basis of these data it is possible to receive within thirty minutes real time and but a few minutes computer time, a map of the test site which visually highlights any single use or combination of uses in a form less visually complex than the multi-colored maps, and also a file on the land use summary tabulations formatted to be compatible with the Dartmouth System's correllation, regression, and clustering routines. Perhaps the greatest, but as yet untapped, asset of this system is its application to land use change detection investigations.

Comparability, Cost and Time Effectiveness.

Comparability. The state of Connecticut is unquestionably one of the national leaders in the quality and completeness of its land use data. Just this year after three years of preparation a new land use map was published at a cost of more than a million dollars. This map was compiled from low-altitude photos of a scale 1:12,000, that is, almost 90 times larger than ERTS. The resultant map was of a scale 1:24,000 and contained 55 categories of land use.

At the same time a small-scale version of this map was published (1:250,000) on which the 55 categories of land use had been aggregated into eleven, thus corresponding closely to the ERTS map (Fig. 5). While it is unrealistic to expect the two products to provide highly similar results, it does provide an opportunity to at least visually examine the validity of the ERTS map.

Cost and Time Effectiveness. We have assumed that if a meaningful land use map could be made from ERTS-1 imagery it would be at a savings in time and money over other means of production. The completion of the three-state ERTS map makes it possible to test this assumption. In the evaluation which follows, the cost of land-use mapping from ERTS is compared to that from high-altitude aircraft (RB-57 and U-2, scale 1:100,000) and from medium-altitude aircraft (scale 1:20,000).

The ERTS-1 figures have been derived from the present investigation, which has involved mapping approximately 15,000 square miles of southern New England at a scale of 1:250,000 from a single set of CIR transparencies prepared by photo laboratory processes only. The high altitude figures were also derived from the experience of the Dartmouth College Project in Remote Sensing in the investiative mapping of land use in the Boston and New Haven areas (Approximate 1,500 square miles) using NASA RB-57 photography under USGS/GAP contract in 1970-71.

