A VEGETATIONAL INVENTORY AND ECOLOGICAL RESOURCE ANALYSIS FROM SPACE AND HIGH FLIGHT PHOTOGRAPHY

by

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Remote sensing data have limited value until someone uses the information to make a decision or to facilitate action that benefits man. This cannot be achieved until data are converted to information or intelligence, and this in turn relayed to an ultimate user in a comprehensible and useable form. Our attention has been heavily directed to problems of achieving this information flow.

The advent of space and high-flight synoptic photography brought a new need and dimension to renewable resource inventory and analysis. That is, the requirements for (1) an hierarchial classification of vegetation and related resources that is applicable across broad regions as well as adaptable to detailed inventories in restricted areas, and (2) a symbolic legend for the annotation and description of these resource classes.

In meeting these two requirements, the native vegetation worker, in contrast to the agricultural interpreter, must first determine, "what are the subject classes, what are their character and differentiating features, and how are the classes related?" Such an ecological classification provides the only biologically valid basis for making diverse land-use interpretations needed for policy, broad planning, and integrated resource development.

Our work on the classification of ground-truth data from native landscapes led naturally to development of a legend system that contributes significantly to solution of the information transfer problem.

The most familiar land use code is the one by the U.S. Department of Transportation (1969). The broadest classes they use are given in Table I. Their symbol 8 designates the resource production and extractive land uses under which subordinate categories for agriculture, range, and forest resources are found. For the natural resource disciplines, category 9 (undeveloped land and water areas) is both

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misleading in name and redundant with some classes under category 8. While agricultural crops have been broken down in great detail, range and pastures are thrown into a single category, 8191, regardless of their nature, productivity level, or land use potential. Johnson (1969), University of California at Riverside, has provided a slight modification of caption 8191 by adding a fifth digit to separate range from grassland pastures. However, this lacks the specificity we need for ecological resource analysis.

Based on the same numerical symbolization concept, we have developed a similar, symbolic legend that progresses from the general to the specific as one moves from left to right through the symbol (Figure 1). This provides for three hierarchical levels of vegetational classification and three levels of classification of the environmental features associated with each vegetational class.

The primary resource and land use classes which we recommend are shown in Table II. These should have world-wide applicability in a legend system. This legend gives equal hierarchial levels to Barren Land, 1; Water Resources, 2; Natural Vegetation, 3; Agricultural Lands, 4; and Urban and Industrial Lands, 5. The majority of the classes in the Department of Transportation legend will be found under the latter class. The only change is to add the initial digit 5. The highest hierarchial level of natural vegetation classes we have described are shown in Table III. Our colleagues at the Forestry Remote Sensing Laboratory, Berkeley, are taking responsibility for the amalgamation of the agricultural legend into one universally applicable system that treats both cultured and non-cultured vegetation. It is being adapted to preserve the logic and detail of the Department of Transportation legend.

Table IV shows macrorelief classes, the highest level of generalization among the physical environment features. These features are consistently related to vegetation within given ecological provinces. Their recognition provides some associated evidence to narrow choices in the recognition of resource features through photo interpretation.

From space photography it is easy to map these landform classes and relate them to broad vegetational and soil characteristics. We have prepared such maps on enlargements of Apollo 9 color infrared photography, and they are included in our annual report for fiscal 1970 (Poulton et al. 1970). Even at the high hierarchial levels of classification used to make these "space maps," more vegetational resource detail is shown than is presently available, to our knowledge, on any single map of Maricopa County, Arizona. Comparisons with a county soil association map show close and meaningful relationships between vegetation and soils information at these scales.

We have also constructed a photo mosaic from RB57 high flight photography covering 63% of the county. We are in the process of transferring a slightly more detailed inventory of the vegetational resources, land-use patterns and potentials onto this photo map.

Figure 2 is a black-and-white copy of a 1:120,000 photo-scale treatment of the area north of the Whitetank Mountains and west of Phoenix. At this scale, more mapping detail is feasible. The specific units of vegetation that mirror unique productive capacities, environment factors, and land use potentials and limitations are interpreted according to our legend. Land uses that have strongly modified the natural landscape, plus the landform types that are ecologically relevant, can also be interpreted at this working photo scale.

