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B. PRINCIPAL INVESTIGATORS: R.J.P. Lyon: F.R. Honey
School of Earth Sciences
Stanford University
Stanford, California 94305

Phone: (415) 321-2300 ext 4147/2747

C. PROPOSAL # 637: GSFC #UN 142: Contract # NAS 5-21884

D. TECHNICAL MONITOR: E.W. Crump
Code 430
Goddard Space Flight Center
Greenbelt, Maryland 20771

Phone: (301) 982-2857

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Remote Sensing Laboratory
Stanford University
Stanford, California 94305

I. SIGNIFICANT RESULTS

See following pages of Stanford RSL Technical Reports Nos. 74-1 and 74-2 and Stanford RSL Technical Progress Report No. 74-3 (P).

J. DATA REQUEST FORMS SUBMITTED

Following Technical reports.

K. ACCESSION LIST FOR ERTS IMAGERY/TAPES OVER STANFORD

Following Technical Reports.

L. MAILING LIST

At end of report.

STANFORD REMOTE SENSING LABORATORY
TECHNICAL REPORT NO. 74-1

RIPPER: AN INTERACTIVE PROGRAM FOR REDUCTION AND CLASSIFICATION OF ERTS MSS DATA.

BY DR. F.R. HONEY

Since data being generated by ERTS sensors yields a low resolution spectrum of individual pixels, a study was made of their spectral patterns to develop a non-statistical, clustering program, using a simple pattern-recognition procedure for use on our PDP-10 computer.

In order to examine ERTS data in all four bands simultaneously, plots of channel output against channel number were drawn for each pixel. Using this technique it became obvious that for any particular date only a limited number of these low resolution spectral patterns were present in any reasonably sized area. However, although similar overall shapes occur, their absolute levels vary substantially (Figure 1a). This variation in level would provide a problem for an automatic recognition scheme. The variation (within a tape) arises from:

(a) Differing reflectances,
(b) Specular reflectance,
(c) Topographic effects (sunlit slopes)

Since the differing reflectances are the desired final product, other contributions must be removed. Specular reflectances can not be treated simply, if it occurs, so that an assumption is made that the main contribution arises from the topographic effect. Assuming the target is a diffuse reflector, converting the voltages to reflectances, by using standard targets within (or near) a scene location, and followed by normalization of the reflectances to one of the bands, greatly diminishes the topographic effect, and removes atmospheric contributions at the same time.

Figure 1b shows these normalized reflectances for the same samples as Figure 1a. The bi-directional reflectances thus calculated by comparison with the standard targets may be directly compared with ground measured data, taken using a similar geometry to the ERTS measurements. Two or more standard targets should be chosen, preferably 3 X 3 pixels, in area. The low reflectance target ($<5\%$ if possible) should require minimum extrapolation to zero reflectance target radiances, whilst the high reflectance target should not saturate the ERTS system (levels ≥ 127 for channels 4,5,6; ≥ 63 for channel 7) for a particular tape.

Another problem arises with the noise due to the misregistration of the image onto the sensors every sixth scan line. From an examination of results over water, it has been found that channels 4,5, and 7 exhibit this noise in phase, whereas channel 6 is displaced by two scan lines. Any ratioing or normalization therefore increases the frequency of noise. A polynominal smoothing function has been applied to the data and reduces the level of this noise, although it also "blurs" the image slightly. This smoothing procedure is optional in the program.

At this stage, data is in a form suitable for classification. The clustering procedure can operate in two modes:

1) Unsupervised:

In this mode, a pattern is generated from the first pixel element in the geometric matrix, or map, & a symbol assigned to it, then the remainder of the pixels are scanned, being given the same classification if they fit within a certain tolerance of the current "standard" pattern. This tolerance is set (interactively) by the user. The program continues to cycle until all pixels are classified into groups. The clustered scene is then displayed, and the user has the option of re-classifying with different tolerance.

2) Supervised:

In this mode, ground measured bi-directional reflectances are input to the program. The tolerance is set at 2–3 standard deviations of the ground measured data, and the scene searched for pixels falling into the predetermined patterns.

The program output can be determined by the user. Options are:

1) Raw shadeprints, as geometric matricies (maps)
2) Raw numerics,
3) Raw cluster results,
4) Reflectance shadeprints,
5) Reflectance numerics,
6) Reflectance cluster results.

The shadeprint increments may be varied to yield the most suitable grey scale, or with the lowest value being subtracted to increase the effect. All steps are displayed on the sceeen.

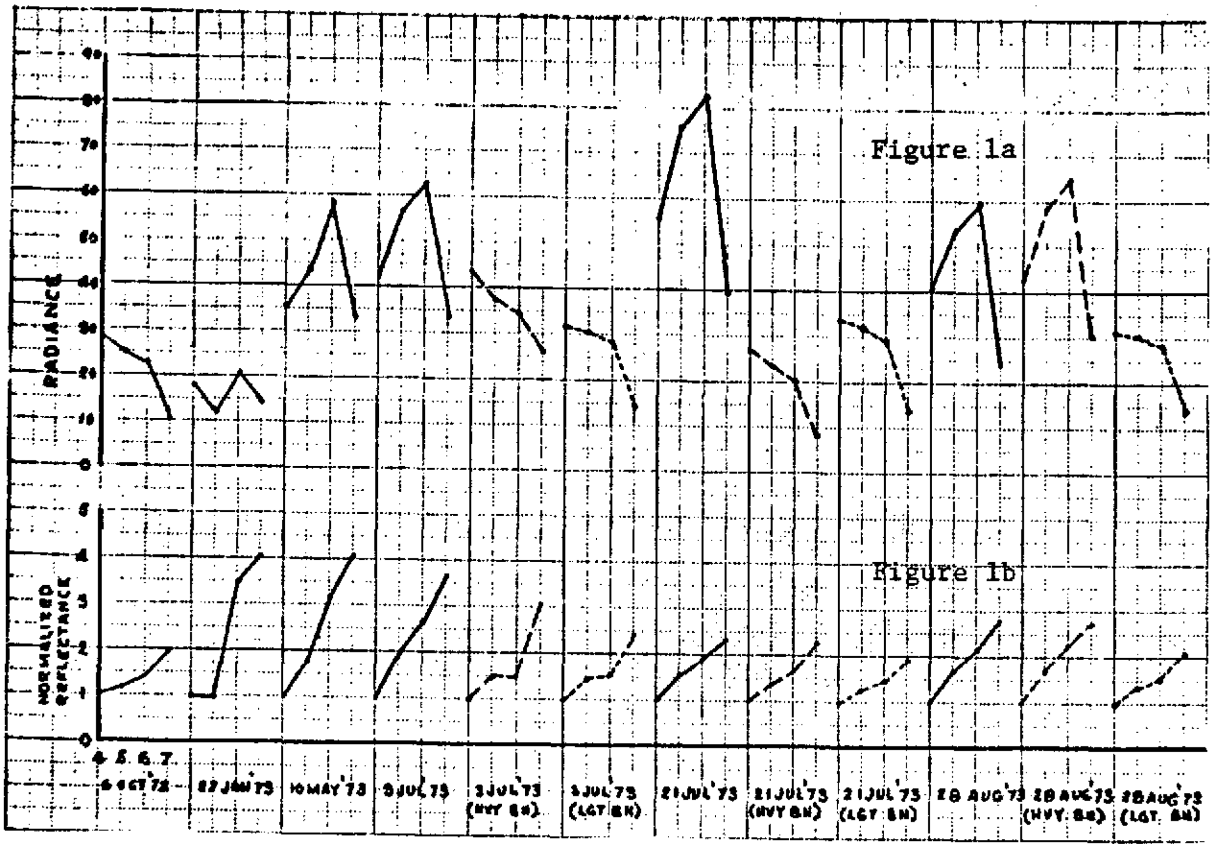
Figure 2 shows the results of a cluster analysis of an island in Mono Lake, California. This island has a dark basalt flow (stippled), which is not readily distinguishable from the surrounding lake when individual bands are examined. The clustering procedures (on raw data) separated this feature. (Note-the data was not smoothed-noise is obvious in the water surrounding the island). For the scene, the clustering procedure required approximately 30 seconds.

