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SECTION 116

RESOURCE ANALYSIS AND LAND USE PLANNING WITH SPACE AND HIGH ALTITUDE PHOTOGRAPHY

by

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The philosophies and concepts upon which this research has been predicated have been clarified in earlier reports to the Earth Resources Program Review by personnel of the Range Management Program, Oregon State University. We have proceeded with the conviction that "remote sensing data have limited value until someone uses the information to make a decision or to facilitate action that benefits man" (Poulton, Faulkner, and Schrumpf, 1970); and with this basic concept: "In naturally vegetated areas the discrete, homogeneous plant communities that occupy the landscape are the best indicators of areas of analogous, effective environment--thus, of ecological site and of equivalent potential" (Poulton, Faulkner, and Martin, 1971). Suggestions have been presented for appropriate photographic scales required to provide resource data for the decision-making processes of land use planning and management (Poulton, Driscoll, and Schrumpf, 1969). A legend system for barren lands, water resources, natural vegetation, agricultural, urban, and industrial lands constructed in a hierarchical framework was introduced, accompanied by a mapping symbol format (Poulton, Faulkner, and Schrumpf, 1970).

The current report deals with the application of these ideas and developments in the production of two natural vegetation resource and land use maps for a major portion of Maricopa County, Arizona; both maps are photo maps. Maricopa County is 9,238 square miles in size. One photo map displays an inventory of approximately 90% of that area, depicting eleven natural vegetation types, areas of intensive agricultural and urban land use, and a macrorelief classification of the landscape. It is constructed from portions of 8x8 inch enlargements of

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[1]In addition to the author, substantial contributions to the work reported here have been made by David P. Faulkner, James R. Johnson, David A. Mouat, and Charles E. Poulton. They are all personnel of the Range Management Program, Oregon State University.

color infrared frames AS9-26-3800 through -3802 (SO-65 Multispectral Photographic Experiment) and presented in Poulton, Johnson, and Mouat (1970). The mosaic for the other photo map consists of seventy black and white copies of high altitude RC-8 Ektachrome photography flown at an original scale of 1:124,000 (NASA Mission 139, July 28, 1970). The working copies of this map are 1:133,000 (Pettinger, L. R., et al, 1970). Approximately 64% of the county is included on this map. Twenty-two vegetation taxonomic units are noted on the map, plus barren lands, water resources, classes of agricultural crops and associated activities, kinds of urban and industrial lands, macrorelief and landform. Of the area imaged, naturally vegetated lands constitute 80%; agricultural lands, 14%; urban areas, 5%; and barren lands and water resources, less than 1%. Each map was produced by first inspecting the photography and grouping images on the basis of macrorelief, color, and pattern characteristics. Ground samples were then obtained representing each class of photographic image. Ground subject-photographic image relationships were determined, and then the remainder of the photography photo interpreted. The locations of ground checking activities and aerial reconnaissance flights are shown in Figure 1. Table I provides a summary comparison of the information content that was portrayed on the two maps. There is an obvious increase in the number of subjects that could be delineated and annotated on the high altitude photo map as compared to the space photo map. This is a result of the increase in interpretive detail and the larger scale available with the larger scale of photography. When comparing the attributes of the two kinds of photography, it can be readily appreciated that the resolution characteristic of space photography imposes limitations on the degree to which identifications can be refined. Furthermore, the photographic scale places limitations on the number of subject representatives that can be delineated and noted on the map, even if they can be properly identified, because of the small size of the photographic images that represent the subjects. A comparison of these two mapping jobs could easily be pushed too far; the purpose of presenting Table I is to give one comparative example of mapping capabilities with the two kinds of photography. Table I does not indicate that high altitude photography is "better" than space photography for mapping purposes. This judgment can only be made in light of the information need that is to be served and the time, money, equipment, and manpower available for satisfying that need.

