GREENPEACE

FORESTCOVER CHANGE IN ROMANIA IN 2000-2011
(Greenpeace Russia GIS Unit)

Goals and Definitions

Forest cover loss map (Fig.1) is needed for the detection and exact delineation of hotspots of deforestation due to logging, agriculture expansion, building, fires, some natural processes (windfalls, rock falls) and low level of fragmentation for the last decades. For this purpose, a consistent spatial coverage of accurate, contemporary and cost-effective high resolution spatial data was used and GIS (geographic informational systems) technology was implemented.

Forest: Forest was defined as 20% or greater canopy cover for trees of 5 m or more in height.

Forestcover Loss: Any area where forest (at the beginning of period of analysis) has changed to any non-forest land cover type, or where forest has become significantly fragmented by selective logging or other human-made or natural processes, or where open woody vegetation has changed to non-forested area. The minimum area was limited as 1ha.

Fig.1. Resulting Romanian Forestcover Loss map 2000-2011

Earth Observation (EO) and Maps Used

The spatial analysis of forestcover change in 2000-2011 was made on the base of freely available high-resolution (HR) satellite images Landsat Thematic Mapper (TM) and Landsat Enhanced Thematic

Mapper Plus (ETM+) archive (United States Geological Survey http://landsat.usgs.gov; USGS Global Visualization Viewer http://glovis.usgs.gov) with 30 m spatial resolution (Table 1). These images comprise Red, Near-infrared (NIR) and Mid-infrared (SWIR) spectral bands which are needed for best mapping of the forest cover. All the images were reprojected into UTM projection (zone 35), WGS84 coordinate system. A map of forest cover loss over 1 ha was done for 2000-2011 on the basis of two periods remote sensing data – circa 2000 and circa 2011 images. Totally 19 pairs with less than 15% cloud cover summer season were analyzed (Fig.2).

Table 1. HR EO data used

Satellite	Sensor	Span, km	Band's number	Spatial resolution, m	Bands used	Years, months
Landsat-5	TM	183	7	Multispectral bands - 30 Thermal band - 120	RGB:543	2010-2011 jul-sep
Landsat-7	ETM+	183	8	Multispectral bands - 30 Thermal band - 60 Panchromatic band - 15	RGB:543	2000-2001 jun-sep

Also Google Earth (Google Earth http://earth.google.com) on-line free software was widely used with approximately 2.5m spatial resolution images (Ikonos, Digital Globe etc.) for result verification.

