Flora 240 (2018) 40–47

Contents lists available at ScienceDirect

Flora

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

A narrow-gauge railway in the Białowieża Primeval Forest as a corridor for non-native species migration

Rafał Łapok[a], Lidia Borkowska[b,*], Marlena Lembicz[c], Kai Jensen[a], Zbigniew Kasprzykowski[d]

[a] Applied Plant Ecology, Biocenter Klein Flottbek, Universität Hamburg, Ohnhorststr. 18, 22609, Hamburg, Germany
[b] Department of Botany and Plant Physiology, Faculty of Natural Science, Siedlce University of Natural Science and Humanities, Siedlce, 08-110, Poland
[c] Department of Plant Taxonomy, A. Mickiewicz University, Umultowska 89, 61-614, Poznań, Poland
[d] Department of Environmental Studies and Biological Education, Faculty of Natural Science, Siedlce University of Natural Science and Humanities, 08-110, Siedlce, Poland

ARTICLE INFO

Edited by Karsten Wesche

Keywords:
Migration corridors
Invasive plant species
Disturbed habitats
Poland

ABSTRACT

Railway territories are man-made habitats forming corridors for non-native species migration. In this study, we assessed non-native species occurrence in plant communities along a railway route of the Białowieża Primeval Forest in Poland in relation to adjacent plant community type and microhabitat (embankment western and eastern sides of the railway track, intertrack space). An 11-km fragment of a narrow-gauge railway route in the western part of the Białowieża Primeval Forest was investigated. This fragment was divided into 416 sections where all observed non-native species were identified, and all individuals, ramets and tussocks were counted. We discovered 12 non-native taxa, most of which (8 species) originated from North America. The highest average number of non-native species per section was recorded in the vicinity of the *Circeo-Alnetum* community. Statistically, more non-native species occurred on the western embankment than on the eastern one and in the intertrack space.

The use of the narrow-gauge railway in the Białowieża Forest has increased the risk of establishment of invasive species in local plant communities. The Białowieża Forest is a refuge for native biodiversity of the utmost importance. Thus, continuous monitoring of the occurrence of non-native species is necessary for the preservation of native plant communities in the vicinity of the narrow-gauge railway route assessed in this study.

1. Introduction

Invasive plant species are most often defined as non-native taxa that spread to new geographical locations and habitats and have negative effects on the environment, economy or human health (Di Castri et al., 2012; Pimentel, 2011). These species (1) disturb native species composition (e.g., Ohlemüller et al., 2006; Seipel et al., 2012; Walther et al., 2009), (2) affect their co-evolutionary interactions (e.g., Burlakova et al., 2014; Mooney and Cleland, 2001), and (3) incur economic costs (sometimes high), particularly if invasive species affect ecosystem services and cause accumulation of natural enemies including pathogens in plant species in their naturalized range (e.g., Lymbery et al., 2014; Pimentel et al., 2000; Torchin and Mitchell, 2004).

Migration of invasive non-native plants may depend on their life strategy, as described by Stearns (1992). Diaspores of invasive plant species like *Acer platanoides*, *A. negundo*, *Buddleja davidii*, *Solidago canadensis*, *Panicum maxima* and *Heracleum mantegazzianum* (Kowarik, 2003; Kowarik and von der Lippe, 2006; Pergl et al., 2011; Veldman and Putz, 2010; von der Lippe and Kowarik, 2007) are often dispersed over long distances. Furthermore, the species are characterised by fast growth and a high reproductive output (Bullock et al., 2002; Cain et al., 2000; Moravcová et al., 2010; Myers et al., 2004; Pitelka, 1997).

In addition to these strategies, invasive non-native plants also use corridors that allow them to migrate quickly from one environment to another (Gavrilova et al., 2011). Some corridors are man-made habitats, including railway territories. Multiple studies have shown that diaspores of both alien and native species migrate along railway lines (e.g., Brandes, 1983; Jehlik, 1981; Hansen and Clevenger, 2005; Wrzesień et al., 2016).

This study was conducted in the Białowieża Forest, one of the most primeval forest complexes of East-central Europe. A part of the Białowieża Primeval Forest is protected as Białowieża National Park, a World Heritage Site. This is the last intact and natural woody landscape in the region. The first observations of non-native species in this forest

* Corresponding author.
E-mail addresses: rafal.l@gmx.de (R. Łapok), lidiabor@uph.edu.pl (L. Borkowska), lembicz@amu.edu.pl (M. Lembicz), Kai.Jensen@uni-hamburg.de (K. Jensen), zbigniew.kasprzykowski@uph.edu.pl (Z. Kasprzykowski).

https://doi.org/10.1016/j.flora.2018.01.002
Received 17 July 2017; Received in revised form 22 December 2017; Accepted 5 January 2018
Available online 09 January 2018
0367-2530/

complex date back to the nineteenth century (Błoński et al., 1888; Błoński and Drymmer, 1889; Brincken, 1828). The percentage of non-native plant species is still much lower in this forest than in other woody landscapes in Europe (Faliński, 1994). Thus, this area offers an unique opportunity to investigate non-native plant invasions into native plant communities (Faliński, 1986, 1998a, 1998b; Sokołowski, 1995). So far, 278 non-native woody species have been recorded in the Białowieża Forest. Of these, only 46 were found to have spread into forest communities (Adamowski et al., 2002).

