

## Evaluation of ground level ozone concentrations and climatic variables in submountain beech forests (Western Carpathians Mts)

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### Abstract

KELLEROVÁ, D., JANÍK, R. 2010. Evaluation of ground level ozone concentrations and climatic variables in submountain beech forests (Western Carpathians Mts). *Folia oecol.*, 37: 51–54.

Research, carried out in submountain beech stand in the Kremnické vrchy Mts (410–570 m a.s.l.), was used to determine differences in ground level ozone concentrations and values of selected climatic variables between a former clear-cut which was the result from a cutting performed in 1989 and also a beech forest stand not subjected to the intervention. Differences in ozone concentrations were pronounced mainly in summer (July, August) when the values on the former clear-cut were much higher than those measured in the forest stand. In August 2004, a value of 118  $\mu\text{g m}^{-3}$  was recorded on the former clear-cut. The increase in air temperature in the region was up to 15.4 °C, compared to the former long term mean value 14.8 °C from years 1961–1990 which was reported from Sliač, this is unequivocal.

### Key words

air temperature, ground level ozone, illumination intensity, precipitation, submountain beech

### Introduction

Forests covering 40% of Slovak territory are subjected to significant changes, including changes to the local climate – initiated due to both anthropogenic and natural influence. Over the past decades, many various changes were characteristic for the whole of Central Europe (ALEWELL et al., 2000). These changes were mainly connected with conversion and innovation of industry, and with measures accepted in legislation. The positive turn over in trends in emissions and airborne pollutants was mainly thanks to a considerable decrease in pollutants of domestic origin (SPIŠÁKOVÁ et al., 2003). The present pollution is caused by particular matter and by ozone (VÁŇA and SMRČKOVÁ, 2000; SHMÚ, 2006). This development shows a positive trend, nevertheless the decrease in  $\text{NO}_x$  – one of ozone precursors was not as steep as that of the  $\text{SO}_2$  emissions (FLEISCHER et al., 2005). Periods of dry warm weather represent unfavourable climatic conditions promoting

an increase in the amount of ground level ozone consequently, creating an adverse effect on public health, vegetation and whole ecosystems (BIČÁROVÁ et al., 2005; GODZIK and GRODZINSKA, 2002; ŠEC et al., 2007). Ozone is a photo-chemical pollutant arising from the presence of precursors: nitrogen oxides and VOC, coupled with the presence of favourable photo-chemically favourable conditions. This substance initiates changes to plant assimilatory organs which slows down photosynthesis and influences synthesis of chlorophyll. In spite of the ecological measures applied, the ozone concentrations reach beyond the limit values (ŠACH and ČERNOHOUS, 2005; ZAPLETAL and CHROUST, 2007). Based on the measurements made by the EMEP network stations, Slovakia has been classified as a country with a medium ozone load. The most severely loaded are industrial European areas such as: Germany, France, and Mediterranean area: Italy, Spain (ELVINGSON and ÅRGEN, 2004). At present, the influence of ozone load is higher in the countryside and mountainous areas rather than

urban areas. For this reason, our research was focussed on pollution of the ground layer of atmosphere in an area of forest type which was sufficiently more remote from urban and local pollution sources. Amounts and characteristics of pollutants at local and regional levels are determined by a range of factors – acting in synergy – the origin of which can be meteorological, organic or caused by precursors. Recognition of causes and regularities in performance of individual climatic factors should help to maintain the necessary equilibrium between all components of ecosystems, humans not omitted.

## Material and methods

The purpose of our research was to determine differences in ground level ozone concentrations and values of selected climatic variables between the ones entering a forest stand and those entering a plot which was subjected in 1989 as clear cutting – this resulted in a stocking density of 0.0. At the moment of cutting intervention, the stand age was 80–90 years. The stand without intervention is dominated by beech, covering 94.7% of the stand area. The research subjects are situated in Central Slovakia, in the SE part of the Kremnické vrchy Mts (Western Carpathians Mts,  $\varphi = 48^{\circ}38' N$ ,  $\lambda = 19^{\circ}04' E$ ), at an altitude of 470–510 m. The slope is exposed on the west, with an inclination of 30–36%. For measuring the long-term influence of immission load to forest ecosystems a suitable method to determine the ground level ozone ( $O_3$ ) concentrations would be provided with the sorption-accumulation method (WERNER, 1991). The values of ground level ozone concentration, air and soil temperature and precipitation amounts were recorded at regular intervals covering the whole growing seasons. Illumination intensity was measured at the time without leaves and at the time of leaves fully developed.

