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It is difficult for China's greening through large-scale afforestation to cross the Hu Line

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1. Spatial patterns of vegetation greening in China

Chen et al. (2019) published the paper "China and India lead in greening of the world through land-use management" in *Nature Sustainability*. Based on MODIS image data from 2000 to 2017, the paper reveals that the leaf area index (LAI) in China and India changed significantly during this period, with China accounting for 25% of the net increase in global leaf area. Forests account for 42% of China's greening and farmland 32%.

Specifically, the spatial patterns of vegetation greening in China were not discussed in detail. However, as shown in Figure 2, China's greening has generally not crossed the Hu Line (Chen et al., 2019). The Hu Line is the demarcation line between China's humid and arid areas, which corresponds to a mean annual precipitation (MAP) of 400 mm. Starting in Heihe in Heilongjiang Province, the line passes through the Greater Hinggan Mountains, the Jibei Mountains, the Luliang Mountains, the Liupanshan Mountains and the eastern edge of the Qinghai-Tibet Plateau, to Tengchong in Yunnan Province. Overall, there was no significant change in forest cover or LAI to the west of the Hu Line (Chen et al., 2019).

Since the beginning of this century, the role of increasing forest cover in China's greening has mainly appeared in the regions south of the Qinling Mountains-Huaihe River Line, which separates southern and northern China. In Southwest China, both the LAI and forest cover increased significantly (Chen et al., 2019), which was consistent with the previously reported increase in both LAI and carbon sequestration capacity in this region, reflecting the contribution of vegetation conservation and ecological engineering (Tong et al., 2018). In Southeast China, the LAI increased significantly, despite a slight reduction in forest cover in some areas (Chen et al., 2019). In the regions north of the Qinling Mountains-Huaihe River Line, the areas with both increased forest cover and LAI include central and southern Shanxi Province and central Shaanxi Province, which is consistent with previous studies on the Loess Plateau (Feng et al., 2016). It is noteworthy that, on the Loess Plateau, the increase of vegetation cover, LAI or net primary productivity has not crossed the Hu Line to the arid and semiarid regions (Feng et al., 2016; Chen et al., 2019). The areas with increased forest cover and LAI also include the Yanshan Mountains, the northern part of the Greater Hinggan Mountains and the Xiao Hinggan Mountains, which are also located to the east of the Hu Line, reflecting the contribution of natural forest conservation and artificial forest construction (Chen et al., 2019).

One of the most recent studies on China's greening considered the change trend in vegetation fractional cover from 1981 to 2013 in the "Three North" region. It was pointed out that the Loess Plateau, Northeast China and the foot of the Tianshan Mountains were the three areas with the most significant increase in vegetation cover (Wang et al., 2019). The regional range of significant increase in vegetation cover during the 1981–2013 period is similar to that of the farm-

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land LAI increase since the beginning of this century in Chen et al. (2019). The results show that vegetation greening occurred in the southeastern part of the Loess Plateau, and the Northeast Plain located to the east of the Hu Line (Wang et al., 2019). The greening to the west of the Hu Line is confined to the oasis farming areas at the foot of the Tianshan Mountains; however, a significant increase in forest cover and LAI since the beginning of this century was also not found (Chen et al., 2019).

2. Why is it difficult for China's greening to cross the Hu Line?

The Hu Line is the boundary between forest and grassland. The survival of forests requires appropriate water conditions. Based on the satellite-estimated global woody cover products provided by Hansen et al. (2005), we conclude that the woody cover in China varies with MAP and further find that only in areas with MAP greater than 400 mm can the forest cover approach saturation, whereas in areas with MAP less than 400 mm, the forest cover is generally below 30% and even less than 10% (Figure 1). This fact shows that it is difficult for large-scale forest distribution to cross the Hu Line.

Monsoon rainfall mainly determines forest distribution in China. Previous studies have also shown that the location of the northern boundary of the East Asian summer monsoon has continued to shift; it has been advancing northwestward since 1980 (Chen et al., 2018). Interannual variations of the East Asian summer monsoon can affect grassland vegetation cover and growth (Ma et al., 2010), which responds rapidly to precipitation. The short-term northward migration of the monsoon is unlikely to lead to an increase in forest cover. Because forest life spans can be nearly 100 years and can reach hundreds of years or even longer, forest cover responds more to long-term climate variations.

Artificial forestation in China is also restricted by the Hu Line. In the arid and semiarid areas west of the Hu Line, although annual precipitation increased significantly from 1981 to 2013 (Wang et al., 2019), artificial forestation did not lead to significant changes in regional forest cover, nor did it lead to significant changes in LAI (Chen et al., 2019). In contrast, the mortality rate of afforestation in this region is high, and the contribution to greening is negligible (Wang et al., 2019).

3. Future climate change and vegetation construction in arid and semiarid regions of China

In the context of global warming, arid areas are becoming more arid, while humid areas are becoming more humid

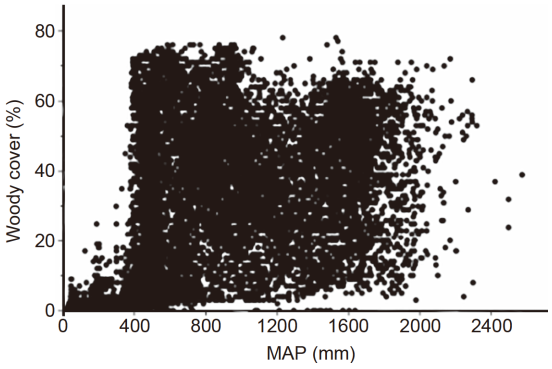

Figure 1 Changes in woody cover in China with mean annual precipitation (MAP) based on global woody cover products by Hansen et al. (2005).

(Feng and Zhang, 2015). There is a risk of the further expansion of the arid and semiarid areas in the future (Huang et al., 2016). Overall, future climate change is not conducive to vegetation growth and forest expansion in arid and semiarid regions west of the Hu Line.

Future climate change also poses challenges to vegetation construction in arid and semiarid regions of China. In the context of climate drought, forests in semiarid regions have declined and even suffered die-off (Liu et al., 2013). Future vegetation construction in arid and semiarid regions should consider climate suitability and climate change trends. The overall goal should be to restore natural vegetation on a large scale (Wang et al., 2019). Facing future climate change, the vegetation reconstruction policy should be focused on building and maintaining artificial forests on a local scale with a guaranteed water supply rather than massive regional forestation.

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