USE OF REMOTE SENSING WITH AREA SAMPLING FRAMES

by
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In this presentation I will introduce various types of remotely sensed data and their application to Area Sampling Frames. In its general context, remote sensing may be defined as the collection of information about an object or area without being in physical contact with the object or area. Aircraft and satellites are the most common vehicles from which remote sensing observations are made. Most of you are very familiar with aerial photography, some are familiar with LANDSAT images, and a few of you may be acquainted with digital satellite information and radar images. This presentation attempts to give some characteristics of the available remote sensing data and show the advantages and disadvantages found when applying them to Area Sampling Frame methodology. Much of my discussion will be directed toward LANDSAT based data specifically. Other applications of this data mentioned are: Yield and yield modeling, digitization, digital classification, linear measurements of areas, and specific examples of its use. Topics discussed will include scale, resolution, and timing of remotely sensed data.

Aerial Photography and Radar

Aerial photography is the original and most familiar form of remote sensing and is widely used for topographic mapping, engineering and environmental studies, agricultural estimation, crop disease information, military observations, and exploration for oil and minerals. Most of these successful applications were done using only the visible light portion of the electromagnetic spectrum. In the 1960's, technological developments enabled imagery to be acquired at other wavelengths including thermal infrared (IR) and microwave. The various altitudes and sensors available require some definition as to the concept of scale. For my purposes, small scale imagery would be at 1:500,000 or less, intermediate scale between 1:500,000 and 1:50,000 and large scale imagery defined as greater than 1:50,000 scale. Collectors of aerial photography range from high altitude reconnaissance aircraft, operating at altitudes of 30,000 meters, to helicopters hovering directly above the area to be observed.

The most common photography available is black and white (B & W) visible light coverage at scales close to 1:50,000. This is especially useful for mapping purposes. B & W infrared photography (IR), is very useful for agricultural applications. IR photography offers advantages of improved haze penetration, maximum reflectance for vegetation occurs in these wavelengths, and IR radiation is absorbed by water giving very clear boundaries between land and water. Different cover types of vegetation sometimes are most easily detected in the IR photographic regions of the light waves. Stress on crops is shown very well also. Another type of application of aerial photography is found with stereo pairs. These pairs are two sets of photography taken of the same area but at different angles to the sun and ground. For example, stereo pairs are very useful in determining type, size, and density of tree cover in forestry studies.

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Since the human eye can more easily discriminate color changes than tones of gray, color photography gives greatly increased information content for photo interpretation. Color IR photography, combines the properties of IR B & W film with the advantages of color. The major drawback to color photography is that B & W photo coverage already exists for most areas while color photos generally must be acquired specially. Where new photography is to be acquired, however, color photographs are generally well worth the cost in improved information.

Aerial photography from adjacent flight lines typically have 30% sidelap. The photos may be matched and mounted on a base to form a photo mosaic. Mosaics are useful because they provide broader coverage than the individual photos. Sometimes, though, information in mosaics is obscured by individual photo edges, staples, or pins, feature matching problems, and differences in processing the various flight lines. Although topographic maps are usually made from these mosaics, the mosaics themselves give better detail for our purposes in such things as stratification, count unit delineation, and segment selection. Aerial photography is sensitive to atmospheric conditions, clouds and haze.

Radar imaging systems provide a source of elecomagnetic energy to "illuminate" the terrain. This energy is in the radio and microwave bands and thus is not dependent on lighting conditions and weather. In addition, the terrain can be illuminated in the optimum direction to enhance features of interest. Bursts of energy are transmitted at a specific wavelength and for a specific period of time. The reflected energy from the terrain is used to determine the position of terrain features on the image. Bright features on radar images come from urban areas, mountain ridges, and surf on the ocean. Dark image areas are seen to be water, beaches, and canyons. Vegetation gives an intermediate image, reflecting a portion of the transmitted energy and scattering the rest. With respect to agriculture, radar images may be useful in identifying certain crops that are planted in regular rows and with tree crops.

Satellite Imagery

Imagery of the earth's surface taken from space provides a comprehensive overlook of large areas and is, therefore, very useful to delineate the homogeneous areas we call strata in area sampling frames. LANDSAT imagery is especially well suited for this because it lacks the breaks in continuity from processing, overlap edges, and staples found in photo mosaics. There are different satellite systems available. Here I will discuss only those types of images available from the LANDSAT (formerly ERTS) satellites. For our purposes there are two main types of data available from LANDSAT. They are the images produced by the Multi Spectral Scanner (MSS) and the Return Beam-Vidicon (RBV). In the near future one other type of image will be available from LANDSAT, the thematic mapper (TM). The above mentioned data is readily available in image format at several scales: 1:1,000,000, 1:500,000, 1:250,000., and 1:125,000. Cloud cover represents the major problem with saellite data acquisition. Some areas remain cloud covered or overcast for much of the crop growing season.

The LANDSAT satellite covers the earth in a North to South orbit. This orbit is fixed at 918 km altitude. Coverage of a given area is acquired every

18 days per satellite. When there are two satellites operating, coverage is provided every 9 days. The first satellite, LANDSAT I, was launched in July 1972 and functioned until March 1977. The second, LANDSAT II, was launched in February 1975 and functioned until December 1979. Some problems with LANDSAT II were corrected by June 1980 when it was activated again; it still functions in a limited capacity. LANDSAT III launched in March 1978, functioned until December 1980 when it was officially turned off. The fourth satellite, LANDSAT D, is to be launched in July 1982 and will carry the thematic mapper.

