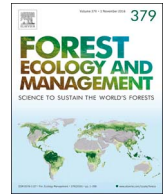




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Variability of *Tamarix* spp. characteristics in riparian plant communities are affected by soil properties and accessibility of anthropogenic disturbance in the lower reaches of Heihe River, China

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ABSTRACT

Tamarix, one of the most widely distributed riparian shrub genera, plays an important role in ecosystem stabilization in arid zones. Various studies have assessed the effect of stressors on *Tamarix* spp. in riparian plant communities in homogenous habitats. However, less is known about the factors driving variation of *Tamarix* spp. characteristics across heterogeneous habitats in desert riparian zones, which would constrain effective ecological conservation in such areas. In this study, field experiments were conducted to determine the variability of *Tamarix* spp. characteristics and its driving factors across various riparian plant communities in the lower reaches of Heihe River, China. Five riparian plant communities containing *Tamarix* spp. were classified, ranging from tree–shrub–herb community to shrub dune. With the increase of height and crown diameter of *Tamarix* spp., its capacity to resist drought increased, while community diversity formed a bimodal variation pattern instead of consistently decreasing trend due to variations of vegetation–environment interactions across the heterogeneous habitats. Among environmental factors, accessibility of anthropogenic disturbance and soil properties, explaining 42% of vegetation variance, were deemed the key factors influencing the variation of *Tamarix* spp. characteristics. By contrast, water availability (e.g., soil moisture and proximity to the river) showed a weak relationship with *Tamarix* spp. characteristics due to the drought tolerance of *Tamarix* spp. and its interactions with the extreme environment. As accessibility of anthropogenic disturbance and soil properties were regarded as major environmental factors driving the *Tamarix* spp. characteristics, multiple measures such as establishing protective zone, controlling cantaloupe planting and developing water-saving irrigation were proposed to secure the vegetation structure of *Tamarix* spp. and maintain the resilience of riparian plant communities under intensive human activities.

1. Introduction

Riparian zone is the interfaces between land and water, characterized by a heterogenous environment and various vegetation communities (Naiman and Décamps, 1997). *Tamarix* (also called: saltcedar or tamarisk, family *Tamaricaceae*) is one of the most widely distributed riparian genera because of its ability to adapt to a range of saline and drought conditions. (Ding and Zhao, 2016; Stromberg et al., 2009). It provides multiple ecosystem services to humans and it functions as an ecological protection against desertification, especially in arid ecosystems (Ma et al., 2009). As a result of its strong drought tolerance and adaptive ability, *Tamarix* spp. grows with other species and develops into different riparian plant communities under long-term

vegetation–environment interactions (Yang et al., 2002). Various studies have explored the interaction between *Tamarix* spp. and environmental factors in riparian plant communities, and the results varied with the habitat investigated (Stromberg et al., 2009). Studies in humid riparian areas showed that the *Tamarix* spp. was characterized by strong competition for water and the ability to secrete salt into the soil, which would alter the growth condition of native species, form a single-species community, and thus, decrease the biodiversity (Natale et al., 2010). By contrast, other studies, mainly in desert oasis areas, reported that interactions between *Tamarix* spp., shrubs, and environmental factors could provide good wildlife habitats through the ‘fertile island’ effect, resulting in a higher level of biodiversity (Li et al., 2007). Although the interaction between *Tamarix* spp. and environmental factors

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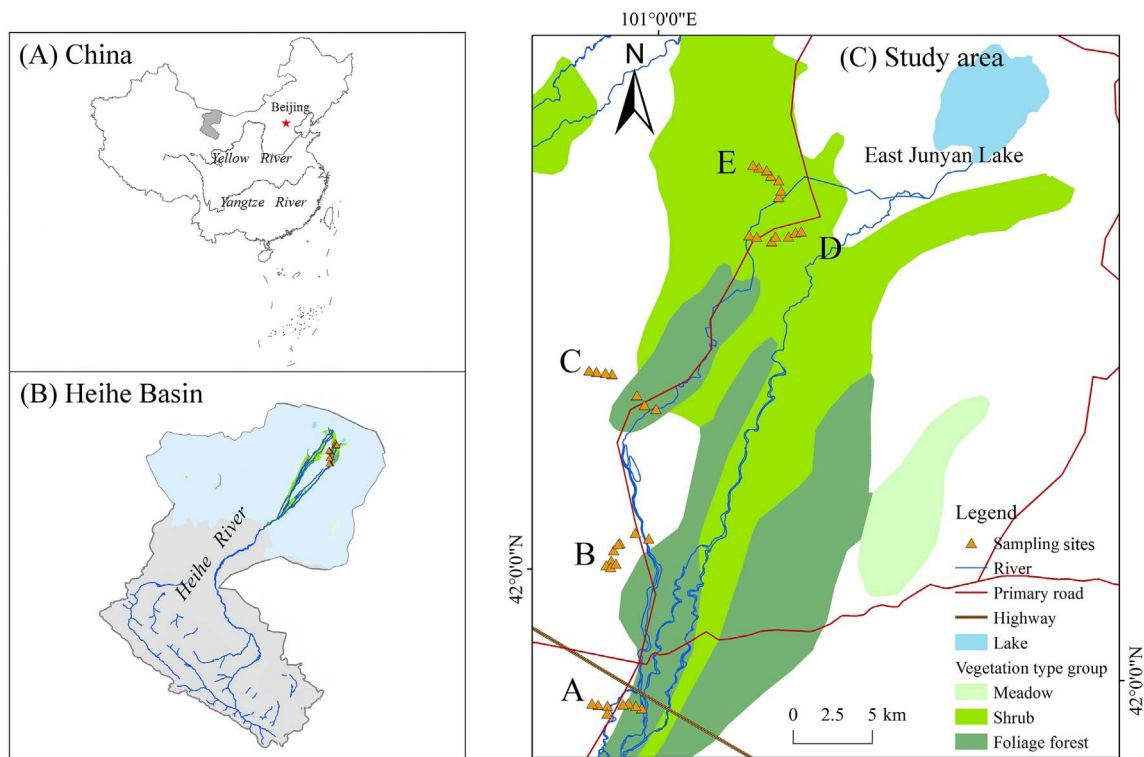


