REMOTE-SENSING BASED FOREST VITALITY MONITORING SYSTEM

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Abstract

The remote-sensing based Forest Vitality Monitoring System is a major component of the Forest Monitoring and Measuring System coordinated by the Forest Research Institute (FRI). The ecology and forest protection department of the FRI started to develop the system in 2016 and aims to gather near real-time forest vitality information about the forests in Hungary using automatic remote sensing methods.
The monitoring system is based on the 250m resolution MODIS 16-day composite NDVI. The algorithms automatically download, process and store the vegetation index data in a database using various geoinformatic packages in R. Various statistical indicators are used to evaluate the present forest vitality. For validation purposes we plan to use past and current field observations and higher resolution satellite data.

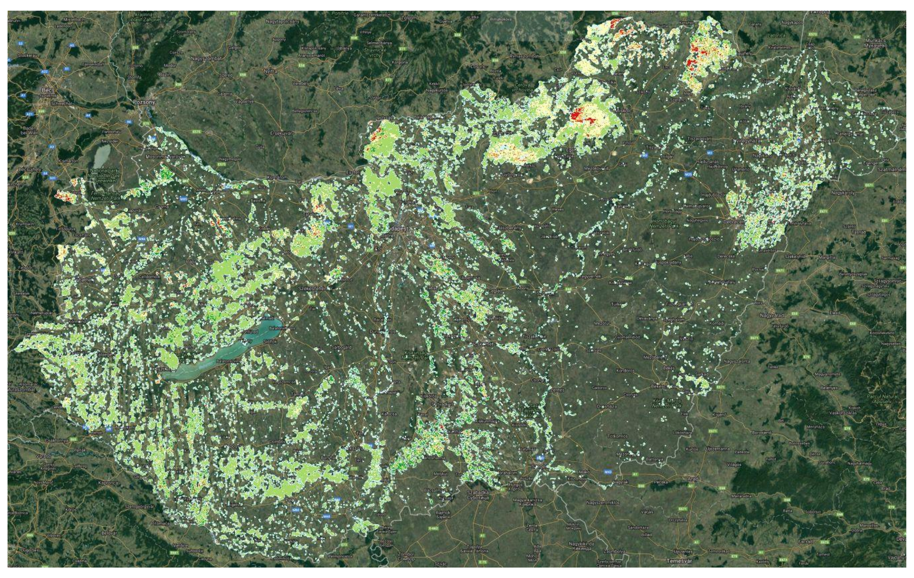

Figure 1. The monitored forest area in Hungary in Spring of 2017

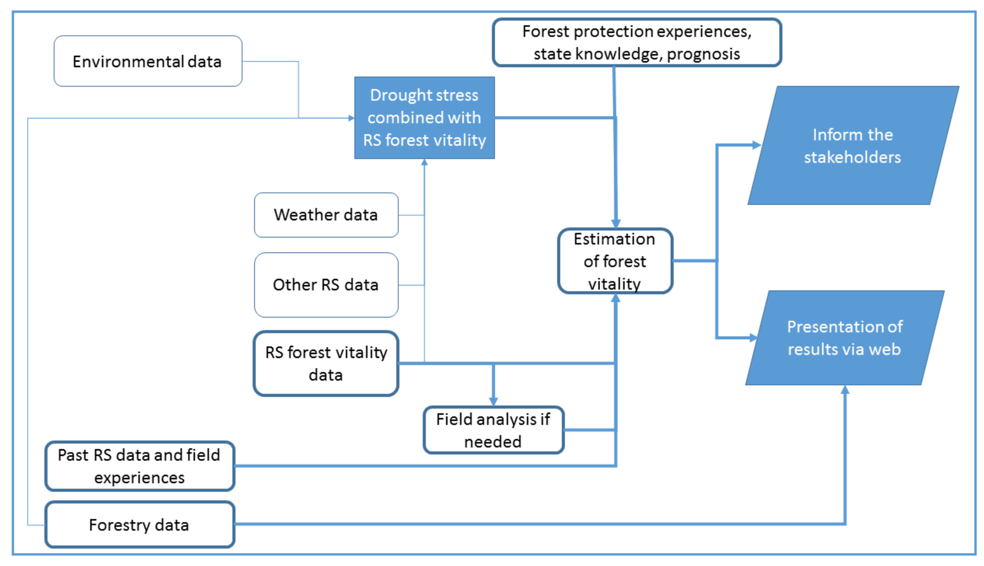