The MSS carried by the LANDSAT satellites measures energy radiated by the earths surface in four bands of the electromagnetic spectrum: green, red, and two near infrared bands. The area for which data is collected is called a picture element or pixel, and covers an area of 80 by 59 meters. The raw data acquired by the satellite is distributed in units of 10.6 million contiguous pixels, called a scene, on magnetic computer tapes. This scene covers an area of 185 by 170 km. Most natural land covers fill a smaller area than a LANDSAT pixel. Thus the spectral values measured for a given pixel represent normally a mixed area, especially in areas with small farms. Fields sizes of about 8 ha. are required on order to be specifically located.

MSS scene images are obtained by computer processing of the raw spectral data. These images are produced at the various scales in photographic type products for visual use. The image products in their simplest form are black and white photo-type products in one band with the lightness or darkness representing the amount of energy reflected in the specific band. Another product, called a false color composite, is made by photographically processing several of the bands together with each band being represented by a different color. The false color images are much more expensive than the black and white images. Further computer processing of the raw data to detect edges and color changes results in even better images (called enhanced images), which are also very expensive.

RBV imagery is also useful for some applications. The imagery is obtained using three camera type sensors mounted in the satellite. The data from these sensors is combined together on a photo-sensitive screen and transmitted to the ground in a manner similar to television video pictures. The RBV covers an area of approximately one fourth the size of the MSS scanner. Thus, it has an increased resolution for the same area. The disadvantage to RBV is that the combining process of the three sensors causes loss of some spectral discrimination properties of the individual bands. Research is being done into combining the MSS and RBV data together via computer processing, but as of now only one image has been produced.

The thematic mapper scheduled for LANDSAT D should be much more useful for our purposes than either of the above mentioned systems. It will have increased resolution, the pixel being 30m by 30m, and seven spectral bands instead of four as in the MSS. Results for simulated TM data in research studies is very encouraging.

Use of Remote Sensing in An Area Sampling Frame

Remotely sensed data can be of great help in construction and use of area frames. Specifically, it can be useful for stratification, count unit delineation, segment delineation and selection, segment enumeration, digital classification of agricultural areas, and in the updating of existing frames. Here I will discuss the various types of remote sensing that are most useful for each step in area frame sampling.

Stratification can be accomplished by various methods. Included in these are interpretation of: photo mosaics, LANDSAT images, and map products. Our recommended approach would be to delineate gross strata on transparent plastic overlaid on a LANDSAT image. This stratification would be done first without regard to natural boundaries. The LANDSAT imagery would be obtained at a scale of 1:125,000 (RBV) or 1:250,000 (MSS). This stratification should then be transferred to a map or aerial photo mosaic base using identifiable boundaries that as closely as possible correspond to the gross strata features seen in the LANDSAT image. This transfer could be enhanced by using transparent map overlays which are blown up to the image scale. The map or photo mosaic base should be at a scale of from 1:50,000 to 1:75,000 if possible. Next we delineate small stratum blocks on the map or photo base that were not visible on the LANDSAT imagery.

On this same map or photo base, the stratum blocks should be split into count units of approximately equal size using the visible natural boundaries. These count units would then be numbered in a predetermined fashion. Each count unit would then be measured to determine its area. These measurements could be done using a plaimeter, a grid, or a process called digitization which employs a magnetic tablet and computer to record field boundaries and compute their areas. Another method of measuring area is by using a linear measuring set.

Using the measurements, the sampling process will select count units to be broken down into their individual segments. This segment delineation could be done on the map or photo base; or if sufficient boundaries are not visible there, on enlargements of individual photos or by field checking.

During the actual period of survey enumeration, the enumerators should have both maps and aerial photography of the specific segment locations. Maps for enumeration should be at a scale of from 1:5000 to 1:20,000. The aerial photo (enlargements) of the segment locations should be at a scale close to 1:10,000. Enumerators can use these photos to mark actual field boundaries and label the specific fields to correspond to the questionnaire. This process is very useful for controlling non-sampling errors such as double coverage of the same farm or missing a farm in a segment.

LANDSAT imagery has been used successfully for stratification in Costa Rica, Tunisia, Sierra Leone, the Philippines,and Indonesia. Other countries have begun use of these products.

In addition to reduction in sampling error due to stratification, remote sensing data in its digital form can be used to further reduce sampling error. Computer techniques are applied to the digital data to differentiate between crops and other land covers based on the reflected energy found in the four MSS bands. This differentiation , called classification, is based on a set of rules formed from a sample of pixels for each cover type. Averages for the energy readings in each band are computed for each cover type found in the sample. This forms a description, called a signature, of the crops or covers as they appear to the computer. The segments of the area sampling frame provide the sample pixels for this set of signatures. Some error is expected in the classification, and a relation must be estimated between the pixels classified to a crop and the area planted to that crop. The better the relationship between classified pixels and ground area, the greater the reduction in sampling error.