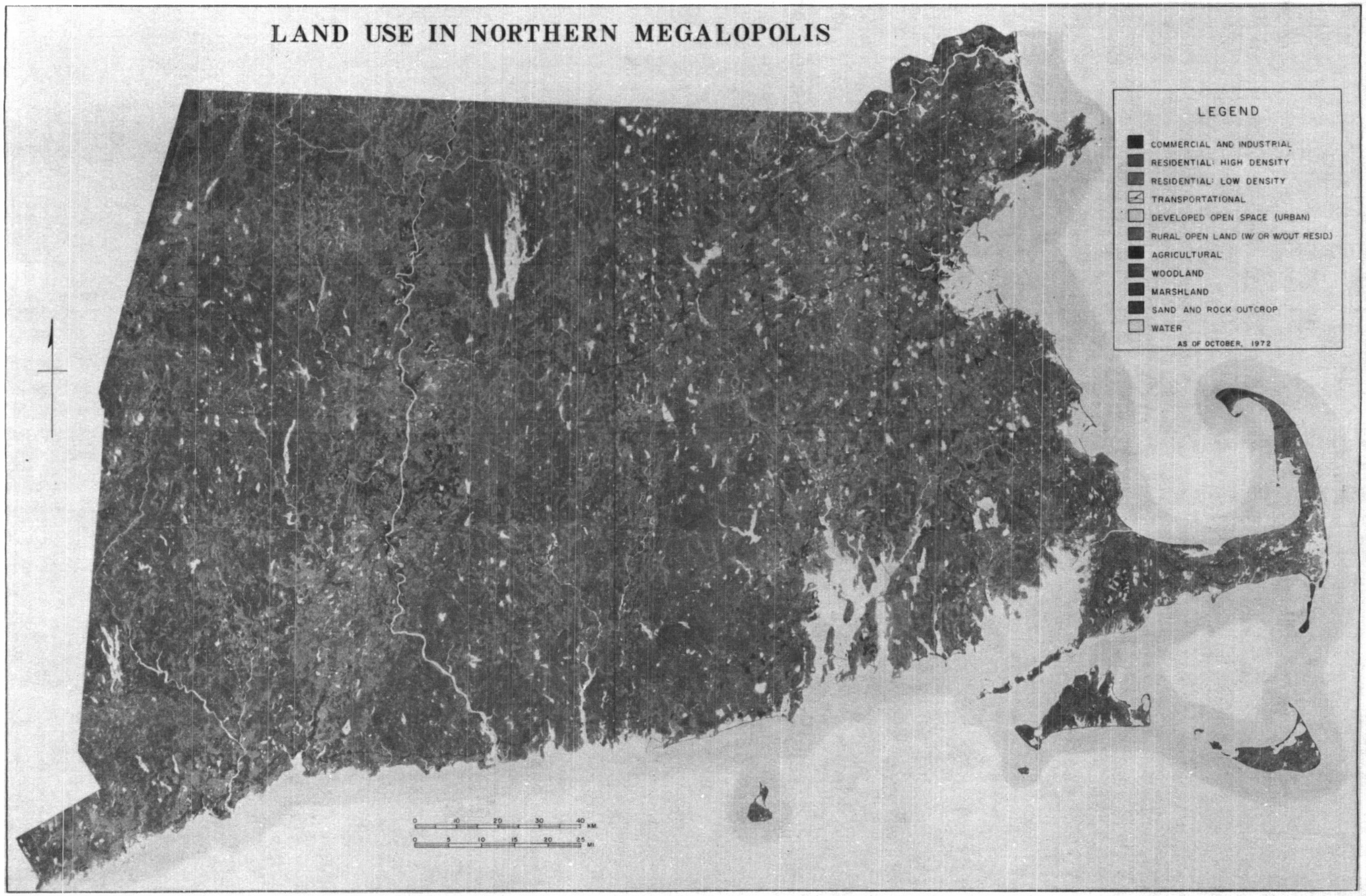

Fig. 3 Land Use Map of Northern Megalopolis

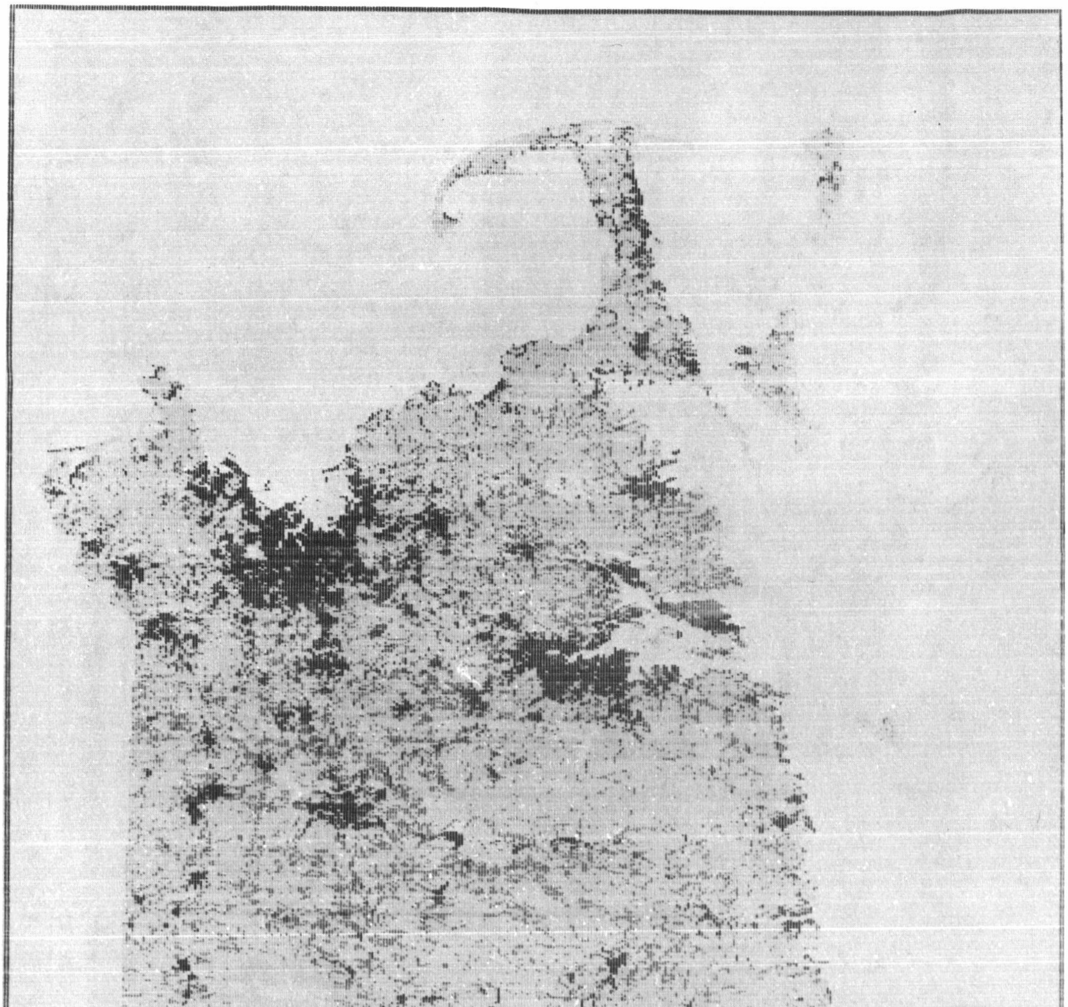

Fig. 4 Computer Map Illustrating Built-Up Land Uses Within Test Site

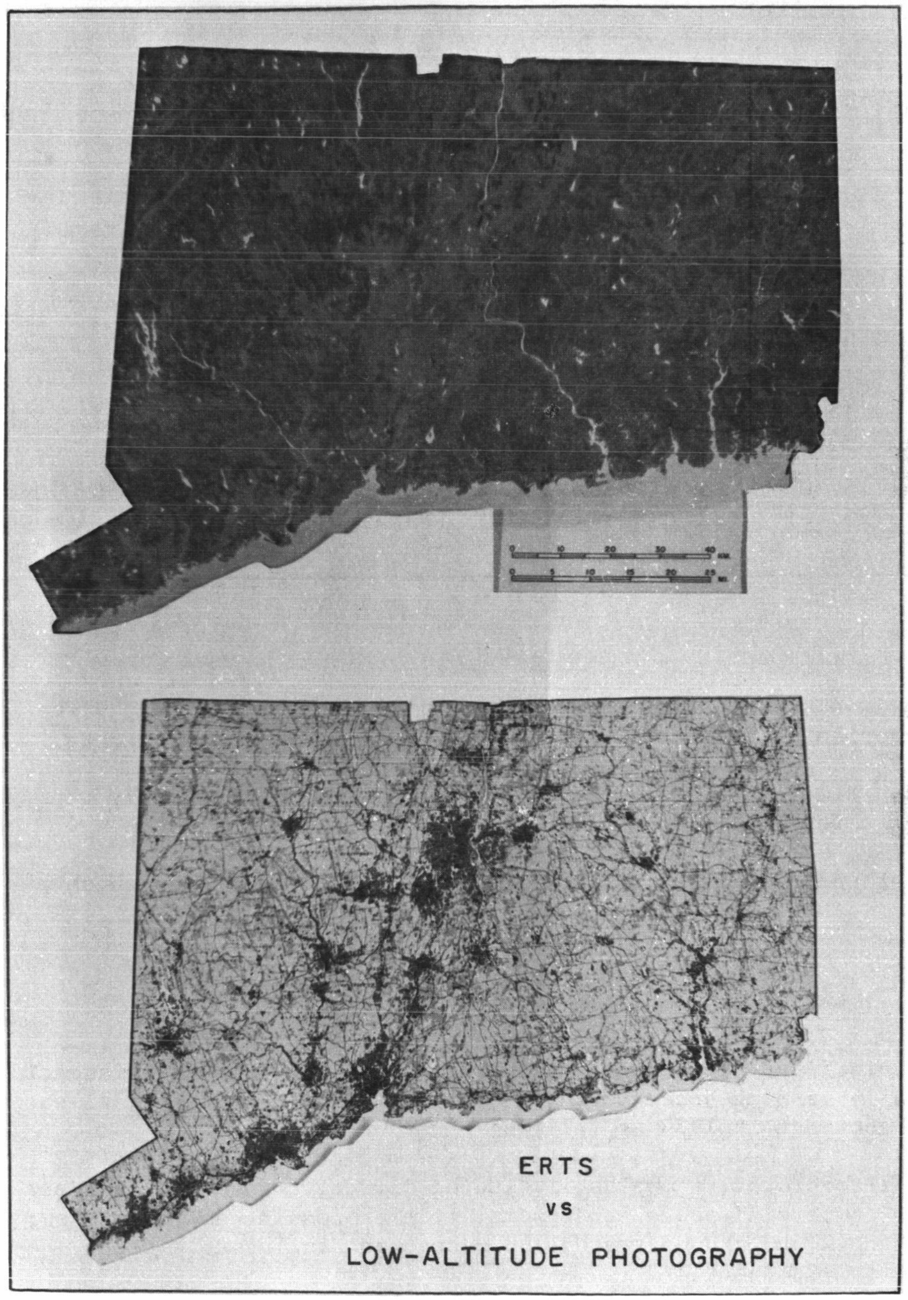

Fig. 5 Comparison of Connecticut Land Use Map with ERTS

Fig. 6

Estimates of Comparative

Cost- and Time-Efficiency in Land Use

Mapping

	(a) Cost ($/sq.mi.)	(ratio)	(b) Time (interp.hrs/ 1000 sq.mi.)	(ratio)	(c) Scale of Imagery	(ratio)	(d) Status
ERTS-1	$ 1.06[1]	1:	45[5]	1:	1:1,000,000	1:	Experimental
High-altitude aircraft	10.46[2]	10:	328[6]	7:	1:100,000	10:	Experimental
Medium-altitude aircraft	15.50[3] (23.80)[4]	15: (22:)	1,380[7]	31:	1:20,000	50:	Operational

Assumptions:

* Product is a numerically coded b/w, or rough color-coded, map with 11 categories of land use

