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Prescribed Fire Effects on Population Dynamics of an Annual Grassland☆

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ABSTRACT

Medusahead (*Elymus caput-medusae* [L.] Nevski) is a highly damaging invasive annual grass in California rangelands. While it has been shown that prescribed fire can be a successful tool in controlling medusahead populations, fire treatments are not always successful. Given the sociological and economic constraints of prescribed fire use, it is critically important that we maximize likelihood of treatment success. We conducted experimental investigation of population dynamics of competing species from different functional groups: invasive annual medusahead, naturalized but forageable nonnative wild oat (*Avena* spp. Pott ex Link), and native perennial purple needlegrass (*Stipa pulchra* [Hitchc.] Barkworth). We observed population dynamics at the 1-m^2 scale before and after treatments of prescribed fire and seed-limitation (weed whipping in a 1-m buffer area). We asked 1) what is the role of seed dispersal from burn edges on subsequent medusahead population size? and 2) how do density and fecundity of the dominant species respond to fire? Results showed that 1) seed dispersal is an important factor in recovery dynamics and 2) wild oat fecundity significantly increases in the year after fire while medusahead and needlegrass fecundity seem minimally affected. Ultimately, managers should consider fire as a preferable first-entry tool and should thoroughly consider shape and size of planned burns, as well as what vegetation is present to play a role in post-treatment seed-dispersal dynamics.

Introduction

Medusahead (*Elymus caput-medusae* [L.] Nevski) is one of the most damaging invasive plants in North American rangelands. More than 400 000 hectares of the western United States have been invaded by medusahead, and its range is increasing at an average rate of 12% per year (Duncan et al., 2009). An annual grass, medusahead propagates efficiently and can quickly approach densities of 1 000 to 2 000 plants per square meter after initial establishment (Mangla et al., 2011). Mature plants are unpalatable to livestock; in invaded areas, grazing capacity can be reduced by 75 − 90% (M. Hironaka, 1961). Medusahead invasion has also been shown to significantly reduce species richness and diversity on the landscape (Davies and Svejcar, 2008), an effect believed to lead to an overall reduction of ecosystem services (Walker et al., 1999).

Although most past research has shown that prescribed fire can reduce medusahead populations, some results have shown much less success (DiTomaso et al., 2007; Kyser et al., 2008). Given the environmental, social, and economic constraints on using prescribed fire (Quinn-Davidson and Varner, 2011), it is important to maximize its effectiveness if fire is to be a successful management tool. Understanding the effects of prescribed fire on key aspects of medusahead population dynamics and relative species densities will guide public and private land managers about more effective ways to efficiently improve rangelands. Previous research on fire effects on medusahead indicated that burns should be timed when seed heads are ripe and doughy but not yet dispersed (DiTomaso et al., 2005; Sweet, 2005). Because medusahead has a later seasonal phenology than other grassland species, carefully timed prescribed fire can expose medusahead seeds to maximum heat, after other species' seeds have already dropped, escaping the heat of the fire and remaining viable on the soil surface. However, even with this timing, burns are not always successful (Kyser et al., 2008). A hitherto unexplored factor that may influence the effectiveness of prescribed burns is burn size and the influence of treatment edges. If burns are conducted with high populations of medusahead surrounding burn edges, medusahead could quickly reinvade from burn edges even when the burn successfully treated medusahead within the burn. Another aspect needing more research is how the density of medusahead within the treatment unit affects fire impact. Finally, the postfire fecundity responses of rangeland focal species are also unknown.

We evaluated the recovery dynamics of an annual rangeland treated with prescribed fire targeting reduction of medusahead. Specifically, we address the following questions: 1) What is the role of seed dispersal from burn edges on subsequent medusahead population size? and 2) How do density and fecundity of the dominant species respond to fire? We expect a burn-edge interaction in burn plots with low initial within-plot medusahead populations and undisturbed medusahead presence in plot edges. This information can be applicable at larger

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spatial scales to help guide decisions regarding how land managers approach medusahead management.

Methods

Study Area

The study was conducted at Sierra Foothills Research and Extension Center (SFREC), a University of California—owned property located 97 km northeast of Sacramento in Browns Valley, California (Fig. 1). The project site is an annual rangeland characterized by Mediterranean climate, with cool, wet winters and hot, dry summers. Weather data from the California Irrigation Management Information Systems station in Browns Valley shows that, since 1962, annual precipitation varies from 23–132 cm per year, with a mean of 71 cm, and air temperatures range from an average of 4°C minimum in winter and 32°C maximum in summer. Total precipitation during both years of the experiment was below average. Precipitation from September to May leading up to the experiment in 2013 totaled 52 cm, with most occurring in December 2012. Precipitation in the year following treatments totaled to 44 cm, with most occurring in February and March of 2014 (California Irrigation Management Information System). The soil is mapped as Sobrante-Timbuctoo Complex, primarily composed of a moderately deep and well-drained gravelly loam (Lytle, 1998). Cattle graze this pasture site every year but for the 2 yr preceding this study were excluded from the project area.

