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GLOBAL WARMING AND THE RELATIONSHIP OF PLANT CANOPY STRUCTURE TO LATITUDE

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EXTENDED ABSTRACT

A model of total photosynthesis from a monolayer canopy of plant leaves is developed. This model is used to calculate the mean leaf angle of an array of closely packed plant leaves, weighted by the photosynthetic rate of each leaf. Greater weight is given to leaf elevation angles that result in high total canopy photosynthesis and thus the predicted mean leaf elevation angle correlates with the mean leaf elevation angle of a canopy structured to maximize total canopy photosynthesis. Results from the model show that when the sun is high in the sky, the predicted leaf elevation angle is large. As the sun moves towards the horizon, the predicted leaf elevation angle decreases.

The arctic and alpine shrub *Dryas octopetala* has a remarkably large range, extending from the arctic to 35-40° N. latitude in Asia, Europe and N. America. *Dryas* forms a flat, almost monolayer canopy, with leaves packed closely together, a structure that corresponds closely to the simple monolayer canopy model. Data collected from sites in Europe, ranging from arctic Norway to Romania and from sites in North America and the Caucasus show that leaves of *Dryas* are steeply elevated at the southernmost extent of its range and less steeply elevated in the arctic.

Predictions of the monolayer canopy model and experimental observations are compared by plotting the experimental mean leaf elevation angles as a function of the minimum zenith angle of the sun on the longest day of the year, a measure corresponding to the latitude of a single population of *Dryas*. This comparison shows that the experimental data are in excellent qualitative agreement with predictions of the model. Leaves are less elevated at high latitudes, where the maximum sun position is low in the sky than at low latitudes, where the sun is high in the sky. If leaves were elevated more or less than observed, the model predicts that photosynthesis of the total plant canopy would decrease. Therefore, the model suggests that there is an optimal set of leaf elevation angles for each latitude.

If global warming causes temperatures to increase worldwide, plant distributions may shift latitude and thus remain in a similar temperature regime. However, the sun tracks will change with latitude. As the result of global warming, the scalar temperature environment will change independently of the vector environment of sun tracks. The result may be a need for plants to change parameters of canopy structure, such as leaf elevation and position. Results of present study suggest that studies of the genetic basis of plant canopy structure, including leaf elevation, and remote sensing methods used to characterize plant canopies, are of critical importance in understanding the response of plants to global warming.

Key words: *Dryas*, latitude, photosynthesis ‘canopy model’, ‘global warming’, ‘leaf elevation’, ‘leaf orientation’