A non-statistical approach was utilized in an attempt to reduce computation times. Comparative runs using the BMDO7M FØRTRAN program on our IBM360/67 require approximately ten times the computing time.

The program has been developed as an entirely interactive system, so that a person with minimal computing experience can use the console and carry out an extensive search, classification and analysis. Different scenes may be examined, and if required, classified with the same set of patterns as earlier scenes.

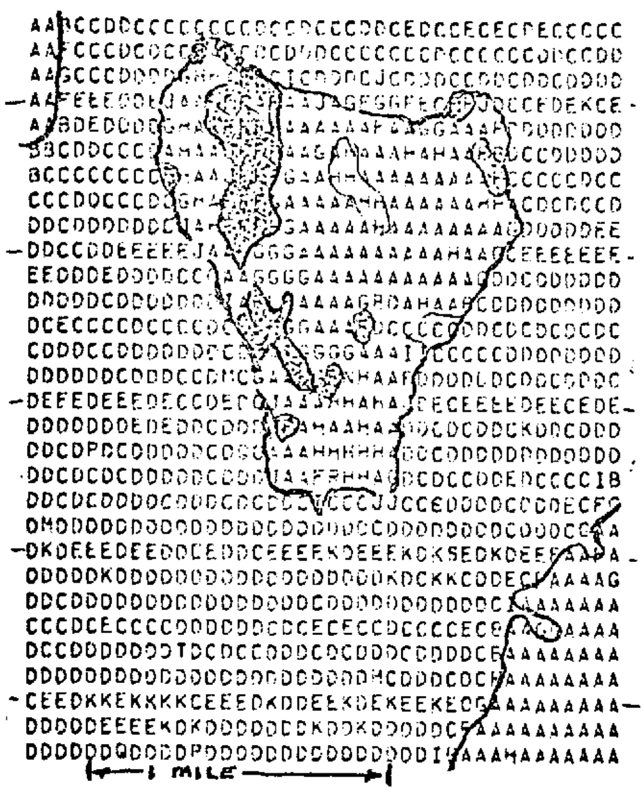
The program is at present being extended to output statistical information for all the clusters, and for any small areas, within a scene.

A plotting routine is also being written to output contour maps of either shade prints or cluster results, taking account of the 3.75° scan in the image (due to Earth rotation), and scaling the map co-ordinates so that it may be directly compared with standard maps.



Figures 1a and 1b.

Figure 2.



STANFORD REMOTE SENSING LABORATORY
TECHNICAL REPORT NO. 74-2

EVALUATION OF NUMERICAL CLASSIFICATION TECHNIQUES

BY DR. A.E. PRELAT

An evaluation of the main numerical classification techniques was made in order to determine which ones would be most effective and economical in classifying spectral data. Four of these techniques, two of which are supervised and two of which are unsupervised, will be briefly discussed in this report.

I. SUPERVISED CLASSIFICATIONS:

A classification is supervised when the unknown sample points are assigned into *a priori* defined classes.

A. NEAREST NEIGHBOR: (Computer Program in FØRTRAN IV)

Most of the methods depend upon the assumption that samples have been drawn from a normal population. This method makes inferences without any assumptions as to the form of distribution in the population (non-parametric test). The technique consists of classifying unknown data into known categories through comparison with known data. Each sample is allocated to that group to which it is nearest in terms of ordinary Euclidean distances. Each group is represented by its center of gravity, that is the mean vector computed for that group.

The nature of non-parametric statistical inferences usually requires testing with large amounts of data to achieve a respectable degree of accuracy.

B. MULTIVARIATE DISCRIMINANT ANALYSIS: (Computer Program BMD07M in FØRTRAN IV).

Multivariate discriminant analysis is a statistical method of assigning samples to previously defined populations on the basis of the number of variables considered simultaneously. Discriminant analysis takes the original p variables ($X_1, X_2, \ldots X_p$) and produces K-1 pseudovariables, called canonical variables (K=number of groups). The basic assumptions about the data are:

(i) The observations in each group are randomly chosen;
(ii) The probability of an unknown observation belonging to either group is equal;
(iii) Variables are normally distributed within each group.

The BMD07M is a stepwise discriminant analysis program, and is part of a series of bio-medical statistical analysis programs compiled by the UCLA Health Services Computing Facility. The program calculates the coefficients of the canonical variables and chooses the signs (+ or -) for the linear function that will best offset the difference among groups.

II. UNSUPERVISED CLASSIFICATIONS:

A classification is unsupervised when similar sample points are assigned into an unknown number of distinct categories with the sample points in each category being more similar to each other than to the sample points in all other categories.

A. CLUSTER ANALYSIS BASED ON DISTANCE FUNCTION MATRIX:

(Computer Program in FØRTRAN IV)

A distance function matrix is obtained to determine the relationship of the data. The sample points are grouped or clustered in a hierarchical dendritic network (dendogram) so that their interrelationship, as contained in the distance function matrix, are shown with greatest simplicity.

In the simple situation of two dimensions, two samples are plotted according to the values of the two variables, X and Y. The distance between these two points is, by simple geometry, the square root of the sum of the squared differences between the X and Y values of the two points; as in a right triangle the square of the hypotenuses is equal to the sum of the squares of the two sides of the triangle.

This calculation of the simple distance function assumes that the input variables (or the axis from which they are measured) are uncorrelated, that is, orthogonal or at right angles to each other. However, most raw variables are correlated to different degrees so that the coordinate axis would not be at right angles and the simple Euclidean distance formula would be inaccurate. To overcome this difficulty, the original variables are transformed to orthogonal uncorrelated) variables by the R-mode principal component analysis. The R-mode principal component analysis is somewhat equivalent to passing new axis through the data in such a fashion as to account for the largest portion of variance. The position of the points are measured from the new transformed axes, not from the original coordinates. A new origin is defined by normalizing the new factor measurements, so that all measurements are positive and range from zero to one. A distance function matrix is used for correlation purposes. Distances close to zero represent closest similarity. Distances close to one represent closest dissimilarity.

Finally, a Q-mode (sample-by-sample) cluster analysis is performed using distance function computed from factor measurements. A cluster diagram is printed out with the value of the distance function. Groups of similar samples can be selected at any desired level of similarity, and each group can be plotted on a map.

B. ISOMIX (PDP-10 Computer Program in ALGOL)

Similar programs have been developed by Stanford Research Institue (ISODATA), Purdue University (LARSYS) and Lockheed Electronic Company (ISOCLS). ISOMIX (Stanford) is still in progress with several new ideas being incorporated. The following is an outline of the main steps: The program starts computing the initial cluster centers and assigning them to regions of high density sample points. The samples are sorted one by one on the basis of the Euclidean distance from a set of initial cluster centers. Each sample goes into the subset having the closest cluster center. After the samples have been sorted the mean and standard deviation for each subset in each dimension (variable) is computed.

