14th Congress of the International Society of Photogrammetry

Hamburg 1980

Commission VII

Presented Paper

FOREST REMOTE SENSING SYSTEM

V.I.Sukhikh

V/O "Lesprojekt", Moscow, USSR

ABSTRACT: For monitoring of forest resources it's necessary to have a complex operative system of forest study and forest resources management. The information potentiality analysis of remote sensing data obtained from space permits to regard such system as practicable. Now its content is already determined. The system includes a large number of different problems and requires mainly multispectral data of different operativeness and resolution, obtained by photographic, TV, IR-thermal, radar and radiometric equipment.Visual observations from space, as well as selective aerial and ground observations are also of great importance in solving these problems.

One of the main nature-protective and national - economic problems is to provide the rational use of all forest resources. In order to solve this problem it is necessary to dispose data characterizing forest in time and space.

However it is difficult to obtain these data for forest is constantly altering. Forest is increasingly changing under anthropogenic influence. That means: forest is cut at large areas, it is damaged by fire, diseases, natural calamities and other unfavourable factors. The forest fund is subjected to different forest management activities which have changed fo-

rest characteristics. All this makes it necessary to increase the range of studying and mapping forests, executing forest condition control, improving the methods of their conducting.

The Earth space imagery performed during the last decade by various space carriers presenting multispectral data with resolution from few kilometers to dozens of meters and numerous tasks on interpretation of survey data have demonstrated perspectivity and reality of the widest usage of space images for forest fund study.

Space imagery data from satellites of "Meteor" series, manned spaceships and orbital stations have already found practical application in forestry.

Nowadays some methods of inventory and small-scale forest mapping are developed on multispectral space imagery data in connection with sample large-scale airphotography or aerovisual and ground observations. In forest inventory and mapping using the materials of space imagery the following characteristics are determined by sets of direct and indirect features on space images: dominant tree species or groups of species, site-class, density class, growing stock. The summary characteristics of non-forest areas are also determined. The volume of forest information obtained from space images is proportional to spatial and spectral resolution of the data used. Multispectral space photos with ground resolution of 20-50 m obtained from the manned spaceships by multispectral camera MCP-6 contain the largest volume of information. "Meteor" data with ground resolution from 200-300 m to 1-2 km providing delineation of large nature-territorial complexes and permitting to divide the mapped area into districts are widely used in forest mapping. The methods provide collecting cartographic data and statistics, characterizing the forest fund along with project materials for treating the problems of prediction and planning of forest resources utilization and reproduction. It's important to stress that forest fund data for extensive areas can be taken from space images coordinated in time and space, which can't be done using the conventional methods of forest study based on aerial and ground observations.

One of the most serious forestry problems is forest fire protection.

For operational planning of works on forest fire protection and extinguishment some measures are required. There should be information on forest fire and meteorological condition of the forest fund area.

Now forestry organizations receive daily space imagery data through radiochannels from meteorological satellites "Meteor" covering the total forest area of the country. These data serve to assess pre-fire forest condition, to control forest fire locations, regions of smoke-screens and smoke density thus permitting to chose strategic directions of forest fire dynamics prediction, forest fire detection and extinguishment.

Television and radiometric equipment on board the satellites provide operational information about form, distribution and dynamics of cloudiness, i.e. the data that could be assumed as a basis of modern means of pre-fire forest condi-

tion detection depending on the weather characteristics.

Strict documentation of space imagery makes it possible to detect snow-melting boundaries with more certain exactness and to plan the period of spring and autumn airpatroling in due time. A possibility to measure the upper cloudiness boundary from a satellite opens the perspective of getting the reliable assessment of the main parameters of resource cloudiness for artificial precipitation causing forest fire extinguishment. The modern space techniques also enable to control thunder cloudiness which is one of the reasons of mass forest fire outbreaks.

Operational assessment of meteorologic and fire condition from space images supported by space-visual observation data from the orbital stations makes it possible to distribute the air and ground means to concentrate them in the most fire-dangerous regions of the country, to take measures for detection and extinguishment of forest fires with the least losses for forestry.

