

BIOGRAPHICAL SKETCHES

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While fulfilling his educational objectives, he has been employed as a Project Leader for the Image Enhancement and Interpretation Unit of the Forestry Remote Sensing Laboratory where he has helped to develop interpretation techniques for performing resource inventories at the NASA test site at Phoenix, Arizona. He is a member of the American Society of Photogrammetry, Society of American Foresters and Xi Sigma Pi, and was a recipient of the ASP's Wild Heerbrugg Photogrammetric Fellowship Award in 1968.

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FIELD DATA COLLECTION - AN ESSENTIAL ELEMENT

IN REMOTE SENSING APPLICATIONS

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INTRODUCTION

Field data collected in support of remote sensing projects are generally used for the following purposes: (1) calibration of remote sensing systems, (2) evaluation of experimental applications of remote sensing imagery on small test sites, and (3) designing and evaluating operational regional resource studies and inventories which are conducted using the remote sensing imagery obtained. In other words, field data may be used to help develop a technique for a particular application (uses 1 and 2 above), or to aid in the application of that technique to a resource evaluation or inventory problem for a large area (use 3 above). Scientists at the Forestry Remote Sensing Laboratory have utilized field data for both purposes. This paper will describe how meaningful field data has been collected in each case.

FIELD DATA FOR TECHNIQUE DEVELOPMENT - THE SIMPLEST CASE

Studies of the first type (technique development) have been performed on several occasions using a stationary sensor platform 150 feet above the ground on the catwalk of a water tower at the Davis campus of the University of California (Figure 1). Over a period of several years, various kinds of target arrays have been positioned beneath this water tower such that they can be imaged using any of a variety of sensors.

For example, the usefulness of multiband photography has been investigated by photographing color panels, soil samples, and arrays of growing crops from the water tower (Figures 1 and 2). The same camera station is occupied for each camera exposure taken, thus eliminating one of the major problems, that of obtaining several matching multiband exposures of the same target array from an aircraft. All efforts to collect ground data are also simplified because there is only a single target array at one location. One field crew can record the condition of each target, obtain spectrometric data, and perform other operations as needed in an efficient manner (Figure 1).

Experiments using thermal infrared sensors have also been performed from the same platform. Thermal data can be obtained on an around-the-clock basis, and radiometric, surface temperature, and soil moisture measurements can be made at the time each thermal record is made from the tower (Figure 1). Continuous communication between the sensor operator and personnel on the ground below is made possible because the camera station and target array are both in a fixed position, separated by a short distance which can be bridged by voice or with portable battery-operated radios.

THE NEXT STEP: PROBLEMS ENCOUNTERED

A number of problems arise in attempting to apply remote sensing techniques to extended areas, and these must be acknowledged before the gap between technique development and application can be successfully bridged to extract meaningful resource information for potential users from remote sensing data.

First of all, studies of a large geographic area involve greater travel and the need for increased coordination between field teams. The need for communication among teams becomes more critical, especially in terms of coordinating field activities with the schedule of the remote sensing vehicle, be it aircraft or spacecraft. If there is a need for measurements to be made on the ground at the same time as the vehicle is overhead (e.g., spectrometric and radiometric readings, soil moisture determination, and enumeration of livestock), then frequent air to ground contact is essential.

Secondly, representative areas on the ground in which to gather information must be selected so that enough data will be collected within the economic constraints of the project. Preliminary sampling to determine the distribution and variability of each of the important resource features is helpful in this regard.

Thirdly, a rapid, efficient means must be developed for collecting large amounts of data in the field, storing it for later use, and extracting it in a meaningful fashion.

BRIDGING THE GAP: A CASE STUDY

Agricultural inventory techniques using small scale aerial and space photography of the Phoenix, Arizona area have been developed by personnel of the Forestry Remote Sensing Laboratory. This research which began in March, 1969, represents an interesting example of how remote sensing techniques were developed, and how the gap between technique development and application was bridged. The following discussion will concentrate upon the way in which field data collection methods were developed to provide information with which to evaluate the techniques developed, and to assess the application of these techniques on a regional basis.

Apollo 9 multiband photography was obtained in March, 1969, for use in developing improved capability for the inventory and analysis of earth resources. In addition to the Apollo 9 photography, the Phoenix test site has been the subject of regular high altitude (60,000 feet flight altitude) multispectral aerial photographic missions made possible through the NASA Earth Resources Survey Program. These missions, the first of which coincided with the Apollo 9 experiment, were flown at frequent intervals during the ensuing two years. Eighteen missions occurred between March, 1969, and March, 1971.

It became apparent at the outset of the experiment that the nature of the photography which was to be obtained -- i.e., broad areal coverage at regular intervals through a variety of seasonal conditions -- was such that it would lend itself well to performing regional resource surveys. The decision to orient the research towards performing surveys of agricultural crops in Maricopa County (which contains the city of Phoenix) was made for several reasons:

(1) there exists a need for accurate, timely, and inexpensive crop inventory information; (2) the seasonal variability which characterizes crop development patterns in the test site provided the basis for analysis on sequential aerial photography; and (3) the relatively uniform appearance of each crop type (as contrasted to the irregularity of wildland vegetation) simplifies the task of developing workable reference materials and photo interpretation keys for crop identification. The location of Maricopa County, where the survey was performed, and an indication of the distribution of agricultural land is presented in Figure 3. The first year's efforts were centered upon monitoring crop sequences and determining how high altitude aerial photography, obtained sequentially, could best be used to identify the major crops. Thus, procedures for crop identification constituted a major technique being developed, and agricultural inventory was the ultimate application under consideration. Data collected in the field consisted only of that information which affected crop identification directly (crop type, stage of maturity, percent cover, etc.). For this reason, no crop yield data or detailed vigor assessments were made.

