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Modeling the grazing effect on dry grassland carbon cycling with modified Biome-BGC grazing model

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Identifying the factors that determine the carbon source/sink strength of ecosystems is important for reducing uncertainty in the global carbon cycle. Arid grassland ecosystems are a widely distributed biome type in Xinjiang, Northwest China, covering approximately one-fourth the country's land surface. These grasslands are the habitat for many endemic and rare plant and animal species and are also used as pastoral land for livestock. Using the modified Biome-BGC grazing model, we modeled carbon dynamics in Xinjiang for grasslands that varied in grazing intensity. In general, this regional simulation estimated that the grassland ecosystems in Xinjiang acted as a net carbon source, with a value of 0.38 Pg C over the period 1979–2007. There were significant effects of grazing on carbon dynamics. An over-compensatory effect in net primary productivity (NPP) and vegetation carbon (C) stock was observed when grazing intensity was lower than 0.40 head/ha. Grazing resulted in a net carbon source of 23.45 g C m-2 yr-1, which equaled 0.37 Pg in Xinjiang in the last 29 years. In general, grazing decreased vegetation C stock, while an increasing trend was observed with low grazing intensity. The soil C increased significantly (17%) with long-term grazing, while the soil C stock exhibited a steady trend without grazing. These findings have implications for grassland ecosystem management as it relates to carbon sequestration and climate change mitigation, e.g., removal of grazing should be considered in strategies that aim to increase terrestrial carbon sequestrations at local and regional scales. One of the greatest limitations in quantifying the effects of herbivores on carbon cycling is identifying the grazing systems and intensities within a given region. We hope our study emphasizes the need for large-scale assessments of how grazing impacts carbon cycling.

Most terrestrial ecosystems in Xinjiang have been affected by disturbances to a greater or lesser extent in the past several decades (e.g., land-use change, timber exploitation, and air pollution). However, regional evaluations that account for all of the local disturbances have been difficult. Data from field measurements play a pivotal role in comparing model simulations with observations.