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Wild ungulate herbivory suppresses deciduous woody plant establishment following salmonid stream restoration

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ABSTRACT

Domestic and wild ungulates can exert strong influences on riparian woody vegetation establishment, yet little is known about how wild ungulate herbivory affects riparian restoration in the absence of cattle. We evaluated elk (*Cervus elaphus*) and mule deer (*Odocoileus hemionus*) impacts on the establishment of deciduous woody riparian plantings along 11 km of Meadow Creek, a steelhead (*Oncorhynchus mykiss*) and Chinook (*Oncorhynchus tshawytscha*) salmon stream in northeastern Oregon, USA. We compared survival and growth between protected and unprotected plantings (from wild ungulates), and assessed the contribution of the plantings to the total deciduous woody cover after two growing seasons. Riparian use by wild ungulates was estimated by tracking a subset of the deer and elk populations using global positioning system telemetry collars. Elk riparian use was 11 times greater than deer, and in contrast to elk, deer were functionally absent from greater than 50% of the restored reach. Wild ungulate herbivory decreased planting survival by 30%, and growth by 73%, and was most detrimental to cottonwood (*Populus balsamifera*; increased likelihood of mortality by 5 times and suppressed growth by more than 90%). Herbivory impacts resulted in survival rates below regional criteria (50%) for restoration success after only two growing seasons. Naturally recovering shrubs accounted for 99% of the deciduous woody cover, and were mostly composed of the same species or genera as those planted. Our results suggest that wild ungulate herbivory can impede riparian restoration along salmonid streams by suppressing woody plant establishment and recovery.

1. Introduction

Stream and riparian habitats are among the most altered ecosystems in the western United States (Chaney, 1993; Belsky et al., 1999). Loss of native species and ecosystem function have made stream and riparian restoration a national priority (Roni et al., 2002; Bernhardt et al., 2005). According to Bernhardt et al. (2005), over $1 billion was spent each year (1990–2003) on riparian restoration in the United States. Such efforts are particularly intensive in the Pacific Northwest where recovery of endangered salmonid species directs most riparian restoration priorities (Roni et al., 2002; Bernhardt et al., 2005; Oregon Watershed Enhancement Board, 2011).

Establishment of in-stream woody debris and streamside woody vegetation are important restoration objectives in the Pacific Northwest. Widespread loss of these structural components has altered stream morphology and degraded stream habitats, resulting in channels that are often inhospitable to salmonids due to increased stream temperatures, decreased summer flows, and habitat loss (Armour et al., 1994; Reeves et al., 1995; McCullough, 1999; Obedzinski et al., 2001). Restoration of woody debris and vegetation is expected to benefit salmonids by: (1) increasing bank stability; (2) influencing stream channel development; (3) contributing organic matter (future large wood recruitment and detritus) to streams; (4) influencing trophic interactions at the aquatic-terrestrial interface; and (5) moderating the effects of future climate change to salmon through shading and increasing stream/floodplain connectivity (Kauffman and Krueger, 1984; Reeves et al., 1995; McCullough, 1999; Allan et al., 2003; Johnson, 2004). Despite huge monetary investments to implement restoration projects, effectiveness monitoring is rare (Bernhardt et al., 2005). Therefore, success rates of revegetation efforts are mostly unknown, and general factors that limit or facilitate woody species establishment are often unidentified.

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Cattle (*Bos taurus*), elk (*Cervus elaphus*), and mule deer (*Odocoileus hemionus*) are widespread throughout western North America, and can have profound impacts on woody plant establishment, structure, and growth (Sarr, 2002; Danell et al., 2006). High intensity browsing by livestock (Kauffman and Krueger, 1984; Belsky et al., 1999; Danell et al., 2006) and wild ungulates (Kay, 1994; Opperman and Merenlender, 2000; Schoenecker et al., 2004) can suppress woody vegetation in riparian habitats. Most restoration practitioners recognize livestock as a threat to woody riparian vegetation restoration, and livestock exclusion can result in woody riparian community recovery (Rickard and Cushing, 1982; Kaufman et al., 2002; Holland et al., 2005; Beschta et al., 2014). However, the impacts of wild ungulates on riparian restoration are often ignored and remain largely unstudied, despite examples where wild ungulates have altered riparian woody species structure and composition (Kay, 1994; Opperman and Merenlender, 2000; Peinetti et al., 2001).

Along Meadow Creek, a perennial stream in northeastern Oregon and the focus of this study (Fig. 1), 22 years of livestock exclusion along much of the stream corridor has not resulted in riparian woody vegetation recovery. Case and Kauffman (1997) reported an initial increase in deciduous woody species density and cover two years after cattle exclusion along Meadow Creek. However, two decades later, suppressed woody vegetation –particularly species preferred by elk and deer such as cottonwood and willow (See Figs. 2 and 3 in Averett et al., submitted for publication)- and low in-stream wood recruitment contributed to local land managers' decision to implement restoration including the installation of riparian plantings along Meadow Creek (USDA Forest Service, 2016). Prior restoration plantings failed to establish along Meadow Creek in the absence of livestock grazing. Bryant and Skovlin (1982) found that almost all of thousands of conifer seedlings and deciduous shrub cuttings planted in 1975 were dead by 1978. Low survival rates were observed both inside and outside of areas grazed by cattle, and were attributed to many different factors including high flow events, scouring by ice flows, wild ungulate browsing, small mammal damage, and unsuitable planting sites (Bryant and Skovlin, 1982). These findings suggest that cattle exclusion alone may not achieve desired restoration goals, and the factors limiting woody species establishment along Meadow Creek are not well understood.