Detailed field studies were begun in two areas south of Mesa, Arizona in March, 1969 at the time of the Apollo 9 overflight (Figure 4). A 16-square-mile area containing more than 125 individual fields was chosen as the primary study area. This site was chosen because (1) it was contiguous, (2) it was easy to reach for gathering crop data on a field-by-field basis, (3) it contained many of the important crop types found in the Phoenix area as well as a number of fields of each crop type, and (4) it was imaged clearly on the Apollo 9 photos as well as on most of the photography taken during subsequent aircraft missions. Additional ground data were also gathered during 1969 for another area of some 22 square miles (more than 250 fields) located in the same general region.

These two areas, totaling over 24,000 acres of agricultural land, were monitored at the time of each photo mission so that distribution and variability of crop type, crop development patterns, and crop signature could be adequately assessed. Coincident with each aircraft mission, each field was visited on the ground and notes were collected regarding crop type, condition, height of stand, and approximate ground cover percentage. Field maps of these test sites were prepared for field use and annotation. Boundary changes could easily be made while crop data was being recorded. Since the same field personnel were used to collect ground data at the time of each flight, they became familiar with the test site and crop patterns.

The most serious limitation to developing useful crop identification techniques lies in the variability of crop type and cropping practices. Any factor which affects the distribution, seasonal development and vigor of a crop will affect its photographic signature, and thus may influence the success with which that crop can be identified. The backlog of field data collected at the test sites near Mesa was used to develop some a priori knowledge regarding these factors which would be useful in developing practical interpretation techniques. Conclusions regarding these factors were as follows:

1. Crop type and distribution. It is generally true that agricultural practices in an area are relatively stable and that totally foreign crops are rarely introduced. For this reason, interpretation keys can be devised for

particular crops in a specific area with little fear that certain crops will totally disappear or that new crops will suddenly be introduced in large number. These generalizations were found to be valid for the main crops grown in central Arizona during a recent 4-year period.

2. Seasonal development. Documentation of the seasonal development of crops is important for determination of optimum times of the year for crop type discrimination. Both within-season and between-season variability will affect the specification of optimum dates for obtaining photography. Knowledge of crop sequences and of the variations which affect these sequences must be understood. For agricultural areas, the cyclic changes and the approximate dates when they occur are best summarized in a table or chart known as a "crop calendar" (Figure 5). In addition to crop development information collected at the time of each flight, generalized crop conditions for the Salt River Valley (the major agricultural producing region of Maricopa County) were obtained from weekly crop condition reports released by the Arizona Crop and Livestock Reporting Service. Using this prepared information, tone values of individual fields (as seen on photography of a given date) can be related to the stage of maturity of the crops on that date, as summarized in the crop calendar. The calendar can then be used to determine either (1) at what single date a particular crop type has a unique signature that could be discriminated from signatures of all other crops, or (2) what combination of dates for sequential photography would best permit identification of that crop type.

3. Crop signature. Since little field detail is discernible at the scale and resolution of the high altitude Nikon photographs (scale 1/950,000) which were studied during 1969, photographic tone or color became the critical factor for identification. Either unique spectral signatures must exist at one date so that individual crop type can be identified, or else sequential patterns of tone or color must exist such that crop type can be distinguished on the basis of changing patterns (i.e., bare soil to continuous cover crop to bare soil) at particular dates through the year.

Interpretation tests were administered using photography of the test sites in which ground data were collected to determine which dates and film/filter combinations were best for identifying specific crop types. Some of the results of these tests are reported upon by Lauer in another workshop paper.

OPERATIONAL SURVEYS - THE FINAL STEP

During 1970, the area around Phoenix which was photographed by the NASA RB57F aircraft was increased to include most all the agricultural land in Maricopa County (Figure 3). At this point it was decided that the type of study initiated in the test sites near Mesa must be extended so that procedures developed might apply regionally instead of locally. The gap between technique development and application would hopefully be bridged at this point. Two aspects of the nature of this gap were assumed which would affect the direction of future work. First of all, it was recognized that crop distribution throughout the entire county would not be similar to the distribution found in the test sites near Mesa. Also, the photographic tone or color signature of given crop would vary throughout the test site as a result of variation in crop condition and development (stage of maturity at a single date, crop vigor, weediness, etc.).

This variation would mean that photo interpretation keys and reference materials prepared from images of the Mesa test sites could not be used with equal effectiveness as an aid to interpretation of an entire set of photography for the county. For these reasons it was decided to expand the scope of field data collection so that regional use of the data would be possible.

Examination of the Apollo 9 Infrared Ektachrome photography (AS9-26-3801) of Maricopa County suggested that there was enough variability in appearance of the cropland that some stratification might be desirable. Strata that appeared homogeneous were delineated on the space photo and 32 four-square-mile field plots were selected for detailed field-by-field study. These plots were allocated to the strata on a proportional area basis. Plot centers were chosen to coincide with the section corner nearest to the map point selected. In this way, the boundary of each square mile of a field plot would be identical to the boundary of a square mile as plotted on a topographic map. The objectives of collecting these data in conjunction with the April, 1970 NASA overflight and at the time of each successive flight were twofold: (1) to determine the distribution of the major crops in the county (determining whether the boundaries delineated on the space photo were meaningful in terms of accounting for crop variability); and (2) to evaluate the accuracy of crop type identification on photography obtained later in the year.

