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TESTING THE USEFULNESS OF ERTS-1 IMAGERY FOR INVENTORYING WILDLAND RESOURCES IN NORTHERN CALIFORNIA

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INTRODUCTION

The Forestry Remote Sensing Laboratory at the University of California is in the process of testing the usefulness of ERTS-1 imagery for inventorying wildland resources in northern California. Studies are being conducted in two large wildland areas, namely, the Feather River Watershed and the Northern Coastal Zone.

The 2.5 million-acre Feather River headwaters area in northern California is the keystone watershed for the California Water Project, one of the most extensive and ambitious water resource developments ever attempted. Consequently, accurate and timely information on the quantity, quality and distribution of timber, forage, water and recreation resources is of immediate importance to each public agency and private group managing this vast, but inaccessible, wildland area.

Likewise, the Northern Coastal Zone (consisting of the counties of Marin, Sonoma, Mendicino, Humbolt and Del Norte) is relatively rural, with an economy based on agriculture, timber, commercial fishing and tourism. However, it is expected that intensive resource use resulting from increasing population will soon become a serious problem unless wise land use planning is undertaken. Thus, this coastal region is particularly well suited to investigations of the ways in which ERTS-1 imagery and other supporting data may be used in conducting land use evaluations.

OBJECTIVES

Research being performed within wildland areas in northern California stresses both the applications of ERTS-1 imagery and the benefits derived from these applications. Specific objectives are to (1) evaluate the feasibility of mapping vegetation/terrain resources with the aid of ERTS-1 imagery, (2) evaluate the cost/effectiveness of resource mapping using various types of data, including ERTS-1 and aircraft imagery, (3) develop suitable aids for training image interpreters (4) test quantitatively selected ERTS-1 images for detailed wildland resource information, (5) compare -- in terms of accuracy of boundary placement, accuracy of type identification and degree of interpretation efficiency -- information

derived from ERTS-1 imagery with that derived from conventional and/or high flight photography, (6) compare ERTS-1 and high flight interpretation results with existing regional mapping capabilities that employ conventional techniques, and (7) evaluate the interpretability of multiband-multidate ERTS-1 image color composites.

Several types of color composite imagery are being analyzed, including those made by diazo overlay, optical projection, direct photo reproduction (multiple exposure), and electronic display (direct from ERTS-1 digital tapes). Emphasis in the results reported below has been placed on documenting levels of accuracy, degree of timeliness, and costs associated with utilizing ERTS-1 imagery for inventorying wildland vegetation/terrain resources.

SIGNIFICANT RESULTS

It is well understood that possibly the most useful characteristic of the ERTS-1 system is its ability to acquire data for the same point on the earth on a repetitive cycle. At the time of preparing this paper, most investigators have had little opportunity to study ERTS-1 data taken sequentially of the same area. However, our preliminary research results derived primarily from ERTS-1 data procured during the first few orbital passes made last July, are extremely encouraging.

Significant conclusions resulting from work done within the Feather River Watershed region are summarized below:

1. Numerous user agency groups have been identified which are keenly interested in the ERTS-1 investigations being conducted in northern California. For each of these agencies, resource management specialists have been contacted by FRSL personnel and avenues of communication and interchange have been established (see Figure 1).

2. Regional analysis of over thirty important wildland resource features within the Feather River Watershed, as seen on ERTS-1 imagery, have resulted in the development of a feasibility table which indicates the general degree of feature detection and identification.

3. A projected cost ratio of 7 to 1 was calculated for interpretation of high flight photography versus ERTS-1 imagery, respectively (see Figure 2).

4. An image interpretation key to 19 resource features occurring within the Davis Lake intensive study area was developed.

5. A quantitative image interpretation test of ERTS-1 imagery showed that within the Davis Lake study area specific resource type identification could be done at a level of accuracy of 65 percent and broad resource type identification at 70 percent (see Figure 3).

6. The Forestry Remote Sensing Laboratory automatic data processing hardware and software systems are now operating efficiently, and ERTS-1 digital magnetic tape data can be displayed on a color TV monitor, and CALSCAN and RECLASS classification procedures can be applied.