## Results and discussion

The values of ozone concentrations obtained by passive sampling were analysed. The research started 10 years after the cutting. The stand left without intervention has maintained its original characteristics – without understorey. The dynamical regeneration running on the former clear-cut has resulted in the current 16-year-old young growth with dominant beech. The description of the two different plots together with mean ozone concentration values and other important parameters are outlined in Table 1. In spring, in the absence of sufficient foliage with an air temperature reaching minima on both plots, the values of ozone concentrations were very similar. The differences in ozone concentrations between the plots were especially marked in summer (July, August) – reaching on the former clear-cut much higher values than in the forest stand: Figs 1 A and B. Such big differences could mainly follow from extremely high ozone concentrations: in August 2004 we recorded on the former clear-cut a value of  $118 \mu\text{g m}^{-3}$ . The mean ozone concentration of  $40 \mu\text{g m}^{-3}$  obtained in years 1999–2003 increased in the following years 2004–2006 to  $55 \mu\text{g m}^{-3}$ . The mean temperature value in 1999–2003 on both  $15.35^{\circ}\text{C}$ , in the following years 2004–2006 it was  $15.45^{\circ}\text{C}$ . Comparing these values with the long term mean from Sliač – representing  $14.8^{\circ}\text{C}$  for years 1961–1990, the increase in air temperature in this region is undisputable.

## Conclusions

In terms of ecological stability, the area of the Kremnické vrchy Mts has previously been considered as only slightly polluted. In spite of this classification, also in this area occur episodes with high ozone concentrations ( $118 \mu\text{g m}^{-3}$ ). Increasing air temperature and ozone concentrations seem to be risk factors in this sub-mountain

Table 1. Dynamics of natural and artificial regeneration of a small-sized clear-cut, history of stocking density in a beech stand in the Kremnické vrchy Mts, mean air temperature, precipitation, illumination intensity and mean values of ground level ozone during vegetation periods

Research plots	Clear cut	Forest stand without intervention
1989 cutting intervention	0.0 density	0.9 density
1999 10 years after cutting	Young growth	0.9 density
2004 15 years after cutting	Small pole stage	1.0 density
1999–2006 mean temperature	$15.6^{\circ}\text{C}$	$15.3^{\circ}\text{C}$
1999–2006 precipitation	678 mm	511 mm
1999–2006 mean $O_3$ concentration	$49 \mu\text{g m}^{-3}$	$46 \mu\text{g m}^{-3}$
Illumination intensity		
Before foliage 1990	36 klx	15.7 klx
Before foliage 2001	6.7 klx	6.7 klx
Under foliage 1990	40.9 klx	2.5 klx
Under foliage 2001	0.6 klx	1.2 klx

