Geographical analysis of the distribution and spread of invasive plants in the Gardiner Basin, Montana
by Emily Nicole Rens

A thesis submitted in partial fulfillment of the requirements for the degree of Masters of Science in Fish and Wildlife Mangement
Montana State University

Abstract:
There is concern over weed invasion of native plant communities in the Gardiner Basin, Montana. The Gardiner Basin makes up the northwest portion of the Northern Yellowstone Winter Range (NYWR) and is a crucial destination for wintering ungulates such as elk (Cervus elaphus), mule deer (Odocoileus hemionus) and bighorn sheep (Ovis canadensis). Invasive plant species that replace native forage in this area are a threat to these wintering ungulates. I had 4 objectives in this study 1) to use GIS and logisitic regression analyses to determine important spread vectors of 4 weed species, cheatgrass (Bromus tectorum), hound's-tongue (Cynoglossum officianale), spotted knapweed (Centaurea maculosa), and Dalmatian toadflax (Linea dalmatica)', 2) to create spread probability maps for each weed species based on important spread vectors; 3) to determine the area of ungulate winter range currently invaded by weeds and the area at risk to future invasions; and 4) to determine if there was a relationship between current weed distribution and prescribed sagebrush burning. Important cheatgrass spread vectors and habitat variables in the Gardiner Basin were distances to rivers, streams, and mining, and cover type. Distances to grazing allotments, streams, and highways, and cover type were included in the most parsimonious model for hound's-tongue distribution. Spotted knapweed was best modeled by distances to streams and rivers, and cover type. The variables used in the top Dalmatian toadflax model were cover type, and distances to mining activity and rivers. Although current distribution, of weeds on ungulate winter ranges are limited, the area of ungulate winter range predicted to be at risk to future invasions varied extensively among ungulate species, weed species, and spread models. Areas that had been burned in prescribed fire programs currently had very few weeds. However, a test of error ranges indicated that there was significantly more cheatgrass on burned areas than on unburned areas. Dalmatian toadflax, which had the highest total percent of cover in the Gardiner Basin, was found more on burned than unburned areas. Spotted knapweed was found more on unburned than burned land, and there was no difference between hound's-tongue distribution on burned and unburned areas.

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A thesis submitted in partial fulfillment
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of

Masters of Science

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Fish and Wildlife Mangement

MONTANA STATE UNIVERSITY
Bozeman, Montana

February 2003

APPROVAL

Of a thesis submitted by

Emily Nicole Rens

This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

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ACKNOWLEDGEMENTS

I would like to thank Reyer, for reminding me to do the first thing first, and for supporting me from start to finish. Thanks to my parents for moral and financial support! I thank Tris Hoffman for her enthusiastic help, and all her time invested; Dan Tyers for grant support, field workers, vehicles, equipment, and literature; and Rob St. John for mapping, crew training, and digitizing. Susan Boonman, Reyer Rens, Jeremy Zimmer, Sarah Coburn, Kat Callard, McCrea Cobb, Nathan Perkins, Steve Yonge, Matthew Tyers, Zach Gergely, and Maria Newcomb thanks for helping me map! Thanks Lynn Irby, Roger Sheley, Carl Wambolt, Kim Keating and Bob White, for being on my committee, and for statistical and modeling help. Thanks to Richard Aspinal, Rick Lawrence, and Elizabeth Roberts for statistical and thesis advice. A big thanks to Colleen Stein, always willing and ready to help with everything; Steve Swain for help learning and using GIS, and Marion Cherry for her enthusiasm, and financial support. Thanks to Tim O'Neil for computer use. This project would not be possible without the funding and support from the Foundation for North American Wild Sheep, the Rocky Mountain Elk Foundation, John and Kathryn Harris, Mary Maj and Larry Timchak with the Greater Yellowstone Coordinating Committee, and the Forest Service. Thanks again to Dan Tyers for all his effort in getting the funding from these groups.

