

THE EFFECTS OF PRESCRIBED BURNING ON DEER AND ELK HABITAT
PARAMETERS IN MONTANA'S MISSOURI RIVER BREAKS

by

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TABLE OF CONTENTS

LIST OF TABLES.....	vii
LIST OF FIGURES.....	viii
ABSTRACT.....	x
1. INTRODUCTION.....	1
2. LITERATURE REVIEW.....	5
Deer and Elk Habitat.....	5
Thermal Cover.....	6
Hiding Cover.....	9
Vegetation Response.....	11
Deer Food Habits.....	12
Elk Food Habits.....	14
Expected Deer and Elk Response.....	16
3. MATERIALS AND METHODS.....	17
Study Area.....	17
Experimental Design.....	18
Hiding and Thermal Cover Measurements.....	18
Vegetation Surveys.....	22
Pellet Group Counts.....	23
Browse Utilization.....	24
Diet Composition Analysis.....	24
Statistical Analysis.....	25
4. RESULTS.....	27
Climate.....	27
Hiding Cover.....	27
Thermal Cover.....	29
Daubenmire Vegetation Survey.....	30
Summer 2003.....	30
Summer 2004.....	33
Dry Weight Rank Vegetation Survey.....	36
Summer 2003.....	37
Summer 2004.....	38
Pellet Group Counts.....	39

TABLE OF CONTENTS CONTINUED

Browse Utilization.....40

5. DISCUSSION.....42

6. MANAGEMENT IMPLICATIONS.....46

LITERATURE CITED.....49

APPENDICES.....54

APPENDIX A: PRECIPITATION DATA.....55

APPENDIX B: TEMPERATURE DATA.....57

APPENDIX C: SPECIES COMPOSITION DATA.....59

APPENDIX D: MULE DEER DIETS.....66

LIST OF TABLES

Table	Page
1. Mean and standard errors for hiding and thermal cover in unburned, scorched, and heavily burned treatments in 2002 and 2003.....	28
2. Mean species composition based on estimated biomass for important mule deer forages (Mackie 1970) in 2003.....	37
3. Mean species composition based on estimated biomass for important mule deer forages (Mackie 1970) in 2004.....	39
4. Mule deer dietary analysis for individual spring and summer months and fall and winter seasons.....	66

LIST OF FIGURES

Figure	Page
1. Map of Fergus Triangle Allotment showing the prescribed burn units and the unburned control.....	19
2. The study site was a mosaic of three treatments: the unburned control (top), scorched areas (middle), and heavily burned areas (bottom).....	20
3. Map of study site showing locations of browse and vegetation transects. Hiding and thermal cover measurements and pellet group counts were taken along vegetation transects.....	21
4. Percent total forb cover in each treatment for summer months in 2003.....	31
5. Percent total grass cover in each treatment for summer months in 2003.....	32
6. Percent total browse cover in each treatment for summer months in 2003.....	33
7. Percent total forb cover in each treatment for summer months in 2004.....	34
8. Percent total grass cover in each treatment for summer months in 2004.....	35
9. Percent total browse cover in each treatment for summer months in 2004.....	36
10. Shrub species abundance and mean browsing pressure of three key browse species along permanent transects.	41
11. Monthly precipitation from October 2001 through August 2004 and the 30 year mean for Roy, Montana.....	55
12. Monthly high and low temperature means from January 2002 through August 2004 and the 30 year mean for Roy, Montana.....	57
13. Species composition for important deer forages (Mackie 1970) in unburned areas in Summer 2003.....	59
14. Species composition for important deer forages (Mackie 1970) in scorched areas in Summer 2003.....	60
15. Species composition for important deer forages (Mackie 1970) in heavily burned areas in Summer 2003.....	61

LIST OF FIGURES CONTINUED

16. Species composition for important deer forages (Mackie 1970) in unburned areas in Summer 2004.....62

17. Species composition for important deer forages (Mackie 1970) in scorched areas in Summer 2004.....63

18. Species composition for important deer forages (Mackie 1970) in heavily burned areas in Summer 2004.....64

ABSTRACT

Fire suppression has been practiced along the Missouri River Breaks for decades and has led to a series of resource issues. Among these issues was a build up of dangerous fuel loads and restricted foraging areas for livestock and big game. Because the Missouri Breaks are an important wintering area for mule deer (*Odocoileus hemionus hemionus* Rafinesque) and elk (*Cervus elaphus nelsoni* Bailey), the Bureau of Land Management (BLM) wanted to know how a series of prescribed burns in late May and early June of 2002 would affect habitat.

The prescribed burns left a mosaic of unburned, scorched, and heavily burned landscape across the study site. There was concern that the reductions in hiding and thermal cover and decreased browse availability would have adverse impacts on the mule deer and elk populations. To evaluate the possible impacts of the prescribed fire on deer and elk populations use of unburned, scorched and heavily burned areas were compared using pellet group counts and winter browsing pressures. Thermal and hiding cover measurements were taken to quantify fire intensity effects on cover loss. Forb and grass rejuvenation was monitored one and two years after the burn to measure the impacts to the forage base.

Thermal cover did not differ significantly ($P>0.10$) between unburned, scorched, and heavily burned areas. Scorched and heavily burned areas had significantly less ($P<0.10$) hiding cover than unburned areas. While grass did not differ significantly among the treatments, forbs were greater in the second year after the burn in scorched and heavily burned areas. Pellet groups counts indicate that mule deer used all burn intensities and showed no indication of preference or avoidance of various cover levels or forage availability. Elk use of the study site was too minimal to analyze. There was no significant difference ($P>0.10$) between browsing pressures in meadows of burned and unburned areas, suggesting that deer did not select browsing areas based on adjacent cover levels. There were however, were significant differences ($P<0.01$) among browsing pressures of the three browse species.

The use of prescribed fire as a management tool without adversely effecting deer and elk populations looks promising. Prescribed fire can be used to improve habitat for mule deer and elk. The prescribed fire maintained sufficient thermal and hiding cover levels while increasing total forb cover including many important species considered important for mule deer.

CHAPTER 1

INTRODUCTION

The Missouri Breaks occur within a 10-50 km wide by 300 km long belt of rugged landscape along the Missouri River in northcentral Montana. The breaks support a mosaic of open, low shrub-grass and timbered vegetation types (Mackie et al. 1998). Ponderosa pine (*Pinus ponderosa* P.&C. Lawson) and a prostrate growing Rocky Mountain Juniper (*Juniperus scopulorum* Sarg.) dominate the rough uplands along the Missouri River drainages. The Ponderosa-Juniper habitat type is considered the most important habitat type in the Missouri Breaks for mule deer (*Odocoileus hemionus hemionus* Rafinesque) and considered locally superior habitat for elk (*Cervus elaphus nelsoni* Bailey) (Mackie 1970). This habitat type occupies 45 % of the Missouri Breaks area (Eichhorn and Watts 1984); and is important winter range for elk and mule deer, providing thermal and hiding cover for both year round.

Natural fires have historically played an important role in maintaining ponderosa pine stands throughout the western United States. Habitats in the Missouri Breaks dominated by ponderosa pine need fire to maintain grasslands, open pine stands, and encourage ponderosa pine regeneration (Fischer and Clayton 1983). Historically, most ponderosa pine stands were maintained through fire occurring every 5-25 years (Fischer and Clayton 1983). However, since the early part of the 20th Century, fire suppression by federal and state agencies has disrupted this cycle in the Missouri Breaks. In its first attempt to bring fire back into the system, the Bureau of Land Management conducted a

series of prescribed burns in late May and early June of 2002 on the Fergus Triangle Allotment, 8 km northwest of Roy, MT. The goal of these burns was to reduce the encroachment of juniper, improve distribution of wildlife and livestock, rejuvenate browse species, reduce fuel loads, and increase riparian health.

The target species for removal by prescribed fire were the 3–8 cm diameter breast height (dbh) ponderosa pine and the prostrate growing Rocky Mountain juniper (USDI 2000). There was concern that removing these species would limit browse availability for winter forage and decrease hiding and thermal cover to levels that would affect mule deer and elk use of the area. While mule deer and elk have been known to browse the target species in the winter, other browse species are preferred (Mackie 1970). Consequently, the BLM prescription contained precautions to prevent burning small meadows intermingled in the coniferous stands where the vegetation is dominated by more palatable browse species such as big sagebrush (*Artemisia tridentata* Nutt. ssp. *wyomingensis* Beetle & Young), rubber rabbitbrush (*Chrysothamnus nauseosa* (Pallas ex Pursh) Nesom & Baird ssp. *nauseosa*), and silver sagebrush (*Artemisia cana* Pursh) (USDI 2000).

Research on the effects of prescribed burning and post fire vegetative response and their effects on deer and elk in the Missouri River Breaks is lacking. However, there is research on deer and elk habitat use and their food habits in the Missouri Breaks (Mackie 1970).

Forbs and browse species play an important role in mule deer's year round dietary needs (Mackie 1970). Eichhorn and Watts (1984) found that burning the juniper

dominated understory in the Missouri Breaks increased forbs, grasses and more palatable browse species. Furthermore, fires of moderate intensity can improve ponderosa pine forests for mule deer by promoting regeneration of crown-sprouting shrubs and preparing the seedbed for forbs and browse (Gruell 1986). Studies have also shown that elk prefer to graze on burned as opposed to unburned sites (Lowe 1975 and Canon et al. 1987). Lowe (1975) found that fire in a ponderosa pine forest increased forbs, grasses, and shrubs, created edge and provided snags for bird cover. In the same study, elk use increased in the burn area, and reached a peak after 7 years when grasses were most abundant (Lowe 1975).

While an increase in nutritious forbs and grasses would be beneficial to mule deer and elk, an increase in forbs and grasses could come at the expense of browse species which dominate the understory. Browse in the Missouri Breaks accounts for 64% of deer's total yearly diet with the highest peaks of shrub use occurring in December and January (Mackie et al. 1998). Consequently, there was concern that prescribed burns would have adverse effects on deer and elk populations. Possible negative effects include detrimental reductions in hiding and thermal cover availability and the elimination of Rocky Mountain juniper, which is a food source for the deer in severe winter conditions.

These questions need to be answered because the BLM believes that fire could be a positive influence in the Missouri Breaks and that where practical the restoration of natural fire regimes should be encouraged. The goal of this research was to evaluate the ecological costs and benefits in terms of mule deer and elk habitat and foraging productivity.

The objectives of this study were to:

1. Investigate whether or not the burn reduced thermal and hiding cover to levels that could impact the use of the area by deer and elk.
2. Measure the level of forb and grass rejuvenation.
3. Determine whether adjacent cover levels or browse species type contributed to the level of browse use.

CHAPTER 2

LITERATURE REVIEW

Deer and Elk Habitat

Wildlife habitat is defined as the resources and conditions present in an area that produce occupancy, including survival and reproduction, by a given organism (Hall et al. 1997). Traditionally it includes four basic components; food, cover, water and space (Skovlin et al. 2002). Mackie (1970) found that mule deer in the Missouri River Breaks select habitat types seasonally and yearly based on the availability of preferred forage. In drought years and years of high population numbers, deer preferred habitat types where deciduous browse was available. During winters, the Pinus-Juniperus habitat type is used most intensively during periods of complete snow cover (Mackie 1970). Mackie (1970) found that elk were more responsive than deer to changes in forage availability within and between seasons and years. Elk in the “Breaks” readily move from one habitat type to another as conditions demanded. The difference in habitat use between years is largely related to precipitation and its influence on forage availability for elk (Mackie 1970). Habitat selection by deer and elk has often been viewed as an optimization process. Deer and elk choose habitats which maximize foraging efficiency and reproductive success (Mackie et al. 1998). The role of hiding and thermal cover, post fire vegetation response, and forage availability and use for deer and elk has been the topic of much research. Understanding these habitat components help managers improve habitat for wildlife.

Thermal cover

Thermal cover is often quantified as percent canopy cover and provides shelter against extreme temperatures, solar radiation, and wind (Mysterud and Ostbye 1999). Overstory cover provides benefits to elk, deer and other wildlife by moderating weather extremes including reducing snow depths and reducing wind velocities (Beall 1974). Cover can be a forest overstory to provide protection from winter cold or summer heat, or topography such as a steep ravine or coulee. Conifer trees are superior to deciduous trees in providing winter cover and dense stands with tall crowns are superior to those stands with fewer trees and short crowns (Skovlin et al. 2002). Thermal cover is needed to help large ungulates maintain an energy balance between fixed body temperature demand and extreme ambient temperatures (Skovlin et al. 2002). By reducing body heat loss, more energy is available for activity and reproductive processes (Leckenby et al. 1982). Conversely, elk use thermal cover in the summer months to dissipate body heat and reduce or limit water loss (Skovlin et al. 2002). This suggests that fire could have negative affects on deer and elk by exposing them to more extreme weather. In extreme heat and cold temperatures elk and deer will minimize travel and seek areas with thermal cover to conserve energy (Skovlin et al. 2002).

The abundance and availability of winter browse interspersed with thermal cover provides ideal winter habitat for deer. Deer seek shelter at lower elevations as the snow becomes deep. When all other factors are equal, deer will respond to cold weather by moving to warmer exposures, and to the warmest sites on those exposures. Vegetative

cover has a positive relationship with site temperature (Loveless 1964). With the exception of ambient temperature and atmospheric moisture, the depth of ground-surface snow induced more response in deer than any other weather element (Loveless 1964). Loveless (1964) found locations used intensively by deer were south and east facing shrub and open timber types and shrub-understory types. These areas had significantly ($P=0.05$) less surface snows than other exposures in the same area (Loveless 1964). Based on this data, optimal winter ranges contain thermal cover consisting of coniferous trees of at least pole-sapling stage, with 75% canopy cover. Optimal summer thermal cover contains trees that are pole-size or larger and has 60% canopy cover (Hoover and Willis 1987).