From Figure 1 it can be seen that approximately 25% of the area represented on the high altitude photo map received intensive ground checking. The remainder of the map was based on photo interpretation. To determine the reliability of the portions of the map produced through photo interpretation an accuracy check was planned and carried out. Sample points located by the intersections of a grid placed randomly over the map were chosen so as to sample delineated subjects in proportion to the total areal amount each contributed to[2] the photo interpreted portion of the map. In ten hours of helicopter flying time, 145 sample points were visited. The areas which include these points are shown in Figure 1. The most distal locations were over one hundred miles apart and several were in very rugged terrain. To accomplish the accuracy check job from the ground would have required many man-weeks. Helicopter navigation was accomplished by visually comparing the high altitude photography (1:124,000) to the terrain while in flight. The locations were found without great difficulty, even in rugged areas. As the helicopter hovered or circled over the sample location, a plant species list with accompanying prominance ratings was recorded. Back in the lab each list was keyed out in the vegetation legend for identification as to taxonomic type. Each accuracy check identification was then compared to the photo map and a tally kept of the correct and incorrect photo interpretations represented on the map. This provided the information given in Table II. A careful study of this Table will yield the following kinds of information.

1) The accuracy with which representatives of specific subjects have been identified. Example: Seventeen of the accuracy check locations supported 321.11 vegetation and they were all identified correctly through photo interpretation giving 100% accuracy (100% - % Error of Omission).

2) The reliability of the photo interpretation identifications for each subject. Example: Thirty-nine accuracy check locations had been determined through photo interpretation as having 321.11 vegetation; of these only seventeen actually did. Therefore, 44% of the 321.11 interpretations were correct (100% - % Error of Commission).

3) A revealing of the kinds of photo interpretation errors that were made. Example: Within the actual 321.2 vegetation group there are three closely related subgroups (321.21, .22, and .23). Photo interpretation errors of the 321.2 group consisted primarily of confusing representatives of the three subgroups. Very few 321.2 representatives were photo interpreted as something outside this group and very few representatives from other than the 321.2 group were mis-identified as 321.2 types.

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[2] A helicopter and pilots were provided by the U.S. Air Force. Arrangements were made by Robert Miller, U.S.D.A. Remote Sensing Technical Coordinator. Lt. Col. James A. Hamilton, Luke A.F.B. and helicopter crews under his command provided the necessary support.

4) An indication of the consistency with which specific errors were made. Example: All 321.15 representatives were photo interpreted as being 321.11 types (the same error was made 100% of the time).

5) A basis for adjusting for errors. Example: 33% of the 321.11 photo interpretation identifications were actually 321.15 types. Therefore, a table showing the amount of 321.11 and 321.15 types present, as determined through photo interpretation, could be adjusted accordingly (33% of the number of 321.11 types tallied would be removed to the 321.15 tally).

In addition to the above kinds of analyses, the accuracy check data may provide evidence suggesting subjects that were not classified during legend development, or the data may indicate a need for revising some classification criteria.

Table III gives an evaluation of the severity of the kinds of photo interpretation errors that were made. Each kind of error was determined through an analysis similar to that given in (3) above. Sixty-five percent of the interpretations were correct; another 28% involved errors that were inconsequential for some purposes.

A vegetation resources, agricultural and urban land use map, while presenting a considerable amount of information about current surface features and activities, certainly need not be considered an end in itself. One potentially very important use of the information contained in such a map is in land use planning. A brief example follows:

Based on characteristics of specific vegetation types and macro-relief classes, and on observations of past and present land use patterns and conversions occurring in the study area, it was possible to establish criteria for classifying land which was potentially suited for agricultural and/or urban development. Area calculations of lands so suited revealed the following. Approximately 1900 square miles of potential agricultural lands exist yet undeveloped. They comprise nearly 86% of the naturally vegetated flat lands in the inventoried area. Urban lands could also potentially come to occupy the flat lands (with the exception of flood plains) in addition to undulating to rolling lands. Potential urban lands include 90% of the total available naturally vegetated flat lands. Obviously, then, a potential conflict exists which must be addressed as expansion in the area continues. While only 10% of the potential agricultural lands are not in conflict with urban expansion (those lands on flood plains), nearly 35% of those lands suited for urbanization are not suited for agricultural development. If agriculture is to remain as a major component in the land use scene of this region, then zoning and taxes will have to be so structured as to eliminate the potential land use conflict.

Overlays can be constructed to show the areas satisfying the potential land use criteria. Separate overlays were constructed to show both potential agricultural and urban lands. When one is placed over the other the location of lands subject to a potential conflict, as discussed above, are clearly revealed. When the overlays are placed over the photo map they show potential land uses in relation to current uses.