Small clusters containing fewer than NMIN sample points, NMIN being an input parameter, are discarded. Splitting of the clusters takes place if the standard deviation in any dimension is greater than STDMAX and has enough sample points in it, STDMAX being an input parameter. The two new cluster centers formed are $(\mu_1, \mu_2, \ldots\ldots \mu_k + S_k \ldots\ldots, \mu_n)$ and $(\mu_1, \mu_2, \ldots\ldots \mu_k - S_k, \ldots\ldots \mu_n)$, where $(\mu_1, \mu_2, \ldots\ldots \mu_n)$ and $S_1, S_2, \ldots\ldots S_n$ are the mean and standard deviation for the dimensions in the original cluster, and where the Kth dimension is that in which the original cluster has the largest standard deviation. If the distance between two groups is less than DMAX, DMAX being an input parameter, the two clusters are combined into one. The distance or measure of similarity between the two clusters C_1 and C_2 is defined as:

$$D(C_1,C_2) = \left[\sum_{i=1}^{n} \frac{\left(\mu_i^{(1)} - \mu_i^{(2)}\right)^2}{S_i^{(1)} S_i^{(2)}} \right]^{1/2} \quad . \qquad (1)$$

Where C_1 is characterized by $\mu^{(1)} = (\mu_1^{(1)}, \ldots\ldots \mu_n^{(1)})$ and standard deviation $S^{(1)} = (S_1^{(1)}, \ldots\ldots S_n^{(1)})$ and C_2 by $\mu^{(2)}$ and $S^{(2)}$.

Finally those subclusters that are close to at least one other subcluster in the group are linked together. This permits to determine subpopulations, the union of which constitutes the parent population. In the last step the overall area proportions of various clusters is obtained, and a confidence interval for each proportion is estimated. The pattern complexity which gives the spatial scale of variation is also calculated. (A pattern that has a cluster A with its samples in a contiguous body is less complex than other with the same proportion of cluster A distributed in many scattered smaller units). The output gives the statistics for each cluster and includes maps showing the final cluster assignments of all points in the area analyzed. Maps are geographic matricies preserving the original spatial position of the data points.

STANFORD REMOTE SENSING LABORATORY
TECHNICAL PROGRESS REPORT NO.74-3(P)

STUDY OF SERPENTINE OUTCROP AREAS ALONG INTERSTATE HIGHWAY I-280, STANFORD SITE, CALIFORNIA

BY SAUL LEVINE

ABSTRACT

Continued study of the serpentine exposures of the San Francisco Peninsula and correlation of results with a study of two devegetated (grass fire) areas; one within Area I, Figure 1 and the other one located on the east side of the Coastal Range (see Figure 2).

I. PROCEDURES AND RESULTS:

A ten-pixel area was selected within the serpentine area of Area I, Figure 1 and a systematic study made of the soil plus grass interaction through the wet/dry seasonal variation existent in the San Francisco Bay area. This was accomplished by means of four-band spectral plots of the mean ground radiance values of the selected areas (on which atmospheric corrections had been made) and then the values normalized to band 4.

Atmospheric correction factors were derived from ground reflectance measurements utilizing the Exotech Inc ERTS Radiometer and scaled down satellite geometry. These measurements were made at two locations in the Bay area; a large light concrete aircraft apron at Moffett Field Naval Air Station, Mountain View and a large by-product carbon dump at Phillips Petroleum Corporation near Concord. These factors were applied as follows:

$$\text{Target Ref.} = \frac{\text{Target Rad-Carbon Dump Ref.(meas)}}{\text{Conrete Rad-Carbon Dump Ref.(meas)}} \times \begin{matrix}\text{Concrete Ref} \\ \text{(meas)}\end{matrix}$$

Radiance plots as well as normalized reflectance are presented in Figure 3. In so far as possible taped data from identical areas within the following ERTS frames were utilized, covering a 11-month time frame.

ID 1075-18183	6 October 1972
ID 1165-18175	4 January 1973
ID 1183-18175	22 January 1973
ID 1291-18182	10 May 1973
ID 1345-18180	3 July 1973
ID 1363-18173	21 July 1973
ID 1399-18170	26 August 1973

Study of this data reveals the following:

a. The normalized reflectance of the soil plus grass is at a maximum, particularly channels 6 and 7 at the height of the rainy season (22 January); roughly twice as high as that during 6 October which is near the end of the dry season. It is estimated that the grass cover varies from approximately 15 to 70% during this period.

b. It can be seen that the normalized reflectance of the soil plus grass gradually diminishes with the end of the rainy season and the entry into the summer dry-out period.

c. Interpretability of the four-band spectra is greatly improved by the application of the atmospheric corrections and normalization of the data to band 4. (Although decreasing the values to very low levels of reflectance).

A fortuitous grass fire within Area I (extent 15 acres) occured 1 July 1973, and can easily be seen in the ERTS coverages subsequent to this date. In fact, the appearance of the dark area was observed prior to the investigation which proved it to be a grass fire. Normalized reflectance plots of the burn area were also made and are presented in Figure 3. The following are of interest:

a. The 3 July normalized reflectance spectra has dropped to a minimum value, possibly as a result of the carbonized-grass remains. High variability exists.

b. By 21 July the normalized reflectance spectra values have approximately doubled, probably as a result of the dispersal of the carbonized ash by the wind, and possibly also by exposure of a low, broad-leaf grass cover in the burn area. Low variability is present.

c. By 26 August the reflectance values have again dropped back to approaching that of 6 October. High variability is present in channel 7.

d. The 3 July, 26 August burn and the 6 October reflectances are identical in trend and close in absolute values.

It would appear that based on the above, a likelihood exists that the reflectance spectra of 6 October is that of serpentine soil with little or no grass reflectance being introduced. Ground measurements of bare serpentine soil were made on 4 February 1974 within Area I and are presented in Figure 4. It can be seen that these values compare with those of 6 October. Ground measurements of lush green grass were also made 4 February 1974 and a hypothetical reflectance spectra based on 50/50, soil plus grass cover is presented in the same figure.

A 10 pixel block within Area III, Figure 1 (6 October 1973, serpentine soil plus grass) was also selected and the reflectance spectra plotted in Figure 5. A close correlation is found with the ground measurements of 4 February and the reflectance spectra of 6 October.

Another soil plus grass seasonal study adjacent to (and within) a grass fire area located in the southeast quadrant of the Midway 7.5' topographic quadrangle was completed (see Figure 2) and the results presented in Figure 6. This area has been mapped geologically as marine sediments. It can be seen that the same trends exist in the data as follows:

a. The normalized reflectance is at a maximum at 4 January 1973, approximately twice that of 6 October.

b. The 6 October reflectance spectra and that of the burn areas are again comparable.

c. The normalized reflectance spectra values gradually diminish with the end of the rainy season and entry into the summer dry out period.

d. Burned over areas show highest variability (coefficient of variability) in the 21 July and 26 August data, again maximized in channels 6 and 7.

It is interesting to note that a comparison of the reflectance spectra for 6 October of both areas studied, indicate that while the same trends are apparent the spectral curve slopes are different and the application of band-ratioing techniques for discrimination may be possible. These differences are particularly pronounced between bands 6 and 7.

II. INTENDED ACTIVITY NEXT PERIOD:

It is intended to conclude this investigation during the next period by obtaining ground measurements for both Areas III, Figure 1 and the Midway area, then investigating the possible use of a computerized clustering program to discriminate the serpentine soils from the background. The details of this program, employing the DEC PDP-10, are covered in SRSL Technical Progress Report No. 74-1.

