AN ASSESSMENT OF PRESCRIBED BURNING VERSUS SHEAR-BLADING FOR ELK HABITAT MANIPULATION IN THE DUCK MOUNTAINS, MANITOBA

By

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ABSTRACT

Prescribed burning was a viable method of habitat manipulation in the Duck Mountains of Manitoba. Elk exhibited an increase in usage of the prescribed burn areas while deer and moose usage did not show any change when compared to the controls. The prescribed burn plots supported significantly greater amounts of desirable forage than their controls and the shear-bladed plots. Shear-blading and prescribed burning treatment areas exhibited many similar effects of vegetation response and ungulate usage with two major exceptions - grass and forb production was increased and woody vegetation was reduced on the areas treated with prescribed burns. The shear-bladed areas exhibited increased woody species production in comparison to the controls.

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Chapter I

INTRODUCTION

1.1 BACKGROUND

Historically, elk (*Cervus elaphus manitobensis*) ranged over most of southern Manitoba (Fig. 1) and today are still found in several areas including the Duck Mountains, Riding Mountain, Porcupine Hills, Spruce Woods, the northern Interlake and the Red Deer River area (Fig. 1). Elk are not as abundant in Manitoba as they once were. Coupled with the risk of severe winters, they are also threatened with loss of habitat and a decline in the quality of habitat remaining. These problems are most evident in the Duck Mountain area of Manitoba (Manitoba Wildlife Branch 1986).

The Duck Mountains of Manitoba are located in the west central portion of the province, approximately 430 km northwest of Winnipeg (Fig. 2). In 1906, a 3760 km^2 area within the Duck Mountains was established as a forest reserve. Within this designation, another area encompassing 1240 km^2 was established as a provincial park in 1961. Throughout the summer and fall of 1961 a fire burned on this area north of Childs Lake (Manitoba Wildlife Branch 1986). This fire had a coverage of 20,720 ha (Davies pers. comm.)

For 10-12 years after this fire, a significant number

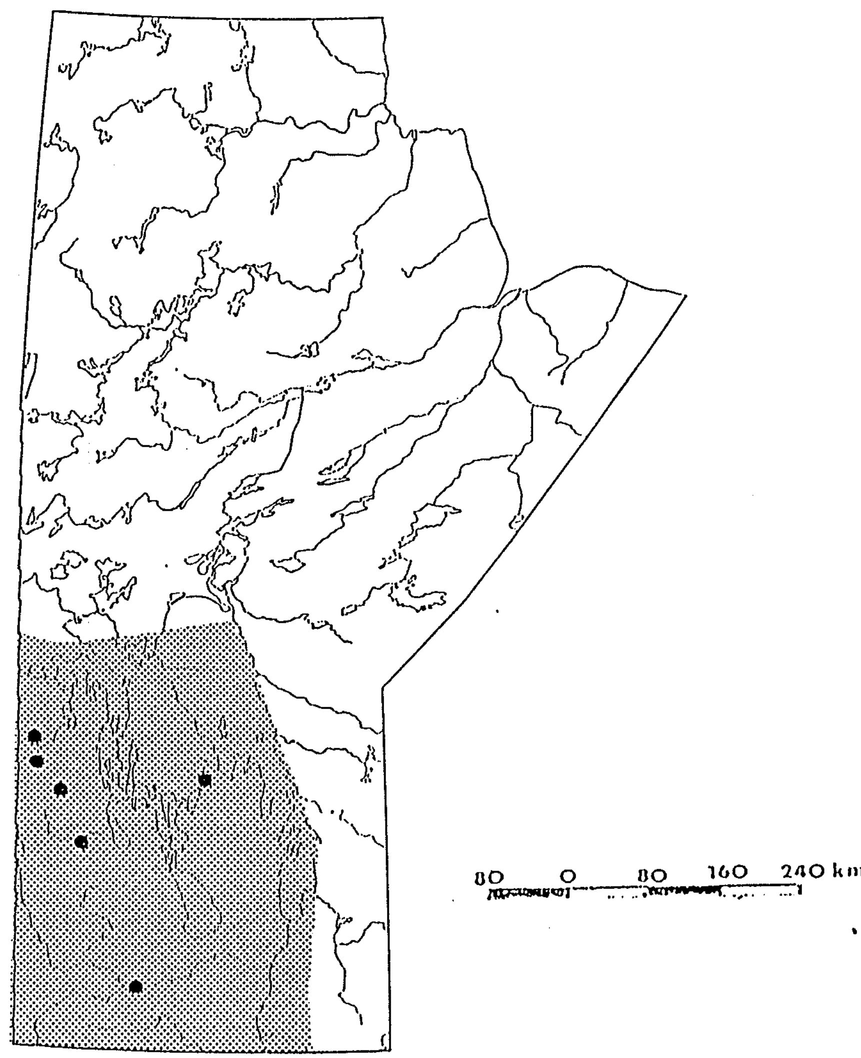


Figure 1: Historical range of elk in Manitoba and current provincial elk populations (modified from Bryant and Maser 1982).

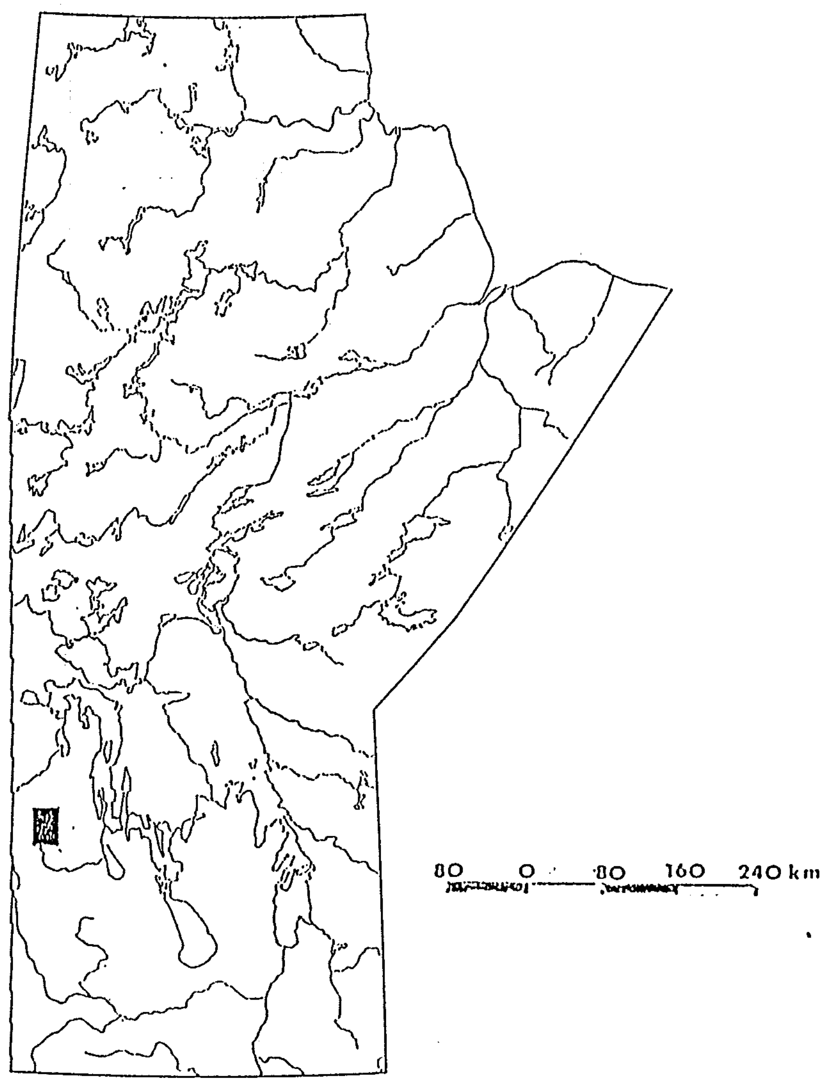


Figure 2: Location of Duck Mountain Provincial Park and Forest

of moose (Alces alces) and elk were supported by the successional changes of the grasses - redtop (Agrostis stolonifera), spiked redtop (A. exerata), fringed brome (Bromus ciliatus), bearded wheatgrass (Agropyron subsecundum), slender wheatgrass (A. trachycaulum), Richardson's needle grass (Stipa richardsonii) and western porcupine grass (S. spartea), - and browse species - such as aspen (Populus tremuloides), willow (Salix spp.), and wild rose (Rosa spp.), - which became abundant after the fire (Manitoba Wildlife Branch 1986).

No management of the vegetation occurred after this fire and, presently, elk habitat within the provincial park and forest consists primarily of mature stands of poplar (P. tremuloides and P. balsamifera) and poplar-conifer stands. Elk winter range is available in the surrounding lowlands but this area is used extensively for agricultural activities (Manitoba Wildlife Branch 1986). The elk population in this area has declined from a high of 2.8 elk/km^2 10-12 years after the 1961 fire to 0.4 elk/km^2 in 1986 (Davies 1973, Ball 1987).

Since 1961 there have been few fires on Duck Mountain, and forestry operations have declined as little virgin timber remains. However there has recently been some interest in the oriented strand board production potential of the Duck Mountains. Much of the area is covered by mature poplar which previously had little market value to forestry operations in the area, and is not of great benefit to wildlife after it grows beyond the reach of browsing animals (Rounds 1979).

Traditional management of the Duck Mountain elk population included limited licencing and seasons. Past habitat management included a development program of bulldozed plots and a spring burning program of 5 upland grass meadows covering 1400 ha (Manitoba Wildlife Branch 1986). Prescribed burning was considered a viable option in attempting to rejuvenate elk habitat because of its potential to modify habitat with time and cost efficiency.

1.2 PURPOSE AND OBJECTIVES OF STUDY

The elk population in the Duck Mountain area of Manitoba is declining due to habitat deterioration, declining amounts of available foodstuffs and increased hunting pressure. Elk depredation on agricultural lands is increasing and it is felt this was a symptom of habitat deterioration. The Manitoba Department of Natural Resources felt that by rejuvenating elk habitat within the Duck Mountains both of these problems could be alleviated. A prescribed burn program was proposed as the best technique for rejuvenating habitat within the provincial park and forest. The purpose of this study was to evaluate the efficacy of a prescribed burning program in meeting management goals by comparing prescribed burning vs. shear-blading.

1.2.1 Objectives

The primary objective of this study was to assess elk habitat manipulation methods in the Duck Mountains of Manitoba. Secondary objectives included:

1. comparison of the effect on vegetation of shear-blading vs. prescribed burning.
2. evaluation of immediate wildlife use - elk, moose, and white-tailed deer (*Odocoileus virginianus*) - on treatment vs. control plots for both treatment types.
3. recommendation of further possible vegetation management procedures to rejuvenate elk habitat within the Duck Mountains.

1.3 RESEARCH QUESTIONS

The following null hypotheses were addressed in this study:

1. Elk would not show change in use of the prescribed burn area after the burn.
2. Other ungulates (moose and white-tailed deer) would not show a change in use of the area after the burn.
3. Vegetation in the treatment areas would not show a change in the abundance of grasses, forbs, and/or woody vegetation.

1.4 DELIMITATIONS

This was a two-year study in which baseline data were gathered. A two-year study is not sufficient to adequately assess the long-term effects of prescribed burning. This study has only attempted to define the quantitative aspects possible within a two-year study. It was assumed that further studies would be conducted in this area in subsequent years. Management recommendations were presented in this report but no formal elk habitat management plan was attempted.

1.5 DEFINITION OF TERMS

The following terms will be used throughout the course of this study.

Cover: the percentage of the ground surface covered by a plant (Smith 1980).

Density: the number of individuals in relation to the space in which they occur (Smith 1980).

Forb: any plant species not falling under the categories of either grasses or woody vegetation.

Frequency: the percentage of quadrats in which a particular species occurs (adapted from Smith 1980).

Grasses: herbs with fruit in the form of grain. Encompasses true grasses and grass-like species (Looman and Best 1987).

Habitat: the range of environments in which a species occurs (Smith 1980).

Prescribed Burn: the application of fire to natural fuels no a pre-determined area to accomplish planned management objectives (Miller 1979).

Quadrat: a sampling unit of any shape and size (Smith 1980).

Shear-blading: the mechanical removal of surface vegetation using a bulldozer equiped with a blade of some sort. Usually accomplished in winter.

Woody Vegetation: encompasses shrubs, saplings and tree species.

Chapter II

LITERATURE REVIEW

2.1 INTRODUCTION

The following is a review of related literature dealing with fire as a tool in habitat manipulation, more specifically elk habitat. This review also deals with some historical aspects of fires and its role in ecosystems as well as possible reasons as to why elk are diminishing in their known range in Manitoba.

2.2 HABITAT AND ELK

Historically, elk were found in large numbers on the Great Plains and mid-continental prairie areas of North America (Murie 1951). Elk habitat preferences are heterogeneous and many ecotypes can sustain populations of elk. Various areas are chosen by elk at different times of the year for different purposes depending on the season or reproductive status of the animal (Nelson and Leege 1982, Skovlin 1982). Today, free-ranging elk are found in 4 provinces and 12 states. They are abundant only in the upland regions of 9 western states and 2 provinces - Alberta and British Columbia. These elk populations are found primarily in coniferous forests associated with mountain, canyon or foothill ranges (Skovlin 1982). Over their North American range prior to settlement, members of the genus Cervus showed wide habitat tolerance. This apparent shift towards the use of rugged, broken terrain and related cover types may be due to the influences of human activities (Skovlin 1982).

In Elk Island National Park, Alberta, elk choose the upland grasslands for feeding (Cairns and Telfer 1980). Other studies show that elk prefer the early to mid-successional stands (Singer 1979, Trottier and Samoil 1978). In Riding Mountain National Park, Manitoba, it has been suggested that the intensive use of shrubland by elk is due to a lack of numerous grasslands in the park. Here the elk feed on forbs and grasses throughout the seasons but woody browse makes up the largest proportion of its diet, increasingly so as the winter progresses (Trottier and Samoil 1978). Hunt (1979) found similar results in his study of elk in Saskatchewan as did Moran (1973) in Michigan, Leege and Hickey (1977) in Idaho, and Gates (1980) in the boreal mixed wood forest of Alberta. These studies indicate that snow depth is a determining factor in food selection as elk will not crater where the snow is too deep. Maximum snow depth in which elk will crater is approximately 60 cm (Moran 1973) and elk will usually not crater in snow deeper than 30 cm (Gates 1980).

The overall decline of elk populations in Manitoba seems to coincide with the peak of the settlement period in 1881 (Dubois 1976). In southeastern Idaho human activity has caused elk to "compress" in remote portions of their range (Hayden-Wing 1979). This has also been cited as a possible influencing factor of elk winter range in Alberta (Telfer 1978). Edge and Marcum (1985) found that logging activities effected elk movements in their Chamberlain Creek, Montana study areas.