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ABSTRACT

There is concern over weed invasion of native plant communities in the Gardiner Basin, Montana. The Gardiner Basin makes up the northwest portion of the Northern Yellowstone Winter Range (NYWR) and is a crucial destination for wintering ungulates such as elk (*Cervus elaphus*), mule deer (*Odocoileus hemionus*) and bighorn sheep (*Ovis canadensis*). Invasive plant species that replace native forage in this area are a threat to these wintering ungulates. I had 4 objectives in this study 1) to use GIS and logisitic regression analyses to determine important spread vectors of 4 weed species, cheatgrass (*Bromus tectorum*), hound's-tongue (*Cynoglossum officianale*), spotted knapweed (*Centaurea maculosa*), and Dalmatian toadflax (*Linea dalmatica*); 2) to create spread probability maps for each weed species based on important spread vectors; 3) to determine the area of ungulate winter range currently invaded by weeds and the area at risk to future invasions; and 4) to determine if there was a relationship between current weed distribution and prescribed sagebrush burning. Important cheatgrass spread vectors and habitat variables in the Gardiner Basin were distances to rivers, streams, and mining, and cover type. Distances to grazing allotments, streams, and highways, and cover type were included in the most parsimonious model for hound's-tongue distribution. Spotted knapweed was best modeled by distances to streams and rivers, and cover type. The variables used in the top Dalmatian toadflax model were cover type, and distances to mining activity and rivers. Although current distribution of weeds on ungulate winter ranges are limited, the area of ungulate winter range predicted to be at risk to future invasions varied extensively among ungulate species, weed species, and spread models. Areas that had been burned in prescribed fire programs currently had very few weeds. However, a test of error ranges indicated that there was significantly more cheatgrass on burned areas than on unburned areas. Dalmatian toadflax, which had the highest total percent of cover in the Gardiner Basin, was found more on burned than unburned areas. Spotted knapweed was found more on unburned than burned land, and there was no difference between hound's-tongue distribution on burned and unburned areas.

INTRODUCTION

Exotic plants threaten native wildlife in the west. This threat has not been fully appreciated nor evaluated. Invasive exotic plants can compete with and replace essential native plants from millions of hectares of wildlife habitat thereby impacting indigenous animal species ranging from insects to keystone carnivores (Trammel and Butler 1995, Belcher and Wilson 1989, Bedunah 1992, Sheley et al. 1999). Many animal species cannot adapt quickly enough to rapid weed invasions that replace essential native forage (Olson 1999). In the west, weeds have already reduced grazing capacity in some areas by 75% (Sheley et al. 1999, Bedunah 1992, U.S. Forest Service 1936). In western Canada and Montana, graminoid production declined 90% on some knapweed (*Centaurea spp.*) infested rangelands (Harris and Cranston 1979, Strang et al. 1979, Bucher 1984, Bedunah 1988).

The most economical and ecologically effective method for managing noxious weeds is to prevent their initial invasion (Sheley et al. 1999). By preventing invasions, land and wildlife managers can preserve native flora and fauna. Prevention plans require, in part, an understanding of the factors governing plant invasions.

Weeds are commonly introduced to new sites by wind, water-flow, and transportation routes, but wildlife may also serve as a mechanism to introduce weeds into new areas by transporting seeds internally (digestive tract) or externally (seeds caught in fur or feathers) (DeClerke-Floate 1997, Sheley et al. 1999, Wallander et al. 1995). However, the importance of wildlife as weed spread vectors is unknown in most ecosystems.

Disturbance is a significant factor in invasive plant spread (Bedunah 1992). Various disturbance types facilitate weed invasions and are even considered a necessity for some species (Forcella and Harvey 1983, Kurtz 1999). Disturbance creates available space for competitive non-native species. After disturbance, native plants often cannot recover as quickly as non-native plants because many noxious weeds are early successional species that colonize recently disturbed sites (Baker 1986). When exotic early successional species compete directly with native plants that are trying to re-establish, native plants are often eliminated. Wildlife and livestock may disturb plant communities by over-grazing, hoof action, trail creation, and excavation (Tyser and Worley 1992).

