Urban Forestry & Urban Greening 17 (2016) 158–165

Contents lists available at ScienceDirect

Urban Forestry & Urban Greening

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

Planting clonal shade-tolerant herbs in young urban woodlands—Effects of compost on plant growth, flowering and survival

Gustav Richnau[a], Jörg Brunet[b], Anders Busse Nielsen[a,c,*], Björn Wiström[a]

[a] Department of Landscape Architecture, Planning and Management, Swedish University of Agricultural Sciences, P.O. Box 66, SE-230 53 Alnarp, Sweden
[b] Southern Swedish Forest Research Centre, Swedish University of Agricultural Sciences, P.O. Box 49, SE-230 53 Alnarp, Sweden
[c] Department of Geosciences and Natural Resource Management, University of Copenhagen, Rolighedsvej 23, DK-1958 Frederiksberg C, Denmark

ARTICLE INFO

Article history:
Received 7 February 2014
Received in revised form 9 December 2015
Accepted 13 April 2016
Available online 22 April 2016

Keywords:
Afforestation
Amenity value
Forest restoration
Habitat creation
Herbaceous layer introduction
Soil conditions

ABSTRACT

Rich herbaceous layers supply important ecosystem functions and amenity values in urban woodlands. However, due to poor dispersal and recruitment, typical woodland herbs often remain absent in woodlands established on post-agricultural and post-industrial sites, especially in fragmented urban landscapes. Efficient methods for active restoration of the herbaceous layer are therefore needed. In a plantation experiment in an 11-year-old oak stand established on post-agricultural land just outside Malmö City, southern Sweden, this study investigated the effects of compost addition and weed control on post-planting survival, growth and flowering of three typical shade-tolerant woodland herb species: *Galium odoratum*, *Lamiastrum galeobdolon* and *Stellaria holostea*. Removal of competing weed vegetation did not affect plant performance, but compost addition dramatically increased growth and flowering of all three species during the first two growing seasons, and also increased survival in *S. holostea*. This positive treatment effect probably derived from a more suitable top soil structure and a higher soil moisture in the compost treatment. We conclude that combined use of planting and composting is an effective method for rapid achievement of profusely flowering carpets of summer-green woodland herbs, which can provide important amenity values in the many woodlands established in and around cities in north-west Europe in recent decades. The method may also be applicable in other woodland restoration projects, where it can promote colonisation by typical shade-tolerant woodland herb species.

1. Introduction

During recent decades, the pace of urbanisation has increased. This has resulted in most of the world's population now living in urban areas, where the pressure on green spaces to provide both biodiversity and human recreation services, with related health and well-being benefits, is higher than ever (Young et al., 2005). Being among the most natural components of the urban landscape, woodland plays a key role in the provision of such services (Alvey, 2006; Nilsson et al., 2011).

Expanding the woodland cover in urban areas has become a clear, consistent political priority in the forest-poor, highly urbanised countries of north-west Europe (Nielsen and Jensen, 2007). In England alone, 10,000 ha of community forest have been established in and around the twelve largest cities since 1990 (England's Community Forests, 2013). During the same period, more than 30,000 ha of post-agricultural land have been afforested in Denmark, much of which is located at the fringe of urban areas (Danish Forest and Nature Agency, 1999, 2010).

However, numerous studies have documented that many typical woodland herb species remain absent in woodlands established on post-agricultural or post-industrial land, so that the community composition bears the imprint of past land use for many decades or even centuries (Flinn and Vellend, 2005). There is general consensus that the low colonisation rate of woodland herbs is due in part to their poor dispersal capacity and in part to recruitment failure in post-agricultural habitats (Flinn and Vellend, 2005). A meta-analysis of studies across Europe has shown that the rate of colonisation is especially poor in highly fragmented landscapes – as often found in urban areas – where the proportion of mature (and ancient) woodlands which act as seed sources is low and these

* Corresponding author at: Department of Landscape Architecture, Planning and Management, Swedish University of Agricultural Sciences, P.O. Box 66, SE-230 53 Alnarp, Sweden.
E-mail address: anders.busse.nielsen@slu.se (A.B. Nielsen).

http://dx.doi.org/10.1016/j.ufug.2016.04.009
1618-8667/

occur mostly in isolated patches (De Frenne et al., 2011). In addition, soil conditions in new urban woodlands are influenced by a persistent legacy of intensive land use. The organic matter content of the topsoil is often reduced, which decreases soil porosity and water-holding capacity (McLauchlan, 2006). As a consequence, desiccation has been identified as a potential reason for poor establishment of introduced woodland herb species (Cohn and Packham, 1993).

In most urban afforestations only trees and shrubs are planted (Francis et al., 1992; Danish Forest and Nature Agency, 1999, 2010), despite the fact that the herbaceous layer is by far the most important contributor to overall plant diversity in mature woodlands and also provides important ecosystem functions and amenity values (Gilliam, 2007). From an ecological perspective, woodlands without an appropriate herbaceous layer can be regarded as "incomplete" ecosystems (Gilliam, 2007). From a social perspective, such afforestations may be perceived by visitors as unattractive and unsuitable for recreation (Gundersen and Frivold, 2008; Jensen and Skovsgaard, 2009). While spring bulbs and vernal geophytes are a major attraction for woodland visitors, Nielsen et al. (2012) found that the shade-tolerant summer-green species are also important and when absent, visitors perceive the woodland to be empty or lacking some vital element.