A recent restoration project in Meadow Creek provided new opportunities to investigate factors influencing success of restoration plantings. This paper describes how herbivory by wild ungulates affected restoration designed as part of recovery efforts for threatened salmonids. Our objectives were to: (1) estimate wild ungulate use within the Meadow Creek study area including ~157 ha of riparian area and ~2059 ha of upland habitat along an ~11 km stream reach; (2) evaluate the effects of mule deer and elk herbivory on survival and growth of deciduous woody restoration plantings after two growing seasons; and (3) assess the contribution of plantings to the overall deciduous woody cover of the restored area after two growing seasons. Because cattle, elk, and mule deer co-occupy millions of hectares of western North America outside National Parks, and: (1) post restoration effectiveness monitoring; (2) manipulative experiments tied to restoration activities; and (3) exclusion of wild ungulates from riparian areas are rare, restoration practitioners will benefit from an increased understanding of how elk and mule deer impact stream recovery efforts in the absence of cattle.

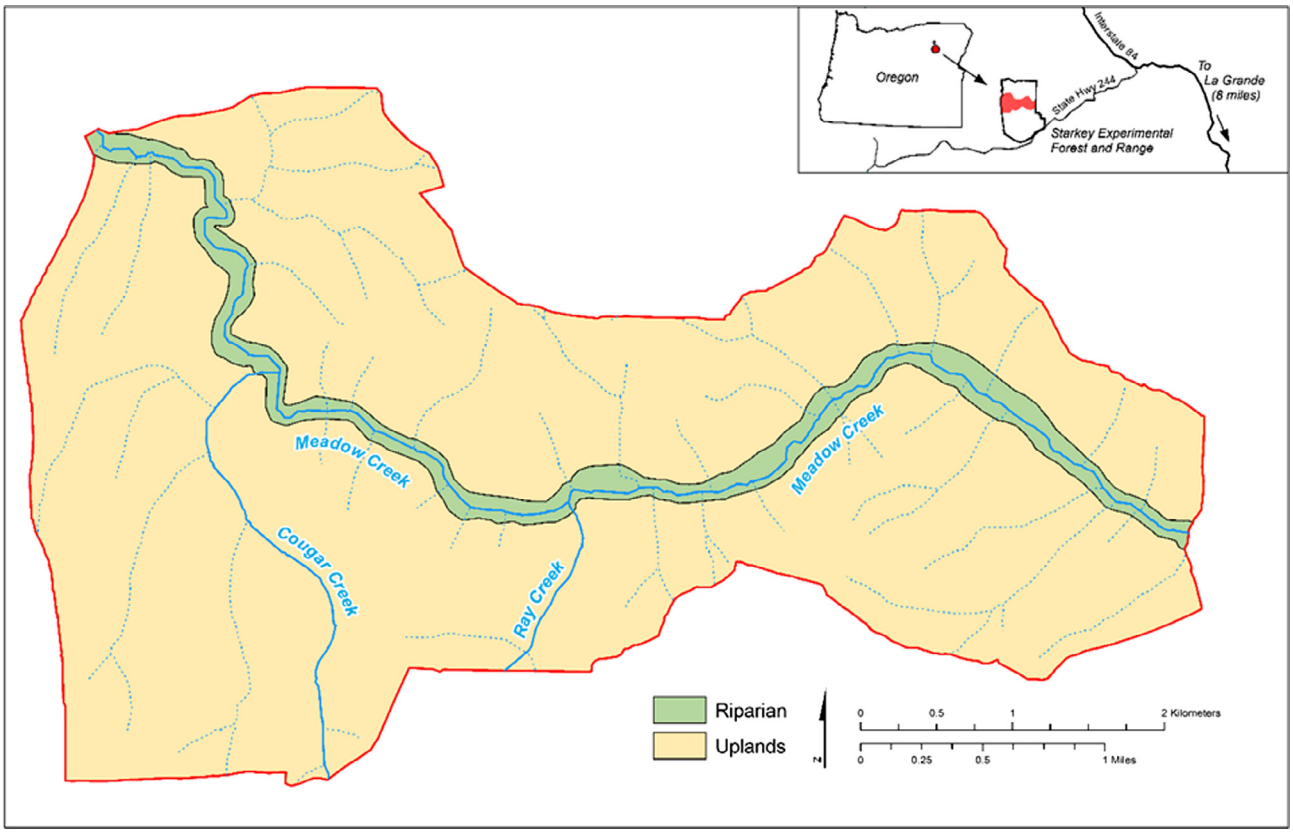

Fig. 1. The 2217-ha Meadow Creek Study Area within the Starkey Experimental Forest and Range (SEFR) in northeast Oregon, USA. The Study Area was defined by the hydrologic boundaries of Meadow Creek within the SEFR and included 157 ha of riparian area and 2059 ha of uplands.