Spring Burning in an Aspen-Conifer Stand for Maintenance of Moose Habitat, West Boulder River, Montana

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IN Montana moose are presently specific to coniferous forests and are specialized in their forage requirements. Studies in Montana and Wyoming indicate that browse is generally the most important yearlong forage class (Knowlton, 1960; Houston, 1968; and Stevens, 1970). Stevens (1970) found on his Lower Gallatin study area that the willow (*Salix* spp.) vegetation type was less important as moose winter range than previous studies elsewhere had shown. For example, Knowlton (1960) and Houston (1968) had extensive willow bottoms which were lacking on the Lower Gallatin study area. The Douglas-fir and aspen types were the key winter ranges of the Lower Gallatin and Douglas-fir (*Pseudotsuga menziesii*), willow (*Salix* spp.), red dogwood (*Cornus stolonifera*), serviceberry (*Amelanchier alnifolia*), mountain maple (*Acer glabrum*), chokecherry (*Prunus virginiana*) and *Populus* spp. were the most important browse items utilized within these types.

The West Boulder Drainage, an area similar to the Lower Gallatin, is located approximately 30 miles east of the Gallatin in the Absaroka Range. Comparison of Forest Service photographs, taken prior to 1930, with field checks of the same areas in 1970 indicate a change in vegetation composition was occurring within the West Boulder Drainage. Areas which had open aspects were found to be covered by conifers or were being invaded by them. The aspen type consisted primarily of mature trees with little, if any, aspen (*Populus tremuloides*) reproduction. Conifers had invaded aspen stands and large decadent or dead willows were scattered throughout conifer areas (Fig. 1). Signs of past fires could be found on most sites. Recognizing that moose in this area are dependent on the Douglas-fir and aspen types for much of their forage, it is apparent that successional change from seral to climax vegetation is lowering the carrying capacity for moose. On the Kenai in Alaska, Spencer and Hakala (1964) had indicated that large moose herds could not be sustained on forest areas where browse had grown out of reach and little was available for utilization by moose. They stated that "moose management ... is

Fig. 1. Within the West Boulder Drainage aspen stands consist primarily of mature trees that are being replaced by conifers.

concerned with the early plant successional stages where deciduous browse is available, and with factors that retard succession and maintain browse stands in seral hardwoods." In the past, as the forest reached the climax stage, fires caused by lightning or by man set the forest succession back, permitting an increase in seral vegetation. Modern fire fighting, however, has become so proficient that the likelihood of any fire burning more than a few acres is not great.

A number ot studies concerning the effects of fire on big game habitat have been reported. Spencer and Hakala (1964) refer to the beneficial effect fire had on a Kenai moose range by providing additional browse. Leege (1966) found that fire stimulated abundant basal sprout production on a brush field in Idaho. Five of the shrub species listed in his study are present within the West Boulder Drainage area. Prior to this study, there apparently had not been an experimental burn of a moose winter range in Montana east of the Continental Divide.

In the West Boulder Drainage, a portion of moose hunting district 516, moose were at a higher population level in the late 1950's and early 1960's than at present. The average moose harvest for the four seasons between 1960 and 1963 was 15 per year when the number of permits issued ranged from 15 to 20. In recent years 15 either-sex permits have been issued each year for a season that runs from mid-September to the end of November. An average of nine moose per year has been harvested the past 5 years from this district. In the future, fire management prescriptions may allow some wildfires to burn under specified conditions. Meanwhile, to sustain a moose population near present levels within the Boulder Drainage, some means of duplicating the effect of wildfire must be used.

A variety of methods, such as prescribed fire, logging and mechanical procedures, can be used to set back forest succession in the aspen type. Due to unstable soils in the West Boulder Drainage, logging and mechanical methods would present special problems in techniques and economics. Prescribed fire, however, should resemble the effect of wildfire on the trees and shrubs and dispose of any slash that would hinder movement of wildlife.

In 1970 the Montana Fish and Game Department and the Gallatin National Forest, U. S. Forest Service, initiated a study to determine the effect fire would have on the regeneration of aspen and associated shrubs and trees that serve as moose winter forage within the West Boulder Drainage. The results of this study may be applied to important moose winter range within the aspen type in south central Montana.

The U. S. Forest Service was responsible primarily for hydrologic and geologic evaluations, slashing, fire plans, fireline construction and treatment, while the Montana Fish and Game Department was responsible primarily for monitoring the effect of the treatment on the vegetation and writing up the final report. Both agencies assisted each other on most phases of the project.

PHYSIOGRAPHY

The Absaroka Mountain Range extends south from Livingston, Montana with the highest peaks rising over 11,000 feet above sea level. The mountains are bordered on the east and north by the Northern Great Plains. The mountains are composed of granite, gneiss and basic intrusives with carboniferous limestone exposed along the mountain front (Gleseker, 1956). The northern portion of the mountains contains high elevation plateaus, rugged peaks and deep glacier-carved canyons. The foothills and plains are generally rough and broken and are composed of cretaceous sandstones and shales. Near the mountain front these rocks are overlaid by glacial till and are exposed only along valley walls and ridges.

The study area, composed of approximately 40 acres, ranges between 5,400 and 6,000 feet above sea level and is readily accessible for treatment, fire control and the monitoring of the vegetation. It is located in a small drainage on the northeastern flank of the Absaroka Range within the Gallatin National Forest. This drainage flows eastward into the West Boulder River at a point near the West Boulder Ranger Station. It is used as a horse pasture by the Forest Service and is considered by Prellwitz and Prinkki (1972) to be the site of active earthflow similar to others in the area. The majority of movement apparently occurred during the last stages of glaciation when failure occurred in a shale layer bounded by layers of sandstone. After the initial slide, slumping near the head of the drainage continues to add material to the surface of the earthflow resulting in periodic movements and adjustment. It was determined that treatment would not contribute to increased movement.

The topography within the drainage consists of a number of parallel pressure ridges, intervening troughs and slumps. Sandstone ridges which border the drainage appear to dip 18 degrees northeast.

METHODS

Vegetation Analysis

Classification of vegetation types within the West Boulder Drainage was determined primarily by direct observation. Quantitative data were collected on the aspen type within the burn area prior to and following treatment. Several methods were employed. Transects were located on the lower half of the treatment area.

A method modified from the one described by Lyon (personal communication, 1970) was used to measure the response of the total plant community to fire treatment. Two (25 m) transects, each with a series of five contiguous (25 m^2) blocks, were placed within representative sites. Measurements were read in inches and feet.