TABLE I

ID 1075-18183 — CRYSTAL SPRINGS — 6 October 1972

4	5	6	7
24	18	19	9
27	20	19	10
25	20	19	20
25	20	19	10
25	21	22	9
26	21	22	11
26	22	22	12
25	21	19	8
25	20	22	8
26	21	19	9

	4	5	6	7
Mean	25.4	20.3	20.2	9.6
Std. Dev.	0.84	1.06	1.55	1.26
Coef. of Var.	0.03	0.05	0.08	0.13
Reflectance	5.11	6.26	8.19	13.97
Normalized	1.00	1.23	1.58	2.73

ID 1183-18175 — CRYSTAL SPRINGS — 22 January 1973

4	5	6	7
16	9	17	9
17	12	17	9
17	12	17	9
17	12	18	10
17	13	17	9
17	12	17	8
18	13	20	10
16	12	17	10
17	10	18	10
16	10	13	7

	4	5	6	7
Mean	16.8	11.5	17.1	9.1
Std. Dev.	0.63	1.35	1.73	0.99
Coef. of Var.	0.04	0.12	0.10	0.11
Reflectance	3.01	4.43	13.65	20.80
Normalized	1.00	1.47	4.53	6.90

ID 1291-18182 — CRYSTAL SPRINGS — 10 May 1973

4	5	6	7
30	27	41	23
27	22	37	21
33	29	27	21
33	28	41	24
28	27	44	27
30	27	43	25
29	26	35	19
29	26	37	20
29	25	37	20
29	25	37	21

	4	5	6	7
Mean	29.7	26.2	37.9	21.1
Std. Dev.	1.95	1.93	4.86	2.56
Coef. of Var.	0.07	0.07	0.13	0.12
Reflectance	4.85	7.14	14.45	27.00
Normalized	1.00	1.47	2.98	5.57

ID 1345-18180 **CRYSTAL SPRINGS** 3 July 1973

4	5	6	7
37	40	44	22
38	42	42	22
36	34	41	21
40	43	47	25
37	38	45	22
38	40	47	22
36	34	43	23
38	36	47	24
37	35	44	24
38	35	42	21

	4	5	6	7
Mean	37.5	37.7	44.2	22.6
Std. Dev.	1.18	3.37	2.25	1.35
Coef. of Var.	0.03	0.09	0.05	0.06
Reflectance	8.63	11.19	20.86	25.60
Normalized	1.00	1.30	2.42	2.97

ID 1345-18180 **CRYSTAL SPRINGS** 3 July 1973
(Burn Area)

4	5	6	7
31	26	26	12
30	23	20	8
31	26	23	10
31	30	31	14
34	29	37	18
28	21	20	7
30	22	21	8
31	24	24	9
36	33	35	13
28	20	19	7

	4	5	6	7
Mean	31.0	25.4	25.6	10.6
Std. Dev.	2.45	4.22	6.54	3.6
Coef. of Var.	0.08	0.17	0.26	0.34
Reflectance	5.60	6.03	7.66	11.38
Normalized	1.00	1.08	1.37	2.03

ID 1363-18173 **CRYSTAL SPRINGS** 21 July 1973

4	5	6	7
34	27	42	22
31	26	42	24
34	27	38	22
30	26	41	23
34	33	47	24
38	35	42	22
33	31	35	19
36	34	41	21
32	33	40	21
32	30	42	23

	4	5	6	7
Mean	33.4	30.2	41.0	22.1
Std. Dev.	2.37	3.49	3.09	1.52
Coef. of Var.	0.07	0.12	0.08	0.07
Reflectance	6.47	8.06	15.97	25.01
Normalized	1.00	1.25	2.47	3.87

ID 1075-18173 FARM HILL RD(AreaIII) 6 October 1973

4	5	6	7
30	30	27	12
30	32	29	13
30	27	26	11
30	26	26	11
33	28	28	12
27	26	26	13
28	27	26	12
29	26	25	11
28	26	23	11
29	26	25	14

	4	5	6	7
Mean	29.4	27.4	26.10	12.0
Std. Dev.	1.65	2.07	1.66	1.05
Coef. of Var.	0.06	0.08	0.06	0.09
Reflectance	7.55	10.17	11.60	17.45
Normalized	1.00	1.35	1.54	2.31

ID 1075-18183 MIDWAY 6 October 1972

4	5	6	7
27	24	24	10
25	20	18	8
27	24	24	10
28	25	23	9
26	22	21	9
28	22	21	9
32	32	26	13
32	29	26	11
31	28	23	11
28	28	22	11

	4	5	6	7
Mean	28.4	25.4	23.3	10.1
Std. Dev.	2.46	3.75	2.75	1.45
Coef. of Var.	0.09	0.16	0.12	0.14
Reflectance	8.03	9.59	11.23	15.55
Normalized	1.00	1.19	1.40	1.94

ID 1165-18175 MIDWAY 4 January 1973

4	5	6	7
18	14	29	16
18	14	29	17
18	14	26	14
18	14	31	18
18	13	30	17
18	14	28	15
18	14	32	18
18	14	30	16
18	14	23	12
19	14	28	17

	4	5	6	7
Mean	18.9	13.9	28.6	16.00
Std. Dev.	0.32	0.32	2.59	1.89
Coef. of Var.	0.02	0.02	0.09	0.12
Reflectance	4.43	5.90	29.50	36.50
Normalized	1.00	1.33	6.67	8.21

ID 1363-18173

CRYSTAL SPRINGS (Burn Area) 21 July 1973

4	5	6	7
39	37	45	22
36	32	42	22
30	26	40	23
32	33	42	23
34	33	42	23
34	35	44	23
32	34	44	23
33	35	43	23
32	33	45	23
32	34	43	23

	4	5	6	7
Mean	33.4	33.2	43.0	22.8
Std. Dev.	2.55	2.9	1.56	0.42
Coef. of Var.	0.07	0.09	0.04	0.02
Reflectance	6.47	9.39	16.45	25.84
Normalized	1.00	1.45	2.54	3.99

ID 1399-18170

CRYSTAL SPRINGS 26 August 1973

4	5	6	7
33	35	36	18
31	32	34	19
30	32	34	18
30	32	34	18
32	33	36	18
30	32	34	19
33	34	37	19
33	30	39	19
32	34	36	19
31	30	34	19

	4	5	6	7
Mean	31.5	32.4	35.4	18.6
Std. Dev.	1.27	1.65	1.71	0.52
Coef. of Var.	0.04	0.05	0.05	0.03
Reflectance	5.96	9.90	18.30	21.66
Normalized	1.00	1.66	3.10	3.63

ID 1399-18170

CRYSTAL SPRINGS (Burn Area) 26 August 1973

4	5	6	7
31	27	31	16
30	30	31	16
30	30	29	17
28	25	25	12
27	22	20	10
28	25	23	11
28	23	22	9
26	23	20	9
26	24	22	10
27	22	23	10

	4	5	6	7
Mean	28.1	25.1	24.6	12.00
Std. Dev.	1.73	3.0	4.25	3.13
Coef. of Var.	0.06	0.10	0.17	0.26
Reflectance	4.20	6.52	7.93	13.54
Normalized	1.00	1.55	1.89	3.22

ID 1345-18180 MIDWAY (Light Burn Area) 3 July 1973

4	5	6	7
33	31	31	14
38	29	30	14
30	29	28	12
30	29	26	12
30	28	28	13
35	33	32	13
32	33	29	13
31	27	24	11
32	33	29	14
35	36	32	15

	4	5	6	7
Mean	32.1	30.8	28.9	13.1
Std. Dev.	1.91	2.86	2.56	1.20
Coef. of Var.	0.06	0.09	0.09	0.09
Reflectance	6.10	8.30	8.26	14.34
Normalized	1.00	1.36	1.35	2.35

ID 1363-18173 MIDWAY 21 July 1973

4	5	6	7
57	73	83	41
52	73	77	40
49	63	77	38
59	82	84	42
58	78	84	40
53	71	79	37
59	83	86	41
59	83	89	40
55	75	81	36
58	80	85	41

	4	5	6	7
Mean	55.9	76.1	82.5	39.6
Std. Dev.	3.51	6.38	3.95	1.96
Coef. of Var.	0.06	0.08	0.05	0.05
Reflectance	22.11	28.39	36.05	45.75
Normalized	1.00	1.28	1.63	2.07

