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ResearchPaper

Tree species effects on bryophyte guilds on a reclaimed post-mining site

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ABSTRACT

Tree species effects in afforestation of post-industrial lands have important impacts on biodiversity of restored sites. We aimed to assess tree species effects on bryophytes in a novel ecosystem – a reclaimed lignite mine spoil heap. We investigated bryophyte species pools in tree stands of six species: *Alnus glutinosa*, *Betula pendula*, *Pinus sylvestris*, *Quercus robur*, *Q. rubra* and *Robinia pseudoacacia* in two substratum groups: epigeic and epiphytic species. We assessed beta-diversity among tree stand types and bryophyte guilds. We also analyzed impacts of light availability, pH and C/N ratios of bark and soil, annual litterfall and bark water capacity of the main tree species, on bryophyte species pools among tree stands and species groups, using canonical correspondence analysis. Our study revealed tree species effects on bryophyte species richness, beta-diversity and composition. Main mechanisms connected with tree species effects were light availability and substratum C/N ratio, as well as substratum pH and bark water capacity. We confirmed that tree species traits connected with C/N ratios and light availability affect bryophyte species composition. Guilds of bryophytes responded differently to tree species effects on ecosystem properties and their turnover differed between tree stands. Influence of the factors studied on species pools was similar to those reported from mature woodlands. Presence of many woodland specific bryophytes has shown restoration success ca. 30 years after afforestation of post-industrial land. Different tree species provided different habitats for bryophytes, and therefore decisions regarding what tree species to plant affect restoration success and the future bryophyte species pool.

1. Introduction

Trees are foundational elements of forest ecosystems (Ellison et al., 2005), composing most of their biomass and determining their function (e.g. Reich et al., 2005; Dickie et al., 2006; Knight et al., 2008; Mueller et al., 2012, 2016). Different tree species planted in reclaimed post-industrial sites create different ecological niches for different organisms (e.g. Korjus et al., 2014; Woźniak et al., 2015; Kałucka et al., 2016; Kałucka and Jagodziński, 2016). In post-mining sites, where soil parental material initially has no organic horizon and has just started to be transformed into soil (Frouz et al., 2001; Woźniak et al., 2015; Kałucka and Jagodziński, 2016), tree species determine soil properties, as the most important source of soil organic matter is leaf litter and root decomposition (Jagodziński and Kałucka, 2010; Horodecki and Jagodziński, 2017). As vegetation has already started to develop, the biomass production is relatively low (Hüttl and Weber, 2001; Jagodziński and Kałucka, 2010; Jagodziński et al., 2014) and decomposition is limited by low levels of decomposer community development (Filcheva et al., 2000; Frouz et al., 2001; Chodak et al., 2009; Horodecki and Jagodziński, 2017). Thus, soil fertility is low, which in turn decreases the level of plant species richness (Tilman, 1986). Moreover, due to short time of existence, spoil heaps are colonized mainly by pioneer species (e.g. Prach, 1987; Alday et al., 2011; Prach et al., 2013). For these reasons, biotas of post-industrial areas have lower species richness, especially in cases of afforested areas, in comparison with those left to spontaneous succession (Singh et al., 2002; Hendrychová et al., 2012).

Ability to use different substrata makes bryophytes a very efficient

Abbreviations: AIC, Akaike's information criterion; BLM, Bełchatów lignite mine; CCA, canonical correspondence analysis; DIFN, diffusive non-interceptance; β_w, Whittaker's beta-diversity index