Thirty-two plots were chosen because this number could be completely field-checked within a two-day period by a team of three persons (economic constraint), and enough data would be provided for adequate statistical analyses (statistical restraint). A four-square-mile plot size (two miles by two miles) was chosen because it was large enough to contain a representation of the major crops growing in the particular area where the plot was located, yet small enough that several plots could be visited each day.

Maps of each plot showing field boundaries were drawn based on their appearance on earlier high altitude photography. Each plot was visited by a field crew at the time of each NASA overflight for the months of April, May, June, July, October, November, 1970, and March, 1971. Information gathered in this manner (Figures 6 and 7) included the category of crop growing in each field, its stage of maturity and condition, the percentage of ground covered by vegetation, crop height, and direction of rows (if any). The crop category code which was used is an adaptation of a coding system originally developed by the U.S. Government for categorizing land use (U.S. Department of Transportation, 1969) and subsequently refined for specific use in agricultural land use mapping by researchers at the University of California, Riverside (Johnson, et al., 1969).

Since more than 2500 fields were present in the 32 four-square-mile sample plots (comprising more than 80,000 acres), field data were punched on computer cards in order to facilitate access to this information in the future. Programs were then written which made possible the compilation of data by stratum, field plot, crop type, and date, and which provided for subdivisions or consolidations of fields over time. Thus, data are available not only for each date of photography, but for the sequential changes in crop type and conditions through the growing season as well. An example of the computer printout for a few fields from one field plot appears in Figure 8.

Using the data which were derived from the first month's field inventory, the distribution and variability of crop acreage were evaluated to determine if the space photo strata delineations were useful in accounting for some of the variability in crop patterns. Analyses of variance indicated that there were no significant differences between strata in terms of acreages of major field crops. Therefore, it was assumed that acreage estimates from future surveys which used stratification as made on the Apollo 9 space photo of Maricopa County would not be improved. In addition, calculations indicated that the acreage distribution of major crops was so variable that for any plot size, extremely large samples for photo interpretation would be necessary in order to assure acreage estimates that would satisfy accuracy requirements. For example, in order to estimate the acreage of wheat with a standard error of $\pm 10\%$ of the total acreage using a plot size of four square miles, a 75% photo interpretation sample would be necessary.

Once data for all 32 field plots were tabulated and prepared for computer analysis, they were used for two purposes: (1) providing training and reference material for photo interpretation testing for crop identification (as reported upon by Lauer in another International Workshop paper), and (2) adjusting photo interpretation estimates when regional surveys are performed (a workshop paper by Draeger summarizes this application). In addition, this data can be used to determine crop sequences that occur from season to season, and possibly may be employed to predict future crop patterns.

GROUND "TRUTH" - WHEN IT IS AND ISN'T

The term "field data" has been used in this discussion in preference to "ground truth", a term which is widely used among remote sensing scientists -- but occasionally misunderstood by them. Such misunderstanding usually occurs when "ground truth" is accepted as an unbiased statement of the real conditions as they exist on the ground in the area being studied. This may well be a valid conclusion, yet the most rational approach should be to accept field data as an estimate of the ground condition. If measurements taken on the ground are carefully made and relevant kinds of measurement are selected for measurement, then it can be assumed that a near one-to-one correspondence exists between field measurements and the phenomena which they are supposed to characterize. If these precautions are ignored, however, then serious thought must be given to the usefulness of these data.

Since field data are collected by field personnel on the ground where the features and conditions can be seen "close-up", one's inclination is to accept them as "truth". However, two factors may affect the validity of this assumption and strengthen the admonition of the previous paragraph. First of all, ground measurements must be made which can be related to those parameters which are measured on remote sensing imagery. If the wrong field measurements are made, or if certain measurements are omitted which are critical for evaluation of the imagery, then conclusions regarding the worth of the imagery may misrepresent its true value. Secondly, once a set of ground measurements has been chosen, the care with which they are collected will determine the degree to which they can be relied upon for sound data analysis.

The effect of judgment errors which influence the first factor can be described by reference to the collection of field data in the Phoenix area. At present, information of the type summarized in the coded fraction in Figure 8 is collected. Personnel from our lab who have attempted automatic classification by means of scanning microdensitometer readings and computer analysis suggest that more detailed field measurements are needed for thorough analysis. Although no framework has been developed to determine how this added information may be of use in automatic image classification work, it has been suggested that the following items should also be recorded: soil moisture, presence and extent of invading species and weeds, percent bare areas in fields, vigor descriptions where applicable, and detailed mapping of the field environment (i.e., tractor access, storage pens, and drainage and irrigation lines). If this information is, in fact, required for automatic analysis, then current specifications fail to provide the needed information. Of course, requirements for field data collection may be constantly updated, and communication between co-workers (e.g., personnel working with automatic image interpretation and human image analysts) should be encouraged so that each field exercise might produce maximum return for the effort expended.