In the (25 m^2) blocks, shrubs and trees were measured according to their height: greater than (2.5 m), between (1.5 m) and (2.5 m), and between (0.5 m) and (1.5 m). Trees greater than (2.5 m) in height were measured to the nearest inch in diameter, while those less than (2.5 m) but greater than (0.5 m) were counted and recorded by species. Dominance (basal area) was then estimated for larger trees and density for trees and seedlings.

Two diameters of shrub crowns and the average height were determined to the nearest inch within the three height zones. This information provides an estimate of dominance (crown volume), canopy area and density.

The point-center-quarter method (Cottam and Curtis, 1956) was used to determine density and relative density of trees and shrubs, and basal area and relative dominance of trees. Thirteen metal stakes were placed about 20 feet apart along a predetermined line. Measurements were taken on the nearest species to the stake within each quadrant. For the tree category (aspen and Engelman spruce) distance from the stake and diameter (breast height) were obtained.

For shrubs the distance of the closest stem to the stake, plant height and average diameter of the crown were measured.

The age of various tree species was determined by examination of cross sections of their trunks.

Fire Prescription

The upper and lower 300 to 400 feet of the drainage was left untreated. Approximately 40 acres in between served as the area to be burned and consisted primarily of the aspen type although the Douglas-fir type was also represented. Hawthorn and sage grass types were not intentionally burned except along firelines. Untreated areas of aspen and Douglas-fir provided areas of comparison and helped stabilize the soil. They also helped to shade the treatment site from view, protecting the aesthetics of the area.

It was felt that a burn prior to plant growth in the spring would decrease root crown damage to some plants because of higher soil moisture and would allow greater control of the fire than at a later time when vegetation had dried and fire danger was high. Another advantage of a spring burn was that treatment just prior to the growing season would reduce the length of time the soil would be exposed without cover. However, a spring burn has the disadvantage of occurring at a time when the herbaceous vegetation has been knocked down by snow and may be relatively damp on north exposures and drainage bottoms. To provide sufficient fuel to insure that the aerial portions of trees and shrubs were killed, the majority of aspen and conifers greater than 3 or 4 inches in diameter were felled by hand during the summer prior to treatment. The cost of this was high and after burning, there is some question that it was needed.

A fireline was constructed by hand around the treatment area during the summer of 1971. As soon as sections of the fireline became free of snow during the spring of 1972, a buffer area next to the fireline was burned to remove the fine fuels.

The following conditions were considered necessary by Forest Service personnel for a prescribed burn: generally dry conditions, relative humidity between 10 and 30 percent, fuel moisture of 5 to 10 percent, winds calm to 15 miles per hour and temperature between 65 and 85° F.

PREBURN VEGETATION CHARACTERISTICS

The drainage is situated on the ecotone between forest and prairie. Four vegetation types are present and are similar to those described by Stevens (1970) for the Gallatin Mountains. The aspen type is located on mesic sites primarily within the drainage bottom and characterized by a mixed overstory of aspen, Engleman spruce (*Picea englemannii*), and/or Douglas-fir. Prominent understory shrubs include spirea, snowberry, ninebark, red osier dogwood, willow, serviceberry and rose. The Douglas-fir type is located primarily on north-facing exposures. Ninebark (*Physocarpus malvaceus*) is the most prominent shrub. The hawthorn type is dominated by hawthorn (*Crataegus* spp.) and occurs in various size thickets on mesic sites. Snowberry (*Symphoricarpus albus*), serviceberry and rose are important understory shrubs. On some sites hawthorn is found interspersed with aspen and willows. On south and east exposures the primary type is sagegrass. Within this type chokecherry and hawthorn were common on certain sites. There was a mixing of types within the drainage.

Quantitative data on trees were collected on the aspen type within the burn area prior to treatment. The average age of 25 aspen that were checked was 74 years with a range of 58-84 years. This was a conservative estimate as a number of aspen had heart rot with annual growth rings indiscernible. On the Gros Ventre, Krebill (1972) found that the majority of aspen were between 81 and 120 years of age and possibly reaching senility. He refers to Meinecke (1929) who noted that in Utah aspen does not reach much past 130 years in age. In Yellowstone National Park, Houston (1973) stated that present aspen classes are primarily large overmature trees ranging in age from about 75 to 120 years. He cited Gruell and Loope (1973) who found in Jackson Hole, Wyoming that unburned open stands begin to deteriorate after about 80 years. Houston (1973) suggested that fire suppression has allowed aspen to obtain an age greater than would normally occur in Yellowstone Park. This may also apply to the West Boulder as well as surrounding areas. Little aspen reproduction is taking place on the West Boulder study area with the last major fire occurring prior to 1900.

Five large spruce were found to average 101 years in age with a range of 82-127 years. Another spruce was about 47 years in age. The next age class of spruce averaged 23 years with a range of 18-27 years for 15 trees sampled. Spruce seedlings were evident throughout the study area.

The point-center-quarter transect was set up on what appeared to be the most representative portion of the aspen type. In contrast the two sets of five 269 square feet (2.5 m^2) blocks were used to monitor change on areas which had special vegetational characteristics due to site. For this reason the emphasis will be placed primarily on the results of the individual transects rather than an average of all transects.

Preburn density per acre as determined by the point-center-quarter method (Table 1) was 198 aspen and 59 spruce per acre. Preburn tree density was also determined within ten 269 square-foot blocks (Table 2). Only those trees exceeding 19.6 inches in height were recorded. Blocks 1-5 and 6-10 averaged 130 and 583 aspen and 97 and 3,853 spruce per acre, respectively, with an average for all blocks of 356 aspen and 1,975 spruce per acre. All aspen recorded were greater than 8 feet in height. On the Lower Gallatin (Schladweiler, 1974) five aspen stands had an average of 645 aspen per acre. Fourteen percent were under 8 feet high. Reichelt (1973) reported an average density of 735 aspen per acre along the Madison River Drainage in Montana.

In the lake states 300-400 aspen per acre may be average for mature stands (Fralish, 1972), while Krebill (1972) found about 466 aspen per acre in the Gros Ventre for the overstory. With the exception of blocks 6-10, aspen densities appeared to be lower than those in most other areas for mature aspen.

The point-center-quarter method transect had a relative density of 77 percent aspen and 23 percent spruce (Table 3). The relative density of trees with blocks 1-5 was 57 percent aspen and 43 percent spruce, while blocks 6-10 had 13 percent aspen and 87 percent spruce (Table 4). The relative density for all 10 blocks was 15 percent aspen and 85 percent spruce.

Average basal area determined by the point-center-quarter method was 107 square feet per acre for aspen and 25 square feet per acre for spruce (Table 5). Average basal area of aspen per acre (Table 6)

Table 1. Average density per unit area and survival of *Populus tremuloides* and *Picea engelmanii* before and after fire treatment as determined by the Point-Center-Quarter Method.

