The relationships between disturbances in stock camps and the occurrence of spotted knapweed (Centaurea maculosa) in the Selway-Bitterroot Wilderness in Montana and Idaho
by Gary Martin Milner

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Earth Sciences
Montana State University

Abstract:
The purpose of this study was to determine if disturbances and vegetation characteristics in stock camps influence the occurrence of spotted knapweed (Centaurea maculosa). Disturbance levels (light, moderate, heavy or extreme) were determined by using site impact worksheets provided by the United States Forest Service.

Disturbance variables on the site impact worksheets were also examined. These included, vegetation loss, mineral soil increase, tree damage, root exposure, development, cleanliness, social trails, and barren area of the camp. Vegetation characteristics examined were bare ground, moss, forbs, grass, litter, rock, trees and canopy cover. The percent cover for these variables were estimated using 2 X 2 meter quadrats located along twenty-four meter transects which radiated out from the center of the camps.

Six of the thirty camps sampled contained spotted knapweed. No association was found between spotted knapweed and the disturbance levels of the camps. No strong relationship was found between spotted knapweed and any of the measured vegetation variables. There were no significant differences in density levels of spotted knapweed in the horse or human areas of the camps. An association did exist, however, between spotted knapweed and the development variable on the site impact worksheet. All six camps containing spotted knapweed were open canopied, between 1524 and 1829 meters in elevation and were located in areas of high visitor use.

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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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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

The purpose of this study was to determine if disturbances and vegetation characteristics in stock camps influence the occurrence of spotted knapweed (Centaurea maculosa). Disturbance levels (light, moderate, heavy or extreme) were determined by using site impact worksheets provided by the United States Forest Service. Disturbance variables on the site impact worksheets were also examined. These included, vegetation loss, mineral soil increase, tree damage, root exposure, development, cleanliness, social trails, and barren area of the camp. Vegetation characteristics examined were bare ground, moss, forbs, grass, litter, rock, trees and canopy cover. The percent cover for these variables were estimated using 2 X 2 meter quadrats located along twenty-four meter transects which radiated out from the center of the camps.

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CHAPTER 1

INTRODUCTION

The Wilderness Act of 1964 designated a series of wilderness areas that would be "managed to preserve natural conditions." These areas provide an opportunity for native ecosystems to function relatively independent of human activity. The occurrence of exotic plant species can disrupt this function by altering natural processes and providing evidence of human impacts within these lands (Noxious Weed Management 1991). Centaurea maculosa, commonly named spotted knapweed, is an example of one such exotic plant species. This introduced species now occupies thousands of hectares in the Selway-Bitterroot Wilderness Area in Montana and Idaho (Kummerow 1992). Stockcamps may play a role in the introduction of spotted knapweed in wilderness areas. The purpose of this study was to determine if the disturbances in stock camps in a wilderness setting influence the abundance of spotted knapweed.

Weeds can be legally classified as noxious pests. The Montana Department of Agriculture defines a noxious weed as any introduced or established exotic plant species in the state which may render land unfit for agriculture, forestry, livestock, wildlife, or other beneficial uses or that may harm native plant communities (Montana Department of Agriculture 1991). Currently the state of Idaho has thirty-three weeds classified as noxious (Wheeler 1991). Montana

has fifteen such species (Montana Department of Agriculture 1991). In both states spotted knapweed is classified as noxious.

Plants have been designated noxious because of their effects on commodity oriented land uses such as farming and ranching. However, the definition is also appropriate for wilderness areas where these species have the potential to disrupt and alter natural and complete ecosystems (Noxious Weed Management Projects 1993). Given that primary functions of designated wilderness areas are to ensure the integrity of natural ecosystem processes and to preserve natural species diversity, a more complete understanding is needed of the roles that outdoor recreationists play in the spreading of noxious weeds.

