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Urban-rural and temporal differences of woody plants and bird species in Harbin city, northeastern China

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ABSTRACT

Urbanization has been greatly accelerated by the economic growth in China, while its possible effects on woody plants, bird species and their associations are not well defined yet. Here, we analyzed urban-rural gradients (landscape level: urban-farmland-forest-natural reserves; city level: ring road and urban build-up history) and temporal data (1955–1980–2014 for woody plants; 1980s–2010s for birds) in Harbin city, China, to investigate the changes in the composition and diversity of woody plants and birds during urbanization. Both landscape gradient and temporal data confirmed that urbanization had the function of species conservations with sharp increases of alien species and tropical type plants. In the case woody species, 60-yr urbanization in Harbin had induced increases of 9 families and 17 genera, and there were 7–20 more families, 12–35 more genera, 1.6–2.6 higher Margalef richness in urban areas than those in nature reserves and local forest farms; Increases in alien species (4-fold in 60-yr urbanization; 21% in urban area vs <2% for non-urban region) and tropical type plants (1.6-fold in 60-yr urbanization; temperate/tropical ratio at 1.2 in urban area vs >1.6 in non-urban area) were mainly responsible for these compositional changes, which can be proved by their significant correlations. Moreover, moderate disturbance had peak values in alien species, tropical type plants, Shannon-wiener diversity, Margalef richness index and Pielou evenness index, and both ring road- and buildup history gradients showed the similar tendency. Compared with those in 1980s, forest- and eurytopic-habitats birds increased 9–11 species (23–39%), and omnivorous, insect-eating, and phytophagous bird increased 5–9 species (14.1–29.4%) in those in 2010s, indicating that bird temporal changes were closely related with the changes in urban forests owing to food supply and habitat provision. Our findings could provide data for biodiversity evaluation of urbanization effects, and is also useful for ecological re-construction of local cities in China.

1. Introduction

Urbanization is occurring rapidly worldwide. According to the United Nations (2014), urban population accounted for 54% of the total world's population in 2014. By 2050, 66% of the world's population is projected to be urban. In China, economic development has gone hand-in-hand with urbanization. In 1950, 13% of the population was urban; it grew to 54.8% by 2014; and is projected to reach 60% by 2030 (United Nations, 2010). Aggregation of the urban population and high-density construction of urban roads and buildings results in changes in a city's illumination, temperature, precipitation, soil conditions and other ecological factors (Chen et al., 2014b; Wilby and Perry, 2006). Urbanization not only reshapes physical environment but also changes green infrastructure (Burton et al., 2009; McKinney, 2002, 2006), and a basic challenge for biological conservation is to understand how it affects biodiversity including compositions of plants and bird species and their associations (Alvey, 2006; Faeth et al., 2011; McKinney, 2002; Primack et al., 2009).

Urban-rural gradient analyses are a typical method for urbanization studies. Some studies showed that urbanization increased the total number of urban plant species (Chocholoušková and Pyšek, 2003; DeCandido et al., 2004) and changed the number of families and genera (Chen et al., 2014b; Wang et al., 2008), however, some studies found the opposite(DeCandido et al., 2004; Standley, 2003). Urban ring road-related gradients (Chen et al., 2014b; Zhang et al., 2015), urban-rural transacts (Chen et al., 2014a; Chen et al., 2013;