ID 1363-18173 MIDWAY (Heavy Burn Area) 21 July 1973

4	5	6	7
27	21	19	7
25	20	18	6
27	20	17	6
25	21	18	6
27	24	18	8
30	29	27	12
28	242	24	9
27	23	21	8
28	24	24	10
28	27	22	10

	4	5	6	7
Mean	27.0	23.3	20.8	8.2
Std. Dev.	1.63	2.98	3.36	2.04
Coef. of Var.	0.06	0.13	0.16	0.25
Reflectance	3.38	5.00	6.19	8.53
Normalized	1.00	1.48	1.83	2.52

ID 1291-18182 MIDWAY 10 May 1973

4	5	6	7
36	41	56	32
33	39	56	30
33	39	56	33
37	45	62	35
34	42	57	31
37	42	60	35
33	40	58	35
34	43	58	32
38	51	65	39
40	53	51	31

	4	5	6	7
Mean	35.5	43.5	58.9	33.3
Std. Dev.	2.46	4.86	3.03	2.71
Coef. of Var.	0.07	0.11	0.05	0.08
Reflectance	7.75	15.27	25.03	41.34
Normalized	1.00	1.97	3.23	5.33

ID 1345-18180 MIDWAY 3 July 1973

4	5	6	7
46	62	70	38
39	50	59	32
41	53	59	34
42	60	67	34
40	58	60	33
40	53	60	33
42	58	60	30
45	58	63	33
42	56	65	33
45	59	63	32

	4	5	6	7
Mean	42.4	56.7	62.6	23.2
Std. Dev.	2.39	3.68	3.75	2.04
Coef. of Var.	0.06	0.07	0.06	0.06
Reflectance	10.83	19.98	24.74	36.80
Normalized	1.00	1.84	2.28	3.82

ID 1345-18180 MIDWAY (Heavy Burn Area) 3 July 1973

4	5	6	7
23	17	14	6
23	17	15	6
23	17	13	6
23	18	14	7
23	18	15	7
24	21	17	7
23	17	15	6
23	19	15	6
23	19	15	6
23	19	17	6
23	19	17	6
24	21	18	8

	4	5	6	7
Mean	23.2	18.4	15.3	6.50
Std. Dev.	0.42	1.58	1.57	0.71
Coef. of Var.	0.02	0.09	0.10	0.11
Reflectance	1.96	3.10	2.91	7.70
Normalized	1.00	1.58	1.48	3.93

ID 1363-18173 MIDWAY 21 July 1973
(Light Burn Area)

4	5	6	7
34	33	33	14
38	38	33	14
32	32	26	12
32	29	28	13
34	32	28	13
36	34	31	14
34	34	30	13
32	29	28	11
32	29	26	12
34	35	31	15

	4	5	6	7
Mean	33.8	32.5	29.4	13.1
Std. Dev.	1.89	2.95	2.59	1.20
Coef. of Var.	0.06	0.09	0.09	0.09
Reflectance	6.67	9.08	10.36	14.34
Normalized	1.00	1.36	1.55	2.15

ID 1399-18170 MIDWAY 26 August 1973

4	5	6	7
41	53	61	31
41	43	61	29
38	49	53	26
40	51	57	29
40	53	59	29
38	51	57	27
43	54	63	32
43	59	63	34
40	52	58	29
40	56	63	31

	4	5	6	7
Mean	40.4	53.1	59.5	29.5
Std. Dev.	1.71	2.81	3.31	2.01
Coef. of Var.	0.04	0.05	0.06	0.07
Reflectance	10.58	19.48	25.68	35.01
Normalized	1.00	1.84	2.43	3.31

ID 1399-18170 MIDWAY 26 August 1973

(Heavy Burn Area)

4	5	6	7
25	23	17	7
25	21	17	7
25	20	17	7
24	21	17	8
26	21	17	7
29	26	23	9
27	22	20	8
24	21	18	7
25	22	20	7
27	23	22	8

	4	5	6	7
Mean	15.7	22.7	18.8	7.5
Std. Dev.	1.57	1.70	2.30	0.71
Coef. of Var.	0.06	0.08	0.12	0.09
Reflectance	2.96	5.41	4.98	8.00
Normalized	1.00	1.83	1.68	2.70

ID 1399-18170 MIDWAY 26 August 1973

(Light Burn Area)

4	5	6	7
33	33	29	14
33	33	31	14
33	30	29	12
31	30	27	11
36	35	32	14
32	32	29	14
32	29	31	13
30	29	24	11
28	29	24	11
34	32	31	13

	4	5	6	7
Mean	32.2	31.2	28.7	12.7
Std. Dev.	2.20	2.10	2.87	1.34
Coef. of Var.	0.07	0.07	0.10	0.11
Reflectance	6.33	9.25	10.02	14.40
Normalized	1.00	1.46	1.58	2.27