The importance of the second factor can also be stressed with reference to the Phoenix study, where errors by field personnel can easily lead to the collection of inaccurate "ground truth". If field teams must gather crop data on a field by field basis for several thousand acres (as has been done for the Phoenix study) in a short period of time, it is usually possible to visit only one portion of a given field as the crew moves by vehicle through the area. Identifications made at one side of a 40-acre field are extrapolated across that field. A careful look at that field will usually indicate whether the crop is continuous across the field, or if some other crop has been interplanted. However, an example of the possibility for errors to be made is given in Figure 9. This condition is usually corrected if the area is revisited at a later time, in conjunction with a future flight. Different routes through the test sites are generally followed on each date, and different sides of the same field can be visited. Any discrepancies between previous records (copies of which are carried by field teams) can be verified. Also, comparison of field data obtained on a particular date with the imagery obtained on that same date will expose boundaries and crop differences that were not evident to the field teams (Figure 9). Thus, the usefulness of field data for evaluating a set of imagery will depend upon the accuracy of the field estimates made on the ground. Some errors ascribed to photo interpreters should rightfully be ascribed to "ground truth". The possibility for encountering this type of error must be understood when a set of "ground truth" data is collected and used to evaluate remote sensing imagery.

CONCLUDING REMARKS

This paper has distinguished between field data collection for two differing uses: technique development and technique application. The scope of field data collection for each case was outlined and differences in terms of amount, timing, and format for collecting pertinent field data have been indicated. It is most important, for each application of remote sensing technology considered, that these distinctions be evaluated carefully in light of stated objectives so that reliable and timely data will be specified and collected. In addition,

care must be taken to ensure that any measurements are accurately recorded so that they do, in fact, provide an accurate estimate of "ground truth". Also the parameters which are chosen for field measurement should be those that relate most directly to image characteristics of the feature of interest.

The study of agricultural resources in Maricopa County, Arizona, has been described in depth to indicate how field data techniques were developed, first for a small "calibration" test site, then for a regional survey. As applications in other disciplines are pursued, the same kind of problems will no doubt be encountered. Not until regional studies are attempted will the considerations regarding field data collection have such far-reaching implications.

LITERATURE CITED

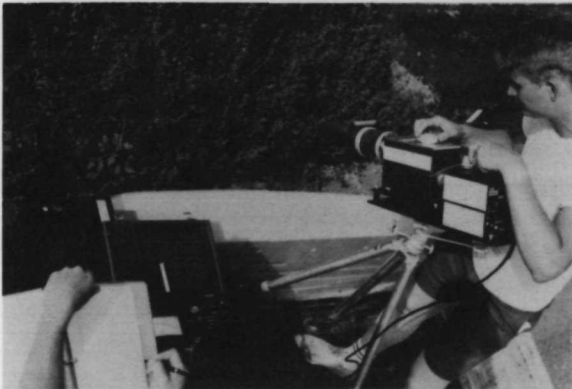
- Johnson, C.W., et al. 1969. A system of regional agricultural land use mapping tested against small scale Apollo 9 color infrared photography of the Imperial Valley. University of California, Riverside. USDI Status Report III, Tech. Report V, Contract 14-08-0001-10674.
- U.S. Department of Transportation. 1969. Standard Land Use Coding Manual. 111pp.



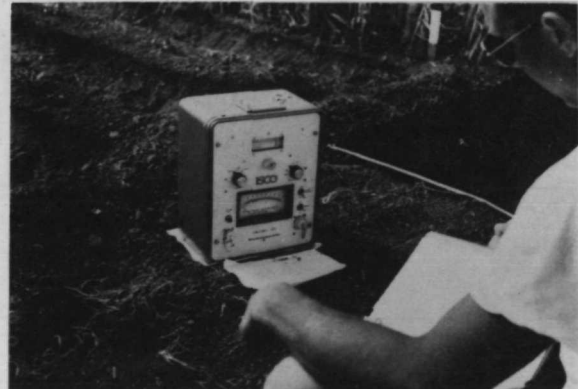
(a) Oblique aerial photo showing the water tower catwalk from which imagery was procured from a near-vertical angle of the target array below. Note that this target array contains crops, soil samples, soil moisture plots, water tanks, livestock, and color panels. Two Barnes Engineering thermal infrared sensors are mounted on the catwalk in this view.



(b) Surface temperature of objects in the array can be measured using a surface temperature probe.

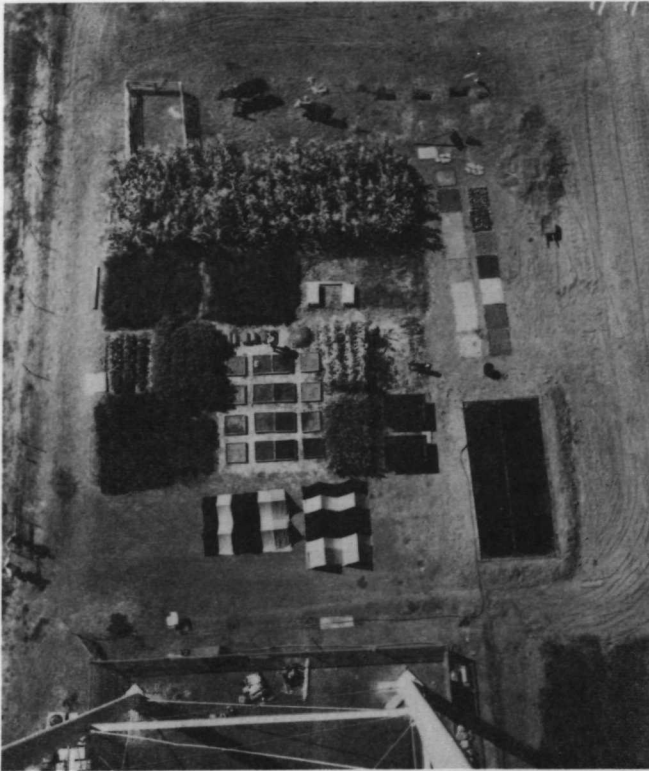


(c) Spectral reflectance data from each target in the array can be obtained at the time of image acquisition using an EG&G Spectroradiometer. Visible and near-infrared reflectance is measured in this manner.