During this study, we (1) recorded the occurrence of non-native plant species along the narrow-gauge railway route in the Białowieża Forest and (2) analyzed the effects of embankment sides of the railway track and adjacent plant community type on the number of non-native species. The obtained data were used to test the hypotheses that the intertrack space is a preferred migration corridor for non-native species and that the number of non-native species differs between neighboring communities.

2. Material and methods

2.1. Study area

The Białowieża Primeval Forest (BPF) occupies an area of 1250 km^2 in northwestern Poland, ranging from 52°29′N to 52°57′N, and from 23°31′E to 24°21′E (Fig. 1). The climate of BPF can be characterized as intermediate between continental and Atlantic. The mean annual temperature is approximately 6.8 °C; the coldest month is January, with an average of −4.2 °C, and the warmest is July, with an average of 17.7 °C. Precipitation ranges from 425 mm to 940 mm, with a mean annual precipitation of 631 mm. Snow cover remains for approximately 197 days. The growing season (i.e., the number of days with a mean temperature above 5 °C) lasts for 208 days on average (Olszewski, 1986). The vascular plant flora present in BPF includes 1071 species, of which 668 species occur in natural plant communities of the area, while the other 403 species are found in man-made habitats (Adamowski et al., 2002; Sokołowski, 1995).

Fig. 1. The studied route of narrow-gauge tourist railway between Hajnówka and Topiło in the Białowieża Primeval Forest, Poland, East-Central Europe.

In the whole Białowieża Forest, the rules introduced by the General Directorate of State Forests and by the directives for the areas of Natura 2000 (Białowieża Primeval Forest PLC200004) are legally binding. The Białowieża Forest is intersected by a network of tracks and roads. Only a small percentage of these routes is paved and regularly maintained. Additionally, there are two railway lines running through Białowieża Forest: Hajnówka-Białowieża (unused since 1994) and Hajnówka-Siemianówka (currently operating) as well as a network of narrow-gauge railways. The construction of the narrow-gauge railway network began in 1916. The aim of this construction was to transport timber. Originally, trees were removed from the construction area. Two current glades near the railway track are the remnants of former timber depots constructed at the time when timber acquiring from the Białowieża Forest was started (during the war period). During World War II, the network of narrow-gauge railways in the Białowieża Forest reached a total length of 360 km. Until 1991, this network (although not in its entirety) was used for timber and local passenger transport (Szawiec et al., 1991). Since 1991, network usage has been restricted, and it is currently used only for tourist transportation along two lines: an 11 km route from Hajnówka to Topiło, and a 6 km route from Hajnówka to Postołowo. The narrow-gauge railways in the Białowieża Forest were mostly built on non-hardened ground and only on a few very wet places sand was deposited, and the ground was hardened. Reopening of the studied railway line resulted in changes in habitats along the track as a result of management including the exchange of ground fragments under the track and mowing of both the intertrack space and 2–3 m of the adjacent embankments at each side of the railway track. Presently, only those trees are removed along the railway track that may pose a threat to the tourist safety.

2.2. Studied route of the narrow-gauge railway

This study focused on an 11 km long narrow-gauge railway in the western part of the BPF, between Hajnówka and Topiło. It crosses different natural plant communities from north to south and has been in service since 1991. The 11-km train route was divided into 416 sections. To avoid spatial autocorrelation, 215 sections that did not adjoin were randomly selected. The distance between the studied sections was 26.5 m at the minimum and these sections were neighbored by well-developed plant communities. Each section included three segments/microhabitats: eastern and western embankment sides (4.0 × 26.5 m each) and the intertrack space (0.7 × 26.5 m; Fig. 2). The intertrack space has been significantly transformed by human use. The eastern and western embankment sides differed in insolation, plant community structure and type (Kwiatkowski, 1994).

2.3. Measurements

In 2013, all species of non-native plants were recorded in each section of the railway route. Invasive species were defined and identified as non-native species, naturalized outside their natural range, which produce reproductive offspring, often in very large numbers, which can spread for a considerable distance from their mother plants (Kolar and Lodge 2001; Pyšek et al., 2004; Richardson et al., 2000). In the case of dicotyledons, all ramets and individuals of a given species were counted within each segment/microhabitat, while the number of tussocks was counted in case of monocotyledons.

The identification of plant communities was conducted during field studies in 2013 and supported by a phytosociological map produced by Kwiatkowski (1994). The following forest communities were found along the railway route: *Tilio-Carpinetum stachyetosum*, *Tilio-Carpinetum typicum*, *Circeo-Alnetum*, *Querco-Piceetum*, *Melitti-Carpinetum*, *Pino-Quercetum*, *Vaccinio myrtilli-Pinetum*, *Vaccinio vitis-ideae-Pinetum*,