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# Recreational use of urban and suburban forests affects plant diversity in a Western Siberian city

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ABSTRACT

The recreational use of urban forests is a highly valued service. However, strong recreational pressure may contribute to the loss of biodiversity in forests. This study assessed the frequency of visitors and their characteristics in 14 urban and 11 suburban forests in the rapidly expanding city of Pavlodar, Kazakhstan, in Western Siberia. Furthermore, the effects of recreation disturbance (trampling, damage to ground vegetation and damage to trees and shrubs) and other human-mediated disturbances (waste deposits, soil disturbance, etc.) on both the vegetation and plant characteristics of urban and suburban forests were quantified. In Pavlodar, urban forests are poorly managed, motivating the people to spend their sparetime in the more distant suburban forests. Urban and suburban forests did not differ in visitor frequency during the summer season (July–September). However, the two forest types differed in the age structure and group size of visitors as well as in the activities of visitors. Urban forests were more frequently visited by younger people for walking, sports, sitting and talking, and playing with children, while suburban forests were often visited by older people for picnicking, fishing and gathering mushrooms. In urban forests, total plant species richness was reduced by recreation disturbance. Urban forests also harboured a large proportion of alien plant species (0.42; in suburban forests 0.24). Neither recreation disturbance nor other human-mediated disturbance affected plant species richness in suburban forests, while both disturbance types enhanced the colonization success of alien species. Alterations in plant life forms can be considered as an indicator of changes in ecosystem function. In suburban forests, recreation disturbance caused a decline of geophytes and an increase of therophytes. We recommended various management actions to improve the recreation value of degraded urban forests in this Western Siberian city.


## 1. Introduction

Urban forests provide a range of important ecosystem services including recreation for residents (Bolund and Hunhammar, 1999), and habitats for plants and animals (Croci et al., 2008). Anthropogenic disturbances are a characteristic of urban forests (Cilliers and Siebert, 2011; Swan et al., 2011). Some of the most obvious types of disturbance include trampling of vegetation and soil compaction (Amrein et al., 2005; Hill and Pickering, 2009), soil pollution, the invasion of alien plants (Sullivan et al., 2005) and green waste deposits (Rusterholz et al., 2012), which all may reduce the quality of ecosystem services. In urban environments, the frequency and intensity of disturbances are the major drivers of plant species richness and composition (Hill et al., 2002; Hamberg et al., 2008).

Empirical data on effects of recreation on plant diversity are restricted to urban forests in Europe, North America and Australia (for an overview see Niemelä et al., 2011), but so far no data are available from urban forests in Central Asia, a region, which differs in various aspects from the previously investigated cities. The present study focuses on effects of recreational activities on plant diversity in poorly managed urban forests as well as in increasingly visited suburban riparian forests in Pavlodar, a city in the transition zone from grassland to forest biome in Kazakhstan, Western Siberia. The people of this region experienced very rapid changes in the traditional husbandry system with a dramatic impact on the social and economical development as a result of the Virgin Land Campaign in the former Soviet Union in 1954–1963. In the 1950ies, approximately 200,000 people were transferred to the state farms in the Pavlodar region (Insebaev et al., 2007). After the failure of the Campaign, these people settled in the city of Pavlo-

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dar, which increased from a few thousands to 331,000 inhabitants in 2013 (Committee of Statistics of the Republic of Kazakhstan, 2014). Nowadays, Pavlodar and its close surroundings constitute a huge industrial agglomerate. Between 1960 and 1970, considerable resources have been invested into the plantation of new forests within the expanding area of the city. However, after the fall of the Soviet Union in 1991, little attention has been directed towards the maintenance of these urban forests. While these forests were originally planted to serve as windbreaks and to improve the urban climate, their importance for recreational use has increased in the past few years. Nowadays most people consider the urban forests no longer attractive and therefore prefer to visit riparian forests for recreational activities (T. Vakhlamova; unpubl. data). These naturally growing suburban forests are restricted to the floodplain of Irtysh river at the western edge of Pavlodar.

In the present study, we assessed the recreational use of urban and suburban forests and its potential impact on plant diversity. We also examined other human-mediated disturbances that might affect floral diversity of forests. Disturbances may not only alter plant diversity and composition but also the function of the ecosystem (McIntyre et al., 1999). The impact of disturbances on the function of ecosystems is frequently assessed by recording changes in the frequency of different plant life forms (Cole, 1995; Roovers et al., 2004a,b; Vallet et al., 2010). We therefore examined changes in frequency of plant life forms in impacted urban and suburban forests. In particular, we addressed the following questions:

(1) Do urban and suburban forests differ in visitor frequency, characteristics of forest visitors and in the extent of both recreation disturbance and other human-mediated disturbances?

(2) Do recreational activities and other human-mediated disturbances affect floral diversity (species richness and number of alien species) and plant life forms to a different extent in urban and suburban forests?