Our current knowledge on introductions of typical woodland plant species is mainly based on studies in basic plant or conservation biology, analysing abiotic or biotic factors limiting plant performance (Menges, 2008; Godefroid et al., 2011). However, recognising that new urban woodlands need more than trees to achieve their amenity and ecosystem functions and services, some research on the introduction of herbaceous layers into recently planted urban woodlands was initiated during the 1980s, particularly in the UK (Francis et al., 1992; Cohn and Packham, 1993), but also in Denmark (Bundgaard Andersen and Mikkelsen, 1983) and Sweden (Hammer, 1991). These studies have shown that a number of vernal geophytes and woodland edge species can establish successfully after simple hand-sowing (Hammer, 1991; Francis and Morton, 2001). In comparison, shade-tolerant summer-green species have been found to be more problematic to establish from seed, due to poor germination and inability to tolerate competition from weeds during slow seedling establishment and growth. Consequently, a higher rate of establishment from planting compared with sowing has previously been reported (e.g. Hammer, 1991; Francis and Morton, 2001; Petersen and Philipp, 2001; Mottl et al., 2006; Menges, 2008; Godefroid et al., 2011).

Planting forest herbs may thus provide a faster and more reliable establishment than sowing, but is also more expensive. However, several of the characteristic shade-tolerant herbs in European temperate forests possess the ability of rapid vegetative spread by rhizomes or stolons (Brunet and von Oheimb, 1998). By providing favourable growth conditions, already a limited number of planted individuals may therefore be sufficient to establish a flowering carpet of understory herbs and thereby rapidly increase the recreational value of a new urban forest.

The use of compost is an old and still widely used practice to improve growing conditions in urban settings where soil conditions are unfavourable for plant growth (Saebø and Ferrini, 2006). Compost addition as site preparation prior to planting as well as compost addition in existing planting improves the physical and chemical structure of the soil and increases the water-holding capacity and cation exchange capacity (Saebø and Ferrini, 2006; Oldfield et al., 2014; Palmer and Davies, 2014). While most studies demonstrated positive effects of compost treatment on soil conditions, effects on tree seedling survival and growth are often absent (Larchevêque et al., 2008; Palmer and Davies, 2014). To our knowledge, no previous study has examined the effects of compost treatment under controlled conditions on the performance of planted understory herbs in urban woodlands.

The objective of this experiment was to analyse the initial effect of compost addition and weed control on the survival, flowering and abundance of three shade-tolerant, clonal herb species introduced as plug plants in an 11-year old *Quercus petraea* (Matt.) Leibl. stand on post-agricultural land. The species used, *Galium odoratum* (L.) Scop. (sweet woodruff), *Lamiastrum galeobdolon* (L.) Ehrend. and Polatschek (yellow archangel) and *Stellaria holostea* L. (greater stitchwort), are characteristic carpet-forming ancient woodland indicator herbs in temperate broadleaf forests of northwest Europe. The hypotheses tested in the study were that: (1) compost addition improves the initial survival, growth and flowering of the three planted clonal woodland herbs and (2) weed control further increases early growth of these woodland species by reducing potential competitors.

2. Materials and methods

2.1. Experimental site

The study was carried out in the Landscape Laboratory located adjacent to the campus of the Swedish University of Agricultural Sciences (SLU) in Alnarp (55.39N; 13.04E) at the fringe of Malmö City, southern Sweden. The Landscape Laboratory was successively established on former arable land between 1983 and 1998 as a full-scale trial, teaching and demonstration area on urban woodland and parks (Gustavsson, 2002; Nielsen, 2011). The original soil at the Landscape Laboratory site is fertile loamy clay with low organic matter content.

The experiment was performed during 2009 and 2010 in a homogeneous *Q. petraea* stand established on flat ground (<0.5 m topographical variation within the stand) with whips planted with 1.5×1 m spacing in spring 1998 (equal to app. 6600 trees per hectare), i.e. 11 and 12 years after tree planting. The stand borders open fields, except to the south where it borders a stand with *Quercus* robur (Fig. 1). No shrub species were planted along the stand perimeter, resulting in abrupt edges where especially the predominately western northwestern winds from the sea (1 km away) penetrate under the canopy. A *Quercus* stand was chosen because this genus is among those most frequently used in urban afforestation in countries in north-west Europe, such as Denmark and Sweden, where it is also one of the most common broadleaf trees in commercially managed forests (Anon, 2009; Jensen and Skovsgaard, 2009). Mechanical weeding was done in the initial three years after stand establishment. As an effect of this and subsequent canopy closure, herb layer vegetation prior to establishment of the experiment was generally sparse (ca. 3% cover, unpublished data), and was mainly composed of the native forbs *Chenopodium* spp., *Plantago lanceolata* L., and *Taraxacum* spp., and the native grasses *Dactylis glomerata* L., *Elytrigia repens* L., and *Poa nemoralis* L. Most of the ground was covered by a thin layer of *Quercus* leaf litter.

The stand was thinned in winter 2009. While the thinning was done just prior to establishment of the experiment it was not primarily motivated by the experiment but rather because the *Quercus*' crown depth was beginning to reach less than the desired 50% of total tree height. Following usual management practice in young oak plantations, 33% of the stems were removed (including the few spontaneously established understory shrubs), resulting in a post-thinning tree density equal to app. 4400 trees per hectare with uniform spacing and no understorey. To avoid soil damage, thinning and extraction of all stems and branches from the stand was done manually.