These displays of information (photo maps and overlays) have been extremely valuable for conveying resource information and analyses of that information to other persons. Additionally, they would appear to provide a powerful tool for generating inputs for making land use planning decisions in a manner that facilitates making those decisions.

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TABLE I.- A COMPARISON OF THE INFORMATION CONTENT PORTRAYED ON THE TWO KINDS OF PHOTO MAPS

Photo Map Type	Number of Mapped Types Annotated on the Photo Maps							Approximate Number of Delineations
	Natural Vegetation	Barren Lands	Water Resource	Agriculture	Urban	Macrorelief	Landform	
Space Photo Map	11	0	0	1	1	7	0	50
High Altitude Photo Map	22	2	1	6	5	8	9	350

TABLE II.- COMPARISON OF ACCURACY CHECK INFORMATION AT 145 LOCATIONS WITH PHOTO INTERPRETATION IDENTIFICATIONS FOR THE SAME LOCATIONS MADE ON HIGH ALTITUDE RC-8 EKTACHROME PHOTOGRAPHY

The numbers (321.11, 321.21, etc.) in the row across the top of the table represent those legend units identified by photo interpretation of high altitude photography and delineated and annotated on the photo mosaic map.

The column at the left indicates those legend units identified from the data gathered at the accuracy check points. Each row of the table begins with one of these legend units and the distribution of the numerals along a row indicate how the representatives of the legend unit were identified by photo interpretation. For example, in the row designated 321.22, seventeen check points had been previously and correctly photo interpreted as 321.22 and four were incorrectly identified as either 321.21 or 321.23. Because these latter four were actually 321.22 units interpreted as another subject they represent "errors of omission."

In the column headed 321.11 the numerals indicate that seventeen 321.11 accuracy check points had been previously interpreted correctly. There were other subjects (321.12, 321,15, 321.17, and 321.21) which had also been identified as 321.11 when they were not. These incorrect identifications are called "errors of commission."

Calculation of percent correct, omission, and commission is demonstrated in the following example. Interpreted units (denoted A) are sampled in the accuracy check (denoted B). A comparison is made between the interpreted units (A) and the accuracy checked units (B).

Correct = A agrees with B
Omission = Area identified in B not included in A
Commission = Area interpreted in A does not agree with B

$$\%\ \text{Correct} = \frac{\text{Number of A's that agree with B's} \times 100}{\text{Total number of B's}}$$

$$\%\ \text{Omission} = \frac{\text{Number of areas identified in B not included in A} \times 100}{\text{Total number of B's}}$$

$$\%\ \text{Commission} = \frac{\text{Number of areas interpreted in A not agreeing with B} \times 100}{\text{Total number of A's}}$$