Increased settlement in traditional elk habitat areas has brought increased agriculture. With this has come the problem of farm crops suffering elk-induced damage. This may cause significant conflicts along the forest-farmland interface, particularly in years of weather-delayed harvests (Hunt 1979). Increased pressure on elk due to legal harvest and illegal harvest coupled with diminishing habitat has influenced elk populations throughout their range (Peek et al. 1982) in Manitoba.

2.3 THE ROLE OF FIRE IN ECOSYSTEMS

In general, fire works within ecosystems to decompose, recycle, and select. As an agent of decomposition, fire releases, in the form of a heat wave, the chemical energy stored in the available fuel, and it liberates, in slightly altered forms, many of the constituent nutrients residing in the litter (Scotter 1972, James and Smith 1977, Pyne 1984).

Fire does more than degrade, it also recycles. On a microscale, it recycles nutrients, inorganic and organic, liberating them from various biological reservoirs and rendering them accessible to different sorts of organisms. On a macroscale, fire recycles the biota itself, sustaining a system of different species, age classes, and physical arrangements. Over long periods of time, fire influences evolutionary developments through its selective actions (Pyne 1982, 1984).

For most ecosystems, fire was the natural catalyst for diversity that provided stability in those ecosystems. Many ecosystems are said to be fire dependent, meaning that the ecosystem's continued existence depends on the periodic occurrence of fires (Kayall 1968, Smith 1980, Swain 1980). When fires occur with sufficient regularity, stability of the ecosystem is increased by maintenance of a mix of successional stages, communities and stand ages (Chandler et al. 1983). Without fires, forested communities tend to become monocultures and are plagued with overstocking of trees, excessive fuel accumulation, stagnation, and inadequate reproduction. These factors encourage disease and insect irruptions (Rowe and Scotter 1973, Pyne 1984). Where fires occur with historical prevalence the fires cannot be extensive because fuels are broken. Fire suppression in these areas causes a build up in fuel loading and can set the stage for much more devastating fires than would have occurred without suppression (Pyne 1982). Wildlife, in most cases, decline in numbers and diversity with a lack of fire (Wright and Bailey

1982).

Fires tend to be conservative rather than catastrophic in their effects. They tend to sustain an existing community rather than replace it, though a certain amount of lag time may be needed to bring about this restoration (Pyne 1984). It is believed that species and communities which evolved with fire may show drastic changes with the exclusion of fire. As an example, communities in the Boundary Waters Canoe Area Wilderness of Superior National Forest and contiguous Quetico Provincial Park (Ontario) regions have adapted to fire and in the long-term absence of fire, these communities tend to fragment. Fire suppression has likely resulted in unforeseen changes in populations and community structures in these areas (Apfelbaum and Haney 1985). These conclusions can be extrapolated to encompass all fire-adapted ecosystems.

In primitive forests, fire was nature's most effective means of maintaining all temporary forest types such as aspens, paper birch (<u>Betula papyrifera</u>) and various pine species. Without fire, none of these species could have persisted in the quantities found by the pioneers (Graham et al. 1963).

Many factors - including temperature, moisture and severity of disturbance - influence the recovery of vegetation in the boreal forest region after disturbance (La Roi 1967, Heinselman 1970, 1973). In the mixed woods section of the boreal forest, Rowe (1956) suggested that, after a disturbance, such as fire, an area goes through a number of seral stages. Poplar-poplar, poplar-spruce, spruce-spruce is one such sequence. The end product of burning in these areas is a mosaic of vegetation on the landscape (Peek 1974, Irwin 1975). This resulting mosaic in the mixed woods section of the boreal forest provides habitat for elk (Blyth and Hudson unpubl.).

Several factors affect the rate of succession and the floristic composition of each seral stage after fire. Precipitation, slope, soil type, root competition, litter accumulation, temperature, animal use and amount of sunlight are a few factors which have a direct effect on succession (Wright and Heinselman 1973). The intensity and frequency of burning also affects the rate of succession (Usher 1977).

In addition to the gross changes in plant communities, fire also affects the structure of each community. Fire opens up the forest canopy to light which can penetrate to the understory. In addition to the increase in plant diversity and numbers, the quality of the forage in the openings is increased (Cowan et al. 1950, Dix and Swan 1971, Rowland et al. 1984, DeByle et al., 1989). After a fire, many browse species are richer in protein and other nutrients (DeWitt and Derby 1955, DeByle et al. 1989).

The Duck Mountain study area falls into the prairie-forest transition zone of the boreal forest and is termed aspen-parkland. A fescue grassland association is present within this designation (Wright and Bailey 1982). Bailey and Anderson (1978) found that a complex relationship exists between prescribed fire and plains rough fescue (Festuca campestris)-western porcupine grass communities in the aspen-parkland of central Alberta. The first growing season, after early spring or late fall burning, total herbage yields were the same as the unburned control. However, there were significant changes in plant composition. Fire usually increased cover and frequency of most forbs. The half-fringed sagebrush (Artemisia frigida) was reduced by both fires.

The plains rough fescue-western porcupine grass community appears to have developed as a fire-climax grassland (Bailey and Anderson 1978). It is well adapted to fire. The decrease in burning because of strict fire control enforcement after settlement in the early 1900's has resulted in tree and shrub invasion in fescue prairie (Maini 1960, Johnston and Smoliak 1968, Bailey and Wroe 1974, Scheffler 1976).

This suppression of fire led to forest invasion of grasslands all along the prairie-forest border of the Great Plains (Ahlgren 1960, Kucera et al. 1963, Daubenmire 1968, Anderson 1973, Bragg and Hulbert 1976). Throughout the prairie-forest transition region in North America, a complex of factors interact to determine the rate and extent to which prairies are invaded by woody vegetation. Along the transition zone in the Northern Great Plains, the principal woody invader is trembling aspen, which, in the absence of fire, grazing, mowing or other disturbance, will actively encroach into prairies and, where moisture is sufficient, will eventually develop dense forest stands, thereby replacing the prairie species. In the aspen-parkland region, aspen typically occurs in groves or "aspen islands" in a prairie expanse. Aspen is an especially persistent woody species of the prairie where it occurs because of its ability to vigorously resprout after any disturbance such as fire (Svedarsky and Buckley 1975).

Annual spring burning for 25 to 30 years in one area of central Alberta eliminated few plant species, increased the diversity of herbaceous species, and maintained forest cover at about pre-settlement levels (Anderson and Bailey 1980). In unburned areas, aspen forest cover increased from 5 percent in 1940 to 68 percent in 1975. Wright and Bailey (1980) stated that "based on present knowledge, fire apparently has the potential to remove litter build-up on ungrazed fescue grassland and to control shrubs with only moderate damage to the grasses. Forage losses can be minimized by using fire only during those springs that are preceded by above normal precipitation. The desired interval for use of fire to control shrubs is probably 5 to 10 years."

Shrubs of the aspen-parkland are well-adapted to fire. After a burn, even though a majority of the aspen may be killed, these species will sucker profusely (Graham et al.

1963, Davis and Brown 1973, Wright and Bailey 1982). Without new sprouting and in the absence of disturbances that keep out its taller competition, aspen groves become senescent and eventually succeed to other trees (Pyne 1984). Controlled burning may help to restore the disturbance regime (Christensen 1985).

Besides aspen, other species that sprout in great numbers after fire include western snowberry (Symphoricarpos occidentalis), willow, roses (Rosa spp.), wild raspberry (Rubus spp.), saskatoon (Amelanchier alnifolia), hazel (Corylus spp.), mountain maple (Acer spicatum), alder (Alnus spp.), wild gooseberry (Ribes oxyacanthoides), serviceberry (Amelanchier florida), and cherries (Prunus spp.) (Leege and Hickey 1971, Wright and Bailey 1982). New suckers of all species are palatable browse (Wright and Bailey 1982). In addition to the increased production of vegetative portions of shrubs, the production of fruit also increases (Wright and Heinselman 1973).

The herb component of the understory changes significantly after a fire; pioneer species such as thistle (Cirsium spp.) and goldenrod (Solidago spp.) are the first to colonize the clearings (Daubenmire 1947). Ferns (Pteridium and Osmunda spp), blueberries (Vaccinium spp.) and grasses (Poa, Festuca, Stipa and Agrostis spp.) invade the clearings soon after the pioneer species (Wright and Bailey 1982) by vegetative sprouting or suckering, viable seed buried in the soil, and invasion by propagules (Johnson 1981).

The effect of fire on soil indirectly affects the vegetation and its response to disturbance. As there is little cover over the soil after a disturbance, the soil heats up and cools much faster. The result is earlier growth of plants in spring (Daubenmire 1947). Fire also rids the soil surface of organic debris releasing nutrients from the debris (Pyne 1984).

2.4 ELK HABITAT AND MANIPULATION

Historically, many native Indian tribes used fire to modify their surroundings. The Sioux were known to use fire on the Great Plains as were other tribes (Pyne 1984). Certainly, the most pervasive impact of aboriginals on elk was that of habitat modification by fire. These activities may have been conducive to producing and maintaining healthy elk herds. This was a favourable influence in that fire set back plant succession to stages that produced a wide variety and abundance of palatable forage. Combined with natural fires, these set fires probably affected thousands of hectares of elk habitat annually (McCabe 1982).

With the arrival of the European settlers to North America came an era of fire suppression. Settlers tried to control fires to prevent loss of crops, livestock, and buildings. Early studies supported the belief that people viewed all fires as bad and demonstrated that vigorous suppression practices received virtually unanimous public support (Taylor and Mutch 1985). Consequently, fire as a tool for habitat manipulation, has not always been well-received and this invasion of woody vegetation is a contributing factor to habitat decay for species dependent on grasslands (Wright and Bailey 1982).

Since wildland fire is no longer prevalent throughout much of the elk range, some form of manipulation is often necessary to maintain or enhance elk habitat. The best type of habitat manipulation includes plots at various stages of succession rotated on a long-term cycle. The elk can then use the different seral stages in the plots and still be near to cover within the mature stands (Stelfox et al. 1976).

Prescribed fire is most useful in areas where land is managed extensively rather than intensively, where management objectives seek to harvest natural products or to preserve natural processes, and where at least some of the desireable effects stem from the nature of the fire (Pyne 1984).

A prescribed burn is defined as the skillful application of fire to natural fuels under conditions of weather, fuel moisture, and soil moisture that will allow confinement of the fire to a pre-determined area and achieve a desired intensity in order to accomplish certain planned benefits to one or more management objectives (Miller 1979). The major benefits of using prescribed burning as a management tool include the control of undesirable shrubs and trees, burning of dead debris, increase in herbage yields, increase in utilization of coarse grasses, increase in availability of forage, and improvement of wildlife habitat - more food with unburned patches for cover (Wright 1974). Several of these objectives can be achieved simultaneously with one burn which is the major advantage of using fire as a management tool.

Elk need adequate cover for shelter in winter and for concealment from predators throughout the year. Studies in Arizona and Colorado suggested that standing timber left after fire provided adequate cover (McCulloch 1969, Roppe 1974).

Various authors have reported that fires have produced beneficial habitat modifications for big game, including elk (Miller 1963, Lyon and Stickney 1966, Hendricks 1968, Biswell 1969, Lyon 1971, Martinka 1976, Davis 1977, Rowland et al. 1984, DeByle et al. 1989). Post-fire succession of herbs and shrubs can provide excellent habitat for elk until the forest canopy again closes out the understory (Skovlin 1982).

Results of prescribed fires for elk habitat management have been encouraging. Prescribed burns of forage areas have been used to maintain productivity of elk winter ranges by Leege (1968, 1969) and Leege and Hickey (1971). The results of these studies indicate that shrub height was reduced, basal sprouting was profuse, some new germination was recorded and forage was found to be more palatable to elk. In a study done at Canadian Forces Base Shilo in southwestern Manitoba, Strong

(1981) concluded that the regular occurrence of fire on the Reserve had enhanced elk habitat and influenced distribution and range use by altering habitat.

Rowland et al. (1983) found that elk diets on burn sites in their study area were nutritionally superior to those of elk in a comparable, unburned area. Additionally, blood parameters and weights of elk wintering on the burn indicated better condition of those animals (Weber et al. 1984). Because reproductive success is closely associated with animal condition and nutrition, the number of elk wintering on a burn area may increase due to increased productivity of the herd (Rowland et al. 1984).

DeByle et al. (1989) concluded that the benefits of prescribed fires (increases in quantity and quality of forage and browse) to ruminants, both wild and domestic, were substantial during the summer and autumn of the first several postburn years on their study sites in the Caribou National Forest, Wyoming. Aspen on the burned areas had higher digestibility and higher crude protein content than on unburned sites. They, like Rowland et al. (1984), found that the burned areas provided a more nutritious forage resource than unburned areas. Forage also became more accessible because dense shrub clumps were reduced and the biomass was within easy reach of grazing ungulates. Davis (1977) found, in his study area in southeastern Wyoming, that elk and deer use was greater in burned areas with standing dead timber than in clearcut areas without it. Fire opened up the canopy allowing light to enter, stimulating growth of forage plants, while the dead trees left standing provided good protective cover. Davis also stated there was a significant relationship between elk and deer use and the number of plant species present on his study sites. Davis found big game species selected feeding sites with a wide variety of forage species and he concluded that forage variety appeared to be as important as amount of forage.

Chapter III

METHODOLOGY

The Manitoba Department of Natural Resources, beginning in 1988, conducted prescribed burns on three small areas within the Duck Mountains in the hopes of rejuvenating elk habitat within this area (Fig. 4, 5, 6). A complete burn summary can be found in Appendix B.

A detailed vegetation survey was used to compare the immediate vegetation response of areas treated with prescribed burns and areas treated using shear-blading. Immediate ungulate response was evaluated using a variety of techniques. Statistical analyses were conducted following Sokal and Rohlf (1981).

3.1 DESCRIPTION OF SAMPLE AREAS

There were 5 different sample areas, 3 prescribed burn plots and 2 shear-bladed areas. These five areas were determined by the Manitoba Department of Natural Resources staff as being valuable for potential elk habitat. The 3 burn plots were 40 ha, 20 ha, and 64 ha respectively. The 2 shear-bladed areas were 10 ha each. Each of these manipulated areas had an adjacent control of similar size, floral community and physical aspect.