To illustrate what some of these legend symbols mean, specific examples are given. First, on the high flight photo (Figure 2) note that the initial digit signifies a major class according to Table II. The digit 2 in the tens position also occurs on all native vegetation delineations. This indicates that in the bottomlands, valley fills, bajadas, and hills, desert vegetation is found—in this case, Sonoran Desert. The "1" in the units position, or "321," indicates that this is microphyll desert commonly with cacti.

What kind of land and vegetational resources are indicated in the extensive area designated by 321.11? This symbol identifies an open stand of creosote bush. It produces an understory of annual grasses and forbs when weather conditions are favorable. It occurs on flat macrorelief, in this instance dissected flat macrorelief; and the landform is usually valley fill and occasionally lower bajadas.

Symbol 321.21, appearing in the medium gray toned areas just below the hills on the high flight photo, represents plant communities identified by bursage, saguaro, and paloverde. This vegetation is typical of the upper bajadas, fans, and terraces, and is most commonly found on flat, but occasionally on undulating, macrorelief.

Symbol 321.22 indicates the vegetation common to the hills. The "21." shows that it still belongs to the Sonoran microphyll-cactus Desert. This vegetation type is identified by brittlebush, but with bursage, saguaro, and paloverde persisting. It is most commonly associated with hilly macrorelief, class 3. It is normally found on landforms we chose to call slopes, but also occasionally on strongly undulating uplands.

The final native vegetational delineation that appears on the high flight photo is designated 321.94. It is characterized by its location in drainageways and floodplains, usually on flat to slightly dissected lands. The vegetation is variable, but usually includes foothill paloverde, mesquite, ironwood, and/or tamarisk.

This is only an abbreviated example of our legend and its use. We have had occasion now to carry this legend concept successfully in application from the Ft. Huachuca test area, where it was first developed, to the Phoenix test area. In October of this year, we had an opportunity to test the legend in cooperation with the Bureau of Land Management in Southern California. There, as in the Phoenix area, we found it necessary to add some additional vegetational indicator units at secondary and tertiary levels. We also dropped a few, but the broad legend classes in both numerator and denominator fit these areas very well, thus attesting to the region- and possibly the continent-wide application of the legend concept and the broader classes.

Now consider the practical value of this kind of resource mapping as a basis for land use planning and policy. Notice in Figure 2 how agricultural cropland conversion is moving into vegetational unit 321.11, comprising 18% of our intensive study area. This indicates a kind of land well suited to agricultural development, the best of the potentially irrigable land. It is from these areas, the creosote bush types, plus the broad-bottomland riparian types 321.94, that most of the good cropland has been carved in the Sonoran Desert.

In contrast, agricultural development has tended not to move into the areas designated by 321.21 suggesting that these latter area, which comprise 43% of the study area, are not well suited to agricultural devlopment.

Space photography vividly and accurately shows how urban sprawl is eating into the choicest of the agricultural land in the area. The legend designator 519.14 indicates new suburban areas being developed as small acreages. In the upper right-hand corner of the high flight photo (Figure 2), two such areas are being developed in the 321.11 type (choice potential agricultural land). Other such areas are being developed well within the 321.21 type (in NE quadrant of Figure 2) where they more appropriately belong. Had such land classifications been recognized prior to development, urban growth could have been more appropriately encouraged or discouraged.

Other stories may be told to illustrate the relationship between ecological resource analysis and land use planning. Such knowledge gives a truly ecological basis for setting policy, planning, and zoning for the optimum use of the resources in a specified region. It is through ecological classification and relating of natural ecosystems to land use, development, and management that we will be able better to guide man's use of his environment and provide for a secure future by designing legislation, policy, regional plans, and resource management programs that are compatible with the biological dictates of each kind of resource area. It is in providing the ground work for this kind of approach that ecological resource analysis and remote sensing from space and high flight can be successfully teamed in operational programs to help man meet his environmental challenges of today and tomorrow.

REFERENCES

1. Johnson, C. W. 1969. A System of Regional Agricultural Land Use Mapping Tested Against Small Scale Apollo 9 Color Infrared Photography of the Imperial Valley. University of California, Riverside. USDI Status Report III, Tech. Report V, Contract Number 14-08-0001-10674.

2. Poulton, C. E., J. R. Johnson, D. A. Mouat, B. J. Schrumpf. 1970. Inventory of Native Vegetation and Related Resources from Space Photography. Annual Report for Earth Resources Program, OSSA/NASA. Range Management Staff, Oregon State University, Corvallis, Oregon. 32 pp.