Figure 2. The flowchart of the monitoring system

Introduction and objectives

Negative impact of climate change on vitality, growth and resilience of many woody species in Hungary has been found. Due to the increasing stress further decline of forests could be suspected. The monitoring of vitality and functioning of forests becomes a more and more important task. The aim of the project is to continuously gain reliable, near real-time forest vitality information about the forests for the whole country using remote sensing data.
The monitoring aims also to follow the droughts triggering major forest declines thus we plan to develop a novel drought index that combines meteorological data with remote sensing based vegetation index.
In the near future we publish the results in a web-based software that is currently under development. Finally we plan to inform the stakeholders in case of suspicion of major forest decline.

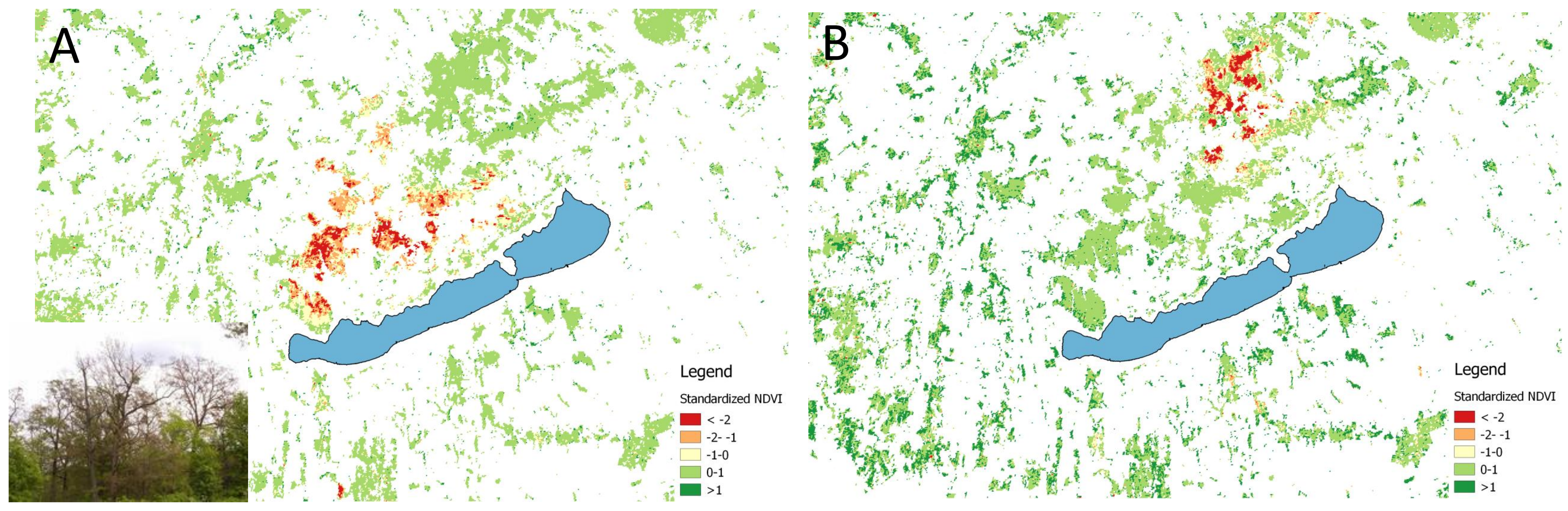

Figure 3. NDVI loss triggered by gypsy moth gradiation in 2004 (A) and in 2005 (B)