7. Within the Bucks Lake study area, boundaries between contrasting forest types were properly mapped by image interpretation on ERTS-1 imagery and subtle boundaries between less contrasting types (and, therefore, the less important boundaries) were the ones which were most often misplaced (see Figure 4).

8. The ERTS-1 imagery yielded less detailed information than conventional aerial photographs at the Bucks Lake study area, but the image interpretation was done much more cheaply (e.g., type delineations were drawn nearly 20 times faster on the ERTS-1 image than on black-and-white photographs, scale 1:15,840). (See Figure 5.)

9. A quantitative interpretation test was performed on several single observation ERTS-1 color composite images and one single band (#5) image. In no case were interpretation results derived from one image type significantly different than from those derived from another for the three vegetation types identified (conifers, brush and dry site hardwoods).

10. Initial vegetation/terrain type computerized classification results within the Bucks Lake study area using CALSCAN showed that three out of six types are reliably separated; these types were meadows, brush fields and barren areas.

Likewise, significant conclusions resulting from the work done within the Northern Coastal Zone Test Site are summarized below:

1. Contacts were made and interviews conducted with environmental planners throughout the north coast counties of California, resulting in the definition of parameters which are important for determining the potential of an area in terms of land use.

2. Within the southern portion of the Northern Coastal Zone Test Site, 23 mapping units were delineated by image interpretation on an ERTS-1 color composite image. However, when working with only single-date ERTS-1 imagery, an interpreter could consistently identify only five mapping unit categories.

3. A quantitative image interpretation test was performed within the San Pablo Reservoir study area using 300 ground controlled points. Differentiation on ERTS-1 imagery between various types of woody vegetation (i.e., Monterey pine, mixed hardwoods, eucalyptus, and chaparral) was difficult -- Monterey pine was identified correctly 78 percent of the

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time, but all other types were identified correctly less than 50 percent of the time.

4. The quantitative image interpretation test performed at the San Pablo Reservoir area, however, showed that a skilled image analyst could identify woody vegetation, versus everything else, with better than 86 percent accuracy.

5. The perimeter around a large burned area and damage levels within the perimeter were mapped on ERTS-1 imagery taken over the Pocket Gulch fire ten days after suppression. The burned area was accurately mapped on the ERTS-1 image as 13,340 acres while California Division of Forestry personnel estimated the burned area at 10,340 acres (see Figure 6). Low altitude oblique photography indicated that the estimate obtained from the ERTS-1 imagery is accurate.

6. The costs associated with mapping burned areas using conventional methods are 10 times greater than by using the ERTS-1 image.

CONCLUSIONS

In summary, it is much too early to reach definitive conclusions regarding the feasibility of using ERTS-1 for detecting, inventorying and monitoring wildland resource features and conditions in northern California. However, the preliminary results reported upon above have been surprisingly good. There appears to be every indication that many kinds of regional resource information can be obtained more quickly, more reliably and at lower costs through the use of ERTS-1 imagery in comparison to conventional data gathering techniques. Likewise, intensive area resource information, such as forest land classification, major vegetation type identification and post fire maps, can be easily and accurately obtained from ERTS-1 imagery by applying manual and/or automatic data extraction techniques which are currently operational. It must be remembered that (1) most of the case studies reported upon herein were done with the aid of the very first ERTS-1 images, taken in July over California, and (2) the unique characteristics of ERTS-1 lie in its synoptic view, sequential capabilities. Consequently one can expect that as ERTS-1 continues to procure high quality imagery on an 18-day cycle, the relatively high accuracy and low cost figures associated with each study done to date will be improved -- and results derived from other experiments currently in progress will be equally as impressive.

