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REMOTE SENSING IN FOREST MANAGEMENT

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Abstract: *Forest management, as a component of the management of natural protected areas, has the mission to adopt the most effective measures in relation to climate change. The forest management activity is based on management plans drawn up for a period of 10 years, a period appreciated, until recently, to be sufficient for management plans to be considered up to date. Their updating is done with the data provided in field by the rangers through direct observations and measurements, but the accuracy of these data is complemented by data obtained through modern technologies. Analyses of the distribution of forest vegetation, its composition and its evolution, both in time and in the area, and last but not least, the technical measures for implementing the most effective treatments for preserving its health, the optimal structure and biomass production is made using the latest technology, such as Free Open Source Software and GIS. Recent services provided free of charge by some remote sensing operators make it possible to adopt the most appropriate technical measures, real-time tracking of their implementation and expected results. This paper aims to bring to light some of the most useful free remote sensing services and how to use them.*

Keywords: remote sensing, forest administration, vegetation index

1. Introduction

The forestry administration, through the field staff, aims to implement the management plans and monitor the effects of the technical measures adopted. One of the needs it faces is the real-time identification of areas affected by natural disasters such as destructions caused by wind and snow. Most of the time they occur during the winter when significant amounts of precipitation occur, respectively in spring when the speed of the wind intensifies and the effect is cumulative (the snow on the branches is even more vulnerable to trees). In most cases, these areas are inaccessible because in the mountain area transport routes are closed until after the second half of April, so obtaining information on natural disasters becomes a necessity, especially for the early adoption of the necessary technical measures.

Photosynthesis is the essential process of plant organisms. Quantification of photosynthesis, gross raw production (GPP) is important for understanding climate change, agriculture and biodiversity. Satellite remote sensing, in recent years, has made remarkable progress in biosphere productivity [2, 4].

Health monitoring is one of the major objectives of the forest administration and any degradation of the forest should be identified as soon as possible so that plant protection measures have the best effect. The use of the NDVI vegetation index ensures efficient identification of the areas where the vegetation has a downward trend. Field observations will either confirm the

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hypothesis of degradation of vegetation health. Badgley proposes to introduce a new index, the near-infrared reflectance of vegetation (NIRV), as the product of total scene NIR reflectance (NIRT) and the normalized difference vegetation index (NDVI), a common measure of vegetation cover. From the point of view of the physical perspective, NIRV represents the proportion of pixel reflectance attributable to the vegetation in the pixel [1]. In this study we use only the NDVI.

Making new roads through the forest is conditioned, in order to prevent soil degradation, by an inclination of the terrain to maximum 25 degrees [8], and the longitudinal slope must not exceed a limit value [3]. When designing tractor roads, the design step will take into account the limit value of the longitudinal gradient with the help of level curves.

2. Materials and methods

The study was carried out in the Rasinari forestry area (Fig. 1), Sibiu County, Romania.

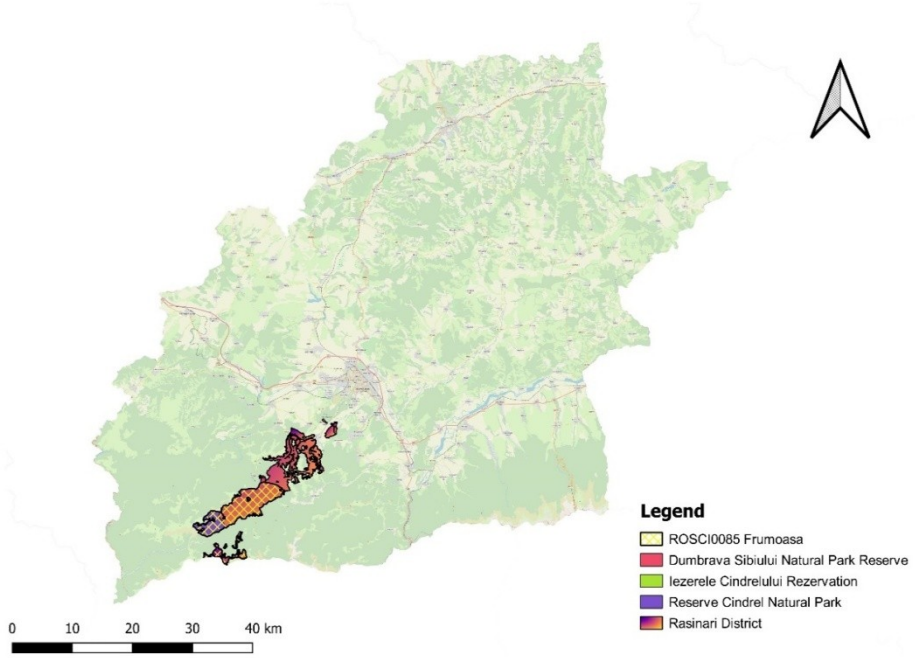

Figure 1. Research localization - Rasinari Forest District (N 45.61805, E 23.93134).

The Rasinari forestry administration manages an area of 9966 hectares over which the protected natural areas overlap – 5796 ha and 58% of the whole area (Table 1), which involves a correlation of the forest management plans with those of the protected natural areas [5].