Methods

The spatial resolution of the 250m resolution MODIS 16-day composite NDVI images (Huete et al. 2002) fits very well to the forest subcompartments (approx. 5 ha), the primary forest management unit in Hungary. We monitor all MODIS pixels that are covered by more than 75% forests thus the results are not significantly influenced by the different spectral nature of other vegetation covers. The forest area is covered by approximately 240 thousand pixels (Figure 1).
The monitoring is composed of three main parts. The first element is the gathering and handling (masking, quality filtering, computing indices and uploading to database) of NDVI data that is automatically done by the system. The second element is a spatial database that includes all the NDVI data since 2000 for all forest pixels. Finally, the last part is a drought index (under development) that establishes a relationship between the droughts and the state of the forests (Caccamo et al. 2011) (Figure 2).
We apply three statistical indicators to evaluate the present vitality state of the forests. The standardized NDVI shows the deviation of the actual state from the long-term mean. The other two indicators are used to check whether a trend is present in the affected region. For this purpose we apply the NDVI data from previous years. We track only those deviations that larger than around 1000 ha.
In case of larger disturbances we try to identify the reason of the problem using several relevant environmental parameters (weather conditions, dominant tree species, age and mixture ratio, soil hydraulic type, topography).
We plan to use higher resolution satellite data (e.g. Sentinel) for validation of forest vitality results of MODIS. Occasionally, in case of future large-scale forest decline the comparison of vegetation indices of different spatial resolution would be very promising. It is inevitable to control the satellite data in the field by comparing the degree of forest damages with the indicators. Finally we plan to inform the stakeholders in case of suspicion of major forest decline.

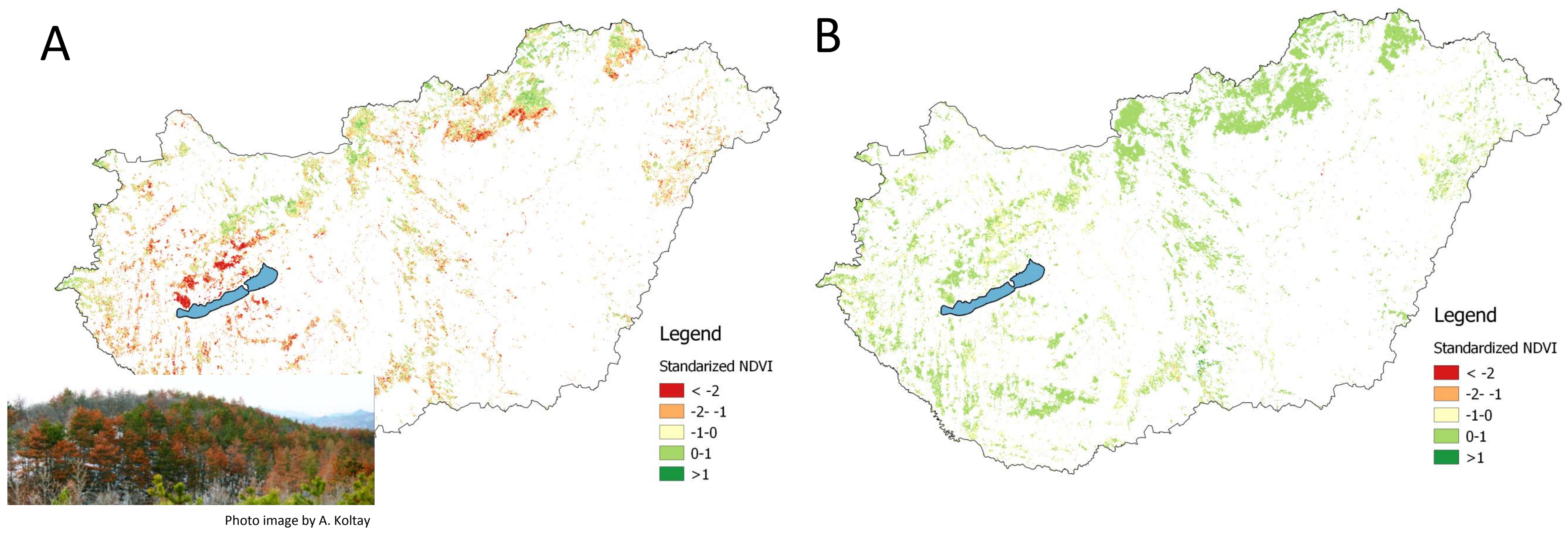

Figure 4. The standardized NDVI shows the effect of drought in 2012 (A) compared to 2010 (B)