USER GROUP AGENCY	PERSONNEL CONTACTS	REMOTE SENSING RESEARCH APPLICATION
CALIFORNIA REGION FRAMEWORK STUDY COMMISSION FOR SOUTHWEST WATER AGENCY COMMITTEE WATER RESOURCES COUNCIL	MR L H COOK (USFS) MR L F ELLIBEN (USFS) MR [illegible] FRAMP	REGIONAL VEGETATION/TERRAIN MAPPING LAND USE PRACTICES AND CHANGES LANDSLIDE AND STREAM SEDIMENTATION DETECTION
REDWOODS NATIONAL PARK U S NATIONAL PARK SERVICE	MR [illegible] HATZIMANOLIS RESOURCES MANAGEMENT SPECIALIST	CHANGE DETECTION ANALYSIS LAND USE PATTERNS ON ADJACENT LANDS VEGETATION INVENTORY REGENERATION ANALYSIS
DEPARTMENT OF WATER RESOURCES STATE OF CALIFORNIA	MR G SAWYER MR A DE RUITE	SNOWPACK DETECTION HYDROLOGIC OUTPUT PREDICTIONS
CALIFORNIA COOPERATIVE SNOW SURVEY	MR [illegible] EMMONS	SNOWPACK DETECTION AND HYDROLOGIC PREDICTIONS
CALIFORNIA DEPARTMENT OF CONSERVATION DIVISION OF FORESTRY	MR T ARVOLA MR C PHILLIPS	VEGETAT SOILS INVENTORY FIRE APPRAISAL RANGE & CONTROL BURNING MONITORING COMPLIANCE WITH FOREST PRACTICE ACT
U S FOREST SERVICE	MR [illegible] LAUGHLIN	SOILS-TERRAIN ANALYSES
TAHOE REGIONAL PLANNING AGENCY	MR [illegible]	ENVIRONMENTAL CHANGE DETECTION SEDIMENT POLLUTION ANALYSIS LAND USE INVENTORY
CALIFORNIA STATE DEPARTMENT OF PARKS AND RECREATION	MR GEORGE HACKENBROCK MR JOHN HAYNES MR SANDY RABINOWITCH MR KEN FOLLIER MR ED MORE	LANDSCAPE INVENTORY SITE LOCATION AND PLANNING

Figure 1. Cooperating user agency personnel who have shown a keen interest in the ERTS-1 experiments being conducted within wildland areas in northern California.

TASK	SMALL SCALE CIR TRANSPARENCY (9 x 9 in.)	ERTS-1 COLOR COMPOSITE PRINT (16 x 16 in.)
DELINEATION OF WATERSHED BOUNDARY (2.5 MILLION ACRES)	3.0 HOURS	0.5 HOURS
PLOTTING EFFECTIVE AREAS	6.5 HOURS	0.0 HOURS
DELINEATION OF HOMOGENEOUS AREAS	48.0 HOURS	3.0 HOURS
PHOTO INTERPRETAT ON TRAINING & TESTING	6.0 HOURS	2.0 HOURS
RESOURCE TYPE CLASSIFICATION	215.0 HOURS	30.5 HOURS
TOTAL INTERPRETATION TIME REQUIRED	272.0 HOURS	35.5 HOURS
HOURLY WAGE	$7.00/HOUR	$7.00/HOUR
TOTAL INTERPRETATION COSTS (TIME)	$1,904.00	$248.50
TOTAL COST/ACRE	0.07¢	0.0098¢
COST RATIO	7	1

Figure 2. Projected time and costs associated with mapping vegetation/terrain resources throughout the entire 2.5 million-acre Feather River Watershed using high flight photographs or ERTS-1 imagery.

COMPONENTS	A,BB,C,E		F,:1		KK,K		N,N(V)		Q		R,P		L,S		V,W,WB		X		
COMPREHENSIVE RESOURCE	CONIFEROUS FOREST		HARDWOOD FOREST		MOUNTAIN CHAPARRAL		XERIC GRASSLAND		CULTIVATED CROPS		MESIC RANGELAND		SAGEBRUSH SCRUB		EXPOSED SOIL		STANDING WATER		TOTALS
NO. TEST CELLS	71		4		31		17		4		23		44		10		6		210
INTERPRETER ID	A[a]	B[b]	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
NO. CORRECT	57	60	0	0	23	19	0	4	4	3	22	17	36	32	7	4	6	6	155	145
NO. COMMISSION	6	15	1	0	9	5	0	3	0	0	4	4	7	8	5	3	0	0	32	38
NO. INDICATED	63	75	1	0	32	24	0	7	4	3	26	21	43	40	12	7	6	6	187	183
NO. OMITTED	14	11	4	4	8	12	17	13	0	1	1	6	8	12	3	6	0	0	55	65
PERCENT OMITTED	19	15	100	100	25	38	100	76	0	25	4	26	18	27	40	60	0	0	26	30
PERCENT COMMITTED[c]	8	21	25	0	29	16	0	17	0	0	17	23	15	18	50	30	0	0	15	18
PERCENT COMMITTED[d]	9	20	100	0	28	20	0	42	0	0	15	19	16	20	41	42	0	0	17	20
PERCENT CORRECT	80	84	0	0	74	61	0	23	100	75	95	73	81	72	70	40	100	100	73	69