## 2. Methods

### 2.1. Study area

The study was conducted in urban and suburban forests in the city of Pavlodar in northern-eastern Kazakhstan (52°18′N, 76°57′E). The city is situated on the eastern embankment of the river Irtysh in the Western Siberian Plateau at the elevation of 125–150 m above sea level (Fig. 1). The dry, continental climate of the region is harsh for forest vegetation. Annual precipitation averages 228 mm, and mean annual temperature is 2.1 °C. Mean January temperature is −18.1 °C (minimum −47 °C) and mean July temperature 21.3 °C (maximum 42 °C; Kazhydromet, 2011). There is usually a constant snow cover (depth 12–14 cm) from beginning of November to beginning of April.

The residential area of Pavlodar covers about 77 $km^2$ and contains 123 small-sized forest patches ranging in size from 0.05 ha to 16.5 ha (total area: 233 ha [3.02% of a residential area]). For our investigation, we chose 14 urban forests planted 34–51 years before the survey (an exception being one forest with an age of 20 years; Fig. 1; Table 1). These urban forests were dominated by the trees *Acer negundo, Betula pendula, Pinus sylvestris, Populus alba, P. nigra* and *Ulmus pumila.* Urban forests with other dominant tree species including parks, roadside plantations, spontaneous green spaces overgrown by shrubs and trees on formerly steppe-like grassland were not considered in this study. Most urban forests are properties of the municipal government (Table 1).

Suburban forests are part of the strip of riparian deciduous forests (70,000 ha in the region) extending along the river Irtysh. Due to alluvial accumulation, the soils of the floodplain contain clay sediments and are more fertile than the other regional soil types. The riparian forests, restricted to uneven micro-relief, are fragmented by hay meadows. The forests serve as recreation zone, and provide habitat for wildlife, but are not managed or used for timber production.

Multivariate ordination analysis revealed that urban and suburban forests differed in the species composition of their ground vegetation (data not shown).

### 2.2. Sampling design and plant survey

Fourteen urban and eleven suburban forests were examined in this study (Table 1). Urban forests were situated at an average distance of 4.015 km (range 0.25–9.1 km; n = 14) from the city centre, suburban forests at a distance of 6.225 km (range 2.3–13.0 km; n = 11). Urban forests measured on average 1.71 ha (range 0.09–9.9 ha; n = 14), suburban forests 2.35 ha (range 0.2–9.9 ha; n = 11). For plant surveys, six plots measuring 4 m × 4 m were installed randomly distributed over the entire area of each forest. The number of vascular plant species in the ground vegetation and the cover of single species were assessed in a 2 m × 2 m subplot established in a randomly chosen corner of each 4 m × 4 m plot using the (Braun-Blanquet method (1964; *r*: 0.01%; +: 0.1%; 1: 5%; 2: 17.5%, 3: 37.5%; 4: 62.5% and 5: 87.5%). To complete the plant species list in the entire sampling plot, the other three 2 m x 2 m subplots were searched for 20 min each, and all new species were recorded. The numbers of shrub and tree species and stem density were assessed in the 4 m × 4 m plots. The total cover of ground vegetation, leaf litter and bare soil were estimated in each plot using the scale of Braun-Blanquet (1964). Plant surveys were carried out between late June and the middle of August 2013. Plant species were identified following the references given in Vakhlamova et al. (2014).

### 2.3. Number of forest visitor and their activities

Systematic non-participatory observations were carried out in each urban and suburban forest between 8:00 h and 20:00 h, both on working days and weekends, between July and September 2014. Following a given transect line, each forest was crossed during a standard scan period of 1 h, equally distributed over the day. This procedure was repeated 5–6 times for each forest. The scan periods were similarly distributed over both types of forest resulting in a total observation time of 77 h in 14 urban and 58 h in 11 suburban forests. During a scan period, the number of visitors staying or moving in the forest, their gender (male or female), age (children 1–12 years, teens 13–19 years, adults 20–60 years, older adults 60 years or older), the group size (single, pairs, small group [≤4 people], large group [>4 people]) and the activity of the visitors were recorded. Visitor activities were a priori assigned to ten categories: walking, sports (jogging, fighting, gymnastics), biking, picnicking, playing with children, sitting and talking, observing nature, gathering mushrooms or berries, fishing, others (including reading, working, washing cars).

### 2.4. Habitat and landscape structure characteristics

For each forest, four habitat and seven landscape characteristics were derived from satellite maps (Google Earth, 2013). As habitat characteristics, the minimum distance from the forest edge to the built-up area, the distances from the forest edge to the nearest road, to the nearest other forest and water body were assessed (Appendix A). The percentage cover (estimated to the nearest 5%) of built-up area and traffic infrastructure within a radius of 200 m and 500 m around the most central sampling plot chosen in each forest were determined using the pixel counting function of Adobe Photoshop, version 10.0.1. In the same way, we assessed the percentage cover