Stockcamps are one component of recreational activity that may contribute to weed establishment through habitat disturbance and plant/seed dispersal. As stated by Bedunah, "disturbance is always a significant factor in the spread of exotic species" (Bedunah p. 8, 1992). Stockcamp disturbances include damaged trees, exposed roots, and soil exposure. Camps may also be centers for seed/plant dispersal, because alien species can be carried by pack and saddle stock as seed in feces, in supplemental feed or on the fur and hooves (Cole 1989). If established, plants may spread out from these centers to more remote parts of the wilderness (Noxious Weed Management 1991). By examining the roles that stockcamp disturbances have in noxious weed establishment, we may in the

future prevent or attenuate the spread of exotics in wilderness settings.

The primary goals of this research were to: (1) further our understanding of the relation between spotted knapweed and stockcamp disturbance characteristics; (2) furnish baseline data which can be used to determine ecological changes related to noxious weeds; (3) determine if differences exist between spotted knapweed levels in the horse and human areas of the camps; and (4) determine the relationship between spotted knapweed and recorded vegetation variables. The results of this research may help resource managers find ways, whether through regulation or education, to prevent the spread of non-native plant species and to manage wilderness areas so that natural conditions are maintained.

Background Literature Review

Noxious weeds such as spotted knapweed have received extensive study in the agricultural West. The research has largely focused on their negative effects on livestock and crop production (Bedunah 1992). Non-agricultural areas such as forested lands have received limited attention. The following sections will summarize the general history, biology and environmental factors associated with spotted knapweed.

History of Spotted Knapweed in the United States

Exotic weeds such as spotted knapweed were originally transported to North America from Europe and Eurasia during colonization and periods of early settlement (Noxious Weed Trust Fund 1992). For the past century successive waves of these weeds have moved across the Western landscape, each disrupting natural plant communities and in some cases the animals that depend on them. Millions of acres have been affected, particularly along roads and other disturbed sites (O'Loughlin1992).

Spotted knapweed is a native plant from the steppes of Europe (Eddleman and Romo 1988). This plant, along with other species of knapweed, was first introduced to North America near the beginning of the twentieth century as contaminants in Turkistan alfalfa seed (Groh 1940). Having no natural enemies to keep its populations in check on the North American continent (Chicoine 1984), spotted knapweed spread across much of the western United States.

The plant was documented in Gallatin County, Montana in 1927. It presently occurs in all 56 Montana counties (Lacey et al. 1992). Agricultural development, road construction, off-road disturbances and other forms of land disturbance have contributed to the spread of spotted knapweed (Noxious Weed Trust Fund 1992). Today's landscape features help facilitate exotic weed migrations. Modern transportation systems allow for increased dispersal and enable weeds to colonize areas previously unaffected by exotics

(Forcella 1991). Examples of these dispersal patterns will be discussed later. The rapid spread of several species in the knapweed genus through the West has been a concern since the early 1960's as their potential impacts on agricultural production began to be realized (Table 1).

Table 1. Total area infested by spotted knapweed in nine western states as of 1988 (adapted from Lacey 1989).

STATE	ACRES	HECTARES
Colorado	2500	1000
Idaho	2,293,000	917,200
Montana	4,721,060	1,888,424
N. Dakota	0	0
Oregon	3000	1200
S. Dakota	2500	1000
Utah	500	200
Washington	29,070	11628
Wyoming	100	40
Total	7,051,730	2,820,692

Habit

Centaurea maculosa is a member of the Asteraceae or Composite family. Over 500 species make up the genus (Chicoine 1984). Spotted knapweed is a biennial or a short lived perennial

forb with a stout branched taproot. The plant can have one or more stems which may be branched to about one meter high. Generally the plant remains in a rosette stage during the first year. Basal leaves are up to six inches (15 cm) long with blades narrowly elliptic to oblanceolate. The flowers are showy purple or occasionally white in color and are solitary at the end of branches (Whitson et al. 1992). Spotted knapweed can be distinguished from other knapweed species by the black tipped bracts subtending each flower head (Lacey et al. 1992) (Figure 1).