One approach to determining the importance of wildlife as a weed-spread vector is to compare weed distributions with the distribution of wildlife and other potential vectors including those associated with human activity (Forcella and Harvey 1983, Kurtz 1999). Kummerow (1991) and Benninger-Traux (1992) found that trails were often avenues of weed infestations. Cole (1989) and Benninger-Traux (1992) found that human camping areas had high incidences of weed infestations. The prevalence of weeds was also related to climatic variables in studies by Forcella and Harvey (1983), Baker (1986), Mack (1986) and Weaver and Woods (1986). Wildlife were found to be weed-spread vectors by Robocker (1970) and Tyser and Key (1988).

My study had 4 objectives; 1) to determine the importance of habitat variables and spread vectors in weed spread, 2) to model current and future potential weed distribution in the Gardiner Basin, 3) to estimate the area of wildlife winter range at risk

to weed invasion, and 4) to determine if there was a relationship between prescribed burns and current weed distribution.

By comparing Geographic Information System (GIS) data layers of factors, such as burned areas, trails, cattle allotments, mined areas, roads, and wildlife distributions, with weed distribution layers, I determined spatial and temporal patterns that indicated the importance of specific vectors in the spread of weeds. I also identified areas where land managers should focus weed prevention efforts.

I chose the Gardiner Basin as a study area because of the availability of GIS layers and its importance to wintering ungulates in the Yellowstone Ecosystem. Native plant communities in the Gardiner Basin are essential to ungulates including bighorn sheep (*Ovis canadensis*), Rocky Mountain elk (*Cervus elaphus*), mule deer (*Odocoileus hemionus*), and pronghorn antelope (*Antilocapra americana*) and are experiencing increased pressure from human development of the area. Exotic plant species are present in the Gardiner Basin and could exacerbate habitat loss associated with housing and commercial development. I focused on the 4 most common non-native plant species in the Gardiner Basin: cheatgrass (*Bromus tectorum*), hound's-tongue (*Cynoglossum officianale*), spotted knapweed (*Centaurea maculosa*), and Dalmatian toadflax (*Linea dalmatica*). These plants are identified as aggressive rangeland invaders and are locally abundant in the study area.

Weed Taxa History and Biology

Cheatgrass

Cheatgrass (downy brome) is a winter annual grass originally from southwestern Asia. It is thought to have come to the United States in the mid-1800s in contaminated soil in the ballasts of ships arriving from Eurasia (Mosley et al. 1999). Cheatgrass is widely distributed in the United States and is a major range weed (Young et al. 1987) that limits establishment of native perennials via competition for moisture. Cheatgrass seedlings develop an efficient root system that gives them a competitive advantage in the spring when temperatures are adequate for shoot growth. Roots from fall-germinating plants of cheatgrass can continue to grow in the winter while the aerial portion of the plant remains dormant (Young et al. 1987). Cheatgrass establishment has dramatically increased fire frequency in areas where wildfires were once rare or non-existent (Billings 1990). After burning, sagebrush/bunchgrass dominated grasslands become fire-prone annual grasslands with cheatgrass as the dominant species. Preferred native bunchgrass species are out competed and, therefore, unavailable to wildlife when cheatgrass is dominant. Native wildlife species generally eat little cheatgrass.

Hound's-tongue

Hound's-tongue is a deep taprooted perennial from Europe that spreads via its barbed, Velcro-like nuttlets or burrs. Each plant can produce 1-8 flower stalks, which in turn can produce several hundred burrs (DeClerke-Floate 1997). Hound's-tongue is toxic, containing pyrrolizidine alkaloids which cause liver cells to stop reproducing in wildlife and domestic animals (Knight et al. 1984, Baker et al. 1989). Although livestock avoid

eating hound's-tongue, their hair serves as an effective vector for spread; and, therefore, this weed is frequently found in areas used by cattle. It is often all that remains in pastures after more palatable and desirable species are grazed. The success of hound's-tongue is likely due to extensive disturbance caused by logging and other human-related activities in conjunction with the abundance of dispersal agents such as cattle and indigenous ungulate species (DeClerke-Floate 1997).

