RESILIENCE INDUCED SUB-OPTIMAL CARBON ALLOCATION IN PLANTS

Venkatraman Srinivasan, University of Illinois at Urbana-Champaign, 217-778-4728, vsriniv3@illinois.edu

1. Venkatraman Srinivasan, Department of Civil Engineering, University of Illinois at Urbana-Champaign
2. Praveen Kumar, Department of Civil Engineering, University of Illinois at Urbana-Champaign
3. Murugesu Sivapalan, Department of Civil Engineering, University of Illinois at Urbana-Champaign

The prediction of carbon allocation within plants is a challenging problem in itself and challenges get compounded under climate change scenarios. Empirical and mechanistic models have limited success in capturing carbon allocation patterns within plants especially under climate change. More recently, optimality based models have been used to replace existing empirical and mechanistic models with reasonable success. Among the different optimality functions utilized, the idea of maximizing the end of life cycle reproductive biomass (Iwasa 2000) is the most promising as it has an inherent evolutionary fitness perspective embedded within it.

In this work, we couple a process based carbon assimilation model (Drewry et al 2010a) with an optimality based carbon allocation model to simulate the soybean-corn ecosystem. Our results indicate that the soybean-corn ecosystem demonstrates significant sub-optimal behavior where the end of season model generated optimal seed biomass is higher (>20%) than the observed measured seed biomass under ambient conditions (CO_2 ~ 280 ppm). Similar result was also obtained in the FACE experiments with artificially elevated CO_2 (~550 ppm) concentrations. We devised an experiment to test this suboptimal behavior by artificially modifying the natural plant allocation patterns towards a more optimal allocation strategy as guided by our model. The allocation modification experimental results demonstrated an increase in end of season seed biomass in agreement with the model predictions.

We propose that the reason for the observed suboptimal behavior is associated with the resilience requirement in natural systems in addition to the optimality constraint. Resilience can be conceptualized as the capacity of a system to absorb disturbance and still retain its basic structure and function (Walker and Salt 2006). In the case of the soybean-corn ecosystem, disturbances can be drought, leaf damage (hail or herbivory) etc. Based on this modeling effort we propose a resilience constraint on the optimality based carbon allocation using a multi objective framework. This framework is then used to predict carbon allocation patterns in future climate scenarios.