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PHYSIOLOGICAL ECOLOGY - ORIGINAL PAPER

How do riparian woody seedlings survive seasonal drought?

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Abstract In semi-arid regions, a major population limitation for riparian trees is seedling desiccation during the dry season that follows annual spring floods. We investigated the stress response of first-year pioneer riparian seedlings to experimental water table declines (0, 1 and 3 cm day^{-1}), focusing on the three dominant cottonwood and willows (family Salicaceae) in California's San Joaquin Basin. We analyzed growth and belowground allocation response to water stress, and used logistic regression to determine if these traits had an influence on individual survival. The models indicate that high root growth (>3 mm day^{-1}) and low shoot:root ratios (<1.5 g g^{-1}) strongly predicted survival, but there was no evidence that plants increased belowground allocation in response to drawdown. Leaf $\delta^{13}C$ values shifted most for the best-surviving species (net change of +3.5 per mil from -30.0 ± 0.3 control values for Goodding's willow, *Salix gooddingii*), implying an important role of increased water-use efficiency for surviving water stress. Both *S. gooddingii* and sandbar willow (*S. exigua*) reduced leaf size from controls, whereas Fremont cottonwood (*Populus fremontii*) sustained a 29% reduction in specific leaf area (from 13.4 to 9.6 m^2 kg^{-1}). The functional responses exhibited by Goodding's willow, the more drought-tolerant species, may play a role in its greater relative abundance in dry regions such as the San Joaquin Basin. This study highlights the potential for a shift in riparian forest composition. Under a future drier climate regime or under reduced regulated river flows, our results suggest that willow establishment will be favored over cottonwood.

Keywords Ecophysiology · Cottonwood and willow · Water use efficiency · River regulation · Drought stress

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Introduction

Riparian corridors in dry regions provide important ecosystem services, where abundant water—a limiting resource in the surrounding upland landscape—promotes a local community with typically high plant density, biomass, diversity and structural complexity (Naiman and Decamps 1997; Patten 1998; Scott and Auble 2002). Commonly, the stream channel feeds a perennial, shallow groundwater table that supports floodplain forest stands, including those of fast-growing, generally drought-intolerant pioneer species such as willows and poplars (family Salicaceae). However, in many arid and semi-arid regions, these trees must contend with decreased soil moisture during a portion of the year, particularly in Mediterranean climates where the dry season may extend for several months (Gasith and Resh 1999). Seasonal drought is one reason why abiotic conditions are primary drivers structuring riparian plant communities in arid and semi-arid regions (Hughes et al. 2001; Scott et al. 1999).