Spotted Knapweed

Spotted knapweed was introduced from Eurasia and is currently found in 14 western states and in Canada. It was introduced in the late 1880s as an alfalfa contaminant (Sheley et al. 1999). It has deep taproots, forms rosettes, and can produce seeds annually. Competing with native plants, it reduces livestock and wildlife forage, increases soil erosion, and reduces bio-diversity (Sheley et al. 1999). Spotted knapweed can invade a wide range of elevations (500-3,050 meters), annual precipitation zones (20-200 cm), and soil types. It can produce 5,000 - 40,000 seeds/m^2 annually and can be spread by wind, water, animals, hay, and vehicles.

Dalmatian Toadflax

Dalmatian toadflax, a short-lived perennial native to the Mediterranean region, has become well established in the Northwest United States and Canada. Its introduction to North America in 1874 was intentional. It was used to make fabric dye and as an ornamental in gardens. It has since escaped the confines of home gardens and has become a successful weed in rangelands and agricultural areas. Dalmatian toadflax can flourish in

diverse environmental conditions and has high genetic variability that allows it to undergo local adaptations. This makes control efforts and management plans difficult. Also it is highly competitive, producing up to 500,000 seeds each year (Robocker 1970), reproducing vegetatively through buds on the rootstock, and emerging earlier in the spring than most desirable species. Dalmatian toadflax is not considered a forage source for wildlife or livestock and can decrease available forage by replacing native species in many plant communities.

STUDY AREA

Location

The Gardiner Basin is located in the northwest portion of the Northern Yellowstone Winter Range (NYWR) in southwestern Montana (Fig. 1). Although land ownership in the Gardiner Basin is divided among the Forest Service, National Park Service (NPS), Montana Department of Fish, Wildlife, & Parks (MDFWP), and private ownership, only Forest Service land was mapped for weeds. The Gardiner Basin runs north/south encompassing 10 different drainages from the Gallatin Range to the west and the Absaroka-Beartooth Mountains on the east. The Yellowstone River flows north out of Yellowstone National Park and runs through the valley floor of the basin. Foothills rise steeply from the floodplains to rolling benchlands with 50-60 degree slopes (McNeal 1984). Most land on the river terrace is in private ownership.

History

Plant and animal communities in the Gardiner Basin have been relatively stable since the ice sheets retreated in the Pleistocene. Human activity in the area was limited to hunter-gatherer societies until the late 1800s when the northern Rocky Mountains were settled by Europeans, who introduced large herds of cattle (Olson 1999, Bedunah 1992). Species composition in climax plant communities has remained relatively unchanged