Multispectral space imagery data provide detection and mapping of forest fund areas damaged by fire. Fresh burns are located on refined colour multispectral images by a dark background and broken character of boundaries. Multidate space images are especially effective for these purposes.

Great changes take place in the forest fund due to forest cutting. The forest fund utilization for timber procurement is regulated by projects of forest stand development and forest cutting rules thus providing rational use and reproduction of forest resources and preservation of forest protective functions.

Therefore forestry organizations are obliged to control the rational exploitation of the forest fund and observe the cutting rules. But most of ground control techniques used in practice are often time-consuming and sometimes not effective.

Space imagery data permit to control the cutting rules in industrial logging areas, estimate in complex correctness of forest fund development.

At the same time it is possible to see if the areas of actual forest cutting correspond to the project of forest exploitation on large areas and to study the dynamics of reforestration on cutting areas. The experience of using enlarged (more than 20 X) multispectral space photos obtained with MCP-6 camera showed that having them a researcher can measure the parameters of cut areas with high accuracy, determine their location concerning the landforms as well as to have some other characteristics including observation of cutting rules.

Space images are perspective in using for a number of other tasks in forestry.

Today we can say that very important but only the first step has been made in studying forest with the help of space means for potentialities of space methods and techniques are far from being exhausted. So far only separate fragmentary tasks are being solved on their basis, though at the same time space means permit to develop a complex operati-

onal system of all-round forest study and forest condition assessment.

Now the outline of such a system which is based on utilizing space remote sensing data and includes various nature-protective and national-economic tasks has been defined.

All the complex of tasks to be solved by the system may be divided into three groups according to their purposes:

Group I. Thematic mapping and forest inventory as a base of all nature-protective and management activities.

Forest mapping should be in scales from 1:10000 to 1:2500000 to provide all branches of national economy, scientific, educational, nature-protective and other institutions with thematic forest maps. The main maps should be: of forest fund, forest raw-materials, groups of site-classes (forest types), division of forest fund and zonal-geographic systems of forest management into districts, zones of typical forest of different types including recreational forests, forest reservations and specially protected forest fund areas (national parks, reserved forests, natural monuments, protective forests,etc.); of forest amelioration fund, maps of forest condition, forest management; of predicting fire danger, of game preserves and some other.

Group II. Forest fund condition control which includes: forest fire protection (pre-fire forest condition detection, detection of thunder cloudiness as a source of forest fire, detection of fire centres, control for their dynamics and extinguishing operations, detection of resource cloudiness for artificial precipitation provoking, detection and mapping of areas damaged by fire, natural calamities, insects and industrial pollution as well as other unfavourable factors and estimation of losses, control for forest cutting and forest fund exploitation, etc.

Group III. Solving of nature-protective and scientific tasks such as: planning of recreational, field-soil protective, water-protective and other extremely important categories of forests, control for their condition and level of utilization, study of forest fund area hydrologic regime, water regime observation of large rivers and lakes within the forest fund, forest fund area pollution control, observations of phenologic forest condition, dust-soil-sandy storms, forest-economic,forest growing and other special division into districts,etc.

The forest remote sensing system implies using remote sensing data which differ by their operativeness, informational value, viewing level of generalization and scale. The system consists of three levels and includes means of space, aerial and ground observation.

The first- space level of remote sensing - should include meteorological and resource satellites, long-term orbital stations, automatic spaceships and provides the following:

a) multispectral operative TV data with ground resolution of 30-80 m, 200-300 m and 1 km;
b) multispectral photographic data with ground resolution no less than 20-50 m;

c) space-visual observation data;
d) radiometric photography.

The second - aircraft level includes multispectral or spectral photography, IR-thermal imagery, radar sensing and aero-visual observations. Aerophotography ground resolution must be estimated from parts of a meter to 5-10 m.

The third level is ground level.

