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AN INTERREGIONAL ANALYSIS OF NATURAL VEGETATION ANALOGUES USING ERTS-1 IMAGERY

Charles E. Poulton and Robin I. Welch, *Earth Satellite Corporation, 2150 Shattuck Avenue, Berkeley, California 94704*

ABSTRACT

We are seeking to determine if ecological analogues of natural vegetation and a key food crop, rice, have sufficiently analogous signatures to be interregionally and, potentially, globally identifiable from ERTS-1 imagery. In the proper seasons, rice does have a unique signature in one of our test sites and we have identified within-field variation that is production related. We have also demonstrated unique signatures for four natural vegetation analogues from color prints and are developing some promising color additive analytical techniques to support this and other projects. Even this limited progress is encouraging with respect to feasibility of a uniform ecological inventory of vegetational resources from ERTS imagery.

Space-acquired imagery has made it possible and practical to inventory and monitor vegetational resources in the global context. Full realization of this potentiality requires three things in addition to the imaging capability. <u>First</u> is a vegetational resources classification concept that is logical and that can be maintained in synoptic treatment across political and jurisdictional boundaries. In contrast to established classifications of the plant geographer and plant ecologist, a usable classification must also be compatible with the requirements for interpretation of remotely sensed images, including the concept of multistage inventory. <u>Second</u> is the determination of the interregionally applicable vegetational signatures that can be used to identify image areas in this context. This requires identification of the characteristics of the signatures of each analogue and determination of the extent to which each signature can be extrapolated for application in regional, interregional, and eventually global inventories. This knowledge should permit optimum use and maximum benefit from interpretation criteria developed in one region of the globe as it is used in image analysis of agroclimatologically analogous regions elsewhere. The third requirement is the determination of image interpretation procedures essential to the recognition and mapping of vegetational analogues by use of the interactive system of space and aircraft imagery with human knowledge and skills.

To help meet these requirements, we have selected two pairs of interregional test sites in the United States. One pair (Southern Louisiana and Interior Valley California) is for the study of a key food crop analogue and the other pair (Colorado Plateau and Sierra-Lahontan) for natural vegetational analogues. In this ERTS-1 Symposium, we are reporting preliminary results relating to requirements one and two above. Our concern with requirement three is minimal to this point in time.

One of our analogues is the world-important food crop, rice. Definitive work on this analogue will start with the 1973 growing season. From ERTS-1 imagery in July and September, 1972, we have made some meaningful observations in the California test area. Among crops in this area, rice does have a highly unique, pre-ripening signature in the color reconstituted ERTS-1 data. It appears that highly accurate identification will be possible. We have also determined that some within-field variation can be detected directly from the ERTS imagery at operationally feasible, color reconstituted scales. In this instance, we are seeing the ground-confirmed influence of soil salinity. This is an example of one of the negative production factors that will be used in a procedure we have developed for yield prediction.

Aircraft photography is an integral part of these predictions. Highflight provides the second stage in multistage sampling. The higher resolution enables both refinement of delineation and identification of other more elusive yield-influencing environmental factors as evidenced in plant growth.

Now turning to the natural vegetation component of our investigation, in theory and in fact, no two stands of vegetation are identical; but in spite of this seeming dilemma, we have an operational legend system that meets previously mentioned requirements one and two. If one concentrates attention on the similarities instead of the differences and considers the plant community as a whole rather than as individual economic species, highly useful classifications are possible. It is well established by plant sociologists and plant geographers that the concept of vegetational analogues is valid. Demonstration of the degree of analogy is dependent on the classification criteria used and on the recognition of hierarchically comparable levels in the classification scheme. With special attention to the needs of ERTS interpretation, we have adapted a uniform ecological legend system initially devised by my graduate students and me at Oregon State University to the needs of this project. It is a devisive system in which the three broadest hierarchical levels are based on physiognomic and structural characteristics of the vegetation. The fourth level is based on floristic criteria, generally at generic level. The more refined hierarchical levels below this are based on plant sociological criteria and are best developed by agglomerative classification methods (Poulton, 1972).

In this study, we are not considering these latter, highly refined classes because they are generally not identifiable from space imagery except through associated and convergent evidence. In general, as one moves from the local to the regional, to the continental, and to the global scene, ecological analogues are demonstrable only by moving up the hierarchical classification to broader generalizations. The problem of interpreting analogous vegetations from remotely sensed imagery requires that we first determine the level in the hierarchical legend that is appropriate to the scale, resolution, and discriminating power of each system. Our work on interregional analogues is helping to define these legend levels for the ERTS-1 system.