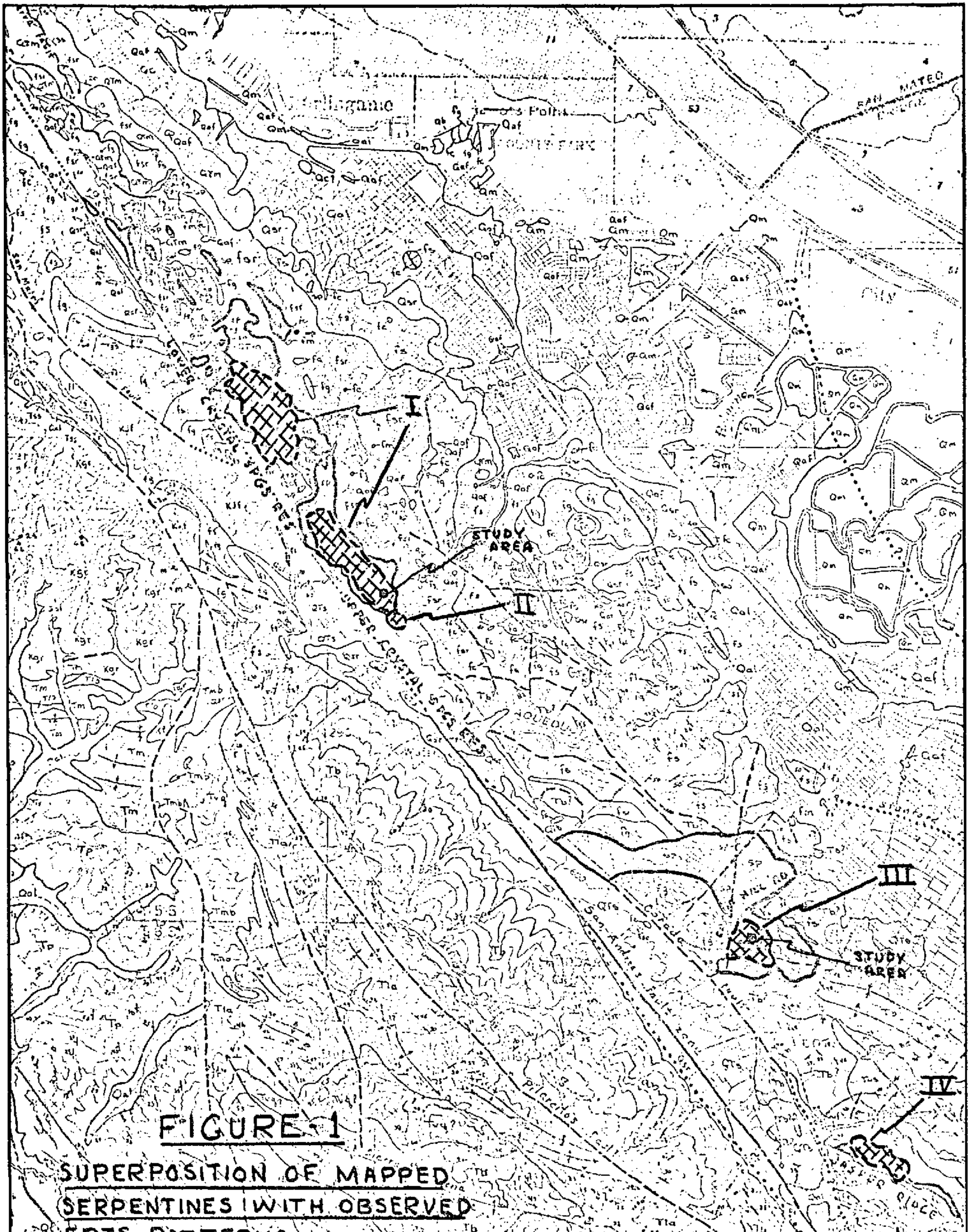
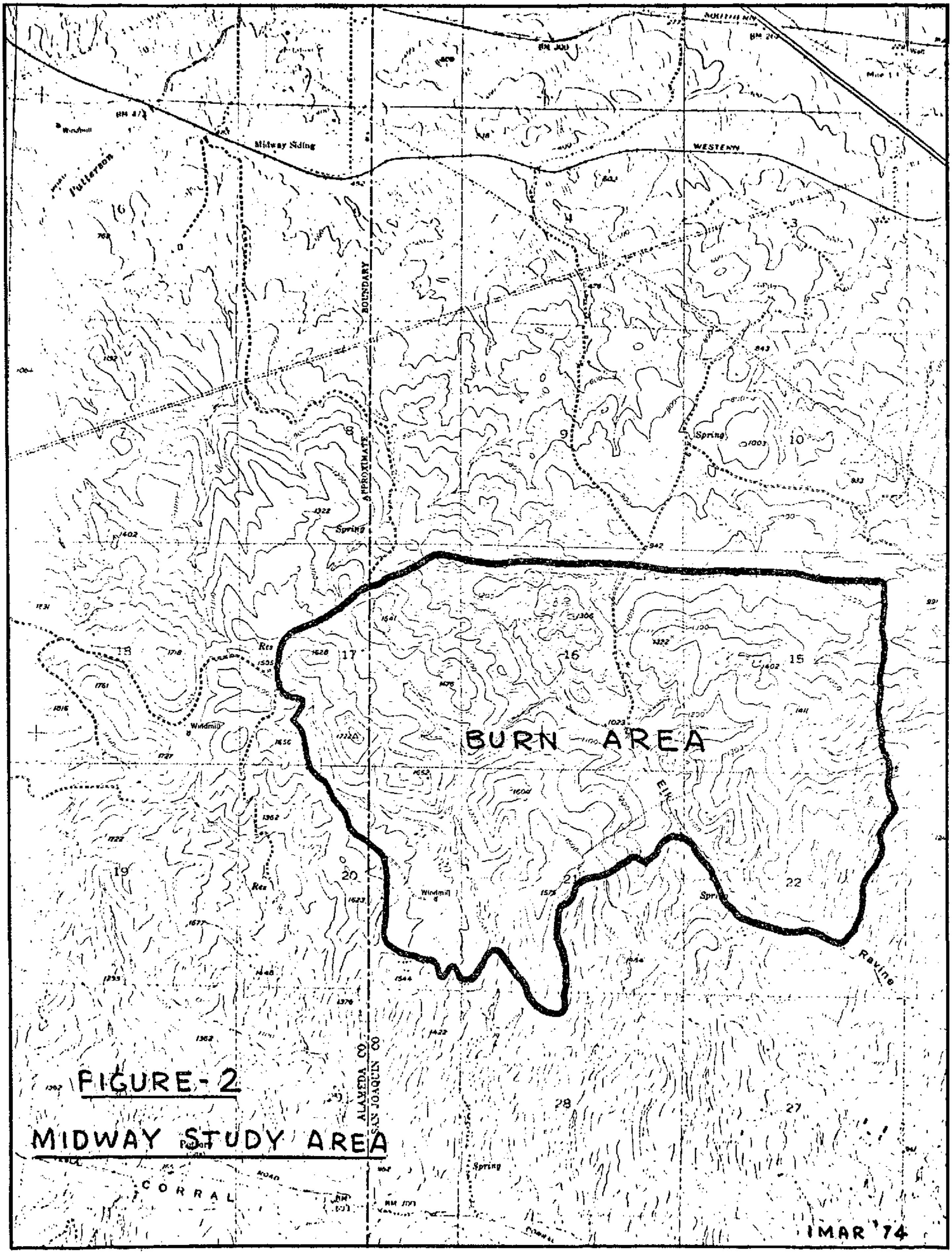


FIGURE-1

SUPERPOSITION OF MAPPED SERPENTINES WITH OBSERVED ERTS PATTERNS


BURN AREA
FIGURE - 2
MIDWAY STUDY AREA
1 MAR '74
Midway Siding
Patterson
WESTERN
SOUTHERN
APPROXIMATE BOUNDARY
ALAMEDA CO
SAN JOAQUIN CO
Spring
Windmill
Ravine
CORRAL

