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NATURAL VEGETATION INVENTORY

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ABSTRACT

Unique characteristics of ERTS imagery can be used to inventory natural vegetation. While satellite images can seldom be interpreted and identified directly in terms of vegetation types, such types can be inferred by interpretation of physical terrain features and through an understanding of the ecology of the vegetation.

The concept of utilizing recognition of natural vegetation as indicators of environments having similar biological potential is not new. This approach has been extensively applied in Europe and somewhat in Australia. However, application in the United States has amounted to little more than some small percent of the potential. The indicator values of some plant species and vegetations are known and have enabled land managers to recognize environmental characteristics which impact management schemes. For example, some species indicate soils conditions which result in plant toxicity to grazing animals, others are susceptible to frosts and, therefore, indicate areas that may have climatic conditions suitable for frost intolerant crops, and some vegetation is indicative of soil suitable for rangeland reseeding.

Personnel of the Rangeland Resources Program, Oregon State University, conducted studies of natural vegetation in southern Arizona utilizing S065 photography from Apollo 9 and NASA high altitude aircraft photography. That work concluded with a vegetation resource inventory for the Phoenix vicinity. This set the stage for demonstrating the utility of such an inventory in an analysis showing the lands most likely to have potential for agricultural and/or urban development. The significant result was that most of the land potentially suitable for agricultural development was also suited to urbanization. The converse of this was not true. This work can be reviewed in Pettinger and Poulton, 1970; Poulton, Johnson, and Mouat, 1970; and Poulton, et al.,

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1971. One solution to the conflict is to seek out new agricultural lands and delay the direct conflict between the two land uses by shifting the location of one. Receipt of ERTS-1 imagery provided the opportunity to search for other areas which appear to fulfill the criteria of potential agricultural lands. Extensive, broad, minimally dissected valleys are present south-southwest of the Phoenix area and can be identified on ERTS-1 imagery by visual interpretation. NASA ERTS E-1068-17382 recorded on 29 September 1972 shows these areas as the lighter toned valley fill having a braided drainage network supporting enough vegetation to make the network darker toned and contrasting with the lighter toned interfluves. A check of land ownership patterns (U.S.D.I., BLM, 1964) in the region reveals that the lands which appear to have agricultural potential are parts of military ranges and wildlife refuges, a situation which presumably precludes the possibility of agricultural development. In conclusion, it would appear that the land use conflict between agricultural development and urbanization that is currently existing in this region will have to be settled primarily on those lands which are currently in agricultural use or available for development.

Having once recognized the appearance on ERTS-1 imagery of the vegetation/landform unit indicative of potential agricultural land (MSS Band 5 was the most useful), a photo interpreter can quickly review hundreds of square miles of the southern Arizona terrain in search of similar images. ERTS not only greatly facilitates that task, but also provides for a very quick review of current and potential agricultural activities in relation to land ownership patterns. In this manner, the land use conflict in the region is drawn into sharper focus and better perspective. While the conclusion must be considered as tentative, it does provide a more complete background to contribute to the directing of regional planning.

The analysis briefly mentioned above began with, and depended upon a classification and inventory of the natural vegetation. Our strong belief in the value of vegetation classification and inventory as a starting point for solving many natural resource management problems guided the formulation of our current research with ERTS data. That data is being used in the development of inventory approaches which make use of multistage sampling, plant phenology pattern recognition, computer classification of apparent radiance data, and relationships among physical features of the terrain and vegetation. To date, our efforts have produced results primarily with the last approach.

A test site, 3200 square miles in size, was selected with Tucson, Arizona in the northwest corner and Willcox Playa, Arizona in the northeast. The test area contains a great diversity and complexity of vegetation and therefore provides a good opportunity to develop and apply the approaches listed in the preceding paragraph. The vegetation of the area includes representatives of the Sonoran and Chihuahuan Desert shrub, grassland, savannah, chaparral, woodland, and forest. Images of this landscape obtained from a satellite seldom contain characteristics that can be interpreted directly in terms of the vegetation. However, those same images provide a considerable amount of detail pertaining to the physical terrain features. In fact, these features are some of the more salient characteristics of the ERTS images. A broad range of elevation, all classes of macrorelief, drainage densities, soil parent materials, aspects, slopes, etc., are present and depicted in the images. These variables were sampled at 250 locations in the test site (Mouat, 1972). At each location, data was collected pertaining to the physical terrain features and the plant species. The species present were recorded and assigned prominence ratings (these ratings are explained in Poulton, Faulkner, and Martin, 1971). This information was supplemented by ground photographs. The plant species information was also collected at an additional 250 locations. A vegetation classification resulting in 31 broad types was produced from analysis of the field data. The classification is based primarily upon the presence or absence of the more common plant species and, secondarily, on the prominence of those species.

