



Ecology of skunkbush sumac (*Rhus trilobata* Nutt.) in Montana with special reference to use by mule deer

by Peter Raymond Martin

A thesis submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE in Fish and Wildlife Management

Montana State University

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Abstract:

This study determined various ecological characteristics and relationships for skunkbush sumac (*Rhus trilobata* Nutt.) within its range in Montana east of the Continental Divide. Intensive investigations were conducted in 25 skunkbush stands on 5 widely separated study areas.

Highest skunkbush densities were associated with areas of extensive rough "breaks" and uplands adjacent to major rivers and frost-free or growing seasons longer than 120 days. Skunkbush stands occurred significantly more often ($P=.01$) on south exposures, slopes with gradients between 40 and 80 percent, and at altitudes below 5,000 feet. Soils associated with the stands tended to be sandy clay loams, low in organic matter (3.09 percent), mildly alkaline ($\text{pH}=7.44$), very low in phosphorus (22.4 ppm), and high in potassium (377.4 ppm). The stands were typically "open" with a distinct tree overstory either lacking or only poorly developed and a generally sparse ground cover. Ponderosa pine, Rocky Mountain juniper, bluebunch wheatgrass, and fringed sagewort were the most important plant associates. Skunkbush was the dominant shrub in most stands with a mean stand density of 549 plants/ha. and an overall importance rating of 1.61. It attained highest importance in stands on southwest exposures, slopes less than 40 percent, and at elevations below 5,500 feet. Skunkbush plants tended to be rather low growing with dense rounded crowns comprised of many leaders, a growth form resulting from natural "hedging" and predominantly lateral, twig growth. Upon completion of annual growth, twigs either developed flower buds terminally or died back to the first lateral vegetative bud. Average measurements for 500 plants were. 2.35 meters diameter, .079 meters height, 3.5m^2 live crown area, and 26 percent of total crown dead. Plant size and growth form varied among stands and study areas in response to local weather and site conditions. Annual growth of skunkbush plants commenced with flowering in late April and early May. Twig growth began about mid-May and was essentially completed by mid-June. The longest annual growth twigs were produced on open sites, dominated by skunkbush, of south and east exposure, and at lowest elevations with relatively long growing seasons. An average of 1.34' annual growth twigs developed from each year-old twig. Of the 1.2 flower buds which developed on each "fruiting" twig, only 10 percent produced mature fruits and seeds. Reproduction from seed was extremely rare, while the potential for vegetative reproduction through resprouting was extremely high. Skunkbush was important as forage only for mule deer. In eastern Montana utilization occurred primarily during summer and fall while on foothill ranges in west and south central Montana use occurred primarily during winter. Total utilization varied from 3.4 to 27.0 percent among the study areas. Broad variation between areas and years seemed related to the seasonal use patterns and the relative availability of other higher quality and more preferred forage plants. Correlation coefficients between counted- and estimated twig use were very high, $r=.94$ and $.93$ for spring and fall, respectively.

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ECOLOGY OF SKUNKBUSH SUMAC (Rhus trilobata Nutt.)
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TO USE BY MULE DEER

by

PETER RAYMOND MARTIN

A thesis submitted to the Graduate Faculty in partial
fulfillment of the requirements for the degree

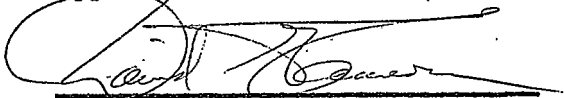
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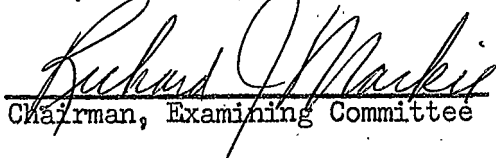
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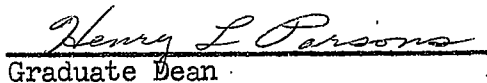
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ABSTRACT

This study determined various ecological characteristics and relationships for skunkbush sumac (Rhus trilobata Nutt.) within its range in Montana east of the Continental Divide. Intensive investigations were conducted in 25 skunkbush stands on 5 widely separated study areas. Highest skunkbush densities were associated with areas of extensive rough "breaks" and uplands adjacent to major rivers and frost-free or growing seasons longer than 120 days. Skunkbush stands occurred significantly more often ($P=.01$) on south exposures, slopes with gradients between 40 and 80 percent, and at altitudes below 5,000 feet. Soils associated with the stands tended to be sandy clay loams, low in organic matter (3.09 percent), mildly alkaline ($pH=7.44$), very low in phosphorus (22.4 ppm), and high in potassium (377.4 ppm). The stands were typically "open" with a distinct tree overstory either lacking or only poorly developed and a generally sparse ground cover. Ponderosa pine, Rocky Mountain juniper, bluebunch wheatgrass, and fringed sagewort were the most important plant associates. Skunkbush was the dominant shrub in most stands with a mean stand density of 540 plants/ha. and an overall importance rating of 1.61. It attained highest importance in stands on southwest exposures, slopes less than 40 percent, and at elevations below 5,500 feet. Skunkbush plants tended to be rather low growing with dense rounded crowns comprised of many leaders, a growth form resulting from natural "hedging" and predominantly lateral twig growth. Upon completion of annual growth, twigs either developed flower buds terminally or died back to the first lateral vegetative bud. Average measurements for 500 plants were 2.35 meters diameter, .079 meters height, 3.5m² live crown area, and 26 percent of total crown dead. Plant size and growth form varied among stands and study areas in response to local weather and site conditions. Annual growth of skunkbush plants commenced with flowering in late April and early May. Twig growth began about mid-May and was essentially completed by mid-June. The longest annual growth twigs were produced on open sites, dominated by skunkbush, of south and east exposure, and at lowest elevations with relatively long growing seasons. An average of 1.34 annual growth twigs developed from each year-old twig. Of the 1.2 flower buds which developed on each "fruiting" twig, only 10 percent produced mature fruits and seeds. Reproduction from seed was extremely rare, while the potential for vegetative reproduction through resprouting was extremely high. Skunkbush was important as forage only for mule deer. In eastern Montana utilization occurred primarily during summer and fall while on foothill ranges in west and south central Montana use occurred primarily during winter. Total utilization varied from 3.4 to 27.0 percent among the study areas. Broad variation between areas and years seemed related to the seasonal use patterns and the relative availability of other higher quality and more preferred forage plants. Correlation coefficients between counted and estimated twig use were very high, $r = .94$ and $.93$ for spring and fall, respectively.

INTRODUCTION

Skunkbush sumac, Rhus trilobata Nutt., occurs extensively on rangelands throughout Montana east of the Continental Divide. It has been reported to be a major browse plant, at least locally, for mule deer (Trueblood 1960, Mackie 1970, Dusek 1971, Eustace 1971a, Knapp 1972). The Montana Fish and Game Department recognizes skunkbush as a key browse species in eastern Montana where about 110 permanent transects have been established on important mule deer ranges to annually measure utilization and plant condition trends.

Like most other browse plants, little ecological information has been available for skunkbush sumac on Montana's rangelands. This lack of knowledge has hindered the interpretation of range survey data and has precluded consideration of the biological and ecological attributes of the species in the formulation of big game and land management programs in eastern Montana. The only previous study of skunkbush, conducted by Sanford (1970) in the badlands of western North Dakota, helped fill this void but further studies are needed.

The present study was established in the spring of 1971 to obtain basic ecological information for skunkbush sumac in eastern Montana. Specific objectives were: (1) to determine general distributional, edaphic, climatic and synecological characteristics; (2) to determine and describe certain autecological characteristics such as reproduction, growth and development, and forage production; and (3) to evaluate the essential relationship between skunkbush and deer throughout its range in Montana.

Field studies were conducted full time during the summer of 1971 and the spring and summer of 1972. Additional data were collected irregularly during the fall and spring of 1971 and the winter of 1972. Intensive investigations were conducted at five widely separated locations in the southwestern, southeastern, southcentral, northcentral and westcentral portions of Montana. Extensive surveys in intervening areas and other portions of eastern Montana provided supplementary data.

Skunkbush sumac is a member of the Sapindales order and the Anacardiaceae (cashew) family which includes about 60 genera and 600 species found mainly in tropical regions (Porter 1967). The genus Rhus, studied primarily by Fred A. Barkley (1937, 1938 and 1940), has been recognized from Greek times when some species were used for preparation of dye, medicine, seasoning and tanning of hides. It contains approximately 120 species with about half of these in the United States. Barkley (1937) lists Rhus trilobata and seven varieties as occurring in the western and midwestern United States and Mexico with a small extension into Canada above Montana and western North Dakota. Skunkbush was referred to as "Ho at to o nuts" by the Cheyenne Indians near the Bighorn Mountains who used it in a smoking mixture (Barkley 1940).

Booth and Wright (1959) refer to skunkbush as a "low branching, erect shrub, rather strongly aromatic; the young brachlets hairy; leaves 3-foillate, deciduous, more or less hairy on both surfaces; terminal leaflet 2.5 to 5.0 centimeters long, 3-lobed and coarsely toothed, the lateral leaflets smaller, round-ovate, scarcely lobed; flowers yellowish,

appearing before the leaves in short spike-like clusters; sepals 5, petals 5; stamens 5; ovary 1-celled; occurring on dry hillsides and plains." While several authors (Hitchcock, et al. 1961, Barkley 1937, St. John 1956 and Porter 1967) list Rhus with polygamous or dioecious flowers and make no reference to skunkbush, McKean (1956) indicates male catkins and persistent fruits occur simultaneously on skunkbush plants.

PROCEDURES

The geographical range and distribution of skunkbush sumac in Montana were determined by aerial survey, vehicle reconnaissance, examination of State Fish and Game Department browse survey records, review of ecological literature concerning Montana rangelands, and discussions with game management personnel. During aerial and ground surveys, skunkbush stands were arbitrarily rated as of low, moderate or high density.

Intensive studies were conducted in five locations, selected to represent broadly different geographic areas, habitat types and histories of skunkbush utilization by deer. Five individual skunkbush stands were studied at each location. These were representative of stands occurring on the various exposures and slope gradients, at various elevations and/or within various vegetational communities characterizing the distribution of skunkbush in each area. A 100 foot x 60 foot plot, including at least 20 representative skunkbush plants, marked the study site in each stand.

For each site, exposure was estimated from two azimuth readings with a Silva type 1 compass oriented downslope. Slope was estimated to the nearest 5 percent as the mean of two readings with a K & E pocket transit. Elevation was determined with a simple altimeter and verified from U.S.G.S. topographic maps for most sites. Soil characteristics, including pH, organic matter content, salt hazard and five important elements, were determined from a composite of 10 soil subsamples obtained from a

depth of 4 inches to 8 inches at each site and analyzed by the Montana State University Soils Testing Laboratory. Precipitation and temperature data were taken from climatological records for the U.S. Department of Commerce weather station nearest each major study area.

Synecological data for each stand studied were obtained as follows: Low growing species, grasses, forbs and shrubs less than two feet tall were quantitatively sampled by the canopy coverage technique (Daubenmire 1959). Ten 2 x 5 decimeter frames were placed at 10-foot intervals along each of three or four 100-foot lines, spaced 20 feet apart, which followed the contour of each slope. Coverage of each species, as well as bareground, rock and litter, were recorded by class in each plot. Classes were: (1) less than 5 percent; (2) 6-25 percent; (3) 26-50 percent; (4) 51-75 percent; (5) 76-95 percent; and (6) 96-100 percent. An additional measure of ground cover was provided by recording whether each leg of the Daubenmire frame touched a living plant, litter, bareground or rock. A total of 919 frames were analyzed. Trees and shrubs were quantitatively sampled using a modification of the point-center-quarter method (Cottam and Curtis 1959) as employed on skunkbush by Sanford (1970). Seven points were situated at 50-foot intervals along each of 3 lines; one near the top of the slope containing the skunkbush stand, one near the base of the slope and one through the study site. Data recorded for the nearest tree or shrub in each quadrant of each point included: (1) distance to the plant center, to the nearest 0.1 meter; (2) species;

(3) width of minor and major axis, to the nearest 0.1 decimeter; (4) height, to the nearest 0.1 decimeter; (5) percentage of crown dead; and (6) crown density (percentage of crown canopy cover within a line circumscribing the outer edge of the plant). Decadence and crown density were recorded by class as used in canopy coverage estimates. Importance values were obtained by adding relative dominance (percentage of total corrected crown area comprised by a species), relative density (percentage of total possible plants sampled, 84), and relative frequency (percentage of times an individual species occurred among 21 points).