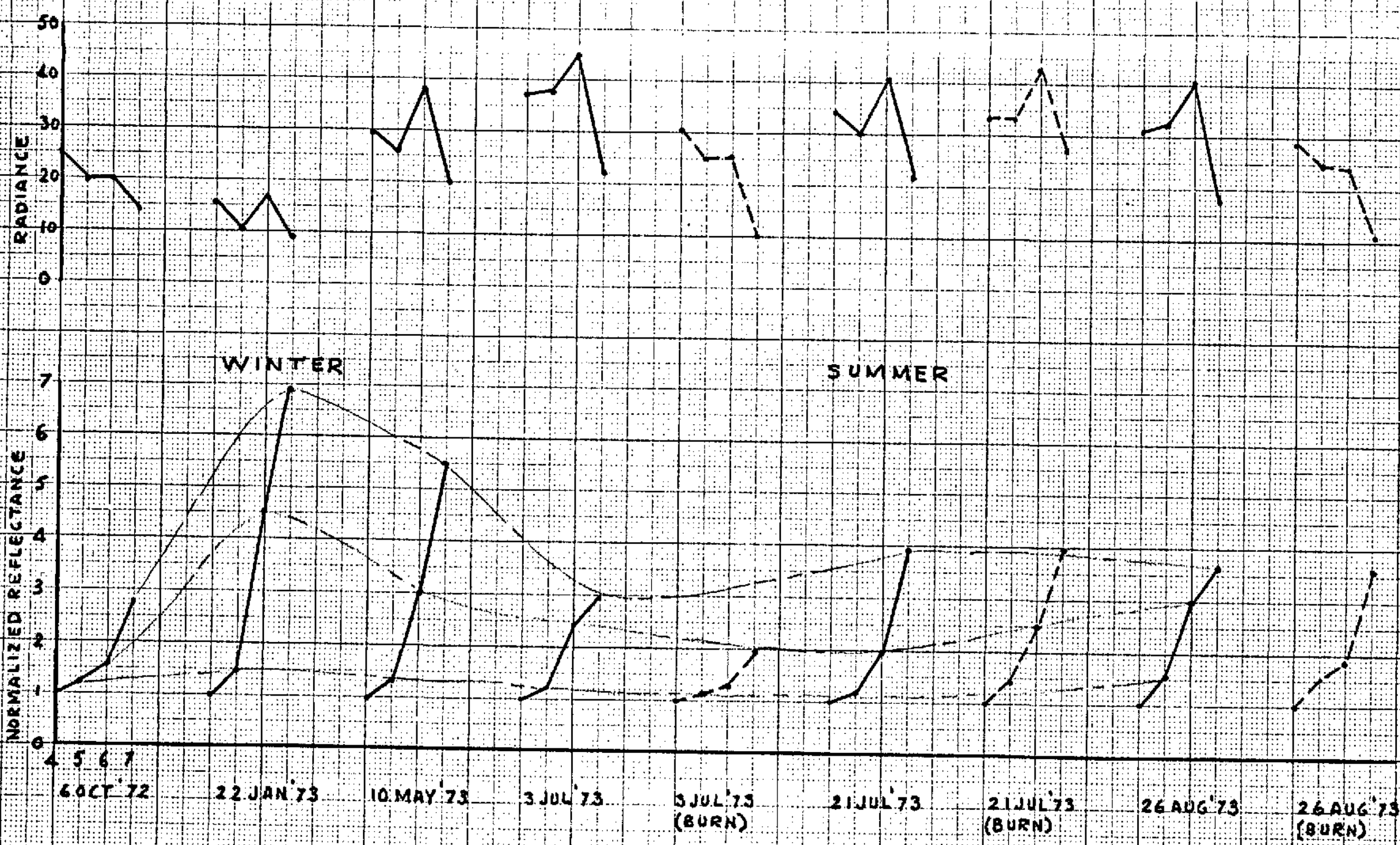


FIGURE 3 - RADIANCE AND NORMALIZED REFLECTANCE SPECTRA - SOIL/GRASS (CRYSTAL SPRINGS)

MAR '74

1 MAR '74

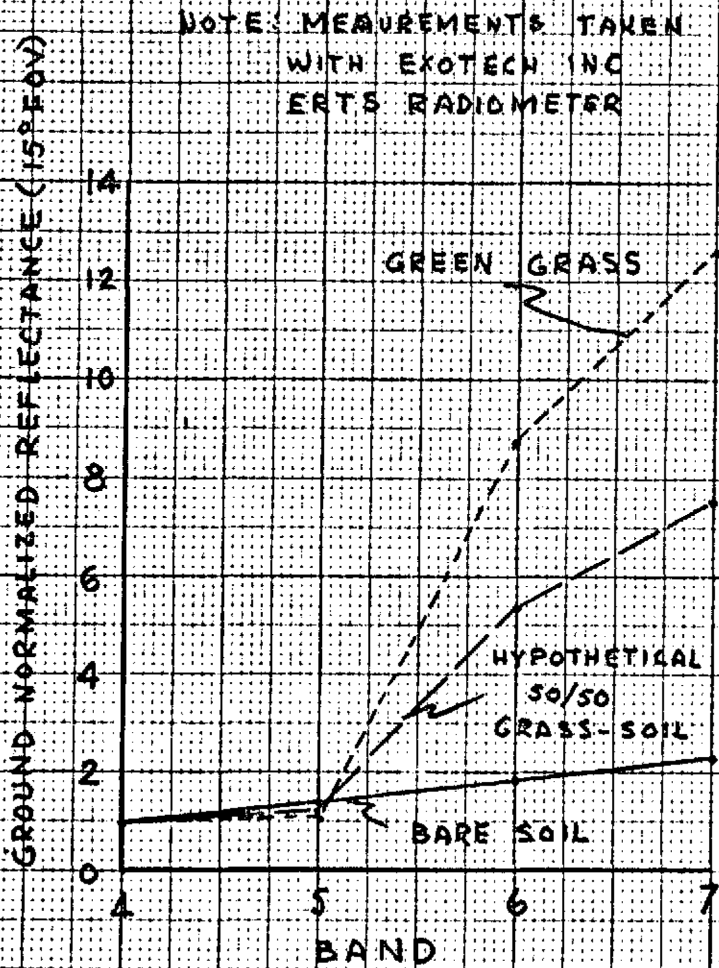


FIGURE 4

GROUND MEASUREMENTS

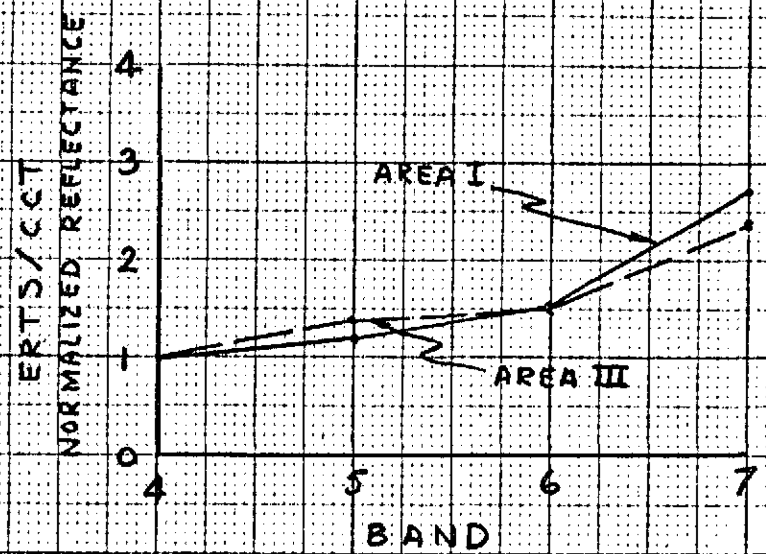


FIGURE 5

COMPARISON - AREA I AND III (6 OCT 1972)