	Pre-Fire Treatment		Post-Fire Treatment		
		Treatment Survival	Growing Season 1	Growing Season 2	Survival
Species	Stems Per Acre	%	Stems Per Acre	Stems Per Acre	%
Populus tremuloides	198	0	27,396[1]	26,241[2]	96
Picea engelmanni	59	0	0	0	—

[1]Average height 22 inches with a range of 9 to 47 inches.
[2]Average height 36 inches with a range of 11 to 65 inches.

Table 2. Average density per unit area and survival of *Populus tremuloides* and *Picea engelmannii* before and after fire treatment as determined by ten 269 Sq Ft (25 Sq M) Blocks[1].

		Pre-Fire Treatment		Post-Fire Treatment		
			Treatment Survival	Growing Season 1	Growing Season 2	Survival
Blocks	Species	Stems Per Acre	%	Stems Per Acre	Stems Per Acre	%
1-5	*Populus tremuloides*	130	0	49,315	43,741	87
	Picea engelmannii	97	0	0	0	–
6-10	*Populus tremuloides*	583	0	34,441	42,738	124
	Picea engelmannii	3,853	0	0	0	–
1-10	*Populus tremuloides*	356	0	41,878[2]	43,239[3]	103
	Picea engelmannii	1,975	0	0	0	–

[1]Only trees above 19.6 inches (.5 m) were counted.
[2]Not greater than 59.1 inches (1.5 m) in height.
[3]A total of 10% had obtained a height greater than 59.1 inches (1.5 m).

Table 3. Relative density of *Populus tremuloides* and *Picea engelmannii* before and after fire treatment as determined by the Point-Center-Quarter Method.

	Pre-Fire Treatment	Post-Fire Treatment	
		Growing Season 1	Growing Season 2
Species	Relative Density %	Relative Density %	Relative Density %
Populus tremuloides	77	100	100
Picea engelmannii	23	0	0

Table 4. Relative density of *Populus tremuloides* and *Picea engelmannii* before and after fire treatment as determined with ten Sq Ft (25 Sq M) Blocks[1].

		Pre-Fire Treatment	Post-Fire Treatment	
			Growing Season 1	Growing Season 2
Blocks	Species	Relative Density %	Relative Density %	Relative Density %
1-5	*Populus tremuloides*	57	100	100
	Picea engelmannii	43	0	0
6-10	*Populus tremuloides*	13	100	100
	Picea engelmannii	87	0	0
1-10	*Populus tremuloides*	15	100	100
	Picea engelmannii	85	0	0

[1]Only trees above 19.5 inches in height were counted.

as determined within the ten 269 square-foot blocks was 99 square feet with 60 and 138 square feet for blocks 1-5 and 6-10, respectively. Average basal area for spruce for the 10 blocks was 22 square feet per acre.

Table 5. Average diameters, basal areas and relative dominance of 40 *Populus tremuloides* and 12 *Picea engelmannii* as determined by the Point-Center-Quarter Method prior to fire treatment.

Species	Average D.B.H. (in)	Range D.B.H. (in)	Basal Area Per Acre (Sq Ft)	Relative Dominance (%)
Populus tremuloides	9.0	.5-18.0	107	81
Picea engelmannii	4.7	.5-27.0	25	19

The average basal area for aspen on the Madison Drainage (Reichelt, 1973) was 144 square feet per acre. In the Gros Ventre live aspen averaged about 138 square feet per acre (Krebill, 1974). In Utah's Wasatch Mountains (Johnston and Doty, 1972), aspen basal area varied from 20 to 140 square feet per acre with an average of 82 for aspen considered to have poor form. Jarvis (1968) reported that for poor sites in Saskatchewan, aspen 70 years of age had a basal area of 109 square feet while for Ontario aspen of the same age on poor sites had basal areas of 125 square feet. It appears that basal areas of aspen in this study are similar to basal areas of aspen in other areas that are considered to be in poor condition or are growing on

Table 6. Average diameters and basal areas of 52 *Populus tremuloides* as determined by the Point-Center-Quarter Method following fire treatment.

Post-Fire Treatment			
Growing Season 1		Growing Season 2	
Average Basal Diameter (In)	Basal Area Per Acre (Sq Ft)	Average Basal Diameter (In)	Basal Area Per Acre (Sq Ft)
.2	6.7	.3	13.1

poorer sites. The fact that this stand lies on the ecotone between forest and prairie means the site it occupies is probably not as ideal as for those stands situated more within the forest.

Relative dominance (basal area) of aspen and spruce was found to be quite similar by both methods. The relative dominance for aspen and spruce as determined by the point-center-quarter method (Table 5) was 81 and 19 percent in the order mentioned. Within the 269 square-foot blocks (Table 7), the relative dominance of aspen and spruce averaged 82 and 18 percent, respectively.

Table 7. Average diameters, basal areas and relative dominance of 21 *Populus tremuloides* and 64 *Picea engelmannii* in ten 269 Sq Ft (25 Sq M) blocks prior to fire treatment.

Blocks	Species	Average D.B.H. (In)	Range D.B.H. (In)	Basal Area Per Acre (Sq Ft)	Relative Dominance (%)
1-5	*Populus tremuloides*	10.5	8.0-13.0	60.7	81
	Picea engelmannii	9.0	9.0	14.3	19
6-10	*Populus tremuloides*	5.8	1.8-11.9	138.0	82
	Picea engelmannii	1.6	.8-3.5	30.0	18
1-10	*Populus tremuloides*	6.7	1.8-13.0	99.5	82
	Picea engelmannii	1.9	.8-9.0	22.3	18

The average diameter of 40 aspen measured by the point-center-quarter method (Table 5) was 9.0 inches with a range of 0.5-18.0 inches. Spruce averaged 4.7 inches and ranged between 0.5 and 27.0 inches.

Twenty-one aspen measured within the ten 269 square-foot blocks (Table 7) averaged 6.7 inches in diameter and ranged between 1.8 and 13.0 inches. The average diameter of 64 spruce was 1.9 inches and the range 0.8 to 9.0 inches.

Thirteen shrubs, four of which were considered by Stevens (1970) as important browse for moose in the aspen and Douglas-fir types, were recorded during this study. Point-center-quarter measurements (Table 8) indicated that white spirea (*Spiraea betulifolia*) had the greatest preburn density (15,749/acre) followed by snowberry, ninebark, rose, serviceberry and chokecherry. Willow and red dogwood were not recorded.