Twenty representative skunkbush plants in each stand were selected for autecological studies of growth and reproductive characteristics. During the summer of 1971, the height and major and minor diameters, to the nearest 0.1 decimeter, and the percentage of dead crown of each plant were measured. Age and form classes (Cole 1958) were noted. Crown density and percentage of crown dead were also recorded for each plant in 1972.

Prior to the onset of growth in 1972, the following data were recorded for each of four branches on two randomly selected plants per site: numbers of last year's leaders; last year's terminal leaders; flower buds; and terminal leaders with flower buds. After growth began, the first 10 leaders on each branch were measured to the nearest 0.1 centimeter at approximately two-week intervals until it became apparent that growth had ceased. After growth was complete and seeds had ripened, I recorded

total numbers of current annual growth twigs, new terminal twigs or leaders, buds flowering, and buds producing fruits and/or seeds.

Dates of important phenological events, including opening of flower buds, peak of flowering, emergence of leaves, commencement of leader growth, termination of leader growth, formation of fruits and ripening of seeds were noted or calculated during the course of six or more visits to each stand.

Seed production was recorded for each plant in both 1971 and 1972. In 1972, the percentage of twigs bearing flowers and buds flowering and producing fruits and/or seeds were calculated. Numbers of resprouts of two plants on each stand were counted to determine the extent of vegetative reproduction.

Utilization of skunkbush by deer was determined in the fall (late September and early October) of 1971 and in the spring (early April) of 1972, for each stand using a modification of the Key Browse Survey Method (Cole 1958). Percentages of current annual growth twigs utilized were estimated by class, as for canopy coverage. Additional indication of browsing intensity was obtained by counting the number of leaders browsed for four marked branches on each of five plants in each stand during the fall of 1971 and the spring of 1972. Total numbers of twigs available per branch and numbers of leaves per twig were counted in the summer of 1971.

Methods of statistical analyses followed Snedecor and Cochran (1967).

They included one and two way analyses of variance in combination with least significant difference analysis where warranted, 95 percent confidence intervals, and linear regression. A computer program prepared by Dr. Martin A. Hamilton, Department of Mathematics, Montana State University, was used for comparing means of independent samples with unequal variances. Most calculations were performed using the Monroe Programmable Calculator, Model 1785 W1.

Common and scientific names of plants followed Booth (1950) and Booth and Wright (1959).

DESCRIPTION OF STUDY AREAS

Five major study areas were located in the Fort Howes area in southeast Montana, in the Missouri River Breaks of northcentral Montana, on the Beartooth Game Range in westcentral Montana, in the vicinity of Big Timber in southcentral Montana and along the Madison River in southwest Montana (Figure 1). Cadastral descriptions, exposures, slope gradients and elevations for the five representative stands in each area are listed in the Appendix, Tables 15 and 16.

Fort Howes

This area was located on the Custer National Forest in southern Rosebud and southwestern Powder River Counties approximately 20 miles south of Ashland. Knapp (1972) described the area as a ponderosa pine (Pinus ponderosa) woodland interspersed with a mixed grass prairie. Brown (1965) listed Artemisia-Atriplex-Agropyron and Rhus-Agropyron community types (Figure 2) as predominant, comprising 30 and 17 percent, respectively, of the vegetation in the area. Skunkbush stands selected for study ranged in elevation from 3,450 to 3,980 feet, in slope from 60 to 90 percent, included ENE, SSE, WSW, WNW and NNW exposures and were dominated variously by Rocky Mountain juniper (Juniperus scopulorum) and Indian ricegrass (Oryzopsis hymenoides), ponderosa pine and bluebunch wheatgrass (Agropyron spicatum), and skunkbush and bluebunch wheatgrass (Figure 3) or Japanese chess (Bromus japonicus). According to Knapp (1972), skunkbush was the most important browse species used by mule deer in summer and fall, comprising 40 and 41 percent, respectively,

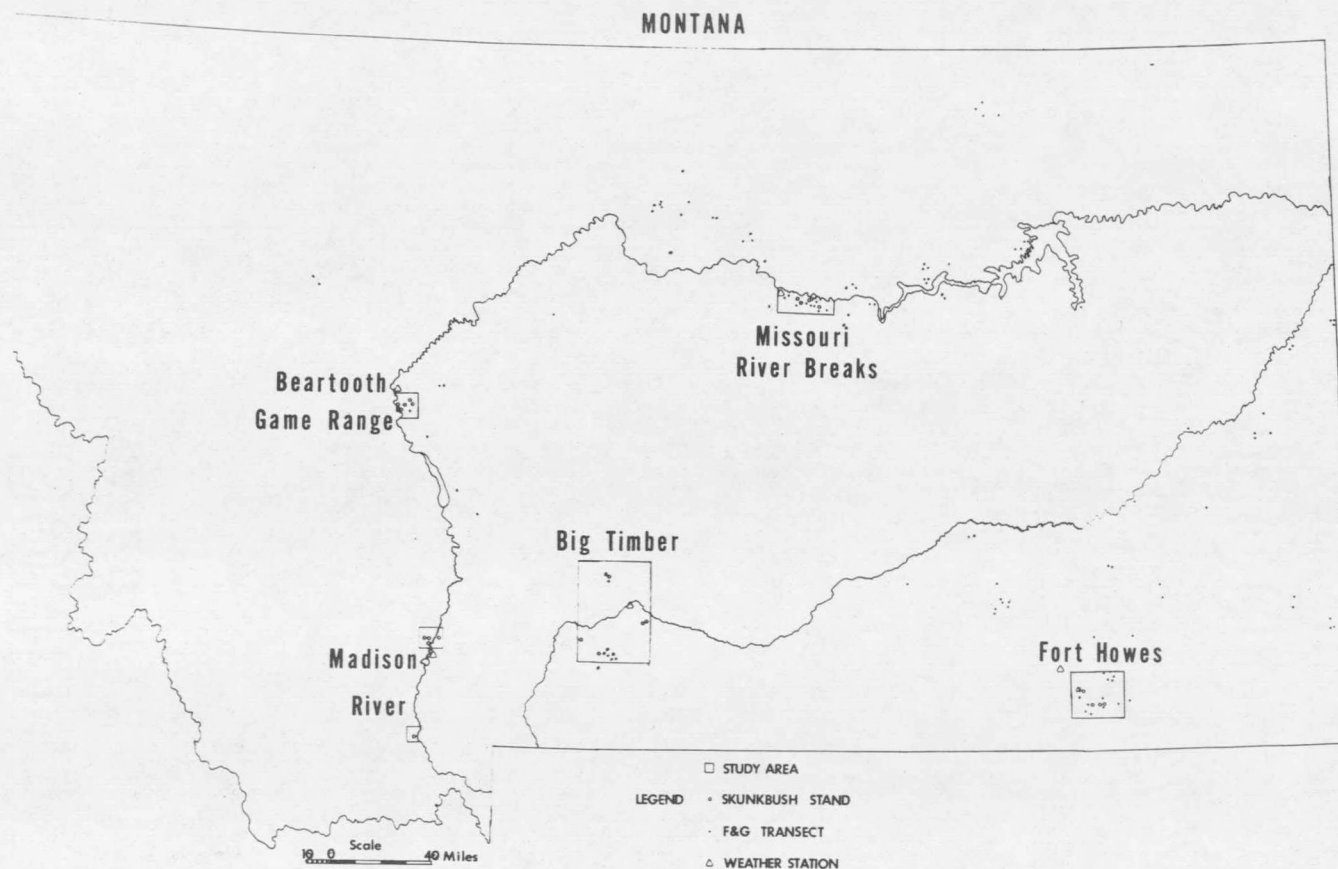


Figure 1. Five major study areas (FH-Fort Howes; MB-Missouri River Breaks; BG-Beartooth Game Range; BT-Big Timber and MR-Madison River) showing approximate location of study sites along with Fish and Game skunkbush transects and weather stations.

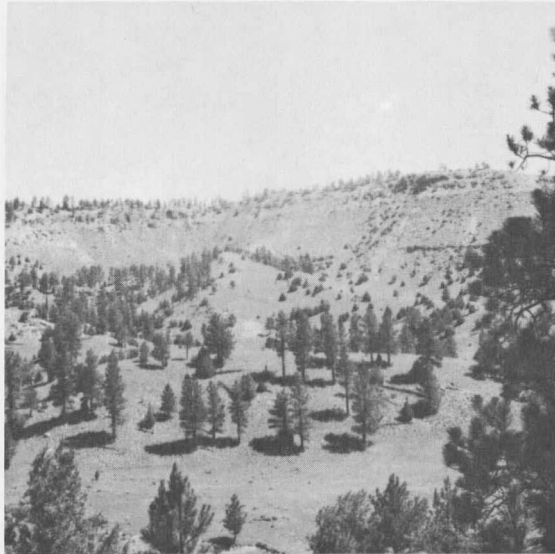


Figure 2. Ponderosa pine woodland with interspersed grassland in the foreground and Rhus-Agropyron community on steep talus in the background located near site 25.



Figure 3. Site 22 on South Fork of Taylor Creek with SSE exposure, 90% slope, 3,980 foot elevation and dominant cover Rhus-Agropyron.

of the diet. The Montana Fish and Game Department has sixteen skunkbush utilization and condition trend transects in the area. These generally indicate moderate to heavy utilization from 1961 to 1971, with wide yearly variations; e.g., one site varied from 76.4 percent use in 1964 to 3.2 percent in 1966.

Missouri Breaks

This area, located in northeast Fergus County about 75 miles northeast of Lewistown, is characterized by "breaks" composed of interspersed ridges, steep sided coulees and creek bottoms resulting from erosion of a broad plateau extending south and west from the Missouri River. Mackie (1970) described the vegetation of the area as dominated by Pinus-Juniperus, Artemisia-Agropyron, and Pseudotsuga-Juniperus habitat types which comprised 45, 31 and 13 percent, respectively, of his study area. Skunkbush stands selected for study ranged in elevation from 2,720 to 2,990 feet, from 30 to 80 percent slope, included WNW, WSW, S, ENE, and NNE exposures and were dominated variously by skunkbush and bluebunch wheatgrass or bluestem (Agropyron smithii) and Rocky Mountain juniper and bluebunch wheatgrass (Figures 4, 5, and 6). Mackie (1970) reported skunkbush to be a key browse plant for mule deer, ranking second among all taxa in total use during the summer. Fall browsing intensity was somewhat lower followed by a major reduction during the winter and spring. Average percentages of skunkbush used at feeding sites during summer, fall, winter and spring from 1960 to 1964 were 24, 15, 4 and 4,



Figure 4. Site 27 near Carrol Coulee with S exposure, 30% slope, 2,990 foot elevation and Rhus-Agropyron dominant cover.



Figure 5. Site 29 on Sand Creek drainage, NNE exposure, 70% slope, 2,720 foot elevation and Juniperus-Agropyron dominant cover.

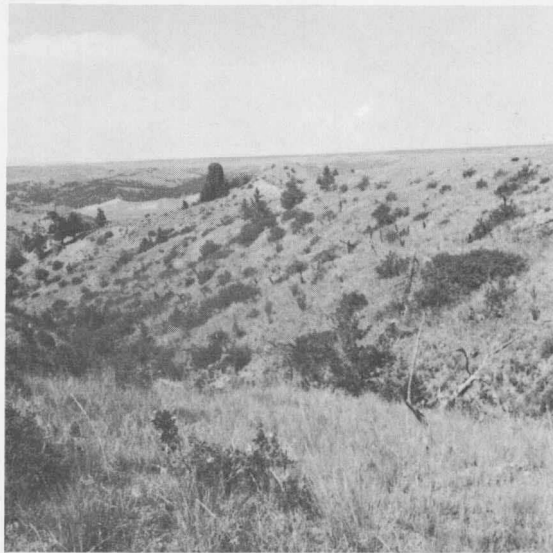


Figure 6. Site 30 near Missouri River with WSW exposure, 50% slope, 2,750 foot elevation and Rhus-Agropyron dominant cover.

respectively. Thirty-five skunkbush utilization and condition trend transects have been established in the Missouri River Breaks by Montana Fish and Game personnel. Transect data from 1960 to 1971 show heavy skunkbush utilization in most years. Use on one transect ranged from 86.8 percent in 1962 to 2.6 percent in 1971.