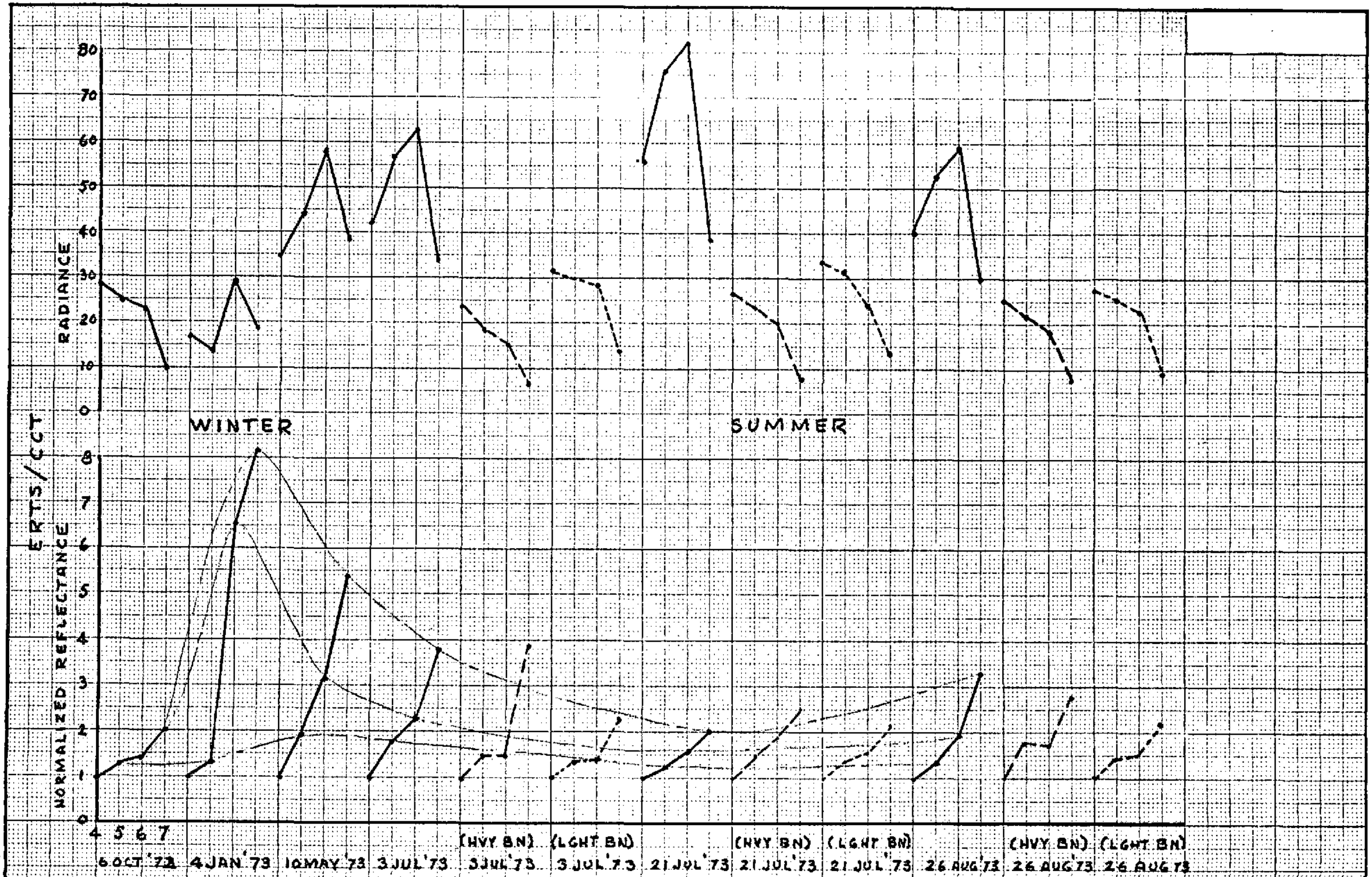


FIGURE 6 – RADIANCE AND NORMALIZED REFLECTANCE SPECTRA – SOIL/GRASS (MIDWAY)

NDPF USE ONLY

D ______
N ______
ID ______
AA ______
TM ______

DATA REQUEST FORM O

1. DATE March 4, 1974

2. USER ID UN142

4. SHIP TO: R.J.P. Lyon

ADDRESS School of Earth Sciences ☐ NEW

Stanford University

Stanford, California 94305

5. TELEPHONE NO. 321-2300 ☐ NEW

2747/4147

6. CATALOGUES DESIRED

STANDARD ☐ U.S. ☐ NON-U.S.

DCS ☐

MICROFILM ☐ U.S. ☐ NON-U.S.

APPROVAL TECHNICAL MONITOR ______

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
Coalinga 1560-18081	N3605/W12047	4-7	D	9		1	U
San Luis 1560-18075	N3731/W12020	4-7	D	9		1	U
[illegible]erington 1560-18072	N3856/W11951	4-7	D	9		1	U

TABLE 02. TAPES IN STANFORD RSL DATA FILE

STANFORD

1003-18175	07/26/72
(+1003-18175 RBV)	
1075-18173	10/06/72
1183-18175	01/22/73
1255-18183	04/04/73
1273-18183	04/22/73
1291-18182	05/10/73
1345-18174	07/03/73
1489-18152	11/24/73

MONO LAKE

1055-18055	9/16/72
1091-18062	10/22/72
1063-18063	1/02/73
1235-18070	3/15/73
1307-18064	5/26/73
1397-18053	8/24/73
1361-18060	7/19/73

WALKER LAKE

1055-18053	09/16/72
1091-18055	10/22/72
1163-18060	01/02/73
1235-18064	03/15/73
1289-18063	05/08/73
1307-18062	05/26/73
1361-18054	07/19/73
1397-18051	08/24/73
1415-18045	09/11/73
1505-18032	12/10/73

SAN LUIS

1074-18114	10/05/72
1254-18125	4/03/73

S. SALINAS

1290-18130	5/09/73

BERRYESSA

1075-18170	10/06/72

TABLE 01. ERTS IMAGES ACQUIRED OVER STANFORD UNIVERSITY TEST AREA

	OBSERVATION ID	FIELD DATA	MICROFILM ROLL NO.	DATE ACQUIRED	CLOUD COVER	ORBIT NUMBER	PRINCIPAL POINT (C) OF IMAGE LAT.	LONG.	SUN AZIM	SUN ELEV	(R=REQUESTED) PRODUCTS RECD. AT STANFORD M	S	B7	P	M9
1.	1003-18175	-	10001/0126/7	07/26/72	10	42	3805N	12146W	118.7	58.7	4	4	-	2	R
2.	1021-18172	-	10001/1226	08/13/72	0	293	3724N	12145W	124.5	55.8	R	8	R	R	-
3.	1039-18172	-	10002/0074	08/31/72	0	544	3725N	12150W	132.5	51.9	4	2	R	R	-
4.	1057-18172	-	10002/0598	09/18/72	20	795	3721N	12149W	140.2	47.1	R	R	R	R	-
5.	1075-18173	-	10004/0236	10/06/72	0	1046	3729N	12144W	146.8	41.6	4	8	R	2	4
6.	1093-NO FRAMES TAKEN			10/21/72	-	1297			152.	35.	-	-	-	-	-
7.	1111-18181	-	10004/1570	11/11/72	60	1548	3715N	12153W	153.9	30.9	4	8	-	2	-
8.	1129-18181	-	10005/0498	11/29/72	20	1799	3725N	12150W	154.6	26.7	4	8	-	2	-
9.	1147-18181	-	10006/0333	12/17/72	90	2050	3718N	12151W	153.4	24.5	-	-	-	-	-
10.	1165-18175	-	10006/0898	01/04/73	10	2301	3724N	12146W	151.1	24.2	4	8	-	2	R
11.	1183-18175	-	10007/0170	01/22/73	20	2552	3732N	12146W	148.2	26.3	4	8	R	2	4
12.	1201-18181	-	10007/0782	02/09/73	80	2803	3725N	12151W	144.9	30.5	-	-	-	-	-
13.	1219-18182	-	10008/0440	02/27/73	100	3054	3726N	12156W	141.6	36.3	-	-	-	-	-
14.	1237-18183	-	10009/0470	03/17/73	40	3305	3727N	12200W	138.1	42.8	4	8	-	2	-
15.	1255-18183	-	10009/1329	04/04/73	0	3556	3730N	12201W	134.2	49.4	8	4	-	1	4
16.	1273-18183	-	10010/0613	04/22/73	0	3807	3726N	12201W	129.4	55.2	4	8	-	2	4
17.	1291-18182	F	10010/1539	05/10/73	0	4058	3731N	12201W	123.3	59.6	8	4	-	1	4
18.	1309-18181	F		05/28/73			3735N	12201W	117.0	61.0	8	4	-	2	R
19.	1327-18180	F		06/15/73			3730N	12153W	113.0	62.0	4	8	-	2	R
20.	1345-18174	F	10012/1181	07/03/73	30	4811	3725N	12202W	112.5	61.6	4	8	-	2	R
21.	1363-18173	F	10013/0135	07/21/73	30	5062	3725N	12202W	115.0	59.0	4	8	-	2	R
22.	1381-18172	R	10013/1276	08/08/73	50	5313	3721N	12203W	122.0	56.0	-	-	-	-	-
23.	1399-18170	R		08/26/73		5564	3726N	12201W	129.0	52.0	-	8	-	2	4
24.	1417-18164	-		09/13/73			3725N	12158W	137.9	48.0	4	8	-	2	-
25.	1435	-		10/01/73							-	-	-	-	-
26.	1453	F		10/19/73							-	-	-	-	-
27.	1471-	-		11/06/73											
28.	1489-18152	F	10018/0397	11/24/73	30	6819	3727N	12151W	153.9	27.5					
29.	1507-	-		12/12/73 Rain											
30.	1525-18145	F	10019/0697	12/30/73 Clear	10	7321	3723N	12155W	151.0	23.0					
31.	1543-18141			1/17/74			3732N	12150W	148.0	25.0					
32.	1561-18133			2/04/74 Foggy			3729N	12145W	144.0	28.0					
33.	1579-18131	F		2/22/74			3733N	12147W	141.0	33.0					
				3/12/74 Cloudy											