The Application of a Functional-Structural Plant Model to Validate a Mechanistic Model of Ozone-Induced Photosynthetic Rate Reduction in *Populus tremuloides.*

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Abstract:

The problem of predicting ozone-induced reduction of leaf photosynthetic rates in the context of elevated CO_2 poses significant modeling challenges. Biologically realistic damage models must reflect the complex inter-relationships between stomatal conductance, photosynthetic rate and intercellular CO_2 concentration. Recognizing the apparent high level of variability between plant species, such models should allow for ozone scavenging mechanisms, as well as leaf damage and repair capabilities, all of which may be dependent on leaf photosynthetic rate and leaf age. Moreover, if such models are to be useful for predicting tree and stand level ozone effects, these models must be calibrated in a light environment that is representative of real forest canopies.

The authors will report on the development of a process-based model of ozone-induced photosynthetic rate reduction in the presence of ambient (~360ppm) and elevated (~560ppm) concentrations of carbon dioxide gas. The model extends the earlier work of [4] in that it attempts to explicitly model leaf damage and repair mechanisms. It differs conceptually from [4] in that the photosynthetic rate parameters Vcmax and Jmax are assumed to depend on the (effective) fraction of healthy chloroplasts within the leaf. The rate change of this indicator of leaf health is modeled as the difference between the damage rate attributed to unscavenged "reactive oxygen species", which are created by the reaction of ozone within the leaf, and a hypothesized leaf repair rate.

Chamber studies from the literature have been used for the initial validation/calibration of the model in the context of highly controlled light, temperature, relative humidity and ozone treatment levels. In order to test the performance of the model under more realistic environmental conditions, the model has been installed in the functional-structural plant model ECOPHYS [2], [3]. ECOPHYS has been developed to simulate the growth of aspen clones raised under conditions measured at the Aspen Free-air CO_2 and O_3 Enrichment (FACE) Project (USDA Forest Service, North Central Research Station, Rhinelander, Wisconsin, USA) [1]. Leaf-level gas-exchange data [5] collected at the FACTS Experiment has been used to calibrate the ozone damage/repair model for a specific clone of *Populus tremuloides*.

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