Table 1. Natural protected areas

Natural Protected Area	Forest Surface -ha-
DumbravaSibiului Natural Park Reserve	16
Iezerele Cindrelului Rezervation	1
Reserve Cindrel Natural Park	1 195
Nature 2000 Site ROSCI0085 Frumoasa	5 780

The objectives of this study include the identification of free remote sensing services for the determination of areas where natural calamities occurred, the determination of vegetation indices, the digital modeling of the land, the automatic generation of level curves, the determination of the inclination of the land. In order to achieve the objectives, the steps presented in Fig. 2 were followed.

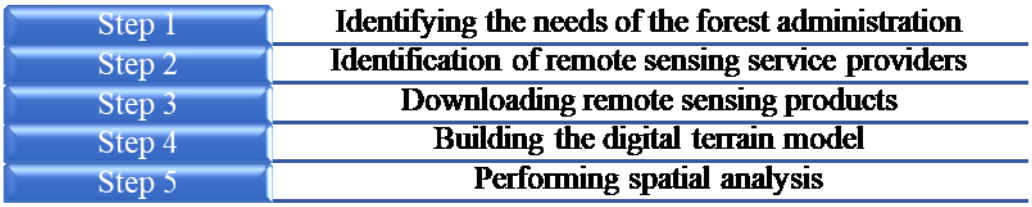

Figure 2. The steps followed in this study

Data processing and analysis were done using the QGIS software, version 3.6.1. The data were collected in 2018 (Sentinel 2) by means of the SRTM (Shuttle Radar Topographic Mission) — altimetric data model 2009.

3. Results and discussions

Of the providers of free remote sensing services, solutions were tested by means of Landsat 8, Sentinel 2 and ALOS PALSAR. The Landsat 8 features are shown in Fig. 3A, and those of Sentinel 2 in Fig. 3b [6, 9, 10].

	Bands	Wavelength (micrometers)	Resolution (meters)
Landsat 8 Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS) Launched February 11, 2013	Band 1 - Coastal aerosol	0.43 - 0.45	30
	Band 2 - Blue	0.45 - 0.51	30
	Band 3 - Green	0.53 - 0.59	30
	Band 4 - Red	0.64 - 0.67	30
	Band 5 - Near Infrared (NIR)	0.85 - 0.88	30
	Band 6 - SWIR 1	1.57 - 1.65	30
	Band 7 - SWIR 2	2.11 - 2.29	30
	Band 8 - Panchromatic	0.50 - 0.68	15
	Band 9 - Cirrus	1.36 - 1.38	30
	Band 10 - Thermal Infrared (TIRS) 1	10.60 - 11.19	100
	Band 11 - Thermal Infrared (TIRS) 2	11.50 - 12.51	100

a.

Sentinel-2 Bands	Central Wavelength (µm)	Resolution (m)
Band 1 - Coastal aerosol	0.443	60
Band 2 - Blue	0.490	10
Band 3 - Green	0.560	10
Band 4 - Red	0.665	10
Band 5 - Vegetation Red Edge	0.705	20
Band 6 - Vegetation Red Edge	0.740	20
Band 7 - Vegetation Red Edge	0.783	20
Band 8 - NIR	0.842	10
Band 8A - Vegetation Red Edge	0.865	20
Band 9 - Water vapour	0.945	60
Band 10 - SWIR - Cirrus	1.375	60
Band 11 - SWIR	1.610	20
Band 12 - SWIR	2.190	20

b.

Figure 3. a-Landsat 8 and b-Sentinel 2 band characteristics [6, 9, 10].

As we can see from Fig. 3, although both products are multi-spectral, the resolution of Sentinel 2 of Red (R), Green (G), Blue (B) and Near Infrared (NIR) responds better to the necessity of this study (10 m), so that the spatial data analysis used the latter. A healthy vegetation (chlorophyll) reflects more near-infrared (NIR) and green light compared to other wavelengths. But it absorbs more red and blue light. This is the reason why the vegetation is seen as green [7]. The Vegetation Index (NDVI) was calculated with the relationship 1.

$$NDVI = \frac{NIR-R}{NIR+R} \quad (1)$$

NDVI takes values between -1 and +1, which means that the areas with active vegetation will have a value close to 1, and for non-vegetation surfaces the value tends to -1. In the case of natural disasters such as damages caused by wind and snow, as well as in areas affected by biotic factors, NDVI will have different values from unaffected surfaces, so that the forestry administration can proceed with the implementation of the most appropriate technical measures.

