Brandýsová, V., Bucha, T., Zverko, J.: Effect of understory vegetation on the course of phenological curve of the beech forests. Šiška, B. – Hauptvogl, M. – Eliašová, M. (eds.). Bioclimate: Source and Limit of Social Development International Scientific Conference, 6th – 9th September 2011, Topoľčianky, Slovakia

EFFECT OF UNDERSTORY VEGETATION ON THE COURSE OF PHENOLOGICAL CURVE OF THE BEECH FORESTS

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Abstract. The understory vegetation is a natural component of forest ecosystems. The dynamics of this vegetation is necessary to be monitored by terrestrial phenological observations of trees for the validation of phenological observations from satellite data. It is because the phenological curve derived from satellite data begins to rise before the start of leaf onset in spring vegetation period. The research subject was the phenological curve of the ground vegetation and trees in beech forests located in VšLP TU Zvolen, localities Turová and Bukovina. The dominance of ground vegetation was compared with the gradual increase in NDVI values until the period of 100 % leaf onset.

Introduction

Many works from phenology, climatology and remote sensing solve the matter of reaction of plant communities to current climate changes. The phenology is a science of the periodic plant and animal life cycle events depending on the complex environment conditions (Kolektív autorov, 1993). Therefore the changes in plant reactions are considered as a suitable factor of the changed natural conditions.

In the past, the plant phenology was the object only of the field (ground) observations. However, technical developments in remote sensing allowed monitor the changes in the land cover dynamics using the satellite records. In some forests, the leaf onset begins earlier in understorey vegetation than in the tree canopy. This is due to a strategy of „phenological escape“, when plants take advantage of the high-light period in spring before canopy development (Richardson & O'Keefe, 2009). Several authors concluded that the presence of the underground vegetation and undergrowth in forests can significantly affect the vegetation index values in the time before the leaf onset.

The aim of this work was to quantify the contribution of understorey vegetation on the growth in the NDVI values of the forests with dominant representation of beech, during the spring until the 100% leaf onset.

Data and methods

The object of our research was five forests with predominant representation of the beech, and minimal representation of the evergreen trees. These forests are situated on localities Turová and Bukovina, and belong to University Forest Enterprise of Technical University in Zvolen. Here was observed the coverage of understorey vegetation and spring phenological phases of trees in 5-7 days intervals. There were also taken the pictures of the tree canopy and vegetation, and collected some samples of the green leaves, the understorey vegetation, the litter and the beech bark for the purpose of the spectral analysis.

The coverage of understorey vegetation was estimated on the square areas of side 10 m. A five monitoring areas were established in each forest (pixel). The distance between centers of these areas was 50 m. The method by SHMÚ (1984) was chosen for phenological observations. Followed spring phenological phases were observed on selected tree groups: bud bursting (BB), leaf unfolding (LU) and leaf onset (LO).

MODIS product selection as well as the procedure of satellite data obtaining, processing, and derivation of NDVI were described by Bucha & Koreň (2009). NDVI values are derived from spectral reflectance in red (RED: 620–670 nm) and infrared (IRED: 841–876 nm) channel using the function [1]:

$$NDVI = \frac{(IRED - RED)}{(IRED + RED)} \quad [1]$$

The growing season in our climate and nature conditions can be modeled by sigmoid logistic function (Fisher et al., 2006) [2], which captures one increasing (spring) and one decreasing (autumn) term:

$$v(t) = v_{min} + v_{amp}\left(\frac{1}{1+e^{m_1+n_1 t}} - \frac{1}{1+e^{m_2+n_2 t}}\right) \quad [2]$$

where v_t - NDVI value; v_{min} - minimum NDVI value; $_{vamp}$ - total NDVI amplitude; m_1, m_2, n_1, n_2 - fitting parameters controlling phase and slope for both greenup (m_1, n_1) and senescence/abcission (m_2, n_2). Software Phenological profile was used to determine the course of the phenology. This software models the phenology with function [2] proposed by Fisher (2006). Input data were the NDVI time series of the year 2011.

The spectral reflectance of the taken samples was measured by spectroradiometer Li-1800 in laboratoral conditions. The NDVI values of these samples were calculated from measured reflectance values. These NDVI values were input data to the NDVI forest model [3]:

$$NDVI_{model} = \%NDVI_{KT} + \%NDVI_{KH} + \%NDVI_{V} + \%NDVI_{LDrU} + \%NDVI_{LDrP} + \%NDVI_{O} \quad [3]$$

Where $\%NDVI_{KT}$ – NDVI for the percentage of thin branches; $\%NDVI_{KH}$ – NDVI for the percentage of the trunk and large branches; $\%NDVI_{V}$ – NDVI for the percentage of ground vegetation; $\%NDVI_{LDrU}$ – NDVI for the percentage of tree canopy leaves; $\%NDVI_{LDrP}$ – NDVI for the percentage of tree undergrowth leaves; $\%NDVI_{O}$ - NDVI for the percentage of litter.