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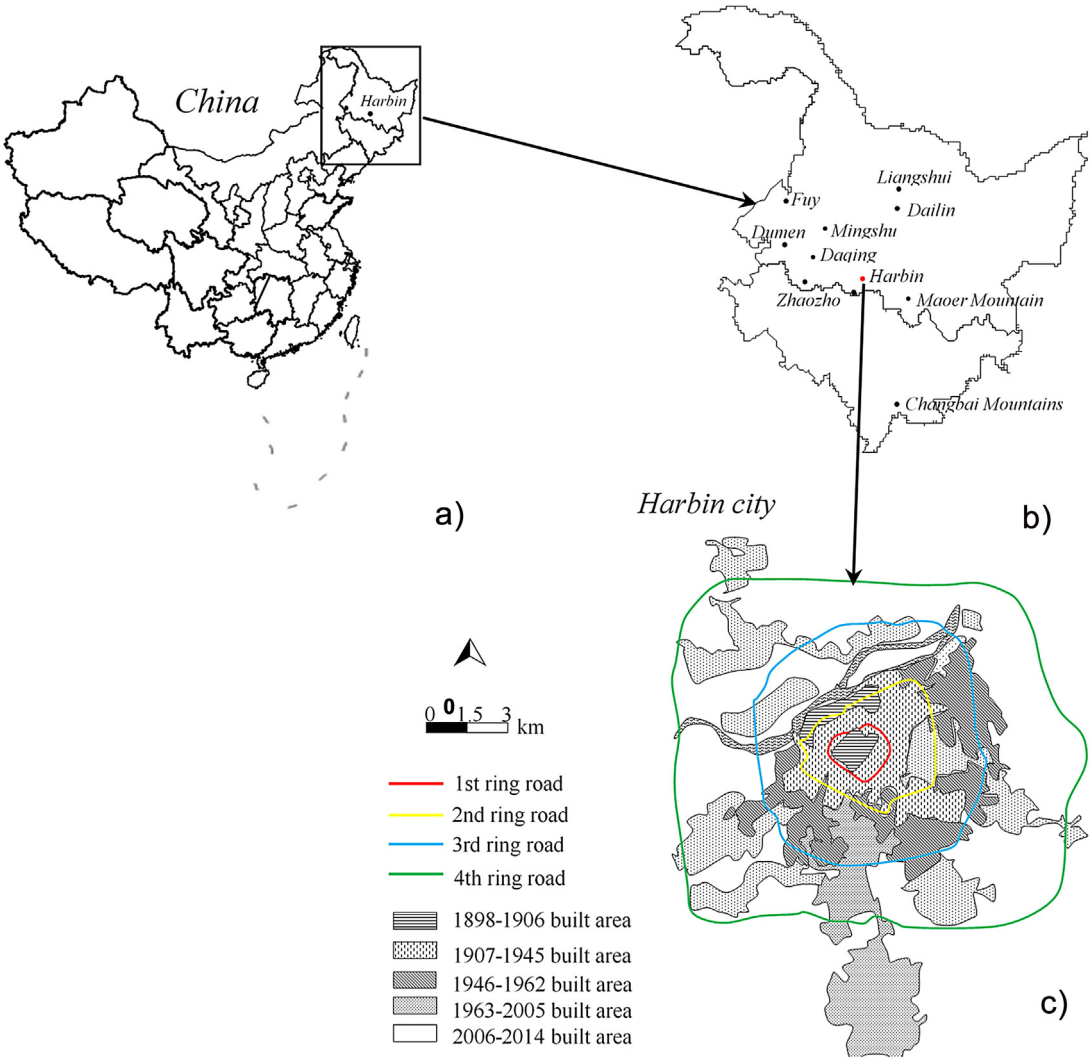

Fig. 1. Location of Harbin City in China (a), sampling sites in urban-farmland region-local forest farms and natural reserves gradients (b) and sampling sites and data classification rationale within Harbin City(c).

Fang et al., 2011) or land-use types (desert, urban and agriculture) (Kaye et al., 2005; Walker et al., 2009), or urbanized-semi-natural ecosystem comparison(Pautasso et al., 2011b) have been used in defining urbanization gradient. A combining urban-rural gradients of various abovementioned scales might provide a holistic view of urbanization effects. Furthermore, temporal changes with long-term species records could provide more exact evidences (Drayton and Primack, 1996; Primack et al., 2009), while very limited data availability make such study scarce. Together with urban-rural gradient analysis at different scales, a temporal change with present data and long-term recording data may improve the exact understanding of biodiversity changes during urbanization effects (Primack et al., 2009).

Different classifications of plant and bird functional types used for urbanization effects may favor biodiversity changes and underlying reason clarification (Walker et al., 2009). Geographical plant types have been recognized as widespread, tropical and temperate species according to its global distribution map (Good, 1974; Myers and Giller, 1988), which has been used for studying plant compositional changes in various ecosystems (Jing et al., 2014; Tian et al., 2015) and any changes of them indicate interspecific evolution and climate adaptation (Wu et al., 2003). Plant species alternations might be associated with changes of alien/native plant species (Honnay et al., 2003; Knapp et al., 2008; McKinney, 2006), or changes in floral composition and geographical types (Cox and Moore, 2010). Richness index (e.g. Margalef index), diversity index (e.g. Shannon-wiener index), evenness index (e.g. Pielou index) and similarity index (e.g. Jaccard index) are common indexes for measuring different aspects of plant species diversity (Jim and Zhang, 2015; Knapp et al., 2010; Walker et al., 2009; Zhang et al., 2015). Bird richness is closely associated with plant species (Chen et al., 2012; Davids and Glick, 1978; Jokimäki, 1999) and possible links are habitat selection and food availability (Tilghman, 1987; Wang et al., 2014). Combination of various functional groups classifications and various diversity indexes for woody plants and bird species will favor the scientific understanding of urbanization effects on biodiversity.

Harbin, capital of China's northernmost province Heilongjiang, was founded in 1896 and is striving to be an ecological garden city today (http://www.upp.gov.cn/). To date, limited data are available on the composition and diversity of tree species and birds in Harbin city, comparison with natural forests and long-term historical data (Baranov et al., 1955; Chen and Feng, 1985). The aim of this paper is providing a data supplement aiming to quantify urban-rural and temporal changes in woody plant species and birds within Harbin city, and their associations. The specific objectives