A step-wise discriminant analysis (SWDA) was used to detect the relationships existing among vegetation types and the physical terrain features sampled. This analysis had already been conducted to relate plant species and terrain features (Mouat, 1972). A detailed explanation can be found there.

Results from the vegetation type-terrain feature analysis indicate that the terrain features which appear to be the better discriminants of vegetation are elevation, macrorelief class, solar radiation class (a function of aspect and slope), drainage density, and parent material, in that order. No one feature can be used to successfully discriminate all vegetation types. Table I includes the means and the 95% confidence interval for elevation data for 25 vegetation types used in the SWDA. Elevation proved to be the best discriminant of vegetation types. This table shows that the range for each vegetation type, as defined by the mean elevation plus and minus one standard deviation, overlaps those of other vegetation types. These tendencies to overlap reflect a degree of ecological similarity among groups. However, when several terrain features are considered, vegetation types that showed similarity in one case may show dissimilarity in others.

Figure 1 depicts such a consideration. The three vegetation types are referred to as: *Hilaria mutica* and *Prosopis juliflora* (Himu), *Prosopis juliflora* and *Bouteloua* without *Quercus* and *Juniperus* (Prju), and *Cercocarpus brevifolius* with *Juniperus deppeana* and/or *Pinus cembroides* and usually with *Quercus* (Cebr). In this case, the terrain feature, macrorelief, is sufficient for discriminating the three types.

The three types are also discriminated by considering the terrain features: elevation and drainage density. This example oversimplifies the real world, however, the possibility is suggested for an ERTS image interpretation key. It would make use of the interpretability of terrain features and the ability to narrow down the likely possibilities for vegetation types on the basis of the terrain feature characteristics of a given portion of the landscape.

The following is given as an example. A location chosen from within the test site has these terrain feature values: elevation, 5320 feet; macrorelief class, 5; solar radiation class, 1; drainage density, 71 miles/square mile; and parent material, 2 (sandstone). By SWDA, the following vegetation types are likely to occur where each of the above terrain features prevail.

Elevation, 5320': vegetation types 17, 18, 23, 24, 25, 26, and 30

Macrorelief class, 5: vegetation types 12, 17, 23, 25, 27, and 30

Solar radiation class, 1: vegetation types 14, 16, 17, 23, 24, 26, 27, and 30

Drainage density, 71: vegetation types 9, 10, 11, 12, 15, 16, 17, 18, 19, 23, 25, 26, 27, 29, and 31

Parent material, 2: vegetation types 3, 8, 9, 15, 16, 17, 19, 23, 25, 26, 27, 29, 30, and 31

From the above vegetation type possibilities, it is easy to determine by a process of elimination that vegetation types 17 and 23 are the types most likely to occur at this site because they are the only types included as likely possibilities in the case of the five terrain features considered.

Step-wise discriminant analysis does appear to be able to suggest a small number of vegetation types which would most likely be expected to occur in a given area. However, SWDA may not be able to provide a means for 100% accuracy of vegetation type identification from interpretation of terrain feature variables on ERTS imagery.

Utilizing natural vegetation types for recognizing analogous areas of the landscape having similar biological potentials has been an approach proven useful to land managers. High altitude and space imagery have been used in a corollary approach to inventory areas appearing to have agricultural and/or urban development potential. With ERTS-1 imagery, a reconnaissance was rapidly conducted over a much more extensive region. A detailed study utilizing ERTS-1 imagery in vegetation inventories has been initiated. Several approaches are being

explored including one which utilizes the interpretability of physical terrain features on ERTS imagery as a basis for inferring vegetation types. A vegetation classification and some relationships among vegetation types and terrain features have been established.

Contributions to the research reported in this paper have been made by James R. Johnson, David A. Mouat, and other personnel of the Rangeland Resources Program, in addition to the author. The work effort is defined as Task I (Inventory and Monitoring of Natural Vegetation and Related Resources in an Arid Environment by the Use of ERTS-A Imagery) of contract NAS5-21831 between National Aeronautics and Space Administration, Goddard Space Flight Center, and Oregon State University.

TABLE I. Elevation means and 95% confidence intervals of elevation data for 25 vegetation types used in the step-wise discriminant analysis. Vegetation types are identified by number only.