Dispersal Mechanisms and Reproduction

Spotted knapweed seeds can be transported over long distances and have the ability to lie dormant for several years. The plant reproduces only by seed (Story 1992). Seed production of spotted knapweed averages 1000 per plant in Montana (Chicoine 1984). Studies by French and Lacy (1983) suggest seeds may remain viable in the seed bank for up to five years. Davis et al. (1993) found that seeds may remain viable for up to eight years. Even after extensive control of spotted knapweed has occurred on an infested site, there may still be a sizable portion of viable seeds left in the seed bank (Mooers 1982). In rural and urban settings large scale movement of spotted knapweed is accomplished in a variety of ways. For example, farm machinery such as combines and hay balers may spread weed seeds from field to field or along right-of-

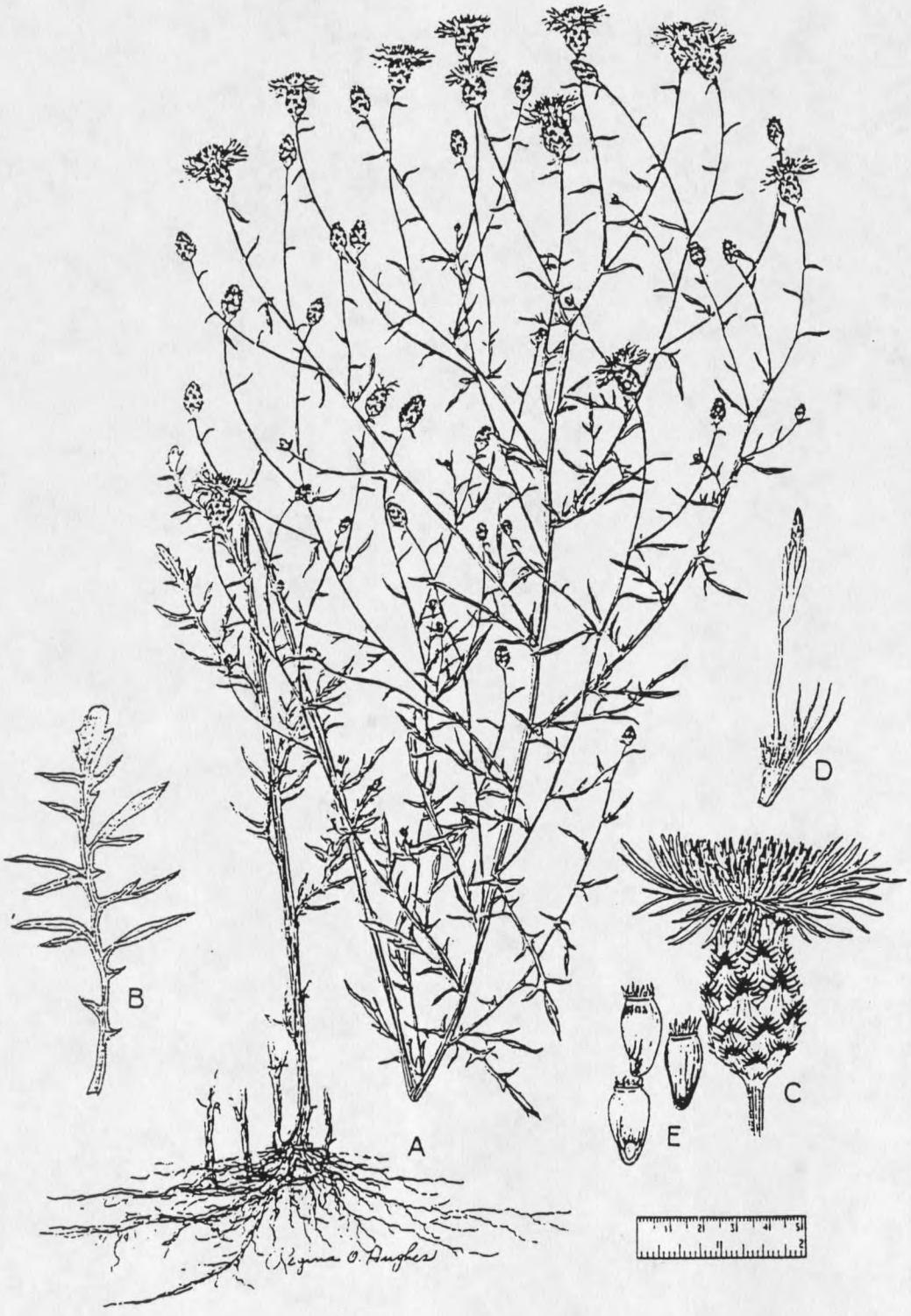

Figure 1. Centaurea maculosa L. Spotted Knapweed. A; Habit. B; leaf C; flower head. D; disk flower. E; achenes. Source: United States Department of Agriculture 1971.