Fig. 1. The lower reaches of Heihe River basin (B) in China (A) and the location of sampling sites in the study area (C). Notes: A–E in (C) indicate the sampling transects.

in riparian plant communities has long been recognized, these studies mainly focused on homogeneous habitats in the study area. However, vegetation–environment interactions vary with habitat types and habitats in the desert riparian zone are highly heterogeneous, varying from humid riparian areas near the riverbank to drought-stressed desert peripheries. Previous studies in desert riparian zones mainly focused on vegetation–environment interactions in shrub dune habitats (Xie et al., 2015). However, less is known about the factors determining the variability of *Tamarix* spp. characteristics in riparian plant community across heterogeneous habitats in desert riparian zones, which inhibits effective ecological restoration of *Tamarix* spp. in riparian plant communities in this crucial ecosystem (Lü et al., 2011).

The variation in *Tamarix* spp. community characteristics (e.g., community structure, floristic composition and diversity) results from interactions between vegetation and multiple environmental factors (Flato et al., 2013). Water availability is a key factor that positively influences vegetation characteristics, particularly in arid and semiarid ecosystems (Fang et al., 2016). *Tamarix* spp., as a drought tolerance species, depends on multiple water resources to maintain its growth. Soil moisture, especially a depth of 40–60 cm is the direct water resource for *Tamarix* spp. in riparian plant communities; by contrast, groundwater, to a depth of 10 m, representing the survival threshold for *Tamarix* spp., is its stable water resource (Long et al., 2014). In addition, as both groundwater and soil moisture are recharged by rivers or streams, the distance from river channel can be regarded as a proxy for water availability, given that the influence of river will weaken with the distance from river channel (Hao et al., 2010). Soil properties (e.g., soil physical properties and soil chemical properties), as the foundation of vegetation growth, also shape the community floristic composition and species vitality by influencing ecological and hydrological processes (Stirzaker et al., 1996). Previous studies have reported that soil heterogeneity is one of the main factors determining the dominant species in vegetation communities, whereas changes in soil nutrition contribute

greatly to variation in species diversity in desert riparian areas (Díaz and Cabido, 2001).

Except for natural factors, the impact of anthropogenic disturbances on vegetation has significantly increased in the Anthropocene (Lavorel et al., 2015). The ‘accessibility to anthropogenic disturbance’ is a comprehensive index which could represent the possibility of communities being disturbed by various anthropogenic activities, with mainly negative effects on community characteristics (Liu et al., 2014b; Zeng et al., 2011). Vegetation communities near to roads are more easily disturbed by grazing and tourism, which in turn can alter the environmental conditions (e.g., soil properties and water availability), leading to degradation of vegetation communities. In addition, vegetation communities near road are easily accessed by large agricultural machines and disturbed by other human activities (e.g., collecting firewood, expanding farmland), which may alter community structure and decrease ecosystem resilience significantly (Daryanto et al., 2013). Although previous studies provide some insight into the interactions between *Tamarix* spp. in riparian plant communities and environmental factors (DiTomaso, 1998; Li et al., 2007; Stromberg et al., 2009), key factors that drive the formation of *Tamarix* spp. characteristics in desert riparian zones remain unclear. In addition, previous studies mainly concentrated on natural factors, such as water availability and soil properties (Ma et al., 2009; Natale et al., 2010; Xu et al., 2011), which, without consideration of anthropogenic effects, cannot provide a comprehensive view of *Tamarix* spp. characteristics’ formation, especially in desert riparian zones, which are characterized by heterogeneous habitats and intense anthropogenic activities.

In the current study, we surveyed multiple vegetation community characteristics (including community floristic composition, community structure indices, and diversity indices) and environmental factors (including water availability, soil properties, and accessibility to anthropogenic disturbance) in the lower reaches of Heihe River. We first classified riparian plant community types that contains *Tamarix* spp. in

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