Fig. 2. Pairs of Landsat images used in forestcover monitoring. Red signs – date of circa 2000 images, blue signs – date of circa 2011 images
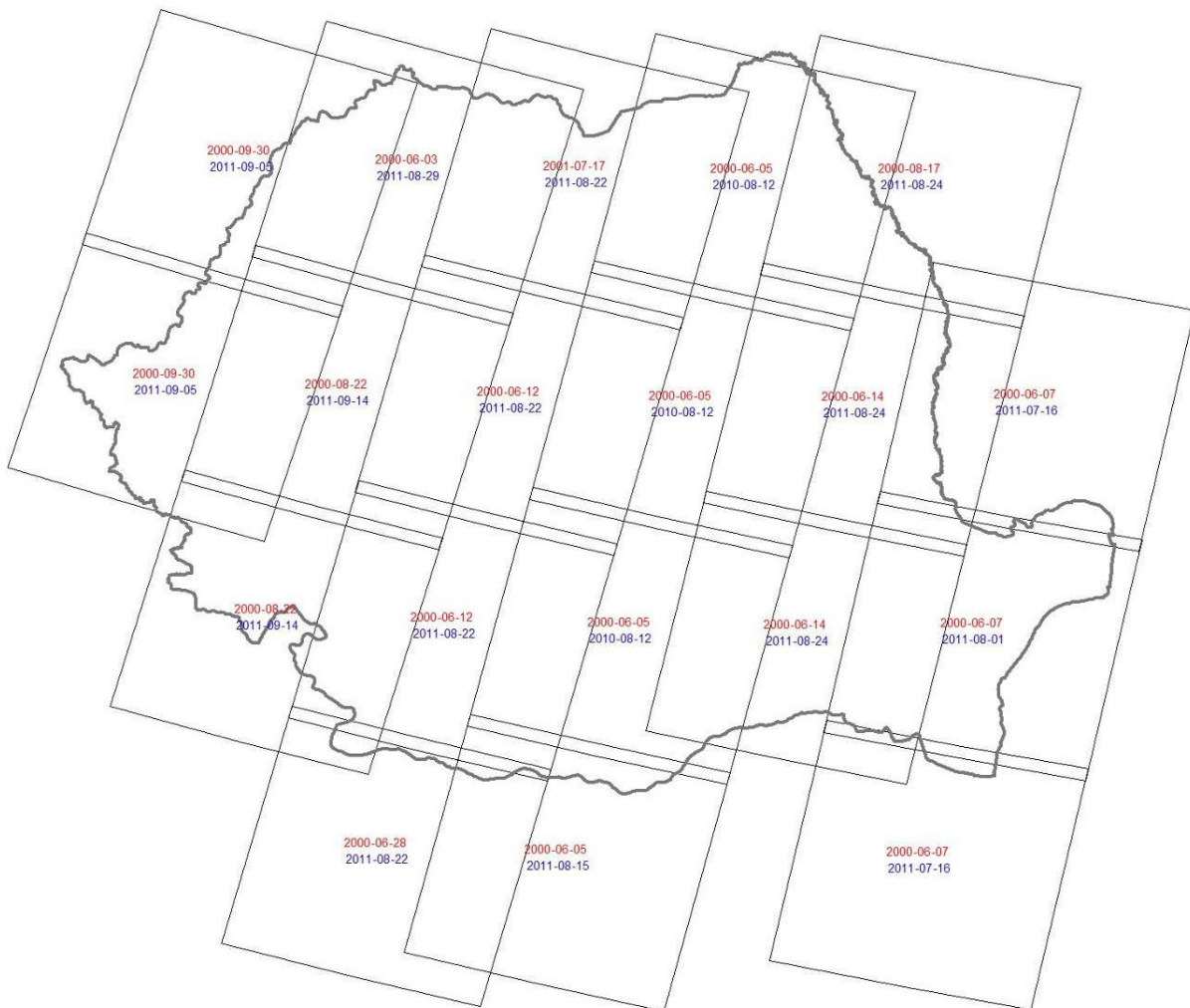
Available vector thematic maps were used in this work for layouting:
-        Global MODIS-derived forest cover map (status 2000). Spatial resolution 250m. Potapov P., Hansen M., Turubanova S. University of Maryland, 2011 (unpublished)
-        Map of virgin forests, 1: 2 500 000 (Iovu-Adrian Biris and Peter Veen http://www.veenecology.nl/index.php?id=19)
-        Map of intact forest landscapes of Romania and the rest of the globe, created on the base of Landsat ETM+ and TM data (Intact Forests Landscapes http://intactforests.org)
-        World Database on Protected Areas, 1: 100 000 (World Database on Protected Areas http://www.unep-wcmc.org/wdpa/)
-        Vmap-0 data: populated places, roads, rivers, county's borders, 1:1 000 000 (Vmap0 http://geoengine.nga.mil/)

Forest Cover Loss Analysis Algorithm

Data analysis and change detection processing comprises the following steps (Fig.4-6):

-        *Preparing images for the analysis*
Choosing pairs of images for 2000 and 2011 (Fig.2), creation of catalog. Image pre-processing, including layer stacking (bands mid infra-red, near infra-red, red; RGB:543), co-registration of images, reprojection into UTM projection (zone 35), WGS84 coordinate system. Masking of images – exclusion of clouds, cloud shadows and choosing the work area.

-        *Synthesis image of SWIR bands*
SWIR (mid-infrared) band is one of the most appropriate for vegetation detection. The reflectance is low in both the blue and red regions of the spectrum (Fig.3), due to absorption by chlorophyll for photosynthesis. It has a peak at the green region which gives rise to the green color of vegetation. In the near infrared (NIR) and mid infrared (SWIR) regions, the reflectance is much higher than that in the visible bands due to the cellular structure in the leaves.
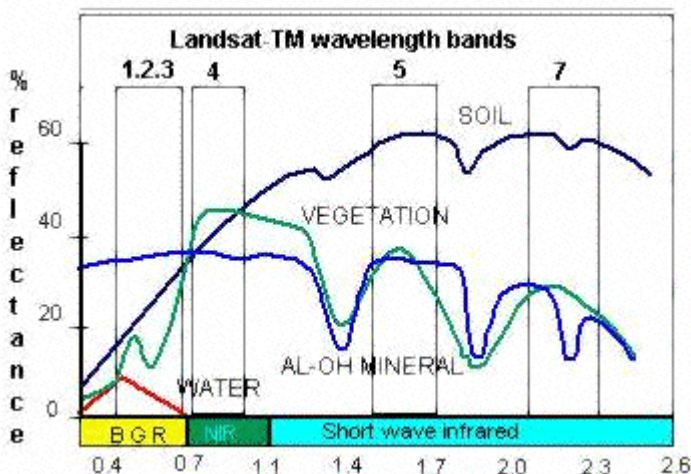

