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A Mathematical Model of Tree-Grass interactions using Impulsive Differential Equations and non-linear feedback functions of grass biomass onto fire-induced tree mortality

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Abstract: Explanations accounting for tree-grass interactions in savanna ecosystems are often based on either facilitation/competition for resources, or differential sensitivity to fires. We propose a tree-grass model which accounts both phenomena (i.e. competition and fires). In the literature, several models used positive feedback between grass biomass (fuel load) and fire intensity, however, they did not incorporate nonlinear response of fire frequency/intensity to tree biomass. Our model explicitly considers the impact of pulse fire on tree biomass by mean of two non-linear impact functions including the response function of woody biomass to fire intensity. By considering two impact functions, our system yields complex dynamics, allowing for various possibilities of bistability and periodic equilibria in the ecosystem. We investigate local and global properties of equilibria. We highlight three parameters of bifurcations: the fire period, the tree-grass competition parameter, and the fire intensity. Using an appropriate nonstandard numerical scheme, we provide numerical simulations to discuss some ecologically interesting cases our model is able to exhibit along a rainfall gradient. In order to represent spatial patterns observed in different environmental regions, a preliminary work that explicitly represent the spatial interactions among trees and grasses is introduced.