Use of Remote Sensing in forest management

Kacprzak M., Rotchimmel K., Kotlarz J.

Institute of Aviation, al. Krakowska 110/114, 02-256 Warsaw

www.hesoff.eu

Introduction:

About 30% of the global total land area is covered by forests (40 million km^2). These areas are called the green lungs of our planet. Forests are the basis for carbon cycle in nature, they are crucial for the conservation of biodiversity, and constitute a shelter habitat for the unprecedented number of animal and plant species (it is estimated that there are over 2/3 flora and fauna species live in forests). Unfortunately, deforestation is increasingly noticeable in the modern world. Huge forest complexes are rapidly disappearing from the surface of the Earth. Part of the loss is compensated by new plantings main in Europe. In recent years, positive changes have been observed in Asia, particularly in China and Vietnam.

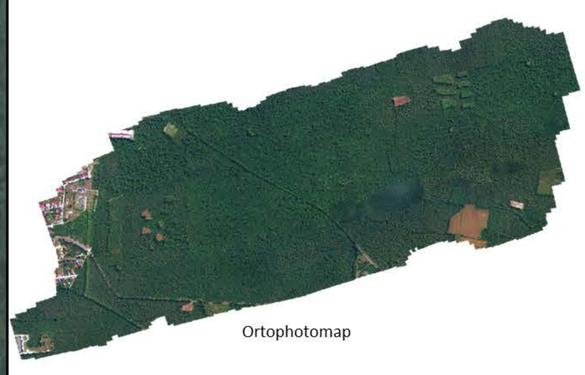
So far conducted research has shown high usefulness of Remote Sensing methods to assess the level of deforestation. Global assessment of forest cover is mainly based on satellites (Earth Observation Systems) images. Landsat images (resolution of 30 meters) were used to assess global changes in forest cover over a period of twelve years (2000-2012). The work showed a loss of 2.3 million square kilometers and an increase of 0.8 million square kilometers.

Scientific work conducted by authors was based on the UAV aerial photographs acquired in 2014 and 2015 (GDS = 25cm; 521 photo). Based on them, several algorithms have been developed: for estimating defoliation levels, land cover classification, single tree crown detection and change analysis.

Methods:

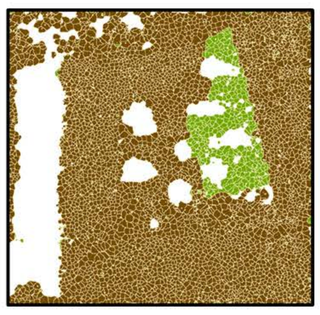
During HESOFF project (2013 - 2017) an attempt was made in order to develop effective methodology for oaks (*Quercus robur* L.) defoliation estimating. Aerial (UAV) multispectral images were acquired with the use of six-channel platform QUERCUS.6 (spectral range: 0.46 – 0.95 µm) developed in Center of Space Technologies (CST; Institute of Aviation - Warsaw). Classic photogrammetric methods were used for ortophotomap creation; 521 photos and 17 GCP were used in aerotriangulation. Modification of Watershed Segmentation method was used to detect particular trees in ortophotomaps (2014 and 2015). Next, ISOCLASS algorithm (in spectra 6-dimensional space) was used in the tree classification process.

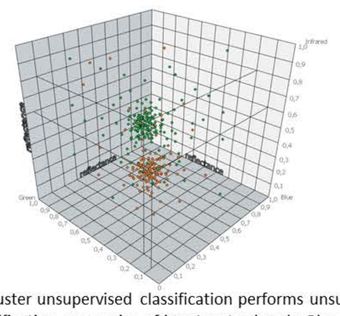
For selected control tree defoliation parameters were measured with standard observation (in situ) methodology. In next step, deep data analysis of multispectral value were performed in order to determine final correlation coefficients.



Ortophotomap

Tree detection and change analysis





ISO cluster unsupervised classification performs unsupervised classification on a series of input raster bands: Blue, Green, Infrared.

