Forest Ecology and Management 258 (2009) 1350–1358

Contents lists available at ScienceDirect

Forest Ecology and Management

journal homepage: www.elsevier.com/locate/foreco

Controls on early post-fire woody plant colonization in riparian areas

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ARTICLE INFO

Article history:
Received 7 April 2009
Received in revised form 22 June 2009
Accepted 25 June 2009

Keywords:
Riparian areas
Fire
Pacific Northwest
Early succession
Vegetation dynamics

ABSTRACT

Fire in riparian areas has the potential to influence the functions riparian vegetation provides to streams and aquatic biota. However, there is little information on the effects of fire on riparian areas. The objectives of the present study were to: (*i*) determine how fire severity interacts with riparian topographic setting, micro-environmental conditions, and pre-fire community composition to control post-fire regeneration; (*ii*) determine how riparian regeneration patterns and controls change during early succession; and (iii) determine how critical riparian functions are influenced by and recover after fire. Study locations included the Biscuit Fire in southwestern Oregon and the B&B Complex Fire in the Cascade Mountain Range of west-central Oregon, USA. We measured post-fire woody species regeneration, and measured factors such as fire severity, pre-fire species composition, and stream size as potential factors associated with post-fire regeneration patterns. At a relatively coarse spatial scale, patterns in post-fire colonization were influenced by elevation. At finer spatial scales, both conifer- and hardwood-dominated riparian plant communities were self-replacing, suggesting that each community type tends to occur in specific ecological settings. Abundant post-fire regeneration in riparian areas and the self-replacement of hardwood- and conifer-dominated communities indicate high resilience of these disturbance-adapted plant communities.

1. Introduction

Riparian areas are among the most diverse, complex, and dynamic terrestrial habitats (Gregory et al., 1991; Naiman et al., 1993; Naiman and Decamps, 1997). Riparian areas provide key habitat to a diverse array of species and serve as a refuge for wildlife by providing a water source, forage, and escape from predators (Naiman and Decamps, 1997). Riparian areas also provide multiple ecological functions to stream systems. Root systems of riparian plants help to maintain soil structure and bank stability (Swanson et al., 1982; Minore and Weatherly, 1994; Johnson, 2004), and prevent erosion into streams (Naiman and Decamps, 1997). Shade provided by riparian tree canopies reduces stream temperatures, improving habitat for cold-water species such as salmonids (Swanson et al., 1982; Gregory et al., 1991; Minore and Weatherly, 1994; Johnson, 2004). Organic matter from riparian vegetation provides food resources for aquatic organisms (Swanson et al., 1982; Gregory et al., 1991; Naiman and Decamps, 1997). Riparian areas also act as a source of large woody debris for in-stream structure and habitat (Swanson et al., 1982; DeBano and Neary, 1996).

Many riparian areas are subject to frequent disturbance, including flood, avalanche, wind, fire, drought, plant disease, insect outbreaks and herbivory. Fire is a dominant disturbance process in many types of ecosystems, and although the effects of fire in upland systems are relatively well-studied, few studies have investigated riparian vegetation response to fire. Fire in riparian areas has the potential to influence the functions riparian vegetation provides to streams by changing plant community abundance, structure, and composition, and the regeneration of post-fire riparian vegetation likely dictates the magnitude and duration of fire effects on stream systems (Minshall, 2003). Determining management goals and associated management practices for these critical areas of the landscape requires an understanding of how disturbance processes affect them.

Riparian vegetation has potential for great resilience after fire due to a suite of adaptations that allow for rapid recovery (Dwire and Kauffman, 2003; Reeves et al., 2006; Richardson et al., 2007). For example, sprouting facilitates the survival of plants on site, while propagule dispersal by wind and water contribute to recolonization in post-disturbance environments (Dwire and Kauffman, 2003). Riparian areas are characterized by high soil moisture and high water tables, which can lead to faster vegetation recovery compared to uplands (Reeves et al., 2006). The network structure of riparian areas may also increase resilience to disturbance (Swanson et al., 1998). The linkages between the

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doi:10.1016/j.foreco.2009.06.038

floodplain and channel (lateral linkages), upstream and downstream and upstream river sections (longitudinal linkages), and river bed and channel (vertical linkages) have been identified as critical elements that lend resilience to riverine systems (Sedell et al., 1990; Richardson et al., 2007). These linkages allow surviving species in areas with low disturbance severity (refugia) to recolonize areas with high disturbance severity (Sedell et al., 1990; Swanson et al., 1998).

Plant community successional processes and species composition are controlled by a long-recognized array of ecological factors, including environmental conditions, available resources, soil characteristics, and disturbance (Gleason, 1926; Pickett et al., 1987; Wimberly and Spies, 2001). Factors at both fine and coarse scales have been shown to control plant community composition in riparian areas (Baker, 1989; Bendix, 1994; Turner et al., 2004). However, the ecological role of fire in riparian plant community succession and species composition is uncertain, as is the relative role of fire versus other ecological controls on plant community composition.

The present study examined post-fire woody plant regeneration processes through observations of riparian plant communities 2 and 4 years post-fire. Specific objectives were to: (i) determine how fire severity interacts with topographic setting, microenvironmental conditions, and pre-fire community composition to control post-fire regeneration; (ii) determine how riparian regeneration patterns and controls change during early succession (from 2 to 4 years post-fire); and (iii) determine how critical riparian functions like shade and bank stability are influenced by and recover after fire.