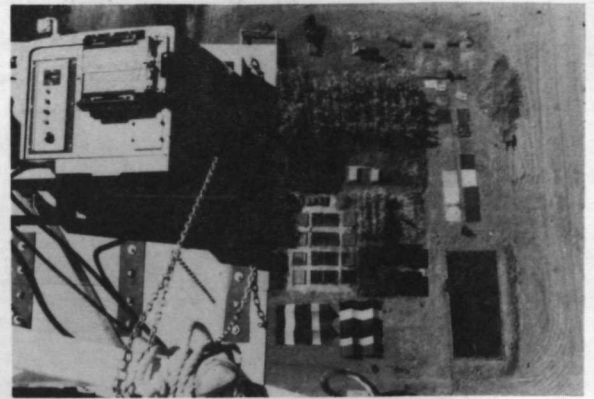


(d) The quantity and spectral distribution of incoming solar radiation can be measured with an ISCO Spectroradiometer.

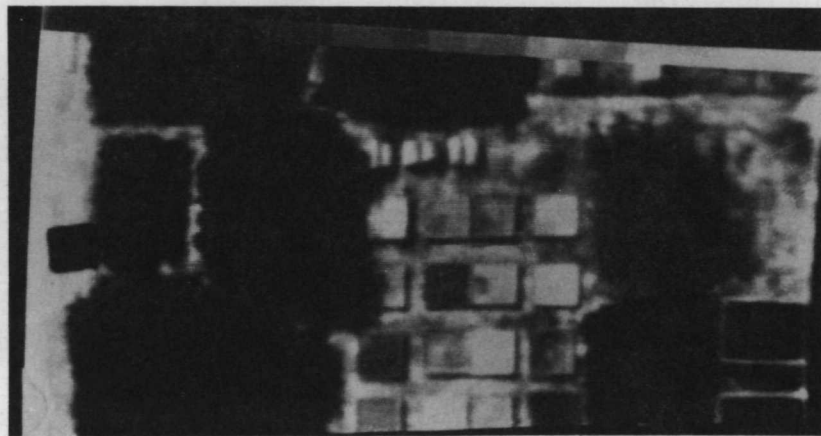
Figure 1. An oblique aerial photo of the target array and water tower sensor platform at the University of California, Davis campus, appears at (a) above. Various instruments used to measure spectrometric and radiometric characteristics of objects in the array are shown at (b), (c), and (d).



(a) This photo is one of many multiband photos taken of the target array below by exposing panchromatic film with a Wratten 25 filter.



(b) Near-vertical view of target array in (a) as seen from water tower catwalk. One of two Barnes Engineering thermal infrared sensors is visible. An example of a thermal infrared image obtained with this sensor appears in (c).



(c) This photo-like image was made using the Barnes Engineering thermal infrared sensor seen in (b). Only the central part of the array was imaged because the field of view is somewhat limited. Light tones are indicative of relatively warm features while dark tones are cold features.

Figure 2. The images reproduced in (a) and (c) above were obtained on Sept., 14, 1967, from the sensor platform shown in Figure 1. Note that near-vertical imagery of the target array was procured in both cases from the catwalk of the water tower (c).