The ISO cluster algorithm computes the minimum Euclidean distance when assigning each candidate cell to a cluster. The number of iterations is a ‚free' parameter.

Month (2014)	III	IV	VI	VII	VIII	IX
D-index and in-situ defoliation index (correlation) [%]	69,66	28,92	91,03	88,27	74,56	72,11

High positive correlation of NIR reflectance with in-situ defoliation for selected trees

Red band reflectance used as correction parameter (low correlation with defoliation)

$$D \sim \frac{I_{0,73\mu m}}{I_{0,64\mu m}}$$

Index should be calculated only for treetops area (only UAV/aerial images)

Can be used for all stands with low trees height variability.

Results:

Remote sensing methods enabled the determination of quantitative and qualitative parameters of trees in the indicated area. Within the scope of the work a test area of over 5 ha has been analyzed. Changes were made at the turn of the year. The species composition and number of felled trees have been precisely defined.

Spectral ranges were analyzed and it was determined that the defoliation level of individual trees based on spectral channels 730 and 640 [nm] is strongly correlated (~ 91.03%) with the defoliation parameter evaluated with traditional forestry methods. The optimal term for the RS_defoliation study is June. Additionally, results of the work on automatic analysis of changes in the indicated area are presented in the form of three-dimensional visualization. Presented cylinders are representing individual trees with the height corresponding to the photogrammetric methods measured

Conclusion:

Remote Sensing methods can be successfully used in the operational work related to forest management. Their main advantage is speed, high reliability and ease of use. This poster present how to obtain valuable data with utilization of UAV multispectral images. Orthophotomaps generated with their use are source material for evaluation useful quantitative and qualitative parameters of individual trees.

Indicated methods and algorithms can be implemented in any GIS software, however in The Department of Remote Sensing, work aimed to creation of dedicated Forest Management Software (FMS) is being carried out. Detailed information related to Forest area are the basis for making right decisions by foresters.

Number of Leaf trees: 191
Number coniferous trees: 136

Total Area of leaf trees: 10 516 m^2
Total Area of coniferous trees: 6 702 m^2

$$\text{Volume of oak wood per Ha} = 2999.8\,\frac{\text{m}^3}{\text{Ha}}$$

$$\text{Volume of collected oak wood} = 3154.6\ \text{m}^3$$

Forest area affected by changes: 32,17%

References:

- Asner G.P., 1998. Biophysical and biochemical sources of variability in canopy reflectance. Remote Sensing of Environment. 64:234-253
- Gitelson A.A., Mierzylak M.N., 1996. Signature Analysis of Leaf Reflectance Spectra: Algorithm Development for Remote Sensing of Chlorophyll. Journal of Plant Physiology. 148: 494-500
- Filella I., Porcar-Castell A., Munne-Bosch S., Back J., Garbulsky M.F., Penuelas J., 2009. PRI assessment of long-term changes in carotenoids/chlorophyll ratio and short-term changes in de-epoxidation state of the xanthophyll cycle. International Journal of Remote Sensing. 30(17):4443-4455
- Silla F., Gonzales-Gil A., Gonzalez-Molina M.E., Mediavilla S., Escudero A., 2010. Estimation of chlorophyll in Quercus leaves using a portable chlorophyll meter: effects of species and leaf age. Annals of Forest Science. 67(108)-7
- Stereńczak K., 2009. Single tree detection based on airborne LIDAR (ALS) data. Annals of Geomatics, Volume VII, number 2(32), 121-128.
- Pitkänen J., Maltamo M., Hyyppä J., Yu X., 2004. Adaptive methods for individual tree detection on airborne laser based canopy height model. International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences 36, 187-191
- Patias P., Stournara P., 2016. Estimating wood volume for Pinus Brutia trees in forest stands from Quickbird-2 imagery. The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Prague, Czech Republic, Vol. XLI, Part B7, pp. 329-334.