Sensing by Satellite for Forest Surveys

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Since the Earth Resources Technology Satellite (LANDSAT-1) was first launched in July 1972, studies on the use of imagery sent from the satellite for forest surveys and their experimental applications have been undertaken.

Information by which we can monitor changes in forests from time to time are very valuable for the estimation of forest resource quantity, forest development and for effective forest management. For that purpose, aerial photography and field surveys have been employed so far, but these methods are quite difficult to cover a large area simultaneously and with repetition.

Records obtained by the satellite can reduce dramatically costs and time required for the resource survey by increasing efficiency of the use of aerial photography and by cutting back field survey to a great extent, although the usage of the records varys with the kinds of information required. Particularly with the development of land use systems, periodically repeated observations which are made possible by satellite sensing become to offer great advantages.

Furthermore, for the planning of forest management and regional development programmes diversified information are required. By combining the records from the satellite, the satellite sensing can be very effective in anlyzing land capability and in formulating basic guidelines for forest workings.

Records and techniques employed

Data from LANDSAT are supplied as film imagery by different wavelength and computer comparative tapes (CCT). Film imagery are used to produce color composite for visual interpretation, and CCT is used for producing imagery corresponding to map co-ordinate, for earth surface featuring at every pixel unit which is a minimum resolution of signals sent from the satellite (in case of LANDSAT: 60 m × 70 m), or as the numerical records for statistical analysis data.

In the visual interpretation of the imagery, major forest tree species, vegetation types and land use patterns can be identified with conventional photo-interpretation techniques, without requiring any sophisticated methods. However, there is a limitation that at the optimum degree of preciseness maps at least up to the scale of 1 : 100,000 can be expressed. On the other hand, assessment by CCT requires expensive electronic instruments such as image analysis apparatus and image display apparatus, but it is possible to speed up works, to assess up to at pixel units and to obtain sum-up tables simultaneously with imagery production.

To establish assessment standards, to verify results, and to increase degree of preciseness if necessary, aerial survey and field survey are made in association with the satellite sensing.

As each of the satellite sensing, aerial survey and field survey has it own advantages, forest surveys can be made most efficiently by combining these methods according to the purpose of survey. Characteristics of these methods are shown in Table 1. Observation data obtained from space are the reflected electromagnetic waves based on physical properties of earth surface objects, and which represent land cover features. On the contrary, what we need are information about resources related to human activities, present status and future

Table 1. Characteristics in data acquisition

System	Specificities							
	Wide area coverage	Simultaneity in a wide area	Periodicity	Response to urgency	Qualitative accuracy	Quantitative accuracy	Digitalization	Cost
Field survey	Many survey stations needed ***	Difficult ***	Very difficult ***	Difficult to respond ***	High *	Adequate *	Low efficency **	Expensive to cover a wide area ***
Air borne survey	Frequent flights needed **	Frequent flights needed **	Expensive ***	Adequate *	High resolution *	Difficult except for some objects ***	Possible but expensive ***	Expensive to cover a wide area ***
Satellite sensing	Unique advantage *	Unique advantage *	Every 18 days by LANDSAT *	Depends on oppotunity ***	Low resolution **	Difficult, supplemental data needed ***	Best *	Least expensive except for cost of satellite and earth station *

Note: Rating: * very excellent, ** slightly better or ordinary, *** slightly inferior

possibility of land use, and the prediction of resulting changes in bio-environment. Most of them can be inferred from the land cover features, but with an increasing requirement for information with higher degree of preciseness, the role of each of the survey methods to be used in combination changes in its importance.

For example, levels of preciseness of data, the scale of maps required, and the necessary level of resolution for that in Japan are given in Table 2. Information supplied by LANDSAT gives an accuracy higher than 90% either by visual or mechanical assessment of the imagery at the level 1. Assessment at the level 2 can also be made by mechanical method if training data by aerial photography are provided. The level 3 represents, by its nature, a level which can be obtained by the combination of aerial photography and field survey including cultural information, but if the well-arranged information up to the level 2 is available, a remarkable saving of costs and time is possible in the assessment at the level 3. Conversely, it is inefficient and time-

Table 2. Levels of preciseness of data applicable to surveys with different purposes

Level	Unit area size	Applicability
I	2,000–500 m net work (Resolution 100–50 m) Map scale 1 : 500,000 to 1 : 100,000	Regional planning Vegetation naturality survey
II	500–200 m net work (Resolntion 50–20 m) Map scale 1 : 100,000 to 1 : 50,000	Forest inventory Basic management plan Land faculty survey
III	100–50 m net work (Resolution 20–10 m) Map scale 1 : 50,000 to 1 : 5,000	Agriculture productivity Forest management Road construction Ecological survey Vegetation growth and damage etc.

