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Diversity and distribution of the urban tree population in ten major Nordic cities

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ABSTRACT

In order to have a healthy and sustainable urban tree population, a high diversity of species and genera is needed. This study examined (1) the diversity and distribution of genera and species of urban trees in the Nordic region; (2) the diversity in different sites of the city, distinguishing between street and park environments; and (3) the presence of native versus non-native tree species in urban environments in the Nordic region. The analysis of tree diversity was based on urban tree databases comprising a total of 190 682 trees in 10 Nordic cities – Aarhus and Copenhagen in Denmark; Espoo, Helsinki, Tampere and Turku in Finland; Gothenburg, Malmo and Stockholm in Sweden; and Oslo in Norway. The tree databases for Copenhagen, Espoo, Helsinki, Stockholm and Tampere only record street trees, while the remaining databases also include park trees. Tilia was the most dominant genus in Arhus, Copenhagen, Espoo, Gothenburg, Helsinki, Oslo and Stockholm, while Sorbus was the most dominant in Malmo and Betula in Tampere and Turku. *Tilia* × *europaea* was the most common species, comprising 16.0% of the total number of tree species. There was a higher proportion of species in parks than in street environments. The number of non-native species was higher than the number of native species in both street and park environments. However, the number of individuals belonging to native species was higher than the number of non-native individuals in all cities and environments except park environments in Arhus. The concluding recommendation from this study regarding greater diversity of genera and species is to exploit local experiences of rare species from local urban tree databases. After appropriate evaluation, urban tree planners can evaluate these rare species in larger numbers for e.g. street environments, where the need is greatest.

Introduction

Urban trees have a number of effects that are beneficial for the quality of life in urban areas. They help reduce the urban heat island intensity (King and Davis, 2007), and thus decrease the need for energy for cooling buildings (Akbari et al., 2001; Maco and McPherson, 2003). Urban trees are capable of reducing storm water runoff and thereby reduce flooding and damage to urban property (McPherson et al., 1997). They also act as noise filters and purify the air through capturing particulate matter, carbon dioxide, ozone and other air pollutants originating from traffic and industrial activities (McPherson et al., 1997; Becket et al., 2000; Nowak et al., 2006). Urban trees also play an important role in recreation for the urban population since they are an important element in green spaces in residential and commercial areas (Tyrväinen et al., 2007). However, the above-mentioned effects are only possible if the urban tree stock is vital and unaffected by pests and diseases.

In order to have a healthy and sustainable urban tree population, a high diversity of species and genera has been proposed as a key solution (e.g. Duhme and Pauleit, 2000; Raupp et al., 2006; Bassuk et al., 2009). The imperative and most frequent argument for high diversity is the recurring outbreaks of diseases and the threat of invasive pests and diseases in the most commonly used tree species (e.g. Sun, 1992; Tello et al., 2005; Raupp et al., 2006). Climate change, with predicted increased average temperatures, more frequent heat waves and periods of drought during summer (IPCC, 2007), is another important issue to take into consideration. Barker (1975) was one of the first to suggest the use of a broad range of species. He recommended that no given species should account for more than 5% of the total tree population. Smiley et al. (1986) and Miller and Miller (1991) recommend that the maximum share of any species should be less than 10% of the population. Grey and Deneke (1986) present a similar view, that one species should not amount to more than 10–15% of the total population. In a refined model, Moll (1989) recommends that no species should

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exceed 5% of a city's tree population and that no genus should exceed 10%. Santamour (1990) extends the recommendations even further to include a recommended maximum use of species and genera from the same family; no species should represent more than 10%, no genus more than 20% and no family more than 30% of the population. Such strategic recommendations for species choice are important guidelines for more diverse use of tree species in the urban environment.

In order to analyse the susceptibility of the tree population to outbreaks of pests and diseases and its tolerance to more stressful climates, the composition of the urban tree stock has been studied in many cities (e.g. Sanders, 1981; Jim and Liu, 2001; Pauleit et al., 2002; Sæbø et al., 2005; Frank et al., 2006; Raupp et al., 2006; Negandra and Gopal, 2010). However, no such studies have been made exclusively for the Nordic region. Pauleit et al. (2002) carried out a European survey in order to evaluate tree establishment and management practices in 17 countries and nearly 100 towns and cities. In the Nordic region, the study included Denmark (Copenhagen), Finland (Helsinki and Kuopio) and Norway (Oslo). However, the study was limited to newly planted trees in urban areas. In that particular survey Oslo stood out, as 70% of all newly planted trees in street environments belonged to one clone of *Tilia* (*Tilia* × *europaea* 'Pallida'; Pauleit et al., 2002). This lack of diversity clearly indicates the importance of a full review of the tree population in order to avoid future risks. However, since that survey was restricted to newly planted trees and since the data were taken from only a small sample of the total urban area, a complementary study for the Nordic countries is necessary in order to evaluate regional risks for the urban tree population, including both old trees and newly planted trees.

