BI-MONTHLY PROGRESS REPORT

For the period beginning July 1, 1973 and ending August 31, 1973

A. Title: "An Interdisciplinary Analysis of Colorado Rocky Mountain Environments Using ADP Techniques"

ERTS Proposal Number: SR 030/040

B. Principal Investigator: Dr. Roger M. Hoffer

GSFC Identification Number: UN 103

C. There were no noteworthy problems encountered during this reporting period.

D. Emphasis during this reporting period has been placed on conducting field research. Personnel from both INSTAAR and LARS research staffs spent considerable time working on the Ecological and Geomorphological Inventories during July and August in the Indian Peaks and San Juan Mountains Test Sites. The importance of field research to the development of ADP mapping systems cannot be emphasized too strongly as specific examples will be described under the appropriate project sections of the experiment.

1. Ecological Inventory. Portions of July and August were spent working in the San Juan Test Site, primarily in the Lemon Reservoir and Ludwig Mountain quadrangles. (See Figure 1, attached.) INSTAAR has made extensive use of Mission 213 aerial coverage in field mapping of both forest and tundra cover types, but some problems may arise with the use of this imagery for vegetation mapping in the tundra. Due to the date (Fall 1972) of this imagery, elevation and moisture gradients appear to introduce sharper contrasts on the imagery than actually exist in the vegetative cover. Aerial coverage in August, 1973, should help to resolve this problem. The unusual shortened growing season plus high moisture conditions of summer 1973 has decidely affected the appearance of the tundra vegetation.

Work continued using the 20 cluster classification of the Ludwig Mountain quadrangle derived by LARS from test fields selected by INSTAAR. By changing the method of grouping 20 spectral classes into the four major types (non-forest, conifer, deciduous and shadow-water), the test field accuracy was increased from 67.0 percent to 90.9 percent. As explained in the procedures section of the Type II Report*, the test field accuracy does not necessarily indicate classification accuracy. The planimetered areas previously used (see Type II Report, July 1, 1973, pp. 17-26) were again used to evaluate the new cluster grouping. Some areas of coniferous forest were classified as non-forest and deciduous forest, resulting in differences as great as 16.4 percent between the classification and the U. S. Forest Service type map (Table 1).

TABLE 1.

Group	Percent area on USFS type map	Percent area on classification	Difference
Non-forest	38.9	42.2	+ 3.3
Conifer	54.6	38.2	- 16.4
Deciduous	6.4	17.7	+ 11.3
Shadow-water	0.0	2.0	+ 2.0

* "An Interdisciplinary Analysis of Colorado Rocky Mountain Environments Using ADP Techniques", prepared under NASA contract NAS5-21880, for the period January 1 - June 30, 1973.

A possible explanation is that the criteria used to choose test fields differed from that used to map vegetation. The vegetation was mapped by communities and the test fields were chosen by selecting areas represented by uniform symbol association on the computer printouts.

By changing the groupings of the 20 cluster classification so that the classification visually correlated with the U. S. Forest Service type map the test field performance dropped to 74 percent. With this grouping the percentage of area classified into each major type was within ± 1.6 percent of the corresponding area on the U. S. Forest Service type map (Table 2).

TABLE 2.

Group	Percent area on USFS type map	Percent area on classification	Difference
Non-forest	38.9	40.5	+ 1.6
Conifer	54.6	54.2	- 0.4
Deciduous	6.4	5.1	- 1.3
Shadow-water	0.0	0.2	+ 0.2

The essence of these results demonstrates the difficulty that exists in evaluating the accuracy of the classification results of natural cover type situations. At this point it was not known whether the U. S. Forest Service type map or INSTAAR'S test fields more accurately represented ground conditions.

The intensive field work conducted jointly by LARS and INSTAAR personnel during the early portion of August included the examination of a number of differences existing between the detailed cover type maps made by INSTAAR and the existing Forest Service type maps. In comparing the cover type maps to the results obtained thus far from the ERTS data, it appeared that some changes in the analysis approach were necessary.

