Forest Ecology and Management 318 (2014) 239–249

Contents lists available at ScienceDirect

Forest Ecology and Management

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

Assemblages of epigaeic beetles and understory vegetation differ between stands of an introduced pine and its native congener in boreal forest

Jean-Michel Roberge *, Fredrik Stenbacka

Department of Wildlife, Fish and Environmental Studies, Faculty of Forest Sciences, Swedish University of Agricultural Sciences (SLU), SE-90183 Umeå, Sweden

ARTICLE INFO

Article history:
Received 5 October 2013
Received in revised form 17 January 2014
Accepted 21 January 2014
Available online 12 February 2014

Keywords:
Exotic species
Ground dwelling insects
Introduced species
Plantation forestry
Species assemblages
Understory plants

ABSTRACT

There is growing interest in the use of introduced (i.e. non-native) tree species as part of intensified forestry. This study aimed to evaluate the local-scale effects of the use of introduced tree species on animal and plant assemblages in a boreal setting. Capitalizing on a large-scale experiment involving the plantation of the North American lodgepole pine (*Pinus contorta*) and native Scots pine (*Pinus sylvestris*) in Sweden, we compared assemblages of epigaeic (i.e. ground-dwelling) beetles (Coleoptera) and understory vegetation between middle-aged stands of the two pine species. Total abundance of epigaeic beetles in lodgepole pine stands was approximately one-half of that in Scots pine stands. Lodgepole pine stands had lower beetle species richness than Scots pine but only in the event of past thinning. Such negative effects were apparent for beetles linked to most substrate types, but there was more variation in the response of different beetle families. Multivariate analyses revealed differences in the structure of beetle assemblages and understory vegetation between stands of the two pines. Many common beetles, including the superabundant *Zyras humeralis* (Staphylinidae), had lower abundance under lodgepole pine compared to Scots pine, whereas few displayed an opposite pattern. Several abundant understory vascular plants had lower cover at the expense of mosses in lodgepole pine stands. Our results show that many native epigaeic beetle species and the most common understory plants do occur in middle-aged stands of the introduced lodgepole pine in Sweden. Yet, the observed differences suggest that – in spite of the phylogenetic relatedness of the two tree species – the use of lodgepole pine as an alternative to Scots pine in Fennoscandian forestry is likely to affect the structure of epigaeic beetle and understory vegetation assemblages within stands. Further research will be needed to quantify the effects of different landscape-scale proportions and configurations of forest dominated by lodgepole pine and other introduced tree species on boreal biodiversity.

1. Introduction

Global demand for forest-based products has increased during the past decades, mostly as a result of human population growth and expansion of the biofuel industry (Schlamadinger and Marland, 1996; Nabuurs et al., 2007). In light of this rising demand, forest ecosystems worldwide are being managed with increased intensity (FAO, 2010). Intensified forest management may involve a range of measures such as the planting or seeding of high-yield tree species or hybrids, optimization of nutrient and water supply, tight control of forest stand structure, as well as maximization of biomass extraction at harvest (Larsson et al. 2008). To date, studies of the general impacts of intensive forestry on biodiversity have had a strong focus on tree plantations in tropical and temperate regions (e.g. Brockerhoff et al., 2008; Bremer and Farley, 2010). In comparison, knowledge of the effects of highly intensive management is relatively limited for boreal forests (Larsson et al., 2008). Yet, the boreal biome includes about 29% of the world's forests (Kuusela, 1992), and there is a fast-growing interest in intensified forest management in this region, both in Europe (Larsson et al., 2008) and North America (Messier et al., 2003; Ménétrier et al., 2005). Expert knowledge about habitat requirements of forest species suggests that intensively managed boreal forest stands may have strongly reduced biodiversity compared to more natural boreal ecosystems (Strengbom et al., 2011). In order to mitigate negative impacts on biodiversity, we need quantitative knowledge about how boreal animal and plant assemblages respond to each of the specific measures involved in intensive forest management.

* Corresponding author. Tel.: +46 705878359.
E-mail addresses: jean-michel.roberge@slu.se (J.-M. Roberge), fredrik.stenbacka@slu.se (F. Stenbacka).

http://dx.doi.org/10.1016/j.foreco.2014.01.026
0378-1127/

Among these different measures, the use of fast-growing introduced (i.e. non-indigenous, non-native) tree species has received much interest from the forest industry. Globally, about one-fourth of all planted forests comprise introduced tree species (FAO, 2010). Although introduced tree species are most widespread in the south, there is increasing interest in their use also at northern latitudes. Within the boreal biome, some New World species (e.g. lodgepole pine *Pinus contorta*, black spruce *Picea mariana*, poplar hybrids) are being planted in the Old World, whereas Old World species (e.g. Norway spruce *Picea abies*, Scots pine *Pinus sylvestris*, hybrid larch *Larix* × *marschlinsii*) are being introduced for intensive forestry in parts of the New World (Ménétrier et al., 2005; Swedish Forest Agency, 2009). These transcontinental tree species introductions are done with the dual aim of increasing wood production and adapting forestry to anticipated climate change (Thorpe et al, 2006; Swedish Forest Agency, 2009).