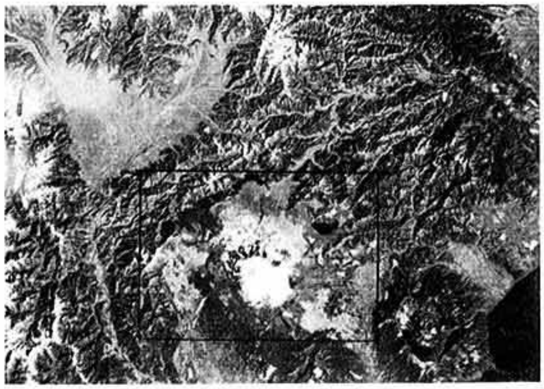

Plate 1. Color composite of LANDSAT data. 1/400,000 (Mt. Fuji area, Dec. 15, 1972)

Table 3. Land use identification level from LANDSAT data

Level I	Level II	Level III
Map scale 1 : 20, 000 (Spectral)	Map scale, manual 1 : 100, 000 Digital 1 : 50, 000 (Spectral+Graphical)	Map scale, Digital 1 : 50, 000 (Spectral+Graphical+Sociological)
Town (Artificial construction)	Residential	High density town Low density town Residential construction Village Others (School, Campus etc.)
	Factory	Factory
	Special Facilities	Athletic field Others (Tunk, Greenhouse etc.)
	Road	Auto road Main Road Other Road
Agriculture	Paddy field	Paddy field
	Farm	Farm Others (Tea, Mulberry, Nursery etc.)
	Grassland	Range Loan Wild grass Shrub Wet grass
Forest	Coniferous	Artificial forest Natural coniferous
	Hard wood	Ever green forest Deciduous forest
	Mixed	Mixed forest
	Others	Orchard Other forest
Bare surface	Rock	Lava Stone factory Rock
	Gravel	Volcanic ash Gravel Other sandy
	Soil surface	Reclamation Under construction Open space
	Others	Dry grass Wet land
Water	River drainage	River drainage Lake, Pond Artificial pond, Pool
	Sea	Sea
Snow	Snow	Snow
Ice	Ice	Ice
Cloud		
Shadow		

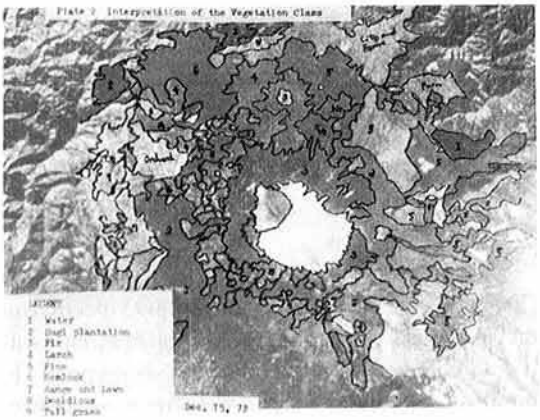

Plate 2. Photographic interpretation of land cover types from enlarged print of Plate 1 area (Level II)

Plate 3. An example of the digital pattern recognition by M-das. (1/50, 000) Minimum resolution (pixel) size: 60cm ×70 cm (Level III) (Mt. Fuji area, near Yamanaka Lake)

consuming to get data at the level of 1 or 2 from the information at the level 3.

Earth surface identification by the use of LANDSAT data at each level is shown in Table 3. An example of the identification at each level is demonstrated in Plate 1–4, taking an area around Mt. Fuji as a sample.

New utilization of LANDSAT data

The survey for formulating Regional Forest Management Plan is carried out every 5 years, as a rule, in Japan. However, in recent years it becomes necessary to trace changes which occur during the 5 year intervals. With

Plate 4. An example of IR air photo. of square marked area on Plate 3. Pine forest (upper) and fir forest (lower)

national forests and community forests, logging, afforestation, land slip occurrence, etc. are recorded annually, but it is difficult to grip the actual situation of private forests, resulting in a constraint for regional planning. Although aerial photography is taken roughly every 5 years, it is impossible to carry out a large amount of work necessary for comparisons.

In the study using LANDSAT's data obtained in October 1972 and in September 1975 on 250,000 ha of forest area in Kiso District, almost all sites of logging and afforestation done in areas larger than 1 ha during 3 years from 1972 to 1975 were detected. Furthermore, growth of trees in planted areas and amount of soil run-off at the sites of logging and land slip were identified at 3 levels respectively. On the other hand, in forest areas adjacent to plains many changes in land use occur due to the invasion of golf courses or resorts, so that vegetation maps produced 5 years ago are almost useless. Digital display imagery by LANDSAT was proved to be very useful to detect these changes, with less than one-tenths of the costs and procedures required by conventional method. This study is still in progress, looking for a new systematization of survey on resources and environment.

In the forest conservation plan covering 1,500 km^2 of area, extending over three prefectures in northern Kanto region, analysis and assessment on wood production, land slip, flood control, water storage, and land use for public welfare were made at every 2 km square, by using 14 items of earth surface identification of LANDSAT data, supplemented by topography data and cultural data of the national census, and the regional classification based on 6 zones (for natural conservation, erosion control, wood production, flood control, water storage, and land use for public welfare) aiming at forest conservation was carried out. This was the first example showing that the utilization of quantitative data supplied from LANDSAT made it possible to have a rapid and scientific designing of the regional plan for a large area through quantifying natural and cultural data.

Future research projects

There is a plan in Japan to construct a ground observation station for LANDSAT by 1979. Studies on the practical application of remote sensing technology are in progress, including the plan for launching domestic-made satellite. In the field of forestry, it is intended to promote studies centering on the following research projects:

1. Development of monitoring procedures for functions and environment of forests, and
2. Control of snow damage in forest areas and methods of predicting run-off of melted snow.

Through these researches, it is anticipated that the forest land development, prediction of disasters, and planning of natural environment conservation will be systematized by monitoring always the functions of forest areas and their changes as well as resulting effects.

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