Larger elk may be less affected by environmental extremes than the smaller mule deer (Beall 1974). Beall (1974) observed that elk winter bedding areas could be predicted using wind, ambient temperature, and solar radiation in the Bitterroot River area of Montana. Elk did not frequent open areas during high winds and extremely low temperatures (Beall 1974). Beall (1974) concluded that winter habitat selection was more correlated with thermal and solar radiation than with ambient air temperatures. Leckenby (1984) found that thermal cover was also important during summer months. In the same study, elk actively searched for habitat with greater cover when ambient temperatures exceeded 13° C (Leckenby 1984).

Recently it has been suggested that thermal cover is not as important to elk performance as previously proposed. Cook et al. (1998) questioned the importance of thermal cover and its relation to elk condition and found no positive effect on body

condition of elk during four winter and two summer experiments. Energetic benefits of thermal cover seem inconsequential and it is suggested that forage is the primary mechanism through which habitat influences individual animal performance (Cook et al. 1998). Results from a study on the Pacific coast did not support the hypothesis that elk require forest cover in the summer to maintain body temperatures. Merrill (1991) found that elk used open cover types (less than 15% canopy cover) during the summer midday far more than in the closed canopy types (greater than 15% canopy cover) under all solar radiation conditions. Irwin and Peek (1983) found that forests classified as both thermal and hiding cover were used by elk proportionately less than availability during the fall, and elk used lower seral stage stands that produced more forage.

While deer and elk habitat selection sometimes appear to be of thermal benefit, their habitat use patterns must ultimately be optimized in response to perceived total costs and benefits (Parker and Robbins 1984). For example, ungulates might choose habitats with low snow cover and more available forage over habitats that protect them from cold temperatures. If the thermal costs of remaining in the open were counterbalanced with opportunities for increased energy intake, then an animal's choice would not be directly based on thermal cover availability alone (Parker and Robbins 1984). While thermal cover is an important consideration in mule deer and elk management, it should be evaluated relative to the broader trade-offs involved in an optimization process (Parker and Robbins 1984). Under most conditions cover does not function as an independent element in determining distributional patterns of deer (Loveless 1967). Loveless (1967) found that deer showed preference for habitats which provided food or food and cover,

and deer rarely used areas with little forage regardless of cover characteristics. The debate continues over the specific requirements for forest cover by elk, and it has been suggested that elk need cover primarily for hiding rather than for thermal benefits on summer range (Peek and Scott 1985).

Hiding Cover

Hiding cover is used for protection from predators and humans. Deer and elk rely on vegetation and/or topography for concealment from predators. This allows them to run effectively through dense vegetation to escape (Cooperrider et al. 1986). A qualitative measure of hiding cover is sight distance, which is a function of stem density and understory forest vegetation (Skovlin 1982). Patches of hiding cover as small as 0.81 to 4.05 hectares are sufficient for social groups of deer. Optimum distribution of hiding cover across a landscape consists of continuous, interconnecting zones, and scattered patches vegetative cover (Leckenby et al. 1982). In a mule deer habitat use study in the Missouri Breaks, Mackie (1970) reported maximum numbers of deer occurred in well developed coniferous stands that provided relatively high levels of hiding cover. These stands are considered the most important habitat type for bedding (Mackie 1970). Naugle et al. (1997) showed that white-tailed deer moved into areas of greater cover during hunting season and when a natural disturbance decreased habitat cover. In that study, the deer eventually moved to adjacent land with greater cover when the availability of hiding cover decreased (Naugle et al. 1997).

In the Missouri Breaks, deer use diverse habitats at greater intensities than homogeneous habitats. Rugged topography followed by diversity of vegetation are the two ultimate factors influencing mule deer use of an area (Hamlin and Mackie 1989). Mule deer selectively use structurally diverse forest vegetation, especially for reproductive habitat when it is available. Habitats with greater numbers of vegetation patches and diversity cover types are more heavily used than areas that are unused or used only occasionally (Mackie et al. 1998). Topographic variation and structurally diverse conifer types provides the highest quantity of forage and the greatest opportunity for extending selective foraging through the lactation period. Those two factors also provide the greatest spatial isolation for productive females, hiding cover for fawns, and the least opportunity for interspecific competition with elk and livestock (Mackie 1998).

Ideal hiding and calving cover for elk are grasslands or meadows interspersed with forests that have large amounts of edge (Skovlin 1982). The amount of hiding cover also affects the response of the elk to hunting and activities along roads (Basile and Lonner 1979, Lyon 1979). Coop (1971) found that in central Montana elk use of open meadows decreased in fall, and was particularly notable with the onset of hunting season. An increase in use of older timber stands and stands with dense understory vegetation during the fall have been reported by Lonner (1976) and Marcum (1975).

Topography combined with vegetative cover can increase the effectiveness of hiding cover (Thomas et al. 1979). However, deer prefer vegetation to topography for cover at bed-sites because it breaks up the image of the deer and allows deer to be more concealed (Smith et al. 1986). In the Black Hills of South Dakota elk chose summer bed

sites that had a greater canopy cover, but hiding cover was not different between bed sites and random plots (Millsbaugh et al. 1998).

Vegetation Response

One of the expected outcomes of the Fergus Triangle prescribed fire was the reduction of the Rocky Mountain juniper, which dominated the understory, coupled with a corollary increase in productivity and availability of palatable grasses and nutrient rich forbs for livestock and big game. Historically ponderosa pine forests experienced frequent fires as a result of highly combustible leaf litter, an abundance of cured herbaceous vegetation, and a long season of favorable ignition sources (Arno 2000). The removal of dead material and release of nutrients into the soils encourages rejuvenation and increased productivity of grasses and rich forbs (Fischer and Clayton 1983). Prescribed fire has been recognized as an effective management tool to reduce and control juniper (Fischer and Clayton 1983), and many shrubs and herbaceous plants are able to renew themselves after a fire. Vegetation response to fire is a function of soil and litter moisture, physiological stage of the plant, and the severity of the fire. The amount of heat that travels through the soil and litter layers influences the vegetative response to fire (Fischer and Clayton 1983). Plant propagules often immigrate from surrounding unburned patches within or adjacent to the burned area creating new foraging areas for livestock and wildlife (Fischer and Clayton 1983).

Research on the vegetative responses to fire in the Missouri Breaks is minimal. What is known from other areas is that the undergrowth in ponderosa pine forests are

primarily composed of fire resistant grasses and forbs that resprout after each burn (Arno 2000). Eichhorn and Watts (1984) measured plant succession over a 10 year period following wildlife fires as old as 28 years within five different plant associations in the Missouri River Breaks. Vegetative responses of the two major forested types, *Pseudotsuga/Juniperus* and *Pinus/Juniperus* were similar. After 4 years grass canopy cover on burned sites equaled or exceeded that on the control site. Grass canopy cover on burned sites increased steadily for 12 years and then fluctuated. Forbs peaked at 4 years on the *Pinus/Juniperus* association and then steadily decreased. Forb canopy cover on burns in both timbered types equaled or exceeded forb coverage on the control in all years. While the burn eliminated juniper on both sites, other shrub canopy cover steadily increased after the burn (Eichhorn and Watts 1984).

Deer Food Habits

Mackie (1970) recorded plant use frequencies at feeding stations to determine forage selection by mule deer in the Missouri Breaks. Forbs are particularly important in the months of May, June, and July when they account for 60-70% of the diet (Mackie et al. 1998). The most important forb during the summer months is yellow sweetclover (*Melilotus officinalis* (L.) Lam.). Mackie (1970) found yellow sweetclover accounted for 45% of the summer diet, and other forbs like bastard toadflax (*Comandra umbellata* (L.) Nutt.) and yellow salsify (*Tagopogon dubius* Scop.) received less but moderate usage. Browse ranks second for summer forage use with deer browsing primarily on skunkbrush sumac (*Rhus aromatica* Ait.), snowberry (*Symphoricarpos albus* (L.) Blake),

woods rose (*Rosa woodsii* Lindl.), and chokecherry (*Prunus virginiana* L.) (Mackie 1970). Grass and grass-like plants make up an insignificant proportion of deer summer diets (Mackie 1970).

A seasonal change in deer diets occurs in the fall as deciduous shrubs and forb use decreases and consumption of rabbitbrushes and sagebrushes increase (Mackie 1970). While most forbs receive very little use in early fall, yellow sweetclover is an important forage and continues to receive intensive use. In October important forbs are white sagebrush (*Artemisia ludoviciana* Nutt.) and buckwheat (*Eriogonum multiceps* Nees), and in November, spiny phlox (*Phlox hoodii* Richards) is important forage. Grass use in the fall is generally minor. Rubber rabbitbrush may be the single most important plant for feeding in October and November.

Potential negative effects of the prescribed fire could include the elimination of Rocky Mountain juniper, which is a food source for the deer in severe winter conditions. Browse accounts for 64% of their total yearly diet with the highest peaks of shrub use occurring in December and January (Mackie et al. 1998). Mackie (1970) found that shrubs make up 88% of winter mule deer diets in the Missouri Breaks. Big sagebrush is believed to be the most important browse species comprising 33% of diets throughout the winter, and is browsed most intensively during midwinter and times of snow cover (Mackie 1970). Rubber rabbitbrush is the second most important winter forage and receives most intense browsing in early winter (Mackie 1970). Deer wintering in coniferous stands of ponderosa pine and Rocky Mountain juniper browse Rocky Mountain juniper and big sagebrush heavily in times of heavy snow and cold

temperatures, otherwise juniper is of only minor importance. Other shrubs were minimally browsed and were of little importance (Mackie 1970). Forage quantity and quality are the primary factors influencing local and seasonal movements within home ranges (Mackie 1970).

Browse species continue to be the most important forage for mule deer throughout the spring. Big sagebrush is browsed most intensively in the month of March (Mackie 1970). As green-up occurs in late spring browse use will decrease significantly as deer utilize grasses more than any other time of the year. Sandberg bluegrass (*Poa secunda* Presl.) is preferred but Western wheatgrass (*Agropyron smithii* (Rydb.) A. Löve) and Junegrass (*Koeleria macrantha* (Ledeb.) Scult.) are also grazed (Mackie 1970). As green-up continues forbs will become more important in April and eventually begin dominating diets in May (Mackie 1970).

Elk Food Habits

Elk consume diverse amounts of grasses, forbs, and shrubs in the spring and early summer when most forages are nutritious and abundant (Wisdom and Cook 2000). Mackie (1970) also studied food habits of Rocky Mountain elk in the Missouri Breaks in all four seasons for several years by recording frequencies of plant use at feeding sites. Elk in the Missouri Breaks feed primarily on forbs in the summer months. Forbs comprises 75% of the diet in the summer with yellow sweetclover being the most important forage species. Yellow sweetclover makes up over half of the total summer diet and accounts for more than two-thirds of the use on forbs (Mackie 1970). Browse

comprises 15 % of the total summer diet with more intensive browse use occurring in drought years. Chokecherry, snowberry, and skunkbrush sumac are the most important shrubs during summer months. Grasses constituted a minor percentage of the summer use with western wheatgrass being the most important species (Mackie 1970).

Grass use increases as the summer progresses and by fall constitutes 62% of their diet. Western wheatgrass continues to be the primary grass species and comprises 30% of the fall diet (Mackie 1970). Yellow sweetclover and American licorice (*Glycyrrhiza lepidota* Pursh) are important food sources in September but receives minor use later in the fall. Chokecherry, skunkbush sumac and longleaf sagebrush (*Artemisia longifolia* Nutt.) are browsed intensively in September but received relatively minor use in the late fall (Mackie 1970).

During the winter, snow cover conditions often required elk to be opportunistic due to the unavailability of grasses and forbs. Grass, forb, and browse species that persist throughout the winter and are not snow covered typically dominate elk diets in winter months (Wisdom and Cook 2000). Mackie (1970) found that grasses were the predominate forage in winter months with western wheatgrass, sandberg bluegrass, and junegrass being the preferred species. Shrubs are of moderate importance and account for 17% of winter diet. Big sagebrush is the most browsed winter species accounting for more than half of the total browse diet. Increased utilization of big sagebrush, Rocky Mountain juniper, silver sagebrush and snowberry are correlated with severe temperature and snowcover (Mackie 1970).

In the spring elk continue to feed mainly on grasses. Mackie (1970) observed that grass constitutes 82% of use in the Missouri Breaks. Western wheatgrass comprises about 50% of feeding instances during the spring. Sandberg bluegrass is also important forage for elk throughout the spring (Mackie 1970). As forbs increase during March and April intake will be replaced with a wide variety of newer sprouting forbs. Browse use is minimal throughout early spring (Mackie 1970).

Expected Deer and Elk Response

Based on the existing literature, there are several expectations regarding deer and elk use of the prescribed burn and vegetation responses. While the prescribed fire was expected to reduce thermal and hiding cover levels, the amount of cover loss was not expected to impact the use of the area by deer and elk. The rugged topography combined with the surviving and regenerating vegetation from the fire were thought to be sufficient to not deter elk and deer use. With the elimination of Rocky Mountain juniper, an increase in palatable forbs and grasses is expected. The resulting increase in forage will encourage deer and elk to use the burned areas, and possibly show a preference over that of the unburned area. With the elimination of Rocky Mountain juniper the deer and elk will shift to other browse species available in the open meadows during fall and winter months. By increasing palatable forbs and grasses and maintaining adequate cover and browse levels, the burns were expected to improve wildlife habitat for deer and elk.