In addition to expected patterns in species composition with elevation and plant association, we hypothesized that: (i) post-fire riparian deciduous hardwood regeneration is most abundant in areas where local topography is conducive to deciduous hardwood growth (along larger streams, in wider valleys, and in areas with more gentle stream gradient and slope) and with greater pre-fire deciduous hardwood composition; (ii) post-fire riparian conifer regeneration is most abundant where local topography is conducive to conifer growth (along smaller streams, in narrow valleys, and in areas with steeper slopes and stream gradients) and where there is greater live conifer abundance before and/or after the fire; and (iii) post-fire riparian regeneration is influenced by fire severity, and the importance of seed bank and dispersed seed strategies increases with fire severity, while sprouters are more abundant in areas with lower fire severity. We expected these patterns to become more apparent as early succession progressed from 2 to 4 years post-fire. In addition, because of adaptations that allow for rapid vegetation recovery in riparian areas, we expected effects of fire on riparian functions to be short-lived and less apparent with increasing time since fire.

The study was initiated after two recent fires in Oregon, USA, the Biscuit Fire in the Klamath–Siskiyou ecoregion of southwestern Oregon and the B&B Complex Fire in the Cascade Mountains of west-central Oregon. In both regions, fire is an important, recurring disturbance agent (Agee, 1993). Thus, this study gives an indication of the present-day effects of fire in riparian areas of fire-prone forests.

2. Methods

2.1. Study area

2.1.1. Biscuit Fire

The 2002 Biscuit Fire occurred in the Siskiyou Mountains of southwestern Oregon. The fire covered an area of approximately 200 000 ha, with nearly equal areas of low severity (up to 25% canopy mortality), moderate severity (25–75% canopy mortality), and high severity (>75% canopy mortality) (assessment from satellite imagery; USDA Forest Service, 2004).

Climate in the study area is characterized by cool, wet winters and warm, dry summers. Mean annual precipitation in the study area ranges from 250 to 300 cm (PRISM Group, 2004), with higher precipitation levels on the western (coastal) side of the study area. Most precipitation falls between November and April. Mean temperature in January ranges from 2 to 5 °C, and mean temperature in July ranges from 18 to 20 °C.

Terrain in the Biscuit Fire region is highly dissected with steep slopes. Elevation of study sites ranged from 200 to 1200 m. Parent material in the study area is primarily schist-phyllite, metamorphic/volcanic, metasedimentary/conglomerate, and metasandstone/siltstone. Major soil subgroups include Typic Dystrochrepts and Typic Hapludults. Ultramafic soils are common in the study region but were not sampled.

Prior to the Biscuit Fire, riparian forest overstories were dominated by conifers such as Port-Orford-cedar (*Chamaecyparis lawsoniana* (A. Murr.) Parl.), Douglas-fir (*Pseudotsuga menziesii* (Mirbel) Franco), western hemlock (*Tsuga heterophylla* (Raf.) Sarg.), and western redcedar (*Thuja plicata* Donn ex D. Don). Red alder (*Alnus rubra* Bong.) was also a major component of the overstories, while vine maple (*Acer circinatum* Pursh), red alder, tanoak (*Lithocarpus densiflorus* (Hook. & Arn.) Rehd.), and willow (*Salix* spp. L.) dominated the midstories.

2.1.2. B&B Complex Fire

The 2003 Bear Butte and Booth (B&B) Complex Fire occurred on the east slope of the Cascade Range in west-central Oregon. The fire burned over approximately 37 000 ha, with 38% unburned or low severity, 18% moderate severity, and 44% high severity (assessment from satellite imagery; USDA Forest Service, 2005).

Climate in the B&B Complex Fire area is moderate with cool, wet winters and warm, dry summers. Annual precipitation in the fire area ranges from 50 cm at the lower elevations to 140 cm at the upper elevations (USDA Forest Service, 2005). Most of the precipitation falls from November to March. Precipitation above 1000 m falls mainly as snow in the winter.

The B&B Complex fire area is characterized by gentle to moderately steep topography. Slope aspects within the fire area are generally easterly with north- and south-facing valley slopes. Elevation of sample areas ranged from 800 to 1500 m. The east slope of the Cascades where the B&B Complex Fire burned is a geologically young and complex volcanic region.

Prior to the B&B Complex Fire, riparian forest overstories were dominated by ponderosa pine (*Pinus ponderosa* P. & C. Lawson), Engelmann spruce (*Picea engelmannii* Parry ex Engelm.), grand fir and white fir hybrid (*Abies grandis* (Douglas ex D. Don) Lindl. × *Abies concolor* (Gord. & Glend.) Lindl. ex Hildebr.), and Douglas-fir. Understories were dominated by deciduous shrubs, such as thinleaf alder (*Alnus incana* (L.) Moench), Pacific ninebark (*Physocarpus capitatus* (Pursh) Kuntze), white spiraea (*Spiraea betulifolia* Pallas), boxwood (*Pachistima myrsinites* (Pursh) Raf.), and thimbleberry (*Rubus parviflorus* Nutt.).

In both fire areas, activities such as logging, mining, fire suppression, and cattle grazing likely took place in some study plots. Although we were not able to account for all past land management activities in our study plots, there was no detectable evidence of recent (<15 years ago) prior fire or logging.

2.2. Site selection

A stratified random sampling design was used to select points in each fire area that represented a range of plant associations/productivity, broad fire severity classes (low, moderate and high), pre-fire tree size classes (small, medium, and large), and stream