ALIEN PLANT SPECIES IN PROTECTED AREAS AND THEIR MATRICES:

UNDERSTANDING INVASIONS AT MULTIPLE SCALES

by

Aníbal Pauchard

Licenciate in Forestry Sciences, Universidad de Concepción

Presented in the partial fulfillment of the requirements for the degree of

Doctor of Philosophy

The University of Montana

2002

Approved by:

_____

Committee Chair

_____

Dean, Graduate School

_____

Date

Abstract

Aníbal Pauchard Ph.D., 2002, Forestry

Alien Plant Species in Protected Areas and Their Matrices: Understanding Invasions at Multiple Scales

Committee Chair Dr. Paul B. Alaback

Alien plant invasions are an increasing threat to ecological processes and biological diversity. These human-caused invasions are affecting both human-disturbed landscapes and also natural reserves or protected areas even in remote areas with harsh climates. To understand invasions in the complex landscapes of protected areas, it is necessary to consider the surrounding landscape matrix. In chapter 1, I review evidence about the importance of assessing invasions at multiple scales. While most evidence about invasion is collected at the local scale, mechanisms that control invasions operate over a broad range of scales. Integrating observations from several scales may help to capture the complexity of these invasions. I studied the influence of elevation, landuse and landscape context in the distribution of alien species in Villarrica National Park, South Central Chile (chapter 2). I found that elevation is negatively associated with alien species richness and abundance. This response may be explained by changes in landuse, propagule pressure and microclimatic differences. I also studied the effects of edge type in determining edge effects on alien and native plant diversity in *Pinus contorta* forests around West Yellowstone, Montana, in the interface between Gallatin National Forest and Yellowstone National Park (chapter 3). Highways appeared as the only edge types with consistent presence of alien species. I conclude that propagule pressure is as important as edge effects in determining alien species distribution. In the same area, I studied the invasion of *Linaria vulgaris* using a multi-scale method (chapters 4 and 5). I determined that this perennial herb is colonizing both human and naturally disturbed areas, increasing its abundance at the local scale and extending its distribution at the landscape scale. However, significant annual variation associated with climatic fluctuations can be observed in *L. vulgaris* populations and the invaded plant community (chapter 5). This dissertation illustrates the importance of considering landscape processes, such as cross-boundary dispersal, when studying and managing plant invasions in protected areas. It also emphasizes the advantages of using multi-scale methods to address invasion processes in the complex landscapes of protected areas.

To my wife Paula

for all her support, help, advice, hard work and friendship

that helped to make this possible

Acknowledgements

To Paul Alaback for his continuous academic and personal support through the long process that started before coming to the US and is ending with this document. Thanks to my committee, Don Bedunah, Carol Brewer, Len Broberg, Tom DeLuca and Eric Edlund for their help and continuos challenge. Especially to Eric, who had the patience to help me with spatial analyses and manuscripts editing.

This research has been funded by National Park Service Rocky Mountain CESU, with Kathy Tonessen as coordinator, and by Center for Invasive Plant Management, Bozeman.

My doctoral studies have been funded by the President of the Republic Scholarship, Chile and by the School of Forestry of the University of Montana.

For their help in fieldwork, I thank Paula Díaz, David Watts and Andrés Maturana.

Thanks to my family and friends for give me emotional support and four years off to come to study to Montana.

Each chapter mentions special thanks to key people that helped in their development.

Overview

I started my dissertation thinking about the influence of the surrounding landuse on ecological processes in natural reserves. Evidence had shown that while protected areas were increasing in size and total coverage, the rapid development of the surrounding matrices was threatening the ecological integrity of the protected ecosystems.

These types of questions have been addressed in the emerging discipline of landscape ecology, with much emphasis in capturing patterns of landscape fragmentation and connectivity. However, I felt that there was still little connection between the theoretical models at the landscape scale with the diverse and complex ecological processes that were occurring across a broad range of scales in real landscapes.

On the other hand, biological invasion was becoming a topic of concern and interest for ecologists and managers. But few studies had been conducted in protected areas and surrounding matrices, even less have tried to understand invasions as landscape processes. Therefore, it seemed apparent that a combination of both landscape ecology and biological invasions would be an appropriate approach to my dissertation. Having the possibility of conducting research in two completely different study sites (and hemispheres), I decided to study similar invasion processes in both Villarrica National Park, Chile and Yellowstone National Park, Montana.

Chapter 1 reviews concepts of scale and its interaction with biological invasions. I found it extremely interesting how scale determines the driving mechanisms in ecology. This principle also applies to alien plant invasions, and to understand its basis may help to develop better tools to capture and manage invasions. In this Chapter, I have chosen to review elements of dispersal, disturbance, invasibility and ecological impacts that vary with scale.

Chapter 2 shows the results of my research in cross-boundary invasions in Villarrica National Park, Chile with emphasis in roadsides and road-forest edges. The results suggest that both elevation and landuse are major drivers of the presence of alien species along roadsides.

Also, it highlights the importance of roads as corridors of alien species into core areas of natural reserves. Even though, edges are recognized as facilitators of the percolation of alien species into interior habitats, in this study area, I found that most species tend to stay in the open environments along roadsides.

Chapter 3 presents the results of my study in edge effects and the interaction with edge type in determining alien and native plant species patterns. I compared highway, clearcut and burned areas forest edges in *Pinus contorta* forests of West Yellowstone, Montana. Most alien species occur in highway matrices and edges and only a few get to the interior. Burns and clearcut show a few exotic species that are not invasive. This suggest that propagule availability, and thereby landscape context is as important as physical changes in determining edge effects on alien plants.

Chapter 4 is dedicated to understanding the advantages of using a multi-scale method to assess plant invasions. I show the results for a perennial herb (*Linaria vulgaris*) that is invading natural and human disturbed sites in Yellowstone National Park and adjacent Gallatin National Forest. I found that the species is highly invasive in disturbed areas and shows rapid filling of colonized area, with wide distribution over the landscape. In the light of these results I discuss the implications for invasive species assessment in protected areas. I conclude that a multi-scale method is more efficient and useful that a single-scale method in capturing the patterns and mechanisms of invasions, especially in the complex protected area landscapes.

Chapter 5 illustrates the potential value of monitoring invasive species over longer time intervals. Based on the methods of Chapter 4, I monitored the population and stand dynamics during three growing seasons. I found significant annual variation in both *Linaria vulgaris* attributes and overall plant community attributes that was related to climatic variation. This study suggests that monitoring is needed to really understand the long-term implications of the process of invasion. As with multiple scales, monitoring also should be run at multiple temporal scales.

Chapter 6 summarizes my dissertation results, highlighting the major generalities that emerge from this work. Even though, West Yellowstone and Villarrica study areas represent complete different ecological and cultural systems, a few major trends in invasion processes can be observed in both cases. First, alien species are more abundant in the matrices of protected areas than in their interiors. Second, roads act as major corridors for the introduction of alien species into more pristine areas. Third, propagule dispersal appears as a constraint to invasion. These results emphasizes the importance of considering the landscape context of protected areas (their matrices) when studying and managing invasive species.

Table of Contents

.

List of Tables

List of Figures

CHAPTER 5