Fig. 3. Source: Geospatial Data Service Centre
http://gdsc.nlr.nl/gdsc/en/information/earth_observation/band_combinations

Creating synthesis from two SWIR bands of different periods images and using RGB: 211 combination we can see changes in vegetation. In blue – gross of vegetation and in red – loss of vegetation. So synthesis image gives us visual observation of forestcover changes. But still this is raster image and we want to make these results geocoding somehow.

- *The areas of increasing brightness detection (change mask)*

The first step was detecting of increasing reflectivity in SWIR band. For this a simple threshold of Landsat band 5 (SWIR) difference between circa 2000 and circa 2011 images was done. The threshold was selected in a way to include all forest cover loss areas. Selected areas, however, also included landscapes affected by other change dynamics (cropland areas due to differences in rotation stage, wetlands with water table level fluctuations, etc.). To decrease "noise" (with no significant increased reflection) and catch threshold of significant increasing of reflectivity multi-step grid classification and mathematic operations were done.

- *Forested areas inside change mask choosing*

Anyways the resulting change mask contained not only forests. To exclude non-forest areas from the change results an unsupervised classification of early image (2000, Landsat ETM+) for 100 classes within the change mask was done. Forest classes were manually labeled. The resulting layer showed forest cover area which increased reflectivity (loss forest areas) during 10 years. Generalization, and filtering polygons (all change polygons with an area of less than 1 hectare were excluded from further analysis) were performed to remove remaining noise.

- *Manual check*

Manual control with further elimination of "noise" – adding and deleting features, dissolving overlaying polygons, area calculation. Area were calculated in Albers Equal Area projection (coordinate system WGS84) with parameters: central meridian – 25, st.parallel 1 – 42, st.parallel 2 – 48, False Easting – 8500000.

The mapping procedure is described in publications (Achard et al. 2006; Forests of Central and Northern part of European Russia, 2008; Potapov et al. 2012).
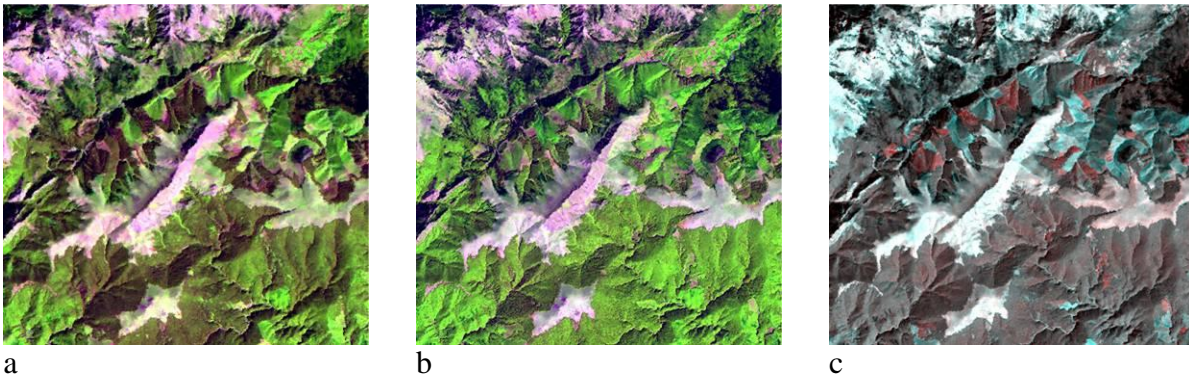

