Agricultural and Forest Meteorology 250–251 (2018) 47–63

Contents lists available at ScienceDirect

Agricultural and Forest Meteorology

journal homepage: www.elsevier.com/locate/agrformet

Windstorms and forest disturbances in the Czech Lands: 1801–2015

Rudolf Brázdil[a,b,*], Peter Stucki[c,d], Péter Szabó[e], Ladislava Řezníčková[a,b], Lukáš Dolák[a,b], Petr Dobrovolný[a,b], Radim Tolasz[f], Oldřich Kotyza[g], Kateřina Chromá[b], Silvie Suchánková[e]

[a] Institute of Geography, Masaryk University, Kotlářská 2, 611 37, Brno, Czech Republic
[b] Global Change Research Institute, Czech Academy of Sciences, Bělidla 986/4a, 603 00, Brno, Czech Republic
[c] Oeschger Centre for Climate Change Research, Falkenplatz 16, CH-3012, Bern, Switzerland
[d] Institute of Geography, University of Bern, Hallerstrasse 12, CH-3012, Bern, Switzerland
[e] Institute of Botany, Czech Academy of Sciences, Department of Vegetation Ecology, Lidická 25/27, 602 00, Brno, Czech Republic
[f] Czech Hydrometeorological Institute, Na Šabatce 17, 143 06, Praha 4-Komořany, Czech Republic
[g] Regional Museum, Mírové nám. 171, 412 31, Litoměřice, Czech Republic

ARTICLE INFO

Keywords:
Windstorm
Documentary data
Forest disturbance
Forest damage
Czech Lands

ABSTRACT

The long-term relationship between windstorms and forest disturbances in the Czech Lands is analysed in this paper, covering a very long period of 215 years (1801–2015). Based on documentary evidence and instrumental records, long-term series of severe windstorms in the summer half-year (April–September) and in the winter half-year (October–March) are compiled. Severe windstorms were more frequent in the 1820s–1840s, 1900s–1930s, and 1960s–2000s, less so in the latter half of the 19th century and in the 1940s–1950s. Their long-term variability is revealed with three differently-created series of forest damage for the periods of 1801–1900, 1900–1980 and 1963–2015. Based on these comparisons, 14 windstorms that did outstanding damage to forests are selected: 12 occurred in the winter half-year and two in July. They are further investigated with respect to their meteorological character and the damage done. In this sample, the high-impact winter half-year windstorms are typically related to very distinct (> 45 hPa) pressure gradients between low pressure systems over the North/Norwegian Sea and high pressure systems south-west of the Iberian Peninsula, which exhibits an eastward-shifted and tilted NAO pattern, inducing the passage of frontal waves across the Czech Lands. High temperatures arising from south-westerly airflow and wet ground before windstorms provided conditions conducive to extensive windthrow in forests, sometimes with damage exacerbated by subsequent bark-beetle calamities. The increase in windstorms with outstanding forest damage after 1950 may be attributed in part to the negative consequences of forest management that prioritises high, short-term profits over ecological well-being.

1. Introduction

Windstorms are among the meteorological extremes that impact severely on human society (Ulbrich et al., 2013). Material damage occurs when wind force exceeds the limits of the strength or resilience of objects both natural and constructed. The spectrum of possible wind-damage is very broad, appearing as direct harm to houses and other buildings (roofs carried away in whole or in part, walls collapsing, electrical power-lines and their supports brought down, and more) on the one hand, and as secondary damage arising out of matter transported (e.g. roof coverings), uprooted (e.g. trees) or falling (e.g. walls, cranes) on the other (Holmes, 2015). All of these events can lead to human casualties, some of them fatal, with examples regularly recorded for both historical and more recent windstorms (Brázdil et al., 2004, 2017b,c,d).