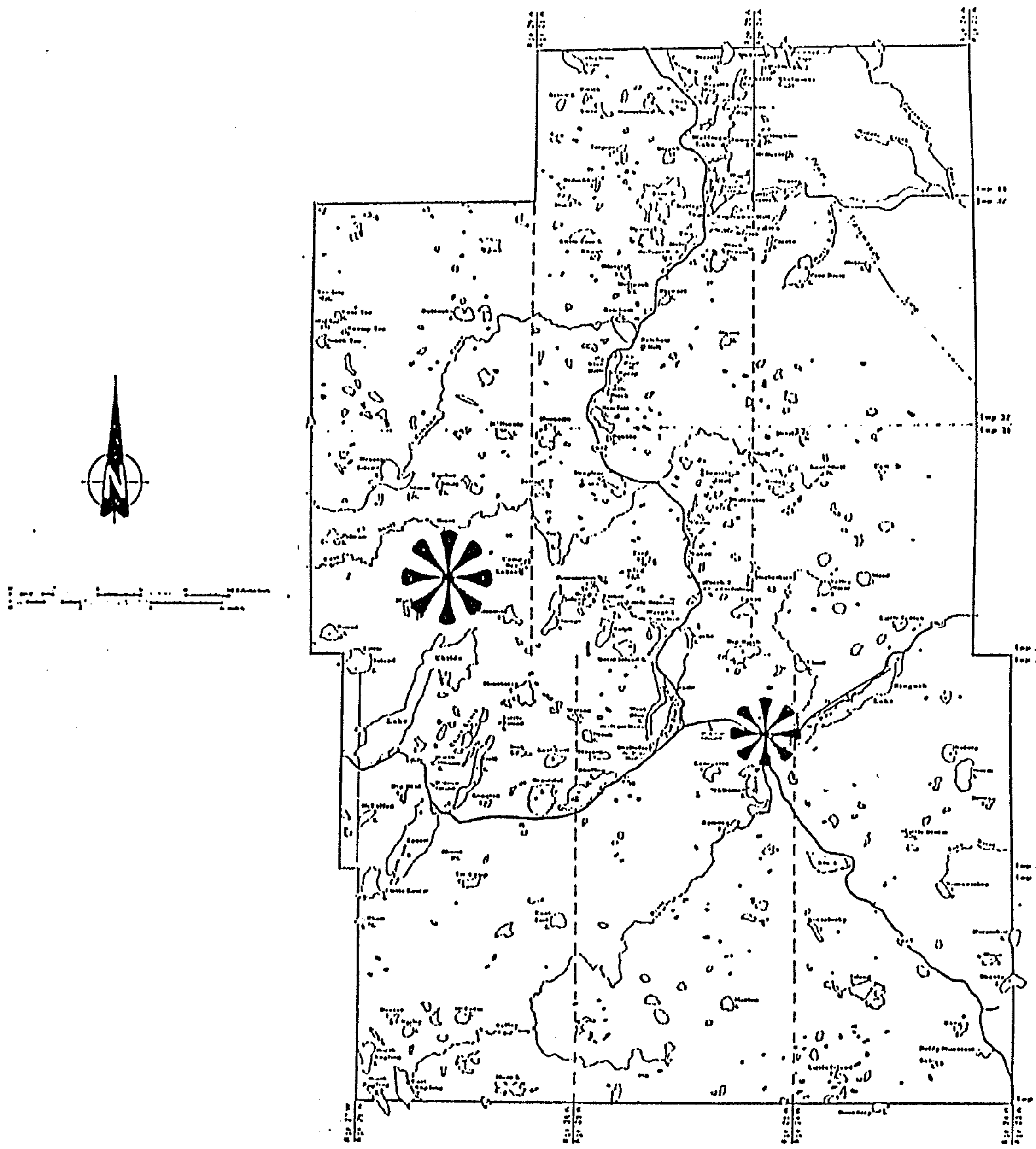


Figure 3: Location of Study Areas Within Duck Mountain Provincial Park and Forest

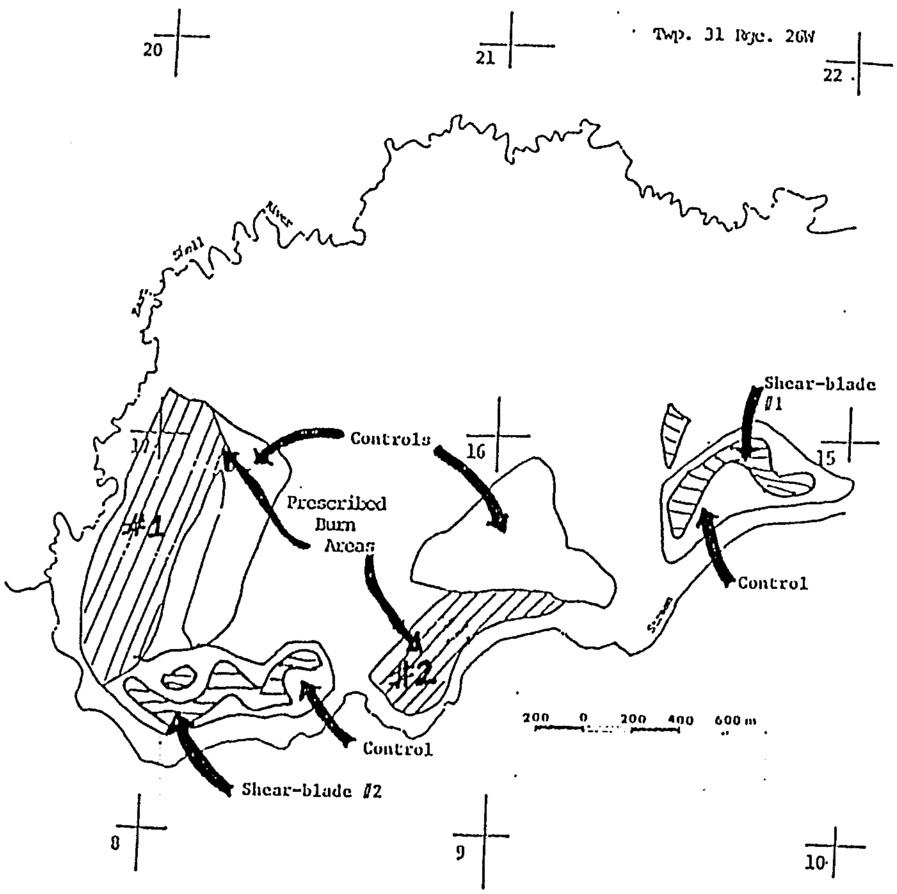


Figure 4: Location of Childs Lake Prescribed Burn Plots, Shear-bladed Plots and Their Adjacent Controls

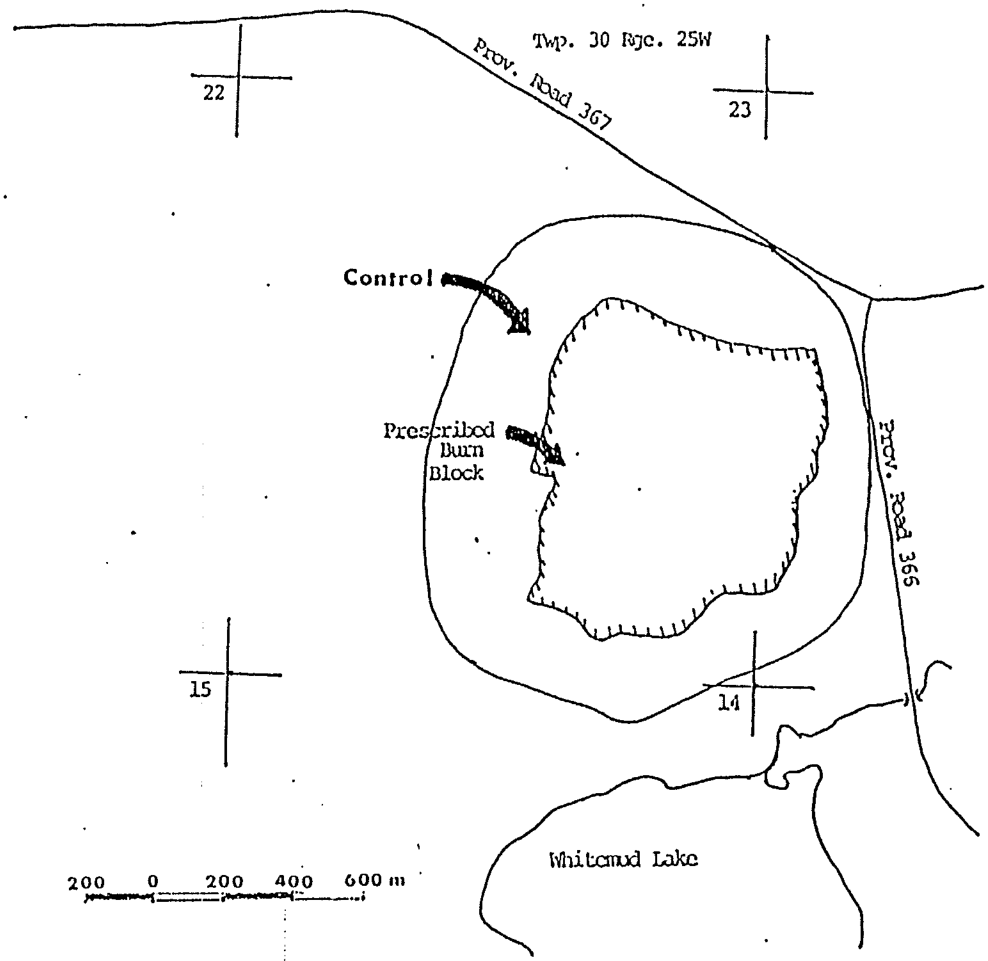


Figure 5: Location of Singush Lake Prescribed Burn Plot and its Control

3.2 PRESCRIBED BURN AREAS

3.2.1 Burn Plot # 1

This plot was located north of Childs Lake (Fig. 4, 5). It was a long, relatively narrow area of 40 ha running north and south with a small stream adjacent to its west side. Prior to the burn this plot had an aspen dominated overstory with small pockets of open, grass/willow areas and ground cover dominated by goldenrod, raspberry, veiny meadow rue (*Thalictrum venulosum*) and wild rose.

3.2.2 Burn Plot # 2

This plot was also located north of Childs Lake (Fig. 4, 5). It was an area of 20 ha running east and west with a small stream adjacent to its south side. Aspen dominated the overstory of this site pre-burn but grass/willow areas were fairly common and the ground cover was dominated by goldenrod, American vetch (*Vicia americana*), Canada Anemone (*Anemone canadensis*) and raspberry.

3.2.3 Singush Lake Plot

This 64 ha plot was located just west of the junction of provincial roads 366 and 367 (Fig. 4, 6). It had a marshy area adjacent to the south side. Some aspen bluffs were present on this site pre-burn but only on a limited basis. Grass/willow dominated the area. Jack pine (*Pinus banksiana*) was also present on this site, in limited numbers. Prior to the burn the ground cover was dominated by goldenrod, strawberry (*Fragaria virginiana*), veiny meadow rue and stinging nettle (*Urtica dioica*).

3.3 SHEAR-BLADED AREAS

3.3.1 Shear-blade Plot # 1

This 10 ha site was located north of Childs Lake and was east of the prescribed burn areas (Fig. 4, 5). This area had some variation in topography and also had a wetter area dominated by *Carex* spp. on the western end. Pre-manipulation this site had an aspen dominated overstory whereas the ground cover was dominated by species such as wild sarsaparilla (*Aralia nudicaulis*), raspberry, strawberry and wild peavine (*Lathyrus leucanthus*).

3.3.2 Shear-blade Plot # 2

This 10 ha site was also located north of Childs Lake (Fig. 4, 5) but was closer to the prescribed burn areas than the relatively remote shear-blade plot # 1. In comparison to Shear-blade # 1 there was very little variation in topography and there was no "wet" area on the site. Pre-manipulation this site's overstory was dominated by aspen with the occasional large spruce, and the ground cover was dominated by such species as goldenrod spp., raspberry, wild rose, and tall lungwort (Mertensia paniculata).

3.4 COMPARISON OF TREATMENT AREAS

The objective of this study was to compare prescribed burn and shear-bladed areas vs. their controls as well as a direct comparison of the two treatment types. In order to accomplish this, a detailed vegetation survey was conducted on the treatment types and their controls.

In 1988, 5 transects were randomly selected along the length and width of each sample area with 6 randomly placed 1 m^2 quadrats along each transect - 30 in total. These same quadrats were used in each of the subsequent sampling periods during this year. In 1989 the same 5 transects were used with 8 - 1 m^2 quadrats placed randomly along each transect - 40 in total. These same quadrats were used in each of the subsequent sampling periods conducted during this year. This increase in the number of quadrats was initiated to further reduce sampling error. The amount of 40 quadrats was deemed sufficient as per Daubenmire (1959) for these areas.

3.5 DURATION OF SAMPLE PERIOD

Due to the occurrence of a 1988 spring flood and the resulting inaccessability of the study area, sampling was conducted monthly in 1988 from June 30 to August 30. Each treatment area and its control were sampled on two different occasions during this period. In 1989 sampling was conducted monthly from May 30 to August 30. Each treatment area and its control were sampled on three different occasions during this period. Repeated sampling allowed for seasonal variation in the vegetation growth and provided a solid data base.

TABLE 3.1

SAMPLING DATES FOR TREATMENT AND CONTROL PLOTS

Sampling Plot	Date Sampled	Date Sampled	Date Sampled
		1988	
SB #1	X	July 5	August 5
SB #1 Control	X	July 6	August 8
SB #2	X	July 19	August 10
SB #2 Control	X	July 21	August 12
BP #1	X	July 13	August 11
BP #1 Control	X	July 13	August 11
BP #2	X	July 12	August 9
BP #2 Control	X	July 12	August 9
		1989	
SB #1	June 15	July 18	August 3
SB #1 Control	June 15	July 19	August 3
SB #2	June 21	July 26	August 14
SB #2 Control	June 22	July 26	August 15
BP #1	June 20	July 25	August 16
BP #1 Control	June 20	July 25	August 16
BP #2	June 16	July 20	August 18
BP #2 Control	June 16	July 21	August 18
SL	June 9	July 5	August 4
SL Control	June 10	July 6	August 4

3.6 FLORAL COMPOSITION

The floral composition of each sample area was required to compare and evaluate the vegetation response to each treatment type. Floral composition also provides information as to the relative quantity of vegetation and quality of this vegetation in elk habitat. All vegetation found rooted within the 1 m^2 quadrat were recorded and classified to genus and species where possible following Looman (1982), Vance et al. (1984), Looman and Best (1987), and Cody (1988).

