Lesn. Cas. For. J. 61 (2015) 196–202

REFERÁT – DISCUSSION PAPER

Lesnícky časopis - Forestry Journal
http://www.nlcsk.sk/fj/

Historical abiotic damage to forests in the Moravian-Silesian Beskids (Czech Republic)

Historie abiotického živelního poškození smrčin v Moravskoslezských Beskydech (Česká republika)

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Abstract

Historical sources provide evidence of the condition and damage to forests over time. Lesprojekt (The Forest Management Institute, which is a governmental institution under the Ministry of Agriculture of the Czech Republic) evaluated data from records deposited in the national archives in three cycles of historical research (1966–67, 1976, 1982–83) conducted in the state forests (forest enterprise of the state forests). The processed data was critically evaluated and formed the foundation of a long term series (1875–2012) of windfalls and snow damage. The aim of this paper was to summarise the data pertaining to such enormous abiotic damage in the Moravian-Silesian Beskids (Outer Western Carpathians, Czech Republic), its temporality, frequency and intensity. A spatial analysis of snow calamities was conducted during the last disturbance episodes in the winters of 2005/2006 and in October 2009. The historical records showed that the most extensive disturbances occurred in 1916, when 600,000 m^3 of wood was damaged in the monitored area. Some findings were discussed in relation to silvicultural interventions in the Moravian-Silesian Beskids. In the conclusion, some problems and limitations concerning the reliability of data obtained this way are indicated.

Keywords: forest stands; wind and snow damage; *Picea abies*; frequency of disturbances; spatial analyses

Abstrakt

Historické prameny přinášejí svědectví o stavu a poškození lesů v minulosti. Lesprojekt vyhodnocoval údaje z dokumentů uložených ve státních archívech ve třech cyklech Historických průzkumů (1966–67, 1976, 1982–83) pro tehdejší lesní závody státních lesů. Zpracované informace byly kriticky zhodnoceny a staly základem dlouhé časové řady (1875–2012) větrných a sněhových polomů. Cílem této práce bylo sumarizovat údaje o výskytu těchto velkých abiotických poškození v Moravskoslezských Beskydech, jejich časovost, četnost a intenzitu. Také byla provedena prostorová analýza sněhových kalamit při posledních kalamitních epizodách v zimě 2005/2006 a v říjnu 2009. Historické záznamy ukázaly, že nejrozsáhlejší kalamity vznikly v roce 1916, kdy došlo ve sledované oblasti k poškození 600 tisíc m^3 dřevní hmoty. Některé poznatky byly diskutovány ve vztahu k pěstování porostů v Beskydech. Na závěr jsou načrtnuty některé problémy a omezení spolehlivosti takto získaných údajů.

Klíčová slova: lesní porost; škody větrem a sněhem; *Picea abies*; frekvence kalamit; prostorová analýza

1. Introduction

A forest is an irreplaceable part of the environment (Act no. 289/1995 Coll.), and preservation and regeneration of a forest as a national resource, together with fulfilling of all its functions, is the task of sustainable forest management. Forest ecosystems are repeatedly affected by events which disrupt sustainable management and negatively influence the functional continuity of a forest (Konôpka et al. 2008). The volume of timber processed after the impact of harmful agents accounts for tens of percent of the total logging volume in the Czech Republic every year (Rychtecká & Urbaňcová 2008). More than a half of salvage cutting is caused by harmful factors: wind, snow, rime – so called abiotic agents. Forest damage caused by abiotic agents is common in areas where forestry is based on artificial regeneration with one predominant tree species (Spiecker 2000). This situation prevails in central Europe as well as in Great Britain, Scandinavia, North America, Australia, Japan or New Zealand (Slodičák 1996). In Europe, the annual average salvage cutting amounts to 35 million m^3 of timber (Schelhaas et al. 2003), most often it is a result of windfall. The impact of abiotic agents on forestry has been intensively studied around the world (e.g. Jalkanen & Mattila 2000; Talkkari et al. 2000; Zhu et al. 2006; Mickovski et al. 2005; Konôpka et al. 2007; Klopcic et al. 2009; Lehtonen et al. 2014). The impact of harmful agents is influenced by a number of factors which can synergise due to which stating the importance of individual agents is not a simple matter (Kamimura & Shirashi 2007). Harmful abiotic agents occur irregularly and depending on the synoptic situations of meteorological variables (Konôpka et al. 2007; Lehtonen et al. 2014).

