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The response of plant phenological seasons and spring-flowering to climate change in Beijing

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Botanical gardens have a unique set of resources that allows them to make important contributions to climate change research. China National Botanical Garden (CNBG) is located at 40°N and belongs to the warm temperate continental monsoon climate with distinct seasons. More than 18,000 living plants grow within the garden. There is a long history of meticulous recording of plant phenology. We used Frequency Distribution Method to analyze the phenophase data of 286 trees in CNBG from 2008 to 2020, divided the phenological seasons, and indicated the characteristics of each season. The division of phenological seasons is: 6^{th}–19^{th} pentad (5-day period) for Spring, 20^{th}–44^{th} pentad for Summer, 45^{th}–58^{th} pentad for Autumn. Compared with data from the 1980s, this study reveals that spring and summer came earlier by a pentad while autumn came later by two pentads; additionally, summer duration prolonged by three pentads while autumn duration shortened by two pentads. Furthermore, we collected the dates of spring-flowering (the First Flowing Date (FFD) and the End Flowing Date (EFD)) of 12 woody plants in CNBG from 2008 to 2020, as well as the temperature data during the same period. The results of Correlation Analysis and Regression Analysis showed that the annual average temperature showed an increasing trend of 0.73℃/decade; The FFD and EFD of 12 plants were obviously advanced, with an average of 3.2 days/decade and 1.5 days/decade respectively; Statistical correlations were found between the changes of spring flowering and the temperatures of one or several months before the phenophase. A warming of 1℃ led to an advanced FFD and EFD of 4.4 days and 3.8 days respectively. The results have implications for spring-flowering tourism and living collection strategies in CNBG, and provide biological indicator evidence for climate change in Beijing.