The base level of the complex forest remote sensing system is space level, since only it may provide operational obtaining of the greatest part of forest geosystem information.

Aerial and ground observations must provide as a rule selective examination of studied areas to specify the results of space photointerpretation and obtain additional, more detailed features of the objects which are studied and mapped, if necessary. The role of each level may vary in fulfilling certain tasks. For example, observations of convective and thunder cloudiness, of snow-cover dynamics, river and lake water regime, dust-soil-sandy storms and phenologic forest condition observations may be carried out only on the base of space observation. At the same time such applications as forest fire protection, forest inventory and mapping, estimation of forest management executed by various organizations should require both space and aerial and sometimes ground means and techniques.

The tasks which require different conditions of operativity and informational value of survey materials are included in the forest remote sensing system. This system requires information of different resolution, varying from parts of cm to dozens and even hundreds meters and to kilometers; as to operativeness, it may vary from some hours to days, weeks, months and even years. This requirements to information demand the use of different carriers, such as helicopters, aircrafts, space vehicles.

According to the latest researches aerial and space techniques of vegetation study require surveys in wide wavelength range. Nevertheless scientists came to the conclusion that 3-6 bands are quite sufficient for multispectral scanner and photographic forest surveys. We consider that for studying forests and their condition multispectral scanner and photographic surveys should be performed in two-six spectral bands. But wavelength range and number of bands may vary from a certain forest characteristic and task to be done. The zone of survey must be determined on base of research data for each region and each task or a number of tasks. In some cases imagery in one band (for example airphotography of desert forests) is sufficient. In other cases imagery must be performed in two bands using the perfect multispectral film of SN-6M type (large-scale imagery in forest inventory). Sometimes it is necessary to obtain imagery in three-six bands (for example for forest condition determination).

Radiolocative radiometric and IR-thermal imagery is suggested as additional for forest fire detection and fire dynamics control, snow cover control, assessment of forest in-

sect damage, forest fund area hydrologic regime and some other tasks. These kinds of imagery must supplement to the information received by scanner and photographic systems in visible and near-infrared bands.

To solve many tasks airphotographic, aerovisual and ground data are required along with space imagery. The volume of airphoto, aerovisual and ground works depends on the task to be solved and on the requirements to its details. In most cases the volume of work should be relatively small as airphoto, aerovisual and ground observations must be performed only for sample testing of space photo interpretation results. Presently and in the nearest future such tasks as determination of condition of forests damaged by industrial pollution, forest inventory of intensively exploitated zone, large-scale forest mapping (1:50000 and larger) and some others should be based on airphotography and ground observations, as conventional space photography in these cases can't be used because of insufficient resolution.

Alongside with the remote sensing system an additional ground contact subsystem is badly needed for more directed space observation of unfavourable factors and concentration of observation on certain forest regions. This system must provide detailed measurements on the ground stations placed according to a certain scheme on the forest fund area. Some environmental characteristics should be measured preferably by ground automatic stations (air and soil temperature and moisture, smoke and dust concentration, reservoir pollution, etc.). In case of having critical values indicating an unfavourable factor or favourable conditions for its appearance ground station data must be automatically transmitted to the Earth satellites. On having received infirmation on unfavourable factors in some areas from ground stations the observation from theEarth satellites should be carried on such areas in the first place.

Space visual observations from long-term orbital stations are also of great importance in the forest remote sensing system. From long-term orbital stations the cosmonauts can carry on in the future the following investigations: phenologic forest condition observations, forest fire centres detection, fire dynamics control, thunder cloudiness detection, dust-soil-sandy storms observations, target photography of the certain objects, specification of interpretation data of inaccessible regions :space photos. The list is far from being full.

A complex of automatic analysis and interpretation means of all types of observations as well as the registration of their results should be regarded as an integral part of the ground level. The investigations carried out permit to regard that the task of automatic aerospace imagery data interpretation in the conversational man-machine regime is practicable.

The creation of the complex forest remote sensing system and its functioning must give considerable economic and nature-protective effect.