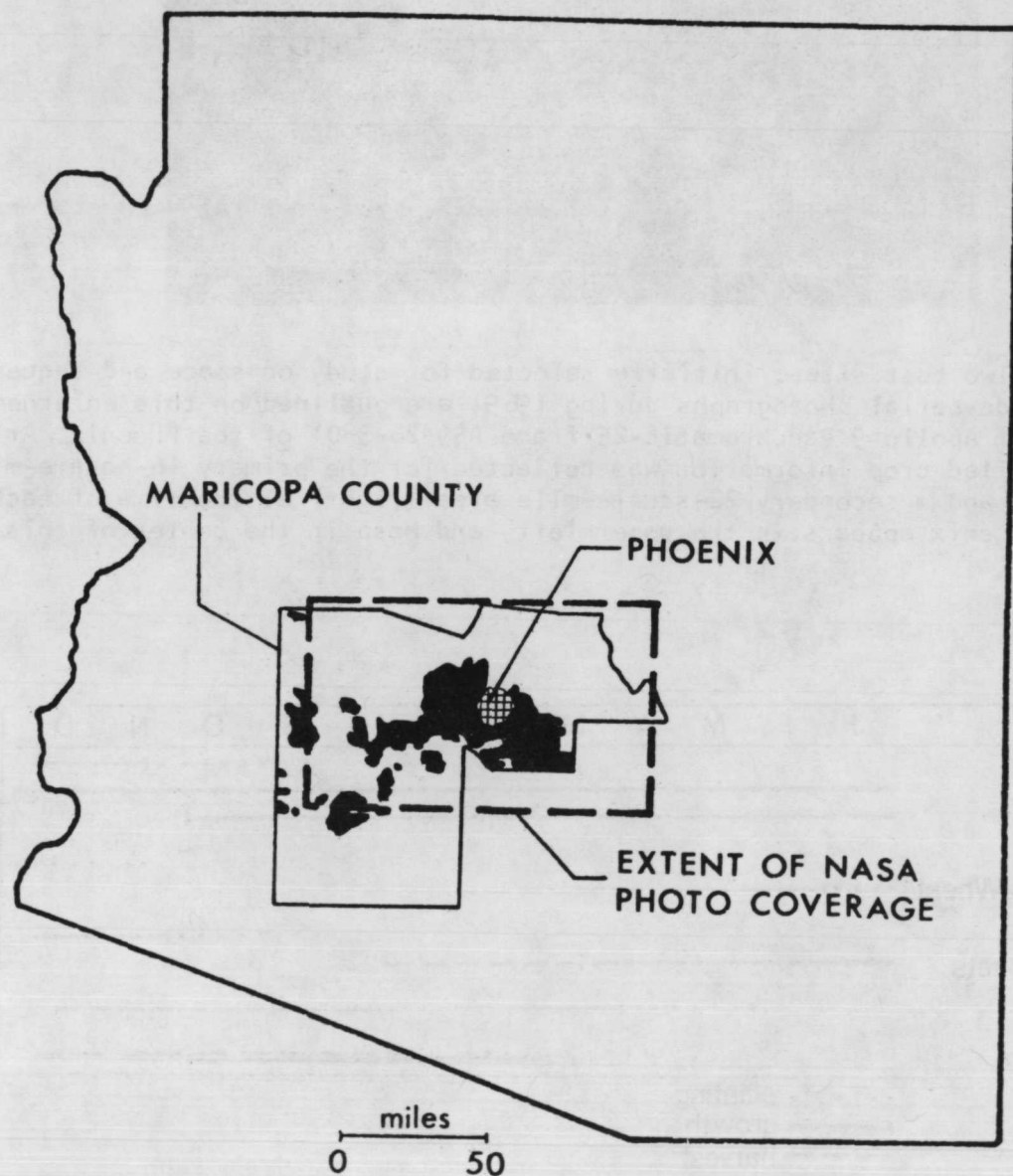


Figure 3. The location of the Maricopa County, Arizona test site is indicated on this map of the state of Arizona. The areal extent of NASA-obtained photographic coverage for each mission during 1970 is indicated. Note that essentially all agricultural cropland in the county is contained within the area photographed. As discussed in the text, 32 4-square-mile plots within the cropland area were selected for detailed field study.



Figure 4. Two test sites, initially selected for study on space and sequential high altitude aerial photographs during 1969, are outlined on this enlargement of a portion of Apollo 9 Panchromatic-25 frame AS9-26-3801 of the Phoenix, Arizona area. Detailed crop information was collected for the primary 16-square-mile area (left) and a secondary 22-square-mile area (right) at the time of each flight. Phoenix appears in the upper left, and Mesa in the center of this frame.

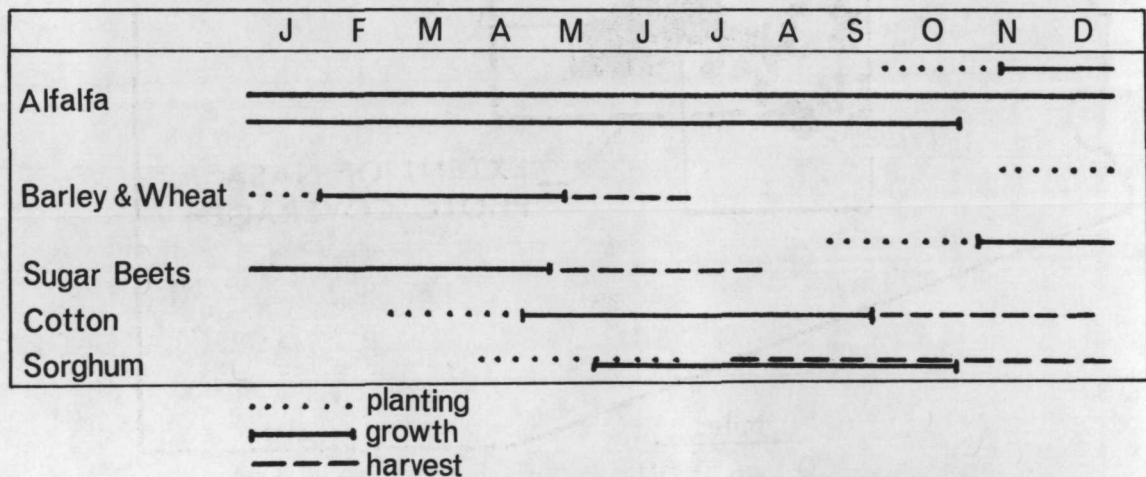


Figure 5. This crop calendar summarizes the development patterns of five major crop types in the Phoenix test site. The duration of each of the three main phases of development (planting, growth, and harvest) is indicated. It was prepared using field data and published crop status reports for Maricopa County. This kind of information is used to select optimum dates for discrimination of each crop type on aerial and space photography.

