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The influence of competition between plant functional types in the Canadian Terrestrial Ecosystem Model (CTEM) v. 2.0

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The Canadian Terrestrial Ecosystem Model (CTEM) is the interactive vegetation component in the earth system modelling framework of the Canadian Centre for Climate Modelling and Analysis (CCCma). In its current framework, CTEM uses prescribed fractional coverage of plant functional types (PFTs) in each grid cell. In reality, vegetation cover is continually adjusting to changes in climate, atmospheric composition, and anthropogenic forcing, for example, through human-caused fires and CO_2 fertilization. These changes in vegetation spatial patterns occur over timescales of years to centuries as tree migration is a slow process and vegetation distributions inherently have inertia. Here, we present version 2.0 of CTEM that includes a representation of competition between PFTs through a modified version of the Lotka-Volterra (L-V) predator-prey equations. The simulated areal extents of CTEM's seven non-crop PFTs are compared with available observation-based estimates, and simulations using unmodified L-V equations (similar to other models like TRIFFID), to demonstrate that the model is able to represent the broad spatial distributions of its seven PFTs at the global scale. Differences remain, however, since representing the multitude of plant species with just seven non-crop PFTs only allows the large scale climatic controls on the distributions of PFTs to be captured. As expected, PFTs that exist in climate niches are difficult to represent either due to the coarse spatial resolution of the model and the corresponding driving climate or the limited number of PFTs used to model the terrestrial ecosystem processes. The geographic and zonal distributions of primary terrestrial carbon pools and fluxes from the versions of CTEM that use prescribed and dynamically simulated fractional coverage of PFTs compare reasonably with each other and observation-based estimates. These results illustrate that the parametrization of competition between PFTs in CTEM behaves in a reasonably realistic manner while the use of unmodified L-V equations results in unrealistic plant distributions.