Vegetation Type	Mean Elevation (feet)	95% Confidence Interval (feet)
2	2913	2614-3212
3	3360	3082-3638
9	3587	3322-3851
6	3663	3336-3990
22	3978	3621-4334
21 (Himu)	4071	3754-4388
8	4081	3664-4498
10	4243	4109-4377
15 (Prju)	4284	4051-4517
31	4340	4076-4604
14	4435	3629-5241
29	4471	3818-5124
11	4531	4257-4805
7	4535	4397-4673
12	4546	4242-4850
27	4773	4436-5110
16	4785	4449-5121
19	4811	4545-5077
18	4879	4287-5471
25	4961	4566-5357
17	5077	4537-5616
24	5126	4834-5418
26	5244	5090-5398
30	5321	4963-5679
23 (Cebr)	5406	5230-5582

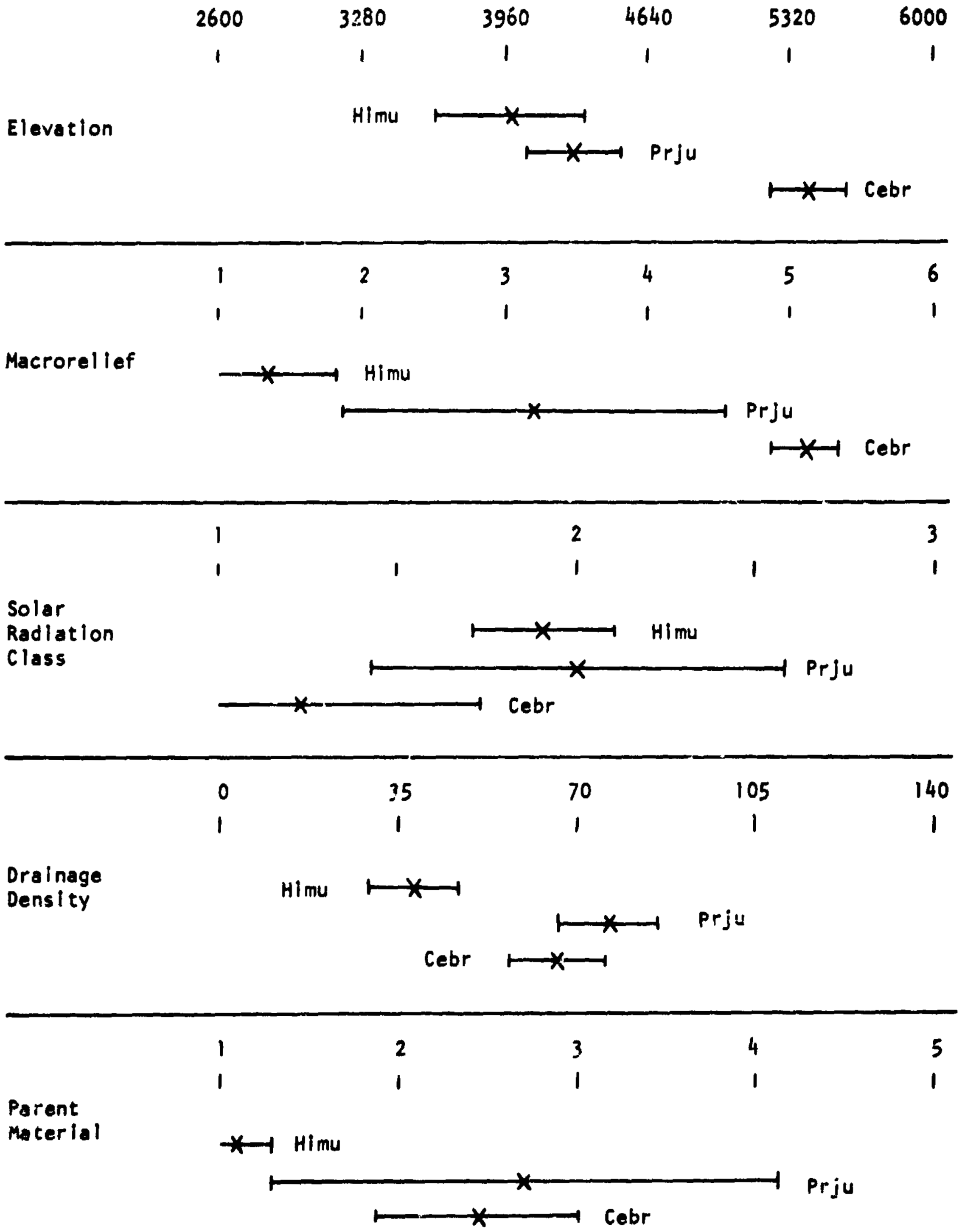

FIGURE 1. SELECTED VEGETATION TYPE-TERRAIN FEATURE RELATIONSHIPS (With 95% confidence interval; x = group mean)

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