* Costs and time shown are for imagery interpretation phase only (no charge for imagery)

* Bases for individual derivations are shown in the footnotes which follow

Footnotes:

[1] Basis: This figure represents an approximation of DCPRS experience in experimentally mapping three southern states of New England (14,371 sq. mi.) under NASA contract in 1973 as follows:

Photo interpreter, 4 months, including direct, fringe and indirect costs; commercial photo lab special film processing and enlarging; field check and ground truth; and management including direct, fringe and indirect)

Total $ 15,300

Average cost of $ 1.06/sq. mi.

[2] Basis: based on DCPRS experience in experimentally mapping the Boston area (1,100 sq. mi.) under USGS contract in 1970.

Photo interpreter time reduced from 12 to 9 weeks due to reduction of categories mapped from 24 to 11, and elimination of extensive hand coloring.

Total $ 11,506

Average cost of $10.46 sq. mi.

[3] Basis: cost estimates received from three commercial mapping agencies, for mapping an area similar to state of Connecticut (5,000 sq. mi.)

Average of the 3 was $15.50 per sq. mi. (for interpretation and map making only)

[4] Basis: this figure represents $15.50 plus $8.30/sq. mi. for photography the average of prices submitted be the 3 companies.

[5] Basis: same as for footnote (1)

14,371 sq. mi. in 4 months (640 hrs.) of interpretation time

Average of 45 hrs. interpretation per 1,000 sq. mi.

[6] Basis: same as for footnote (2)

1,100 sq. mi. in 9 weeks (360 hrs.) of interpretation time

Average of 328 hours interpretation per 1,000 sq. mi.