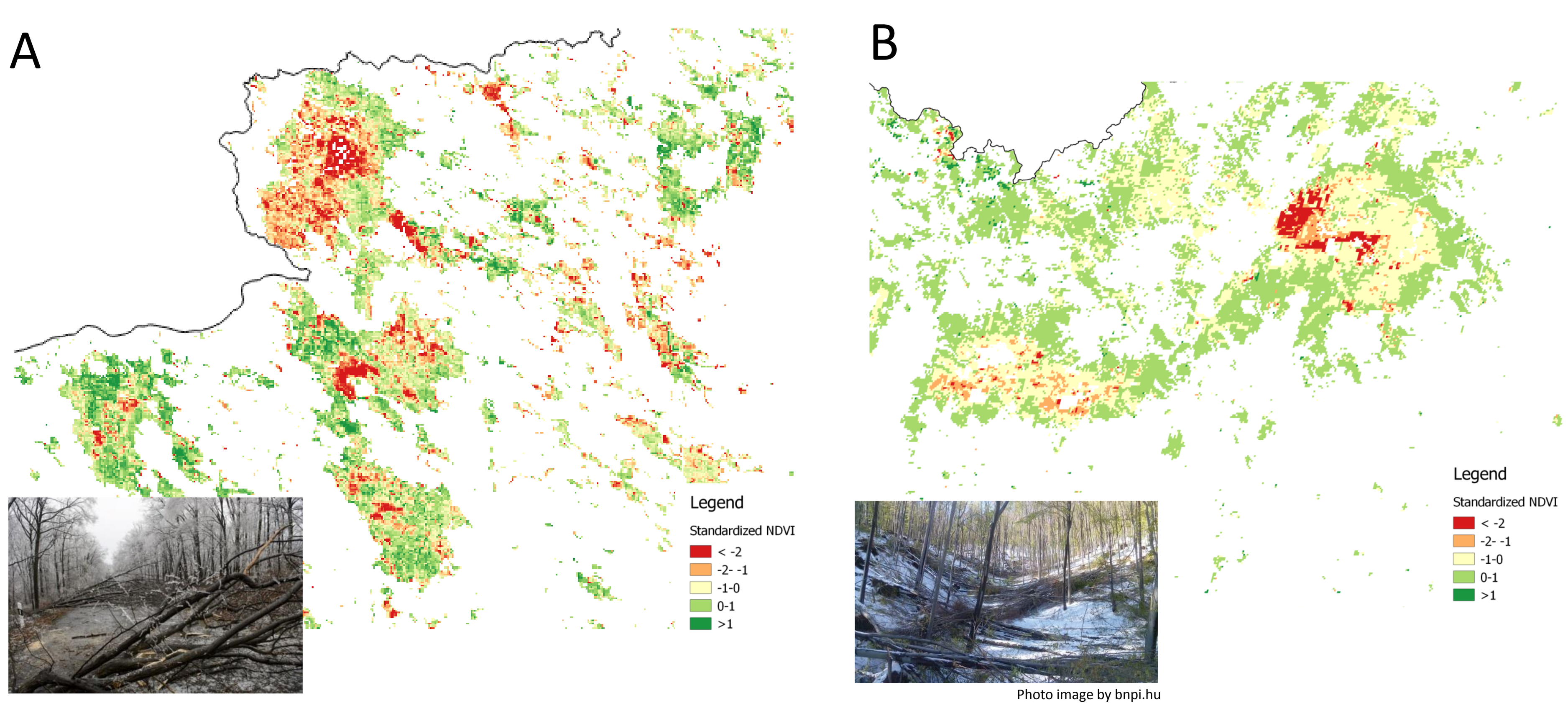

Figure 5. The effect of ice rain in the Visegrádi and Börzsöny mountains in December 2014 (A) and frost damages appears in the Mátra and Bükk mountains after a heavy snowfall in April 2017

Results

We found that the MODIS NDVI is a good indicator of forest vitality caused by various environmental changes. The gradation of gypsy moth after the extreme drought years in 2004 and 2005 caused decline of NDVI (Figure 3.). The effect of drought in 2012 near the lake Balaton is clearly visible (Koltay et al. 2012) by comparison with the rainy year 2010 (Figure 4). In December 2014 ice-rain hit the mountains in the northern regions of Hungary causing mass mortality of mainly beech forests (Figure 5a.). In April 2017 cold and snowy weather triggered damages and frostbite of leaves in the higher mountains, the effect of this phenomena can be detected even nowadays (Figure 5b).

References

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