The classification categories of the various cover types were incorporated into a scheme shown in Table 3 which specifies progressive levels of detail. Table 3 resulted from the examination of the interrelationships among the major factors which caused differences in spectral response in the ERTS data. Results thus far have indicated in addition to cover type per se, spectral response in the ERTS data is strongly related to vegetative density as well as slope and aspect. Consequently, Level 1 in Table 3 indicates the major vegetative categories, i.e. coniferous, deciduous, agricultural, and non-agricultural. Level 2 defines the vegetation types or vegetative communities, while Level 3 is a further breakdown by crown closure densities of the major vegetative units.

TABLE 3

MAP CATEGORIES & COVER TYPE BREAKDOWN

9/14/73

General		Level 1		Level 2		Level 3
FOREST	C	Conifer(Con)	.1	Pinon- Juniper(PJ)	.01	0- 30%
			.2	Ponderosa Pine(P.Pine)	.02	30- 70%
			.3	Doug Fir - Wt. Fir(DWF)	.03	70- 100%
			.4	Spruce - Fir(SF)		
			.5	Krummholz(Krum)		
			.6	Col. Blue Spruce(CBS)		as above
	M	Deciduous- Coniferous(De-Con)	.1	DWF, P. Pine,(other con?)& Aspen(Mix)		as above
	D	Deciduous(Decid)	.1	Cottonwood- Willow(Cot-Wil)		
			.2	Alpine Shrub(AS)		
			.3	Oak- Shrub(OS)		
			.4	Oak(O)		
			.5	Aspen(A)		
HERBACEOUS	A	Agricultural(Agrl)	.1	Cultivated Crops(Cul. Crop)		
			.2	Cultivated Pasture(Cul. Past)		
			.3	Pasture(Past)		
	N	Non- Agricultural(Non-Ag)	.1	Meadow(M)		
			.2	Tundra(T)	.01	0-30%
					.02	30- 70%
					.03	70- 100%
			.3	Wet Meadow(Wet Mead)		
NON- VEGETATED	B	Rock - Soil(Bare)	.1	Exposed Rock(B. Rock)		
			.2	Exposed Soil(B. Soil)		Wet
						Dry
		Shadow		Ridge Shadow(Shadow R)		
				Cloud Shadow(Shadow C)		
	W	Water		Clear		
				Turbid		
		Snow		Snow only		
				Snow - Forest Mix(Snow - For)		
		Cloud				
	U	Urban				

Examination of the gray scale printouts of the ERTS imagery indicated that 10 spectral groups is too many to use for defining areas of uniform spectral responses. Possibly, six or perhaps eight designated groups should be used for this purpose. This will be checked during the next reporting period.