TABLE II.- CONTINUED

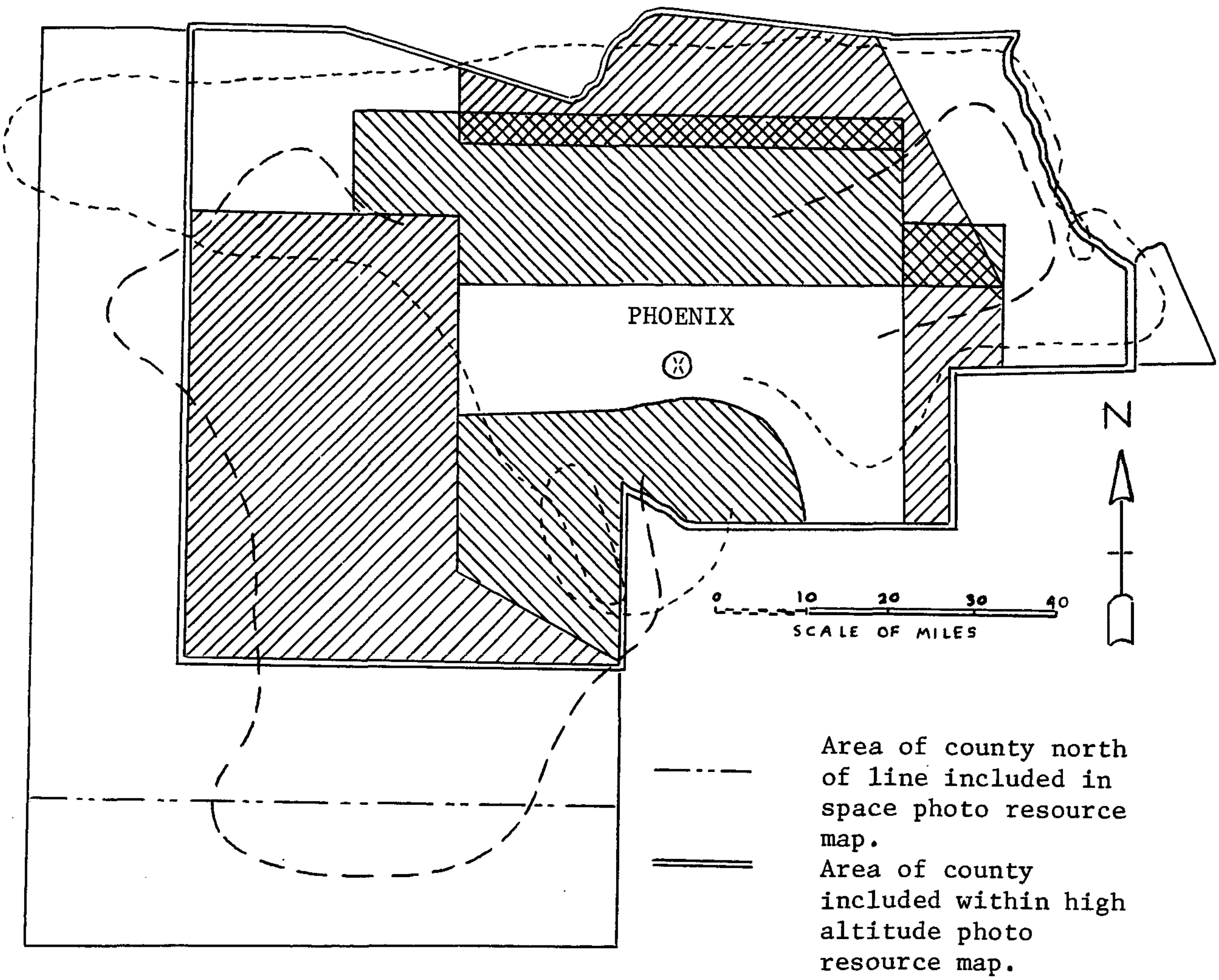
INTERPRETED UNITS

ACTUAL UNITS	321.11	321.21	321.22	321.23	321.32	321.41	321.9	321.93	331.	342.1	Actual total Number	% Error of Omission
321.11	17										17	0
321.12	5										5	100
321.15	13										13	100
321.17	1										1	100
321.21	3	27	5	7			1				43	37
321.22		1	17	3							21	19
321.23		3	2	26		1					32	19
321.9							1				1	
321.92							1	1			2	
321.93								2			2	
331.2									1		1	
342.1										3	3	
361.2										1	1	
144								1			1	
400					1						1	
484					1						1	
Total Number Interpreted	39	31	24	36	2	1	3	4	1	4	145	
% Error Commission	56	13	29	28								

TABLE III.- EVALUATION OF HIGH ALTITUDE EKTACHROME PHOTOGRAPHY INTERPRETATION ACCURACY

Degree of Accuracy	Evaluation	Number of Locations in Sample	Percent of Total
No error	Accuracy check and photo interpretation indicated the same vegetation	95	65
Closely related vegetation types were confused by improper identification of secondary plant species	These errors would have little impact on agriculture or urbanization land use projections	40	28
Moderately related vegetation types were confused by improper identification of major plant species	These errors could have strong impact on agriculture land use projections; the vegetations confused were contained within the microphyll desert portion of the legend	6	4
Apparently distantly related vegetation types were confused by improper identification of physiognomic types	A woodland and chaparral type were confused	1	1
Primary resource was incorrectly identified	Idle agricultural fields or barren stream channel lands were interpreted as naturally vegetated	3	2
	TOTAL	145	100

Figure 1.- Location of Ecological Resource Inventory and Classification Activities and Accuracy Check Areas Within Maricopa County, Arizona.



Flight paths of aerial reconnaissance.

Areas of intensive ground sampling.

Areas of photo interpretation accuracy check.