Table 8. Average density per unit area and relative density of shrubs before and after fire treatment as determined by the Point-Center-Quarter Method.

	Pre-Fire Treatment		Post-Fire Treatment			
			Growing Season 1		Growing Season 2	
Species	Average Density Per Acre	Relative Density (%)	Average Density Per Acre	Relative Density (%)	Average Density Per Acre	Relative Density (%)
Spirea betulifolia	15,749	42	51,754	46	114,664	42
Physocarpus malvaceus	5,726	15	12,941	12	26,077	10
Amelanchier alnifolia	2,148	6	2,153	2	5,205	2
Symphoricarpos albus	10,023	27	30,189	27	78,176	29
Rosa woodsii	2,863	8	15,094	13	31,282	12
Prunus virginiana	760	2	0	0	0	0
Berberis repens	0	0	0	0	15,641	6

Serviceberry and chokecherry, the two most important browse species for moose along this transect, made up only 8 percent of the total number of shrubs recorded. The average height of shrubs is shown in Table 9.

Within the ten 269 square-foot blocks, three height classes of shrubs were recorded as follows: above 98 inches, between 59.1 and 98.0 inches and between 19.6 and 59.1 inches. Prior to treatment within the 98.0+ inches height class in blocks 1-5, willow had the greatest average density (227/acre) followed by hawthorn, serviceberry and red dogwood. Serviceberry, red dogwood and willow combined made up 71 percent of the total number of shrubs recorded.

In blocks 6-10 willow, hawthorn and serviceberry each averaged about 65/acre with chokecherry averaging about 32/acre. Serviceberry, chokecherry and willow made up 78 percent of the total shrubs recorded in this height range.

In the middle height class of blocks 1-5 (59.1 to 98.0 inches), serviceberry had the highest pretreatment average density (194/acre) followed by rose, chokecherry and hawthorn. Combined, serviceberry and chokecherry made up 69 percent of total shrubs recorded within this height range.

In blocks 6-10 serviceberry had the greatest average density (162/acre) followed by ninebark, rose and silverberry (*Eleagnus commutata*). Serviceberry and willow together made up 55 percent of the number of shrubs recorded in the height class.

Within blocks 1-5 and 6-10 (height class 19.6 to 59.1 inches), snowberry had the greatest average preburn densities (7,319/acre and 5,472/acre, respectively), followed by red dogwood and rose as seen in Table 10. Gooseberry (*Ribes* spp.) was an important component of blocks 1-5, but was not present within blocks 6-10. Ninebark had an average density for each set of blocks of 389/acre. Serviceberry had an average density of 712/acre and 358/acre for blocks 1-5 and 6-10, respectively. Chokecherry was represented within only blocks 1-5 (227/acre). Other shrubs found within one or both sets of blocks include spirea, currant (*Ribes* spp.), hawthorn and silverberry. In blocks 1-5 serviceberry, red dogwood, chokecherry and willow made up 20 percent of the relative density, while these species made up only 18 percent within blocks 6-10.

Table 9. Average height of shrubs before and after fire treatment as determined by the Point-Center-Quarter Method.

	Before Treatment		One Growing Season After Treatment		Two Growing Seasons After Treatment	
Species	Average Height	Range	Average Height	Range	Average Height	Range
Amelanchier alnifolia	27.3	7-39	24.0	—	18.0	)
Berberis repens	00.0	0-0	00.0	0-0	2.3	1-4
Physocarpus malvaceus	30.5	20-46	16.6	3-33	19.2	7-35
Prunus virginianus	31.0	—	00.0	0-0	00.0	0-0
Rosa woodsii	28.0	26-33	11.0	4-20	16.0	3-22
Spiraea betulifolia	18.9	14-30	7.8	2-17	14.1	6-24
Symphoricarpos albus	21.5	13-30	8.9	3-21	10.2	1-20

Table 10. Average density per unit area and relative density of shrubs before and after treatment as determined by ten 269 Sq Ft (25 Sq M) Blocks Below 59.1 inches in height.

Blocks	Species	Pre-Fire Treatment		Post-Fire Treatment			
				Growing Season 1		Growing Season 2	
		Average Density Per Acre	Relative Density (%)	Average Density Per Acre	Relative Density (%)	Average Density Per Acre	Relative Density (%)
1-5	*Amelanchier alnifolia*	712	6	421	13	518	7
6-10		358	4	227	23	259	4
1-10		534	5	324	16	389	6
1-5	*Cornus stolonifera*	1,489	12	1,069	33	1,328	18
6-10		1,036	13	259	27	1,133	19
1-10		1,263	12	664	32	1,231	18
1-5	*Crataegus* spp.	0	0	0	0	32	—
6-10		97	1	0	0	65	1
1-10		49	—	0	0	16	—
1-5.	*Eleagnus commutata*	0	0	0	0	0	0
6-10		65	1	0	0	0	0
1-10		32	—	0	0	0	0
1-5	*Physocarpus malvaceus*	389	3	291	9	356	5
6-10		389	5	97	10	162	3
1-10		389	4	194	9	259	4
1-5	*Prunus virginiana*	227	2	32	1	97	1
6-10		0	0	65	7	162	3
1-10		113	1	49	2	130	2

Table 10. Average density per unit area and relative density of shrubs before and after treatment as determined by ten 269 Sq Ft (25 Sq M) blocks below 59.1 inches in height (Cont.).

		Pre-Fire Treatment		Post-Fire Treatment			
				Growing Season 1		Growing Season 2	
Blocks	Species	Average Density Per Acre	Relative Density (%)	Average Density Per Acre	Relative Density (%)	Average Density Per Acre	Relative Density (%)
1-5	*Ribes* spp. (Currants)	97	1	0	0	0	0
6-10		32	—	0	0	0	0
1-10		65	—	0	0	0	0
1-5	*Ribes* spp. (Gooseberries)	939	7	356	11	1,684	23
6-10		0	0	0	0	0	0
1-10		470	5	178	9	842	13
1-5	*Rosa woodsii*	1,004	8	615	19	810	11
6-10		583	7	65	7	551	9
1-10		793	8	340	16	680	10
1-5	*Salix* spp.	32	—	194	6	356	5
6-10		0	0	32	3	97	2
1-10		16	—	113	5	227	3
1-5	*Spiraea betulifolia*	291	2	0	0	162	2
6-10		65	1	0	0	615	10
1-10		178	2	0	0	389	6
1-5	*Symphoricarpos albus*	7,314	59	227	7	2,072	28
6-10		5,472	68	227	23	2,914	49
1-10		6,396	62	227	11	2,494	38

Of more significance than shrub density is canopy area and crown volume as they provide a better impression of forage availability. The point-center-quarter transect data (Table 11) indicate that ninebark had the highest preburn canopy area per unit area (5,953 square feet/acre) followed by spirea, snowberry, rose, serviceberry and chokeberry. Serviceberry and chokeberry made up 9 percent of the relative canopy area.