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The forecast of their occurrence is therefore arduous and the temporal analysis requires a long-term data collection series of sufficient volume.

The aim of this paper is to conduct an analysis of a long-term series of events causing ecosystem disturbances in altered spruce forests in the Western Carpathians based on historical records, and to outline the possibilities and limitations of information obtained this way.

2. Materials and data

2.1. The study area

The Natural Forest Area (NFA) 40 – Moravia-Silesian Beskids (Fig. 1) is defined in the amendment to the 1 Regulation of the Ministry of Agriculture in CZ no. 83/1996 Coll. It covers this mountainous region (geomorphological region Ondřejník included) in the Outer Western Carpathians system in the Czech Republic. It is an area of 824,3 km^2 with 75% forest coverage (Holuša 2000). In terms of species composition, there is a prevalence of spruce *Picea abies* [L.] Karst. (80%), mostly at non-indigenous sites (75%; Culek 1996). This concerns the 5th – to 7th locations on the forest altitudinal vegetation zone (FAVZ) according to the typological forest classification (Plíva 1971), with a prevalence of 5th, i.e. fir-beech FAVZ – practically four fifths of the area (Holuša 2004). The majority of the original fir-beech forest was harvested during the colonisation of Valašsko in the 16th century (Pavelka & Trezner 2001), the current stand is nonindigenous (pursuant Council Directive 1999/105/EC 2000) or secondary spruce forests (Slodičák 1995; Slodičák & Novák 2006). The reforestation of the Beskid Mountains in the 19th century was completed mostly with reproductive material from South Tyrol (an area of Innsbruck; Holuša 2004). These spruces are not adapted to the natural conditions of the Central European Carpathians, they are characterised by high production, broad crowns and low resistance to physical damage caused by natural abiotic factors – wind, snow and rime (Rottmann 1985; Valinger et al. 1993; Nykänen et al. 1997). The territory belongs to the areas with the highest precipitation totals in the Czech Republic (Tolasz et al. 2007). In addition, the highest snow depth of all the meteorological stations in the Czech Republic (491 cm during 8th – 9th March 1911) was recorded on the top of Lysá hora (1,323 m a.s.l.; Appendix 1a).

2.2. Historical Surveys

An important data source on forest disturbances in the past can be archive materials, processed in so called historical surveys, which contain specific figures/data on forest management from the recent modern period. Therefore, they can become a foundational building block of a historical data time series on forest damage. In 1983–1984, Lesprojekt, the Engineering Institute in Brandýs nad Labem, which is a governmental institution under the Ministry of Agriculture of the Czech Republic, drew up papers on the 'History of Forests' – cycles II and III. They processed and evaluated historical sources from relevant archive collections such as the State District Archives in Opava, Kroměříž, Brno, Janovice u Rýmařova, the District Archive in Vsetín and in Archiv powiatowy in Czieszyn (Poland), first in 1966–1967 and again in 1976 within the framework of the so called historical survey. The outcomes were the papers prepared for the individual forest enterprises (FE) of the former Severomoravské státní lesy (Northern Moravian state forests); in the Moravian-Silesian Beskids they were prepared for the following FEs (Fig. 1): Jablunkov (Žaloudík 1984c), Frýdek-Místek (Žaloudík 1984b), Ostravice (Žaloudík 1983a), Frenštát pod Radhoštěm (Žaloudík 1984a) and Rožnov pod Radhoštěm (Žaloudík 1983b). These papers usually include "e) the development of harmful effects" data on factors and events that caused forest damage in the past. They traced damage back as far as the oldest data found in the archives – most often from the second half of the 19th century. If the extent of damage was quantified, it usually concerns the data revealed by summaries and calculations from the archive data for indi-