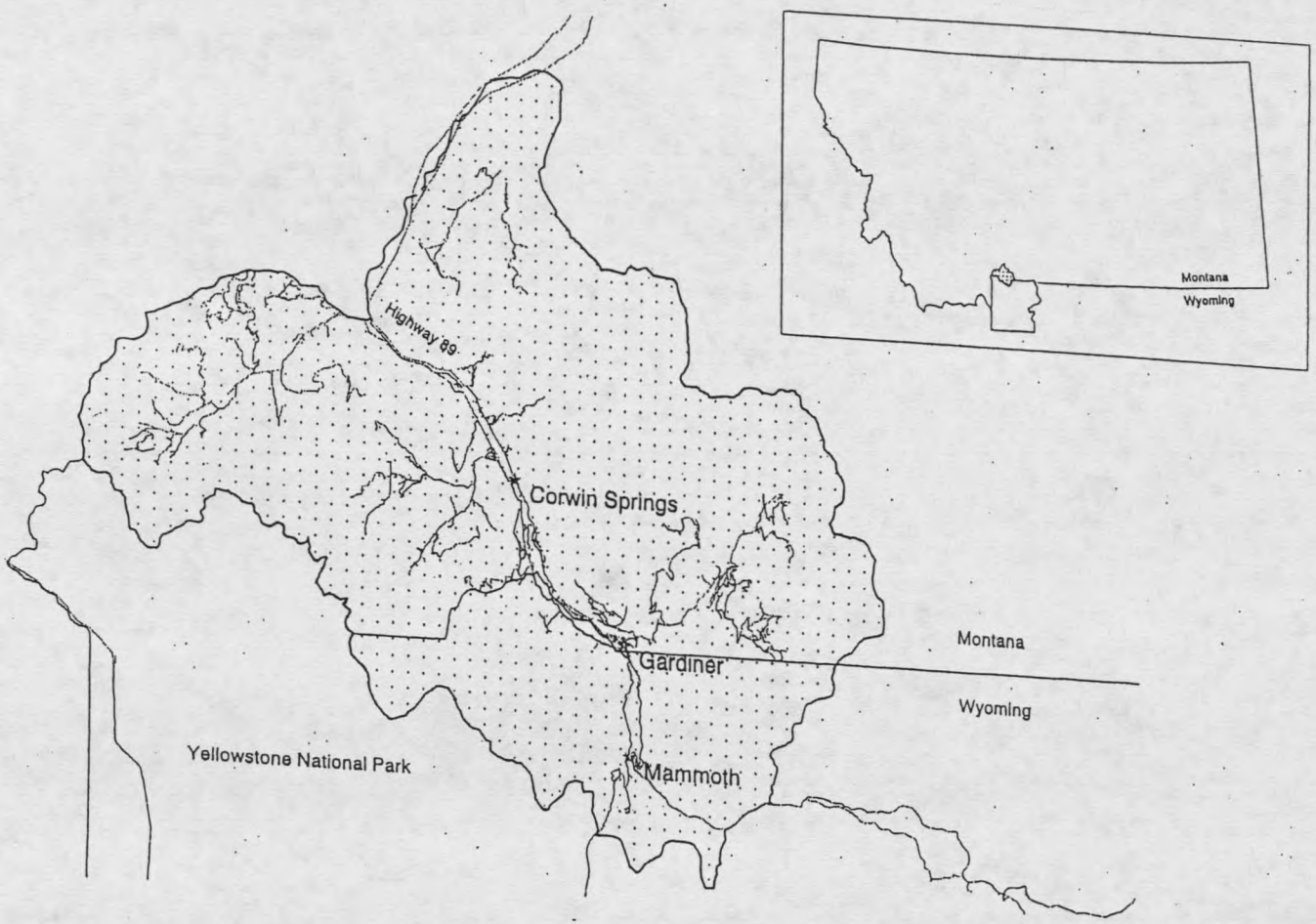

Figure 1. Gardiner Basin study area.

following European settlement. Natural disturbances such as fire, drought, and insect outbreaks undoubtedly have occurred throughout the Basin's history; however, native climax communities presumably are adapted to these disturbances. Introductions of non-indigenous plant species which have occurred over the past 100 years have the potential to produce major changes in species composition. At least 9 species of non-native weeds have been recorded in the Gardiner Basin. The 4 species I examined in this study are currently the most abundant of the nine.

Cheatgrass was seen in the Gardiner Basin area as early as the 1950s around the town of Gardiner and appears to be most abundant in areas where human activity is high (D. Tyers and P. Hoppe, US Forest Service, personal communication). Hound's-tongue was first recorded in Tom Miner Basin in the mid-1960s along private and Forest Service trails and was also found along drainages in Beatie Gulch (Fig. 2). Increases in hound's-tongue were noted in the 1980s (D. Tyers and P. Hoppe, US Forest Service, personal communication). Spotted knapweed was first found along Highway 89 in Yankee Jim Canyon in the late 1960s and on Deckard Flats in the 1970s. The first record of Dalmatian toadflax in the Basin was in the early 1970s along Eagle Creek, a popular recreation area.

Other non-native weed species, including leafy spurge (*Euphorbia esula*), oxeye-daisy (*Chrysanthemum leucanthemum*), diffuse knapweed (*Centaurea diffusa*), white-top (*Cardaria pubescens*) and mullein (*Verbascum thapsus*), are also found in the Gardiner Basin, but the abundance and distributions of these species are very limited at present.