ways as they travel on roadways (Montana Department of Agriculture 1986). Motorized vehicles also contribute to the spread of spotted knapweed as plants can be caught in their undercarriage (Lacey et al. 1992). Infestations of spotted knapweed along roadways, parking lots, loading areas, or vacant lots serve as source points where motor vehicles may pick up the weed and transport it to new locations (Mass 1989). Research in Glacier National Park has shown that primary roads help facilitate the migration of spotted knapweed into adjacent native grasslands (Tyser and Worely 1992).

In wilderness areas, spotted knapweed may be initially transported to trailheads by motor vehicles or livestock trailers. However, as the use of motorized vehicles is prohibited within wilderness boundaries, other vectors of transport are needed to assist successful colonization of spotted knapweed deep within wilderness areas. Saddle and pack animals are a significant source of non-native vegetation in backcountry areas. Seeds from species such as spotted knapweed which infest farms and ranches may be transported into wilderness areas in hay used for pack stock feed (Marion et al. 1985). Spotted knapweed may also find its way into wilderness settings by means of pack animal manure. Seeds consumed by animals prior to entering wilderness areas can be transported many miles. These seeds may then germinate after excretion by the animals far within wilderness boundaries (Dale and Weaver 1974; Marion et al.1985; Montana Department of Agriculture 1986).

Once established in wilderness areas there are a variety of dispersal agents which help to spread exotics such as spotted knapweed. The seeds may be transported along trails to campsites or to other locations where favorable conditions exist for germination. Seeds can be carried some distance from the parent plant by becoming attached to humans or pack stock as they pass along trails (Marion et al. 1985; Watson and Renney 1974). Movement of exotic vegetation along trail corridors has been documented in Rocky Mountain National Park of Colorado (Benninger-Truax et al. 1992) and in the Bob Marshall Wilderness area of Montana (Marion et al. 1985). Seeds may also adhere to damp tarp or tent bottoms and be transported from one camp to another (Marion et al.1985).

Natural dispersal methods are also important in backcountry areas. Populations and individual plants of spotted knapweed expand their territory through peripheral enlargement (Watson and Renney 1974). Roughly two to three weeks after maturity, the bracts of the plant open due to dehydration. This process loosens the achenes in the seed head. Seed dispersal is accomplished by means of a flicking motion when the plant is disturbed. This flicking motion distributes the seeds up to one meter from the parent plant.

It has been suggested that species in the Centaurea genus use allelopathy to maintain density levels (Chiocione 1984). Allelopathy is any harmful effect that one plant causes another by the production of chemicals that spread into the environment. However, work by

Kelsey and Bedunah (1989) suggests that allelopathy is not a significant ecological factor which contributes to the spread of spotted knapweed. Harvey and Nowierski (1989) have found that spotted knapweed depletes the soil of valuable nutrients such as phosphorus, thus depriving surrounding plants with the nourishment they need to survive.

Environmental Factors Affecting Spotted Knapweed Distribution

Spotted knapweed possess the ability to adapt to, colonize and reproduce under a wide range of environmental conditions. That the plant is now found in every major habitat type west of the Continental Divide in Montana is proof of its adaptability to a broad spectrum of environments (Mooers and Willard 1989).