CHAPTER 3

MATERIALS AND METHODS

Study Area

A prescribed burn was conducted by the Bureau of Land Management (BLM) on the Fergus Triangle Allotment (T19N R21E, sections 28-32) along the 445 ha coniferous north slope of the Dry Armells Creek. Burning was accomplished over a 2-week period from 28 May to 10 June 2002. While the majority of the land burned is comprised of public land managed by the BLM, small amounts of adjacent private land were also part of the project. Mackie (1970) characterized the climate as being semiarid with moderately low rainfall and extreme summer and winter temperatures. The vegetation is dominated by ponderosa pine forests with an understory dominated by snowberry and other shrubs, as well as a rich assortment of perennial forbs and grasses (Pfister et al. 1977). Mean annual precipitation ranges from 250-360 mm (Nesser et al. 1997). However, since 1999 this area has only received 73-94% of the mean annual precipitation. January is the coldest month with an average temperature of -8.9°C and July is the warmest month with an average temperature of 21°C (Mackie 1970). Total snowfall is around 635 mm a year but heavy snow cover seldom persists for more than a few days due to the warm “chinook” winds that are characteristic of north central Montana (Mackie 1970).

Experimental Design

Figure 1 displays the layout of the prescribed fires, Unit 1 (80 ha), Unit 2 (98 ha), Unit 3 (75 ha), and Unit 4 (64 ha) are all burned units and surround the larger unburned control (128 ha) on the east and west boundaries. The spring fires changed the research area to a mosaic of scorched, heavily burned, and unburned landscape (Figure 2). In the scorched areas, the density of small trees (dbh of 3-8 cm) was reduced 93% from pre-burn levels with minimal loss of mature trees. In the heavily burned areas, the density of small trees was reduced 100% and the tree canopies were burned. For purposes of this study, unburned, scorched and heavily burned areas were considered as treatments. Six permanent 50 m transects were randomly established in each of the three treatments (Figure 3). Cover and vegetation surveys, and deer and elk use measured by pellet group counts were taken along each transect.

In both burned and unburned treatments there are small meadows where the vegetation is dominated by browse species. These areas were intentionally not burned to limit the negative impacts to deer, elk, and sage grouse. Fifteen permanent 50 m transects were randomly placed in the open meadows in burned and unburned treatment areas (Figure 3). Browse utilization measurements were taken along these transects.

Hiding and Thermal Cover Measurements

Six 50 m transects were randomly placed in each of the three treatments and hiding cover was estimated using a 2.5-cm x 2.0 m hardwood cover pole (Griffith and

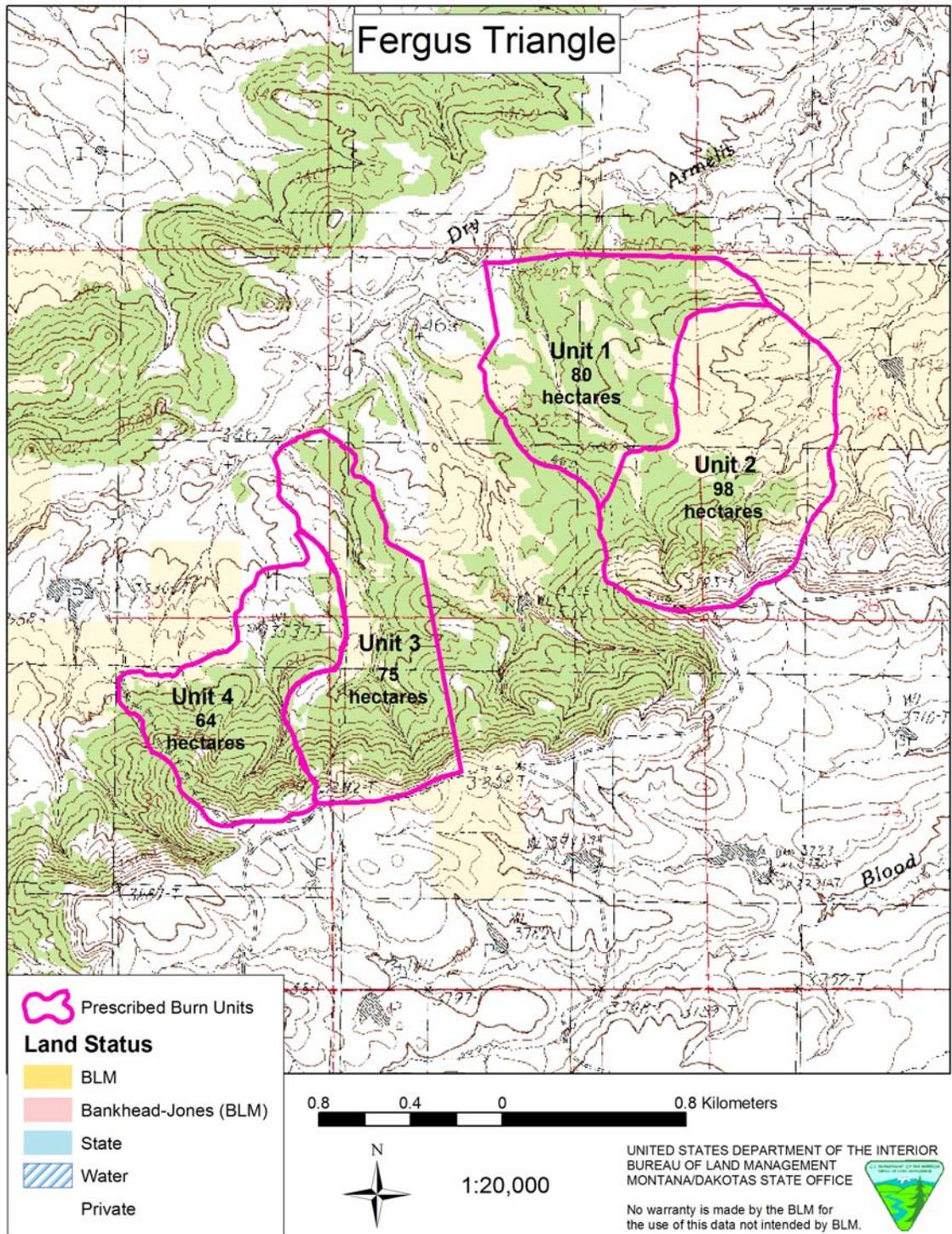


Figure 1. Map of the Fergus Triangle Allotment showing the prescribed burn units and the unburned control.



Figure 2. The study site was a mosaic of three treatments: the unburned control (top), scorched areas (middle) and heavily burned areas (bottom).

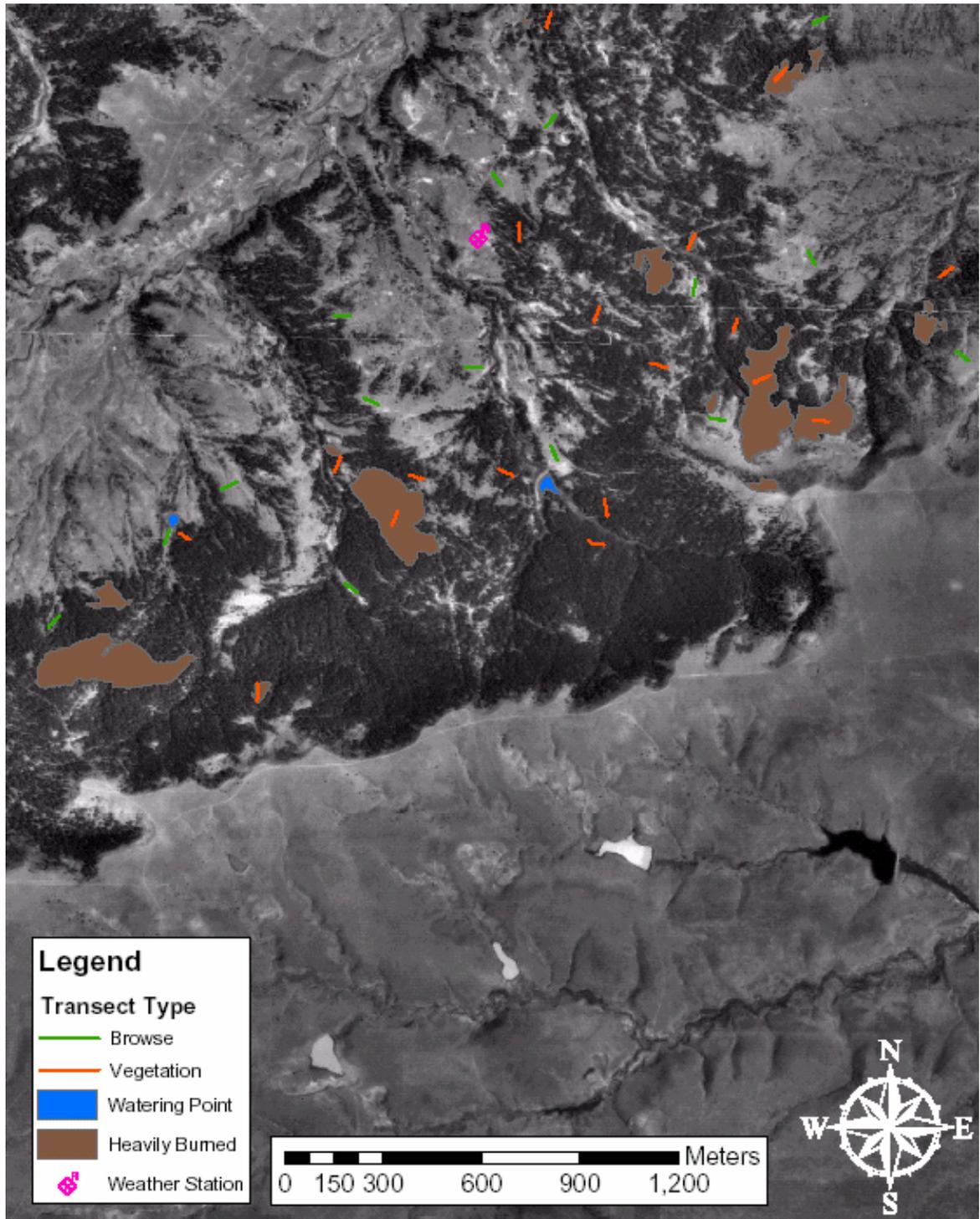


Figure 3. Map of study site showing locations of browse and vegetation transects. Hiding and thermal cover measurements and pellet group counts were taken along vegetation transects.

Youtie 1988). Every 5 m along the transect the cover pole was placed at a 90° angle from the transect line in a random direction and at a standard distance of 15 m (Nudds 1977). The percentage of the cover pole concealed by the vegetation or topography was estimated and recorded. Measurements were taken two months after the burn while dead needles were still on trees, and again one year later after most needles had fallen off.

Thermal cover, quantified by forest canopy cover, was measured every 5 m along the same transects. A vertical densiometer was used to estimate canopy cover. Trees were determined to be “cover” by sighting through the densiometer and determining whether any portion of a tree crown intersected the vertical line of sight through the densiometer. Percent cover was calculated by dividing the number of points where any portion of a tree crown was seen by 10, which was the total number of sample points along the transect (Strumpf 2000).

Vegetation Surveys

During the summers of 2003 and 2004 vegetation surveys were conducted along 18 permanent transects in unburned, scorched, and heavily burned areas from spring green up (mid April) until late summer (late August) (Figure 3). Measurements were taken every 5 m along 50 m transects for a total of 10 measurements per transect. Two different vegetation survey techniques were used. The Daubenmire method was used to estimate vegetative composition (Daubenmire 1959) and was conducted once a month. This survey monitored the percent bare ground and litter as well as canopy cover of total grasses, forbs, and browse species.

While the Daubenmire method looked at total forb, grass, and browse cover, a second survey of potential deer forages was made with the Dry Weight Rank method, and looked at individual species abundance. Measurements were conducted along the same transects that the Daubenmire measurements were made. The Dry Weight Rank method consists of observing various quadrats and ranking the three species that contribute the most apparent weight or biomass in the quadrat to calculate percent composition (USDI 1996). Ten permanent quadrats were established along each 50 m transect and measurements at the same permanent quadrat location throughout the late spring and summer were used to assess species composition through time.

Pellet Group Counts

Deer and elk use of the study site was estimated using deer and elk pellet group counts. The number of pellet groups in unburned, scorched, and heavily burned areas were counted along the vegetation transects using a 4 m wide 50 m belt transect after each season from Fall 2002 through Summer 2004. Seasons were defined as fall (September - November), winter (December - February), spring (March - May) and summer (June - August). Thirty or more pellets had to be present to count as a group, and adjacent groups of very similar appearance were counted separately unless they were definitely connected by scattered pellets (Neff 1968). Pellet groups were then spray painted or collected to avoid counting the same groups twice (Hart 1958).

Browse Utilization

Winter browsing pressure provided another indirect measure of game use of the study site. Use of three key browse species (big sagebrush, silver sagebrush, and rubber rabbitbrush (*Chrysothamnus nauseosa* (Pallas ex Pursh) Nesom & Baird ssp. *nauseosa*) in Winter 2002-2003 and 2003-2004 were measured in the small browse meadows surrounded by burned stands and those meadows surrounded by unburned stands. These species were chosen because of their abundance and value to big game (Mackie 1970). In early November 2002 and 2003 browse species that intersected the transect line were permanently marked around the stem base with colored wire (Thorne et al. 2002). The ellipsoid canopy volume (EV) was measured for each individual shrub (Thorne et al. 2002). This ellipsoid volume technique is sensitive to changes in plant size over short time intervals (Thorne 1998) and avoids “missed” readings when game did not use tagged shrubs leaders. In late March the ellipsoid volume was measured again on the tagged shrubs to determine the change in volume from November to March. Winter browsing pressure (WBP) was defined as $(\text{November EV} - \text{March EV} / \text{November EV}) \times 100$.

Species that crossed the transect lines at each transect were also counted for a frequency measurement.