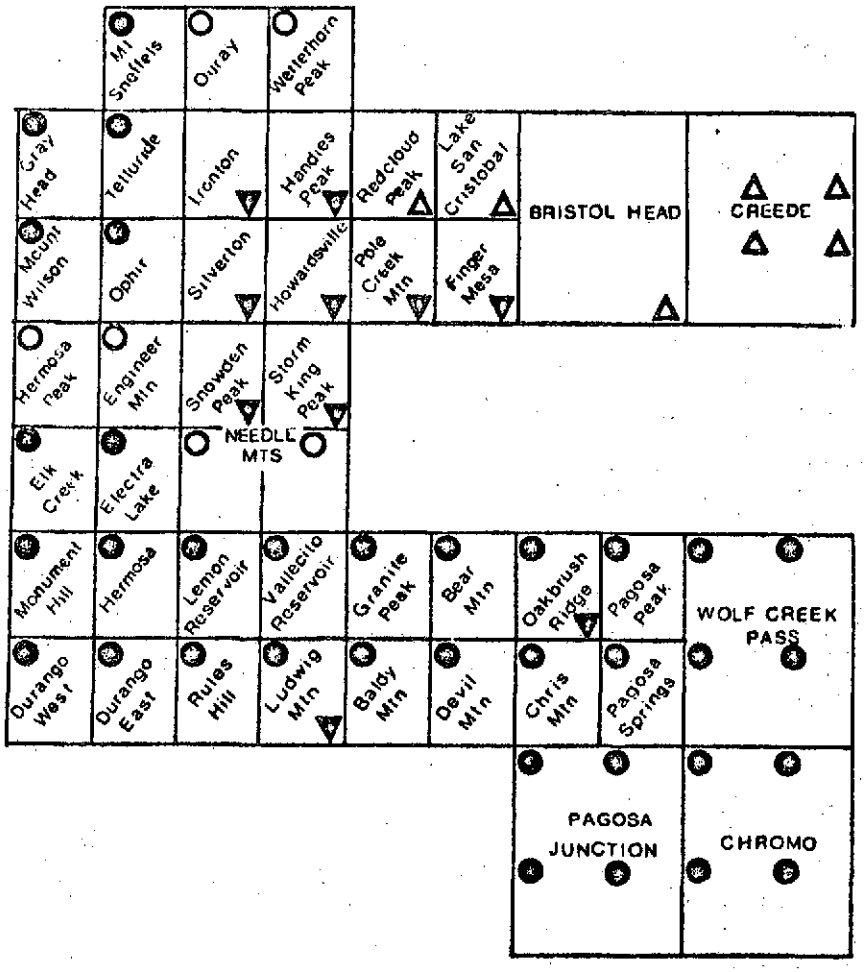
A concentrated effort to determine the accuracy of cover type mapping will utilize a large number (approximately 200) of test areas in the four quadrangle test area of Ludwig Mountain, Rules Hill, Lemon Reservoir, and Vallecito Reservoir (see Figure). This area is large enough (14 x 20 miles) to have a variety of slopes, aspects, and crown densities for each vegetation type, and yet small enough to be represented on a 3' x 4' computer prinout of the ERTS data at a scale of 1:24,000. The test area will be selected from the aerial photography of the area with comparison with USGS quadrangle maps and the U.S. Forest Service and INSTAAR type maps. The test areas are determined as areas within a uniform vegetation type (based on type map data), with a uniform density (aerial photographs), and with uniform slope and aspect (obtained from the USGS quadrangle maps). Each of the test areas is then ground checked to verify this information.

A total of 183 test areas, ranging from 20 to 120 acres, in the four quadrangle area were defined by the criteria established and all but a few were ground checked.

After returning to LARS, the first project was delineating the coordinates of test fields from the areas examined on the ground. Coordinates for the test fields were obtained by laying a geometrically corrected gray scale printout of ERTS over the quad centered photography on a light table. Field boundaries were drawn on the printout within ground checked areas. An effort was made to reduce the number of variables involved by keeping all test fields similar in size (20 acres). A total of 250 such test fields were delineated. A computer card was made for each field and listed the coordinates, vegetation type, slope and direction. The crown density has yet to be determined for each field.

Work now being planned includes estimating crown closure for each field. The new fields will be used to evaluate the classification on the major vegetation type level, Level 1.

2. Hydrological Features Survey. The Snow Monitoring Study, as reported on July, 1973 (Type II Six Month Progress Report), included a two cluster classification for the Animas watershed for four dates. This same procedure has been completed for scene ID 1317-17204, 5 June 1973.



U.S.G.S. quadrangle maps included within the boundries of the San Juan Mountain Test Site. Outline defines the area designated for entensive field mapping and ADP analysis.

A comprehensive table indicating the percent and acreage of snow cover is shown below:

Date	Percent Snow Cover	Acres	Variation
1 Nov, 1972	76.1	27636	
19 Nov, 1972	68.3	24791	10.2% Decrease
12 Jan, 1973	62.6	22731	8.3% Decrease
30 Jan, 1973	65.1	24757	8.9% Increase
5 June, 1973	84.6	29913	20.8% Increase

