Extreme Climate Events and the Ecological Dynamics of Plant-Herbivore Interactions

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Extreme climate events are a common feature of many ecosystems, and they are becoming more universal and stronger with climate change. A basic understanding of how the properties of an ecosystem interact with the characteristics of an extreme climate event that foster an ecological response is necessary for our ability to predict the consequences of climate change. We constructed a seasonal delay differential equation model around a common phenology of herbivore-plant interactions. We simulated numerous extreme climate events on four general systems to determine their reaction patterns. We found that systems with high herbivore growth rates and/or plants with delayed defensive responses to herbivore attack are more sensitive to extreme climate events. Further, systems where herbivores gain immunity to plant defenses with ontogeny are relatively more stable in response to extreme climate events. In addition, extreme climate events were generally more influential when they directly altered plant defense level or herbivore density (e.g., mortality) than when they temporarily altered the parameters governing the plant-herbivore interaction. Finally, all of these effects depended on when an extreme climate event occurred relative to the seasonal patterns of the herbivore-plant system. Our results indicate that extreme climate events have the potential to dramatically alter ecological dynamics for many years after a single event, and the details of the consequences depend on the ecological characteristics of the ecosystem, the ways in which the event influences the organisms in the ecosystem, and the seasonal timing of the events.