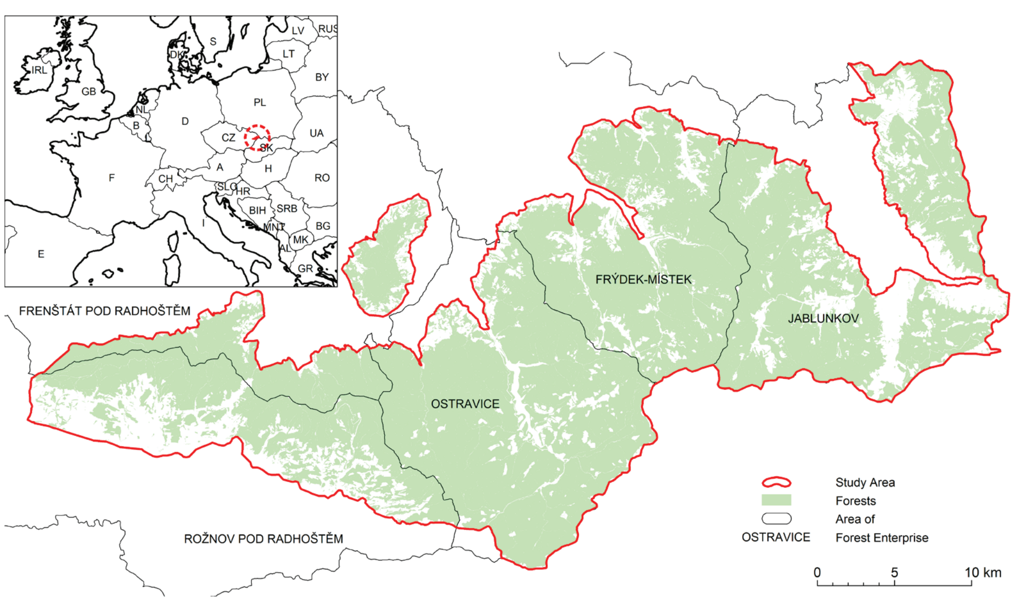

Fig. 1. Study region of the Moravian-Silesian Beskids Natural Forest Area.

vidual forest estates. During the preparation of the Regional Forest Development Plan (Holuša 2000), 'History of Forests' papers were revised and the data on "harmful effects on forests" were summarised in a review of the development of individual harmful agents which was included in the chapter about forest protection (Telecký 2000).

This work combines two sources, the Regional Forest Development Plan as well as the papers on the 'History of Forests'. When the archive material contained a reference to wind, snow or rime breakage and this entry was included in 'History of Forests', this piece of information was placed into a time series of natural abiotic damage, whether it had already been quantified or not. The criterion in this case is significance of the situation for recording in historical materials. Lesprojekt began to collect forest management reports from individual organisational units of state forest enterprises (FE) in the second half of the 20th century, the sum of salvage cutting included.

The stated volume of damage since 1964 is summarised in the above mentioned FE reports. The most recent data since 1998 was taken from Zpravodaj ochrany lesa (Knížek & Modlinger 2013), where it is summarised based on the statistical reports from forest owners and forest managers.

3. Data analysis

The quantified data were critically evaluated and processed into a graph of the history of environmental abiotic damage (Holuša et al. 2010). When assessing the frequency of the occurrence of natural breakage different approaches were applied:

(i) Damages above 100,000 m^3 of salvage cutting were considered as "big" breakageg. For comparison: in the period 1998–2012, the salvage cutting reached more than 1.5 million m^3, i.e. on average it was just over 100,000 m^3 per year, however, this period included two big cases of snow damage (2006 and 2009) and 130,000 m^3 due to hurricane Kyrill (2007) – in other ("normal") years the volumes of salvage cutting were lower.