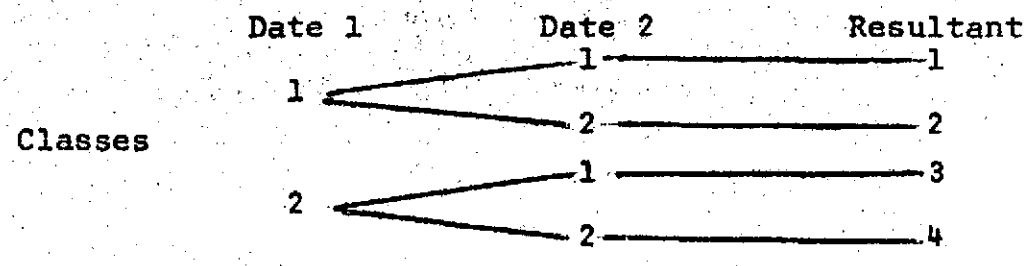
Data tapes for several intervening dates for the period between January and June have been ordered from Goddard and will be analyzed and inserted in the above table when they are received.

The spectral differention of snow and clouds has been studied using bulk CCT data from scene ID 1299-17205. As with other data sets for the San Juan Mountain site, this differention does not seem possible.

Scene ID 1299-17205 - 18 May 1973

Channel	4	5	6	7	4	5	6	7
Test Area								
Snow 1	125.25	125.40	118.27	48.56	6.35	6.28	11.69	9.04
Snow 2	126.66	126.87	122.80	58.96	2.94	1.42	6.62	5.09
Snow 3	124.28	125.32	119.03	54.36	8.99	7.46	10.54	8.98
Snow 4	124.85	125.38	119.24	53.00	8.76	6.71	10.40	9.35
Cloud 1	124.58	125.43	119.78	58.83	6.53	4.76	8.68	6.24
Cloud 2	124.49	123.85	118.91	58.85	7.38	10.62	11.08	9.53
Cloud 3	126.94	127.00	125.45	62.30	0.50	0.00	1.73	1.59
Cloud 4	123.37	124.81	119.70	59.48	9.54	6.40	9.66	6.23

A computer program for defining areas of snow redistribution is nearing completion. The program will have the capability of comparing two classifications from two dates with two classes each for the same geographic area. The resultant classification will have four classes: 1) Snow on both dates; 2) Snow on Date 1, non-snow on Date 2; 3) Non-snow on Date 1, snow on Date 2 and 4) Non-snow on both dates. A flow diagram defining the concept is presented below:



Output will be presented geographically in map format, where symbols will be used to identify the four classes.

The objective of this project is to provide the researcher with snow distribution patterns within watersheds and thereby assist him in predicting runoff by analyzing areal fluctuations.

Primary work by INSTAAR on the Hydrologic Features Project has involved monitoring the reduction in snow cover in the front range along a north-south transect from Estes Park to Rollingville, Colorado. A temporal overlay of data in this area will be developed to correlate with these field observations.

Future plans call for studying clear cut areas in the San Juan Mountains and attempting to determine the relationship between clear cutting and perturbations in the hydrograph in addition to the continuation of current projects reported above.

3. Geomorphological Features Survey. Primary emphasis during the past reporting period has been the collection and subsequent reduction of field data stressing its application to ADP mapping problems in the test site area. Accomplishments during this period are reported below.

The following field areas were visited:

1. Telluride Area, Colorado

   Ice Lake Basin
   This is our primary target area in the San Juan Mountains for studying spectral response and variations in rock lithologies, talus and mass wasting surfaces, and cover types.

   Wilson Mesa
   This area provides training for determining the number and range of spectral classes developed on a single geologic material, and for field comparison of relationships of material types and cover to class distributions shown on classified imagery.

2. Durango-Florida Mesa, Colorado

   This area was the subject of the paper presented at the ERTS-1 Goddard Symposium in March, 1973. Ground truth objectives were to obtain information on materials and cover types not definitely identified by reference to the geologic literature or by the machine classification previously generated.

3. San Luis Valley

   Satisfactory ERTS imagery over the San Luis Valley on 29 April 1973, plus the availability of WB-57

color photography (M x 211) of the area taken September 1972, suggested the value of using our physical presence in the area to obtain ground truth on crops and general land use during the growing season. This provides a backup capability for future machine analysis of the area.

