REMOTE SENSING FOR CROP AND LIVESTOCK ESTIMATES

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"Remote sensing" means acquiring information about objects or phenomena without placing the information--gathering device, the sensor, in direct contact with the subject under investigation. The sensor may be a camera, an infrared or microwave scanner or radiometer, or some other device that records electromagnetic radiation, magnetic fields, gravity, acoustical energy or other physical phenomena. The human is not considered as being a sensor. The field embraces all matters concerned with acquiring and using remotely sensed data, with interest centered on data obtainable from aircraft and satellites.

Extensive work in remote sensing is being done at the University of Michigan, Kansas University, University of California, Purdue University, Cornell University and by the Agricultural Research Service (USDA) at Weslaco, Texas.

Livestock Inventories

During the past four years the Statistical Reporting Service has worked with the University of California in developing aerial photographic techniques and livestock identification keys. The results of these four years of study are well covered in the report, "Use of Remote Sensing for Livestock Inventories," by H. F. Huddleston and E. H. Roberts. The capabilities and limitations of identifying sheep and cattle from aerial photographs have been established. But very little has been obtained pertaining to capabilities of identifying swine. The unfavorable cost ratios at present between "enumerated" data collection and remote sensing data collection make double sampling technique unpractical, but the possible use of remote sensing in reducing certain kinds of nonsampling errors for quality control purposes is appealing.

Michigan has done some work with thermal infrared to obtain livestock numbers. However, with the unclassified equipment presently available it has not proven satisfactory.

Crop Acreage and Yield

The use of remote sensing in estimating crop acreage and yield has been limited but the potential is great. The University of California has done work in developing crop identification keys using black and white and color photography. The most spectacular results in computer processing of information collected by remote sensors has been done at Purdue University.

The technique that Purdue had developed during the past four years is the collection of spectral data with a multichannel optical mechanical scanner mounted in an aircraft. The major breakthrough with this method is the use of computers to do the interpretation which is a very important factor if large volumes of data are to be collected and analyzed. An unpublished paper, "Contribution of Automatic Crop Surveys to Agricultural Development," covers the procedure. Several other publications are also available (see the list of references).

In working with Purdue during 1967, SRS reviewed some aerial photography obtained as supplementary coverage that had been taken in Indiana. From the aerial photographs it was possible to identify row crops and cereal crops in late June. By the first of August it was possible to identify corn and soybeans with very little trouble using color photography at scales of 1:20,000.

The possibility of forecasting yields or estimating yields of field crops from aerial photography is still in the "twilight zone." However, it is possible to detect disease in some crops which might provide a useful supplement to present SRS methods of estimating yields.

SRS has been working with photography in developing objective yield methods for deciduous fruits. A preliminary report, "The Use of Photography in Sampling for Objective Yields of Deciduous Fruits," by Harold F. Huddleston, covers most of the results found so far. This technique involves the photographing of sample trees from 15-25 feet away. The fruits are counted from the photograph and compared with actual counts. If counts are found to be consistent the possibility of using a double sampling scheme becomes promising. More research is being conducted in 1968 on peaches, apples, tart cherries and almonds. Some interest has been shown for work to be done with citrus.

The California Crop and Livestock Reporting Service has successfully used aerial panchromatic photography to estimate accumulative raisin production as the harvest season advances. The raisin area, consisting of some 800 square miles centered near Fresno, was photographed approximately seven times at a 1:17,000 scale with a panoramic system during the harvest season of about six weeks. Although, complete photographic coverage was obtained in these missions, a sampling procedure was used to estimate the portion harvested for raisins of the total known grape acreage. Dots superimposed over sample plots on master photographs taken during the first survey of the season were observed on succeeding operational film to determine whether or not they fell in areas where grapes were drying on trays to form raisins. An indication of yield was obtained by (1) tray counts on the photographs and (2) ground visits on a subsample basis to weigh and count the number of trays in specified areas. This unique application of aerial photography has considerable economic significance, since growers must decide at what point the anticipated market demand for raisins has been satisfied. When this condition has been met, the remaining grape harvest can be more profitably diverted to wine production.

Fruit acreage surveys using aerial photography have been conducted by the California field office of SRS with State funds and matching RMA funds. The investigation may be classified into two phases: (1) Research in the use of aerial photos as a primary data source (fully exploiting photo-interpretation) and (2) aerial photos as a vehicle for an initial complete mapping, with subsequent change detected by comparing later identical photos.

