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# Parallels between drought and flooding: an integrated framework for plant eco-physiological responses to water stress

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Plants are highly sensitive to the water status of the soil in which they grow, with too little soil moisture causing drought stress whereas too much soil moisture causing flooding stress. This stress in response to opposing water conditions can be understood from the fact that plant growth demands both sufficient water uptake from the soil and rapid gas exchange with the environment. Given that drought and flooding events can occur in the same system and even consecutively, a single model simulating plant responses to a continuum of soil water conditions from drought to flooding would be attractive. However, as far as we know, such a model with sufficient mechanistic biological details currently does not exist. In this study we propose a theoretical framework of an integrated mechanistic model that is capable of describing plant responses to both flooding and drought, building on the biophysics of plant water transport and gas exchange and its dependence on environmental conditions. Since the restricted root water uptake and stomatal activity that limits gas exchange through photosynthesis are essential processes in both scenarios, we propose using a combined SPAC-Farquhar model that describes these processes as a “backbone” of the envisioned model framework. Further we propose to add processes related to oxygen dynamics and hormonal signaling, as oxygen deficit serves as the main driver of flooding stress to which hormonal signaling plays an essential role in plant response. The model aims to mimic various responsive strategies by different plant species. These strategies include isohydric and anisohydric strategies for drought response, and “escape” and “quiescence” strategies for flooding response. Stomatal activities of isohydric plants are reported to be more sensitive to leaf water potential but less sensitive to abscisic acid compared to those of anisohydric plants. This can be achieved by assigning different sensitivity coefficients. Plants that are tolerant and adaptive under flooding stress can generally switch between the “escape” and “quiescence” strategy, depending on shoot ethylene concentration. This integrated model framework is envisioned to mimic the complex behavior of plant responses to consecutive drought and flooding events, as the physiological processes involved occur on various time scales, ranging from sub-hours to weeks. Moreover, hormones and certain irreversible morphological changes can serve as “memory factors”, leading to the history-dependent nature of plant responsive behavior. We hope that the proposed theoretical model framework will serve as a

basis for model research on resilience to combined drought and flooding in both agriculture and natural vegetation systems.