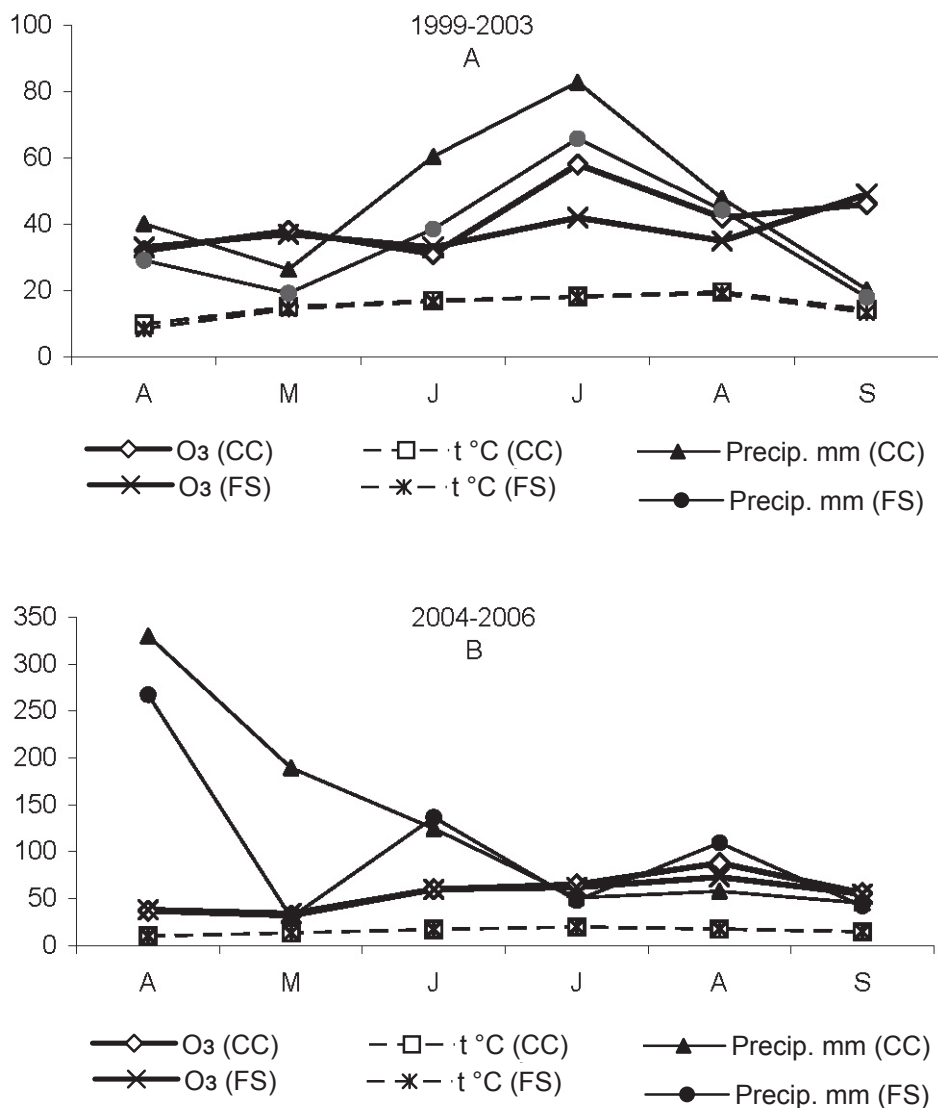


Fig 1. History of air temperature, precipitation and ozone concentrations (warm half-of-year) on a former clear-cut (CC) and in a forest stand (FS) not subjected to cutting intervention situated in submountain beech in the Kremnické vrchy Mts: A – 10 years after cutting, B – 15 years after cutting, (O<sub>3</sub> concentration: µg m<sup>-3</sup>)

area, in spite of the fact that they do not reach extreme values reported from other regions of Slovakia. Conditions necessary for ozone creation are dependent on developing meteorological situations and the maintenance of extensive areas during anticyclones.

#### Acknowledgement

This work was supported by the Scientific Grant Agency of the Ministry of Education of Slovak Republic and Slovak Academy of Sciences (Projects No. 2/0034/10, 2/0055/10, 2/0068/10, 2/0045/08). We also acknowledge D. Kúdelová for preparing the English text.

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## Hodnotenie meraní koncentrácií prízemného ozónu a klimatických faktorov v podhorských bučinách (Západné Karpaty)

### Súhrn

Zámerom výskumu v podmienkach podhorských bučín v Kremnických vrchoch (410–570 m a. s. l.) bolo zistiť diferencie v koncentracii prízemného ozónu a klimatických faktorov na pôvodnej holine, ktorá vznikla ťažbou stromov v roku 1989 a v bukovom poraste bez ťažbového zásahu. Diferencie sa ukázali najmä v letných mesiacoch júl a august, kedy boli na pôvodnej holine v porovnaní s porastom najvyššie koncentrácie ozónu. V auguste 2004 bola na pôvodnej holine nameraná hodnota  $118 \mu\text{g m}^{-3}$ . Nárast teplôt vzduchu na  $15,4 \text{ }^\circ\text{C}$  v regióne je v porovnaní s dlhodobým priemerom  $14,8 \text{ }^\circ\text{C}$  z rokov 1961–1990 zo Sliača jednoznačný. Priemerná teplota  $15,6 \text{ }^\circ\text{C}$  na pôvodnej holine bola vyššia ako  $15,3 \text{ }^\circ\text{C}$  v poraste, podobne aj zrážok (678 mm) tu bolo za rovnaké obdobie zachytených viac ako v poraste (511 mm).

Received October 28, 2009  
Accepted December 18, 2009