Diet Composition Analysis

While not part of the designed study, deer pellets were collected in all unburned, scorched, and heavily burned areas to develop a basis for evaluating forb importance for

deer. Samples were collected along 50 m belt transects monthly one year after the burn from April 2003 through March 2004. From April through September 2003 twenty pellets were selected from each pellet group and pooled together for a composite monthly sample. Occasional snow cover during the fall and winter made monthly pellet group collections unfeasible from October 2003 through March 2004. However, breaks in snow cover allowed enough pellets to be collected to assess seasonal use. Fall samples (October through November) and winter samples (December through mid March) were collected for seasonal analysis. The Wildlife Habitat Nutrition Laboratory at Washington State analyzed the six monthly and two seasonal composite samples.

Statistical Analysis

Mean thermal and hiding cover levels were calculated for unburned, scorched, and heavily burned areas. Thermal and hiding cover levels, Daubenmire vegetative composition, pellet group counts and winter browsing pressures for all three treatments were compared using ANOVA. The experimental unit for these analyses was the transect (n=15). Treatment differences were considered significant when $P < 0.10$.

Winter browsing pressures by shrub species, without regard to adjacent treatments, between the three key browse species was also analyzed using ANOVA ($P < 0.10$).

Because of the numerous zeros recorded during the observation periods a signed rank test was used to analyze the Dry Weight Rank data. The mean percent composition for each species was calculated for each period and then the means from all time periods

within each treatment were pooled for statistical analysis. Differences among treatments were analyzed using ANOVA ($P < 0.10$).

CHAPTER 4

RESULTS

Climate

Precipitation and temperature information from the National Water and Climate Center's weather station, located 13 km northeast of Roy, MT, show that drought conditions continued through 2003. The long term records indicate the annual mean precipitation at 360 mm. However, precipitation in 2001, 2002 and 2003 was 336 mm, 280 mm, and 254 mm respectively. In 2004 precipitation was near normal levels for the first time since 1998. Rainfall through August in 2004 was 96% of the 30 year mean (Appendix A). Drought conditions were accompanied by above average temperatures in July of 2002, and June and July of 2003 (Appendix B). March and April of 2002 experienced below average temperatures, while the winter of 2003-2004 experienced temperatures above the 30 year mean.

Hiding Cover

As burn intensity increased hiding cover decreased. In 2002, hiding cover levels ranged from 42-60% in unburned, 30-48% in scorched and 16-28% in heavily burned areas, with the mean hiding covers at 49%, 40% and 23% respectively (Table 1).

One year after the burn (2003) most of the needles had fallen off scorched trees and hiding cover was remeasured. Hiding cover levels in 2002 and 2003 remained

Table 1. Mean and standard errors for hiding and thermal cover in unburned, scorched, and heavily burned treatments in 2002 and 2003.

	Hiding Cover				Thermal Cover			
	2002		2003		2002		2003	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Unburned	49% ^a	3	45% ^a	2	78% ^a	7	77% ^a	6
Scorched	40% ^b	3	32% ^b	5	78% ^a	9	68% ^a	8
Heavily Burned	23% ^c	2	21% ^b	2	60% ^a	10	58% ^a	9

Mean hiding and thermal cover levels between treatments within each year followed by the same superscript are not significantly different ($P > 0.10$)

similar in unburned and heavily burned areas (Table 1). However, hiding cover levels decreased in scorched areas from 2002 to 2003, due to scorched trees losing needles and dead trees falling down. Hiding cover levels ranged from 40-57% in unburned, 18-50% in scorched and 14-30% in heavily burned areas, with the mean hiding covers at 45%, 31% and 22% respectively (Table 1).

Hiding cover in heavily burned areas was significantly less ($P=0.01$) than unburned areas in both 2002 and 2003, and significantly less than scorched areas in 2002 ($P=0.01$) but not 2003 ($P=0.12$). Hiding levels in scorched areas were significantly less than in unburned areas in 2002 ($P=0.05$) and in 2003 ($P=0.04$).

Thermal Cover

The burn also reduced thermal cover levels. With the dead needles still on the scorched trees in summer 2002, thermal cover values ranged from 20-90% on heavily burned, 40-100% on scorched, and 50-100% on unburned areas. Mean thermal cover was 60%, 78%, and 78% for unburned, scorched and heavily burned areas respectively (Table 1).

There was minimal change in thermal cover levels in unburned and heavily burned areas from 2002 to 2003. However, needle loss in scorched areas caused thermal cover levels to decrease from 2002 to 2003. In 2003, thermal cover levels ranged from 50-90% in the unburned, 40-90% in the scorched and 20-80% in the heavily burned areas, with mean thermal covers at 77%, 68% and 58% respectively (Table 1).

There was no significant difference in thermal cover levels between unburned, scorched, and heavily burned areas in 2002 ($P=0.26$) and 2003 ($P=0.27$).

Daubenmire Vegetation Survey

Summer 2003

Litter was greatest in unburned areas and decreased as fire intensity increased. In the summer months of 2003 there was no significant difference in litter cover between unburned and scorched areas ($P>0.10$). In all months except June, scorched areas had significantly greater litter cover than heavily burned areas ($P<0.10$). Unburned areas also had significantly greater litter cover levels than heavily burned areas in all months ($P<0.10$).

Conversely, bare ground was greatest in heavily burned areas and decreased as fire intensity decreased. Overall, bare ground decreased in June when forbs and grasses were most abundant but steadily increased as the summer progressed and forbs and grasses decreased. In all summer months of 2003 bare ground was significantly greater in heavily burned than in scorched areas and significantly greater in scorched areas than in unburned areas in all months except June ($P<0.10$). Heavily burned areas had significantly greater amounts of bare ground than unburned areas in all summer months ($P<0.10$).

Total forb cover did not differ significantly ($P > 0.10$) between the three treatments on year after the burn (Figure 4).

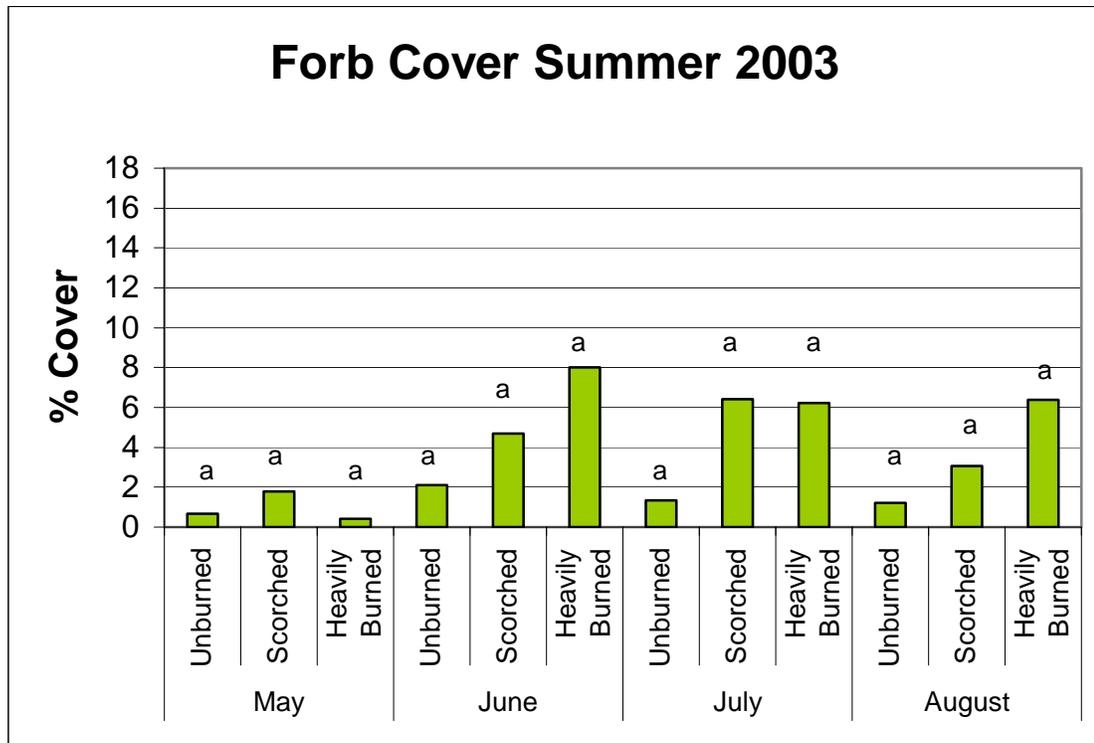


Figure 4. Percent total forb cover in each treatment for summer months in 2003. Cover levels of treatments within each month followed by the same superscript are not significantly different ($P < 0.10$).

Like forb cover, differences in total grass cover between unburned, scorched, and heavily burned areas in summer 2003 were not significant ($P < 0.10$) (Figure 5).

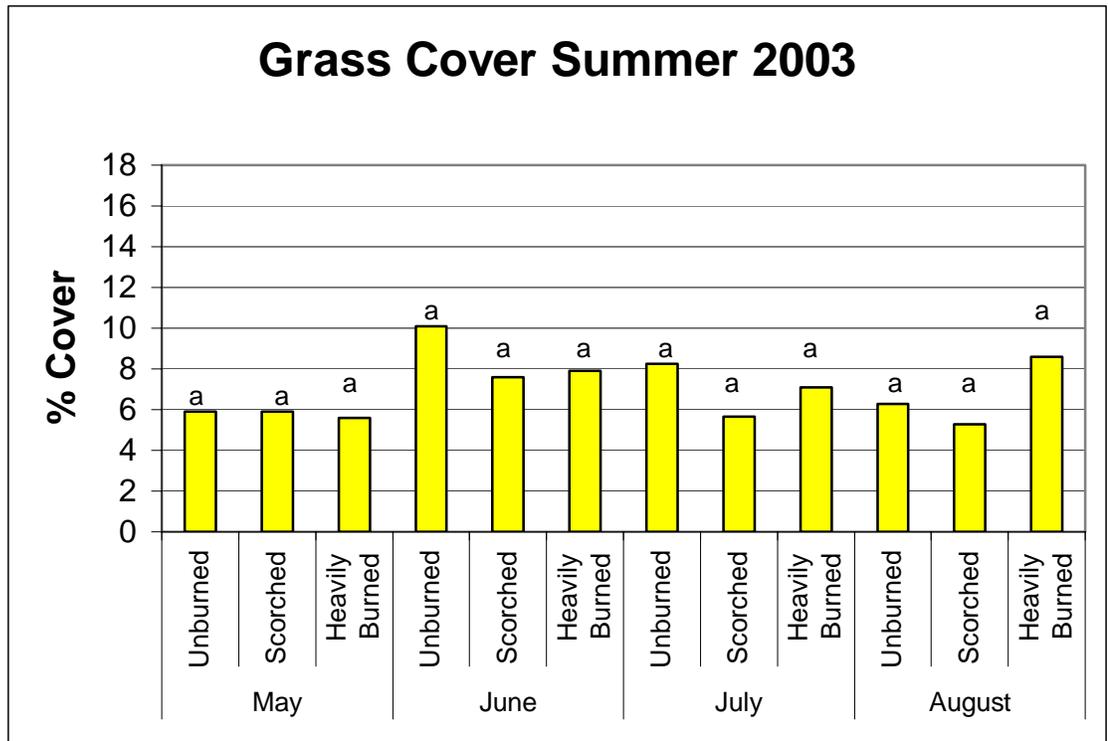


Figure 5. Percent total grass cover in each treatment for summer months in 2003. Cover levels of treatments within each month followed by the same superscript are not significantly different ($P < 0.10$).

The burn decreased total browse cover levels to less than 1% in both scorched and heavily burned areas (Figure 6). Browse cover levels for scorched and heavily burned areas did not differ significantly from each other ($P > 0.10$). Unburned areas had significantly more browse cover than scorched and heavily burned areas in all months ($P < 0.10$).

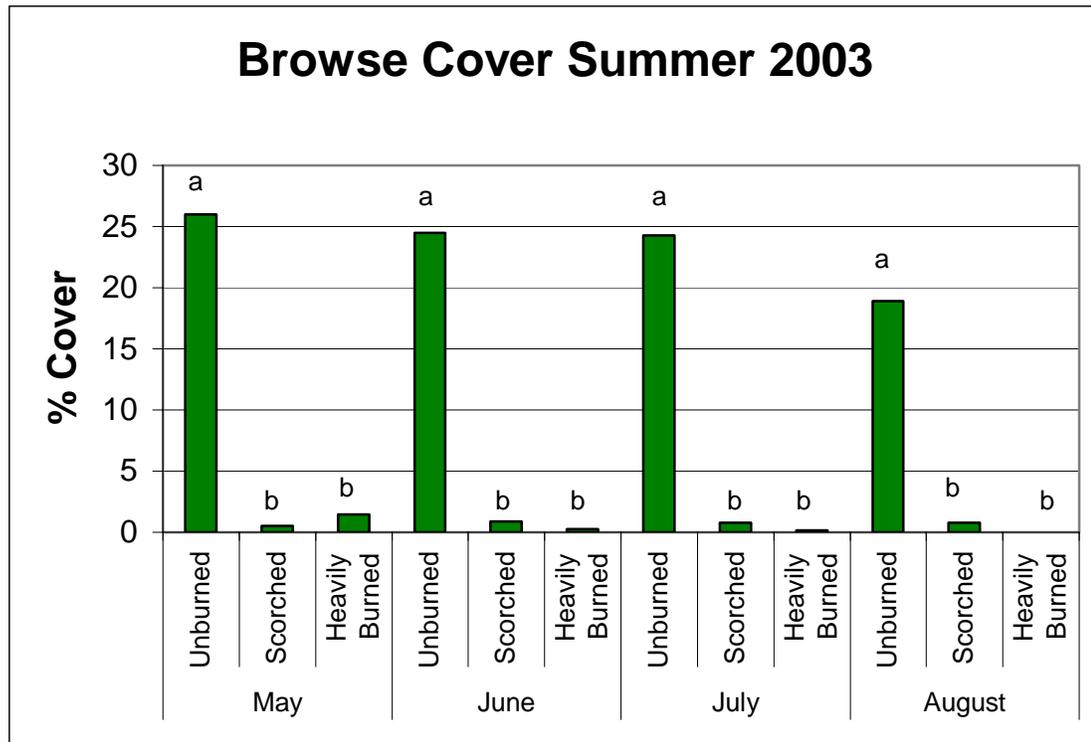


Figure 6. Percent total browse cover in each treatment for summer months in 2003. Cover levels of treatments within each month followed by the same superscript are not significantly different ($P < 0.10$).