CELL 2-1
 DATE 7-20-70
 CREW SLW

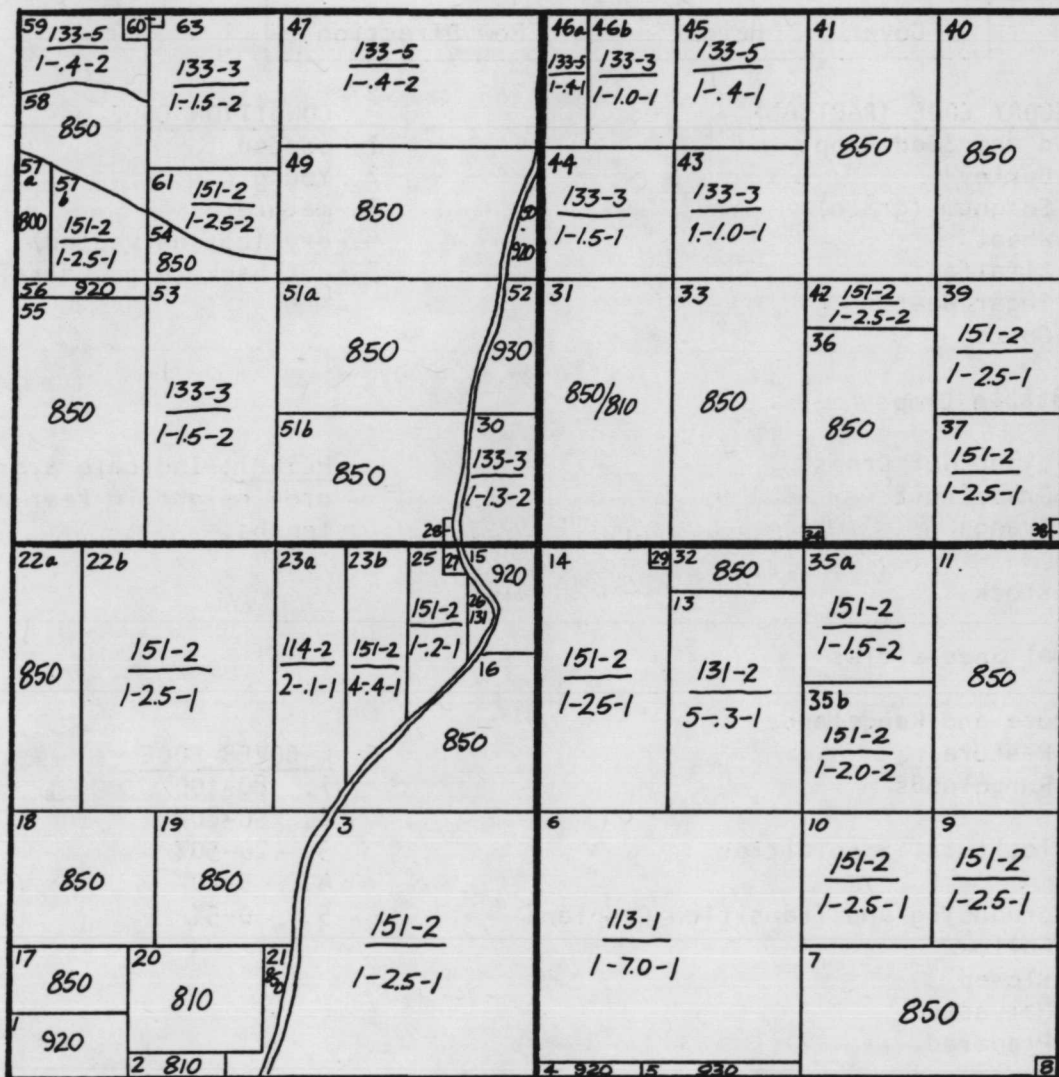
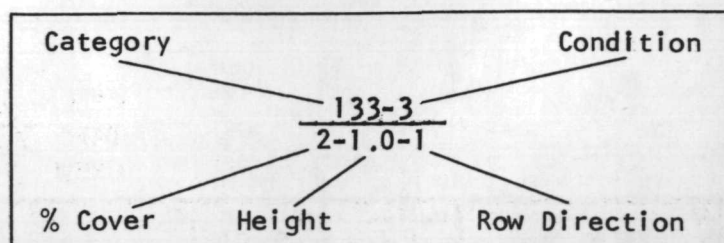


Figure 6. This map contains field data collected for one of the 4-square-mile plots in Maricopa County at the time of a NASA high altitude overflight. The coded fraction in each field is explained in Figure 7. Computer storage of survey data, collected at the time of each flight on a field-by-field basis, facilitates sequential analysis of crop patterns as well as evaluation of photo interpretation test results.

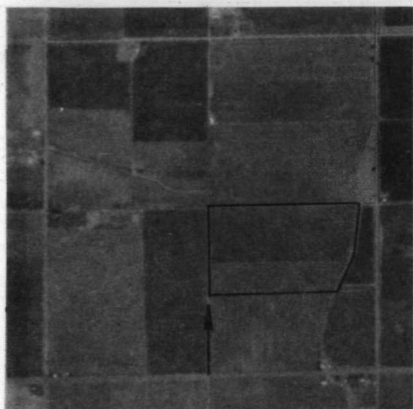


<u>CATEGORY CODE (PARTIAL)</u>	<u>CONDITION CODE</u>
100 Field and Seed Crops 111 Barley 114 Sorghum (grain) 118 Wheat 133 Alfalfa 142 Sugar Beets 151 Cotton	1. seeded 2. Young 3. mature 4. dry (not harvested) 5. cut back (e.g., alfalfa)
200 Vegetable Crops	
300 Fruit and Nut Crops 331 Grapefruit 335 Orange	<u>HEIGHT:</u> Indicate average crop height in feet and tenths.
400 Livestock	
500 Animal Specialties	
600 Pasture and Rangelands 610 Pasture 620 Rangelands	<u>% COVER CODE</u> 1. 80-100% 2. 50-80% 3. 20-50% 4. 5-20% 5. 0-5%
700 Horticultural Specialties	
800 Non-producing and Transition Cropland 810 Fallow 820 Plowed 850 Harvested 860 Prepared	
900 Other Uses 910 Urban 920 Farmhouses and Farm-related Structures 930 Agricultural-related Activities 940 Native Vegetation	<u>ROW DIRECTION CODE</u> 1. N-S 2. E-W 3. NW-SE 4. NE-SW