(ii) The criterion for damage occurrence in the archive data was the fact that the breakage was recorded, i.e. it was so significant that it was worth recording in historical materials.

(iii) In the newest summaries of forest management documentation and reports on the occurrence of the harmful forest agents (Knížek & Modlinger 2013), the criterion for damage occurrence was 20,000 m^3 of windfall timber.

The proportions of years with extraordinary events in the individual periods or among different regions were compared by the χ^2-test in the Statistica 12 software.

4. Results

The historical surveys since 1875 recorded four cases of big snow and rime damage and eight windfalls. During each individual case, more than 100,000 m^3 of wood[1] was cleared (Fig. 2).

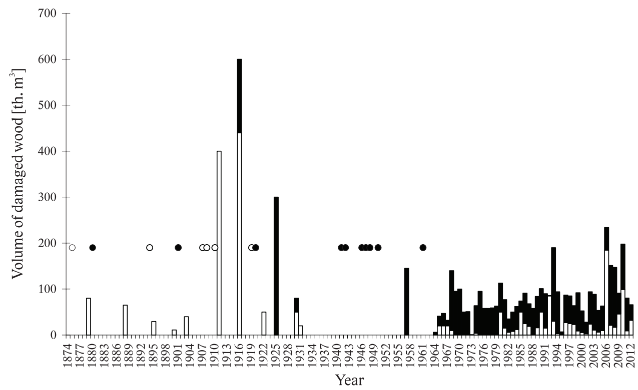

Fig. 2. Survey on volume of damaged wood caused by wind and snow over the period 1875–2012; white = snow and ice, black = wind, circle = larger historical damage without precise volumes.

Smaller snow damage was recorded (frequently without stating the volume) in the winters of 1894–95, 1907–08, 1910–11, 1930–31, 1992–93; in the years 1965–1968 snow damage was recorded four times in four seasons, and in the years 1907–1911, four times in five seasons. On the contrary, in the period 1932–1964 no record of snow damage was found in the historical entries. In the period of 1874–1932 (in 58 years) 16 cases of snow damage without volume quantification were recorded (ratio 0.28). In the period 1965–2014 (in 50 years), 18 records of snow damage exceeding 20,000 m^3 were found (ratio 0.36). The number of years with these breakages did not significantly differ between the two periods ($\chi^2 = 3, 34$; $p > 0.05$).

Windfalls were recorded six times in two consecutive 165 years: 1941–42, 2007–08, three times consecutively in the years 1946–1948, and the years 1968–1970 were three years with windfalls following four winters with snow damage.

According to the historical data, the most extensive snow damage took place in April 1916, the data states 600,000 m^3 of toppled trees. In the recent period there is a record of snow damage from the winter of 2005/2006 which reached minimally 185,000 m^3 (Appendix 1c). In six cases the historical entries mentioned snow damage without stating the approximate extent or they contained such incomplete data that it was impossible to reconstruct them. The greatest wind damage was recorded in 1925: around 300,000 m^3 of toppled trees. The damage caused by hurricane Kyrill (2007) overlapped with the end of salvage cutting due to snow damage after the winter of 2005/2006 and storm Ivan (Šrámek 2009) in the following year 2008, and therefore it can only be estimated at approximately 130,000 m^3. In the historical records, a wind catastrophe without the information about its extent was mentioned 13 times. In the period 1998–2012, from which

[1] Among the more recent known disturbances are the windfalls caused by hurricane Kyrill in the Beskids (approx. 130, 000 m^3), snow damage from the winter of 2005/2006 (185, 000 m^3) and snow damage from October 2009 (just around 100, 000 m^3 of cleared wood). Since these events took place across the whole studied territory, we considered this the minimum criterion for an extraordinary event.

detailed data are available, the salvage cutting reached more than 1.5 million m^3 (over 100,000 m^3 per annum), whereas the share of wind factor in the damage was approximately the double of the volume of snow and rime damage.