3.7 CANOPY COVER

The Daubenmire (1959) method was used to determine the canopy cover of species within the treatment areas and their controls. In this method, the relative percent coverage of each species growing within each 1 m^2 quadrat was estimated using a series of percentage intervals (0-5, 5-25, 50-75, 75-95, and 95-100) as set out by Daubenmire. All plots were standarized and the 10 dominant species for each treatment plot and its control were determined.

Elk were the target species of this study and each plant species found on the sample areas was classified as highly valuable, valuable, less valuable or non-valuable in regards to elk usage. Determination of a plant species' relative value as a food source, at some point during the year, was made using literature information from studies conducted by Hunt (1979) in Saskatchewan, Wydeven and Dahlgren (1983) in Wind Cave National Park, South Dakota, Edge et al. (1988) in the Chamberlain Creek, Montana area and comparative data from Rocky Mountain and Roosevelt elk studies from various authors compiled by Nelson and Leege (1982). These studies rated or ranked value of a species by a variety of criteria such as percentage of diet and site selection. A differentiation in the time of year elk chose these species were included in these studies.

The average percent cover of the "valuable" species for the prescribed burn plots was compared pre- and post-burn using a t-test. This was also used to compare average percent cover of desirable species on the prescribed burn plots vs. the shear-bladed plots.

The average percent cover of shrubs, forbs, and grasses for both treatment types was determined. The average cover of each within the prescribed burn areas vs. their controls were compared using a t-test. A t-test was also used for comparing the average cover of each on the prescribed burn areas vs. the shear-bladed areas.

Each of the individual prescribed burn plots received a treatment of varying intensity because of burn conditions present on each. The average percent cover of grasses for each individual prescribed burn plot was compared to its control using a t-test. Only the percent cover of grasses was compared because increased native grass production was a primary management objective for the prescribed burn project.

3.8 OVERSTORY RESPONSE

Tree density (live trees) on the prescribed burn plots was calculated using the point-quarter method (Smith 1980). Prior to the prescribed burns, in 1988, 200 individual trees were sampled on each of the three prescribed burn plots. After the prescribed burns, in 1989, these same 200 individual trees were re-sampled where physically possible. The frequency and relative density of trees for each plot, pre- and post-burn, were determined. Trees were considered "dead" if they were destroyed by the fire or if there was visible fire damage done to the cambium layer (Weber pers. comm. 1989).

3.9 SPECIES DIVERSITY

The number of species for each treatment type was tallied. Pre- and post-burn numbers were tested using an F-test, and post-burn numbers were also compared to shear-blade plot numbers using an F-test. Changes in species composition was also noted.

3.10 UNGULATE RESPONSE

Relative ungulate use was evaluated on both the prescribed burn plots and the shear-bladed plots using a variety of sampling techniques. Pellet group counts were conducted on both treatment types and their controls and pellets were identified as to species and the numbers of each. Pellet groups were counted using the same 5 transects used in the vegetative sampling and any found along these 1 m wide transects were counted. Twelve or more pellets constituted a pellet group and those pellet groups having at least half of the pellets falling on the 1 m wide transect were counted in this study. These numbers were compared using a Chi-square contingency table to determine if there was an overall difference in ungulate usage on treatment vs. controls and also on prescribed burn vs shear-blade areas. The numbers of each species was compared on treatment vs. controls.

Bedding site counts were conducted on both treatment types and their controls and the numbers on each were recorded. Bedding sites were counted using the same 5 transects used in the vegetative sampling and any found along these transects were counted. These numbers were compared using a Chi-square contingency table to determine if there was an overall difference in ungulate usage on treatment vs. controls and also on prescribed burn vs. shear-blade areas.

Track counts were conducted on the treatment areas during the winter of 1988/89 by members of Watchdogs for Wildlife, a local community group, on 2 separate occasions, each after fresh snowfalls. Mr. Doug Storey, Wildlife Technician - Dauphin, aided in familiarizing participants in the survey with the study areas. Prior to this, a copy of the sampling format was sent to Mr. George Bulloch, president of Watchdogs for Wildlife.

Only 2 counts were made because of a lack of snow during the early part of the winter. Presence vs. absence was the criterion used and tracks in and out of the perimeter of the study area were counted. From this information an estimate of numbers for each species was made.

Aerial surveys were flown by the Manitoba Department of Natural Resources during the winter of 1988/89 using a helicopter and fixed-wing aircraft and again in 1989/90 using a fixed-wing aircraft only. Numbers of animals and the species present were recorded.

3.11 EXTERNAL COST ANALYSIS

A breakdown of external costs to the Department of Natural Resources incurred by both treatment types was obtained (Storey pers. comm. 1990). External costs/hectare for each treatment were calculated for comparison.

Chapter IV

RESULTS

4.1 VEGETATION RESPONSE

4.1.1 AVERAGE PERCENT COVER OF VEGETATION

4.1.1a Prescribed Burn Areas

The percent cover of each species was averaged pre-burn for the 2 sample trials completed during the 1988 field season and post-burn for the 3 sample trials completed during the 1989 field season. There are inherent problems associated with averaging the percent cover because certain species present early in the study period may not be present in the middle or later portions of the study period. The same may be true for late growing species. By averaging these species along with all others present may introduce unaccepatable sampling error.

However, the percent cover was averaged for each plant species in this study because, virtually, all species sampled were present in at least one 1 m^2 quadrat during each of the sampling periods. Since sampling was initated relatively late in the growing season, June (1989) and July (1988), and ended in August, the early and late growing species would likely not have occurred in the sampling areas.

The 10 most dominant species, in terms of relative percent cover, are listed for each of the 3 prescribed burn areas in Tables 4.1 to 4.6. Woody vegetation less than 1.0 m in height was included in ground vegetation tallies and any mentioned in the following tables fall into that category. Because of poor weather and time limitations, the Singush Lake Burn Plot was not sampled during the 1988 field season. The control plot data for this site are shown as they were representative of pre-burn conditions on the experimental site.

Total percentages do not add up to 100 percent. The remainder of percent coverage was comprised of plant species that were not included in the 10 most dominant species, bare ground and/or debris. Combined grasses mentioned in the following tables include fringed brome, redtop, spiked redtop, bearded wheatgrass, slender wheatgrass, Richardson's needle grass and Western porcupine grass. These grasses appeared on every study area at some point during the study.

TABLE 4.1

Percent Vegetation Cover for Burn Plot # 1 1988 (Pre-burn)

Species	Average Percent Cover
Grasses	10.86
Goldenrod spp.	10.77
Raspberry	7.80
Wild rose spp.	6.31
American Vetch	5.38
Veiny Meadow Rue	5.20
Western Snowberry	5.01
Common Strawberry	5.01
Wild Peavine	5.01
Common Dandelion*	3.25

* *Taraxacum officinale*

TABLE 4.2

Percent Vegetation Cover for Burn Plot # 1 1989 (Post-burn)

Species	Average Percent Cover
Grasses	17.42
Goldenrod spp.	10.65
Wild Peavine	8.03
American Vetch	7.78
Raspberry	6.78
Common Dandelion	5.44
Common Strawberry	5.03
Veiny Meadow Rue	4.84
Canada Anemone	4.36
Western Snowberry	3.99

TABLE 4.3

Percent Vegetation Cover for Burn Plot # 2 1988 (Pre-burn)

Species	Average Percent Cover
Grasses	16.35
Goldenrod spp.	15.15
American Vetch	11.19
Quaking Aspen	8.70
Canada Anemone	6.02
Raspberry	4.91
Common Dandelion	4.48
Veiny Meadow Rue	3.79
Common Strawberry	3.18
Western Canada Violet*	2.67

* Viola rugulosa

TABLE 4.4

Percent Vegetation Cover for Burn Plot # 2 1989 (Post-burn)

Species	Average Percent Cover
Grasses	14.91
Goldenrod spp.	12.67
American Vetch	11.55
Canada Anemone	6.47
Quaking Aspen	6.30
Common Strawberry	5.61
Common Dandelion	4.72
Veiny Meadow Rue	4.07
Wild Peavine	3.86
Raspberry	3.69

TABLE 4.5

Percent Vegetation Cover for Singush Lake Control Plot 1989 (Pre-burn)

Species	Average Percent Cover
Grasses	10.21
Goldenrod spp.	14.72
Common Strawberry	8.16
Veiny Meadow Rue	7.06
Stinging nettle	5.12
Fireweed*	4.95
Northern Bedstraw**	4.02
Western Snowberry	3.67
Wild Peavine	3.43
American Vetch	3.35

* *Epilobium angustifolium*
** *Galium boreale*

TABLE 4.6

Percent Vegetation Cover for Singush Lake Burn Plot 1989 (Post-burn)

Species	Average Percent Cover
Grasses	22.46
Goldenrod spp.	10.15
Fireweed	7.56
Veiny Meadow Rue	6.38
Northern Bedstraw	5.18
American Vetch	4.20
Western Snowberry	4.20
Common Strawberry	4.10
Canada Anemone	3.85
Willow spp.	3.76

4.1.1b Shear-bladed Areas

The relative percent vegetation cover for each species within the sample area was determined as outlined in the previous chapter on methodology. The percent cover of each species was averaged for the 2 sample trials in 1988 and again for the 3 sample trials in 1989. There are inherent problems associated with averaging the percent cover of species because early and late growing species may be under-valued by averaging. However, the time sampling was initiated, June (1989) and July (1988), and terminated, August, would help to eliminate any early and late growers. The percent cover was averaged for each plant species because, virtually, all species sampled were present in at least one $1m^2$ quadrat during each of the sampling periods. The 10 most dominant species, in terms of relative percent coverage, are listed for each of the two shear-blade areas in Tables 4.7 to 4.10. Woody vegetation less than 1.0 m in height were included in the ground vegetation tallies. Total percentages do not add up to 100 percent. The remainder of percent coverage was comprised of plant species that were not included in the 10 most dominant species, bare ground and/or debris. Combined grasses mentioned in the following tables include fringed brome, redtop, spiked redtop, bearded wheatgrass, slender wheatgrass, Richardson's needle grass and Western porcupine grass. These grasses appeared on every study area at some point during the study.

TABLE 4.7

Percent Vegetation Cover for Shear-blade # 1 1988 (Post-treatment)

Species	Average Percent Cover
Grasses	18.15
Quaking Aspen	13.85
Balsam Poplar	8.12
American Vetch	6.88
Common Strawberry	6.30
Raspberry	6.02
Tall Lungwort	3.72
Sedge spp.	3.72
Wild Peavine	3.72
Northern Bedstraw	3.53

TABLE 4.8

Percent Vegetation Cover for Shear-blade # 1 1989 (Post-treatment)

Species	Average Percent Cover
Grasses	17.34
Quaking Aspen	13.50
Common Strawberry	7.08
Balsam Poplar	6.96
American Vetch	6.53
Raspberry	5.16
Sedge spp.	5.12
Tall Lungwort	4.20
Wild Peavine	3.25
Northern Bedstraw	2.64

TABLE 4.9

Percent Vegetation Cover for Shear-blade # 2 1988
(Post-treatment)

Species	Average Percent Cover
Grasses	12.11
Quaking Aspen	13.56
Raspberry	9.00
Goldenrod spp.	8.86
Common Strawberry	5.88
American Vetch	5.67
Tall Lungwort	4.71
Northern Bedstraw	4.29
Canada Anemone	2.90
Aster*	2.70

* Aster spp.

TABLE 4.10

Percent Vegetation Cover for Shear-blade # 2 1989
(Post-treatment)

Species	Average Percent Cover
Grasses	13.42
Quaking Aspen	16.38
Goldenrod spp.	8.91
Raspberry	7.88
Common Strawberry	6.84
American Vetch	6.31
Tall Lungwort	4.94
Northern Bedstraw	4.00
Willow spp.	3.12
Western Snowberry	3.06

4.1.1c <u>Comparison of 10 Most Dominant Species</u>

The 10 most dominant species, in terms of relative percent cover, for both the prescribed burn areas and the shear-bladed areas are listed in the Table 4.11. The percent coverages listed were derived by averaging the percent cover within the 3 prescribed burn areas (post-treatment) and the 2 shear-bladed areas. The percent cover was averaged for each plant species because all species sampled were present in at least one 1 m^2 quadrat during each of the sampling periods.

TABLE 4.11

Percent Cover of the 10 Most Dominant Species

Prescribed Burn Areas		Shear-bladed Areas	
Species	%	Species	%
Grasses	18.26	Grasses	15.26
Goldenrod spp.	11.16	Quaking Aspen	14.32
American Vetch	7.84	Raspberry	6.99
Veiny Meadow Rue	5.10	Common Strawberry	6.53
Common Strawberry	4.91	American Vetch	6.35
Canada Anemone	4.89	Goldenrod spp.	4.44
Wild Peavine	3.96	Tall Lungwort	4.39
Common Dandelion	3.89	Balsam Poplar	3.77
Raspberry	3.49	Northern Bedstraw	3.62

4.1.2 PERCENTAGE OF VALUABLE SPECIES

Plant species identified in previous studies by Hunt (1979), Nelson and Leege (1982), Wydeven and Dahlgren (1983) and Edge et al. (1988) as being valuable, highly valuable and less valuable forage and browse for elk at some point during the year are shown in Table 4.12.

Other plant species identified in this study, but not described in any of the above mentioned studies used to determine value to elk as a food source, were included in a non-valuable species category and are listed in Appendix D.

