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# Variation in the nitrogen concentration of the leaf, branch, trunk, and root in vegetation in China

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ABSTRACT

Nitrogen (N) is an essential nutrient that is important for plant growth and productivity. How plants distribute N in different plant organs is aligned to the N use strategy of plants, and, in turn, provides an accurate way of assessing N storage in vegetation at the regional scale. Here, we analyzed variation in N concentrations across different organs and at different spatial scales. Specifically, we obtained 13,526 observations of plant N in China from consistent field measurements and from the published literature. The results showed that N concentration was significantly different across different plant organs (leaf, branch, trunk, and root), with more active organs having higher N. For forests, N concentration was ordered as: leaf (17.35 g $kg^{-1}$) > root (6.66 g $kg^{-1}$) > branch (6.47 g $kg^{-1}$) > trunk (2.79 g $kg^{-1}$). Similar trends were observed in grasslands, deserts, and wetlands. The N concentration of different plant organs significantly differed among different vegetation types [e.g., leaf N was ordered as: grassland (19.20 g $kg^{-1}$) > desert (17.91 g $kg^{-1}$) > forest (17.35 g $kg^{-1}$) > wetland (14.58 g $kg^{-1}$)]. Furthermore, N concentration in different plant organs significantly differed across various regions. With increasing latitude and decreasing mean annual temperature, the N concentration of different plant organs increased, to some extent. Our findings provide new insights about the differences in the N use strategy of plants across plant organs and at different spatial scales. In conclusion, the data assimilated here provide a systematic reference point for estimating vegetation N storage at different scales.

## 1. Introduction

Nitrogen (N) is a principal component of protein and nucleic acid, and is an essential element for plant growth (Vitousek and Melillo, 1979; Vitousek and Howarth, 1991; Zhang et al., 2003; Gao et al., 2007). Moreover, N is important for regulating the composition, structure, and functioning of terrestrial ecosystems. For instance, N fertilization enhances ecosystem productivity, whereas its acidification and eutrophication decreases ecosystem biodiversity (Galloway et al., 2004; Holland et al., 2005). Furthermore, the N concentration of different plant organs is the basic parameter used to estimate vegetation N storage (Finer et al., 2003). Thus, by understanding how N is distributed in different plant organs, the N use strategy of plants could be revealed, which, in turn, could enhance how N storage in vegetation is estimated at the regional scale.

Several studies have focused on the strategies used by plants to balance nutrients, which is also called the leaf economics spectrum (Wright et al., 2004; Shipley et al., 2006; Donovan et al., 2011; Osnas et al., 2013; Poorter et al., 2014). To survive and reproduce, plants make optimal allocations based on resource acquisition among different organs (Chen and Xu, 2014). Therefore, we speculated that N would be distributed differently in different plant organs because it tends to be a limiting factor for plant growth, with plants preferentially transporting more N to organs that are more active to synthesize various compounds, such as proteins and nucleic acids, to promote plant growth. In other words, organs that are more active contain more N. Several studies have confirmed that N concentration noticeably varies among different plant organs by evaluating the characteristics of N concentration in the various organs of different species in certain locations (Sharrow and Ismail, 2004; Mo et al., 2012; Wang et al., 2013; Liu et al., 2015; Zhao et al., 2016). Based on the hypothesis about the spatial variability of leaf N and phosphorus (P), which was proposed by Reich and Oleksyn (2004),

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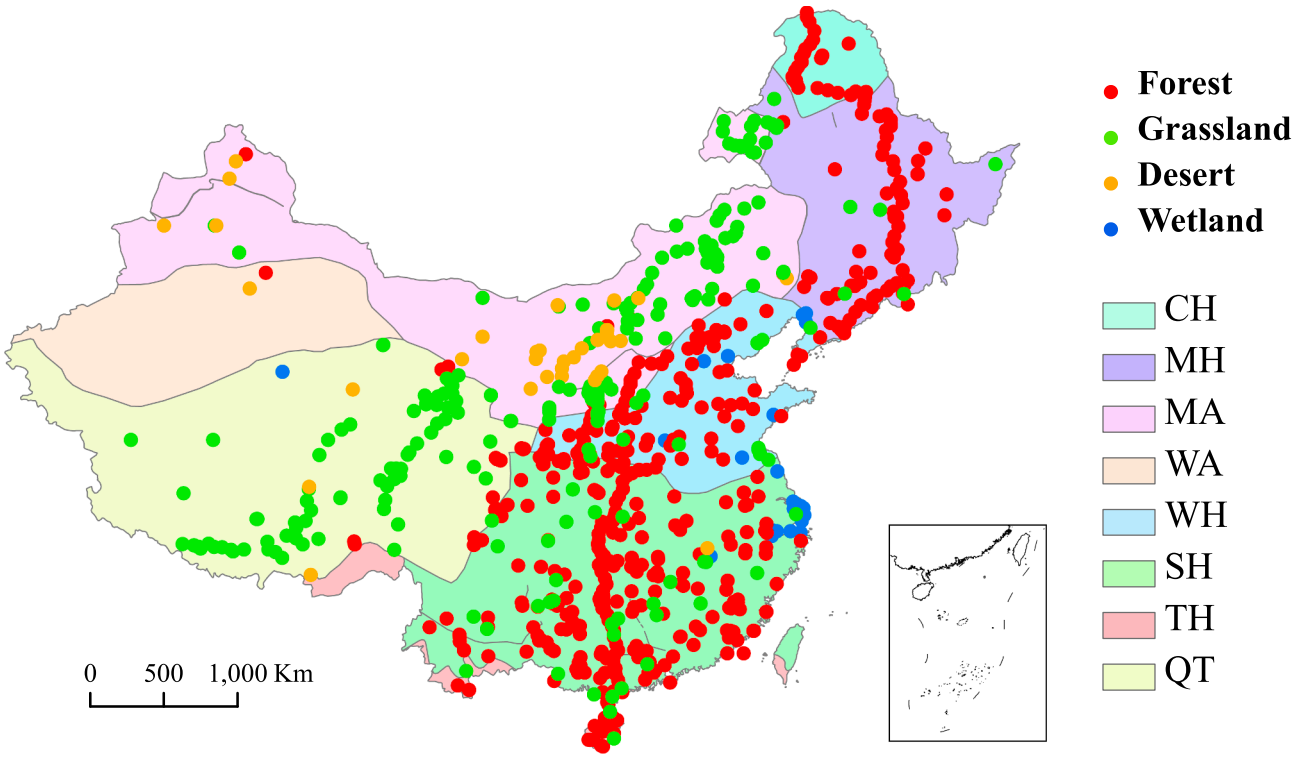