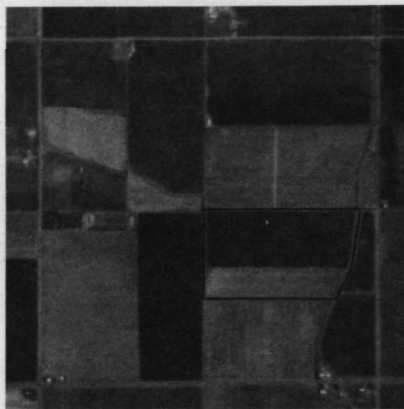
Figure 7. The fraction at the top of this page represents a typical field code as recorded by ground crews gathering information pertaining to the field plots. The example shown is a mature alfalfa field one foot in height, with 50-80% ground cover and rows running in a north-south direction. The complete category code is quite lengthy and therefore not reproduced here. Only the major headings (100, 200, etc.) and a few sub-headings (which are common to the Phoenix area) are presented.

				April 22	May 21					June 16					July 28									
Test Site #	Stratum #	Plot #	Field #	Acreeage	Category	Condition	Height	Row	Direction	Category	Condition	Height	Row	Direction	Category	Condition	Height	Row	Direction	Category	Condition	Height	Row	Direction
--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1	1	3	1A	16.0	92000	0.	09																	
1	1	3	1B	24.0	11831	3.5	02	118	41	3.0	02	850	01	0.7	02	850								
1	1	3	2	37.0	86005	0.	02	151	03	0.2	22	151	23	0.7	22	151	21	2.5	22					
1	1	3	3	9.0	92000	0.	29																	
1	1	3	4	10.0	86005	0.	02	151	05	0.3	12	151	23	0.5	12	151	21	2.5	12					
1	1	3	5	42.0	11831	3.5	02	118	41	3.0	02	850	01	0.8	02	850								
1	1	3	6	25.0	11501	2.5	02	850	01	0.5	02	850	01	0.3	12	850								
1	1	3	7	72.0	13351	0.3	02	133	51	0.3	02	133	31	1.0	02	133	31	1.0	22					
1	1	3	8	35.0	11821	1.5	02	118	31	2.0	02	850	01	0.7	02	850								
1	1	3	9	16.0	86005		02	256	23	0.3	22	256	21	0.4	22	256	22	0.5	22					
1	1	3	10	24.0	86005		02	256	23	0.3	22	256	23	0.4	22	256	22	0.5	22					
1	1	3	11	7.6	86005		02	256	23	0.3	22	256	21	0.4	22	810								
1	1	3	12	56.4	85005		02	133	31	2.0	02	133	31	0.7	22	133	31	1.5	22					
1	1	3	13	2.0	92000		9																	
1	1	3	14	21.0	86005		02	256	23	0.3	22	256	21	0.4	22	256	21	0.8	22					
1	1	3	15	10.0	33502	9.0	21																	
1	1	3	16	10.0	33504	2.0	21																	
1	1	3	17	.5	92000		29																	
1	1	3	18	3.0	92000		29																	
1	1	3	19	10.0	86005		23	19A, 19B																
1	1	3	19A	5.0				130	02	0.	22	130	03	1.0	02	610								
1	1	3	19B	5.0				230	02	0.	12	800												

Figure 8. A portion of the computer printout for four consecutive months is reproduced here. This data for Phoenix test site (site #1), stratum #1, plot #3, fields 1A through 19B, was derived from field notes for each month. The key to each code appears in Figure 7. For example, field 7 is alfalfa which had been recently cut on the first two dates and was mature on the last two dates. Field 5 contained wheat during the first two months. It was harvested and contained stubble on the last two dates. Field 19 was divided into two 5-acre fields in May when pasture grasses were planted in 19A and a vegetable crop was planted in 19B. The system developed can easily handle divisions, consolidations and changes that occur from month to month.



MAY 21, 1970



JUNE 16, 1970

Figure 9. The possibility for errors in ground "truth" data is illustrated here. These two panchromatic photos were enlarged from RC-8 transparencies taken on May 21, 1970, and June 16, 1970. Seen in each photo is a one-square-mile area which is part of a four-square-mile plot where field data was recorded at the time of each aircraft overflight. All of the outlined field was recorded as barley on both dates by field personnel. However, by June 16 all fields containing cereal grain crops have matured and dried (note several light-toned fields on the June 16 photo); therefore, the upper portion of this field cannot contain barley because it still has a dark tone. Subsequent field checking during July has verified that the upper portion was, in fact, alfalfa, a crop which remains green during the entire growing season. This discrepancy occurred because the field crew reached the field along the route indicated by the arrow and, from where they viewed the field, it was identified as barley. Careful field checking and comparison of photography with ground data will help to minimize errors of this type.