Individual trees, growing, for example, in gardens (mainly fruit trees), in parks, in avenues along roads or on streets, are often damaged during windstorms. Forest stands may also be heavily affected. Windstorm disturbances in forests are abiotic (meteorological) factors contributing, together with biotic factors (e.g., insects, fungal diseases, soil type, tree species, rooting structure, human recreational pursuits) to the volume of salvage felling (also known as sanitary logging) and retrieval. In the territory of the recent Czech Republic, damage due to wind, ice deposits and snow accounted for 43.8% of salvage felling in 1900–1950, but the figure reached 73% by the 1951–1980 period. Damage arising out of to drought and air pollution grew from 1.8% to 18.1% (Forst et al., 1985). Taking into account salvage felling for 1963–1999, abiotic factors were responsible for 75% of its volume, divided thus: wind 46.3%, snow 11.5%, drought 7.2%, air pollution 7.0%, ice deposits 3.0% (Brázdil et al., 2004).

* Corresponding author at: Institute of Geography, Masaryk University, Kotlářská 2, 611 37 Brno, Czech Republic.
E-mail address: brazdil@sci.muni.cz (R. Brázdil).

https://doi.org/10.1016/j.agrformet.2017.11.036
Received 5 May 2017; Received in revised form 18 October 2017; Accepted 30 November 2017

The direct effects of excessive wind on forest stands are reflected in windthrows that take various forms: breaking up the crowns entirely or in part, trunk breakage, uprooting, or distortion of the whole of the tree (Vicena, 1992; for a broader perspective, see also Everham and Brokaw, 1996). The type of damage influences the further life of the tree, or dictates further utilisation of the damaged timber, basically whether if it may be used as utility wood or only as fuel.

If the quantity of damaged wood is too high for it to be cleaned and processed in time, calamitous bark-beetle infestation may take place, as recorded, for example, after the disastrous windstorms in 1868 and 1870 in the Czech Lands (Brázdil et al., 2017c,d; Zatloukal, 1998). On the other hand, thinning of stands after windstorms may stimulate the growth of the trees that remain, as occurred, for example, in the Šumava Mts. (Czech Republic) after the 1870 windstorm (Čada et al., 2013).

An extensive body of literature has been devoted to various aspects of wind disturbances in forests (see, in particular, review papers by Lugo, 2008; Mitchell, 2013; Schelhaas et al., 2003; Webb, 1999). Investigations may centre on the impacts of individual windstorms (Bründl and Rickli, 2002; Fink et al., 2009; Nekovář and Valter, 1998; Schüepp et al., 1994; Usbeck et al., 2012), while several papers have addressed their impacts on forests in terms of decades or centuries. For example, Nilsson et al. (2004) analysed storm damage to Swedish forests during the 20th century. In Switzerland, Usbeck et al. (2010) demonstrated increasing storm damage to forests from 1858 to 2007; Stucki et al. (2014) created a catalogue of high-impact windstorms taking place after 1859; and Usbeck (2014) described forest damage done by winter storms in the 1865–2014 period. In the context of recent forest damage, estimation of future impacts in response to recent climate change is important. Blennow and Olofsson (2008) and Blennow et al. (2010) have investigated the probabilities for wind damage in Swedish forests under this changing wind regime. Similarly, Gardiner et al. (2010) have looked into the forthcoming impacts of windstorms on European forests.

Similar studies have also been conducted outside Europe. For example, Canham and Loucks (1984) used US General Land Office survey records to map windthrow areas in Wisconsin in the 19th century. Foster et al. (1998) examined the consequences over time of several large windstorms in the 20th century in northern American forests. Spennemann (2009) studied historical records of 20th-century typhoons in Micronesia. Several studies have employed palaeo-ecological techniques to examine the history of disturbances (including windstorms) in, for example, Thailand (Baker et al., 2005) and Nicaragua (Urquhart, 2009).

A great deal of attention has been devoted to windstorms and their impacts on forests in the Czech Lands on various scales: individual events (Brázdil et al., 2017b,c,d; Gregor, 1955; Hostýnek et al., 2008; Nekovář and Valter, 1998; Setvák and Strachota, 1986; Záloha, 1970); over decades and centuries (Brázdil, 1998; Brázdil and Dobrovolný, 2001; Brázdil et al., 2004; Dobrovolný and Brázdil, 2003; Hošek, 1981; Kašpar et al., 2017), together with their specific effects on forests (Forst et al., 1985; Vicena, 1964, 1992; Vicena et al., 1979).