3. U.S. Department of Transportation. 1969. Standard Land Use Coding Manual. Government Printing Office (reprint of 1965 ed.). 111 pp.

TABLE I.- HIGHEST LEVEL OF GENERALIZATION IN A STANDARD SYMBOLIC NOTATION FOR IDENTIFYING AND CODING LAND USE ACTIVITIES [1]

Code	Category
1	Residential
2	Manufacturing
3	Manufacturing
4	Transportation, Communication and Utilities
5	Trade
6	Services
7	Cultural, Entertainment and Recreational
8	Resource Production and Extraction
9	Undeveloped Land and Water Areas

[1] Abstracted from Standard Land Use Coding Manual (Dept. of Transportation, 1969).

TABLE II.- A SYMBOLIC, TECHNICAL, AND DESCRIPTIVE LEGEND,

PRIMARY RESOURCE AND LAND USE CLASS

Mapping Symbol	Technical Legend	Descriptive Legend
100	Barren Lands	The prominent features of barren lands are bare mineral soils and/or rocks. Vegetation is lacking or so widely scattered that the overall aspect is of a denuded area. Barren lands do not include temporarily denuded lands such as those caused by cultivation or plowing. Man-made barren lands created by urbanization or industry are found within the 500 class.
200	Water Resources	Only those areas perennially covered by water and lacking surface vegetation are classed as water resources. Vegetated water zones should be designated 380.
300	Natural Vegetation	Areas in which successional processes give an aspect of natural vegetation, even though the area may at one time have been strongly altered by man, are considered naturally vegetated. Areas such as logged-over forests or burns left to successional processes fit in this class.
400	Agricultural Lands	Agricultural lands are those which are characterized by man's relatively constant manipulation of the vegetation and micro-environment; the presence of feed, food, or fiber crops; and the general control of both placement and growth of vegetation.
500	Urban and Industrial Lands	Those lands which have been altered by man for living, manufacture, transportation and related activities are considered urban and industrial lands. Because of the nature of some of these land uses, they do not necessarily obscure classes 100, 200, or 300, in which case mapping units may contain these classes along with one or more 500 class.

TABLE III.- A SYMBOLIC, TECHNICAL, AND DESCRIPTIVE LEGEND,

NORTH AMERICAN VEGETATIONAL PHYSIOGNOMIC TYPES

Mapping Symbol	Technical Legend	Descriptive Legend
300	Natural Vegetation	
320	Deserts	Deserts are typified by sparse vegetation and are located in the more arid regions of the Southwestern U.S. and Northern Mexico.
330	Steppes	Within steppes, the herbaceous layer, including both perennial grasses and forbs, is usually prominent. Low to medium height shrubs are scattered or lacking except in some grazing disclimax situations--notably among Great Basin shrub-steppe types.
340	Shrub/ Scrub Lands	Medium to tall shrubs or small trees (scrub) are the prominent vegetation. These usually form a closed layer so that the herbaceous layer is completely subordinate. The herbaceous vegetation is highly variable but can be important.
350	Savannas	Dense stands of herbs overlain by scattered individuals of tall shrubs or trees.
360	Wooded and Forested Lands	The tree layer forms the prominent vegetational feature. This layer often forms a closed canopy over a variety of subordinate vegetation.
370	Alpine and Arctic Tundra	Tundra is characterized by cold temperatures and short growing seasons. The vegetation is usually low and lacks distinct layers.
380	Vegetation of Aquatic Environments	The vegetation of aquatic environments appears above the perennial water cover.

TABLE IV.- A SYMBOLIC, TECHNICAL, AND DESCRIPTIVE LEGEND,

MACRORELIEF CLASSES [1]

Mapping Symbol	Technical Legend	Descriptive Legend
1	Flat Lands	A generally flat landscape with prominent slopes less than 10 percent.
1a		The landscape is essentially smooth. Dissection is minimal. The regional slope in this class is nearly always between 0 and 3 percent.
1b		The landscape is relatively flat; however, dissection has progressed to a noticeable point. Dissection is either sharp and widely spaced (in which case side slopes may be over 10 percent), or gently rolling and more closely spaced. Where side slopes exceed 10 percent, microrelief is generally less than 10 percent.
2	Rolling and Moderately Dissected Lands	A rolling or moderately dissected landscape with prominent slopes 10 to 25 percent (side slopes may exceed that figure in the case of dissected planar surfaces).
2a		The landscape is rolling or hilly; a regional slope is not readily apparent - or - a regional slope of 10 to 25 percent is present.
2b		The landscape consists of a moderately to strongly dissected planar surface (i.e., pediment, bajada, valley fill, etc.). The regional slope is <u>generally</u> between 2 and 6 percent; side slopes must be steeper than 10 percent. If side slopes are steeper than 25 percent, relief must be less than 100 feet. The drainage network is finer than that of 1b.

