APPLICATION OF REMOTE SENSING METHOD TO AN EVALUATION THE DAMAGE OF CONIFEROUS FORESTS IN CZECHOSLOVAKIA

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Introduction

One of the main ecological problem of today is unfavourable health condition of forests, which is caused by plenty of factors. Widespread awareness of environmental implications of human activities has been shown all over the world during the last two decades but only recently more attention has been devoted to the relationships between the different systems and subsystems of the total environment. In case of forests one of the most serious factors is air pollution. Area of damaged forests, especially coniferous trees, is every year greater. Changing of health condition needs operational documentation. The possibilities of mapping the health condition of forests by means of the remote sensing have been verified using photomaps completed from aerial multispectral photographs.

Aerial photographs can be processed and interpreted by various methods for the aim described. Simple forms are represented by analog procedures, based on the corrections of photographs and their improvements in order to reach better results of interpretation. Visual methods of classification play a significant role in this activities, but they are of subjective character. The higher level of quality is represented by digital methods of image processing and classification which minimize the influence of image degradation and make the interpretation procedures more objective.

Selection of the method used is influenced by the requirements on terms of map production as well as on the financial capabilities of the customer.

Presented paper contains a brief outline of the technology of producing the thematic photomaps. This one described enables preparation of the 1 : 5 000 color photomaps illustrating the damages of coniferous forests. It is based on the digital processing and computerized classification of multispectral aerial photographs.

At this time it is emphasized demand for entire look at the health condition of forests. For this purpose it is necessary to use space image data. At the end of our paper is mentioned technology of classification of multispectral space images.

Photomap of coniferous forest damages at scale 1 : 5 000

The most important steps of the technology are as follows:

- multispectral aerial photography
- establishing the digital cartographic data base
- reconnaissance and measurements in situ
- digitizing of multispectral photographs

- photometric correction of image data
- geometric transformation and digital assembly of photographs
- computerized classification of digital image data
- producing the cartographic original of photomaps at scale 1 : 5 000 in form of the combination plate of color composite and the Forest Economy Map.

Multispectral aerial photography

Specifications for aerial photography proceed from demands on taking the high quality multispectral aerial photographs with the resolution adequate for detailed computerized classification of forest damages. The MKF-6 multispectral camera /Carl Zeiss Jena/, taking identical photographs in 6 spectral bands, is used for this purpose.

Band	1	2	3	4	5	6
nm	460-500	520-560	580-620	640-680	700-740	790-890

All photographs contain 9 reseau-marks and a gray wedge with 10 steps necessary for photometric corrections.

The 1 : 12 500 image scale gives sufficent resolution of the crowns of individual coniferous trees. In addition, it is advantageous for geometric transformation of photographs into the cartographic data base.

Aerial photography should be carried out in optimum season /August - September/ when the health condition of coniferous forest displays very distinctly.

Cartographic data base

Digital image of planimetry and annotations of the 1 : 5 000 Forest Economy Map makes a geometric frame of the photomap. Establishing the digital cartographic data base comprehends following operations:
- reducing the fair drafts of the Forest Economy Map to 1 : 25 000 scale on transparent foil
- raster digitizing by the Photomation P-1700 /Optronics, Inc./ device
- choice of the layout of photomaps and of common reference coordinate system
- geometric transformation of individual digitized sheets of the Forest Economy Map into common reference coordinate system by means of linear transformation
- digital assembly of transformed map sheets in the layout of photomaps.

Reconnaissance in situ - definition of training sets

Investigations in situ should be carried out by experts in forestry on selected sites simultaneously with the aerial photography. Every site should cover 2 km^2 and contain 70 classified trees approximately.

The damage level of each coniferous tree is evaluated and registered into the 1 : 2 000 enlargement of multispectral photograph /band 4/ as follows:

damage level 0 ..... healthy tree
damage level 5 ..... dead tree

Various Sun exposure, slope inclination and orientation, forest age categories, damage levels etc. should be considered when choosing the sites for investigations in situ.

Digitizing of multispectral photographs

Multispectral photographs, taken in bands 2, 4, 6, and covering the area to be mapped, were digitized in 3D - logarithmic mode with 50 um picture element using the Photomation P-1700 /Optronics, Inc./ device.

Photometric correction of image data

Degradation of photographs caused by qualities of photographic material, its exposure and processing can be eliminated by introducing photometric corrections. Their application requires:

- acquiring the data on the light quantity used for exposure of the gray wedge during photo flight
- density measurement of the gray wedge
- construction of sensitometric curve
- transforming the densities of all picture elements according to the relevant sensitometric curve.

Geometric transformation and digital assembly of photographs

This part of technology comprehends three operations.

