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Structured population modeling of riparian plants: linkages between flow regime and plant population dynamics

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Modeling riparian plant population dynamics relative to flow-related processes is complicated by the fact that plants have different hydrologic and edaphic requirements and tolerances at different ages or life-stages. With intensifying human demands for water and continued human alteration of river flow regimes, there is a growing need for the development of methods for quantifying flow requirements for sustaining riparian plant populations and predicting responses of these populations to flow alteration (including those related to climate change). We developed a structured population modeling approach that incorporates age or size-specific responses of plant species to specific attributes of river hydrologic regime. Our intent was to (1) consolidate key information concerning plant population dynamics and to incorporate these data into a conceptual and analytical framework, (2) determine whether complex plant stand dynamics can be predicted from basic vital rates of the species and river hydrology, and (3) aid in planning prescribed hydrologic regimes by projecting how altered flow regimes might affect plant populations. We present findings for a native North American riparian forest species (Populus deltoides), an invasive woody species (Tamarix ramosissima), and an herbaceous species. For Populus, we found that abundances of seedlings and younger trees followed a boom-bust cycle driven by high flood mortalities while reproductive adult abundance followed a less erratic 5-15-yr periodicity driven by multiyear sequences of flows favorable to stand recruitment. Chance occurrences of multiple drought years eliminated Populus from up to 50% of available habitat, providing opportunities for competing plant species to establish. By simulat-

ing flow alterations ranging from channelization (many floods/droughts) to damming (few floods/droughts), the model suggested that mature Populus forest should be most abundant near the observed natural flow regime. Model analysis also suggested that flow regimes with high flood frequencies result in stable (albeit small) population sizes, while stable flows result in highly variable population sizes prone to local extinction. We present our approach along with findings of our modeling efforts for native, non-native invasive, and herbaceous riparian species.