In another study, Sæbø et al. (2005) summarised the most common street and park trees in three geographical regions of Europe (Northern, Central and Southern Europe). That survey showed that the range of species was greater in parks than in street environments, indicating that a large number of species are well adapted to the often favourable growth conditions in urban woodlands and parklands, but that finding species able to withstand the challenging conditions in street environments and at other paved sites is much more difficult. In street conditions and other paved environments trees are exposed to a number of stressful elements, e.g. exposure to heat, low air humidity, periods of drought, high lime content and high soil pH, limited soil volume, de-icing salt and other pollutants (Pauleit, 2003; Sieghardt et al., 2005). Even if a city contains high numbers of species in street environments, normally a group of a few species typically dominates the urban tree population (Raupp et al., 2006). Urban tree inventories contain valuable, local information about e.g. rare species used in small numbers. If accessible, this information can help increase the number of rarely used species and thereby increase the diversity of the urban tree population.

Another recent issue in planning for greater diversity of tree species and genera is the question of whether non-native species should be used in urban plantations. There have been extensive discussions about the risk of non-native species spreading from the urban environment to natural environments, thereby risking extinction of native species (Parker et al., 1999; Alien Plant Working Group, 2010; Hitchmough, 2011). Chytrý et al. (2008) and Pyšek et al. (2009) conclude that for a species to successfully escape from cultivation into natural environments and there develop into a potential invasive species, there are two essential factors: propagule pressure (the number of individuals of a species existing in a region) and residence time (how long a species has been cultivated in a region). The longer a species has been in an area, the greater the chances of it escaping. Therefore it is essential to know the number of non-native species present in an area in order to identify eventual invasion threats at an early stage.

Fig. 1. Map of the 10 Nordic cities studied (illustration by Björn Wiström 2010).

Against this background, the objectives of the present study were three-fold: (1) To obtain basic information on the diversity and distribution of genera and species of urban trees in the Nordic region; (2) to examine the diversity at different sites within cities, distinguishing between street and park environments; and (3) to analyse the presence of native versus non-native tree species in the urban environments of the Nordic region.

Materials and methods

The analysis of tree diversity was based on urban tree databases obtained from 10 Nordic cities. A request was sent out to all cities in the Nordic region with more than 200 000 inhabitants, in total 10 cities (SCB, 2010; SSB, 2010; STAT, 2010; Statistikbanken, 2010). These cities were Aarhus and Copenhagen in Denmark; Espoo, Helsinki and Tampere in Finland; Gothenburg, Malmo and Stockholm in Sweden; and Bergen and Oslo in Norway (Fig. 1). However, Bergen did not have a developed urban tree database and thereby did not participate in the study. Instead, Turku (176 087 inhabitants) in Finland was selected in order to include 10 major Nordic cities with rather well developed urban tree databases in the study. The selected cities are partly located in the southern maritime region (Aarhus, Copenhagen, Gothenburg, Malmo and Oslo) and partly in the southern continental region (Espoo, Helsinki, Stockholm, Tampere and Turku) of the Nordic region (Sæbø et al., 2003).

In the request sent out to the cities, urban tree departments were asked to provide their complete tree database. However, the amount and type of data differed between the cities and only information on the species diversity and distribution was available from all cities in the study. For street environments, Aarhus, Copenhagen, Helsinki, Malmo and Tampere had the almost complete datasets (considered complete in the analyses), while for park environments the amount of data differed between the cities. The databases of the remaining cities are still under development, but had sufficient data to allow analysis (Table 1). In this study, street trees are defined as trees placed in or close to streets or roads and needing special management in order to meet the demands of the street environment.

Accurate taxonomic identification of the species in the study was carried out according to Aldén and Ryman (2009). The Nordic Flora (Mossberg and Stenberg, 2003) was used to determine whether the species is native to the region. In the classification of native and non-native species, a hybrid where one of the parents is native to the Nordic region was classified here as native. Trees identified only to genus level were excluded from further analyses