Identification of G.C. points

It is necessary to identify 6-9 G.C. points on earch photograph as well as in relevant parts of the Forest Economy Map.

Determination of parameters for geometric transformation and digital assembly of photographs

An interactive graphical system, the LSI 2/20 microcomputer and corresponding software are applied to the determination of parameters for geometric transformation. Image coordinates needed are measured with the help of cursor on the image display unit. Coefficients for following cases of linear or projective transformation must be determined in a such way:

Band 4 $\xrightarrow{\text{/projective/}}$ Forest Economy Map

Band 2 $\xrightarrow{\text{/linear/}}$ Band 4

Band 6 $\xrightarrow{\text{/linear/}}$ Band 4

Band 2 + Band 6 $\xrightarrow{\text{/projective/}}$ Forest Economy Map.

Geometric transformation and digital assembly of photographs

These operations as well as photometric corrections are carried out on the EC 1045 computer. Input data are represented by digital images on magnetic tape and by sets of transformation coefficients. The computation results in digital photomosaic for spectral bands 2, 4 and 6 separately which form an input

for the consequent computerized classification of digital image data.

Computerized classification of digital image data
This part of technology comprehends also three operations.

Coordinate localization of the training sets
Starting from graphical and numerical registration of types and damage level of vegetation cover more training sets are selected and positioned using the image coordinates determined by a cursor on the image display unit. The areas of coniferous and leafy forest stands as well as of the grassland and abiotic surfaces are identified and computed, then the representative areas of coniferous forest with various grade of its damage are localized in the same way.

Determining the parameters of classifier
A multistage classifier, composed from two classification matrices, template matching and one-dimensional thresholding, is used for recognition of coniferous trees and distribution of other phenomena into 2 classes /of biotic and abiotic character/.

Detailed classification of digital image data
Classification of each picture element is carried out in two steps.

1/ Applying the first classification matrix on image data of two normalized channels the computer decides whether individual picture elements pertain to the class of coniferous trees or not. This decision is confirmed by textural classification in positive cases, otherwise, the picture element is classified into classes of other biotic or abiotic elements. For each square of 80 x 80 pixels /50 x 50 m in the nature/ relative frequency of individual damage levels is computed.

2/ An output data set is created which comprehends the framework grid /80 x 80 pixels/ with annotations and code of average damage level for each square, classified digital image data as well as digitized planimetry and annotations of the Forest Economy Map.

Producing the cartographic original of 1 : 5 000 photomap
Image data classified in detail, are color coded in the following way:

Damage level	0 - 1	2 - 3	4 - 5
Color of pixels	green	blue	red

other vegetation ..... yellow
abiotic elements and unclassified areas ..... gray
square grid 10 x 10 mm with the codes of damage level ..... cyan.

Four color separations for red, green, blue and a negative of the Forest Economy Map are prepared in the Photomation P-1700 visualisation unit. Additive color display MSP-4 /Carl Zeiss Jena/ is used for producing the color composites at scale 1 : 5 000 with superimposed draft of the Forest Economy Map. Each color separation is completed with halftone black-and -white image /band 4/ in order to reach an optimum graphical expression. By means of the technology described 57 sheets of color photomaps covering the area of 175 km^2 have been produced in 1985 - 86.

Photomap of health condition of vegetation cover

The development of digital processing of thematic photomaps from space image data /Thematic Mapper/ is now in progress at the Remote Sensing Centre of the Geodetic and Cartographic Enterprise in Prague. This technology comprehends 6 following steps:

Geometric transformation

Space image data in digital form have to be transformed into the cartographic projection and scale which was accepted in existing cartographic data base. Further details have been mentioned before.

Computing the local textural measures

In frequent cases could be insufficient to analyze the spectral signature of several important objects in the image only. It is necessary to extend the quantity of input information with the local textural measures. They are computed from image data of one or more spectral channels.

Image segmentation using cluster analysis

At the beginning an orthogonal transformation and selection of the most informative features are carried out. Then the strongly homogeneous image points within individual regions are identified. Finaly, the clustering is implemented in order to distribute all image points into different classes.

Segmented image interpretation

Various image point classes found may not correspond to the objects of our investigations. Therefore, a comparison of their areas with data of the reconnaissance in situ must be done.

Health condition evalution of vegetation cover

After adjusting of the classifier various types of vegetation cover and their health condition can be distinguish using the method of linear regression and computerized classification.

Photomap production

The technology of producing the color photomap from space image data is similar to that which has been described in the previous case when multispectral aerial photographs have been used.

Conclusion

Both technologies of producing the thematic color photomaps from digital aerial and space image data make considerable demands on quality of images and specially developed software. Actual costs of digital processing are high enough. Nevertheless, further extension of its application in producing thematic color photomaps can be expected in the near future.