4. Grand Valley

Ute-Uncompahgre area
This area is of great interest (refer Type II Report) geomorphologically, is the subject of a forthcoming paper, and a general outline of the broad problem investigated is contained in the July 1973 Type II Report to NASA on the ERTS-INSTAAR project.

Fruita-Orchard Mesa
This area is also subject of a forthcoming paper (refer Type II Report), in which machine processing techniques are emphasized. Attention focused on crop species identification, soils, and crop distribution in the Fruita area and on Orchard Mesa east and south of Grand Junction.

General Conclusions

If geologic materials are covered with an abundance of vegetation, the accuracy of any machine-generated map is contingent upon the degree of correlation between vegetal class and geologic material. In many instances, this correlation is high, but not in ALL instances. Parenthetically, most earth scientists with considerable field experience are dimly aware that biotic changes probably are related to slope, exposure, lithology, and available moisture; but they are poorly acquainted with either plant identification of species, or slope and exposure, aspect, soil, and water requirements of various assemblages. The result, therefore, is poor utilization of these criteria by earth scientists, whereas proper attention could assist in preparation of more accurate maps. The spectral response interpretation required in machine mapping will, if nothing else, promote proper appreciation and use of vegetative cover by geologists in producing better map products.

Objectives of Future Analysis

Based on the recent field experience, and with adequate ground-based photography and base map notations in hand, a more comprehensive and more accurate classification system of our test areas based on vegetative, topographic, and geologic criteria can be devised and implemented. Ground photos will be particularly useful, as detailed location of vegetative variations developed on each geologic material is possible by appropriate use of these photos. For example, we can now devise a more accurate machine-generated map of the Ice Lake Basin-Wilson Mesa test sites by combining classes that truly reflect the cover types of these areas, and the modification of spectral response by talus, rock blocks, or unvegetated outcrop.

4. Interpretation Techniques Development. Activities for this reporting period include continued development of the terrain impact model, field reconnaissance of the Cannibal Plateau area, and consultation and coordination of efforts with colleagues from INSTAAR. All efforts have focused on continued development of the model to assess spectral variability as a function of terrain irregularity which was described in the preceding progress report (Type II Report for July 1, 1973). Procedures initially involving data from the Finger Mesa area have been transferred to the USGS Cannibal Plateau 7 1/2' quadrangle and data acquisition has been partially completed. Selection of the Cannibal Plateau quadrangle was influenced by availability of cloud free MSS data, relatively large areas of homogeneous cover types and lithologic units verified by field reconnaissance, and suitable topographic variation. Analysis of this area will be completed during the next reporting period.

Consultation with colleagues from INSTAAR focused on coordinating topographic data transmittal to implement and complete SHADE program analysis for the Green Lakes Basin in the Front Range. Data involved consists of Department of Defense (DOD) digital terrain tapes which were requested and described in the previous progress report. This data was received near the end of this reporting period and is presently being duplicated and reformatted in preparation for transmittal to INSTAAR and analysis use by LARS personnel.

Additional accomplishments include necessary program modification to facilitate graphic display of impact model results.

Work during the next reporting period will be directed towards completion of analysis of the Cannibal Plateau area and implementation of this procedure in other areas within the test site for which classification results have been obtained. The applicability of DOD digital terrain data will also be investigated during this period. Particular questions regarding this data are concerned with the degree of topographic detail included within the data and the density of the data with respect to detailed area analysis.

5. Data Collection Platform. The DCP on Niwot Ridge continues operational on all 8 channels, although instrumentation problems have occurred with the precipitation sensor. For 1 May to 31 July 1973, 474 messages have been received between 0800 and 1230 MST and 458 between 1830 and 2300 MST on at least one channel. Initial data reduction (means and standard deviations) for 90 minute time periods, related to the message frequency, is in progress. A specimen tabulation for May 1973 is shown in Tables 1 and 2. This will provide a measure of the value for meteorological and hydrological studies of the irregular message transmissions. The major problem remains the need for storage of maximum and minimum values of most meteorological parameters between messages.