Research in photo-interpretation was undertaken in two trial areas selected because of a number of different fruit situations. Photos were obtained at scales varying from 1:3,000 to 1:24,000, in panchromatic and infrared black and white films, and in aerial ektachrome and camouflage detection color films. Dr. Robert Colwell of the University of California, an authority on aerial photo-interpretation, collaborated in determining the initial photo specifications and in developing photo-interpretation keys. The resulting keys were tested at special sessions attended mainly by statisticians and clerks from the Sacramento field office of SRS. An additional test was performed with a trial sample survey in one of the study areas. The general conclusions drawn from the aerial photo-interpretation phase of investigations were as follows:

1. Neither infrared nor panchromatic black and white films demonstrated any marked overall superiority. Color photography was superior to black and white but does not nearly commensurate with the added cost.

2. Larger scales contribute to ease of interpretation, but the advantage decreases below about 1:9,000.

3. Camera lens and clarity of atmosphere during photography greatly influence interpretability.

4. A skilled interpreter can accurately identify different fruit types. But distinction between varieties, or between varietal groups such as Clingstone peaches versus Freestone peaches, or wine grapes versus raisin grapes, will require more technological development than has yet been attained.

5. The cost of photos together with photo-interpretation does not approach a favorable ratio to cost of ground interview sampling which would be required to make double sampling economically feasible.

Research is now advancing into the second phase. All fruit plantings in two localities have been mapped onto aerial photos procured just prior to survey. This procedure is a painstaking one, and costs of conducting the ground interview census have exceeded the usual census costs by more than the added cost of aerial photography. However, the opportunity for survey control and review is much greater. Fiscal 1969 will provide the first opportunity to complete the full cycle when new photography will be obtained and compared with the old photos to obtain updated estimates. The comparison technique will be verified by sampling on the ground. Some additional ground interviews will be required, but only to determine variety and year of planting for new blocks. The economic feasibility will be dependent on costs projected over an extended period, since the system is essentially a permanent one.

Conclusions

The possibilities of remote sensing are numerous and exciting but the limitations have to be accepted or overcome. More knowledge is needed about the variation under varying conditions and about the correlations between interpretation of signatures and ground truth since all work has been restricted to limited test areas. Methods need to be developed to handle large volumes of data which are produced by remote sensing systems. Procedures are also needed to convert remote sensing data to estimates and the accuracy and costs of such estimates need to be determined. New equipment as it becomes available needs to be tried and tested.

REFERENCES

Baumgardner, M. F., Hoffer, R. M., Johannsen, C. J., and Kozin, C. H., "Contribution of Automatic Crop Surveys to Agricultural Development," unpublished report, Laboratory for Agricultural Remote Sensing, Purdue University, 1967.

Carter, D. L., and Meyers, V. I., "Light Reflections and Chlorophyll and Carotene Contents of Grapefruit Leaves as Affected by N_{a2}, SO_4, NaCl and $CaCl_2$," American Society for Horticultural Science, Vol. 82, 1963.

"Agricultural Application of Remote Sensing—the Potential from Space Platforms," Agriculture Information Bulletin No. 328, ERS, USDA, September 1967.

Hoffer, R. M., "Interpretation of Remote Multispectral Imagery of Agricultural Crops," Research Bulletin 831, Vol. 1, Purdue University Agricultural Experiment Station, July 1967.

Huddleston, H. F., "The Use of Photography in Sampling for Objective Yields of Deciduous Fruits," preliminary research report, unpublished, SRS, USDA, March 1968.

Huddleston, H. F., and Roberts, E. H., "Use of Remote Sensing for Livestock Inventories," unpublished report, SRS, USDA, March 1968.

Research Bulletin 832, Vol. 2, LARS, Purdue University, Agricultural Experiment Station and School of Electrical Engineering, July 1967.

"Summary of Seminar-Workshop on Remote Sensing and Agricultural Development," LARS, Information Note 120667, Purdue University, July 1967.

Manzer, F. E., "Aerial Photographic Methods of Potato Disease Detection," Bulletin 646, Maine Agricultural Experiment Station, March 1967.

Thomas, J. R., Meyers, V. I., Heilman, M. D., and Wiegand, C. L., "Factor Affecting Light Reflections of Cotton," Proceedings 4th Symposium on Remote Sensing of Environment, University of Michigan, Ann Arbor, April 12-14, 1966.

Wiegand, C. L., Meyers, V. I., and Maxwell, Norman, "Thermal Patterns of Solid Fuel Block-Heated Citrus Trees," Journal of the Rio Grande Horticultural Society, Vol. 20, 1966.