TABLE 4.12

Plant Species Valuable to Elk

Plant Name	Season SP	S	F	W	Source
Fireweed	-	V	HV	HV	A*, B*, E*
Redtop	HV	V	V	HV	B, E
Spiked Redtop	HV	V	V	HV	B, E
Richardson's Needlegrass	HV	V	V	HV	B, E
Fringed Brome	V	V	V	-	B, E
Bearded Wheat-grass	LV	V	-	-	B, E
Slender Wheat-grass	-	-	LV	HV	B, E
Sedges[1]	V	-	LV	LV	A, B, C*, E
Heart-leaved Alexanders[2]	HV	HV	-	-	B
American Vetch	V	V	-	-	B
Wild Peavine	V	V	-	LV	A, B, E
Strawberry	V	LV	LV	V	B
Groundsel[3]	V	LV	-	V	B
Dandelion	V	V	V	LV	B, E
Fleabane[4]	V	V	V	-	B
Pale Comandra[5]	-	V	-	-	B
Rough Cinquefoil[6]	V	V	V	-	B
Sow Thistle[7]	-	-	V	-	B

TABLE 4.12 continued

	SP	S	F	W	
3-flowered Avens[8]	LV	-	V	-	B
Yellow Avens[9]	-	-	V	-	B
N. Bedstraw	-	LV	-	LV	B, E
Field Horsetail[10]	-	LV	LV	LV	A, B, E
Canada Thistle[11]	LV	LV	LV	LV	A, B, E
Goldenrod	-	-	-	LV	B
Bearberry[12]	LV	-	-	LV	B
Cow Parsnip[13]	V	LV	V	-	A, B
Prairie Sage-brush[14]	-	-	V	V	C
Yarrow[15]	LV	LV	-	-	E
Sarsaparilla[16]	LV	LV	-	-	A, E
Honeysuckle[17]	-	-	-	LV	A
Aster spp.[18]	LV	LV	LV	LV	C, E
Quaking Aspen	HV	V	HV	HV	A, B, E
Balsam Poplar	LV	-	LV	LV	B, E
Willow	V	V	HV	V	A, B, E
Raspberry	-	V	-	-	A, B
Wild Rose spp.	-	V	V	V	A, B, C, E
W. Snowberry	-	LV	V	LV	B, C, D*, E

*(A) Hunt, 1979 (B) Nelson & Leege, 1982 (C) Wydeven & Dahlgren, 1983 (D) Edge et al., 1988 (E) Nietveld, 1983

1 *Carex* spp.
2 *Zizea aptera*
3 *Senecio* spp.
4 *Erigeron* spp.
5 *Comandra pallida*
6 *Potentilla norvegica*
7 *Sonchus arvensis*
8 *Geum triflorum*
9 *Geum macrophyllum*
10 *Equisetum arvense*
11 *Cirsium arvense*
12 *Arctostaphylos uva-ursi*
13 *Heracleum lanatum*
14 *Artemisia ludoviciana*
15 *Achillea millifolium*
16 *Aralia nudicaulis*
17 *Lonicera glaucescens*
18 *Aster* spp.

The relative percent cover of each category is shown in Tables 4.13 and 4.14 for each of the 3 prescribed burn plots and the 2 shear-bladed areas. Since the Singush Lake burn plot was only sampled during the 1989 field season, its control data have been substituted as 1988 pre-burn data.

TABLE 4.13

Percent Cover of Desirable Food Species
For the Prescribed Burn Plots, Pre- and Post Burn

C	BP #1 1988	BP #1 1989	BP #2 1988	BP #2 1989	SINGUSH Control	SINGUSH 1989
Forage						
"V"	50.97	62.66	57.06	59.81	51.34	58.73
NV	34.70	32.99	36.97	36.68	47.42	39.12
Browse						
"V"	23.88	14.69	20.65	15.75	11.65	10.87
NV	1.21	0.29	0.43	0.43	4.30	1.39
T	99.99	99.98	99.96	100.00	99.99	99.96

C = category
"V" = includes highly valuable, valuable and less valuable
NV = plant species not falling into the "V" category
T = total

TABLE 4.14

Percent Cover of Desirable Food Species
For the Shear-bladed Plots

C	Shear-blade #1 1988	Shear-blade #1 1989	Shear-blade #2 1988	Shear-blade #2 1989
Forage				
"V"	47.18	50.34	46.58	53.47
NV	20.64	14.08	32.32	17.82
Browse				
"V"	31.14	35.05	29.75	36.58
NV	1.02	0.43	0.21	1.03
T	99.98	99.90	100.00	99.99

Prescribed burn plots supported significantly greater amounts of desirable forage (t-test $p < 0.05$) post-burn vs. pre-burn but there was no significant difference (t-test $p > 0.05$) in the amount of desirable browse species.

The burn plots supported significantly less (t-test $p < 0.05$) desirable browse species than the shear-bladed plots but significantly more (t-test $p > 0.05$) desirable forage species than the shear-bladed plots.

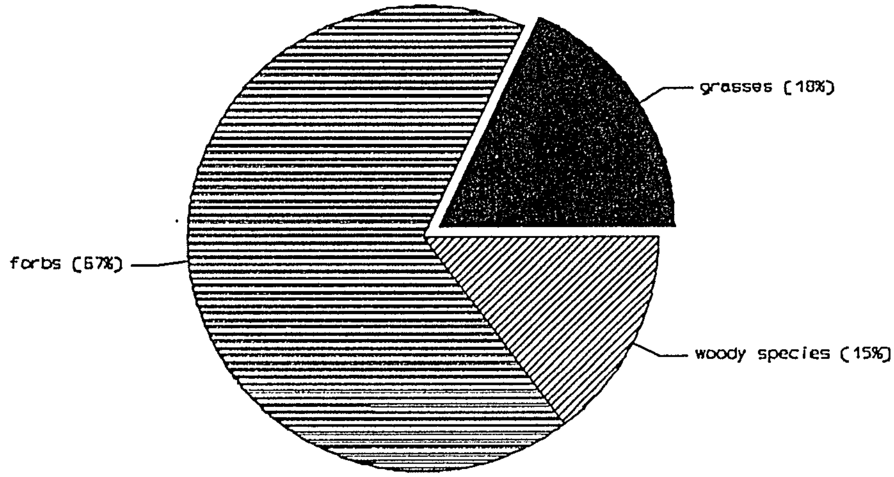
4.1.3 COMPARISON OF GRASSES, FORBS AND WOODY SPECIES

The relative percent cover of grasses, forbs and shrubs were averaged for the 3 burn plots and their controls. This was also done for the 2 shear-bladed plots. These are shown in Fig. 6 and 7.

Prescribed burn plots supported significantly more grasses (t-test $p < 0.05$) than did their controls, but there was no significant difference in the amounts of forbs or shrubs (t-test $p > 0.05$).

The prescribed burn plots supported significantly more grasses as well as forbs than did the shear-bladed plots (t-test $p < 0.05$), but supported significantly fewer shrubs than did the shear-bladed plots (t-test $p < 0.05$).

PRESCRIBED BURN PLOTS (POST-BURN)



CONTROL PLOTS

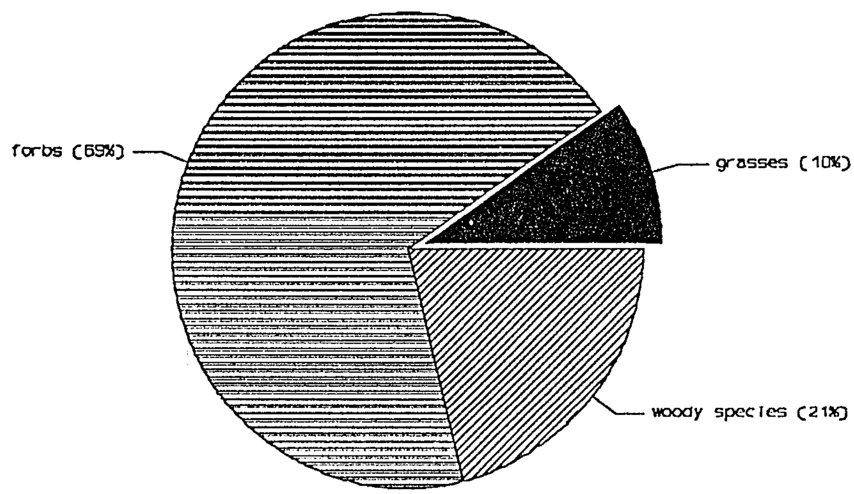
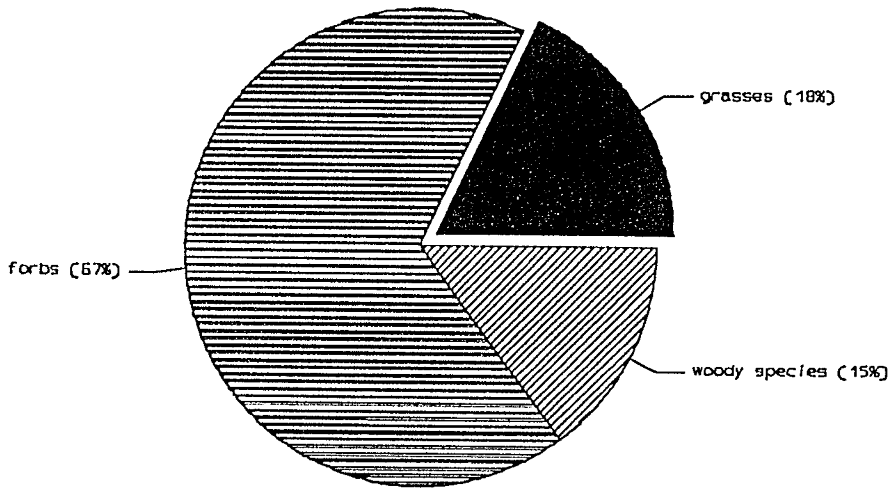


Figure 6: Percent Cover of Grasses, Forbs and Woody Species
Prescribed Burn Plots vs. Controls

PRESCRIBED BURN PLOTS (POST-BURN)



SHEAR-BLADED PLOTS

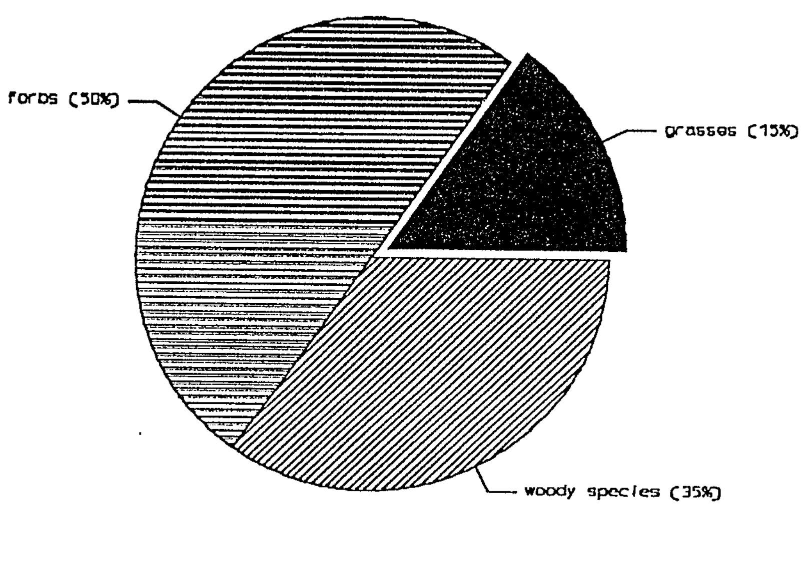


Figure 7: Percent Cover of Grasses, Forbs and Woody Species Prescribed Burn vs. Shear-bladed Plots

4.1.4 COMPARISON OF GRASS PRODUCTION WITH DIFFERING BURN INTENSITIES

4.1.4a Light Intensity Burn - Burn Plot # 2

Burn Plot # 2 received a light intensity burn. For the purposes of this study a light intensity burn was defined as one in which the coverage of the burn is not complete. Only the top leaf layer under the aspen stands was consumed in the fire. Any of the more moist materials remained unaffected and the fire did very light damage to the aspen overstory (Appendix B). On Burn Plot # 2 vs. its control there was no significant difference (t-test $p > 0.05$) in the amount of average percent cover of grasses between the two plots.

4.1.4b Medium Intensity Burn - Burn Plot # 1

Burn Plot # 1 received a burn of medium intensity. For the purposes of this study a medium intensity burn was defined as one in which the coverage of the burn was more complete in comparison to Burn Plot # 2. The fuels consumed in the fire were the top layer of leaves, grasses and small shrubs. There was moderate damage to the large overstory trees (Appendix B). On Burn Plot # 1 vs. its control there was no significant difference (t-test $p > 0.05$) in the amount of average percent cover of grasses between the two plots.

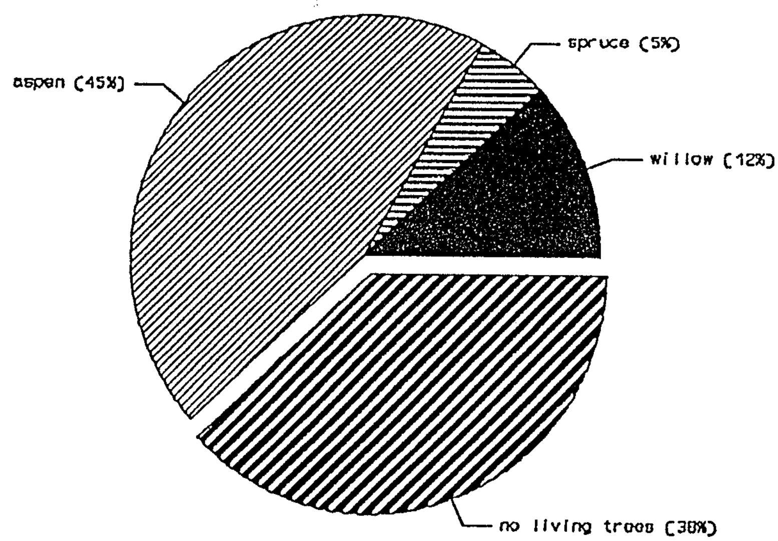
4.1.4c High Intensity Burn - Singush Lake Burn Plot

The Singush Lake Burn Plot received a high intensity burn. For the purposes of this study a high intensity burn was defined as one in which burn coverage was virtually 100 percent. The fire was intense enough to kill the willows on this site and damage was done to the aspen bluffs. The fire consumed all of the grass surface fuels (Appendix B). On the Singush Lake Burn Plot vs. its control there was a significant difference (t-test $p < 0.05$) in the amount of average percent cover of grasses between the two plots.

4.1.5 OVERSTORY RESPONSE

The relative frequency of trees, living or dead, (in percent) for each plot, pre- and post-burn, is shown in Fig. 8, 9, 10. The frequency of living trees on each plot, out of a possible 200 individual trees, pre- and post-burn is shown in Table 4.15.