Summer 2004

In 2004, litter was greatest in unburned areas and decreased as fire intensity increased. In all summer months of 2004 there were no significant differences in cover of litter between unburned and scorched areas ($P > 0.10$). Unburned and scorched areas had significantly greater litter cover than heavily burned areas in all months ($P < 0.10$).

In summer 2004, bare ground was greatest in heavily burned areas followed by scorched and unburned areas. There was no significant difference in the amount of bare ground between unburned and scorched areas in all months ($P > 0.10$). Unburned and

scorched areas had significantly less bare ground than heavily burned areas in all months ($P < 0.10$).

In 2004, two years after the burn, total forb cover in unburned, scorched, and heavily burned areas did not differ significantly in May and June ($P > 0.10$) (Figure 7). However in July and August, forb cover was significantly greater in scorched and heavily burned areas than unburned areas ($P < 0.10$).

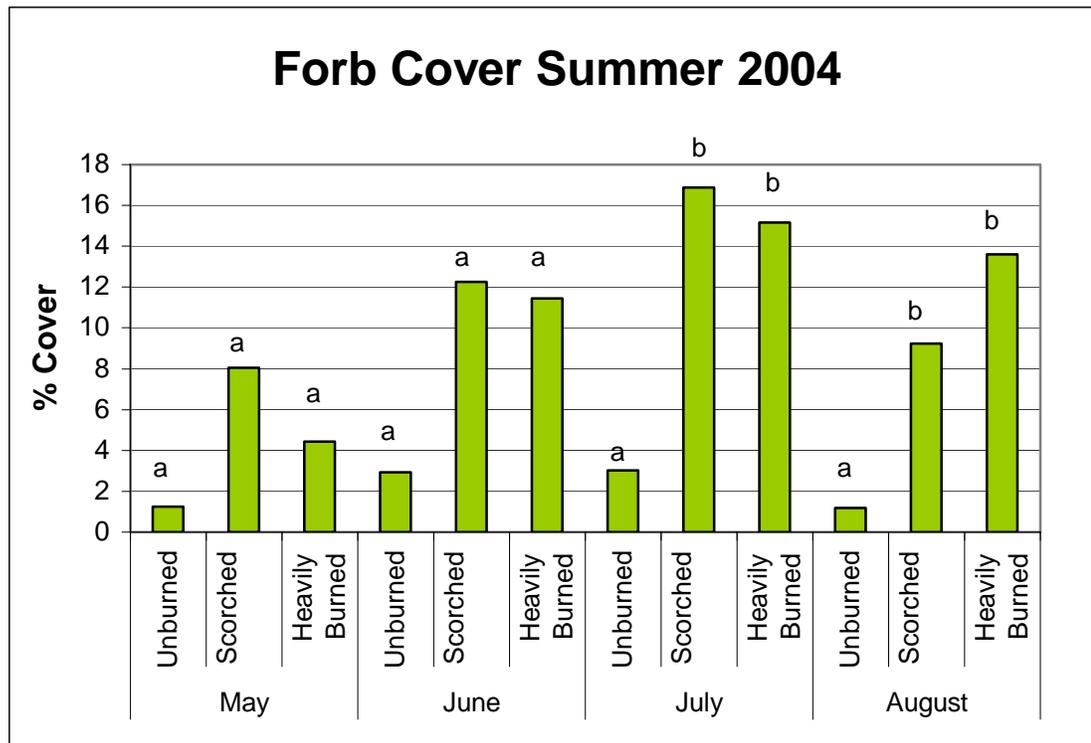


Figure 7. Percent total forb cover in each treatment for summer months in 2004. Cover levels of treatments within each month followed by the same superscript are not significantly different ($P < 0.10$).

There were no significant differences in grass cover amounts between unburned, scorched, and heavily burned areas in 2004 ($P > 0.10$) (Figure 8).

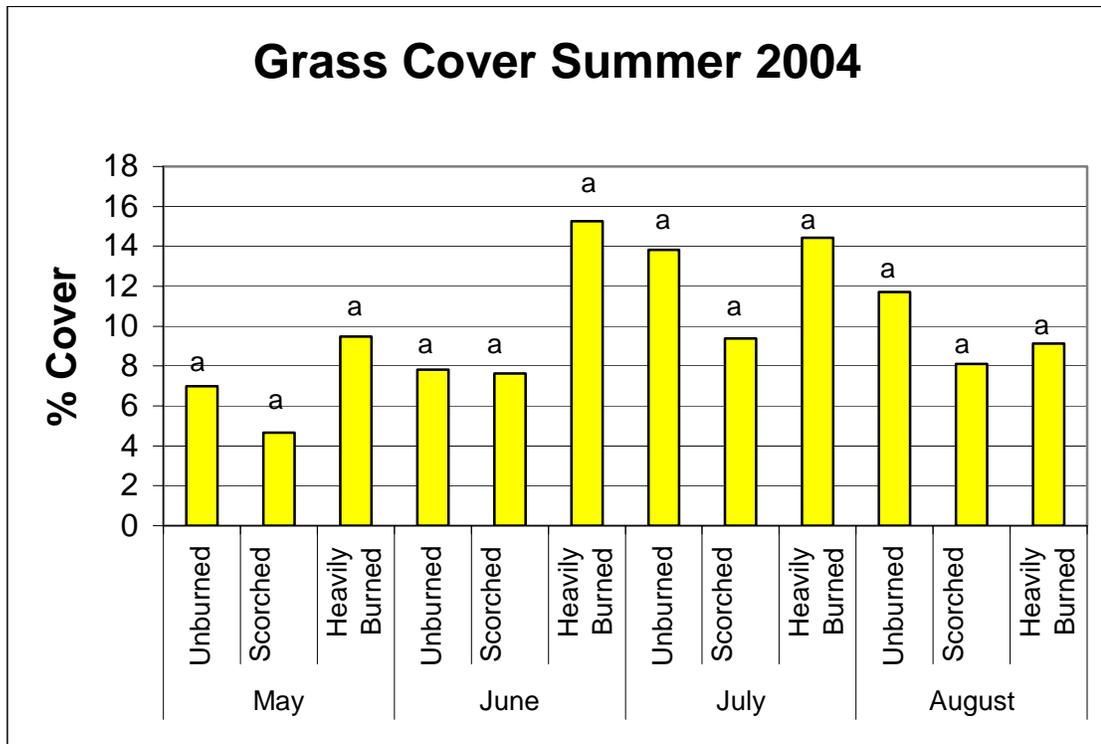


Figure 8. Percent total grass cover in each treatment for summer months in 2004. Cover levels of treatments within each month followed by the same superscript are not significantly different ($P < 0.10$).

In 2004 total browse cover levels were less than 4% in scorched areas and less than 2% in heavily burned areas (Figure 9). Browse cover levels for scorched and heavily burned areas did not differ significantly from each other ($P > 0.10$). While unburned areas had significantly more browse cover than either class ($P < 0.10$).

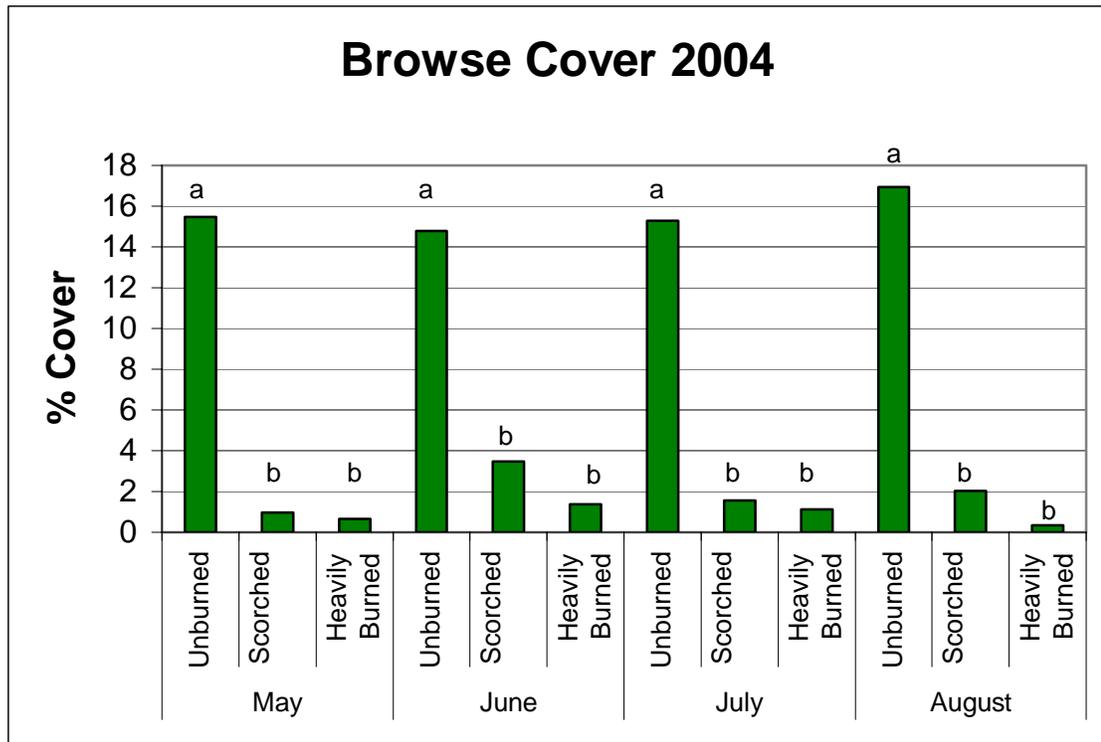


Figure 9. Percent total browse cover in each treatment for summer months in 2004. Cover levels of treatments within each month followed by the same superscript are not significantly different ($P < 0.10$).

Dry Weight Rank Vegetation Survey

Plant species regardless of their potential value for deer or elk were recorded and ranked for all three treatments. However, species considered important for mule deer within the study site were further analyzed for differences in percent composition. Plant species which were most consumed according to the dietary analysis were considered important taxon (see Appendix D). Important taxon were also graphed to show their relative abundance throughout summers 2003 and 2004 (Appendix C).

Summer 2003

Estimated biomass of bluebunch wheatgrass and Kentucky bluegrass was significantly greater in scorched areas than unburned and heavily burned areas (Table 2). Among forbs, estimated biomass of common dandelion and yellow sweetclover increased as burn intensity increased and was significantly greatest in heavily burned areas ($P < 0.10$). There were no significant differences among the three treatments of Missouri goldenrod ($P > 0.10$). Prairie thermopsis had significantly greater estimated biomass in scorched areas ($P > 0.10$). Rocky mountain juniper was dominant in unburned areas and had significantly greater estimated biomass than in scorched and unburned areas.

Table 2. Mean species composition based on estimated biomass of important mule deer forage (Mackies 1970) in 2003.

	Unburned	Scorched	Heavily Burned
Bluebunch wheatgrass	0% ^a	3% ^b	2% ^c
Kentucky bluegrass	2% ^a	12% ^b	2% ^a
Dandelion	0% ^a	2% ^b	13% ^c
Missouri goldenrod	2% ^a	3% ^a	3% ^a
Prairie thermopsis	1% ^a	3% ^b	1% ^a
Yellow sweetclover	0% ^a	2% ^b	6% ^c
Rocky Mountain juniper	32% ^a	0% ^b	0% ^b

Values for each species across the treatments with the same superscript are not significantly different from each other ($P > 0.10$). Differences were detected using rank transformed values.

Weedy species Canada thistle (*Cirsium arvense* (L.) Scop.) increased as a result of the burn. While there was no significant difference in estimated biomass for prickly lettuce (*Lactuca serriola* L.), Canada thistle was significantly greater in scorched and

heavily burned areas ($P < 0.10$). Mean estimated biomass for Canada thistle was 0%, 2.44% and 3.05% for unburned, scorched and heavily burned areas respectively.

Summer 2004

Estimated biomass for bluebunch wheatgrass and Kentucky bluegrass were significantly different among the three treatments ($P < 0.10$) (Table 3). While the burn increased estimated biomass of bluebunch wheatgrass, Kentucky bluegrass was more dominant in unburned areas as opposed to scorched and heavily burned areas. Estimated biomass of common dandelion and Missouri goldenrod were significantly greater in scorched and heavily burned areas than unburned areas ($P < 0.10$). Prairie thermopsis had significantly greater estimated biomass in the scorched than unburned and heavily burned areas ($P < 0.10$). Yellow sweetclover increased as burn intensity increased and there was significantly greater estimated biomass in the heavily burned areas than the scorched and greater in scorched areas than unburned areas ($P < 0.10$). Rocky mountain juniper was predominant in unburned areas and had significantly greater estimated biomass than in scorched and unburned areas.

Table 3. Mean species composition based on estimated biomass of important mule deer forages (Mackie 1970) in 2004.

	Unburned	Scorched	Heavily Burned
Bluebunch wheatgrass	0% ^a	5% ^b	2% ^c
Kentucky bluegrass	6% ^a	4% ^b	1% ^c
Dandelion	0% ^a	5% ^b	6% ^b
Missouri goldenrod	2% ^a	5% ^b	3% ^b
Prairie thermopsis	1% ^a	5% ^b	1% ^a
Yellow sweetclover	0% ^a	1% ^b	6% ^c
Rocky Mountain juniper	31% ^a	0% ^b	0% ^b

Values for each species across the treatments with the same superscript are not significantly different from each other ($P > 0.10$). Differences were detected using rank transformed values.