5. Discussion

Absolute figures of stand damage expressed in volume of windfall timber are not always exact due to several reasons:

(i) Historical records state data based on the property borders (exceptionally based on contemporary administrative boundaries), therefore, it is rather difficult to identify the data with the geomorphological unit or the natural forest area of the Moravian-Silesian Beskids. For example, the stated figures were most frequently taken from the high quality records of Těšínská komora (Sláma 1889), whose forests also partially extend into NFA 39 – Podbeskydská pahorkatina and cover less than a half of the Moravian-Silesian Beskids.

(ii) The absolute figures of windfall timber volumes need to be considered in the context of stock volume which was significantly lower at the beginning of the 20th century (less than a half – see Riedl et al. 2012) than nowadays. The crucial issue, rather than the absolute volume, seems to be the intensity of damage expressed by the ratio of damaged wood compared to the total wood stock (Konôpka et al. 2007). Finding the correct figures for 100 year old events seems to be practically impossible. 100,000 m^3 of cleared wood, which we consider as the working criterion of "big" windfalls in the Beskids, represents currently less than 0.5% of total wood stock (20.5 million m^3; eAGRI 2014).

(iii) Based on the archive records, it is also impossible to state whether the figures included only cleared (therefore measured) windfall timber, or if they informed about the total damage estimate.

(iv) The Chronicles tend to record special[2], exceptional and unique events and to exaggerate their impact, however events with real economic significance may not be given the same importance. In the old records, we found much more data about snow and ice disturbances which state higher volumes of windfall timber than windfalls while the newer data (approximately after the 2nd World War), drawing on the economic evidence, showed the opposite ratio[3] (Rychtecká & Urbaňcová 2008).

(v) While counting and rewriting the archive entries manually, a common typing error which the lapse of time makes impossible to discover cannot be ruled out.

While the large rime and snow damage in 1911 corresponded with the absolute maximum of the snow depth at the meteorological station of Lysá hora (the peak value of snow depth stated as 491 cm on 8th – 9th March 1911) (Lipina 2014), the figure 600,000 m^3 of wood damaged by snow in 1916 seems to be exaggerated. It is quite possible that the volume of 600,000 m^3 also includes wood from windfalls in the autumn of 1916 (around 160,000 m^3) or all logging in the entire Těšínská komora in the given year

The frequency of such events is of much greater importance. It shows that in the Beskids synoptic situations causing natural abiotic damage of smaller extent are irregular but very common. At the same time it can be assumed that some smaller disturbances, especially windfalls, did not appear in the records at all.

Janda et al. (2014) by means of both dendrochronological analysis and study of spatial-temporal development of natural spruce forests in Šumava discovered 13 big wind disturbances over the period of 250 years. This corresponds approximately with the frequency of big windfalls in the Beskids (8 windfalls with more than 100,000 m^3 over approximately 150 years) recorded in the historical archives. This comparison hardly offers more serious conclusions. Nevertheless, it seems that big wind disturbances come with corresponding synoptic weather situations regardless of the applied management system or the influence of the forest ecosystem. On the other hand, the frequent occurrence of snow damage in the Beskids is most likely reinforced by the genetically unsuitable provenience of non-indigenous spruce stands; similarly, in the winter of 2005/2006 an adjacent area of the Western Beskids with non-indigenous spruce stands in Slovakia was damaged by snow more than other Slovak territories (Konôpka & Konôpka 2008; Konôpka et al. 2008). According to the quoted authors, the amount of cleared salvaged material due to snow, rime or wind damage in the north-western part of Slovakia, i.e. Orava and Kysuce, amounted to 488,000 m^3 in 2005, and more than 397,000 m^3 of salvage material in 2006. Yet over the period 1996–2007, the annual volume of salvage mass due to the actions of these elements was around 220,000 m^3.