We have been approaching the study of natural vegetation analogues by working with the black and white photo images until as recently as last week. We have identified a group of analogues that are candidates for interregional comparison (See Type II Report, Poulton and Welch, 31 January 1973). We have just made a first analysis of intra-regional repeatability of some of these signatures in the color reconstituted product from an I^{2}S Addcol. By carefully setting the lamp intensity dials to the same setting for each separate scene, fidelity of the color reconstituted signature for many vegetational analogues was very good among scenes and upon resetting of identical scenes.

In studying these image areas, it is immediately obvious that many of us who are concerned about interpretation of natural vegetation will face two contrasting situations, each with its own unique solution. These situations are:

1) In subhumid and humid areas, vegetation density is sufficient to primarily determine image characteristics.

2) In some semi-arid conditions and particularly in arid environments, sparsity of vegetation produces an image that is overridden by the nonvegetational features of the subject--by the exposed soil surface.

In the first instance, the vegetation analogues are directly interpretable to the extent that their images are consistent within and different among analogues. In the second case, photo-identification of vegetational subjects can be done only from associated and convergent evidence rather than by image features that are related directly to vegetation reflectance. We have so far been concerned with situations where vegetation features override the soil background in determining image characteristics.

We have made one set of intra-regional comparisons between two scenes for analogues of dense Douglas fir/spruce-fir, oakbrush/aspen, juniper, ponderosa pine, sagebrush and saltsage. The consistency of these images between scenes encourages us to expect some interregional applicability of the signatures. The sharpness of color image separations of all these analogues except the oakbrush/aspen and the sagebrush/saltsage also suggests that our experimental hypothesis is sound and that benefits will, therefore, accrue from the characterization and identification of analogous signatures in one region for use in another if the regions are in fact vegetationally analogous. Our work plan now calls for quantification and a more systematic comparison of photo image characteristics for ecological analogues and study of image consistency and identifiability among scenes between regions and over time. It may be that some analogues not identifiable in these single, late-summer scenes will have a unique multidate signature.

Especially to investigate these kinds of phenomena as well as changes in the resource over time, Phil Langley of our Berkeley Office has been experimenting with special optical enhancement techniques by color combining both positive and negative for the same scene and date and by successfully registering among dates. By combining positives of bands 5 and 7 for July with a positive and a negative of band 7 of the same scene for October, he has been able to produce strong color contrasts in areas of change. These included generation of a unique color for changes in agricultural crops between the two dates, detection of areas of deciduous hardwoods, separation of north-slopes supporting Douglas fir/Sugar pine vegetation, and the vivid detection of changes in the areas of lakes. We expect that techniques like these will find usefulness in all of our participating projects where vegetation is the subject of concern.

Aircraft photography is an integral part of our d[illegible]base. The procedure is to plot aircraft highflight lines on the 1:1,000,000 ERTS imagery and then strive to locate all calibration sites in these strips. The designation or mapping of unique images on the highflight serves as an intermediate "ground truth" for ERTS interpretation and will be an essential component of the system where the analogue signatures are to be used in a multistage inventory of natural vegetation or food crop resources. The aircraft photography often helps to explain anomalies in the ERTS imagery where vegetation patterns are intricate. In addition, we have taken low oblique photos over all test areas as an additional aid to image identification and subject characterization.

The following is our assessment of benefit from project activity to date: We have confirmed the advantages of interpreting the ERTS in stereo wherever side-lap permits. This is particularly helpful when relating vegetation to landforms, especially in semi-arid and arid environments or where confirmation of major elevational relationships is important to the identification decision.

From preliminary work with the rice identification problem, we feel that use of ERTS imagery together with aircraft subsampling will lead to efficiencies attributable to the space imagery in estimating acreage and production of this key world food crop.

The capability to provide a uniform synoptic treatment of vegetational resources irrespective of ownerships, agency jurisdiction, and political boundaries brings within our grasp a nation-wide system of uniform ecological inventory and monitoring of our entire vegetational resource base. Because of ERTS, this could now be nearing feasibility in a context not attainable from the myriad of use- and product-biased legend systems and inventory methods used by the many Federal and state agencies concerned with vegetational resources of our country.

To the extent that interregional, and eventually global, vegetation analogues can be demonstrated and their differentiating image features defined and characterized, we will greatly enhance the value and interpretability of ERTS imagery. Our work to date has encouraged us in the feeling that the approach we are using will significantly reduce the eventual cost of ground-truth work as progress on the national, continental, and global assessment of vegetational resources and key food crops is carried out--hopefully with a fully operational satellite imaging system.

LITERATURE CITED

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