Beartooth Game Range

This area, located in the Big Belt Mountains adjacent to the Gates of the Mountains wilderness area in eastern Lewis and Clark County is primarily a winter range for mule deer and elk. The area is characterized by dense Douglas-fir (Pseudotsuga menziesii) and/or ponderosa pine stands on north slopes and open ponderosa pine stands or grass and shrub communities on south slopes. Skunkbush stands selected for study

included ENE, SSE, SSW and W exposures, elevations from 3,720 to 5,040 feet and slopes of 35 to 75 percent and were dominated variously by ponderosa pine and bluebunch wheatgrass and skunkbush and cheatgrass (Bromus tectorum), bluebunch wheatgrass or Junegrass (Koeleria cristata) (Figures 7 and 8). Observations by the game range manager indicate that skunkbush is utilized by mule deer mainly during the winter months. Three Fish and Game skunkbush transects near the area indicate moderate utilization from 1958 to 1970, with one transect ranging from 53.0 percent use in 1960 to 3.2 percent in 1961.



Figure 7. Site 34 near Game Range headquarters with W exposure, 40% slope, 4,210 foot elevation and Rhus-Koeleria dominant cover.



Figure 8. Site 35 on Upper Cottonwood Creek with W exposure, 75% slope, 4,700 foot elevation and Ponderosa-Agropyron dominant cover.

Big Timber

This area, which lies in the westcentral Sweetgrass County and eastern Park County, is located in a transition zone between the prairies of eastern Montana and the mountains of the west. Ponderosa pine stands are common on north slopes becoming denser and more general at higher elevations with mixed grass and shrub communities dominant at lower elevations. Skunkbush stands selected for study included ESE, SSE, SSW, NNW, and NNE exposures, slopes of 25 to 80 percent, and elevations ranging from 4,280 to 5,700 feet and were dominated variously by skunkbush and bluebunch wheatgrass or Japanese chess, antelope bitterbrush (Purshia tridentata) and cheatgrass, and Rocky Mountain juniper and bluebunch wheatgrass (Figure 9, 10 and 11). Although specific studies are lacking,

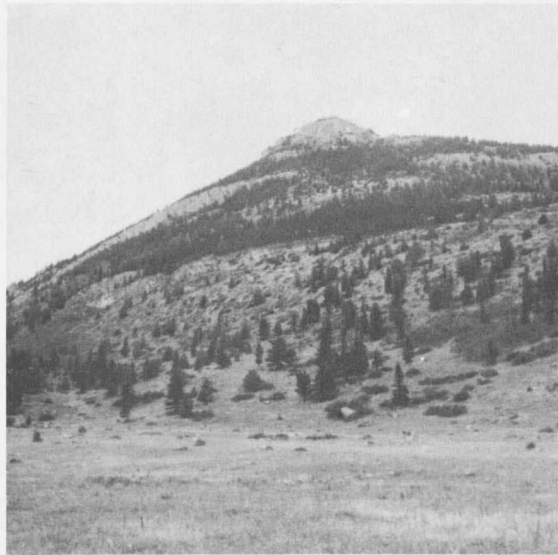


Figure 9. Site 37 on Boulder River near Main Ranger Station with SE exposure, 80% slope, 5,700 foot elevation and Rhus-Agropyron dominant cover.



Figure 10. Site 39 on lower Deer Creek with NE exposure, 25% slope, 4,280 foot elevation and Rhus-Bromus dominant cover.

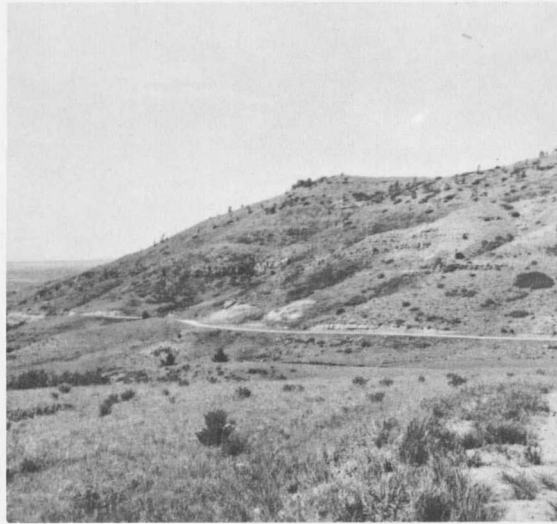


Figure 11. Site 40 on Mission Creek with SW exposure, 55% slope, 5,180 foot elevation and Purshia-Bromus dominant cover.

skunkbush is believed to be important to mule deer, at least locally, during the fall and winter. Nine skunkbush transects have been established in the area. Average utilization has been light to moderate but considerable variation has occurred between years and between sites; e. g., annual utilization at one site ranged from 7.4 to 88.2 percent while at another it ranged from only 0.2 to 21.0 percent during the period 1961 to 1971.

Madison River

This area extends along the Madison River north and south of Ennis in Madison County. Situated in a relatively narrow valley, the area is characterized by gravel bars and benches and sandstone hills covered by a very thin mantle of soil. Open ponderosa pine and Rocky Mountain juniper stands, various shrub communities dominated by curl-leaf mountain

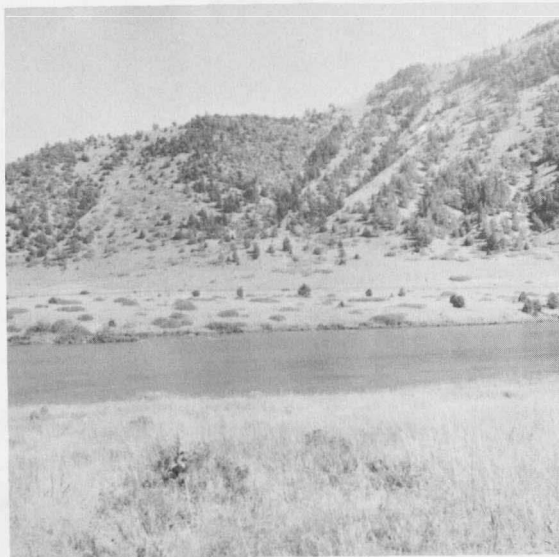


Figure 12. Beartrap vicinity on Madison River with open Ponderosa and Juniperus stands with interspersed shrub communities, mainly Cercocarpus and Purshia. Rhus-grassland community on flood plain in center.



Figure 13. Site 41 on Madison River with ESE exposure, 75% slope, 4,620 foot elevation and Rhus-Bromus dominant cover.



Figure 14. Site 44 on Wall Creek Game Range with ESE exposure, 60% slope, 5,680 foot elevation and Chrysothamnus-Bromus dominant cover. Madison River flood plain in foreground.



Figure 15. Site 45 on Red Bluff Research Ranch with WSW exposure, 45% slope, 5,350 foot elevation and Rhus-Agropyron dominant cover.

mahogany (Cercocarpus ledifolius) and antelope bitterbrush (Figure 12), and mixed grasslands comprise the major vegetation. Skunkbush stands studied ranged in elevation from 4,620 to 5,680 feet, in slope from 40 to 75 percent, included ESE, SSE, and WSW exposures and were dominated variously by skunkbush and bluebunch wheatgrass or cheatgrass, antelope bitterbrush and Idaho fescue (Festuca idahoensis), and cheatgrass (Figures 13, 14 and 15). Skunkbush is considered of little or no importance to mule deer in the Madison River area and no browse utilization and condition trend transects have been established.

RESULTS AND DISCUSSION

Distribution

The general distribution of skunkbush in Montana is shown in Figure 16. Highest densities occurred along the Missouri River from the vicinity of the Pines Recreation Area along Fort Peck Lake west to Virgelle; along and between the Powder and Tongue Rivers from south of the Custer National Forest northeast to Mizpah; along the Bighorn River north of Hardin; along and between the Smith and Missouri Rivers southwest of Great Falls; and, locally, in the Makoshika State Park area south of Glendive, along the west side of the Highwood Mountains, along the Jefferson River near the Lewis and Clark Caverns, and along Sweetgrass and Deer Creeks east of Big Timber. All of these areas are characterized by extensive rough breaks and uplands with steep slopes adjacent to medium to large river systems. Skunkbush was rare or absent in the extreme northeast and northwest portions of Montana east of the Continental Divide, in central Montana around the Snowy Mountains, in the mountains of southwestern Montana and in all of the state west of the Continental Divide. These areas characteristically were relatively flat with deep soils, had thin soils with a gravel base, or were mountainous with dense coniferous forests above 6,000 feet. The distribution and numbers of skunkbush utilization and condition trend transects (Figure 16), which may be indicative of the importance of skunkbush to mule deer in an area, seemed closely related to the density of skunkbush.

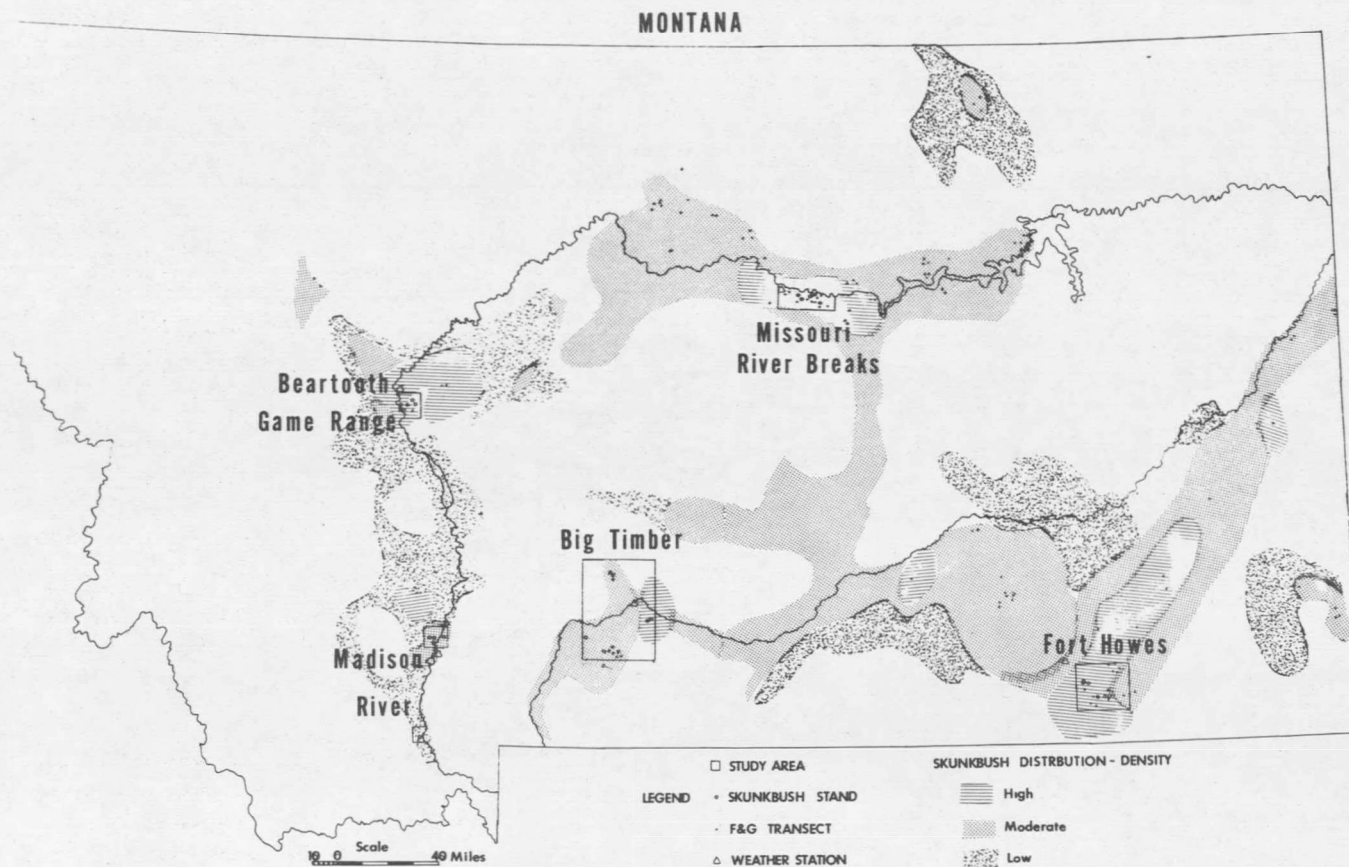


Figure 16. General distribution of skunkbush in Montana, showing high, moderate, low and rare to zero densities.