Canada thistle had significantly greater estimated biomass in scorched and heavily burned areas than unburned areas, the two burn treatments did not differ significantly from each other ($P < 0.10$). The mean estimated biomass for Canada thistle was 0%, 10.59, and 13.38% for unburned, scorched and heavily burned areas respectively. Prickly lettuce had significantly greater estimated biomass in heavily burned areas than scorched areas, and scorched areas than unburned areas ($P < 0.10$). The mean estimated biomass for prickly lettuce was 0%, 3.89%, and 12.05% for unburned, scorched and heavily burned areas respectively.

Pellet Group Counts

There was no significant difference ($P > 0.10$) in use of the unburned, scorched and heavily burned areas by mule deer in Fall 2002, Winter 2002-2003, Spring 2003, Summer 2003, Fall 2003, Winter 2003-2004, Spring 2004, and Summer 2004. Elk use of the area was not analyzed because very few pellets were observed in any treatment areas during

the study period. The lack of pellets supported observations that very few elk inhabited the study area.

Browse Utilization

Frequency measures showed that the most abundant browse species available was Wyoming big sagebrush followed by silver sagebrush and rubber rabbitbrush (Figure 10). Rocky Mountain juniper was not common in the meadows. Browsing pressure in winters 2002-2003 and 2003-2004 indicated there was no significant difference ($P>0.10$) in browse use between meadows of burned and unburned stands. However, in both winters there were significant differences ($P<0.10$) among the three key browse species. In the winter of 2002-2003, rubber rabbitbrush received significantly greater browsing pressure than silver sagebrush, and silver sagebrush received significantly greater pressure than Wyoming big sagebrush ($P<0.10$). The same trend was apparent in winter 2003-2004 (Figure 10).

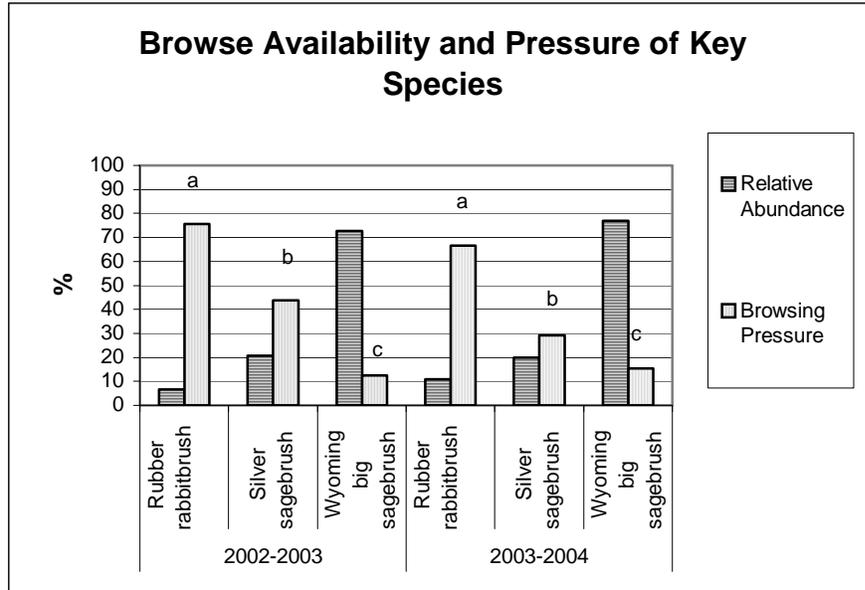


Figure 10. Shrub species abundance and mean browsing pressure of three key browse species along permanent transects. Values are means for each winter season (2002-2003 and 2003-2004). Species within each winter followed by the same superscript are not significantly different ($P < 0.10$).

CHAPTER 5

DISCUSSION

While the prescribed burn decreased hiding cover levels, the decreased cover availability in scorched and heavily burned areas did not deter or increase mule deer use of the area. Mean thermal (canopy) cover in the unburned area was slightly above the optimal winter range canopy cover suggested by Hoover and Willis (1987). Mean canopy cover in scorched areas was slightly above the optimal level in 2002 and below it in 2003. Heavily burned areas had a mean canopy cover below optimal winter range levels both years. There was no significant difference in deer use of the burn intensities in all 4 seasons for both years suggesting that cover levels were adequate to meet thermal needs (Skovlin et al. 2002).

As a result of the burn the browse dominated understory was reduced and hiding cover decreased as fire intensity increased. However, the rugged topography that is characteristic of the Missouri Breaks allows deer to escape rather quickly. The study site was also relatively small compared to the overall landscape available to deer. The study site is part of large landscape of continuous, interconnecting, and scattered patches of hiding cover that Leckenby et al. (1982) describes as being optimal hiding cover. Deer used all treatments year round suggesting that adequate cover was available in all seasons, including fall when deer sometimes prefer areas of greater cover (Naugle et al. 1997) and in early spring and late summer when cover is important for does and fawns (Mackie 1998).

Elk use of the study site was too minimal to analyze. While deer were frequently observed on the study site before the burn, elk sightings were a rarity. The minimal post-burn use of the study site by elk suggests that the burn has not attracted a greater number of elk to the site than pre-burn numbers. Due to the minimal elk use of the study site, conclusions could not be drawn on whether reduced thermal and hiding cover influenced habitat use. However, because elk are less affected by extreme temperatures than mule deer (Beall 1974) and the benefits of thermal cover is of debate among wildlife managers and scientists (Cook et al. 1998), sufficient deer cover probably umbrellas elk needs.

The prescribed burn was effective in eliminating Rocky Mountain juniper in scorched and heavily burned areas. The vegetative response to the burn was dependant upon fire severity. Many plant species, including those deemed important for mule deer, differed significantly in cover and estimated biomass between the unburned, scorched, and heavily burned areas.

Forb response was similar to previous research in the Missouri Breaks by Eichhorn and Watts (1984). One year after the fire, forb and grass cover was not significantly greater in scorched or heavily burned areas than unburned areas. However, by July of the second year, scorched and heavily burned areas had significantly greater forb cover than unburned areas. Forbs of importance to deer that were significantly greater in scorched areas were common dandelion, prairie thermopsis, and yellow sweetclover. This is promising because yellow sweetclover, which has been described as the single most important forb species for deer in summer months (Mackie 1970) became more abundant. However, an increase in weedy species was observed as a result of the

burn. Two years after the burn, Canada thistle and prickly lettuce were significantly greater ($P < 0.10$) in scorched and heavily burned areas than the unburned control.

One and two years after the burn, grass cover was not significantly different between the three treatments. Grass cover is expected to follow the trend observed by Eichhorn and Watts (1984), who found that it took four years for grass cover on burned areas to equal or match that on the unburned. Grass levels are expected to peak 7 years post-burn (Lowe 1975). Bluebunch wheatgrass and Kentucky bluegrass increased as a result of the burn with greatest levels occurring in scorched areas. However, in heavily burned areas these two species were not as dominant, which means that high severity fires could limit the optimal rejuvenation of these both grasses.

Eichhorn and Watts (1984) reported that fire in the Missouri Breaks increased palatable browse species such as chokecherry and snowberry. These two shrubs were not common on this site before or after the burn, and therefore their ability to sprout after the fire was not detected.

Browse utilization was highest in late fall, winter and early spring months (See Appendix D). While some believe that big sagebrush, rubber rabbitbrush, and silver leaf sagebrush were the most consumed, and thus the most important browse species our dietary data indicates that Rocky Mountain juniper was browsed year round and most in the winter. However, winter use of unburned areas did not differ between that of scorched and heavily burned, where juniper was eliminated so the importance and frequency of its use is questionable.

In contrast, big sagebrush, rubber rabbitbrush (*ssp. nauseosa*) and silver leaf sagebrush in the open meadows intermingled throughout all burned and unburned areas received substantial use. Winter browsing pressures indicate that deer did not select browsing areas based on adjacent thermal or hiding cover but the availability of browse. Within in these meadows, rubber rabbitbrush (*ssp. nauseosa*) received the greatest browsing pressure suggesting preference over silver sagebrush and Wyoming big sagebrush. When browse measurements were taken for the second time in late March, rubber rabbitbrush (*sp. nauseosa*) was often browsed to the woody base leaving none of the previous years growth. Its robust basal stems and branches suggest that this occurs annually and the species is tolerant of high browsing pressures.

CHAPTER 6

MANAGEMENT IMPLICATIONS

Using prescribed fire as a management tool in the Missouri Breaks looks promising. Private landowners and public land managers can use prescribed fire to achieve various management objectives, such as improving riparian health and the distribution of livestock, without having adverse impacts on deer and elk populations. Under similar fire prescriptions, where only the understory vegetation is targeted, thermal and hiding cover levels are not reduced enough to negatively impact deer use of the area. However, the size, severity, and patchiness of burn intensities should all be considered.

The heavily burned areas on this site were created because the fire burned in some spots at higher severities than prescribed. While there was initial concern that these areas burned too severe, deer did not show avoidance of these more open heavily burned areas. Heavily burned areas when adjacent to scorched and unburned areas could be beneficial to deer and elk populations by increasing important forb and grass species cover while still providing adequate adjacent cover. Thus, the mosaic created by the prescribed burn diversified the vegetation available within the study site. On a larger scale, the burn diversified vegetation composition and abundance across the landscape. Forb cover was greater in scorched and heavily burned areas in July and August the second year after the burn. Mackie (1970) reported that diverse and abundant vegetation were the ultimate factors influencing deer use of an area.

This burn was relatively small in size compared to the overall site availability to deer. The burn created a mosaic of burn intensities and the unburned areas between the burned areas was abundant in Rocky Mountain juniper, which was a source of browse for deer year round. Future prescribed fires in the Missouri Breaks should consider leaving some Rocky Mountain juniper because of its apparent year round consumption and possible forage value. The meadows that intermingled the ponderosa pine stands also supplied the deer with year round browse. Management practices such as prescribed burning that increase the abundance of the relatively scarce rubber rabbitbrush (Young 1983) should be considered in areas where browsing forage needs rejuvenation or improvement.

Overall, the prescribed fire appeared to improve habitat for mule deer. After two years, the burned areas had more forbs including yellow sweetclover, dandelion, prairie thermopsis and Missouri goldenrod, which were important deer forage species. While some grass species were more abundant after two years, native palatable species were increasing and if the trend continues could increase for up to 7 years in scorched and heavily burned areas (Eichhorn and Watts 1984). An increase in palatable forbs and grasses without the expense of too much cover being lost could benefit both mule deer and elk populations. Elk are more responsive than deer to forage availability and will move to take advantage of optimal conditions (Mackie 1970). A grass continues to increase, an increase in elk use could follow as a result of the burn.

The prescribed fire increased Canada thistle and prickly lettuce, which became significantly more abundant in scorched and heavily burned areas in both years after the

burn. These species are of no benefit to mule deer or elk and compete with more palatable and important species. While weed control is often part of post-fire management plans, Eichhorn and Watts (1984) found that many weedy species increased for 3 or 4 years after a burn, but then naturally decreased. Further monitoring research is needed to determine whether aggressive weed control should follow fires.

Future research is needed in the Missouri Breaks to continue to investigate the role of fire, post-fire vegetative responses and its effects of wildlife habitat and populations. As fire is reincorporated back into the system, findings from this study and future studies will be valuable to landowners and managers as they consider prescribed burning as a management tool. The results of this study complement previous studies and are important in bolstering predictions on prescribed fires and its potential to improve wildlife habitat.

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APPENDICES

APPENDIX A

PRECIPITATION DATA

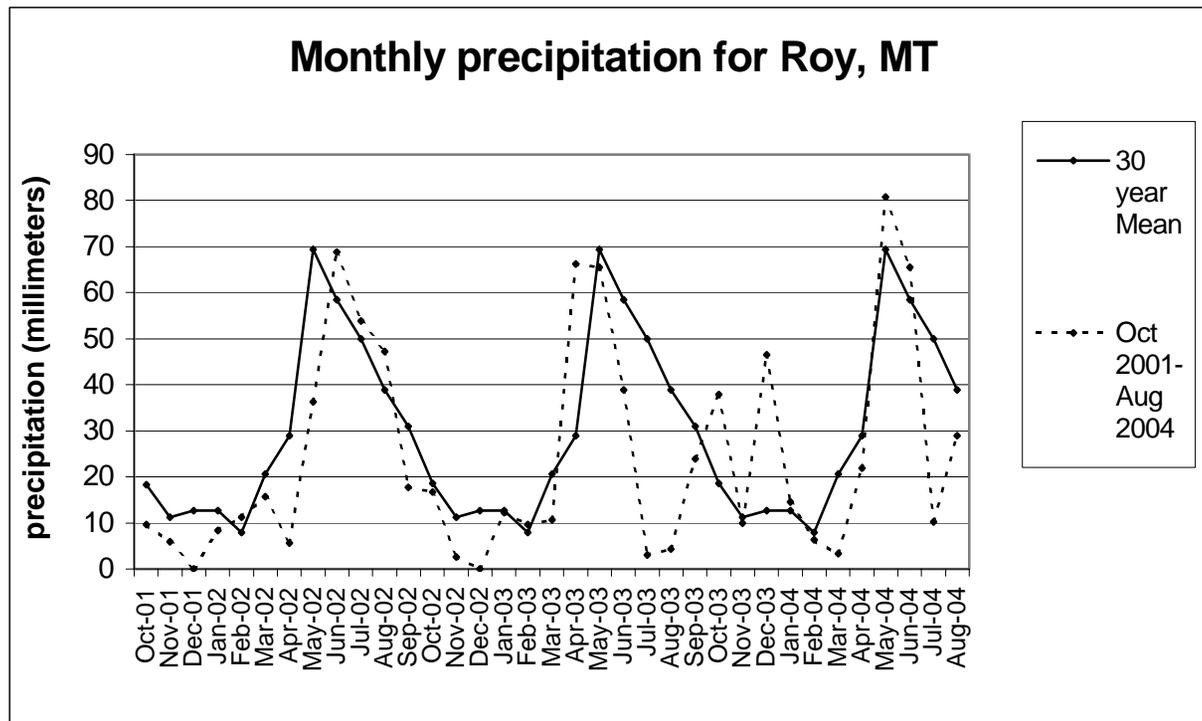


Figure 11. Monthly precipitation from October 2001 through August 2004 and the 30 year mean for Roy, Montana.