When preburn crown volume was considered, ninebark had a crown volume per unit area of 17,394 cubic feet/acre followed by spirea, snowberry, serviceberry, rose and chokecherry. Serviceberry and chokecherry made up 12 percent of the relative crown volume.

Within the ten 269 square-foot blocks, discussion will be limited to the two lower height classes as browse above 8 feet is generally unavailable for forage. In the 59.1 to 98.0 inches height class (Table 12), the preburn canopy areas (860 square feet/acre) and crown volumes (5,697 cubic feet/acre) of serviceberry, chokecherry and willow indicated that those shrubs made up an important portion of the total available preferred forage for moose. Within the 19.6 to 59.1 inches class (Table 13), snowberry had a preburn average canopy area of 6,956 square feet for the ten blocks followed by red dogwood, ninebark, rose, serviceberry, currant and spirea. Hawthorn, chokecherry, gooseberry and willow were recorded in only one set of blocks. Red dogwood and willow made up 19 percent of the relative canopy area, while serviceberry and chokecherry made up 5 percent.

Within the same height class snowberry (Table 14) had an average crown volume of 13,487 cubic feet/acre for the 10 blocks followed by red dogwood, ninebark, rose, serviceberry, gooseberry, chokecherry, hawthorn, spirea and willow. Red dogwood and willow made up 25 percent of the relative crown volume, while serviceberry and chokecherry made up 1 percent.

RESULTS

Treatment

A preburn along the firelines resulted in the consumption of forbs and grasses. Heat killed the crowns of many of the shrubs without

Table 11. Average shrub crown area and volume per acre as determined before and after treatment by the Point-Center-Quarter Method.

	Pre-Fire Treatment		Post Fire Treatment							
			1				2			
Species	Area Sq Ft	Volume Cu Ft	Area Sq Ft	% of Original Area	Volume Cu Ft	% of Original Volume	Area Sq Ft	% of Original Area	Volume Cu Ft	% of Original Volume
Amelanchier alnifolia	1,617	4,985	211	13	423	8	188	12	681	14
Berberis repens	0	0	0	—	0	—	46	—	—	—
Physocarpus malvaceus	5,953	17,394	3,035	51	7,979	46	16,441	276	46,191	266
Prunus virginianus	224	578	0	—	0	—	0	—	0	—
Rosa woodsii	1,741	4,212	941	54	1,201	29	5,518	317	8,522	202
Spiraea betulifolia	5,498	9,409	1,542	28	1,258	13	9,253	168	13,689	145
Symphoricarpos albus	4,455	9,270	1,400	31	1,494	16	5,901	132	6,963	75

Table 12. Average shrub canopy area and crown volume per acre (59.1-85.0 inches height class) before treatment as determined within ten 269 Sq Ft (25 Sq M) blocks.

Blocks	Species	Canopy Area Per Acre (Sq Ft)	Crown Volume Per Acre (Cu Ft)
1-5	*Amelanchier alnifolia*	932	6,265
6-10		303	2,229
1-10		618	4,247
1-5	*Prunus virginiana*	407	2,441
6-10		0	0
1-10		204	1,221
1-5	*Salix* spp.	76	458
6-10		0	0
1-10		38	229

consuming them, but was not intense enough to kill large mature aspen adjacent to the firelines.

On April 30, 1972 a backing fire was started from the upper fireline. It burned to the midway point, when preburn conditions that were met changed radically due to an approaching weather front. This resulted in a cold burn. Approximately 25-30 percent of the fine fuels and 25 percent of the heavy fuels were consumed with the larger fuels burning only in areas of heavy concentration. The majority of large standing aspen crowns were not burned by the fire.

On May 16, 1972 a hot running fire burned from the lower fireline to the midway point (Fig. 2). Conditions during this burn were as follows: Relative humidity was 20 percent, fuel moistures 7 percent, wind 0-10 miles per hour and variable, and temperature 70-80° F. Approximately 90 to 100 percent of the fine fuels were consumed and 25-50 percent of the heavy fuels were charred or consumed. Practically all of the aerial fuels in the lower half were ignited. Litter and soil penetration by the fire was generally shallow. Maximum fire penetration was 3 to 4 inches with the majority of the ground moist at the 2-3-inch level immediately after the burn.

POSTBURN TREE CHARACTERISTICS

After fire treatment no aerial portion of existing live trees within the transects had survived (Tables 1 and 2). The point-center-quarter transect measurements indicated about 27,396 aspen suckers per acre following the first postburn growing season (1972). The average

Table 13. Average canopy area per acre of shrubs between 19.5 (.5 M) and 59.1 (1.5 M) [illegible] determined within ten 269 Sq Ft (25 Sq M) blocks.

Blocks	Species	Pre-Fire Treatment	Post-Fire Treatment			
			Growing Season 1		Growing Season 2	
		Average Per Acre (Sq Ft)	Average Per Acre (Sq Ft)	Percent of Original Area	Average Per Acre (Sq Ft)	Percent of Original Area
1-5	*Amelanchier alnifolia*	459	192	42	147	32
6-10		264	42	16	83	32
1-10		361	117	32	115	32
1-5	*Cornus stolonifera*	2,542	681	27	1,277	50
6-10		1,416	111	8	1,380	97
1-10		1,867	396	21	1,328	72
1-5	*Crataegus* spp.	0	0	0	14	–
6-10		64	0	0	211	34
1-10		32	0	0	18	56
1-5	*Physocarpos malvaceus*	753	76	10	135	18
6-10		865	84	10	134	15
1-10		809	80	10	134	1
1-5	*Salix* spp.	71	657	931	2,155	3,051
6-10		0	85	–	308	–
1-10		35	406	1,151	1,232	3,487
1-5	*Shepherdia canadensis*	0	0	–	0	–
6-10		188	0	0	0	0
6-10		94	0	0	0	0

Table 13. (continued) Average canopy area per acre of shrubs between 19.5 (.5 M) and 59.1 (1.5 M) inches in height before and after treatment as determined within ten 269 Sq Ft (25 Sq M) blocks.