1988 (PRE-BURN)



1989 (POST-BURN)

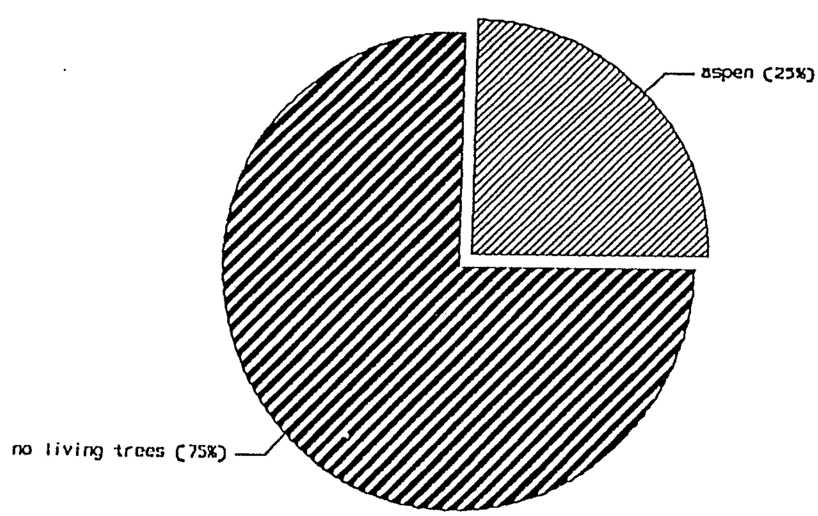
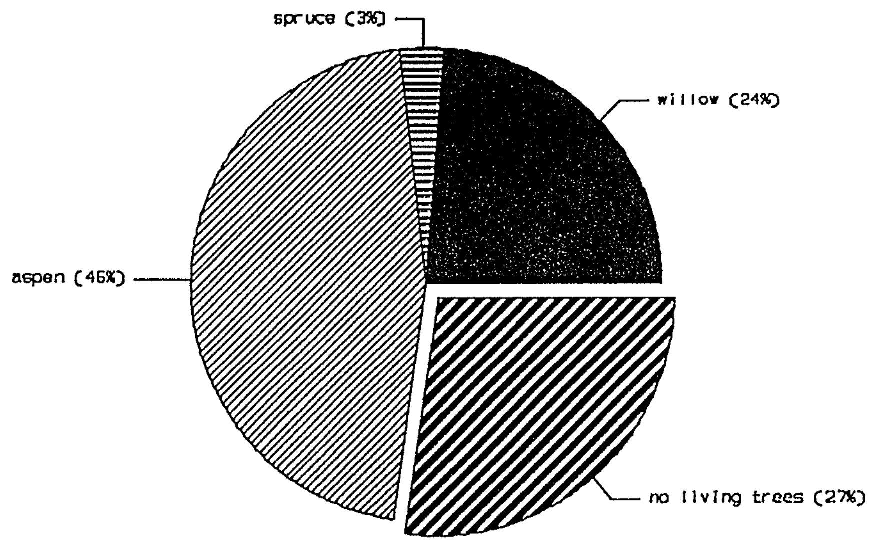


Figure 8: Relative Density of Tree Species (%) on Burn Plot # 1, 1988 vs. 1989

1988 (PRE-BURN)



1989 (POST-BURN)

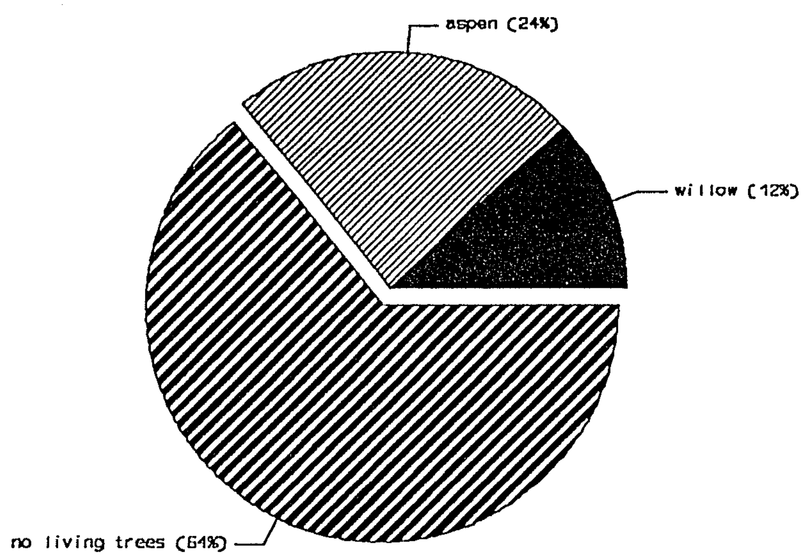
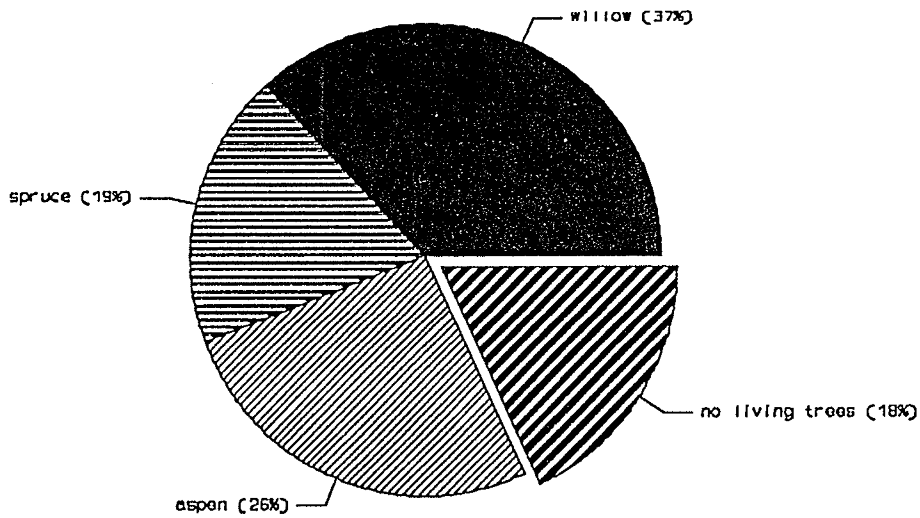


Figure 9: Relative Density of Tree Species (%) on Burn Plot # 2, 1988 vs. 1989

1988 (PRE-BURN)



1989 (POST-BURN)

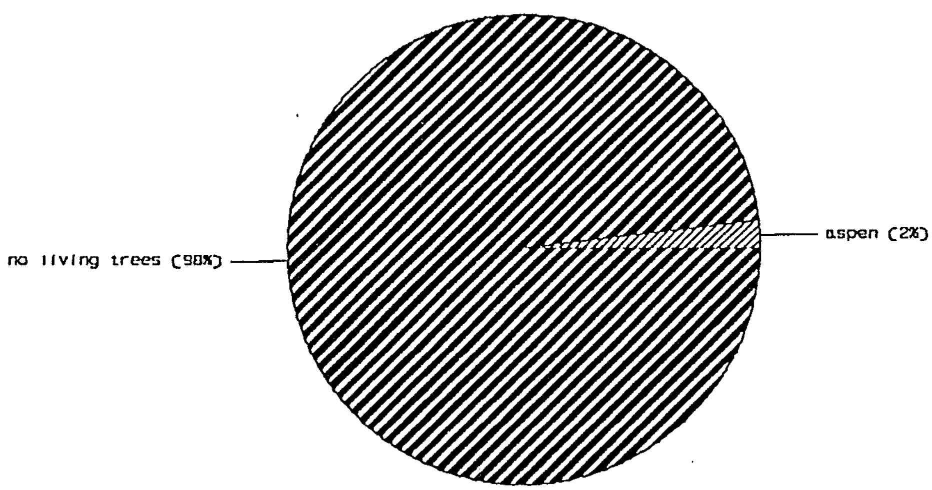


Figure 10: Relative Density of Tree Species (%) on Singush Lake Burn Plot, 1988 vs. 1989

TABLE 4.15

Frequency of Living Trees on the Burn Plots

	Willow		Spruce		Aspen		Dead	
	1988	1989	1988	1989	1988	1989	1988	1989
SL	74.0	0	38.0	0	52.0	4.0	36.0	196.0
BP1	24.0	0	10.0	0	90.0	50.0	76.0	150.0
BP2	48.0	0	6.0	0	92.0	48.0	54.0	128.0

SL = Singush Lake Burn Plot
BP 1 = Burn Plot # 1
BP 2 = Burn Plot # 2

4.1.6 Comparison of Number of Species

The number of species for each prescribed burn plot was tallied pre- and post-burn (control data for the Singush Lake plot was used as pre-burn information). There was no significant difference ($F_{.05(1,4)}$ = 7.71) in pre- vs. post-burn number of species. There was some difference in species composition as 5 species that were present pre-burn were not found post-burn.

The number of species for each shear-bladed plot was tallied for the 1988 and 1989 field seasons. There was no significant difference ($F_{.05(1,5)}$ = 6.61) in shear-blade vs.

post-burn number of species. There was some difference in species composition as 6 species that were present on both the shear-bladed areas and pre-burn areas were no longer found on the post-burn areas.

4.2 UNGULATE RESPONSE

Relative ungulate use was evaluated on both the prescribed burn plots and the shear-bladed plots using pellet group counts, bedding site counts, winter track counts and aerial surveys.

4.2.1 Pellet Group Counts

Pellet group counts were conducted in the spring of 1989 on both the experimental and control plots. Pellet groups were identified as to species and the numbers of each were recorded in Table 4.16. Overall pellet group counts are shown in Table 4.17.

TABLE 4.16

Elk, Deer and Moose Pellet Group Counts
Prescribed Burn and Shear-bladed vs. Controls

	Burn Plots	Control	Shear-bladed	Control
Elk	32	14	27	14
Deer	22	20	32	14
Moose	6	4	5	1
Total	60	38	64	29

There was a significant difference ($X^2_{.05(1)} = 3.841$) between the numbers of elk pellet groups found on both the prescribed burn plots and shear-bladed plots vs. their controls. There was no significant difference ($X^2_{.05(1)} = 3.841$) between the number of deer and moose pellet groups found on the burn plots vs their controls but there was a significant difference ($X^2_{.05(1)} = 3.841$) in the numbers of deer and moose pellet groups found on the shear-bladed plots vs their controls. There was no significant difference ($X^2_{.05(1)} = 3.841$) between the number of elk, moose and deer pellet groups on the prescribed burn plots vs the shear-bladed plots.

TABLE 4.17

Overall Pellet Group Counts

	Prescribed Burn	Shear-bladed	Total
Treatment	60	64	124
Control	38	29	67

The overall number of pellet groups, for all species, on the Burn Plots vs. the number on their controls were compared, and it was found there were a significantly greater ($X^2_{.05(1)} = 3.841$) number of expected pellet groups on the experimental sites vs. the control sites.

The overall number of pellet groups on the Shear-bladed Plots vs. the number on their controls were compared, and it was found there were a significantly greater ($X^2_{.05(1)}$ = 3.841) number of expected pellet groups on the experimental sites vs. the control sites.

The number of pellet groups on the Burn Plots vs. the Shear-bladed Plots were also compared, and it was found there was no significant difference ($X^2_{.05(1)}$ = 3.841) in the number of expected pellet groups on the Burn Plots vs. the Shear-bladed Plots.

4.2.2 Bedding Site Counts

Bedding site counts were conducted in August 1989 on both the experimental and control plots and the numbers of each were recorded in Table 4.18.

TABLE 4.18

Bedding Site Counts

	Prescribed Burn	Shear-bladed	Total
Treatment	20	25	45
Control	9	24	33

The number of bedding sites on the Burn Plots vs the numbers on their controls were compared, and it was found there was a significant difference ($X^2_{.05(1)} = 3.841$) between the number of expected bedding sites on the experimental plots vs. the control plots.

The number of bedding sites on the experimental Shear-bladed Plots vs. the numbers on their control plots were compared, and it was found there was no significant difference ($X^2_{.05(1)} = 3.841$) between the number of expected bedding sites on the experimental plots vs. the control plots.

The number of bedding sites on the Burn Plots vs. Shear-bladed Plots were also compared, and it was found there was a significant difference ($X^2_{.05(1)} = 3.841$) between the numbers of expected bedding sites found on the Burn Plots vs. the Shear-bladed Plots.

4.2.3 Winter Track Counts

Winter track counts were conducted during January and February 1989. An estimate as to numbers of animals on the study sites is shown in Table 4.19. No statistical tests were performed on these data due to insufficient sample size. The estimates of animal numbers were included as a relative indication of ungulate use.

TABLE 4.19

Winter Track Counts

	January			February		
	Elk	Deer	Moose	Elk	Deer	Moose
BP # 1	0	3-6	0	0	0	0
BP # 2	7-10	3	2-3	0	3	4-5
Singush	10-12	3-6	4-5	8-10	10-12	4-6
SB # 1	5-6	0	3-5	0	3-6	5-6
SB # 2	0	6-8	2	0	0	0

4.2.4 Aerial Survey Counts

Aerial surveys were flown by the Manitoba Department of Natural Resources during January and March 1989 and again in January and March 1990. These data are shown in Table 4.20. No statistical tests were possible on these results because of an insufficient data base but are shown here as a relative indication of ungulate usage on the manipulated sites. Mr. Dwain Davies, Regional Wildlife Manager, completed the collection of these data.

TABLE 4.20

1989/90 Aerial Survey Results

January 20/89	Elk	Moose	Deer
Singush Lake Site	0[1]	5[2]	2
Childs Lake Sites	0	10[3]	5[4]

1 Elk cratering sign on burn but no elk seen.
2 Moose within 800 m radius of burn.
3 Moose observed within 1500 m radius of burn and shear-bladed areas but none seen on sites.
4 Deer observed within 800 m radius of burn and shear-bladed areas but none seen on sites.

March 15/89	Elk	Moose	Deer
Singush Lake Site	0[1]	0	0
Childs Lake Sites	0	0	0

1 Eight elk north of highway, by this flight all species had dispersed from previous observed wintering areas.

January 22/90	Elk	Moose	Deer
Singush Lake Site	10[1]	2[2]	0
Childs Lake Sites[3]	0	0	0

1 Elk observed within 1500 m radius of burn, sign of heavy cratering on burn and surrounding area.
2 Moose observed within 400 m radius of burn.
3 No sign of ungulate use on plots, 4 moose and 5 elk within 8 km radius of plots. Snow depth of 60 cm.

March 1/90	Elk	Moose	Deer
Singush Lake Site	6[1]	1[2]	0
Childs Lake Sites[3]	0	0	0

1 Elk observed on and adjacent to (within 400 m) of burn. Sign of heavy cratering on burn and adjacent areas.
2 Moose observed north of highway within 800 m of burns.
3 No sign of ungulate use present. Snow depth of 60 cm.

4.3 EXTERNAL COST ANALYSIS

A comparison of the external costs, to the Manitoba Department of Natural Resources, involved in both treatment types was conducted using equipment rental and necessary supplies as criteria. The breakdown was as follows:

Shear-blading -

Rental of D8F Caterpillar with a Romex KG shear-blade:
\$97.74 / hour for 39 hours = \$3,811.86

Total hectares shear-bladed = 20 ha.

Cost per hectare = total \$ amount / total hectares
= \$3,811.86 / 20 hectares
= \$190.59 / ha

Prescribed Burning -

Rental of Helicopter equiped with a drip-torch:
\$7,127.40 for three burn plots.

Fire-guarding requirements and pre-burn clean-up:
\$6,118.50 for three burn plots.

Gasoline and solvent used in drip-torch:
\$912.97 for three burn plots.

Miscellaneous expenses (food, lodging, and others):
\$1,380.28 for three burn plots.

Total hectares treated = 124 ha.