Due to the role of trees as foundation species providing habitats for entire forest species assemblages, replacing native tree species with introduced tree species may potentially have significant impacts on local biodiversity and ecosystem functioning (Sax et al., 2005). There is a large body of evidence that plantations of introduced tree species host faunas and floras which differ compositionally and structurally from those in forests consisting of native trees (e.g. Magura et al., 2002; Sax, 2002; Meers et al., 2010; O'Hanlon and Harrington, 2012). Large numbers of past studies have found significantly lower alpha diversity across multiple taxonomic groups in forests dominated by introduced trees (e.g. Fahy and Gormally, 1998; Paritsis and Aizen, 2008; Bremer and Farley, 2010; Meers et al., 2010; Sweeney et al., 2010; Boelter et al. 2011, to mention a few), although there are several exceptions (e.g. Ellis et al., 2000; Sax, 2002; Gunther and New, 2003; Lombardero et al., 2012; O'Hanlon and Harrington, 2012; Sitzia et al., 2012).

The aim of this study was to evaluate the local-scale effects of the use of introduced tree species on animal and plant assemblages in a boreal forestry context. We used a unique large-scale experiment in Sweden involving the simultaneous plantation of two phylogenetically related conifers: the introduced lodgepole pine and the native Scots pine. We evaluated the effects on two components of forest biodiversity: epigaeic beetles (Coleoptera) and vegetation. Epigaeic (i.e. ground-dwelling) beetles constitute a taxonomically and ecologically diverse group, and hold documented potential as model organisms or indicators for ecological impact research (Pohl et al., 2007; Koivula, 2011). We studied the entire epigaeic beetle assemblages, including species from all encountered families. We also assessed the effects of planted tree species on understory vegetation, whose composition and structure have a major influence on biodiversity in boreal ecosystems (Nilsson and Wardle, 2005). Hypothesizing that native species may be less adapted to environmental conditions offered by an introduced tree, we predicted that native beetle and understory plant assemblages would be impoverished and structurally different in lodgepole pine stands compared to Scots pine.

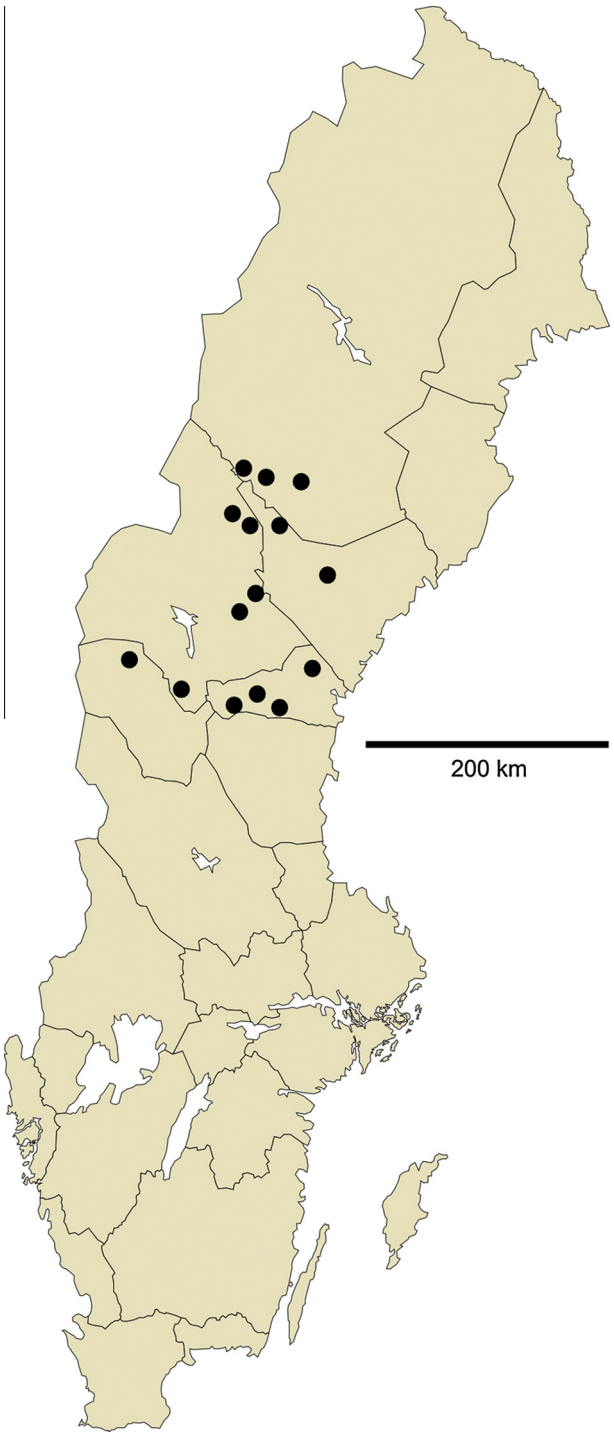

Fig. 1. Map of Sweden (with provinces delineated) showing the location of the 15 experimental pairs of lodgepole pine and Scots pine stands.

2. Materials and methods

2.1. Study system

The study was performed over a large part of north-central Sweden (62°20′–64°35′N and 13°15′–17°19′E, altitude 329–616 m a.s.l.) belonging to the boreal ecoregion (Fig. 1). Forest landscapes in this area are generally characterized by a dominance of two native coniferous tree species (Scots pine and Norway spruce *P. abies*), accompanied by varying proportions of shade-intolerant deciduous trees (predominantly birches *Betula* spp. and aspen *Populus tremula*). Today, most of the productive forest area is under management for the production of Scots pine and Norway spruce timber. However, some introduced tree species are also grown in commercial forestry. Among these, the lodgepole pine (subsp. *latifolia*) is the most widespread in the study region. This species, originating from western North America, belongs to the same genus and also the same subgenus (*Pinus*) as Scots pine (Richardson, 1998). Today, about 650,000 ha of productive forest in Sweden contain ⩾5% lodgepole pine and 475,000 ha contain ⩾65% of that species (OSS, 2010). Most of the lodgepole pine stands have been