E. There are no significant results to report for the past period.

F. There were no published articles, in-house reports, abstracts or other materials presented during the past period.

G. There are no recommendations to be made at this time.

H. Appropriate data request forms are attached as Appendix I of this report.

I. Appropriate Image Descriptor Forms are attached as Appendix II of this report.

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TM _____
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APPENDIX I

ERTS DATA REQUEST FORM
560-213 (7/72)

1. DATE August 3, 1973

2. USER ID UN 103

4. SHIP TO:

ADDRESS R. M. Hoffer ☐ NEW

LARS / Purdue University

1220 Potter Drive

West Lafayette, IN 47906

5. TELEPHONE NO. (317) 749-2052 ☐ NEW

6. CATALOGUES DESIRED

STANDARD ☐ U.S. ☐ NON-U.S.

DCS ☐

MICROFILM ☐ U.S. ☐ NON-U.S.

ADDDHHMMS OBSERVATION IDENTIFIER	C CENTER POINT COORDINATES	B SENSOR BAND	P PRODUCT TYPE	F PRODUCT FORMAT	T TICK MARKS	NN NUMBER OF COPIES	A AREA
1066-17254	37 - 28 N 108 - 47 W	7	B	T		1	U
1066-17254	37 - 28 N 108 - 47 W	7	B	P		1	U

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ERTS DATA REQUEST FORM
560-213 (7/72)

1. DATE August 21, 1973

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1209-17210	37-29N 107-31W	M	D	9		1	U
1245-17211	37-30N 107-38W	M	D	9		1	U
1263-17211	37-32N 107-42W	M	D	9		1	U
1280-17152	37-38N 106-14W	M	D	9		1	U

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321-15595	39-03 N 087-05 W	M		M		1	U

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A DDDHHMMSS OBSERVATION IDENTIFIER	C CENTER POINT COORDINATES	B SENSOR BAND	P PRODUCT TYPE	F PRODUCT FORMAT	T TICK MARKS	NN NUMBER OF COPIES	A AREA
1209-17210	37-29N 107-31W	M	D	9		1	U
1245-17211	37-30N 107-38W	M	D	9		1	U
1263-17211	37-32N 107-42W	M	D	9		1	U
1280-17152	37-38N 106-14W	M	D	9		1	U

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AODDHHMMS OBSERVATION IDENTIFIER	C CENTER POINT COORDINATES	B SENSOR BAND	P PRODUCT TYPE	F PRODUCT FORMAT	T TICK MARKS	NN NUMBER OF COPIES	A AREA
.321-15595	39-03 N 087-05 W	M		P		1	U
.321-15595	39-03 N 087-05 W	7	B	P		1	U

APPENDIX II

ERTS IMAGE DESCRIPTOR FORM

(See Instructions on Back)

NSPP USE ONLY
D
N
ID

DATE September 19, 1973

PRINCIPAL INVESTIGATOR Dr. Roger M. Hoffer

GSFC UN103

ORGANIZATION LARS/Purdue University

PRODUCT ID (INCLUDE BAND AND PRODUCT)	FREQUENTLY USED DESCRIPTORS* Hydro-logy	Geomor-phology	Forestry	DESCRIPTORS
1299-17205 M,D	X			Snow, Clouds, Mountains.
1317-17204 M,D	X			Snow, Mountains, Lakes.
1066-17251 M,D 1066-17254 M,D		X		Anticlinal valley, Lacolith, River, Mountains, Escarpment, Subsequent valley, Mesa, Meander, Graben, Intrusion.
1047-17200			X	Forest, Conifer, Deciduous, Tundra, Meadow, Grassland, Timberline

*FOR DESCRIPTORS WHICH WILL OCCUR FREQUENTLY, WRITE THE DESCRIPTOR TERMS IN THESE COLUMN HEADING SPACES NOW AND USE A CHECK (✓) MARK IN THE APPROPRIATE PRODUCT ID LINES. (FOR OTHER DESCRIPTORS, WRITE THE TERM UNDER THE DESCRIPTORS COLUMN).

MAIL TO ERTS USER SERVICES
CODE 563
BLDG 23 ROOM E413
NASA GSFC
GREENBELT, MD. 20771
301-982-6488

GSFC 37-2 (7/72)