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RESEARCH ARTICLE

Successional Models as Guides for Restoration of Riparian Forest Understory

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Abstract

We compare two successional models as guides for restoring native riparian understory species along a 160-km stretch of the Sacramento River in California. In 2001 and 2007, we surveyed cover, frequency, and richness of native and exotic understory species in 15 sites planted (1989–1996) with overstory species to determine whether native understory species colonized naturally (passive relay floristics model). In 2007, we surveyed 20 additional sites (planted 1997–2003) in 14 of which understory species were planted (initial floristics model) to evaluate whether planting accelerated community recovery. We surveyed 10 remnant forests as references for successional trajectories. Mean cover and frequency of natives changed little over time in sites where they were not planted initially; increases in native cover in a few sites were primarily due to a single common species (*Galium aparine*). Species composition shifted from light-demanding to shade-adapted species, both exotic and native, in response to a doubling of overstory cover. Sites with high intensity understory plantings had greater cover and frequency of native understory species than unplanted sites, but were still low relative to reference forests. Light-demanding natives (e.g., *Artemisia douglasiana*, *Rubus ursinus*, and grasses) established in sites where they were planted; however, a shade-adapted species (*Carex barbarae*) did not survive well. Our research indicates that the passive relay floristics and the initial floristic composition approaches serve to restore a few common native understory species, but that planting species as site conditions become appropriate (active relay floristics model) will be needed to restore entire native understory communities.

Key words: competition, initial floristic composition, relay floristics, Sacramento River, succession, understory.

Introduction

Ecological succession provides insights into how plant communities are assembled and how best to restore them (Ashton et al. 2001; Young et al. 2005; del Moral et al. 2007; Hobbs et al. 2007; Walker et al. 2007; Cramer et al. 2008). The relay floristics (RF) model describes successive appearances of groups of species in which one group creates conditions favorable for the next colonizing group (Cowles 1911; Clements 1916; Connell & Slatyer 1977). The initial floristic composition (IFC) model predicts that some of the species present early on will persist and thus the composition of the mature community will reflect early establishment (Gleason 1926; Egler 1954). Understanding which of these models most closely applies to particular ecosystems can help to guide restoration. For example, if the RF model applies, planting early successional species at the outset of restoration to create appropriate conditions for later successional species may be advisable, whereas introducing all desired species at the outset of restoration makes the most sense if the system follows an IFC model.

Many forest restoration projects take a "passive relay" floristics approach (Clewell 1999; McLachlan & Bazely 2003; de Souza & Batista 2004) in which restorationists plant several species, commonly trees and shrubs that are well adapted to disturbed, early successional conditions, in the first year of restoration assuming they will facilitate (sensu Connell & Slatyer 1977) the establishment of other woody and understory species, as well as a host of fauna, over time. This passive RF approach has been called the "Field of Dreams" (i.e., if you build it, they will come: Palmer et al. 1997; Hilderbrand et al. 2005), but the long-term efficacy of this approach has rarely been tested. If propagule limitation is a concern, which is common in restoration, then taking an "active" RF approach, in which species are introduced over time as conditions become appropriate, would be advisable (Parrotta & Knowles 1999; Cabin et al. 2002; Bonilla-Moheno & Holl, in press). Because of logistical and cost constraints, however, this approach is rarely used.

Few restoration projects use the IFC approach of introducing a large number of species at the outset and not intervening later, probably due to the costs and propagation knowledge required. One of the few IFC examples, efforts to restore Jarrah

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