Experimental Design and Data Collection

We studied population dynamics and prescribed fire treatment effects on three rangeland species dominants, their associated communities, and their interactions. These species were purple needlegrass (*Stipa pulchra* [Hitchc.] Barkworth) as a native perennial, wild oat (both *Avena barbata* and *Avena fatua;* hereafter grouped as *Avena* spp.) as a nonnative forage grass, and medusahead as a nonnative invasive species targeted for removal. These species were chosen because they are prevalent, high-abundance species on annual grasslands with high-impacts on rangeland ecosystems (DiTomaso et al., 1999, 2005, 2007; Kyser and DiTomaso, 2002; Blondel, 2003; Bartolome et al., 2007; Kyser et al., 2008; Sweet et al., 2008). Our study was conducted at small spatial scales (1 m^2), focusing on the influence of edges, providing key insights that are scalable to the role of fire as a restoration tool in annual rangelands with similar species composition.

For project setup, 80 3 × 3 m experimental units were laid out in a grid and categorized into one of three categories by relative dominance of focal species: wild oat, needlegrass, or medusahead. Dominance was determined by ocular estimate of > 50% cover. Medusahead was present in every unit. Of these, 60 units were randomly selected for study—20

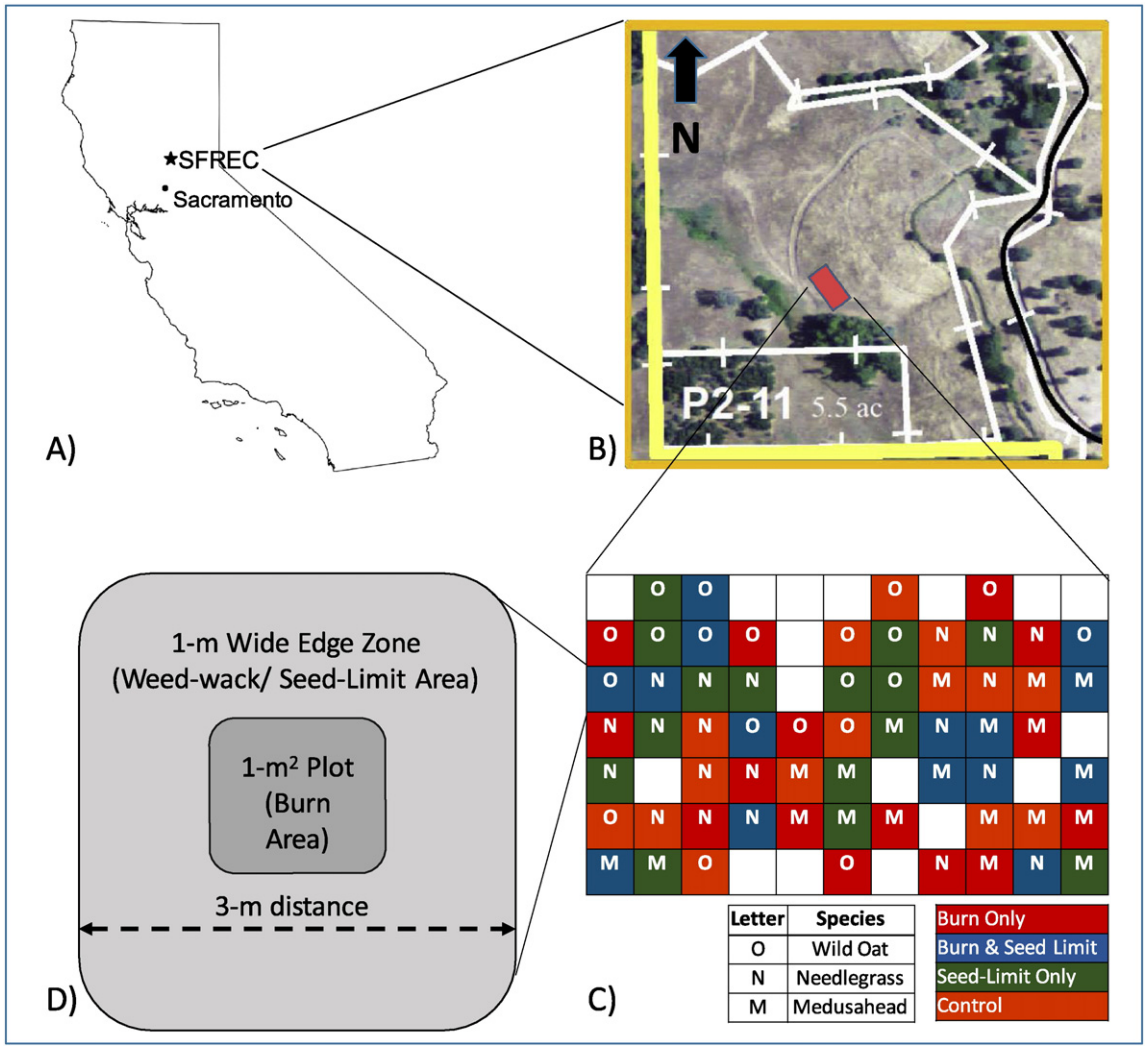

Figure 1. A, Location of study site at the Sierra Foothills Research and Extension Center (SFREC), Browns Valley, California. **B,** Expanded view of pasture at SFREC. Red block indicates study area. **C,** Layout of the experimental units—each color represents a different treatment, and each letter shows a different dominant species category pretreatment (O indicates wild oat; N, needlegrass; M, medusahead). **D,** Layout of experimental plot with 2 × 2 factorial design of treatments: burned or unburned and seed limited or not seed limited.

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