30 Ecological Response to Removal of Invasive Plants— Considering Research Design

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Abstract

Although resource managers commonly use physical, chemical, and biological methods to eliminate invasive, non-indigenous plants, seldom are community-level effects monitored after management is complete. Such monitoring is necessary to determine if the target species has been affected and to assess whether community associates respond positively or negatively to this novel disturbance. Before carrying out such a monitoring study, managers should decide whether results will be applied to other sites and the level of population response considered acceptable relative to management goals. These factors will guide the spatial distribution of study plots and the number of replicates. Controls are fundamental to any monitoring study because all biological systems change through time. Detecting community response to management and measuring system trends in the absence of management might best be approached with a long-term sampling protocol that begins well before and extends well after management.

Introduction

Plant invasions of most critical concern to resource managers are those that involve non-indigenous (NI) species, dramatically change the rate and direction of succession, alter in a fundamental way the physiognomy of vegetation, and cause a corresponding decrease in richness of indigenous (IN) species. Considerable management effort aimed at modifying plant invasion has concentrated on plant control measures and on the success of such measures in achieving population reductions of NI plants. However, relatively little research has been devoted to assessment of such management practice relative to long-term effects on community de-

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velopment. The study of management practice from the perspective of long-term community development, i.e., a successional perspective, is recommended in order to understand spatial and temporal variation of response, document correspondence between management activity and management goals, gradually improve management approaches, and more efficiently allocate management resources.

This paper will present a generalized sampling design that can be used to monitor long-term effects of plant removal. Most commonly, responses of plant populations are monitored; however, responses of animal populations and changes in abiotic environmental factors can also be measured. Although many resource managers maintain that plant invasion has a "negative" impact on natural areas and plant removal has a "positive" impact, few data exist to document these changes. Clearly, better monitoring approaches and more extensive monitoring efforts are needed to rationalize continued management of invasive plants.

Plant Removal as a Pulse Perturbation

When NI plants are important or dominant members of a community, removal of these plants can be considered a pulse perturbation. Specifically, this means that resource availability and species number are suddenly changed (Bender et al. 1984; White and Pickett 1985). Successional development following management will be influenced by (1) availability of propagules at the time of management, (2) propagule interaction with management, and (3) plant performance under conditions of changed resource availability (Luken 1997). Plant species that quickly colonize a site after management is complete may have long-term effects on the successional trajectory.

Propagule availability is commonly assessed as seeds in the seed bank or as presence of plant parts capable of regenerating whole plants. The makeup of the seed bank is influenced by local vegetation sources, distant vegetation sources, seeding efforts, seed germination, seed decay, seed predation, and physical destruction of seeds (Luken 1990). Furthermore, germination of these seeds is controlled by various dormancy mechanisms interacting with site conditions.

It is often assumed that once both NI plants and NI propagules are eliminated, IN species will reassert dominance due to relaxation of competitive pressures. However, IN plant species may show various population trends when a dominant invader is removed (Luken et al. 1997; McCarthy 1997). Long-term monitoring before and after management will allow such trends to be assessed relative to management goals.

BACI (Before-After-Control-Impact)

Detecting community response to a pulse perturbation such as plant removal can best be approached with a sampling scheme designed by Green (1979) and applied to plant invasions by Morrison (1997). The BACI (Before-After-Control-Impact) approach was originally developed to assess effects of unreplicated environmental impacts (Underwood 1994). For purposes of assessing long-term effects of plant removal, BACI would involve establishment of unmanaged plots (NI plants not removed) and managed plots (NI plants removed). Monitoring of both types of plots would occur several times before, and continue several times after, the management impact. Effects would be expressed as the difference in abundance of plants before and after the impact. Unmanaged plots, i.e., controls, are fundamental to this process to establish baseline trends under the pressure of plant invasion. Increased replication of both unmanaged and managed plots allows for increased precision, and better estimation of experimental error; it also increases the extent to which results can be generalized.

The BACI design offers the best approach for assessing long-term management impacts. However, it requires a long period of time for results, and data collection is labor-intensive. Still, these problems can be partially overcome by (1) using data collected from previous monitoring efforts, e.g., U.S. Forest Service plot data, and (2) examining previously managed sites to determine which species should be monitored. Visiting previously managed sites will also provide useful information on the proper scale of measurement.

Spatial Variation in Response

At best, a long-term BACI experiment should now be established in each of the major invaded plant communities of Florida. The will allow an assessment of variable response to management along natural environmental gradients and will also provide baseline data on system trends. Because system attributes will likely change in rapidly urbanizing areas, BACI experiments should be established along urban/rural gradients. Such long-term monitoring, coupled with data analysis and dissemination of results by a single organization, would be of great value as ongoing management efforts are assessed and future management efforts are refined.

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