Results and disscussion

The percentages of individual components of forest ecosystems corresponding to a particular dates, as well as satelite data recorded, were simulated using the data from the field observations and the image analysis. The modeled and satelite NDVI values are noted in table 1. A correction factor as the ratio between the maximum value of the satelite and modeled NDVI values ($a = NDVI_{sat,max} / NDVI_{model,max}$) during the final leaf onset (day159) was introduced due to the large difference between these two NDVI values. Then the $NDVI_{model}$ values were corrected using this correction factor ($NDVI_{kor} = NDVI_{model} . a$). Average difference between the satelite and corrected NDVI was 0.015.

Table 1. Values of the satelite, model and corrected NDVI for individual days.

Dielec	NDVI	Poradový deň v roku				
		101	108	116	125	159
509	$NDVI_{sat}$	0.55	0.64	0.72	0.81	0.92
	$NDVI_{mod}$	0.44	0.50	0.59	0.69	0.76
	$NDVI_{kor}$	0.53	0.61	0.71	0.83	0.92
514	$NDVI_{sat}$	0.56	0.65	0.75	0.83	0.93
	$NDVI_{mod}$	0.45	0.50	0.59	0.68	0.75
	$NDVI_{kor}$	0.56	0.62	0.73	0.84	0.93
531	$NDVI_{sat}$	0.57	0.65	0.74	0.82	0.92
	$NDVI_{mod}$	0.48	0.54	0.62	0.68	0.76
	$NDVI_{kor}$	0.58	0.65	0.75	0.82	0.92
541	$NDVI_{sat}$	0.56	0.65	0.73	0.83	0.93
	$NDVI_{mod}$	0.45	0.51	0.60	0.69	0.77
	$NDVI_{kor}$	0.54	0.62	0.73	0.83	0.93
619	$NDVI_{sat}$	0.56	0.66	0.75	0.83	0.92
	$NDVI_{mod}$	0.45	0.50	0.60	0.68	0.76
	$NDVI_{kor}$	0.54	0.61	0.73	0.82	0.92

The hypothesis, that the growth of phenological function at the beginning of the growing season is caused by understorey vegetation, on the basis of impact of $\%NDVI_{V}$ on $NDVI_{model}$ in individual forests was rejected. Phenological curves generated for each forest started to rise between 70th-80th DOY (day of year), while the NDVI values of unredstorey vegetation started to rise around the 100th DOY. More significant impact on the $NDVI_{model}$ values was recorded in a tree undergrowth ($\%NDVI_{LDrP}$), which is driven by the strategy of phenological escape and reached the 100 % leaf onset already around the 108th DOY. At the same time, the phenophase 50 % bud bursting in the tree canopy was observed and this is the time, when the 1. derivation of the phenological curve reached the local maximum. Based on these findings, we assumed that the onset of spring phenological phases of the undergrowth trees was most likely cause of the rising phenological curve in early spring.

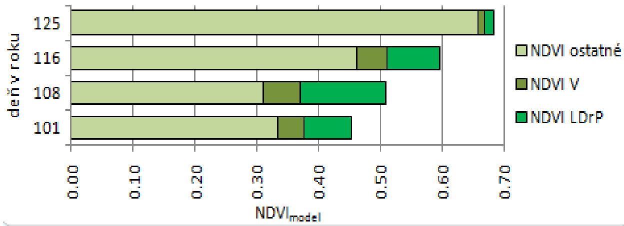

Figure 1. The average proportion of $\%NDVI_{V}$ values and $\%NDVI_{LDrP}$ values on the $NDVI_{model}$ value. On x-axis: DOY, on the y-axis $NDVI_{model}$.

Our results confirmed an argument of Pellikka (2001), that a forest with dense vertical structure may appear to reach half canopy coverage (date of leaf onset) more rapidly than a monolayer forest. Priwitzer (2009) noted the effect of a scrub vegetation in oak forests on the earlier rising of the phenological curve on locality Čifáre. Similarly in our case, this earlier rising of phenological curve was caused by undergrowth trees in the forests with dominant representation of the beech.

Conclusions

This work was concentrated on find out the effect of understorey vegeration on rising phenological curve in the time before the leaf onset. The problem solution recuired the field observations, the laboratoral and picture analysis and using of the simulation method. The corection factor was introduced to minimalize the difference between the satelite and the model NDVI of monitored forests. The hypothesis, that the rising of phenological curve before the leaf onset was caused by the understorey vegetation, was confused. This rising of phenological curve in the time arround 100th DOY is caused by the leaf onset of undergrowth trees. Still stays a question, what couses rising NDVI values of phenological function before the 100th DOY.

Acknowledgements: This work was supported by the VEGA project: num. 1/0281/11 and the APVV project num. APVV-0423-10.

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