APPENDIX B

TEMPERATURE DATA

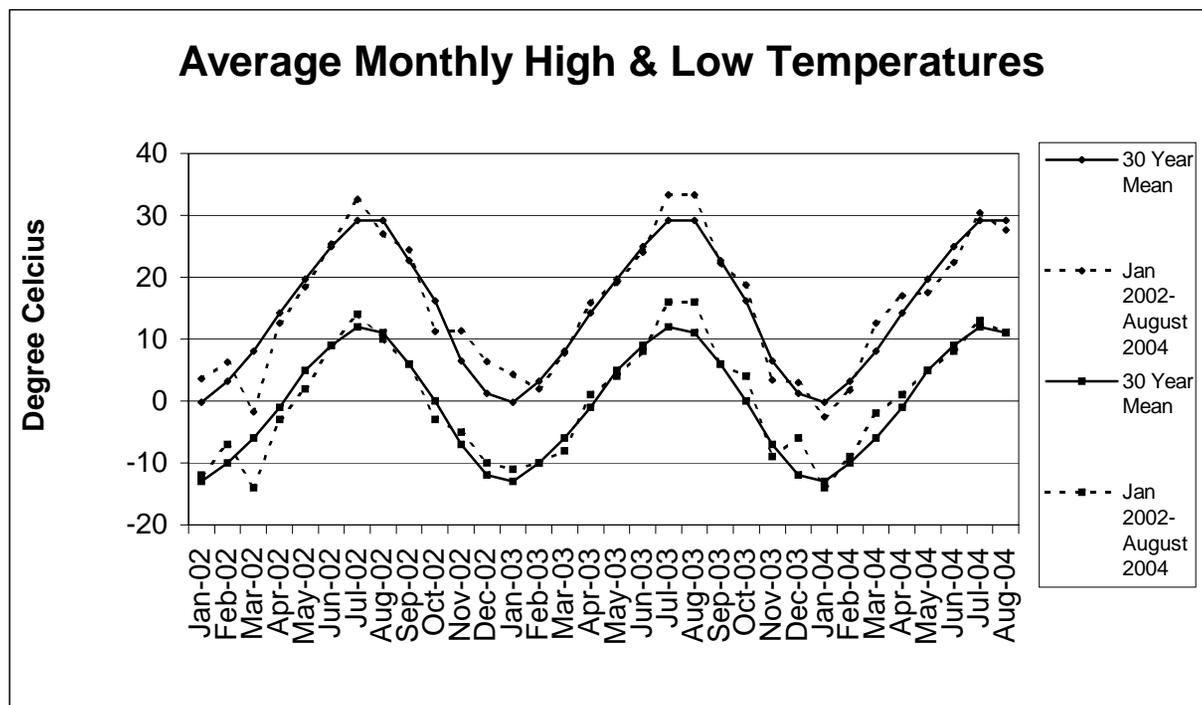


Figure 12. Monthly high and low temperature means from January 2002 through August 2004 and the 30 year mean for Roy, Montana.

APPENDIX C

SPECIES COMPOSITION DATA

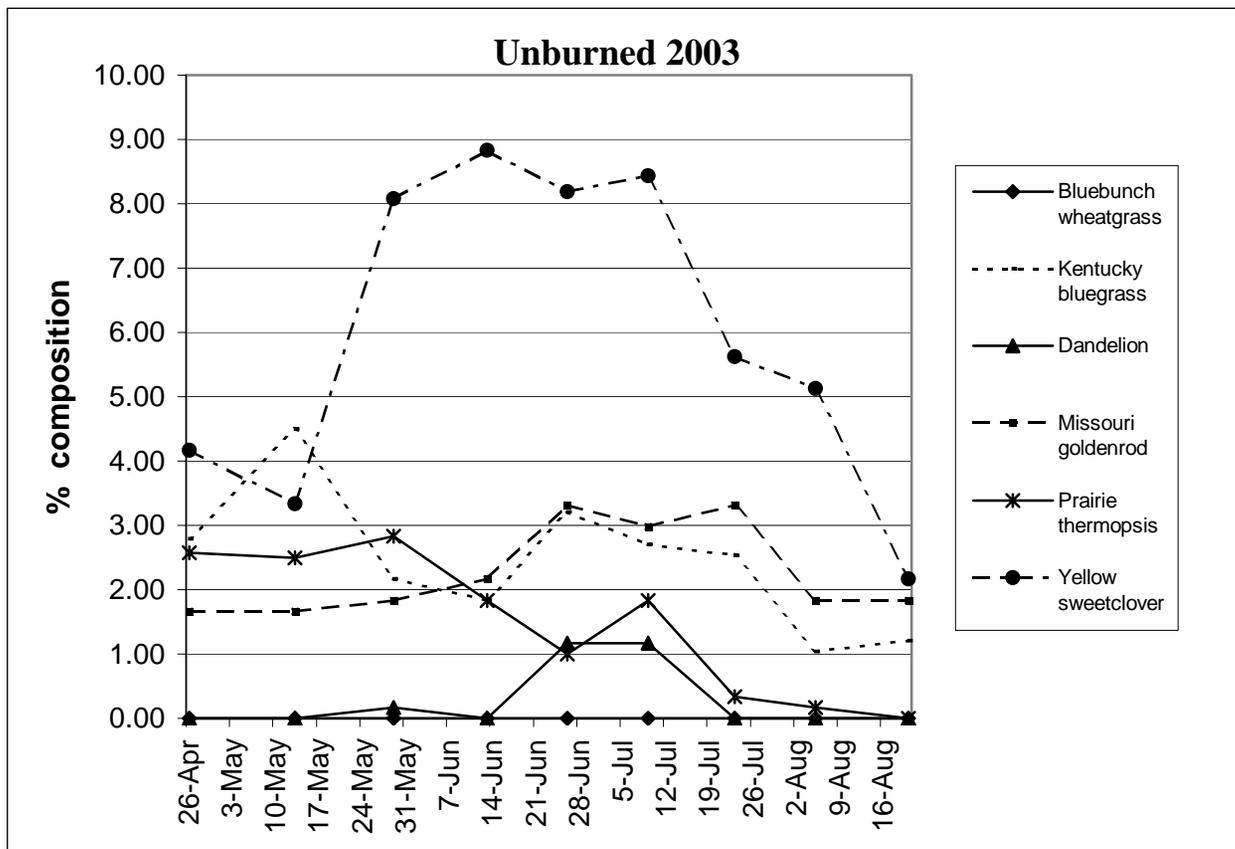


Figure 13. Species composition for important deer forages (Mackie 1970) in unburned areas in Summer 2003.

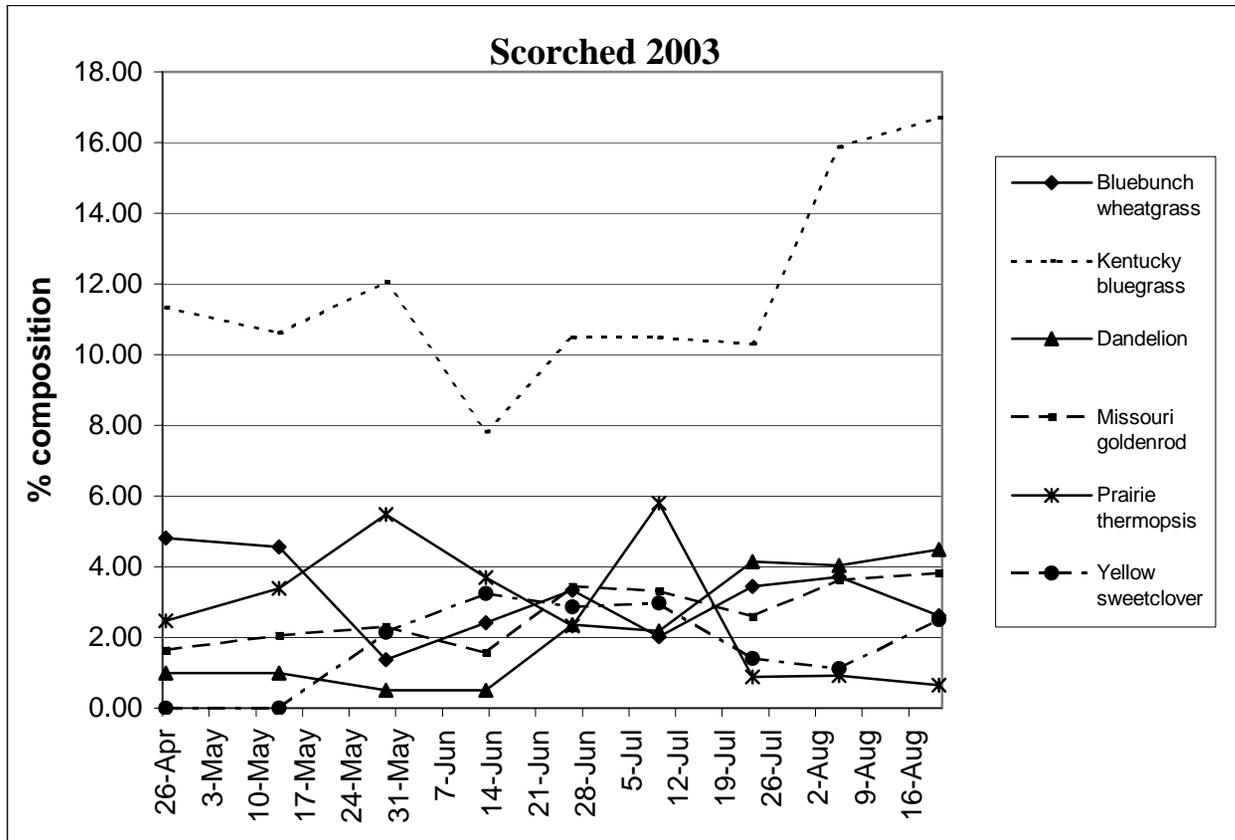


Figure 14. Species composition for important deer forages (Mackie 1970) in scorched areas in Summer 2003.

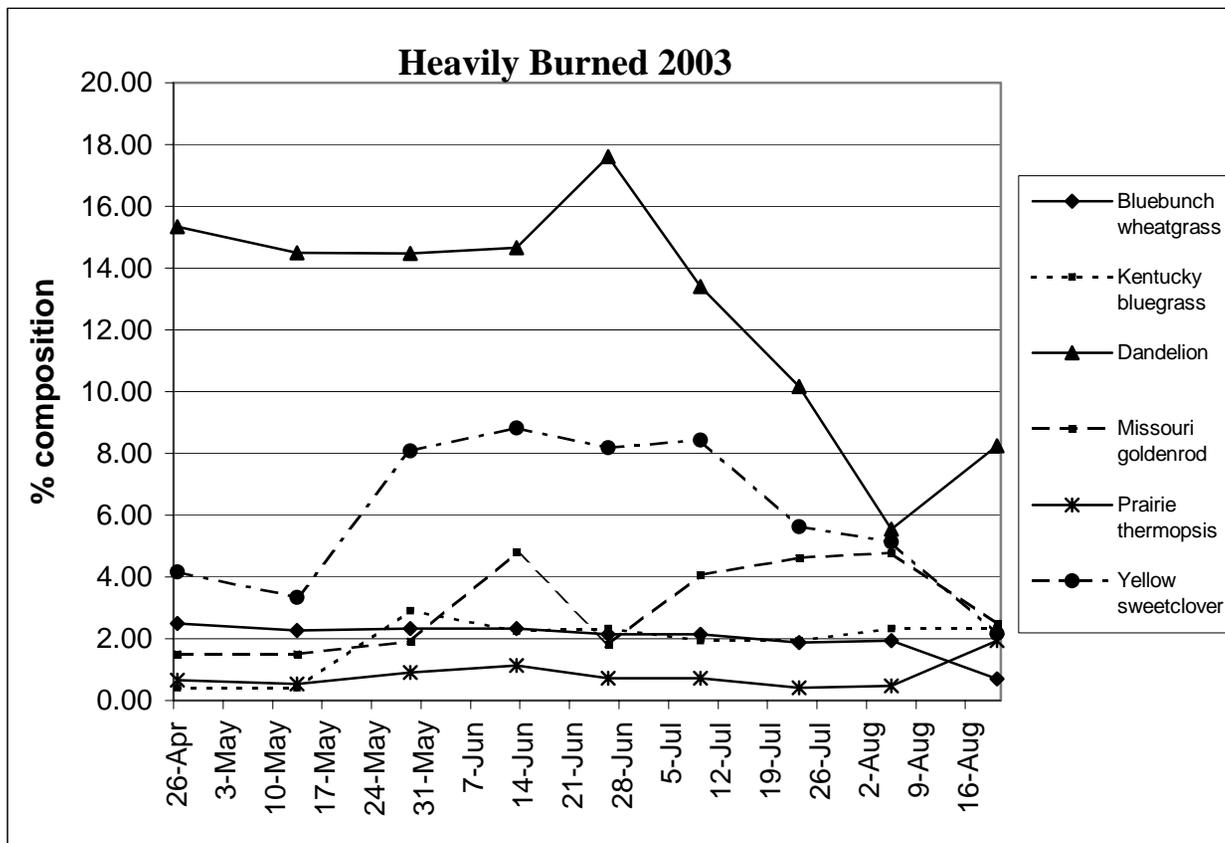


Figure 15. Species composition for important deer forages (Mackie 1970) in heavily burned areas in Summer 2003