[1] Mapping legend for macrorelief adapted to fit the geomorphology of southern Arizona.

TABLE IV.- Concluded

Mapping Symbol	Technical Legend	Descriptive Legend
3	Hilly Lands	The landscape is hilly to submountainous; slopes are moderate to steep, predominantly exceeding 25 percent. Relief is generally over 100 feet but less than 1000 feet. Where relief approaches 1000 feet, the landform system appears to be relatively simple - with smooth slopes. Drainage systems generally have the same base level.
4	Mountainous Lands	The landscape is mountainous, having high relief, usually over 1000 feet. Slopes are moderate to steep, frequently exceeding 50 percent. The landform and drainage systems are usually complex, with drainage networks having base levels quite independent of one another.

GENERALIZED FORM:

Resource Features

general ——————————————— *specific*

Environmental Features

SPECIFIC FORM:

Resource Classes Based on Vegetational Indicators

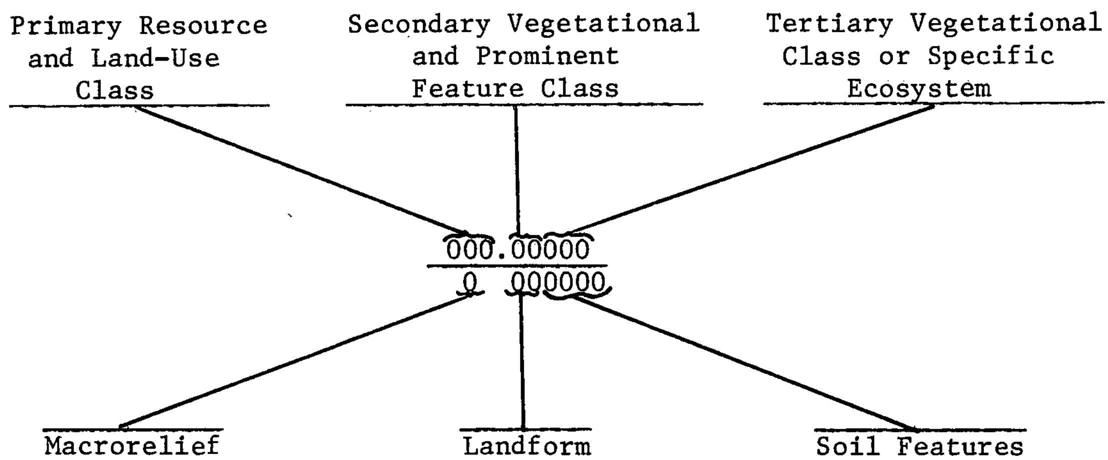

Figure 1.- An ecosystem legend format for range resource and land use analysis from space and supporting aircraft imagery.

Figure 2.– A portion of photo mosaic map of Maricopa County, Arizona, showing natural vegetation resources, agricultural, and urban land use. Mapped on high flight photography.

SYMBOLIC LEGEND	TECHNICAL LEGEND
Native Vegetation	
321.11	Creosote bush often with annuals
321.21	Bursage, saguaro, paloverde
321.22	Brittlebush, bursage, saguaro, paloverde
321.94	Mixed vegetation in desert drainage ways
Agricultural	
400	Mixed agriculture
Urban & Industrial	
510	Residential area
519.1	Small acreage suburban residences
519.14	Developing small acreage suburban residences
545.1	Freeways
545.82	Graded and graveled roads
567.5	Military bases
Macrorelief	
1a	Undissected flat land
1b	Dissected flat land
3	Hilly land
4	Mountainous land
Landform	
B	Bottomland
Ca	Bajadas and fans
Cb	Valley fills
F	Slopes


321.21 / 321.22
3F
321.21
1a Cb
519.14
321.21
1b Cb/Ca
545.82
US-89
519.14
567.5
510
400
321.21
1bCa
321.11
1aCb

Figure 2.