Cost per hectare = total \$ amount / total hectares
= \$15,539.15 / 124 ha
= \$125.32 / ha

CHAPTER V

DISCUSSION

Aspen encroachment in the Duck Mountains appears to have reduced the available habitat for elk. Once a mosaic of prairie and aspen groves, the area has become an almost homogeneous stand of aspen. Prescribed burning was seen as a viable management tool to aid in reversing this situation. A comparison of prescribed burning vs. shear-blading was considered desirable in this study to attempt to differentiate which treatment type was potentially most useful for manipulating elk habitat.

5.1 VEGETATION RESPONSE

One of the objectives of the prescribed burning program was to increase the availability of native grasses on the project area. Overall, the prescribed burn plots supported significantly more grasses than either the control areas or the shear-bladed areas. The disturbance effect of the prescribed burning was apparently more beneficial for the increased production of grasses. There was no significant difference in the amounts of forbs and woody species on the prescribed burn plots vs. their controls but the prescribed burn plots had greater amounts of forbs than the shear-bladed plots and lesser amounts of woody species.

While there was no significant difference in the number of species present on the prescribed burn plots vs. their controls and the shear-bladed plots there were changes in plant composition. The fire either increased the cover and frequency of most forbs or had no effect on each prescribed burn plot. Bailey and Anderson (1978) found similar results in the aspen-parkland of Alberta for the first growing season after early spring or late fall burning. The shear-bladed plots actually showed decreased amounts of forb coverage. Since the shear-blading was done to remove all surface vegetation, many of the forbs may have lost or had damage done to their root systems and would then have had to rely on reseeding to reestablish themselves on the sites.

Although species diversity did not increase significantly on treatment vs. control areas for the prescribed burns, the amount of valuable forage species did increase significantly. On the Duck Mountain study sites the prescribed burn plots supported significantly greater amounts of valuable forage species on the burned areas vs. the unburned areas but there was no significant difference in the amount of valuable browse species.

When comparing the burn plots vs. the shear-bladed plots there were significantly greater amounts of valuable forage species found on the prescribed burn areas vs. the shear-bladed areas. There were significantly greater amounts of valuable browse found on the shear-bladed plots. Prescribed burning appears to provide a greater disturbance effect for the stimulation of forage production and had a greater effect in reducing woody vegetation which was directly in line with project management objectives. Several authors found similar results in their studies. Following a fire, browse species are richer in protein and other nutrients (DeWitt and Derby 1955) and amounts of desirable food species are often increased after fire (Wright and Bailey 1982). DeByle et al. (1989) found that prescribed burning increased the protein content and improved digestibility of aspen as well as increased the forage quality during the first post-burn growing season on their study sites in the Caribou National Forest, Wyoming. Rowland et al. (1984) found similar results on their study sites near Los Alamos, New Mexico. Because this study did not attempt to determine and quantify the specific valuable forage species for Duck Mountain elk, in particular, it will be necessary to undertake a follow-up study to this end.

On the surface it would appear that prescribed burning was more beneficial than shear-blading for manipulating elk habitat. However, when comparing each individual burn plot to its control, only the plot receiving a high intensity burn showed a significantly greater amount of grasses vs. its control. The low and medium intensity burns, received by the other two plots, did not apprear to provide a great enough disturbance to stimulate increased grass production. Usher (1977), in his study of the Sand River area of Alberta, and

Brown and DeByle (1989), in their Caribou National Forest, Idaho study area, found that the intensity of burning affected the rate of succession. Initially, the Duck Mountain study areas appear to illustrate that the intensity of the burn is a determining factor in the rate of succession but further monitoring of this area will be necessary to observe if this trend continues.

It was fortunate that burn conditions differed on each prescribed burn plot resulting in varied burn intensities. This allowed for the three-way comparison and will aid in determining future burn objectives. Following the single application of prescribed fire, all three prescribed burn plots showed a reduction in aspen, willow and spruce. Aspen and willow are well adapted to fire and new suckers of these, as well as many other shrub species of the aspen-parkland, are palatable browse valuable to elk and other ungulates. Vigorous resprouting of willow and aspen suckers was evident on all three prescribed burn plots, therefore continued burning on a regular basis will be necessary to achieve and maintain low densities of mature aspen and other woody species as well as to stimulate browse production. At this point in the evaluation of these plots, it appears a high intensity burn was the most desirable for establishing a grass meadow.

Anderson and Bailey (1980) found that annual spring burning for 25 to 30 years in central Alberta maintained forest cover at less than 10 percent. However, prescribed burning will not be possible every year in the Duck Mountains because of adverse weather and/or fire conditions nor may it be desirable to burn every year. Wright and Bailey (1980) state that the desired interval for use of fire to control shrubs, on fescue grassland, is probably every 5 to 10 years. Continued monitoring of the Duck Mountain sites will be necessary to determine the optimum interval between fires.

5.2 UNGULATE RESPONSE

In comparing the number of pellet groups of different ungulates, all three species - elk, moose, and white-tailed deer - showed no greater preference for either the prescribed burn plots or the shear-bladed plots but showed a preference for both treatments over the controls. This would seem to indicate that the animals were using each treatment type for approximately equal amounts of time. Because the pellet group counts were conducted once in late August of 1989, there could be no differentiation between seasonal preference of foods available on each treatment type. A spring and fall pellet group count may eliminate this problem.

There was, however, a difference in preference in the choice of bedding sites as there were significantly greater numbers of bedding sites found on the shear-bladed areas as compared to the burn plots. This may be because of a reduction in hiding or escape cover in the burn plots. Hiding cover is a feature of habitat that provides elk security or a means of escape from the threat of predators or harassment. It is usually some form of vegetation but may also be a topographic feature. Hiding or escape cover provides screening security for elk (Skovlin 1982) and other ungulates.

Winter track count data were biased because of the effects of snowmobile disturbance on the Childs Lake areas during the month of February. This may not have been such a problem if the weather had been more favourable. Track counts were only possible during the months of January and February 1989 because of a lack of snow during the other months. Track counts during January showed there was ungulate activity on both Childs Lake burn plots (Table 4.18) especially Burn Plot #2. The Singush Lake burn plot had the highest overall January count of ungulates and these numbers were fairly consistent with those recorded in February. Just using the January data, the Singush Lake plot, which received a high intensity burn, appeared to be preferred by elk and other ungulates when compared to the other burn plots and the shear-bladed areas. Unfortunately, no statistical tests could be performed on the data so it is impossible to validate this statement. Further observation in subsequent years will be necessary.

The present data still provide valuable information for formulating a future management plan. Human impacts need to be considered in the formulation of any such plan. Various studies have shown that elk are easily conditioned to repeated patterns of human activity within their home range (Ward 1973) but they are sensitive to deviations from normal patterns (Skovlin 1982). Elk are seldom alarmed at normal disturbance activities such as vehicular traffic, camping, fishing, or other recreational activities beyond a threshold distance of 0.8 km. However, activities within this distance result in evasive movements by elk to reestablish and maintain this 0.8 km "buffer zone" between themselves and the human activity (Ward et al. 1973). Edge and Marcum (1985) found similar results in their Chamberlain Creek, Montana study areas.

Aerial survey data (Table 4.19) supplied supporting evidence that elk preferred the high intensity burn area (Singush Lake site). Although few elk were observed directly, sign of elk usage was apparent on all four flights over the area whereas there was no observed elk usage of the Childs Lake area sites at all on each of the four flights. In general, ungulate usage was somewhat lower in 1990 in comparison to 1989 for all plots. However, snow depths of 60 cm were reported during the 1990 flights. This may have affected winter use of these plots. Moran (1973), Leege and Hickey (1977) and Gates (1980) found similar results in their studies in Michigan, Idaho and central Alberta.

Although a browse survey was not conducted there were signs of heavy browse usage on the shear-bladed sites and both treatment types had a number of ungulate trails running through them. This would seem to indicate that the treatment areas are getting a fair amount of usage.

5.3 COST COMPARISONS

A major incentive for using prescribed burning is to reduce the cost of managing habitat while maximizing the potential benefit for the animals involved. Prescribed burning is a more cost and time effective method of manipulating habitat. The cost per hectare of shear-blading was $190.59 whereas the cost per hectare of prescribed burning was $125.32 resulting in a saving of $65.27 per hectare. 1989 comparison figures from the Minnesota Department of Natural Resources also indicate that prescribed burning is a cost effective method. In burns used specifically in aspen forest for habitat manipulation, the cost per hectare for a similar sized burn (80 - 200 ha) to the Duck Mountain burns was $23.00/ha (Canadian) including fire guarding costs. For a burn of 400 ha or greater the cost (including fire guarding) dropped to $9.00/ha (Canadian). The overall cost in Minnesota is lower because of easier site accessibility and shorter distances to sites resulting in lower transportation costs (Merchant pers. comm. 1990).

Cost is not the only factor to be considered. Prescribed burning is much more time effective than shear-blading. The time needed to burn the three treatment areas amounted to approximately 16 hours whereas the amount of time required for shear-blading was 39 hours. Factoring in the total hectares of each treatment type, 124 ha of prescribed burns and 20 ha of shear-blading respectively, approximately 7.75 hectares are burned per hour of work using a prescribed burn as opposed to the 0.51 hectares shear-bladed per hour.

Labour costs were not considered in this analysis as they were internalized by the Department of Natural Resources. Only existing staff were used on this project and no extra crews were necessary. Larger burns can be conducted as safely as smaller burns with little or no increase in staff so long as the pre-burn preparations are done correctly (Wright and Bailey, 1982). As the size of the burn increases so does its cost effectiveness. Larger burned areas maximize cost effectiveness as well as prevent concentrations of animals on small areas. Burned areas interspersed with unburned areas offer nutritional alternatives to sympatric ungulate populations (Spowart and Hobbs 1985) thus causing "spin-off" benefits for species other than the target species.

CHAPTER IV

CONCLUSIONS AND RECOMMENDATIONS

Prescribed burning is a viable method of habitat manipulation in the Duck Mountains of Manitoba. Elk exhibited an increase in usage of the prescribed burn areas while deer and moose usage did not show any change when compared to the controls. The prescribed burn plots supported greater amounts of desirable forage than the controls and the shear-bladed plots.

Shear-blading and prescribed burning treatment areas exhibited many similar effects of vegetation response and ungulate usage with two major exceptions - grass and forb production was increased and woody vegetation was reduced on the areas treated with prescribed burns. This fulfilled the project management objectives as set out by the Manitoba Department of Natural Resources - Wildlife Branch. The shear-bladed areas actually exhibited increased woody species production in comparison to the controls.

The major benefits of using a schedule of repeated prescribed burns rather than shear-blading as a management tool in this area includes the control of undesireable shrubs and trees, disposal of dead debris and the stimulation of greater grass production. All of these benefits were achieved simultaneously with prescribed burning. This combined with the overall lower cost of the prescribed burning operation makes this treatment a more time and cost effective method of habitat manipulation.

This study has attempted to incorporate the ecological and economic factors necessary to evaluate the potential value of using prescribed burning as a method of elk habitat manipulation in the Duck Mountains. The following recommendations are put forth:

1. This was a two year study, and only one of the years was for post-burn evaluation. Continued monitoring of the study sites is needed to determine if the resulting vegetation changes continue to meet management objectives.
2. A study to determine elk food preferences in and for the Duck Mountains should be implemented. This would prove beneficial for the formulation of future management plans because studies of this sort, as well as related literature, are limited in and for Manitoba.
3. The Manitoba Department of Natural Resources should continue to use a schedule of repeated prescribed burns as a method of elk habitat manipulation since a single burn will likely not meet long term management objectives. A second burn should be carried out in the near future to further reduce woody species still present on the sites and to further establish grass meadows.

4. Once these grass meadows are established, prescribed burning will be most beneficial if a burn is completed every 5 to 7 years so long as there has been sufficient moisture during the previous year. This will allow fuel to build up sufficiently to allow the fire to carry. Prescribed burning used at this frequency will likely reduce the invasion of woody species and should maintain the grass meadows. Fire hazard will remain low in these areas and elk habitat should remain stable and will hopefully encourage elk to stay off agricultural areas.
5. To increase cost effectiveness of prescribed burning, larger areas can be treated with little or no increase in staffing requirements. Elk will benefit with larger grassed areas as long as sufficient areas of cover are available to them.
6. Snowmobile and other off-road vehicle use should be restricted in these areas to further encourage elk use.
7. Public education measures should be implemented as to the beneficial effects of prescribed burning. Continued safe and successful application of prescribed burning will aid in this education process.

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APPENDIX A

PERSONAL COMMUNICATIONS

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APPENDIX B

FIRE BEHAVIOR INFORMATION FOR THE DUCK MOUNTAIN PRESCRIBED BURNS
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PART I: FUELS INFORMATION

General Description

Child's Lake - Area #1 (Ignitied Oct. 7, 1300 CDT)

- Size = approximately 60 acres.
- Comprised mainly of stands of young (27 years old) aspen with small pockets of open, grass/willow areas.
- Fuel loading under the aspen canopy was limited to leaves and a few small shrubs (see pre-burn data for fuel loading amount in t/ha).
- Small, isolated pockets of old medium and large sized slash from the 1961 burn were also present but only in a few small places.
- Duff thickness was 2-3 cm.
- Grass fuel loadings were estimated to be approximately 5-6 t/ha and 95% cured.

Child's Lake - Area #2 (Ignited Oct. 7, 1530 CDT)

- Size = Approximately 100 acres.
- Similar in many respects to Area #1 except that the grass/willow areas were more common and somewhat larger.

Blue Lakes - Areas #3 and #4 (Ignited Oct.8, 1230 and 1500 CDT)

- Size = each block was approximately 80 acres.
- Grass/willow dominated both blocks. Some aspen bluffs were present but only on a limited basis (< 20% of the area). A few merchantable softwoods were in the centre of the blocks.
- Grass fuel loadings were estimated to be 7-10 t/ha and 95% cured.
- The majority of the willow branches were dead and contributed significantly to the available fuel loading.
- Duff layer was < 1 cm.

Fuel Moisture

A few samples of some of the fuel types present on the site were collected just prior to the ignition of each fire (except the last one on October 8). This information is given in Table 1.

Table 1. Fuel moisture information from the Duck Mountain prescribed burns, October 7-8, 1988.