[a]Results for interpreter A

[b]Results for interpreter B

[c]Error based on number of type present

[d]Error based on number of a type indicated

Figure 3. Results of a quantitative image interpretation test of broad vegetation/terrain type identification using ERTS-1 imagery.

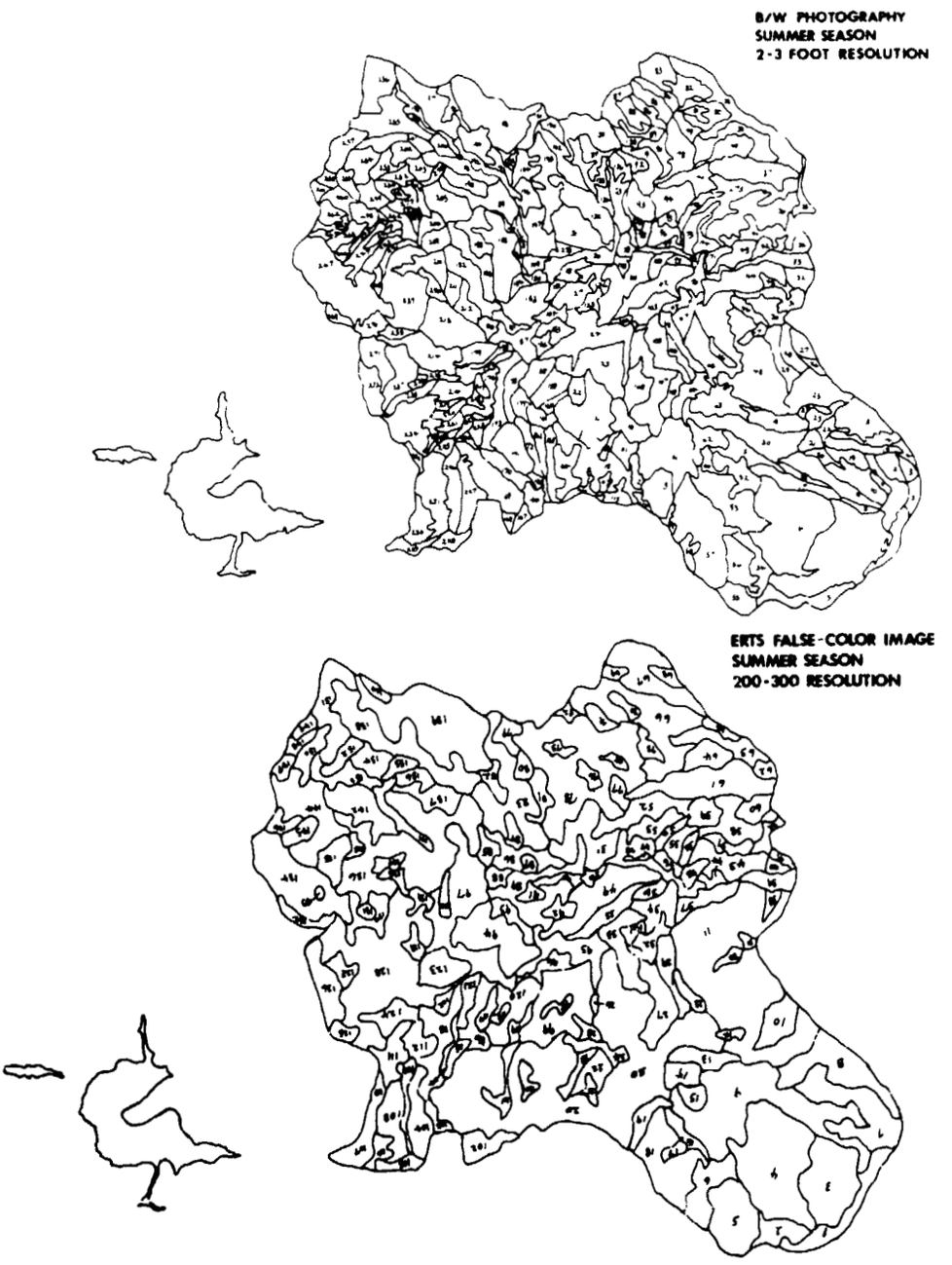

Figure 4. Forestland stratification boundaries made from 78 conventional black-and-white photographs, original scale 1:15,840, at the top and a small portion of an ERTS-1 image, original scale 1:1,000,000 at the bottom.

Task	B/W Photography	High Flight CIR Photo	ERTS False-Color Image
Delineation of watershed boundary	6 hours	1 hour	5 hour
Plotting effective areas on photos	5 hours	0 hours	0 hours
Interpreter training and testing	3 hours	3 hours	5 hour