Skunkbush stands on the five study areas occurred significantly ($P=.01$) more often on sites with south exposures, slope gradients between 40 and 80 percent and at altitudes less than 5,000 feet (Table 1).

Edaphic Characteristics and Relationships

Findings from this study concurred with Sanford (1970) that soils associated with skunkbush usually are only poorly developed, undefinable to extremely thin, and underlain by "scoria" or shale, though some exceptions did occur. Soils in the Missouri River Breaks were relatively deep; but the most extensive skunkbush stands generally occurred on steeper slopes where topsoils were thin or absent.

Analysis of soil samples from the five major study areas indicated that soils associated with the 25 skunkbush stands studied tended to be sandy clay loam in texture, low in organic matter, mildly alkaline, very low in phosphorus content, high in potassium content, and very low in salt content (Table 2).

Sandy loams, loams, sandy clay loams, clay loams, and clays comprised the soil texture at 40, 20, 8, 16 and 16 percent, respectively, of the 25 sites. The mean soil texture, determined by averaging the midpoints of texture classes for all sites, was a sandy clay loam (24.2% clay, 28.0% silt, and 47.8% sand). Sandy clay loam has relatively low silt particle surface area and total pore space, and high individual pore size which allows high rates and amounts of air and water movement through the soil (Foth and Jacobs 1964).

TABLE 1. DISTRIBUTION OF 25 SKUNKBUSH STANDS AMONG VARIOUS EXPOSURES, SLOPE GRADIENTS AND ELEVATIONS COMPARED STATISTICALLY BY ONE WAY ANALYSIS OF VARIANCE.

Site Categories	Number of Stands	Percent
<u>Exposure</u> (Azimuth Degrees)		
NE 1-90	5	20
NW 271-360	4	16
SE 91-180	8	32
SW 181-270	8	32
N 271-90	9	36
S 91-270	16	64*
E 1-180	13	52
W 181-360	12	48
<u>Slope Gradient</u> (percent)		
Less than 40	4	16
40-80	16	64**
More than 80	5	20
<u>Elevation</u> (feet)		
Below 5500	21	84**
5500 and above	4	16
below 5000	18	72**
5000 and above	7	28

* Significantly larger at $P=.05$.

** Significantly larger at $P=.01$.

TABLE 2. EDAPHIC CHARACTERISTICS OF SKUNKBUSH STANDS INCLUDING pH, ORGANIC MATTER, FIVE IMPORTANT ELEMENTS AND SALT HAZARD ON THE FIVE MAJOR STUDY AREAS.

Area	pH	Organic Matter (%)	Potassium (K) (ppm) ^{1/}	Phosphorus (P) (ppm)	Calcium (Ca) (meq) ^{2/}	Magne- sium (Mg) (meq)	Sodium (Na) (meq)	Salt Hazard (mmhos) ^{3/}
Fort Howes	8.24	3.26(L) ^{4/}	176(M)	14.0(VL)	16+	3.99	0.3	0.86
Missouri Breaks	7.00	3.22(L)	622(H)	35.8(L)	14+	8.59+	0.84	2.94*
Beartooth Game Range	7.24	4.18(M)	516(H)	28.2(VL)	14.19+	2.98	0.53	0.40
Big Timber	7.54	3.12+(L)	329.6(H)	13.2(VL)	16+	5.06	0.43	0.46
Madison River	7.16	1.65-(VL)	243.2(M)	2.10(VL)	10.08+	1.26	0.28	0.20

*Slightly salty.

^{1/} ppm - pounds per one million pounds of soil

^{2/} meq - millequivalents/100 grams of soil

^{3/} mmhos - milimhos 1 mho = $\frac{1}{1000}$

^{4/} Ratings from Montana Soils Testing Laboratory Report, ST-Form 2: VL, Very low; L, Low; M, Medium; and H, Heavy.

Organic matter, which is an important source of phosphorus, content from individual sites ranged from less than 0.15 percent to greater than 5.7 percent. The range in means for the five major study areas was from 1.65 percent (very low—Montana Soils Testing Laboratory Report, 1971) in the Madison River area to 4.18 percent (medium) for the Beartooth Game Range area. The overall mean was 3.09 percent (low). This overall mean and average are somewhat lower than expected (3.25 percent and 0.46 to 10.0 percent, respectively) for soils of arid regions (Buckman and Brady 1960).

Sample pH values ranged from a slightly acid 6.3 to a moderately alkaline 8.4 among individual sites. The overall mean for 25 sites was a mildly alkaline 7.44. Soils in the Fort Howes area were the most alkaline, with an average pH of 8.24 for five sites; those of the Missouri Breaks were the least alkaline with a mean of 7.00.

Phosphorus, an important element in plant reproduction and root development (Buckman and Brady 1960), occurred at levels ranging from 5 to 79 ppm among samples for individual sites and from a mean of 13.2 ppm (very low) for the Big Timber area to 35.8 ppm (low) for the Missouri Breaks. The overall mean was very low at 22.4 ppm.

Potassium, which encourages root development but delays maturation processes, comprised 96 to 806 ppm in samples from individual sites. The overall mean was a heavy 377.4 ppm, while means for the five study areas ranged from 176 ppm (medium) at Fort Howes to 622 ppm (heavy) in the Missouri Breaks.

Among the other elements surveyed, calcium levels ranged from 928 ppm to over 3,200 ppm with an overall mean of more than 2,820 ppm; magnesium content ranged from 115.9 ppm to 1,207.8 ppm with an overall average of approximately 536.3 ppm; and sodium comprised 59.8 and 506.0 ppm with an average of 110.4 ppm. Only three sites, one at Fort Howes and two in the Missouri Breaks gave an indication of saltiness, reflecting low soluble salt concentrations.

These soil characteristics interact with each other and with other factors such as rainfall and temperature, in influencing plant growth and development. Loose soil texture may overcome the compaction effects of low organic matter content, resulting in the leaching of soluble salts. Low organic matter content may be at least partially responsible for the low amount of available phosphorus, which, at the overall pH of 7.44., tends to become even less available for plant use than at higher or lower pH's (Buckman and Brady 1960). The presence of potassium, magnesium, calcium and sodium in relative abundance causes an alkaline soil condition. Since these elements apparently were not tied up as soluble salts and pH readings indicated base saturations of soils were quite high (Buckman and Brady 1960), it is possible that these elements were available for use by plants on most sites. The high potassium content, which may counter the effect of phosphorus on plant growth and maturation, in combination with the observed low phosphorus and organic matter contents and the slightly alkaline pH levels, would seem to reflect soil

conditions favorable for plants such as skunkbush which have well developed root systems and a high capability for vegetative reproduction (Sanford 1970).

Climatological Characteristics and Relationships

Weather conditions within the range of skunkbush in Montana are characterized by generally low precipitation and humidity, moderately cold temperatures during the winter months, and long hot days in a relatively short summer. Average temperatures for January, the coldest month, are less than 20°F while July, the warmest month, averages above 64°F (U.S.D.A. 1941). Precipitation appears much more variable than temperature, but averages approximately 14 inches yearly (Figure 17, Jackson 1971). Over three-fourths of the annual precipitation falls as rain with approximately one-half of the total occurring during three months, May, June and July (McConnen 1962). The average growing, or frost-free, season varies from less than 50 days to over 130 days (Figure 18) depending upon elevation and other factors.

Although the distribution of skunkbush did not coincide with the general patterns of temperature and precipitation in eastern Montana, there was an extremely close correlation between the occurrence and density of skunkbush stands (Figure 16) and length of the frost-free period (Figure 18). Moderate and high density stands occurred exclusively in areas having 120 or more frost-free days, with light densities extending into areas with 110-day growing periods. Although stands occasionally

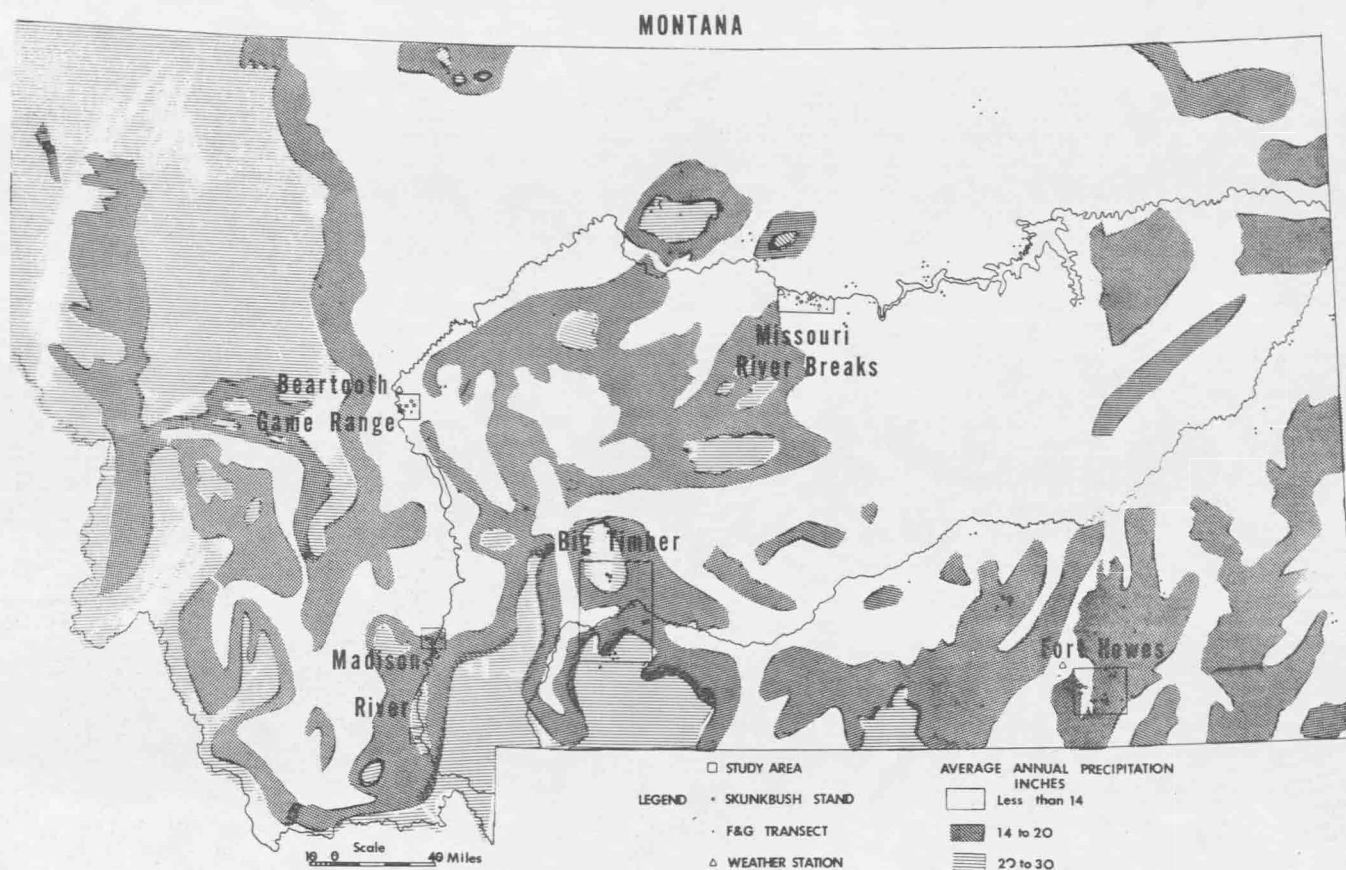


Figure 17. Average annual rainfall.