Although existing Czech papers address various particular aspects of windstorms and forest damage in the Czech Lands, comprehensive studies analysing the frequency of severe windstorms and quantitatively expressed forest damage in the long-term are lacking. Such studies might well reflect changes in windstorm variability (frequency, severity, seasonality, synoptic patterns) in the context of climate change on the one hand, and changes in forestry practice, particularly in terms of the character of non-natural forest stands, significantly affected by human activities, on the other. Of particular interest are changes in the frequency and severity of windstorms with the most damaging effects on forests. Taking into account all of these points, the aim of the current paper is to present a comprehensive analysis of windstorms and forest damage in the Czech Lands, covering the last 215 years (1801–2015), a relatively long period, based primarily on data derived from documentary sources in combination with meteorological measurements and systematically-gathered forest information. Section 2 presents the data available for the creation of long-term series of windstorms and forest damage. After Section 3 has described the methods employed, Section 4 presents basic series of severe windstorms and forest damage in the study period. This is supplemented by an analysis of selected outstanding windstorms. The Discussion in Section 5 turns to data uncertainty, the consequences of windstorms and responses to them in forestry and in the central European context of results obtained. The final section gives a brief summary of the main results of the paper.

2. Data

2.1. Documentary data

Information relating to windstorms and their impacts are included in various types of documentary evidence, which together provide the basic data source for historical climatology (Brázdil et al., 2005, 2010). Examples of the range of data contained within various types of documentary sources appear below.

2.1.1. Chronicles, "books of memory" and memoirs

Narrative sources have always devoted a certain amount of attention to extreme phenomena and their impacts, including windstorms. Such records allow identification of places and times for events, their courses, the damage done and the consequences. For example, František Jan Vavák, a farmer and reeve in Milčice (the location of places mentioned appear in Fig. 1, in the context of the recent territory of the Czech Republic), described a heavy windstorm at the end of January 1801 in the following terms (Skopec, 1924, p. 4): "*And in the night after the 29th* [January], *a great and horrible wind, which arose to the horror and fear of everyone, knocked down houses in settlements and trees in forests, and did much damage. There is not a single village, in which 2, 3, 4 or more barns and other buildings have not been destroyed; in just the Poděbrady domain, 46 barns, among other buildings, were destroyed. Heavy damage was also done in forests by the uprooting of good trees* […] *Even on 30 and 31 January the wind did not cease to blow* […]" An example of a more recent description of windstorms, dating to 1984, occurs in the chronicle for Milešovice (archival source no. 5–further as AS5, pp. 289–290): "*A storm with windstorms swept over our region on the night of 12th–13th July. Around midnight lightning flashed continuously, so much so that it was possible to see as if it were day. The windstorm flattened corn and broke trees. Our village lies in a valley and thus the damage was not so extensive.*"

2.1.2. Daily weather records

Those who kept daily weather records recorded qualitative observations of the weather with detailed descriptions of extreme phenomena. For example, Lukáš Kraus, a member of the Augustinian order in Brno, described the damage done by a tornado on 26 May 1830 as follows (AS1, fol. 97v–98r): "*At half past four a hurricane* [Orkan] *arose and proceeded in terrible fashion. In a moment it threw the fine tower of the church of Brothers of Charity in Staré Brno into the courtyard,* [and] *damaged many roofs, not only in the town, but also in the suburbs; at Špilberk* [castle] *it threw down a whole group of palisades and several people were killed, among them a soldier at Špilberk who had fled to a small guardhouse, which was then turned over and thrown into the moat.* […] *The damage suffered by the monastery amounts to over 1000 gulden.*" The notes kept by Josef Lukotka from Vsetín provide an example of daily weather records combining qualitative records with temperature measurements (Brázdil et al., 2014b). For 5 January 1919, he wrote (AS6, fol. 450v): "*The wind blew today* [5 January] *stronger than yesterday* [4 January] *and did much harm in forests and damaged many roofs. This afternoon the wind tore the metal plating from the entire roof on the south side of the house of Josef Reis.*"