Blocks	Species	Pre-Fire Treatment	Post-Fire Treatment			
			Growing Season 1		Growing Season 2	
		Average Per Acre (Sq Ft)	Average Per Acre (Sq Ft)	Percent of Original Area	Average Per Acre (Sq Ft)	Percent of Original Area
1-5	*Spiraea betulifolia*	65	0	0	10	15
6-10		49	0	0	37	76
1-10		57	0	0	23	41
1-5	*Symphoricarpos albus*	6,956	58	1	634	9
6-10		4,379	22	1	814	19
1-10		5,668	40	1	723	13
1-5	*Prunus virginiana*	118	2	1	24	20
6-10		0	4	0	34	—
1-10		59	3	4	30	5
1-5	*Ribes* spp. (Currant)	141	0	0	0	0
6-10		191	0	0	0	0
1-10		166	0	0	0	0
1-5	*Ribes* spp. (Gooseberry)	271	204	75	173	64
6-10		0	0	0	0	0
1-10		136	102	75	87	64
1-5	*Rosa woodsii*	873	167	19	464	53
6-10		291	14	5	451	155
1-10		582	90	16	458	79

Fig. 2. Aspect of burn site immediately following the hot running fire of May 1972. No aerial portions of existing live trees had survived.

height of aspen measured was 22.0 inches with a range of 9 to 47.0 inches. Aspen suckers averaged 41,878 per acre within the ten 269 square-foot blocks and 49,315 and 34,441 aspen suckers per acre for blocks 1-5 and 6-10, respectively. These were located within the 19.6 to 59.1 inches height class. Aspen sprouts lower than 19.6 inches were not recorded.

Following the second growing season (1973), the point-center-quarter method transect indicated a 96 percent survival of aspen suckers (Table 1) from the 1972 growing season to the end of the 1973 season (26,241-27,396/acre). Their average height had increased about 14 inches over the previous year with an average of approximately 36.0 inches and a range of 11 to 65 inches. Aspen suckers (Table 2) averaged 43,239 per acre for the ten 269 square-foot blocks. Blocks 1-5 and 6-10 averaged 43.741 and 42,738, respectively. This is a survival of 87 percent for blocks 1-5 and 124 percent for blocks 6-10. The latter percentage increase is due to an increase from less than 19.6 inches to a height which would be re-

Table 14. Average crown volume per acre of shrubs between 19.5 (.5 M) and 59.1 (1.5 M) inches in height before and after treatment as determined within ten 269 Sq Ft (25 Sq M) blocks.

		Pre-Fire Treatment	Post-Fire Treatment			
			Growing Season 1		Growing Season 2	
Blocks	Species	Average Per Acre Cu Ft	Average Per Acre Cu Ft	Percent of Original Volume	Average Per Acre Cu Ft	Percent of Original Volume
1-5	*Amelanchier alnifolia*	1,537	373	24	430	28
6-10		725	65	9	174	24
1-10		1,131	219	19	302	27
1-5	*Cornus stolonifera*	7,467	1,359	18	3,725	50
6-10		6,501	362	6	3,800	58
1-10		6,984	860	12	3,763	54
1-5	*Crataegus* spp.	0	0	—	42	—
6-10		235	0	0	46	20
1-10		117	0	0	44	38
1-5	*Physocarpos malvaceus*	2,966	154	6	280	9
6-10		3,522	203	6	347	10
1-10		3,244	188	6	310	10
1-5	*Prunus virginiana*	312	3	1	59	19
6-10		0	7	—	75	—
1-10		156	5	3	67	43
1-5	*Ribes* spp. (Currant)	589	0	0	0	0
6-10		636	0	0	0	0
1-10		613	0	0	0	0

(continued)

Table 14. Average crown volume per acre of shrubs between 19.5 (.5 M) and 59.1 (1.5 M) inches in height [illegible] as determined within ten 269 Sq Ft (25 Sq M) blocks.

Blocks	Species	Pre-Fire Treatment	Post-Fire Treatment			
			Growng Season 1		Growing Season 2	
		Average Per Acre Cu Ft	Average Per Acre Cu Ft	Percent of Original Volume	Average Per Acre Cu Ft	Percent of Original Volume
1-5	*Ribes* spp. (Gooseberry)	849	386	45	375	44
6-10		0	0	—	0	—
1-10		424	193	46	187	44
1-5	*Rosa woodsii*	2,856	356	12	1,114	39
6-10		698	32	5	1,019	146
1-10		1,777	194	11	1,066	60
1-5	*Salix* spp.	188	2,058	1,092	8,838	4,692
6-10		0	169	—	1,653	—
1-10		94	1,114	1,182	5,246	5,569
1-5	*Shepherdia canadensis*	0	0	—	0	—
6-10		879	0	0	0	0
1-10		4,402	0	0	0	0
1-5	*Spiraea betulifolia*	115	0	0	16	14
6-10		95	0	0	67	71
1-10		105	0	0	42	40
1-5	*Symphoricarpos albus*	17,559	109	1	1,210	7
6-10		9,415	50	1	1,620	17
1-10		13,487	79	1	1,415	10

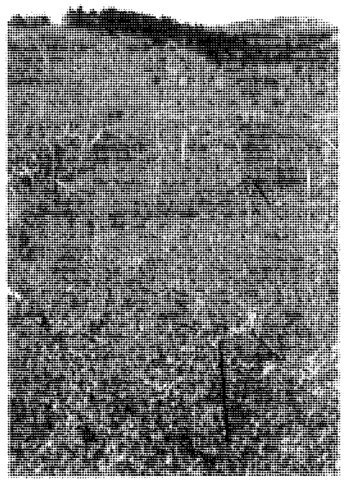

Fig. 3. Aspen stand within the burn site two growing seasons after fire treatment.

corded. During the 1973 growing season about 10 percent of the aspen suckers had obtained a height greater than 59.1 inches. Figure 3 shows the general aspect of the aspen within the burn two growing seasons after treatment.

The survival of aspen sprouts on Smith's study area in Utah (1974) following the second growing season after clearcutting varied between 90 percent to less than half of the first growing season. Perala (1972) indicates that initial high numbers of aspen sprouts in Minnesota (up to 60,000 per acre) are reduced quickly in number by natural mortality. He refers to several studies indicating 6,000 suckers per acre would adequately stock a site, so that greater numbers are not necessary to perpetuate an aspen stand.

Basal area of aspen per unit area as determined by the point-center-quarter method (Table 6) approximately doubled from the previous year, but still was insignificant when compared to aspen basal areas prior to the burn.

No spruce seedlings were recorded or observed on the transect.

Postburn Shrub Characteristics

Following the first growing season after the burn (1972), the density per acre for spirea, ninebark, serviceberry, snowberry and rose showed significant increase between pre- and postburn and between postburn years along the point-center-quarter transect (Table 8).