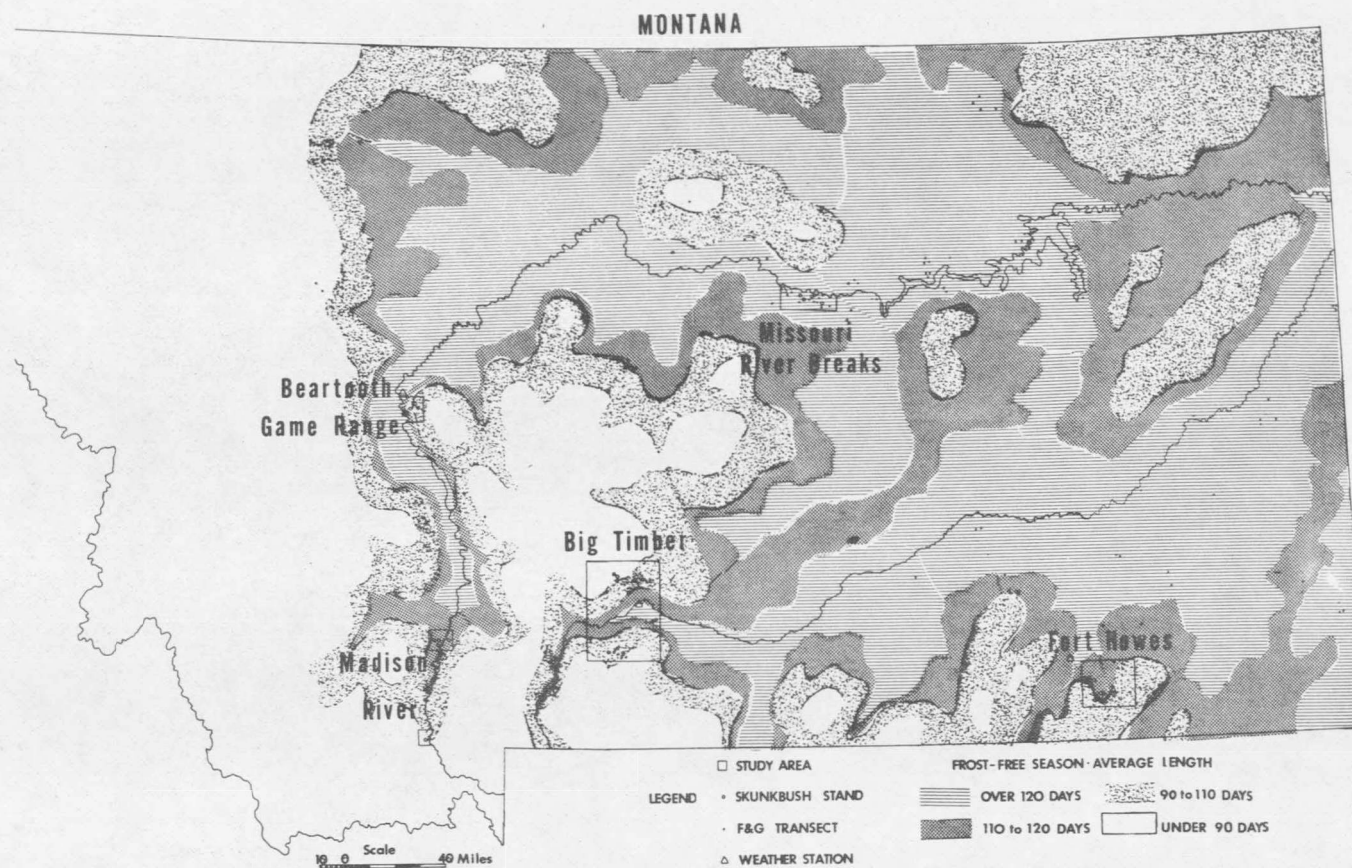


Figure 18. Average frost-free season.

occurred in areas with shorter frost-free periods, they were generally restricted to hillsides or mountain slopes having warmer temperatures due to gravitational movement of cold air (Caprio 1965) or the presence of larger bodies of water. Since frost-free periods at least partially reflect temperature patterns and very few weather stations are located within areas of skunkbush occurrence, more detailed studies of temperature and possibly precipitation in such areas might result in much closer correlations than derived in the gross analysis.

Temperature and precipitation trends were quite similar among the five major study areas during the 1971-72 period (Figure 19). In 1971, temperatures averaged slightly below normal in all areas, except the Missouri Breaks, and in all months except August. Precipitation was near average in all areas through early spring, but below average in most areas during June and July when drought conditions prevailed over much of eastern Montana. Below normal temperatures were coupled with above average precipitation during December 1971 and January 1972. Above or near normal temperatures and precipitation generally prevailed from February through June 1972 when monthly temperatures fell far below normal and precipitation increased substantially.

Annual mean temperatures for 1972 (Table 3) ranged from 40.0°F at Fort Howes to 46.8°F in the Big Timber area, while daily extremes were -45°F at Fort Howes and 107°F in the Missouri River Breaks. Precipitation varied greatly between areas as well as from "normal" within areas.

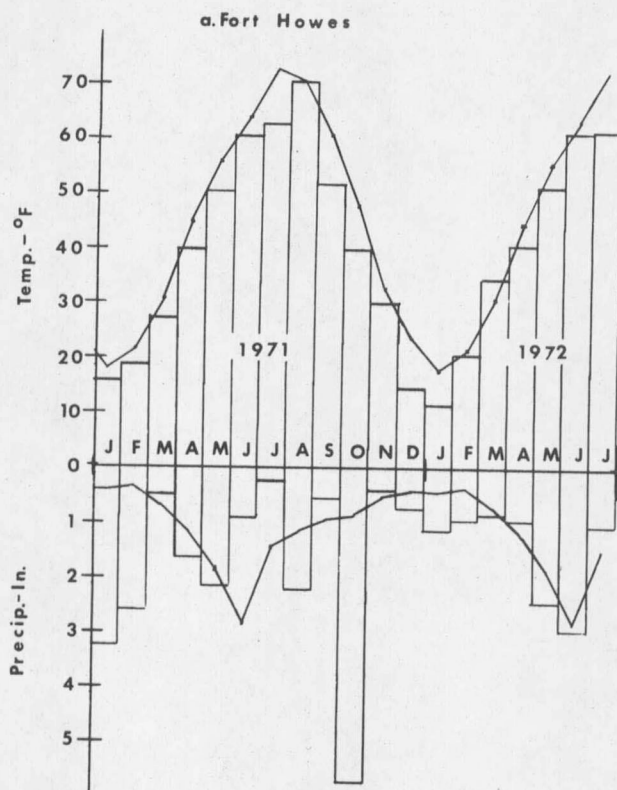


Figure 19. Temperature and precipitation for the five major study areas. (a. Fort Howes) showing monthly figures (bar graph) for 1971 and January-July, 1972 and 'norms' (line graph).

The low was 9.56 inches on the Beartooth Game Range; the high was 21.04 inches at Fort Howes. The latter, normally the driest area with 12.79 inches mean annual precipitation, received more than 11.5 inches during