Type delineation and classification	30.5 hours	17 hours	1.25 hours
Total time required	44.5 hours	21 hours	2.25 hours
Hourly wage	$7.00/hour	$7.00/hour	$7.00/hour
Total interpretation costs (time)	$311.50	$147.00	$15.75
Total cost per acre	.622¢	.294¢	.032¢
Cost ratio	19.8	9.3	1

Figure 5. Time and costs associated with mapping vegetation/terrain resources within the 50,000 acre Bucks Lake study area using conventional black-and-white photographs, high flight photographs and an ERTS-1 image.

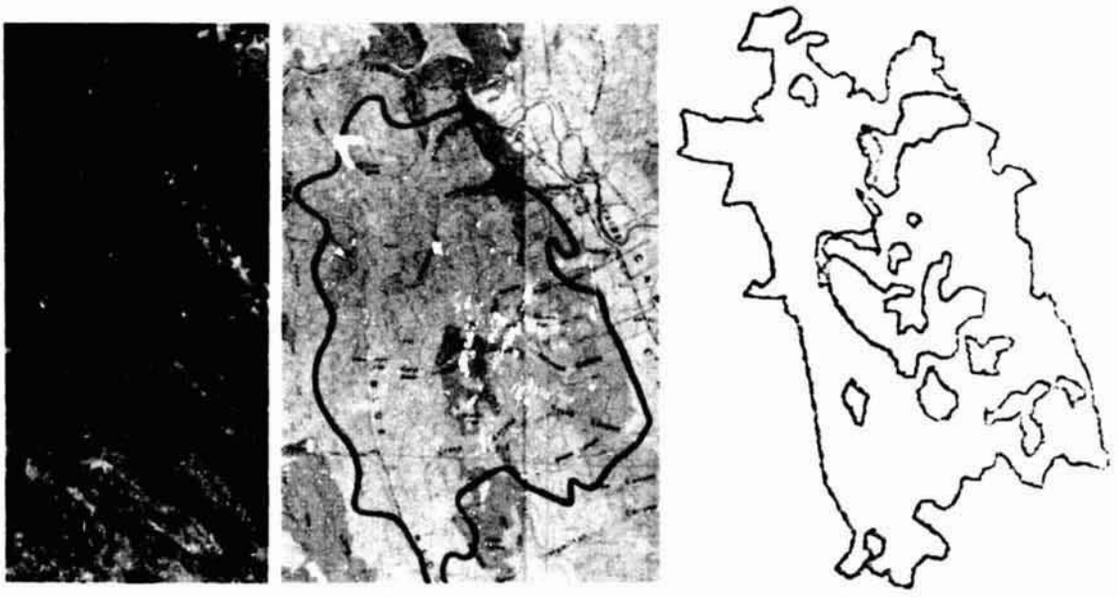

Figure 6. A portion of an ERTS-1 MSS band 7 image showing the Pocket Gulch burn is on the left. The California Division of Forestry map of the burn is in the middle (estimated acreage = 10,340). A map derived from the ERTS-1 image is on the right (estimated acreage = 13,340).