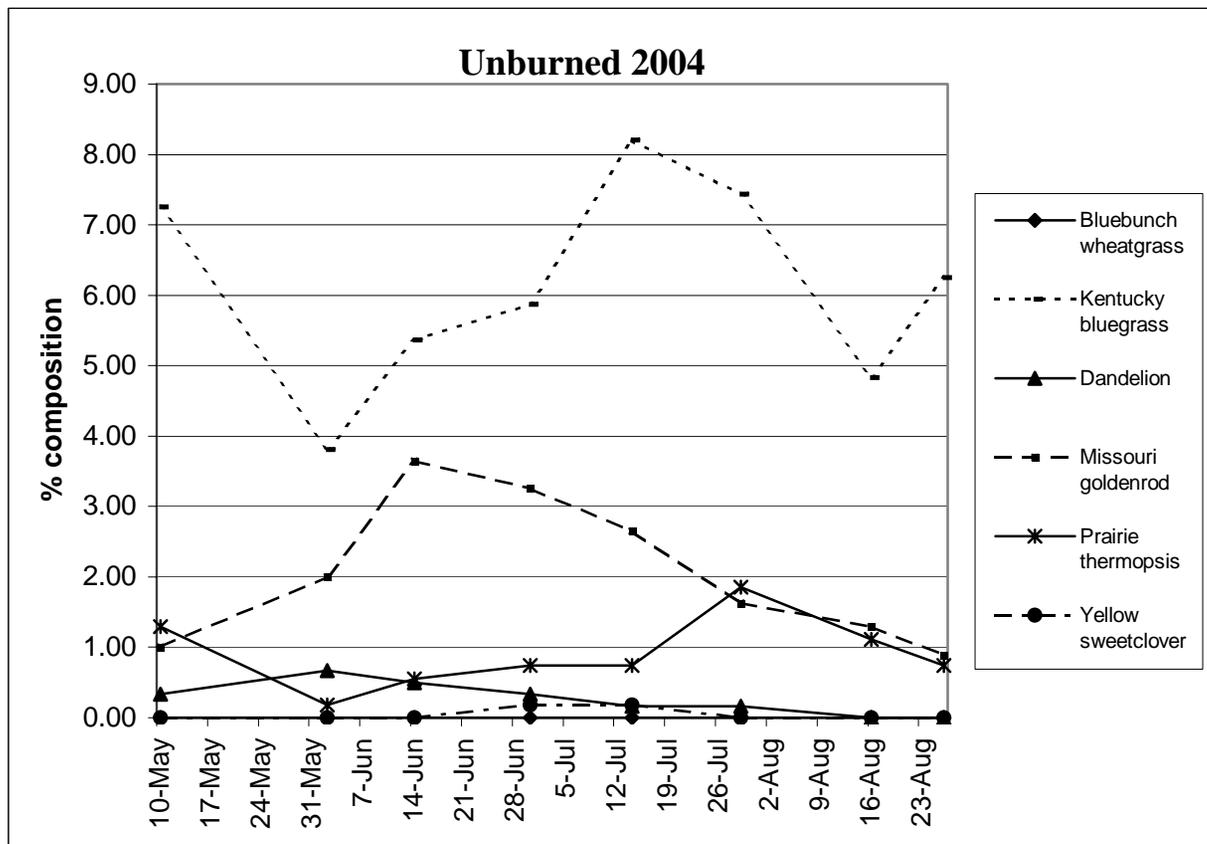


Figure 16. Species composition for important deer forages (Mackie 1970) in unburned areas in Summer 2004.

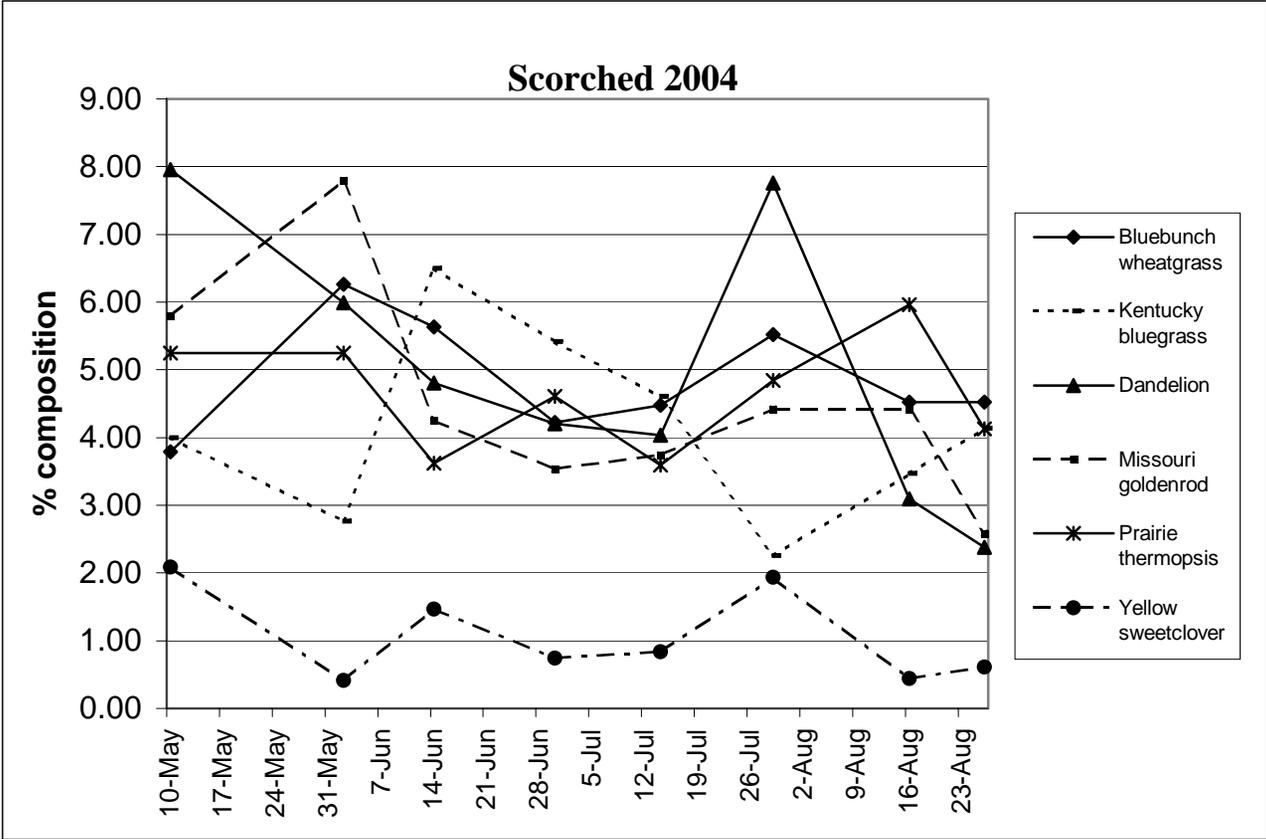


Figure 17. Species composition for important deer forages (Mackie 1970) in scorched areas in Summer 2004.

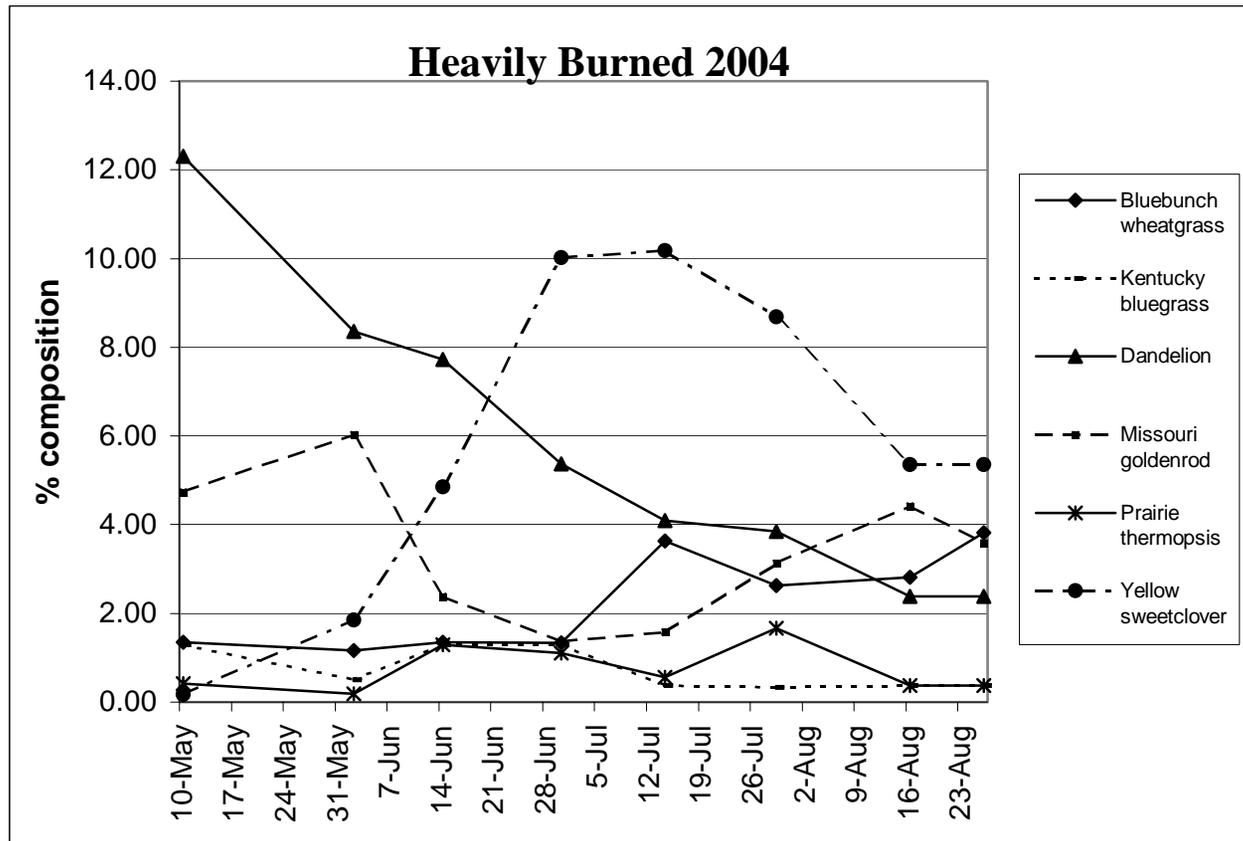


Figure 18. Species composition for important deer forages (Mackie 1970) in heavily burned areas in Summer 2004.

APPENDIX D

MULE DEER DIETS

Table 4. Mule deer dietary analysis for individual spring and summer months and fall and winter seasons.

Plants	Percent							
	April	May	June	July	August	September	Fall 03	Winter 03-04
Agropyron smithii	9.2	3.0	*	1.2	6.4	*	*	
Agropyron spicatum	6.9	0.6		2.1	0.6			
Bouteloua gracilis	*	*	*					
Bromus inermis	*	*	*					
Calamagrostis montanensis	*							
Carex filifolia	*	*		0.2				
Carex geyeri	*	*		2.6	*			
Carex spp.		*		0.2		*	*	*
Hordeum jubatum	*	*	*					
Koeleria macrantha	4.4	*	*					
Poa pratensis	5.5	7.9	4.2	*		5.0		*
Poa spp.	6.5	0.5		*				
Stipa viridula	3.8	*		5.4			*	*
Other Grass							0.1	0.3
Grass (see * above)	4.1	5.2	4.1	1.9	1.9	1.6	2.3	1.0
Total Graminoids:	40.4%	17.2%	8.3%	13.6%	8.9%	6.6%	2.4%	1.3%
Achillea millefolium stem			*	*	*			
Artemisia frigida hair	*	*	*	*		*	*	*
Artemisa ludoviciana hair	*	*		*	*			
Lupinus caudalis stem & hair			*		*			
Melilotus/Medicago stem & hair	*	*	12.2	4.8	8.1	8.0	*	
Solidago missouriensis stem & hair		*	*	*	12.0	12.4	*	
Sphaeralcea coccinea hair			4.4	*	*			
Taraxacum officinale stem			*	*	16.4			
Thermopsis rhombifolia stem & hair			3.7		11.9			
Mustard hair	*	*		*	*			
Other Forb leaf	0.6		0.3					

Other Forb stem	0.6	1.1	0.3		1.0	2.3	0.4	
Forb (see * above)	2.7	4.8	8.5	6.0	4.6	0.8	1.2	0.9
Total Forbs:	3.9%	5.9%	29.4%	10.8%	54.0%	23.5%	1.6%	0.9%
Artemisia spp. leaf		3.0	1.0	1.4	1.6	3.7	0.8	
Artemisia spp. stem	11.3	5.4	7.3	6.6	12.6	38.2	8.0	14.1
Artemisia tridentata hair	2.5	5.0	1.8	4.7		12.0	19.9	32.0
Juniperus spp.	40.0	58.5	43.2	60.3	8.7	14.0	66.8	47.2
Pinus ponderosa		*	4.4	*	5.5			4.2
Conifer bark		0.8						
Other Shrub leaf	0.8				1.9		0.4	
Other Shrub stem	1.1	2.8	2.8		2.6	0.7		0.2
Shrub (see * above)		1.2		1.4				
Total Browse:	55.7%	76.7%	60.5%	74.4%	32.9%	68.6%	95.9%	97.7%
Cornus spp. hair (forb or shrub)	0.0%	0.0%	1.8%	0.0%	4.2%	0.0%	0.0%	0.0%
Seed coat	0.0%	0.1%	0.0%	0.2%	0.0%	0.0%	0.0%	0.0%
Moss	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%
Insect	0.0%	0.0%	0.0%	1.0%	0.0%	1.3%	0.1%	0.0%
Animal Hair	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
TOTAL	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%