A 1985 study aimed at predicting spotted knapweed migrations in Montana found that the plant can tolerate a variety of annual precipitation levels (Chicoine et al. 1985). Eighty-one percent of the study sites occurred in areas with precipitation ranging from 31 to 76 cm (12 to 30 inches) per year. Plants have been found in precipitation zones ranging from 20 to 203 cm (8 to 80 inches) annually (Lacey et al. 1992). During a wet year Schirman (1981) found that more flowers appear on each plant stem and more seeds develop within the flowers. Schirman also observed that seedlings emerging in April had a high rate of survival, with most of the plants flowering the next year, while seedlings which emerged

after mid May had a low rate of survival and fewer flowering stems. Thus precipitation patterns may influence when the plant flowers and the number of seeds produced by each plant (Schirman 1981).

Spotted knapweed is also well adapted to a wide range of elevations. The species has been documented at elevations of 579 meters (1,900 ft.) to above 3048 m (10,000 ft.) (Lacey et al. 1992). The same 1985 study on weed migration trends in Montana found ninety percent of the study site infestations between 610 and 1829 meters (2,000 and 6,000 feet).

The optimum temperatures for germination of spotted knapweed seeds are between 10^0 and 28^0 C (50^o and 82^o F) (Chicoine 1984) . The plant seems most adapted to areas with 90 to 120 frost free days (Chicoine et al. 1986). The seeds of spotted knapweed are able to germinate equally well under a 0 to 100 percent canopy cover. However, after germination has occurred limited light restricts growth (Losensky 1987).

Soil moisture appears to be an important environmental factor for spotted knapweed germination. Optimum germination rates as reported by Spears et al. (1980) occurred when soil moisture content was between 55% and 70%. Germination rates decreased with soil moisture content above 70% and no seedling emerged when soil moisture content was below 55%. Soil type does not play a major role in regulating spotted knapweed populations (Schirman 1984).

Habitat Types Where Spotted Knapweed Occurs

Spotted knapweed can be found in a wide variety of habitat types and occupies every major habitat type west of the Continental Divide in Montana (Mooers and Willard 1989). In broad terms, the success of spotted knapweed is correlated with the amount of disturbance and the amount of moisture in the environment. Mooers (1986) found that as sites became more disturbed or drier, the average distance between spotted knapweed plants decreased. Mooers' study identified shrub, grass, ponderosa pine, and Douglas-fir series habitat types as the most favorable for spotted knapweed success.

Grassland and shrub habitat types often exhibit areas of bare soil, even in undisturbed conditions (Mueggler and Stewwart 1980). These areas with bare soil offer spotted knapweed the opportunity to invade certain habitat types under natural conditions (Morris and Bedunah 1984).

In Montana, the ponderosa pine series is usually the first forest zone above the grasslands (Pfister et al. 1977). This species can endure dryer environments and is usually the belt of climax vegetation separating grasslands from climax Douglas fir (Pseudotsuga menziesii) forests. In the mountains of Montana, stands of ponderosa pine are fairly open with tree regeneration relatively sparse. Areas of bare soil are often found in this series,

especially those with grass understories (Pfister et al. 1977). These areas of bare soil give spotted knapweed the chance to invade.

The Douglas-fir series is also susceptible to invasion by spotted knapweed. This series typically spans a wide range of environmental gradients from dry, exposed southern slopes to the more lush north facing slopes (Mooers 1986). Bare soil occurs less often in these habitat types (Pfister et al. 1977), thus providing spotted knapweed little room for colonizing unless disturbance levels are relatively high.

Habitat types wetter than the Douglas-fir series require a more intense disturbance level for spotted knapweed to thrive as there is little bare soil present for the invading plant. While Watson and Renney's (1974) work shows that spotted knapweed seed production is greater in moist environments such as irrigated fields, Mooers' (1986) research indicates that the plant could not displace the native vegetation found in Douglas-fir or wetter forest types. Several reasons why spotted knapweed cannot displace native vegetation found in these sites are possible (Mooers 1986). First, many of the forest understory plants that spotted knapweed competes with are not preferred by cattle. Hence, selective grazing would not be an advantage for spotted knapweed. Second, native plants have evolved advantages for these environments, unlike spotted knapweed. One example of this advantage may be that native species may retain more vigor than spotted knapweed under the low light conditions typically found in forest settings (Mooers 1986).