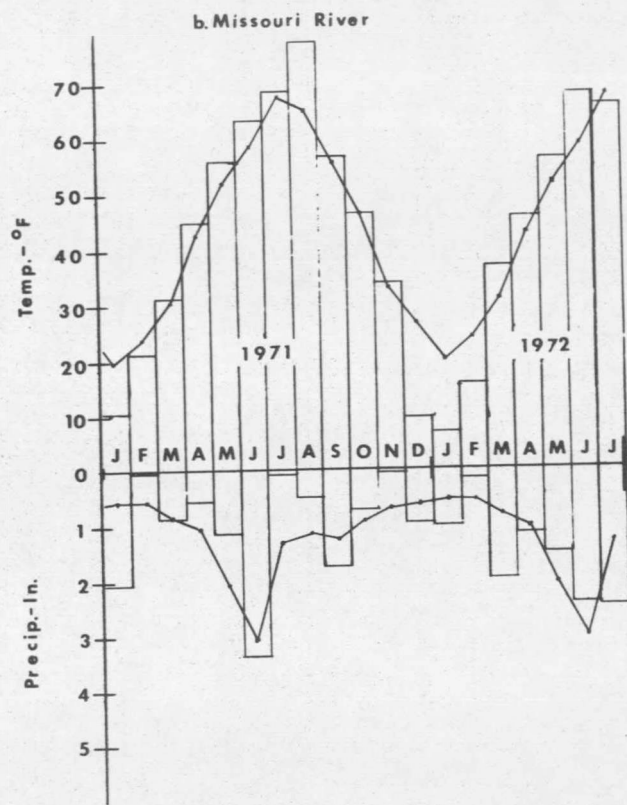


Figure 19. (continued) b. Missouri Breaks

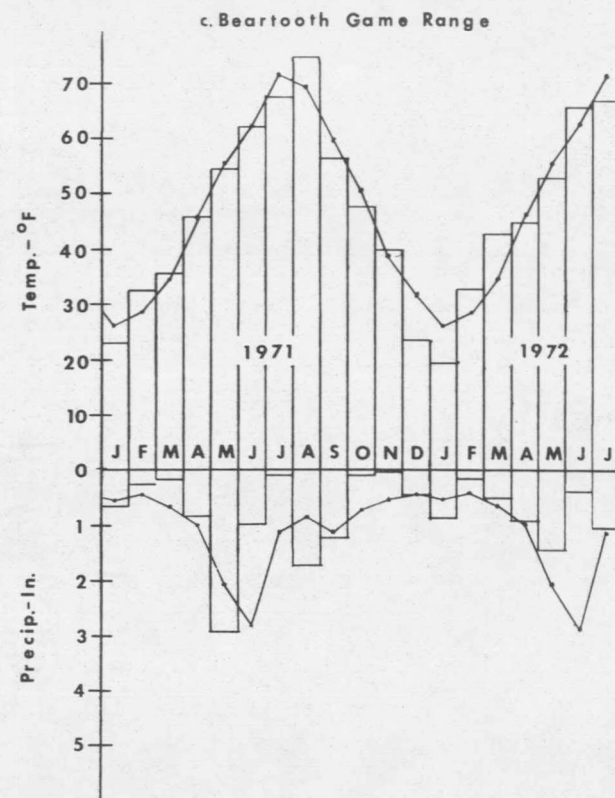


Figure 19. (continued) c. Beartooth Game Range

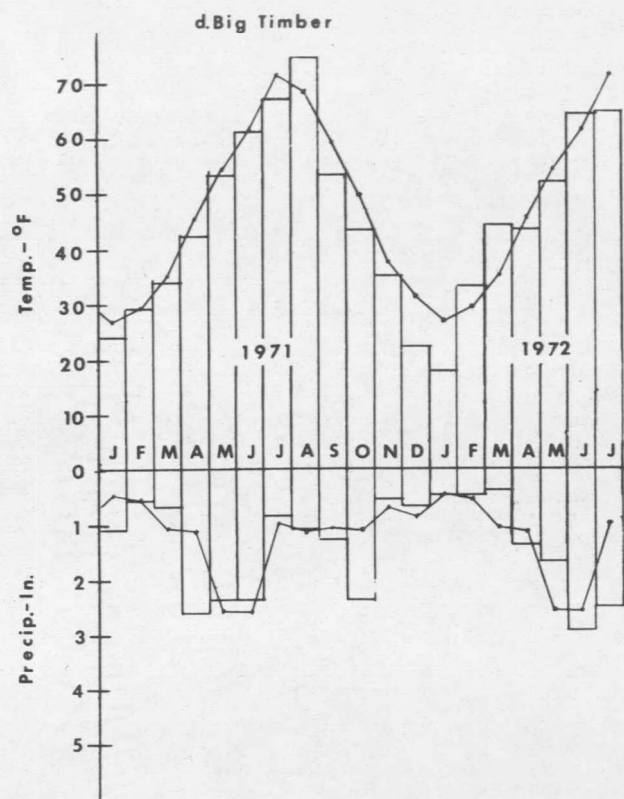


Figure 19. (continued) d. Big Timber

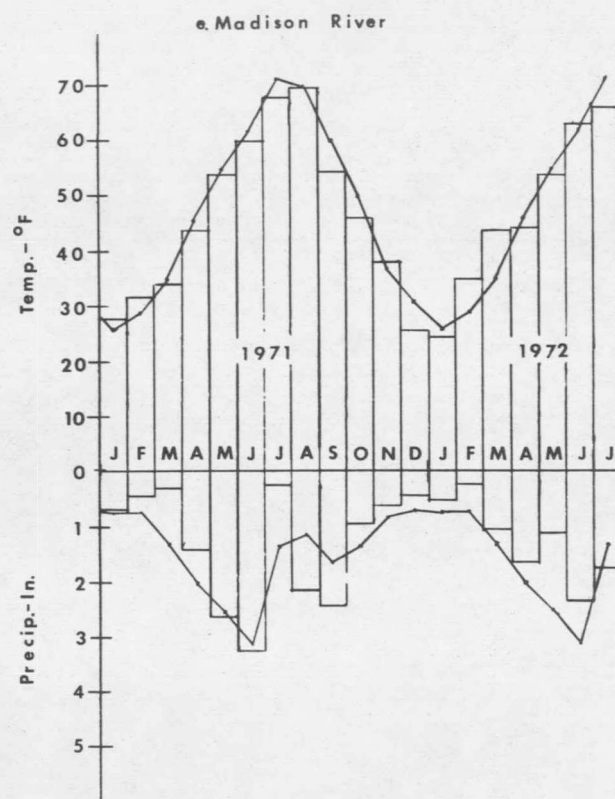


Figure 19. (continued) e. Madison River

TABLE 3. TEMPERATURE, PRECIPITATION AND FROST-FREE PERIOD DATA FROM THE U. S. DEPARTMENT OF COMMERCE WEATHER STATION NEAREST EACH MAJOR AREA FOR 1971 ALONG WITH STATION NORMS.

Area	Weather Station	Temperature ^{1/} Min/Max/Annual	Precipitation (inches)	Frost Free Period (days)
Fort Howes	Birney 15 N. (Southeast) ^{2/}	^{3/} <u>-45. 97 40.0</u> -43 108 44.9	21.04 12.79	26 142 ^{4/}
Missouri Breaks	Roy 24 NE Mobridge (Central)	<u>-36 107 43.2</u> -48 108 43.4	12.02 14.13	126 131 ^{5/}
Beartooth Game Range	Holter Dam (Central)	<u>-22 97 46.8</u> -44 108 47.7	9.56 14.07	147 133
Big Timber	Big Timber (South Central)	<u>-16 100 45.4</u> -47 110 47.8	16.33 14.36	130 123
Madison River	Norris-Madison PH (Southwest)	<u>-12 94 45.8</u> -36 101 47.2	15.81 17.71	143 137

^{1/} In degrees Fahrenheit.

^{2/} Montana weather division

^{3/} Top Row--1971 data

Bottom Row--Previously recorded temperature extremes and norms

^{4/} Row of data from Ashland weather station

^{5/} Row of data from Winifred weather station

three months (January, February and October) which under normal conditions collectively account for less than 2 inches total precipitation. Normal annual precipitation was greatest in the Madison River area—17.71 inches. Growing seasons, which normally range from an average 131 days in the Missouri River Breaks to 142 days at Fort Howes, also varied greatly in 1971. At Fort Howes, only 26 consecutive frost-free days were recorded while the Beartooth Game Range had a 147 day frost-free period.

These weather parameters were generally consistent with those of skunkbush habitats in North Dakota as reported by Sanford (1970)—44°F mean annual temperature with extremes of -47°F and 114°F, 15.63 inches mean annual precipitation, and 120 frost-free days.

Synecological Characteristics and Relationships

General Community Affiliations

Skunkbush sumac occurs extensively in only two of the seven broad physiognomic types recognized in Montana (Montana Agric. Expt. Station, Bozeman 1949)—eastern Montana pine forest-savannah and foothill grassland-sagebrush (Figure 20). Essentially no skunkbush is found in two others—the mountain forest-alpine grassland types and the undifferentiated stream bottom-intermountain valley, grassland, and meadow type. Light populations may occur locally in the three remaining types where

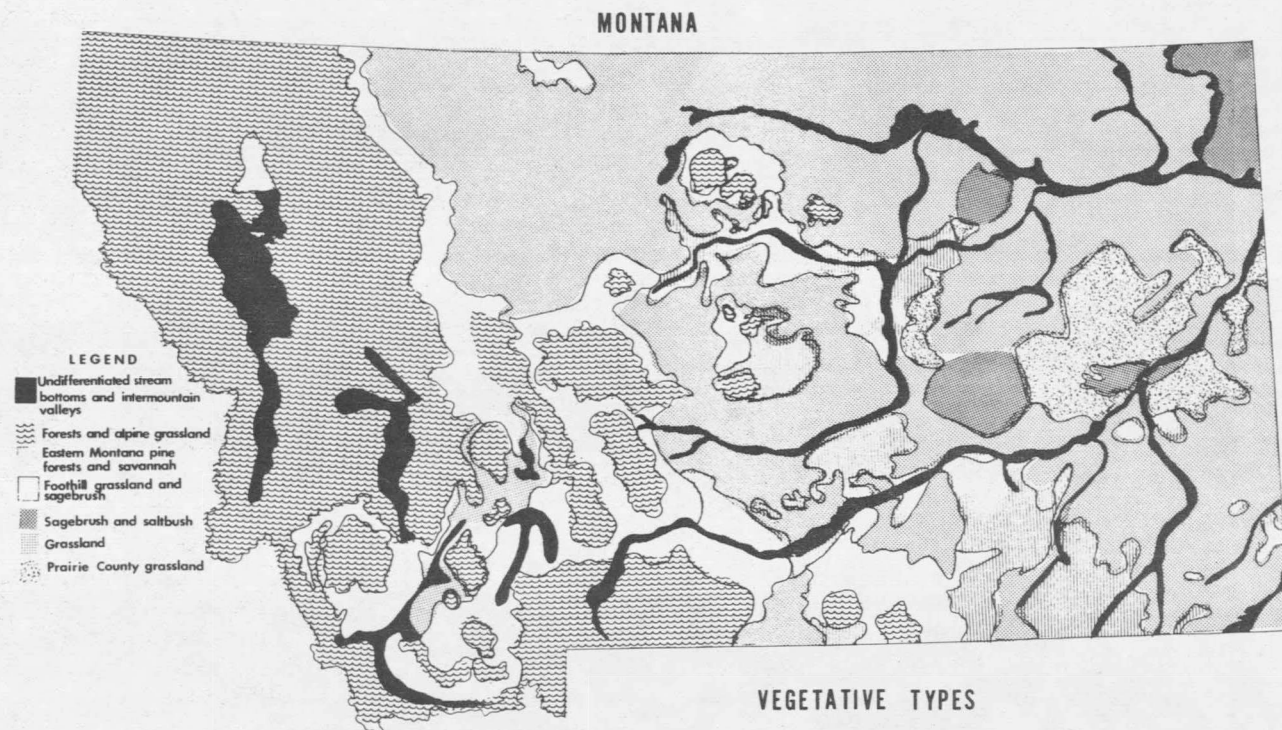


Figure 20. Vegetative rangeland types in Montana.

suitable edaphic and/or microclimatic conditions exist.

Although no attempt has yet been made to singularly classify or describe the vegetation of Montana east of the Continental Divide, some indication of the community affiliations of skunkbush may be obtained from previous ecological studies and general descriptions of vegetation in several areas. Mackie (1970) found skunkbush in 4 of 12 rangeland plant communities in the Missouri River Breaks—the Pinus-Agropyron, Pinus-Juniperus, Pinus-Artemisia and Pseudotsuga-Juniperus Associations. Further north, along the Milk River, Dusek (1971) described deciduous shrub subtypes, in which skunkbush commonly occurred, within the silver sage, big sage, and prairie grassland vegetation types. In southeastern Montana, Jonas (1966) found skunkbush in sapling, pole and sawlog stands of the ponderosa pine community and occasionally in prairie grassland parks in the Long Pines area; while Egan (1957) noted skunkbush as occurring throughout all types in the vicinity of Fort Howes. In a more detailed analysis of vegetation in the Fort Howes area, Knapp (1972) listed skunkbush as occurring in all types—grassland park, ponderosa pine, Rhus-grass and creek bottom—within the ponderosa pine zone. These data, together with observations and findings of this study indicate that skunkbush occurs primarily as a component of (1) ponderosa pine dominated communities, (2) seral communities on sites capable of supporting pine, (3) communities in habitats where pine is seral (e.g., the Pseudotsuga-Juniperus association in the Missouri Breaks), and (4)

shrub communities in habitats similar to those capable of supporting pine but where local edaphic, climatic or other conditions may prevent the establishment of pine. The latter suggests that the ecological amplitude of skunkbush may slightly exceed that of pine.

Skunkbush apparently occurs only accidentally or marginally, if at all, in true prairie grassland and sagebrush-grassland communities. Descriptions of these types in the Missouri River Breaks (Mackie 1970), the Milk River (Dusek 1971), Carter County in southeastern Montana (Campbell 1970, Freeman 1971), the Fort Howes area (Knapp 1972) and Petroleum County (Cole 1956, Bayless 1969, Westland 1968) make little or no mention of skunkbush. Wright and Wright (1948) mentioned the species as widely scattered in only one of the five grassland types they recognized in southcentral Montana. Neither Coupland (1950) in his study of the ecology of mixed prairie in Canada nor Hanson and Whitman (1938) in their report on grassland types of western North Dakota mentioned skunkbush in their discussions. Communities similar to those analyzed in both studies extend into eastern Montana.

Phytosociology of Skunkbush Stands

A total of 162 plant species, including 24 trees and taller shrubs, 10 low shrubs, 26 grasses and grasslike plants, and 102 forbs were identified from plots in the 25 stands studied (Tables 3 and 4 and Table 18 in the Appendix).

TABLE 4. CONSTANCY, CANOPY COVERAGE AND FREQUENCY OF LOW GROWING TAXA FOR MAJOR AREAS AS DETERMINED BY EXAMINATION OF 2 X 5 DECIMETER PLOTS ON EACH OF FIVE SKUNKBUSH STANDS PER AREA.

