**Experimental design**

A UV-manipulation network was established across five sites, spanning approximately 3500 km from east to west through the diverse grassland ecosystems in China. These sites represent a wide range of grassland types: alpine steppe (Naqu, 91°57′23″E, 31°23′3″N; NQ), alpine meadow (Haibei, 101°18′49″E, 37°36′44″N; HB), typical steppe (Guyuan, 106°23′23″E, 36°16′20″N; Xilinhot, 116°42′6″E, 43°37′56″N; GY, XLHT) and desert steppe (Siziwang, 111°53′46″E, 41°46′44″N; SZW) in China (Fig. 1). Using the same materials with Wang et al. (2017), different levels of UV radiation were created with two types of plastic sheets: UV-transparent acrylic (Control) and UV-absorbing polycarbonate (Reduce UV). The UV transmittance of acrylic and polycarbonate sheets is 90% and 10%, respectively, while the transmittance of other wavelengths in the solar spectrum exceeds 90%. These transmittance ratios were used in subsequent model simulation to quantify the cumulative UV dose reaching litter surface. The plastic sheets were placed obliquely on steel frames positioned 10 cm above the ground to ensure minimal disturbance to the surrounding microclimate conditions (Fig. S1). The sheets were placed at each experimental site in 2016 and were replaced in the summer of 2018 to avoid the influence of material aging on transmittance. The grasses growing under the sheets were artificially removed regularly.

A widely distributed grass species *Cleistogenes squarrosa* was grown in a greenhouse. After senescence, we collected the aboveground part as standard litter, and placed it at all the experimental sites to evaluate the effect of climate on litter decomposition. One dominant local species from each site was also selected to evaluate the influence of litter quality variation on litter decomposition rate. Litter with initial weight of 2 g was flattened and placed in 10 cm × 15 cm nylon bags with a mesh size of 1 mm × 1.5 mm. In 2016 autumn, the litter bags were placed on the soil surface beneath the steel frames, and grasses beneath the steel frames were removed monthly during the growing season to prevent vegetation interference with light penetration. The field decomposition study extended over a period of more than 3 years, during which the litterbags were sampled a total of 9 times. In NQ, litterbags were not sampled during the winter of 2018 due to heavy snowfall.



**Figure 1. The geographic distribution, ecosystem types and background environmental conditions of experimental sites.** The mean levels of climate and UV radiation during the field experiment (Sep. 2016 - Jun. 2020) are presented. The pictures on the right show the difference in vegetation among experimental sites. MAT, mean annual temperature (℃). CDI, climate decomposition index, positively correlated with environmental temperature and wetness. UV, the intensity of UV radiation.