The relative density of spirea and snowberry following the first growing season remained similar to that determined during the preburn period (Table 8). The relative density of rose increased, while serviceberry declined and chokecherry was not recorded. The relative density of shrubs following the second growing season (1973) was comparable to the previous year with the exception that Oregon grape (*Berberis repens*) was first recorded.

Data from the point-center-quarter method transect indicate that following the first postburn growing season the average height (Table 9) obtained by ninebark, rose, spirea and snowberry was about half or less of their average preburn height. Although only a very limited number of serviceberry and chokecherry were sampled, average heights for them also decreased. Two growing seasons after treatment average shrub heights had still not equaled average preburn heights.

Within the 269 square foot blocks following the first growing season after treatment (1972), the only height class in which living shrubs were present was between 19.6 and 59.1 inches (Table 10). After the second postburn growing season, all shrubs were still below 59.1 inches in height. Snowberry had the greatest average density of all shrubs on both sets of blocks, but was still significantly less than preburn numbers. Red dogwood density was similar to preburn density, while rose was third with less than preburn density. This is in the same order as prior to the burn. The number of willow was greater within this height class than prior to treatment. Shrubs which increased over preburn densities for one set of blocks include gooseberry, spirea and chokecherry. Serviceberry and ninebark had less than preburn densities for both sets of blocks. The remaining shrub density still remained less than that recorded prior to the burn in this height class.

In blocks 1-5 postburn relative densities of serviceberry, red dogwood, chokecherry and willow were 31 percent, while in blocks 6-10 these species were 38 percent.

The results of pre- and post-treatment measurement indicated that shrub density, composition and height changes were similar to those described in other studies. Lyon (1966) indicated that shrub density in the Douglas-fir zone increased following fire because multiple sprouts were produced from the root crowns of single plants. On the West Boulder the point-center-quarter measurements showed that interspaces between plants lacking aerial shoots prior to the fire had been filled with new sprouts. As these sprouts mature many of them are not expected to survive. The 269 square foot blocks do not adequately represent the total change in densities that occurred because shrubs below 19.6 inches are not recorded. However, they do provide some impression of change in density at various height levels.

At this point in the study no new tree or shrub seedlings have been observed except for Oregon grape. The stable relative density of shrubs before and after treatment in this study (point-center-quarter method) suggests that post-treatment shrubs were largely determined by shrubs existing prior to treatment. This is because the roots were not destroyed by burning and is comparable to the findings of Spencer and Hakala (1964) on the Kenai.

Leege (1966) reported that in Idaho the height of shrubs was considerably reduced following the first growing season after fire treatment. Data from this study also indicate considerable reduction in height. Within the 269 square-foot blocks, it appears that it will take several years before shrubs will approach pre-treatment height levels.

Along the point-center-quarter transect two growing seasons after treatment ninebark had a canopy area (Table 11) of 16,441 square feet/acre followed by spirea, snowberry, rose, serviceberry and Oregon grape. Snowberry, rose, spirea and ninebark had greater canopy area per acre than prior to the burn. Chokecherry was not present. Serviceberry had only 12 percent of its original area and with chokecherry made up less than one percent of the relative canopy area.

Two years after treatment ninebark had a crown volume (Table

11) of 46,191 cubic feet/acre followed by spirea, rose, snowberry, serviceberry and Oregon grape. Volume per acre had increased for four species over preburn volumes, while three species had less volume. Snowberry had 75 percent of the original volume per acre, while serviceberry had 14 percent and chokecherry was not present. Serviceberry made up less than 1 percent of the relative crown volume per acre compared to 12 percent for serviceberry and chokecherry prior to treatment.

The above data indicate that serviceberry and chokecherry, 2 years after treatment, were producing only a small proportion of the forage produced prior to the burn along the point-center-quarter transects.

Two seasons after treatment red dogwood had an average relative canopy area (Table 13) of 1,328 square feet/acre for the 10 blocks (19.6-59.1 inches) followed by willow, snowberry, rose, ninebark, serviceberry, chokecherry and hawthorn. Gooseberry was recorded in only one set of blocks. Willow had 348 percent of its original area per acre, while red dogwood and willow had 72 percent, serviceberry 32 percent and chokecherry 50 percent. The remaining shrubs had less than the original canopy area per acre except for rose, where in blocks 6-10 there was a 155 percent increase. Red dogwood and willow made up 62 percent of the relative canopy area, while serviceberry and chokecherry made up 4 percent.

Two growing seasons after treatment willow had an average relative crown volume (Table 14) of 5,246 cubic feet relative crown volume (Table 14) of 5,246 cubic feet/acre followed by red dogwood, snowberry, rose, ninebark, serviceberry, gooseberry, chokecherry, hawthorn and spirea. Red dogwood had 54 percent of its preburn volume per acre, while serviceberry had 27 percent, chokecherry had 43 percent and willow had 5,569 percent.

When one considers the four primary forage species (serviceberry red dogwood, chokecherry and willow), the mean total crown volume per acre for all height classes below 98 inches (blocks 1-10) available to moose was 14,062 cubic feet/acre (18,208 and 9,911 cubic feet2 acre for blocks 1-5 and 6-10, respectively) prior to treatment and 9,378 cubic feet/acre (13,052 and 5,700 cubic feet/acre for blocks

1-5 and 6-10, respectively) 2 years after. This is a decrease in mean crown volume of 33 percent per acre for blocks 1-10 for these species.

The data indicate that where serviceberry, chokecherry and perhaps red dogwood are primary forage types, a number of years must pass before the canopy area and crown volume per acre equal the original areas and volumes within reach of moose. The data suggest, however, that the reduction in height of willow followed by vigorous sprouting provides a considerable amount of preferred forage available for moose that was formerly unavailable.

The overall effect of this burn is a temporary lowering in available preferred shrubs for several years. In the long run serviceberry and chokecherry will undoubtedly recover and provide abundant forage along with red dogwood and willow.

DISCUSSION

This study documents the effect fire has on the regeneration of aspen and associated shrubs and trees within an aspen, conifer stand that serves as moose winter range in south central Montana. Following a prescribed burn during the spring of 1972, densities of aspen stands per acre had increased due to sprouting from roots from a few hundred per acre prior to treatment to greater than 25,000 per acre following the burn. Whereas, prior to treatment the aspen was unavailable as forage for moose or other ungulates due to its height, 2 years after the burn a large supply of aspen was at a height that could be utilized (Fig. 4). Conifers which had been replacing aspen on the site were completely eradicated by the fire with no evidence of new seedlings 2 years after treatment.