Taxa 1/	Fort Howes Area 198 plots	Missouri Breaks Area 195 plots	Beartooth Gar Range Area 196 plots	Big Timber Area 187 plots	Madison River Area 143 plots	TOTAL 919 plots
GRASS AND GRASS-LIKE PLANTS:						
<u>Agropyron smithii</u>	60 1 13 2/	100 4 31	80 1 16	80 2 28	40 2 15	72 2 21
<u>Agropyron spicatum</u>	80 9 40	100 19 63	80 7 41	100 16 67	80 7 40	88 12 50
<u>Aristida longiseta</u>	20 tr 1	- - -	- - -	20 tr 2	40 1 5	16 tr 2
<u>Bouteloua curtipendula</u>	60 4 19	- - -	- - -	- - -	- - -	12 1 4
<u>Bouteloua gracilis</u>	- - -	- - -	40 2 13	60 1 6	100 5 27	40 2 9
<u>Bromus japonicus</u>	80 1 14	- - -	80 4 42	100 5 31	- - -	52 2 17
<u>Bromus tectorum</u>	40 4 17	- - -	60 13 42	40 4 19	100 21 91	48 8 34
<u>Calamovilfa longifolia</u>	- - -	20 3 12	- - -	- - -	40 3 9	12 1 4
<u>Carex pensylvanica</u>	- - -	40 2 10	- - -	- - -	- - -	8 tr 2
<u>Carex spp.</u>	- - -	- - -	- - -	20 tr 2	40 tr 5	12 tr 1
<u>Festuca idahoensis</u>	40 2 8	- - -	- - -	- - -	40 2 17	16 1 5
<u>Hesperochloa kingii</u>	- - -	- - -	- - -	20 1 3	- - -	4 tr tr
<u>Koeleria cristata</u>	60 tr 5	60 2 11	60 4 23	100 5 36	40 tr 8	64 2 17
<u>Oryzopsis hymenoides</u>	20 2 14	- - -	20 tr 3	40 tr 3	- - -	16 tr 4
<u>Poa pratensis</u>	20 2 7	- - -	40 1 17	60 3 22	- - -	44 1 9
<u>Poa secunda</u>	- - -	- - -	- - -	- - -	40 tr 5	8 tr 1
<u>Stipa comata</u>	20 tr 2	- - -	- - -	60 1 6	100 4 35	36 1 9
<u>Stipa viridula</u>	60 tr 5	80 5 25	80 2 18	40 1 9	- - -	52 2 11
TOTAL GRASS AND GRASS-LIKE PLANTS	100 25 91	100 35 97	100 35 93	100 39 98	100 46 100	100 36 96
FORBS:						
<u>Achillea millefolium</u>	60 1 21	100 2 19	80 1 26	40 1 8	60 tr 9	68 1 17
<u>Alyssum alyssoides</u>	- - -	- - -	40 tr 2	- - -	60 4 26	20 1 8
<u>Alyssum desertorum</u>	- - -	- - -	- - -	80 9 52	- - -	16 2 10
<u>Allium textile</u>	40 tr 2	- - -	40 tr 6	80 tr 6	40 tr 3	40 tr 3
<u>Ambrosia artemisiifolia</u>	60 3 19	- - -	- - -	40 tr 4	- - -	20 tr 4
<u>Anemone patens</u>	40 1 7	- - -	- - -	- - -	- - -	8 tr 1
<u>Antennaria narvifolia</u>	80 tr 7	20 tr 1	- - -	- - -	- - -	20 tr 2
<u>Antennaria rosea</u>	- - -	- - -	- - -	40 1 6	- - -	8 tr 1
<u>Apocynum medium</u>	- - -	- - -	- - -	20 tr 8	- - -	4 tr 2
<u>Arenaria hookeri</u>	- - -	- - -	- - -	40 3 20	- - -	8 tr 4
<u>Artemisia dracunculoides</u>	40 1 5	- - -	20 tr 2	- - -	60 tr 3	24 tr 2
<u>Artemisia frigida</u>	60 tr 5	40 3 18	100 5 38	100 7 49	80 2 30	76 4 38
<u>Artemisia ludoviciana</u>	20 tr 5	- - -	- - -	100 4 21	60 1 8	36 1 7
<u>Aster falcatus</u>	60 1 11	20 tr 1	20 tr 7	100 3 21	- - -	40 1 8
<u>Aster oblongifolius</u>	40 1 7	- - -	40 tr 2	- - -	- - -	16 tr 2
<u>Astragalus bisulcatus</u>	- - -	- - -	- - -	20 1 7	- - -	4 tr 1

(continued)

TABLE 4. (Continued)

Taxa 1/	Fort Howes Area 198 plots	Missouri Breaks Area 195 plots	Beartooth Game Range Area 196 plots	Big Timber Area 187 plots	Madison River Area 143 plots	TOTAL 919 plots
FORBS:						
<u>Astragalus crassiocarpus</u>	- - -	- - -	- - -	- - -	20 1 7	4 tr 1
<u>Astragalus miser</u>	20 tr 1	- - -	- - -	- - -	- - -	4 tr tr
<u>Astragalus purshii</u>	- - -	- - -	- - -	- - -	20 tr 1	4 tr tr
<u>Astragalus straitus</u>	20 tr 1	- - -	- - -	20 tr 2	- - -	8 tr. tr
<u>Astragalus spp.</u>	40 tr 3	- - -	- - -	40 tr 9	- - -	16 tr 2
<u>Berberis repens</u>	40 tr 5	- - -	- - -	- - -	- - -	8 tr 1
<u>Campanula rotundifolia</u>	40 tr 6	- - -	- - -	- - -	- - -	8 tr 1
<u>Chrysopsis villosa</u>	- - -	- - -	20 tr 1	- - -	80 4 29	20 1 6
<u>Cirsium undulatum</u>	20 tr 3	20 tr 1	20 tr 2	80 tr 4	40 tr 5	36 tr 3
<u>Collomia linearis</u>	40 tr 2	20 tr 1	20 tr 7	20 tr 1	- - -	20 tr 2
<u>Comandra umbellata</u>	- - -	80 tr 9	40 tr 8	80 tr 8	20 tr 1	44 tr 5
<u>Erigeron caespitosus</u>	- - -	- - -	20 1 4	40 tr 3	- - -	12 tr 1
<u>Erigeron spp.</u>	- - -	- - -	20 tr 5	- - -	- - -	4 tr 1
<u>Eurotia lanata</u>	- - -	- - -	20 2 16	- - -	- - -	4 tr 3
<u>Galium boreale</u>	20 1 7	- - -	20 tr 7	- - -	- - -	8 tr 3
<u>Gaura coccinea</u>	80 1 19	- - -	- - -	40 tr 3	60 tr 3	36 tr 5
<u>Geum triflorum</u>	80 1 9	- - -	- - -	- - -	- - -	16 tr 2
<u>Glycyrrhiza lepidota</u>	- - -	- - -	20 tr 1	20 tr 5	- - -	8 tr 1
<u>Gutierrezia sarothrae</u>	80 2 12	40 tr 4	80 3 30	80 1 7	- - -	56 1 10
<u>Helianthus petiolaris</u>	- - -	- - -	- - -	20 1 15	- - -	4 tr 3
<u>Liatris punctata</u>	- - -	- - -	- - -	20 tr 5	20 tr 1	8 tr 1
<u>Linum perenne</u>	40 tr 2	20 tr 1	60 tr 7	80 1 15	- - -	40 tr 3
<u>Lupinus sericeus</u>	- - -	- - -	- - -	40 2 11	40 tr 4	16 tr 3
<u>Lupinus spp.</u>	- - -	20 tr 1	40 tr 7	20 1 6	- - -	16 1 6
<u>Medicago lupulina</u>	- - -	20 tr 1	20 tr 9	- - -	- - -	8 tr 2
<u>Melilotus officinalis</u>	20 tr 1	80 1 9	60 tr 4	60 3 16	20 2 5	48 1 7
<u>Microseris spp.</u>	- - -	20 tr 2	40 tr 5	- - -	20 tr 2	16 tr 2
<u>Monarda fistulosa</u>	20 tr 3	- - -	20 tr 8	- - -	- - -	8 tr 2
<u>Opuntia polyacantha</u>	- - -	80 1 8	- - -	40 tr 2	100 4 31	44 1 8
<u>Phacelia linearis</u>	- - -	- - -	- - -	- - -	60 tr 7	12 tr 1
<u>Cerastium arvense</u>	60 1 13	- - -	20 tr 7	100 2 22	- - -	46 tr 8
<u>Plantago purshii</u>	- - -	- - -	20 tr 1	- - -	80 tr 4	10 tr 1
<u>Potentilla hippiana</u>	- - -	- - -	- - -	20 tr 1	- - -	4 tr tr
<u>Psoralea argophylla</u>	40 tr 7	20 tr 1	- - -	- - -	- - -	12 tr 2
<u>Ratibida columnifera</u>	40 tr 3	- - -	40 tr 2	- - -	- - -	16 tr 1
<u>Silens cserei</u>	- - -	- - -	- - -	- - -	20 tr 7	4 tr 1

(continued)

TABLE 4. (continued)

Taxa ^{1/}	Fort Howes Area 198 plots	Missouri Breaks Area 195 plots	Beartooth Game Range Area 196 plots	Big Timber Area 187 plots	Madison River Area 143 plots	TOTAL 919 plots
FORBS:						
<i>Silene</i> spp.	- - -	- - -	20 tr 1	- - -	- - -	4 tr tr
<i>Sphaeralcea coccinea</i>	- - -	80 tr 17	- - -	- - -	60 tr 3	28 tr 4
<i>Thermopsis rhombifolia</i>	40 tr 5	20 1 7	- - -	- - -	- - -	12 tr 2
<i>Tragopogon dubius</i>	60 tr 5	80 tr 5	100 tr 17	100 2 46	80 tr 6	84 1 16
<i>Vicia americana</i>	100 tr 10	100 tr 9	80 tr 17	60 tr 11	20 tr 1	72 tr 10
<i>Yucca glauca</i>	- - -	- - -	- - -	40 1 2	- - -	8 tr tr
TOTAL FORBS	100 19 94	100 9 75	100 7 94	100 47 100	100 25 92	100 21 91
SHRUBS:						
<i>Artemisia tridentata</i>	- - -	40 tr 6	- - -	- - -	- - -	8 tr 1
<i>Physocarpus malvaceus</i>	- - -	- - -	20 5 9	- - -	- - -	4 1 2
<i>Rhus trilobata</i>	20 tr 2	80 tr 3	40 1 9	20 tr 5	- - -	30 tr 4
<i>Rosa arkansana</i>	60 tr 4	80 1 7	20 tr 3	100 1 13	- - -	52 tr 5
<i>Symphoricarpos albus</i>	80 4 29	100 4 34	60 2 16	40 tr 4	- - -	56 2 17
TOTAL SHRUBS	80 6 36	100 6 43	80 9 27	100 2 22	0 0 0	72 5 26
LIVE PLANTS	100 59 100 114/	100 50 100 21	100 65 100 21	100 88 100 16	100 71 100 21	100 67 18
ROCK	100 27 65 23	60 1 11 1	100 15 86 18	100 19 70 18	100 19 91 21	64 16 16
BARE GROUND	100 12 56 25	10 31 94 39	100 15 87 20	100 16 82 18	100 17 91 23	82 18 25
LITTER	100 34 81 49	100 28 93 30	100 30 94 41	100 53 97 48	100 34 97 35	90 36 42

1/ Includes those taxa with a canopy coverage of .5 percent or greater or a frequency of 5 percent or greater in at least one area. Others are listed in the Appendix, Table 17.

2/ Constancy (percent occurrence among sites)/canopy coverage (percent of area covered)/average frequency (percent occurrence among plots).

3/ tr=trace; a value less than or equal to .5 percent.

4/ Constancy, canopy coverage, average frequency (all from within Daubenmire plots) and average frequency (percent contact with 4 legs of each plot).

Tree-Shrub Characteristics.—The stands examined were typically "open". Total tree-shrub densities ranged from a low mean of 791 plants/ha. (320 plants/acre) for five stands on the Beartooth Game Range to 3,038 plants/ha. (1,230 plants/acre) in the Missouri Breaks (Table 4). Combined tree-shrub crown area from an average of 84 m²/ha. (34 m²/acre) in the Missouri Breaks to 344 m²/ha. (139 m²/acre) at Fort Howes.

A distinct tree layer or overstory was either lacking or only poorly developed at most locations. Ponderosa pine, the major tree associate of skunkbush, consistently occurred in or near all of the stands; but densities were generally low, ranging from zero in stands near Big Timber, where the species occurred only as scattered individuals, to a mean 183 plants/ha. (74/acre) in the five stands at Fort Howes. Other trees associates included limber pine (P. flexilis), which occurred at low densities in some stands near Big Timber and along the Madison River, and Douglas-fir (Pseudotsuga menziesii) in a few stands in the Missouri Breaks, Beartooth and Big Timber areas.

Skunkbush was the dominant shrub overall (Table 5) as well as in stands on all exposures except northwest, at all elevations, and on all slope gradients (Table 6). It appeared to attain maximum development, with highest importance values, in stands on southwest exposures, at elevations under 5,500 feet, and on slopes with gradients less than 50 percent (Table 7). Importance values were lowest on sites of northwest

TABLE 5. CONSTANCY, IMPORTANCE VALUE AND PLANTS PER HECTARE OF TREES AND SHRUBS FOR FIVE MAJOR AREAS AS DETERMINED BY POINT-CENTER-QUARTER MEASUREMENTS ON EACH OF FIVE SKUNKBUSH STANDS PER AREA.