**Fig. 1.** Spatial distribution of the sampling sites in the terrestrial ecosystems of China. In the figure, CH = Cold temperate humid region, MH = Medium-temperate humid and sub-humid region, MA = Medium-temperate arid and semi-arid region, WA = Warm temperate arid region, WH = Warm temperate humid and sub-humid region, SH = Sub-tropical humid region, TH = Tropical humid region, QT = Qinghai-Tibet Plateau region.

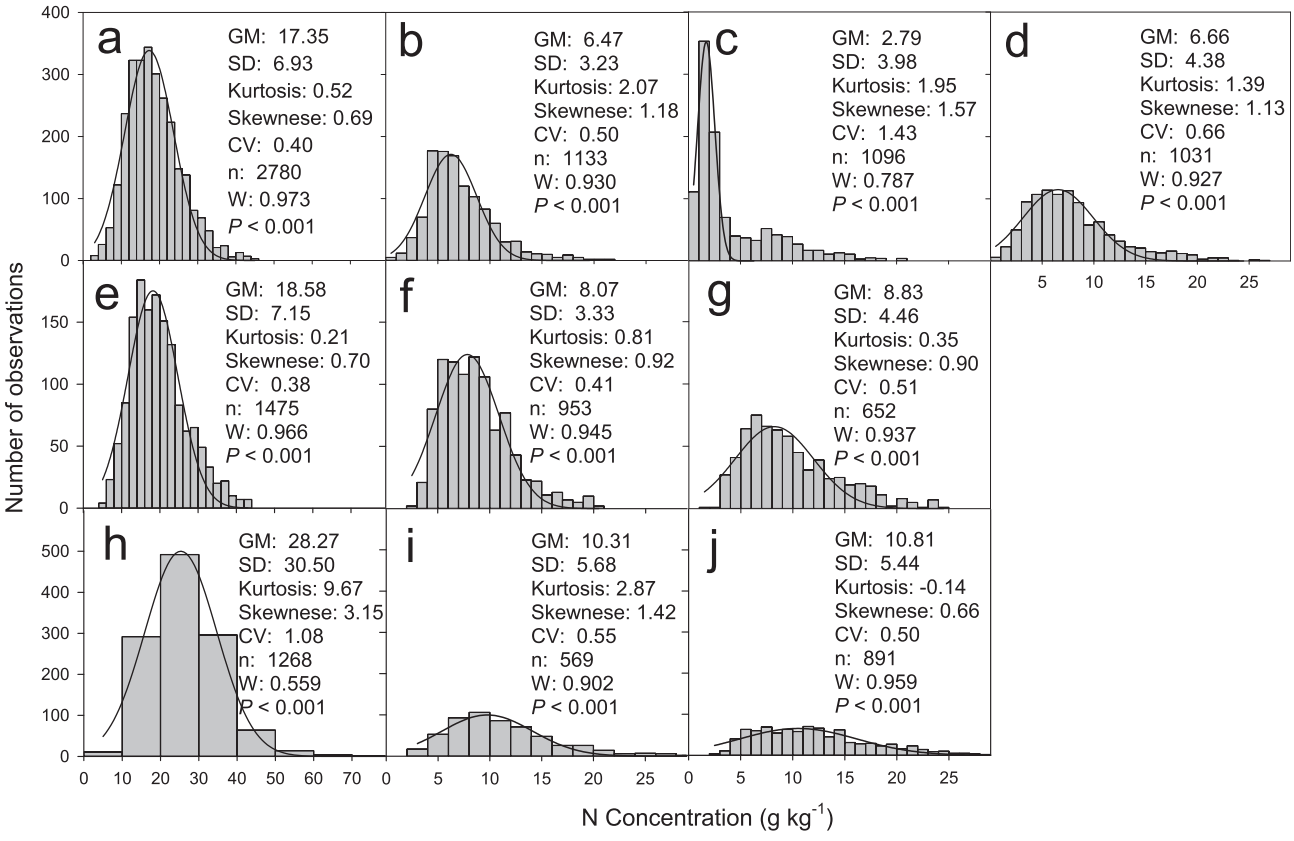


**Fig. 2.** Frequency distribution of N concentration in forests. In the figure, **a** represents tree leaf, **b** is tree branch, **c** is tree trunk, **d** is tree root, **e** is shrub leaf, **f** is shrub branch, **g** is shrub root, **h** is herb leaf, **i** is herb stem, and **j** is herb root.