Vicena et al. (1979) regionalised the former Czechoslovakia in relation to harmful natural abiotic agents, however, in the individual cases, the situation can significantly differ. For example during the 17th – 19th January 2007, European forests were devastated by hurricane Kyrill with windfall of 54 million m^3 (Schuck & Schelhaas 2013), but as it proceeded from the west to the east its impact faded. In 2007, in the Czech Republic, the total amount of windfall processed timber was 9 million m^3, out of which over 3 million m^3 of the timber originated from the South-Bohemian region and 1.75 million m^3 from the Pilsen region (Musil et al. 2008); in the

[2] In 1931, 16 events of snow damage were recorded. Nine of them took place in the spring (late snow), only 3 occurred during winter, 2 of them in the autumn due to early snow (the dates of the remaining 2 were not found), while after the 2nd world war it is the other way round; the last two breakages took place at the beginning of winter (at the break of November/December 2005; Appendix 1c) and due to early snow in October 2009 (Appendix 1b). This difference does not arise from climate change, but rather from the fact that the late snow impacts fruit trees as well and it is recorded as something unusual (it is more appealing for the Chronicles), whereas the early snow is forgotten by the coming winter when snow damage are considered common.

[3] The quoted summary (Rychtecká & Urbaňcová 2008) states 10× higher volumes of salvage cutting caused by wind than by snow or rime in the whole Czech Republic. On the other hand, the intensive research from the period 2006–2011 in the Moravian-Silesian Beskids showed that the volume of windfalls was almost the double of the breakages caused by snow and rime.

Beskids the damage was estimated at only 130,000 m^3. Intensive studies of snow damage (Hlásny et al. 2011) showed that at a local level the image of regionalisation of the damaged stands varies significantly between different cases. While in the winter of 2005/2006, the stands all over the country were wind broken regardless of their location (the key factors were diameter at breast height, stand height, and age), in October 2009 (Křístek et al. 2011) the stands at lower altitudes were significantly damaged whereas the stands at higher altitudes remained undamaged. On the other hand, Konôpka et al. (2008) revealed that in the winter of 2005/2006 the most intensive damage to forest stands in Kysuce occurred at an altitude of around 700 m. The damage at slightly higher altitudes (800–900 m a.s.l.) was less intensive.

6. Conclusion

Historical records about natural disasters in forest properties in the Moravian-Silesian Beskids remind us of the impact of such disturbances on forest management (Konôpka et al. 2008). The results of the historical surveys will be reflected in the preparation of the Regional Forest Development Plan for the period from 2020 which will set general economic recommendations for forest management at the natural forest area level. However exaggerated, difficult to verify or omitted might some figures about windfall be, the frequency of these situations with regard to the long life of the stand (100 years at minimum) suggests that practically every stand in the Beskids encounters such an event during its rotation period. It is highly likely that it will take place at a critical stage of its development when the stand is vulnerable to damage. All measures to support stand stability and resistance to abiotic harmful agents (i.e. Slodičák 1996; Slodičák & Novák 2006; Konôpka et al. 2008) play a key role in the Moravian-Silesian Beskids forest management. Nevertheless, it is crucial to continue the dialogue about the individual silvicultural methods and secondly about the possibility of influencing the stability of the stands with forest management measures (cf. Hlásny et al. 2011).

The analysis of the historical data has not proven a clear tendency (growth or decrease) of snow or windfalls in the area of the Moravian-Silesian Beskids. Based on the data evaluation, it is not possible to make any conclusions with regard to climate change and its impact on the potential danger to the forest stands by those harmful agents in the region in question.

Acknowledgements

This research was supported by projects QJ1520006 and QJ1330233 of the Ministry of Agriculture of the Czech Republic.

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Appendix

Apendix 1a. Lysá Hora Mountain top (Moravian-Silesian Beskids) is the area with the highest recorded snow depth in the Czech Republic (illustrative photo Milena Mifkovičová, 9. 3. 2006).

Apendix 1b. Early snowstorm which caused extensive breakage in forest stands (photo Milena Mifkovičová, 16. 10. 2009).

Apendix 1c. Snow damage to spruce stands in the winter of 2005/2006 (photo Štěpán Křístek, 3. 5. 2006).