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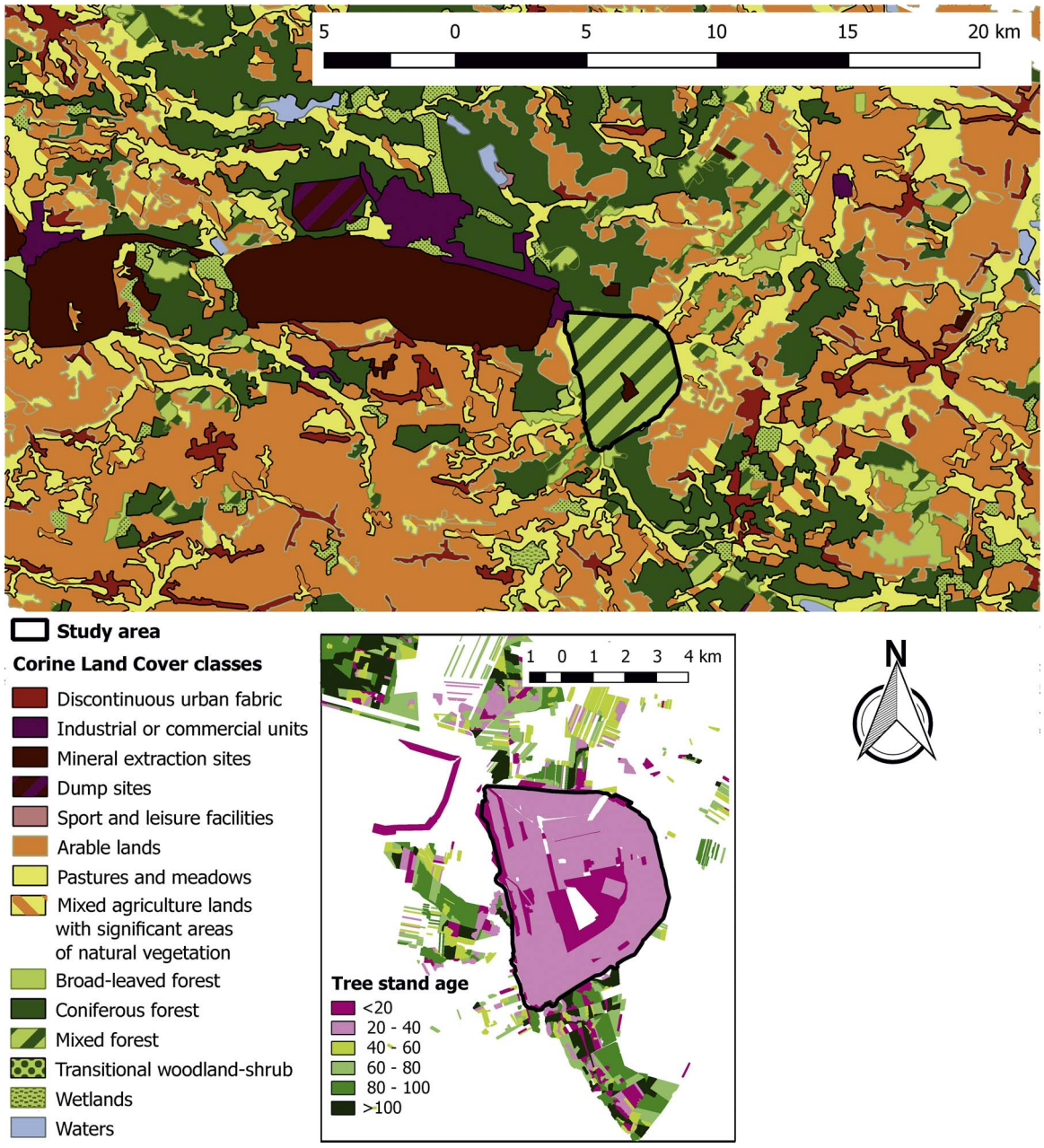

Fig. 1. Locality of the study area in the context of surrounding land-use forms (Chief Inspectorate Of Environmental Protection in Poland, 2012) and tree stand age (Bank Danych o Lasach, 2015).

plant group in terms of inhabiting diverse and complex structures within the forest biochore. Bryophytes are poikilohydric organisms strongly dependent on air humidity and often specific to different substrates, thus they may play an important role as a key component of forest diversity (Kriebitzsch et al., 2013). Due to a narrow ecological amplitude and quick response to environmental changes (Herben, 1987) many species of bryophytes are good bioindicators of important ecosystem functions, e.g. soil development, water retention, seed germination and forest restoration (Bates, 1992; Friedel et al., 2006; Sun et al., 2013). Therefore, it is reasonable to assess their role in nature conservation on post-industrial areas.

Species composition and structure of tree stands drive bryophyte species composition and diversity (Weibull and Rydin, 2005; Király et al., 2013). Species richness of bryophytes at the stand scale increases with trees species diversity (Mežaka et al., 2012; Király et al.,2013). In temperate forests many of the tree species possess a specific epiphytic flora (e.g. Studlar, 1982; Király and Ódor, 2010 Wierzcholska et al., *in prep.*). The differences are mostly expressed among coniferous and broad-leaved tree species and are related to the bark properties, e.g. pH, water capacity, and physical structure (Barkman, 1958; Bates, 2008). The bark properties that support specific epiphytic communities were broadly investigated by Barkman (1958).

Biodiversity conservation should not be limited to only the best preserved sites, but should also occur in disturbed areas (Miller and Hobbs, 2002; Ceballos et al., 2015). This recent need results from increasing knowledge about novel ecosystems – new combinations of habitats, species and human impact, resulting in new interactions between species (Hobbs, et al., 2006; Kowarik, 2011). Biodiversity of novel ecosystems has been studied for a longer time, e.g. in urban or restoration ecology. However, holistic insight on factors driving species diversity or richness in novel ecosystems is rare. Especially, there is a lack of studies regarding diversity of bryophytes. Most of the studies concerning bryophyte diversity were focused on old, well preserved forests (e.g. Mežaka et al., 2012; Király et al.,2013) or on mature