Shrubs, an important component of the aspen-conifer stand sprouted vigorously from rootstocks following the burn. Mean heights were considerably lower after treatment, while the data suggest that the number of stems per acre had increased for most species of shrubs. Canopy area and crown volume of shrubs per acre appeared less than pretreatment volume for most species the first growing season after treatment. However, willow, preferred forage shrub for moose, had greater canopy area and crown volume per acre at a level that made it more available to moose than prior to treatment.

Fig. 4. Aspen stand within the burn site three growing seasons following fire treatment showing the large supply of aspen that was available for forage.

The data indicate that serviceberry and chokecherry had less canopy crown volume per acre two growing seasons after treatment than prior to burning, thus providing less forage. Red dogwood was also found. Ninebark, rose, spirea and snowberry, although existing at a lower height level, had greater canopy area and crown volume per acre two growing seasons after treatment. It is expected that in a relatively few number of years the majority of shrubs will approach their original height and volume. Spencer and Hakala (1964) indicate that browse growth progressively developed following a burn in the Kenai with heavy browse growth being reached in 7 years and maximum growth in 15 years.

The response of the vegetation in this study to fire treatment is similar to the findings of other studies which have documented the results of disturbances to aspen and shrubs. The overstory was completely removed by a spring fire following slashing, allowing maximum stimulus to sprouting aspen and shrubs as described by Smith (1972). He indicates that sprouting vigor of aspen is poor under partial canopy cover. This appears to be a satisfactory means of setting back forest succession to a seral climax in this locale.

Perala (1972) refers to a number of studies where aspen suckers normally increase as cover and understory decrease. He indicates that several conditions are necessary for successful prescribed burns in aspen: uniform fuel distribution, suitable burning conditions and well-cured fuels. Aspen slash might require up to a year before it would sustain fire hot enough to kill standing residuals. On the West Boulder study area aspen slash was allowed to cure about 10 months prior to burning.

Although vegetation response was satisfactory, elimination of slashing would decrease treatment costs considerably. Forest Service personnel believe slashing may not be necessary to carry a fire. As no attempt was made to compare slashing versus no slashing, there is no data from this study to prove that the achieved results would be obtained by fire alone. However, Strothnan and Zasada (1957) indicate that burned aspen stands resprout more luxuriously than those clearcut. It is felt that as long as the tree and shrub overstory can be removed by fire, the sprouting response observed in this study will be possible.

It should be noted that high moisture content of the soil prevented destruction of the rootstocks of aspen and sprouting shrubs by fire. Relative humidity is an important factor in burning.

Considering the size of the side drainage, this particular burn of 40 acres appears greater in area than necessary for big game benefits. Over half of the drainage was burned with two sides of the burn bordered by open grassland. Following the winter of 1973-74, heaviest use by moose of aspen and shrubs was adjacent to control areas where cover was quite dense. This may reflect the availability of cover. It is also possible that lighter animal use in the center of the burn may be due to downed timber that was not consumed by the burn.

Phillips (1973) found that moose in Minnesota shift from low aspen habitat in late winter to areas of tall, mature aspen and willow that seem poor quality moose and deer winter habitat. This shift appears to be due to a preference for cover rather than abundant browse. Schladweiler (1974) indicated that coniferous cover type should be maintained adjacent to moose wintering areas. As Douglas-fir is an important forage in Montana for moose, care must also be taken to maintain this species in sufficient quantities.

Lykke and Cowan (1968) and Ahlen (1968) point out clearcutting in Scandinavia was responsible for improved moose habitat. The basis for this conclusion appears to be a noticeable increased availability of early forest succession. Young growth under 30 years of age made up 25 percent of the productive forest. They emphasized the importance of a scattered distribution of the areas throughout the forest with the size of treatment averaging about 50 acres.

In Montana, Schladweiler (1974) contends clearcutting can be detrimental to moose in some timber types. He believes habitat improvement would be most profitable in the aspen and Douglas-fir types serving as moose winter range. He feels 20 to 25 percent of a wintering area could be logged each year, while Ritchie (1973) suggests 10 percent. In the Boulder Drainage the former figures would be more in order, at least in the immediate future, because of the number of mature aspen. Due to unstable soil conditions within the Boulder Drainage, the use of fire is recommended as a substitute for logging.

The ideal situation for moose appears to be one where there is a mosaic of various age classes and distribution of aspen and associated trees and shrubs within the moose wintering area. This would supply food and cover in close proximity and would take into account Phillips' (1973) concern for preservation of winter cover. Depending upon the amount of natural openings, the areas treated should be no larger than 40 to 50 acres in dense cover and somewhat less in more open forest areas.

Smaller treatments would undoubtedly benefit other species of wildlife. In Wisconsin, McCalley and Creed (1969) indicated openings of 5 acres or less would improve deer habitat. In Minnesota, it is recommended that where aspen are present, numerous small and well-distributed areas of various age classes are most beneficial to deer (Rutske, 1969). Byelich et al. (1972) recommend for Michigan that 25 percent of a forest type should be 1 to 10 years of age and equally distributed with other age classes. In Minnesota, any major alteration of the forest cover on an area larger than 10 contiguous acres will reduce the breeding density of ruffed grouse for a number of years (Gullion, 1971). Gullion and Svoboda (1972) recommended that to sustain high ruffed grouse densities, aspen stands should range in age from suckers to mature trees within a general range of 10 acres for wintering and breeding grouse. This could be accomplished by treating only 10 acres out of any 40 acres each 10 years. On the Boulder Drainage aspen stands are important deer and ruffed grouse habitat and prescribed burns should thus be kept as small as possible.

Elk also make use of aspen types on the West Boulder at various seasons and must be considered in any habitat improvement project. Blood (1966) noticed during aerial surveys in Riding Mountain National Park, Manitoba during February of 1963 that the greatest elk densities were on areas burned 2 years earlier. He believed that was due to a response of increased aspen sucker production resulting after the fire. Reichelt (1972) stated that aspen stands on the West Fork of the Madison Drainage in Montana are probably used by cow elk for rest or for cover during elk calving in adjacent sagebrush areas. This is also true of the West Boulder Drainage.

Several alternatives are possible in considering recommendations for future management of this area. First, proceed as was done prior to this study. This would obviously result in decreased moose habitat and thus decreased moose numbers.

Secondly, prescribed burning such as described in this paper might be applied. This could be done with or without preslashing and it is felt that the latter would be more economically feasible.

The third alternative would be to zone out areas where lightning-caused fires would be allowed to burn under control. Wildfires have been rejected by some as not compatible with other values such as recreational, economical and wildlife use. However, it does appear to be a valid means of altering forest succession where other methods are not feasible.

Last and most logical would be a combination of the second and third alternatives.

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