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# Transpiration as the leak in a carbon factory: tests of a model of self-optimizing vegetation

M. Sivapalan (1), S. Schymanski (2), M. Roderick (3)

(1) Departments of Geography and Civil and Environmental Engineering, University of Illinois, Urbana, Illinois 61801, USA (sivapala@uiuc.edu), (2) School of Environmental Systems Engineering, University of Western Australia, Crawley, Australia, (3) CRC for Greenhouse Accounting, Australian National University, Canberra, Australia

"*Only now it occurred to me that plants are not water pumps but carbon factories*" — Anonymous Hydrologist. Natural vegetation has co-evolved with its environment over a long period of time and natural selection has led to a species composition that is most suited for the given conditions. Part of this adaptation is the vegetation's water use strategy, which determines the amount and timing of water extraction from the soil. When thinking of plants as 'water pumps', we are led to the conclusion that vegetation would tend to maximize the total amount of transpiration while minimizing the occurrence probability of periods without adequate water availability ('stress'). However, this does not do justice to the fact that plants owe their existence to photosynthesis, and can thrive perfectly well even when the relative humidity of the air is very high and transpiration is almost negligible. Photosynthesis provides plants with their main building material, carbohydrates, and with the energy necessary to thrive and prosper in their environment. Therefore we expect that natural vegetation would have evolved an optimal water use strategy to maximize its 'net carbon profit' (the difference between carbon acquired by photosynthesis and carbon spent on maintenance of the organs involved in its uptake). In this presentation, we will present a model in which the maximization of net $CO_2$ uptake rather than maximization of water use or minimization of 'stress' is assumed to be the driving force behind natural selection. Transpiration is the inevitable consequence of $CO_2$ uptake from the atmosphere and water uptake from the soil incurs construction and maintenance costs of a root system, so that water use strategies become a consequence of the maximization of net $CO_2$ uptake and 'stress' becomes an obsolete feature. We will demonstrate that a simple

model based on ecological optimality is capable of reproducing some vegetation and water balance dynamics without any prior knowledge about the vegetation on a particular site, which makes it very powerful for predicting vegetation response to long-term climate- or land use change. The model is based on a physical water balance model by Reggiani et al. ......(2000), an eco-physiological gas exchange and photosynthesis model .......(Cowan and Farquhar 1977; von Caemmerer 2000), and the hypothesis that natural selection leads to a vegetation type that optimally uses available resources to maximize its 'net carbon profit' (the net tradeoff between carbon acquired by photosynthesis and carbon spent on maintenance of the organs involved in its uptake). The model of optimal vegetation is tested for a site in Howard Springs (Northern Territory, Australia) by comparing the modeled fluxes against measurements by Beringer et al. (2003). The comparison gives insights into theoretical and actual controls on transpiration and photosynthesis and tests the feasibility of the optimality approach to modeling gas exchange of natural vegetation with unknown properties.