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A novel approach for assessing the neighborhood competition in two different aged forests

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ABSTRACT

Competition plays an important role in stand dynamics, but the study of competition conducted in natural forests with complex structure and composition is still limited. The traditional methods, which quantify the competition between individual trees, commonly ignore the information of species identity and spatial distribution. This study introduced a new competition index named Structure-based Competition Index (designated as *SCI*), which was calculated according to the characteristics of neighborhood spatial structure. The effectiveness of the new index was tested by: (1) analyzing its correlation with the traditional competition indices (*Hegyi* and *BAL*); (2) comparing its performance in predicting tree growth with the traditional indices, and (3) analyzing the competition effect on tree mortality. The data were collected in two different aged natural forests located in the Jilin and Gansu provinces, China. Results showed that *SCI* was significantly correlated with the traditional competition indices. Basal area increment (BAI) was positively related to initial tree size, and negatively related to competition. Overall, the combination of tree size and competition explained 60.0–70.6% of the total variance in BAI of trees in both sites. The BAI prediction models incorporating *SCI* as one explanatory variable showed better statistical performance than those including the traditional indices. The performance of traditional competition indices showed mixed results in differently aged forests: the *Hegyi* index performed better than the *BAL* index in old-growth forest, while the contrary result was found in secondary forest. In conclusion, *SCI* could be a useful indicator for assessing the competitive status of individual trees in natural forests. It was essential to consider the relative importance of tree size, competitive status and the species identity when analyzing tree growth and mortality in natural forests characterized by complex structure and composition.

1. Introduction

Competition is an important factor in biology (Harper, 1977). Plant community structure is shaped by competitive interaction among individuals. In natural forests, outcomes of these interactions determine the size and position of individual trees, which in turn influence tree light, water and nutrient interception, and subsequently lead to a reduction in the performance (e.g. survival, growth and reproduction) of at least some of the competitive trees (Harper, 1977, Franklin et al., 1987; Coomes and Allen, 2007; Das et al., 2011; Szwagrzyk et al., 2012). This is because some trees are more sensitive to competition than others (e.g. the degree of shade tolerance (Szwagrzyk et al., 2012)). Competition is thus an important determinant of stand dynamics, productivity and ecological process. As recent forest management objective is moving towards maintaining structural and compositional complexity in forests (Bauhus et al., 2009; Pretzsch, 2009; Boyden et al., 2012), understanding how neighboring trees interact in a forest community is crucial to forest management, as well as to forest ecology.

The competition between individual trees is difficult to measure, therefore forest ecologists have extensively explored a range of methods to study the magnitude of competitive effects on growth and survival of individual trees (Aarssen, 1985; Goldberg, 1990, 1999; Connolly et al., 2001; Brooker and Kikvdze, 2008). When attempting to assess the intensity of inter-tree competition, it is a common practice to form competition indices by integrating several primary measures that represent differences in the competitive attributes of individual trees (Weigelt and Jolliffe, 2003). In the past few decades, many indices quantifying neighborhood competition have been developed. Basically, these indices can be divided into two major classes: distance-

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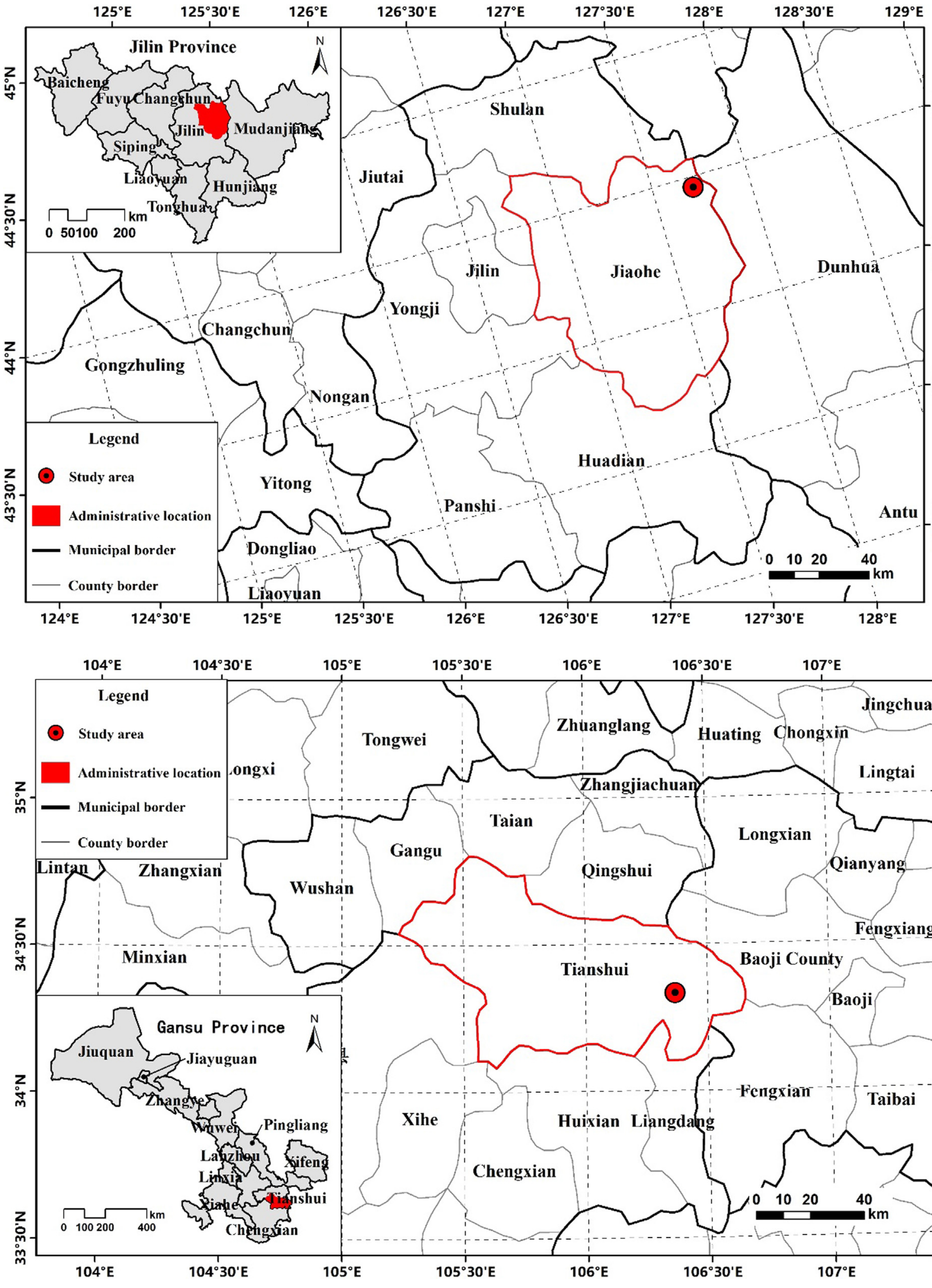

Fig. 1. Location of the study sites in (upper panel) Jilin and (lower panel) Gansu provinces in China.

independent and distance-dependent indices, also known as non-spatially explicit and spatially explicit indices, respectively. The distance-independent indices are calculated based on the size and number of individual trees within a given area (e.g. Wykoff et al., 1982; Biging and Dobbertin, 1995; Schröder and Gadow, 1999), without the requirement of tree locations. Whereas the distance-dependent indices incorporate the distance between a reference tree and its neighbors, and their relative sizes (e.g. Hegyi, 1974; Biging and Dobbertin, 1992; Canham et al., 2004). The advantage of the distance-independent indices is that they are easy to calculate and demand fewer field measurements