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Vegetation responses to natural and salvage logged fire edges in Douglas-fir/hardwood forests

Jacob J. Hanson *, John D. Stuart

Department of Forestry and Watershed Management, Humboldt State University, 1 Harpst Street, Arcata, California 95521, USA

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Abstract

Natural edges created by fire are a common component of forest ecosystems with moderate-severity fire regimes and will continue to be important as the frequency of extreme fire events increases due to historical fire suppression throughout North America. The effect of high-severity fires, with and without salvage logging, on adjacent intact forest patches has not been studied. Fourteen years after a wildfire, we examined the structure and composition of vegetation along the gradient from burned stands into the adjacent forest interior at three salvage logged edges and three unsalvaged edges in Douglas-fir/hardwood forests of northwestern California. Natural, unsalvaged edges were characterized by an increase of native, ruderal species, rather than a reduction of forest interior species. Only two forest interior species reacted negatively to the edge environment, both at salvaged edges. Old-growth community types, identified by two-way indicator species analysis (TWINSPAN), occurred 30 m closer to the edge at unsalvaged sites, compared to salvaged sites. Twenty commonly observed species (>10% frequency) demonstrated significant responses to the edge environment; 11 species had a larger depth of edge influence (DEI) at salvaged edges, three had a larger DEI at unsalvaged edges, and six had an equal DEI. Our results suggest that, compared to unsalvaged stands, the removal of snags and subsequent broadcast burning of salvaged logged stands significantly altered plant composition and structure of the edge environment. By increasing the patch contrast between burned and intact forest stands, salvage logging increased the depth of edge influence of fire-created edges by 15–30 m.

Keywords: Edge effects; Edge; Fire; Salvage logging; Understory; Old-growth; Douglas-fir

1. Introduction

In the Pacific Northwest, most research on forest edges has focused on those created by timber harvest (Chen et al., 1992, 1995; Russell et al., 2000; Nelson and Halpern, 2005), but in disturbance prone forests of the interior west, forest edges were historically created by fire (Wallin et al., 1996; Agee, 1999). Timber harvest forest edges have more variation in temperature and humidity, receive more solar radiation, and experience stronger winds than interior forests (Chen et al., 1995). These 'edge effects', in turn, affect vegetation composition and abundance along the

* Corresponding author. Present address: Department of Forest Ecology and Management, University of Wisconsin–Madison, 1630 Linden Drive, Madison, Wisconsin 53706, USA. Tel.: +1 608 262 9975; fax: +1 608 262 9922.

E-mail address: jacobhanson@wisc.edu (J.J. Hanson).

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intact forest boundary. However, in the only previous study that examined naturally created fire edges, forest structure and species composition differed considerably from harvest edges in black spruce forests of Quebec (Harper et al., 2004). Compared to harvested edges, increased snag densities from fire may moderate wind speeds and decrease solar radiation levels reaching the forest interior. These differences between anthropogenically created edges and naturally created fire edges may affect habitat and species diversity; yet natural fire edges have received little attention.

The amount of forest edge depends on the nature of the disturbance. Forests with moderate-severity fire regimes have more edge and patchiness than either low- or high-severity regimes (Agee, 1998). Moderate fire regimes have a complex mix of low-severity surface fires, patches where some overstory is removed, and patches where all overstory is removed by high-severity fires (Agee, 1993). The result is a complex landscape, consisting of multi-cohort forest stands and various even-aged stands, with a considerable amount of edge (Agee, 1999). However, throughout North America, historical fire exclusion practices have significantly modified the structure and composition of many forest types and made them more prone to extreme fire events (Agee, 1998; Hessburg et al., 2000; Johnson et al., 2001).

Many forest patches burned by these increasingly common high-severity fires are salvage logged as quickly as possible to recoup their economic value. Land managers also view salvage logging as post-fire rehabilitation. In this context, the removal of dead trees reduces fuel loads and the intensity of future fires, and slows the buildup of insect pest populations (Amman and Ryan, 1991). However, there is increasing interest in the ecological impact of salvage logging in post-fire forests (Nappi et al., 2004). Salvage logging removes snags and downed woody structure that: (1) serve as habitat and food for insects and wildlife (Stone, 1993; Morissette et al., 2002); (2) slow soil erosion (Helvey, 1986); and (3) return nutrients to the soil (Beschta et al., 1995). Salvage logging also changes vegetation composition and abundance. In northwestern California, Stuart et al. (1993) found lower shrub cover and higher forb cover 11 years after salvage logging, compared to unsalvaged forests. There is no information on how salvage logging may affect adjacent, intact forests.

In Douglas-fir/hardwood forests of northwestern California, fire is the most common disturbance (Sawyer, 1980; Atzet and Martin, 1992). Frequent fire return intervals and large fire sizes suggest a low- to moderate-severity fire regime (Agee, 1991; Wills and Stuart, 1994; Skinner, 1995), where forest edge was historically common. From August to November 1987, a complex of lightning-ignited wildfires spread throughout the Klamath National Forest, burning unevenly over 97,000 ha. Many high-severity patches burned by the 1987 fires were salvage logged in 1988.

Fourteen years after the wildfire, we sampled vegetation along the gradient from burned stands into the adjacent forest interior at three salvage-logged edges and three unsalvaged edges. We attempted to answer two questions: (1) Is there a change in plant species composition and abundance along the transition from a burned stand into the forest interior? and (2) Does salvage logging alter the vegetation composition and structure of the edge environment compared to an intact, natural edge? Both salvaged and unsalvaged forest patches had comparable fire severities, and thus the only difference between the two treatments was the removal of standing dead trees and subsequent broadcast burning in salvage logged stands.

2. Methods

2.1. Study area

We sampled salvaged and unsalvaged fire edges, plus an old-growth control, on the Salmon River Ranger District of the Klamath National Forest, California. Study sites were within the McNeal, Methodist, and Knownothing Creek drainages, which flow northward into the South Fork of the Salmon River (approximately 41° 14′ N, 123° 19′ W; Fig. 1). Elevations range from 400 m along the South Fork of the Salmon River to 1700 m along the ridgetops, with deeply dissected terrain; slopes commonly exceed 60%. Soils are derived from metamorphosed sedimentary and volcanic parent material, consisting mainly of slate, greywacke, chert, schist, and hornblende (Irwin, 1960; Cashman, 1979).