a   b   c

Fig.4. Basic data for forest cover change analysis
a) Part of ETM+ image (2000), bands: mid infra-red, near infra-red, red (RGB:543)
b) Part of TM image (2011), bands: mid infra-red, near infra-red, red (RGB:543)
c) Synthesis of ETM+ and TM mid infra-red bands (SWIR, 5). Red color – increase reflectivity (logging potentially), blue color – decrease reflectivity, white color – no changes in reflectivity
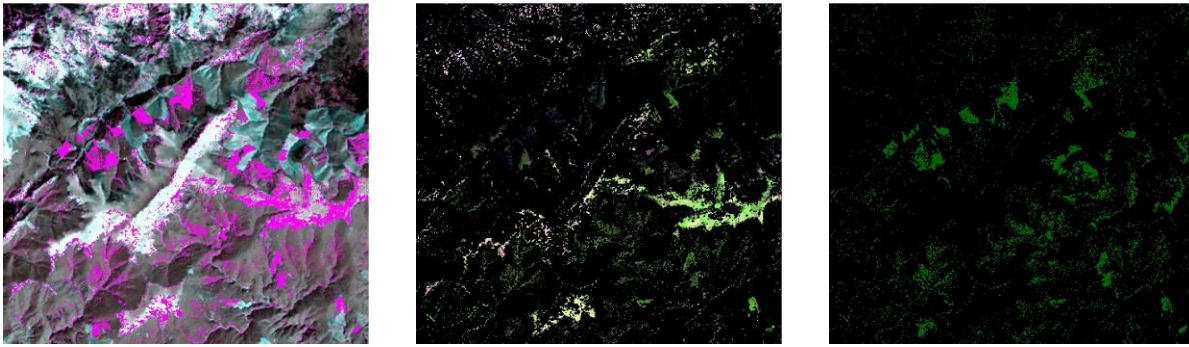
a   b   c

Fig.5. Forest areas with significant brightness increasing detection
a) Significant brightness increasing (more then 5-10%)
b) Masking of ETM+ image with significant brightness increasing areas
c) ETM+ masking image classification with forest class defining
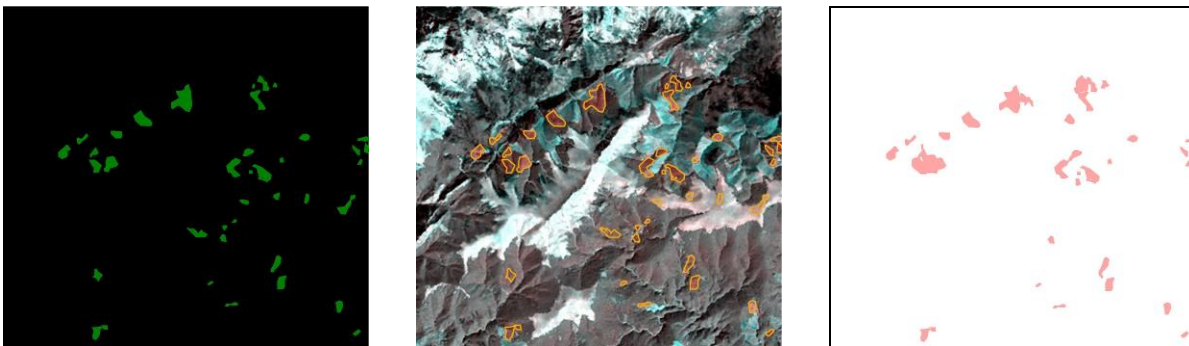
a   b   c

Fig.6. Disturbances detection: automatic results and manual control
a) Classification result generalization
b) Manual control, using ETM+, TM and synthesis images
c) Disturbances occur between ETM+ and TM images

Results

Forests cover 34% of Romania and concentrated mostly in mountain area. Total forest area of Romania in 2000 was 8,171,399 ha. Total area of deforestation and forest degradation in 2000-2011 was 280,108 ha (approx. 28 000 ha per year). It means 3.4% of Romania forestcover was lost or degraded in recent 10 years.

5

Literature Cited

Achard, F., Mollicone, D., Stibig, H.-J., Aksenov, D., Laestadius, L., Lid, Z, Potapov, P., Yaroshenko, A. (2006): Areas of rapid forest-cover change in boreal Eurasia. Forest Ecology and Management, Vol. 237, Issues 1-3, pp. 322-334

Forests of Central and Northern part of European Russia (Map) / A.Yaroshenko, D.Dobrynin, A.Egorov, I.Zhuravleva, A.Manisha, P.Potapov, S.Turubanova, E.Khakimulin. – Moscow, 2008 http://forestforum.ru/info/map_for_print.pdf

Potapov, P., A.Yaroshenko, S.Turubanova, I.Zhuravleva, A.Manisha. Forest cover change within the Russian European North after the breakdown of Soviet Union: 1990-2005. International Journal of Forestry Research. 2012 (on Peer Review)