For determining the digital terrain model (DEM), ALOS PALSAR products with a resolution of 10 m were used. The

downloading of the images was made using the portals of the providers of such services: Sentinel — Copernicus Open Access Hub, respectively ALOS PALSAR — Vertex, the Alaska Satellite Facility's data portal for remotely sensed imagery of the Earth.
The digital terrain model (DEM) was created using the SAGA GIS, and then the level curves were generated. Based on these, the slope of the terrain was generated so that tractor roads will only be made on surfaces that meet the legal criteria [2].
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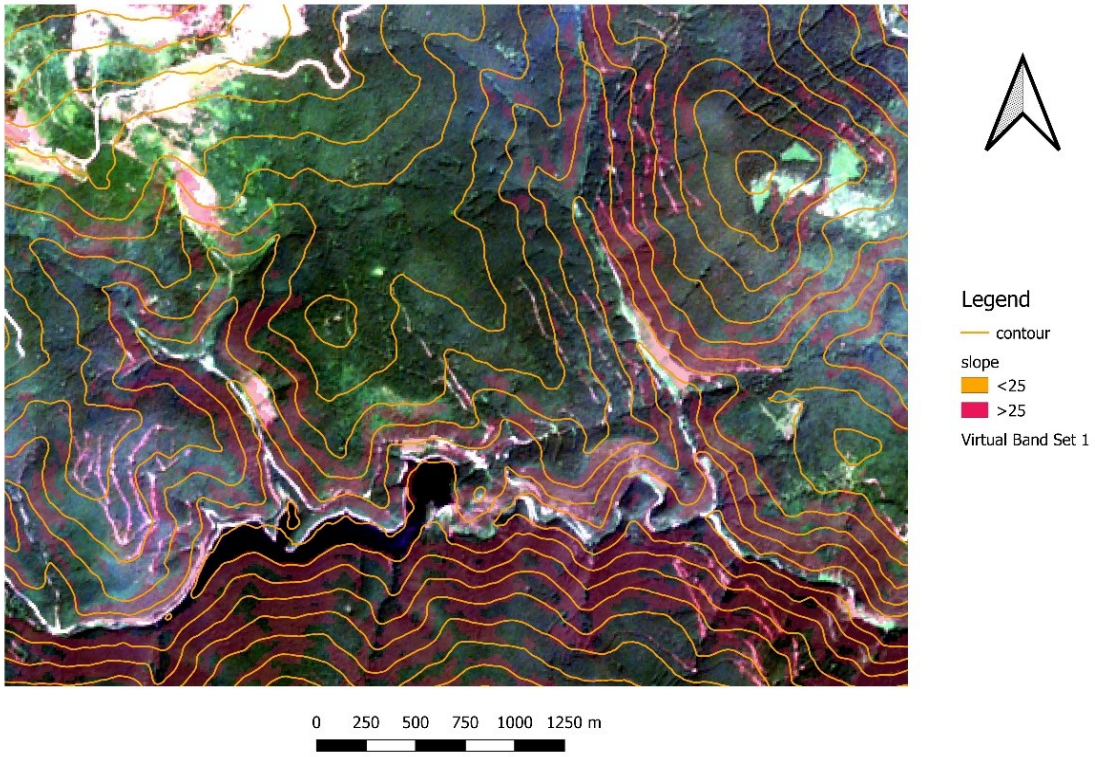

Figure 4. DEM, slope and contours

4. Conclusions

The present study used the data provided by Sentinel 2 and ALOS PALSAR, obtained free of charge from remote sensing providers. We use four spectral bands of Sentinel 2 resampled to a 10 m pixel size. The digital terrain model was created (DEM), level curves were generated, the inclination of the terrain was determined and NDVI was developed.
As a final conclusion, forest administration has modern tools at hand to promote sustainable forestry.Remote sensing at an acceptable resolution ensures timely identification of natural disasters and early detection of pathogen infections.

References

[1] Badgley, G.; Field, C.B.; Berry, J.A. Canopy near-infrared reflectance and terrestrial photosynthesis. Sci. Adv. 2017, 3, e1602244
[2] C. B. Field, J. T. Randerson, C. M. Malmstrom, Global net primary production: Combiningecology and remote sensing.Remote Sens. Environ.51,74–88 (1995)
[3] Ciubotaru, A., *Exploatareapădurilor*, ed. Lux Libris, 1998

[4] C. S. Potter, J. T. Randerson, C. B. Field, P. A. Matson, P. M. Vitousek, H. A. Mooney,S. A. Klooster, Terrestrial ecosystem production: A process model based on global satellite and surface data. Global Biogeochem. Cycles7, 811–841 (1993)
[5] Emergency Ordinance no. 57 of 20 June 2007 on the regime of protected natural areas, conservation of natural habitats, wild flora and fauna
[6] ESA, SENTINEL-2 Radiometric Resolutions, Available online: https://earth.esa.int/web/sentinel/user-guides/sentinel-2-msi/resolutions/radiometric, accessed on 7 February, 2019
[7] GIS Geography, What is NDVI (Normalized Difference Vegetation Index), Available online: https://gisgeography.com/ndvi-normalized-difference-vegetation-index/, accessed on 24 February, 2019
[8] Order no. 1540/2011 for the approval of the Instructions on the terms, modalities and periods of collecting, removing and transporting timber
[9] Satellite Imaging Corporation, Available online: https://www.satimagingcorp.com/satellite-sensors/other-satellite-sensors/sentinel-2a/
[10] U.S. Geological Survey, Available online: https://www.usgs.gov/media/images/landsat-8-band-designations