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Effects of livestock watering sites on alien and native plants in the Mojave Desert, USA

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Abstract

Increased livestock densities near artificial watering sites create disturbance gradients called piospheres. We studied responses of alien and native annual plants and native perennial plants within 9 piospheres in the Mojave Desert of North America. Absolute and proportional cover of alien annual plants increased with proximity to watering sites, whereas cover and species richness of native annual plants decreased. Not all alien species responded the same, as the alien forb *Erodium cicutarium* and the alien grass *Schismus* spp. increased with proximity to watering sites, and the alien annual grass *Bromus madritensis* ssp. *rubens* decreased. Perennial plant cover and species richness also declined with proximity to watering sites, as did the structural diversity of perennial plant cover classes. Significant effects were focused within 200 m of the watering sites, suggesting that control efforts for alien annual plants and restoration efforts for native plants should optimally be focused within this central part of the piosphere gradient.
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Keywords: *Bromus*; Disturbance; *Erodium*; Grazing; Invasive; *Schismus*

1. Introduction

Artificial watering sites can have significant ecological effects in arid and semi-arid desert ecosystems where standing surface water is uncommon. One major effect is the focused grazing and activity patterns of large herbivores around artificial watering sites

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(Andrew, 1988). This focused activity results in a disturbance gradient called a "piosphere" which is centered on the watering site (Lange, 1969). Piosphere gradients have been quantified in terms of large herbivore trail densities (Lange, 1969; Andrew and Lange, 1986a), activity levels (Thrash et al., 1995), and dung accumulations (Lange, 1969; Andrew and Lange, 1986a; Turner, 1998a). They can be created by both wild and domesticated animals and they occur worldwide.

The activity gradient of large herbivores within the piosphere can have many secondary effects. For example, the characteristics of soil nutrients (Tolsma et al., 1987; Perkins and Thomas, 1993; Turner, 1998a, b), soil compaction (Andrew and Lange, 1986a), microtopography (Nash et al., 2003), cryptogamic crusts (Rogers and Lange, 1971; Andrew and Lange, 1986a), and seedbanks (Navie et al., 1996) can vary with proximity to watering sites. Plant communities vary in biomass, cover, defoliation (Andrew and Lange, 1986b; Tolsma et al., 1987; Soltero et al., 1989; McClaran and Anable, 1992; Fusco et al., 1995; Fernandez-Gimenez and Allen-Diaz, 1999) species composition (Andrew and Lange, 1986b; Tolsma et al., 1987; Tueller and Platou, 1991; Perkins and Thomas, 1993; Nash et al., 1999; but see Van Rooyen et al., 1994 for exceptions), and reproductive output (Riginos and Hoffman, 2003). Generalized "ecosystem health" can also vary with grazing intensity near artificial watering sites (de Soyza et al., 1997). Although various environmental impacts associated with piospheres have been documented, much information that could help in the management of these impacts is still unknown. Information specific to the effects of piospheres created by domestic livestock is particularly important in the management of rangelands.

The potentially differing distributions of alien and native plants within piospheres are an important topic that deserves more study. Plant invasions into desert regions may be limited by low soil nutrient levels (Brooks, 1999a, 2003), and concentrated livestock use can increase availability of soil nutrients (Weir, 1971; Perkins and Thomas, 1993). Livestock also remove plant biomass (e.g. Webb and Stielstra, 1979), which may reduce the ability of native plants to compete with and impede plant invasions. Livestock also serve as dispersal vectors for plants, potentially facilitating the invasion of alien species (Sheeley et al., 2002). Although numerous studies indicate that the abundance of alien species can increase with proximity to artificial watering sites (Andrew and Lange, 1986b; Rogers and Whalley, 1989; Tueller and Platou, 1991; Fusco et al., 1995; Landsberg et al., 1997), some studies reported no relationship (Andrew and Lange, 1986b; McClaran and Anable, 1992). Other issues remain unstudied, such as the response of alien plant communities to grazing gradients within piospheres (e.g. alien richness and covariation among alien species), and the effects of landscape features on alien plant distributions within the piosphere (e.g. shrub–intershrub gradients). This information is needed to design effective early detection and control plans for alien plants near livestock watering sites.

The effect of piospheres on plant species richness is another topic that deserves more attention. In general, intermediate levels of livestock grazing are thought to maximize plant species richness (Sousa, 1984). This hypothesis applies in ecosystems with high productivity where high plant cover may otherwise preclude the coexistence of many species. However, it is unclear if high grazing levels promote plant species richness in ecosystems with low productivity such as deserts. Only two studies of plant species richness are associated with piospheres, and the authors report differing results. Landsberg et al. (1997) reported an absence of consistent trends in species richness within 8 piospheres in Australian rangelands, whereas Fernandez-Gimenez and Allen-Diaz (1999) report that