	Fuel	% Moisture Content	Significance
Oct. 7 1200 CDT			
	Leaves	1.8	Recently fallen leaves
	Leaves	7.9	with very low MC
	Decomposed Leaves	35.7	Old leaves with a substan-
	Decomposed Leaves	35.1	tially higher MC
	Humus	50.7	Very high MC given the thin-
	Humus	61.8	ness of the humus layer. Did not contribute to available fuel.
Oct. 7 1515 CDT			
	Leaves	2.9	
	Grass	9.2	
	Decomposed leaves and humus	24.3	Drier than at 1200. May have permitted a more complete burn.
	Humus	62.8	
Oct. 8 1215 CDT			
	Grass	9.5	
	Grass	6.7	
	LFH layer	6.8	Lower MC in this open area
	LFH layer	14.2	than under the aspen stand.
	Dead willow twigs	2.0	Very low MC. Contributed
	Dead willow twigs	3.0	significantly to the fuel loading.
	Live willow twigs	14.1	

Part II: GENERAL ASSESSMENT OF THE FIRE BEHAVIOR

Area #1

Ignition - Ignition started at 1300 h CDT. Small concentric circles were ignited in the centre of the block in an open grass/willow area. The westerly section (an aspen stand) was then lit with the intention that the fire would be drawn inward towards the centre fire (since the winds were calm). The final area to be ignited was the eastern end of the block. A strip type ignition pattern was used in this area.

Fire Behavior - The central smoke column started to develop fairly well in its initial stages however there was not enough convective development to draw the perimeter ignitions inward. For this reason the fire never reached its required intensity because of a very slow spread rate (note: spread rates in the aspen areas averaged between 0.25 and 1.0 m/min with flame lengths of < 0.5 m). The fire burned in patches, usually in a circular shape, backing away from the points where the jellied-gas was dropped. In a few parts of the eastern section, pockets of old slash existed and this extra fuel loading increased the fire intenisty significantly (flame lengths averaged 1.5-2.0 m). In these few spots the fire intensity may have been sufficient enough to damage the aspen as desired.

Fire Effects - The coverage of this burn was not complete. In the aspen stands it was between 50 and 60%. Only the top leaf layer under the aspen stands was consumed in the fire. Any of the more moist materials remained unaffected. The fire did very little if any damage to the aspen overstory.

Area #2

Ignition - A centre fire ignition pattern was used again. The helitorch produced an intense fire which developed a strong convection column. After this column was established, drip torches were used to ignite the perimeter of the fire in order to take advantage of the indraft produced by the column.

Fire Behavior - Fire spread was continuous in an inward direction at a rate of 1 to 4 m/min, depending on the type of fuel that it was burning. Flame lengths in the grass/willow areas were 2-3 m and approx 0.75 m in the areas with a heavy aspen overstory.

Fire Effects - The coverage of this burn was more complete, due to the indraft that developed and the slightly drier fuel moisture conditions which existed. However, the intensity of the burn still may not have been sufficient to damage the aspen overstory. The fuels which were consumed were still only the top layer of leaves, grasses and small shrubs.

Area #3

Ignition - The helitorch was used once again. Two areas in the centre of the block were ignited in order to produce a strong convection column. Some hand ignition using the drip torches was also used on the west (back) side of the fire after the columns were well developed.

Fire Behavior - The fire behavior on this block was the most spectacular of the four areas that were burned. This was due to the heavy fuel loading (grass/willow), the presence of a moderate southwesterly wind, and the development of a strong convective column. The fire spread in a north and east direction (varying according to the wind direction) away from its point of ignition in the centre of the south block. Rates of spread at the head of the fire while burning in the grass/willow fuels were estimated at 10 m/min with flame lengths commonly exceeding 3 m. It eventually spread into the north block and when the head fire reached the eastern fire guard a small spot fire occurred.

The spot fire started in a heavily grassed area and then continued to spread eastward into a stand composed primarily of mature aspen. Once the fire was in the aspen stand the rate of spread and fire intensity decreased significantly. Suppression efforts started very soon after the spot fire occurred and consisted initially of pack-cans. However, it was not really under control until a pump was running and assistance was received from the helicopter which bucketed the head of the fire. The size of the spot fire is estimated to be 0.5-1.0 acre. An estimated height of the convection column produced by the whole fire was 4000 ft.

Fire Effects - This fire was likely intense enough to kill the willows on this site and possibly damage the aspen bluffs. The fire consumed all of the grass surface fuels but did not effect the LFH layer which had a higher moisture content. Coverage of this area by the fire was 100%.

Area #4

Ignition - This final block was ignited very cautiously because of the wind which had become variable (south to west and northwest) and gusty. The northern edge was burned first using drip torches. After a safe fire guard was established the helitorch layed out strips of fire in an east-west direction adjacent to the previously burned strips. This type of strip fire ignition pattern proved effective while the wind was from the south. When the wind shifted to the west the western edge of the block was ignited and the fire was allowed to burn eastward into the section of the block that had burned earlier in the day.

Fire Behavior - Because a strip fire ignition pattern was used the fire was not allowed to become extremely intense on the north side of the block. However, when the fire was allowed to spread unimpeded in an eastward direction, intensities became quite high (similar to those in Area #3). This eastward run also resulted in a fairly large convection column of an estimated height of 8000 ft.

Fire Effects - The fire effects were similar to those in Area #3.

Table 2. Estimated FWI System values for the the Child's Lake and Blue Lakes prescribed burns.

Date	1300 h Weather Observations				FWI System Values					
	Temp. (°C)	RH (%)	Wind Speed (km/h)	Rain (mm)	FFMC	DMC	DC	ISI	BUI	FWI
09/20	7.0	81	11	0.1	59	20	370	1	35	2
09/21	12.0	72	17	0.4	72	21	374	2	38	5
09/22	13.0	54	39	1.0	76	20	378	6	35	13
09/23	14.0	51	18	0	83	22	382	4	38	9
09/24	10.0	88	13	6.3	40	13	363	0	24	0
09/25	10.0	43	7	0.4	65	13	367	1	26	1
09/26	9.0	82	3	0.2	28	7	335	1	13	0
09/27	8.0	76	13	1.4	44	7	338	0	13	0
09/28	7.0	100	9	2.3	28	6	341	0	11	0
09/29	17.0	56	30	5.4	59	4	327	2	8	1
09/30	23.0	29	41	0	89	7	332	28	13	25
10/01	13.0	41	22	0	89	8	336	11	15	15
10/02	13.0	44	24	0	89	10	339	12	19	16
10/03	5.0	65	22	2.4	68	8	340	2	15	3
10/04	8.0	50	13	0	78	8	342	2	15	3
10/05	9.0	43	5	0	83	9	345	2	17	3
10/06	17.0	36	22	0	88	11	348	10	20	14
10/07	19.0	45	5	0	88	13	353	4	24	7
10/08	23.0	29	17	0	90	16	357	10	28	17

PART III: FIRE WEATHER CONDITIONS AT THE 1988 Duck Mountain Prescribed Burns

Synoptic Weather

October 7 - A high pressure ridge was centered over the Duck Mountains and produced clear skies and a very stable atmosphere. Surface winds were very light and variable and remained so throughout the afternoon.

October 8 - As the high pressure system moved eastward a trowal moved in slowly from the west. It passed through the Duck Mountain area between 1400 and 1700 h CDT. This resulted in the winds shifting from southerly at 10-15 km/h to northwesterly at 20-30 km/h. No temperature change occurred with its passage however the dewpoints behind the trowal were higher than those ahead of it, therefore causing the RH to rise slightly.

Canadian Forest Fire Weather Index (FWI) System Values

Fire weather observations at the nearest forest fire weather station (Wellman Lake) ended on September 19, 1988. Therefore, the 1300 h CDT observations of temperature, RH and wind were used from the nearest AES station (90 km southeast), at Dauphin (305 m MSL) and rainfall was determined by averaging the amounts at Dauphin and Swan River (55 km northwest). These observations and the calculated index values are presented in Table 2.

It is worth noting the low DMC (actual values: 13 and 16; desired: 25-35), BUI (actual values: 24 and 28; desired: 36-52) and ISI on Oct. 7 (actual values: 4; desired: 6-14). The low DMCs and BUIs indicate that very little, if any, of the upper duff layer was available for consumption by the fire and the low ISI indicates a very slow fire spread rate. Both of these factors may have reduced the fire's intensity (especially the two Oct. 7 burns) to the point that it was not possible to girdle or damage the aspen overstory.

On-Site Fire Weather Observations

On both October 7 and 8 an automatic weather station was set-up near the burn area and it measured temperature, RH, wind speed and direction (note: wind speed measurements were made at 1.3 m were doubled in order to estimate the standard 10-m open wind speed). Also, manual readings of temperature, and RH were taken with a Bendex fan psychrometer immediately before and after the burn and periodically during it.

October 7 -Both the hourly readings recorded by the automatic station and the manual observations are presented in Table 3.

October 8 - Readings on this day were taken every 10 minutes while the fires were burning. This permitted the peak wind speeds to also be measured. This information in presented in Tables 4 and 5.

Table 3. Fire weather observations during the Child's Lake prescribed burns, October 7, 1988.

Time (CDT)	Temp. (°C)	RH (%)	Wind Speed (km/h)	Wind Dir. (°)
Automatic Station				
1200	18.5	37	1.6	180
1300	20.6	35	2.4	180
1400	21.4	35	3.6	225
1500	22.0	31	5.6	225
1600	23.2	30	2.8	225
1700	22.7	30	1.8	180
Bendex Readings				
1110	16.0	40		
1145	17.5	42		
1235	21.5	35		
1303	20.5	43	ignition	
1349	21.0	36	end of active burning	
1509	21.0	36		
1530	23.0	37	ignition	
1630	21.0	34	end of active burning	
1730	19.5	42		

Table 4. Fire weather observations (manual observations) during the Blue Lakes prescribed burn, October 8, 1988.

Time (CDT)	Temp. (°C)	RH (%)	Comments
1115	19.0	34	
1200	20.5	30	
1232	20.5	30	ignition
1403	21.5	38	end of active burning
1448	24.0	36	2nd ignition
1730	21.5	40	end of active burning

Table 5 . Fire weather observations (automatic station) during the Blue Lakes prescribed burn, October 8, 1988.

Time (CDT)	Temp (°C)	RH (%)	Wind Speed Inst1 (km/h)	Wind Speed Inst2 (km/h)	Wind Speed Gust (km/h)	Direction (°)
1230	20.4	30	10.2	11.4	29.6	180
1240	20.6	29	9.5	11.4	25.4	180
1250	19.8	29	9.6	10.4	25.6	225
1300	19.3	29	8.8	10.4	28.8	180
1310	20.1	30	9.8	11.4	28.2	225
1320	20.5	28	11.2	13	30.6	180
1330	20.5	28	10.4	11.4	24.8	225
1340	20.3	24	8.6	98	24.8	225
1350	20.7	24	9.8	11.8	30.4	315
1400	21.1	26	10.6	12.8	26.2	180
1500	21.2	32	7	8.2	6	270
1510	21.9	31	8.4	10	32	270
1520	22	31	7.6	7.6	28.2	225
1530	21.2	32	9.6	10.4	28	360
1540	21.5	32	8.4	9.4	23.8	270
1550	21.6	32	6.4	7	14.8	270
1600	21.2	31	6.2	6.8	18.4	360
1610	21.5	31	6.8	8.4	29.6	225

APPENDIX C

LIST OF PLANT SPECIES VALUABLE FOR ELK FORAGE

Grasses and Grass-like Species

Fringed Brome	*Bromus ciliatus*
Bearded Wheatgrass	*Agropyron subsecundum*
Slender Wheatgrass	*Agropyron trachycaulum*
Redtop	*Agrostis alba*
Spiked Redtop	*Agrostis exarata*
Richardson's Needle Grass	*Stipa richardsonii*
Western Porcupine Grass	*Stipa spartea*
Sedge	*Carex* spp.

Shrub and Tree Species

Raspberry	*Rubus idaeus* var. *strigosus*
Western Snowberry	*Symphoricarpos occidentalis*
Willow	*Salix* spp.
Wild Rose	*Rosa* spp.
Twining Honeysuckle	*Lonicera glaucescens*
Quaking Aspen	*Populus tremuloides*
Balsam Poplar	*Populus balsamifera*

Forb Species

Northern Bedstraw	*Galium boreale*
American Vetch	*Vicia americana*
Fireweed	*Epilobium angustifolium*

Wild Peavine	*Lathyrus venosus*
Groundsel	*Senecio eremophilus*
Strawberry	*Fragaria glauca*
Field Horsetail	*Equisetum arvense*
Common Dandelion	*Taraxacum officinale*
Goldenrod	*Solidago* spp.
Canada Thistle	*Cirsium arvense*
Sow Thistle	*Sonchus arvensis*
Fleabane	*Erigeron* spp.
Three-flowered Avens	*Geum triflorum*
Yellow Avens	*Geum macrophyllum*
Pale Comandra	*Comandra pallida*
Bearberry	*Arctostaphylos uva-ursi*
Heart-leaved Alexander	*Zizia aptera*
Cow Parsnip	*Heracleum lanatum*
Rough Cinquefoil	*Potentilla norvegica*
Yarrow	*Achillea millifolium*
Wild Sarsaparilla	*Aralia nudicaulis*
Aster	*Aster* spp.
Prairie Sagebrush	*Artemesia ludoviciana*

APPENDIX D

LIST OF PLANT SPECIES NON-VALUABLE FOR ELK FORAGE

Tree and Shrub Species

Bunchberry	Cornus canadensis
Gooseberry	Ribes oxyacanthoides
Shrubby Cinquefoil	Potentilla fructicosa
Black Spruce	Picea mariana
White Spruce	Picea glauca
Jack Pine	Pinus banksiana

Forb Species

Tall Lungwort	Mertensia paniculata
Cow Vetch	Vicia cracca
Canada Anemone	Anemone canadensis
Lambsquarters	Chenopodium album
Strawberry Blite	Chenopodium capitum
Veiny Meadow Rue	Thalictrum venulosum
Western Canada Violet	Viola rugulosa
Smooth Yellow Violet	Viola pennsylvanica
Arrow-leaved Coltsfoot	Petasites sagittatus
Palmate-leaved Coltsfoot	Petasites palmatus
Broad-fruited Bur-reed	Sparganium eurycarpum
Orchis	Habenaria spp.
Grass of Parnassus	Parnassia glauca
Wood Rush	Lazula multiflora

False Solomon's Seal	_Smilacina racemosa_
Beardtongue	_Penstemon gracilis_
Red Indian Paintbrush	_Castilleja miniata_
Harebell	_Campanula rotundifolia_
Snakeroot	_Sanicula marilandica_
Baneberry	_Actaea rubra_
Wild Cucumber	_Echinocystis lobata_
Stinging Nettle	_Urtica dioica_
Field Chickweed	_Cerastium arvense_
Marsh Marigold	_Caltha palustris_
Hedysarum	_Hedysarum alpinum_
Puccoon	_Lithospermum canescens_
Skullcap	_Scutellaria galericulata_