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RESEARCH ARTICLE

Non-Native Grass Removal and Shade Increase Soil Moisture and Seedling Performance during Hawaiian Dry Forest Restoration

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Abstract

Invasive non-native species can create especially problematic restoration barriers in subtropical and tropical dry forests. Native dry forests in Hawaii presently cover less than 10% of their original area. Many sites that historically supported dry forest are now completely dominated by non-native species, particularly grasses. Within a grass-dominated site in leeward Hawaii, we explored the mechanisms by which non-native *Pennisetum setaceum*, African fountain grass, limits seedlings of native species. We planted 1,800 seedlings of five native trees, three native shrubs, and two native vines into a factorial field experiment to examine the effects of grass removal (bulldozed vs. clipped plus herbicide vs. control), shade (60% shade vs. full sun), and water (supplemental vs. ambient) on seedling survival, growth, and physiology. Both grass removal and shade independently increased survival and growth, as well as soil moisture. Seedling survival and relative growth rate were also significantly dependent on soil moisture. These results suggest that altering soil moisture may be one of the primary mechanisms by which grasses limit native seedlings. Grass removal increased foliar nitrogen content of seedlings, which resulted in an increase in leaf-level photosynthesis and intrinsic water use efficiency. Thus in the absence of grasses, native species showed increased productivity and resource acquisition. We conclude that the combination of grass removal and shading may be an effective approach to the restoration of degraded tropical dry forests in Hawaii and other ecologically similar ecosystems.

Key words: bulldozing, invasive species, shade structures, supplemental watering, tropical dry forest, weeding.

Introduction

Invasive non-native species present a barrier to restoration within many ecosystems. These species can degrade communities both by direct interactions with natives (Walker & Vitousek 1991; MacDougall & Turkington 2005) and indirectly through effects on ecosystem processes (D'Antonio & Vitousek 1992; Gordon 1998). Non-native species may also contribute to feedback mechanisms that maintain degraded communities in persistent alternative states (Suding et al. 2004). As a result, restoration is often not a simple process of non-native species removal followed by native species recovery (Cabin et al. 2000) and may require both top-down (e.g. direct removal of the invaders) and bottom-up approaches (e.g. seeding and alteration of environmental characteristics to favor natives) (D'Antonio & Chambers 2006). Identifying the mechanisms by which non-native species limit natives and alter resource availability may thus increase the effectiveness of restoration strategies that incorporate both types of approaches.

Tropical dry forests (sensu Holdridge et al. 1971) make up 42% of all tropical forests worldwide (Van Bloem et al. 2004), and 97% of these forests are at risk from multiple threats (Miles et al. 2006). Non-native grasses are a major threat to dry forest conservation and restoration. In Hawaii, for example, non-native grass invasion has dramatically increased fire frequency, size, and intensity (Tunison et al. 2001). This has contributed to a greater than 90% reduction of native dry forest cover (Bruegmann 1996); consequently, the Hawaiian dry forest flora is among the most endangered in the world (Sakai et al. 2002). Even when Hawaii's remnant dry forests are protected from fire and grazing, non-native grasses generate an almost complete barrier to native plant regeneration by severely limiting resource availability to native plants (Hughes & Vitousek 1993; D'Antonio et al. 1998; Cabin et al. 2000; Cordell & Sandquist 2008). Effective restoration of this ecosystem thus requires knowledge of the mechanisms by which grasses limit native species regeneration and how these mechanisms might be overcome.

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