[7] Basis: Average of the time estimates received from the three contractors referred to in footnote (3) above

1,000 sq. mi. in 1,380 hrs. interpretation time

Average of 1,380 hrs. interpretation per 1,000 sq. mi.

The lower (medium-altitude) aircraft figures represent the numerical averages of estimates provided by three commercial air-photo mapping organizations with extensive experience in Northeastern United States.

In each case purely human - visual image interpretation is assumed using conventional photo laboratory products. Field checking would be limited, but readily available published ground truth would be used extensively.

Column (a) shows that the image interpretation phase of land use mapping can be done from ERTS for about $1/sq. mi. in comparison with approximately $10/sq. mi. from high-altitude aircraft and $15/sq. mi. from medium-altitude aircraft. The latter estimate maybe more conservative than the other two since it is based upon competitive commercial experience rather than on investigative research programs.

Column (b) reveals a greater spread in time-in-work estimates than in dollar-cost estimates. As much area can be mapped in one day of ERTS land use interpretation as in 7 days of U-2 or RB-57 interpretation or in 31 days of conventional photo mapping.

In summary, these figures have been compiled from experience probably as extensive as is yet available in the ERTS program, but it is regional experience and the figures should be revised as national experience accrues.

Conclusions and Recommendations.

On the basis of our research we have concluded that it is completely practical to compile an 11-category land use map for a state or group of states utilizing unenhanced ERTS-1 imagery and conventional manual photointerpretation techniques. Furthermore, the savings in both dollars and time using ERTS as opposed to aircraft are an order of magnitude more.

We have also concluded that the manual read-in by grid cell provides planning offices with a rapid and inexpensive method of converting a manually - compiled land use map to a much more broadly useful and flexible data base. We have likewise found continued user interest in the traditional color-coded land use map.

Our preliminary evaluation of ERTS' utility to planners suggests almost open-ended capabilities for the future. Initial conferences with planners in several of the New England states have revealed a near unanimity in interest in ERTS as a source of land use data. However, their degree of enthusiasm appears inversely proportional to the quality and detail of the land use information which they already have at their disposal. For example, those states which have very detailed maps and statistics perceive ERTS-1 in its present form as a tool of limited value although they see great possibilities in the earth resources satellite concept - in a platform with the performance capabilities proposed for EOS, for example. On the other hand, those states possessing little current land use information can visualize an immediate utility for ERTS-1 data.

It should certainly be pointed out, however, that both types of states are reserving any final judgement on ERTS until further statistical evaluation has been completed. To that end we expect to make an evaluation of the accuracy of our ERTS-1 land use data using land use data acquired by the Connecticut Office of State Planning as a base. Since much of the ERTS research, particularly in land use, has been conducted in the semi-arid West where landscapes are more homogeneous and parcel sizes larger, we feel that the humid Northeast with its smaller parcel sizes, its complex physiographic and cultural landscapes, and its heavier population densities, provides a better test of ERTS' land use capabilities. The smaller size of eastern states, especially in New England, also gives us an opportunity to work with a variety of land use philosophies and planning organizations.

In the remaining months of our ERTS-1 research we of the Dartmouth College Project in Remote Sensing hope to more effectively evaluate ERTS in terms of planners needs. In ERTS-1 we have gathered land use data and prepared maps which we are taking to planners for their evaluation. Under ERTS-B it is proposed that the planners, in this case from the New Hampshire Office of Comprehensive Planning, work with us from the very start, and that the evaluation take place continuously as we compile from ERTS a single comprehensive state land use map for New Hampshire utilizing the latest and most efficient techniques. This map will be compiled with New Hampshire on a cost-sharing basis and when completed should enable us to provide the most penetrating evaluation of ERTS from a land use planning viewpoint yet undertaken.

Finally, we are eagerly looking for progress towards a true second generation earth resources satellite. The 10-meter resolution proposal for EOS should provide us with a truly effective land use mapping tool.