Taxa 1/	Fort Hoves Area 105 points	Missouri Breaks Area 105 points	Beartooth Game Range Area 105 points	Big Timber Area 105 points	Madison River Area 105 points	TOTAL 525 points
<u>Acer glabrum</u>	- - -	- - -	20 2 3	20 1 2	- - -	8 tr5/ 1
<u>Amelanchier alnifolia</u>	40 5 9 2/	- - -	60 11 26	40 3 20	60 5 23	40 5 16
<u>Artemisia cana</u>	100 44 150	20 6 94	- - -	20 3 7	60 25 147	40 16 80
<u>Artemisia tridentata</u>	- - -	100 59 671	- - -	60 19 46	80 22 148	48 20 173
<u>Cercocarpus ledifolius</u>	- - -	- - -	- - -	- - -	20 3 24	4 tr 5
<u>Chrysothamnus nauseosus</u>	40 8 13	100 39 329	60 48 76	40 15 92	40 29 204	64 28 143
<u>Chrysothamnus viscidiflorus</u>	- - -	20 1 12	- - -	20 1 7	60 36 211	20 8 46
<u>Juniperus communis</u>	- - -	- - -	60 8 16	- - -	- - -	12 2 3
<u>Juniperus horizontalis</u>	20 3 6	20 8 8	20 5 6	20 8 10	- - -	16 5 6
<u>Juniperus scopulorum</u>	60 42 130	100 79 293	40 12 24	60 29 94	80 42 67	68 41 132
<u>Physocarpus malvaceus</u>	- - -	- - -	20 15 59	- - -	- - -	4 3 12
<u>Pinus flexilis</u>	- - -	- - -	- - -	60 31 49	20 8 3	16 8 10
<u>Pinus ponderosa</u>	100 117 183	20 16 39	40 28 44	- - -	20 2 5	36 33 54
<u>Populus tremuloides</u>	- - -	- - -	20 1 3	- - -	- - -	4 tr tr
<u>Prunus virginiana</u>	60 13 25	40 8 96	100 15 28	60 20 61	100 14 57	72 14 53
<u>Pseudotsuga menziesii</u>	- - -	20 2 3	20 4 9	40 12 14	- - -	16 4 5
<u>Purshia tridentata</u>	- - -	- - -	- - -	20 34 256	20 26 166	8 12 84
<u>Rhus tylobata</u>	100 146 356	100 99 569	100 211 412	100 176 631	100 171 734	100 161 540
<u>Ribes aureum</u>	- - -	- - -	- - -	- - -	20 3 5	4 tr 1
<u>Ribes cereum</u>	40 9 12	60 4 21	20 1 1	80 26 68	80 2 56	56 9 32
<u>Ribes setosum</u>	- - -	20 2 16	- - -	- - -	- - -	4 tr 3
<u>Rosa arkansana</u>	80 12 27	100 36 233	100 24 59	60 8 50	80 16 60	84 19 86
<u>Sarcobatus vermiculatus</u>	- - -	60 17 95	- - -	- - -	- - -	12 3 19
<u>Symphoricarpos albus</u>	60 10 26	80 41 559	80 11 25	40 11 61	20 2 12	56 15 147
Plants/hectare	937 3/	3,038	791	1,468	1,922	
Plant Crown Area	344 4/	84	298	227	314	

1/ All species samples by point-center-quarter method.

2/ Constancy (percent occurrence among sites)/Importance Value, (relative Frequency+Relative Density+Relative Dominance) X 100/Number of plants per hectare.

3/ Average total plants per hectare of five skunkbush stands.

4/ Average corrected crown area in square meters of five skunkbush stands.

5/ tr=trace; a value less than or equal to 0.5 percent.

TABLE 6. MEAN IMPORTANCE VALUES AND DENSITIES OF TREES AND TALL SHRUBS FROM 25 SKUNKBUSH STANDS COMPARED STATISTICALLY BY THE BEHRENS-FISCHER TEST. 1/

Species*	Rank by Density	Importance Value (X100)	Closest Different Value	Density	Closest Different Value
Skunkbush sumac	1	161	41 <u>2/</u>	540	173
Rocky Mountain juniper	5	41	20	122	46
Ponderosa pine	9	33	16	54	-
Rubber rabbitbrush	3	28	14	143	54
Big sagebrush	2	20	5	173	86
Prairie rose	6	19	5	86	12
Silver sagebrush	8	16	2	80	6
Common snowberry	4	15	tr <u>3/</u>	137	54
Chokecherry	10	14	tr	53	-
Antelope bitterbrush	7	12	-	84	12
Squaw currant	12	8	-	32	-
Limber pine	16	8	-	10	-
Green rabbitbrush	11	8	-	46	-
Western serviceberry	14	5	-	16	-
Creeping juniper	17	5	-	6	-
Douglas fir	18	4	-	5	-
Greasewood	13	3	-	19	-
Ninebark	15	3	-	12	-
Common juniper	20	2	-	3	-
Curl-leaf mountain mohogany	19	tr	-	5	-
Golden currant	22	tr	-	1	-
Rocky Mountain maple	22	tr	-	1	-
Redshoot gooseberry	20	tr	-	3	-
Quaking aspen	24	tr	-	tr	-

*Rank by importance value

1/ From Snedecor and Cochran, 1971, p. 115.

2/ Least significant difference (F_{23-92} , $P=.01$) was 13.5 for importance value and 70.2 for density.

3/ tr= trace, a value = .05.

TABLE 7. SIGNIFICANT SYNECOLOGICAL RELATIONSHIPS WITH EXPOSURE, ELEVATION AND SLOPE GRADIENT BASED ON THE NUMBER OF TIMES INDIVIDUAL SPECIES HAD THE HIGHEST CANOPY COVER OR OCCURRED MOST FREQUENTLY ON 25 SKUNKBUSH SITES.

		<u>Grass</u>			<u>Low Shrubs</u>			<u>Trees & Shrubs</u>		
		<u>Frequency</u>			<u>Canopy Cover</u>			<u>Canopy Cover</u>		
		<u>Agsp</u>	<u>Brja</u>	<u>Brte</u>	<u>Agsp</u>	<u>Brte</u>		<u>Syal</u>	<u>Rhtr</u>	<u>Jusc</u>
		<u>1/</u>								
<u>Exposure</u>		<u>2/</u>	<u>3/4/</u>							
NE	20	-	+	-	-	-	-	-	o	+
NW	16	-	-	-	-	-	-	-	-	-
SE	32	-	-	+	o	-	-	-	*	*
SW	32	-	-	-	-	o	-	-	o	+
N	36	-	o	-	-	o	-	+	*	-
S	64	-	*	-	+	*	-	-	-	*
E	52	-	o	-	o	-	o	-	+	*
W	48	-	o	-	-	*	-	-	-	o
<u>Slope Gradient</u>										
>60%	48	-	-	-	o	-	-	-	-	*
<60%	52	o	*	-	-	o	*	-	+	*
<u>Elevation</u>										
>4000'	48	-	o	-	-	-	*	-	o	*
<4000'	52	-	-	-	o	-	-	-	-	*
<u>Major Dominant</u>										
Skunkbush										
68		-	o	-	o	-	*	-	o	-
Other	12	-	-	-	-	-	-	-	-	*
<u>Between Species Significance</u>										
		*	o	*	*	o	*	o	*	*
Number		9	4	7.5	13	6	10.5	4	10	17
Percent		36	16	30	52	24	42	16	40	68

- 1/ First two letters of generic and specific name, e.g., Agropyron spicatum = Agsp, of those species involved in significant relationships, others listed in Appendix, Table 6.
- 2/ Significance levels (*=.01, o=.05, +=.10, -=Not significant at .10 level) determined by one way analysis of variance.
- 3/ Indicates significance of an individual species between exposures, elevations, slopes, etc., e.g., Brja occurs with greater frequency (P=.10) on NE than on NW, SE or SW exposures.
- 4/ Indicates significance between species on certain exposures, slopes, etc., e.g., Brja doesn't occur more frequently on NE slopes than any other species.

exposure, at elevations above 5,500 feet, and on slopes with gradients greater than 80 percent. The relative importance of skunkbush on slopes less than 40 percent gradient may have been exaggerated by the occurrence of a few extremely large plants near constant water sources on these sites. Plant densities were higher in stands on steeper slopes. Density estimates for skunkbush corresponded closely to importance values for stands on the various exposures as well as above and below 5,500 feet.

Skunkbush plant densities and importance values varied greatly between the major study areas (Table 8). The mean density for five stands in the Madison River area (734 plants/ha. or 297/acre) was more than double that of stands near Fort Howes (356 plants/ha. or 144/acre). Overall importance ratings were highest in stands on the Beartooth Game Range (2.108) due primarily to the relatively large size of individual plants. Plant density was relatively low (412 plants/ha. or 167/acre). The lowest importance value (.985) occurred in the Missouri Breaks where skunkbush was moderately dense (569 plants/ha. or 230/acre) and plants were relatively small.

Other shrubs of importance in the stands included Rocky Mountain juniper, rubber rabbitbrush (Chrysothamnus nauseosus), prairie rose (Rosa arkansana), common snowberry (Symphoricarpos albus), chokecherry (Prunus virginiana), and squaw currant (Ribes cereum) which consistently occurred in stands in all study areas, and big sagebrush (Artemisia

TABLE 8. MEAN SKUNKBUSH IMPORTANCE AND DENSITY VALUES ON VARIOUS EXPOSURES, SLOPE GRADIENTS AND ELEVATIONS ALONG WITH THE NUMBER OF TIMES SKUNKBUSH IMPORTANCE VALUES WERE LARGEST ON EACH COMPARED STATISTICALLY BY ONE WAY ANALYSIS OF VARIANCE.

Site Categories	Mean		Largest Importance Value		
	Importance Value	1/ Density	Number	Category 2/ Percent	All Sites 3/
<u>Exposure</u> (Azimuth Degrees)					
NE 1-90	1.61	503	4	80* 4/	16+
NW 271-360	1.16	479	1	25	4
SE 91-180	1.66	527	7	88**	28**
SW 181-270	1.77	608	5	63*	20+
N 271-90	1.41	492	5	56	20**
S 91-270	1.71	568	12	75	48**
E 1-180	-	-	11	85*	44**
W 181-360	-	-	6	50	24*
<u>Slope Gradient</u> (percent)					
Below 40	1.78	434	4	100*	16**
40-80	1.58	478	9	56	36**
Above 80	1.52	587	4	80*	16+
<u>Elevation</u> (feet)					
Below 5500	1.66	587	15	71	60**
5500 and above	1.16	295	2	50	8
Below 5000	1.57	522	13	72	52**
5000 and above	1.60	587	4	57	16

1/ Plant density in hectares (.405 hectares=1 acre).

2/ Percent of times Skunkbush had the largest importance value in a site category, i.e., of 5 NE sites, Skunkbush had the largest value 4 times for 80 percent.

3/ Percent of times Skunkbush had the largest importance value among all species sampled with a site category on all 25 sites.

4/ **, * and + indicate statistical significance at $P=.01$, $.05$, and $.10$, respectively.

tridentata), silver sagebrush (Artemisia cana), and bitterbrush which were prominently associated with skunkbush in some areas. Although Rocky Mountain juniper usually was only sparsely distributed, averaging 122 plants/ha. (49/acre), its overall importance value, 0.41, was the highest of all tree-shrub associates of skunkbush (Table 5). It was ranked second, next to skunkbush, among plants in this group in stands in the Missouri Breaks and along the Madison River where ponderosa pine was of relatively minor importance (Table 4). Although Rocky Mountain juniper frequently was a dominant species on north facing slopes, analyses of importance values for shrubs with respect to exposure, slope and elevation indicated that no single species was dominant significantly more often than any other (Table 5, Table 19 in Appendix).

The combined importance value for Rocky Mountain juniper and ponderosa pine was inversely related to the importance value of skunkbush ($r = -.65$). This, combined with their coexistence on many sites, suggests skunkbush is a facultative sciophyte (Daubenmire 1959b).

Common snowberry appeared to be the most important low shrub associate despite its low overall importance rating. It was the most frequently occurring shrub among plots in 42 percent of all stands and 41 percent of the stands dominated by skunkbush (Table 19 in Appendix). It appeared to be most important in stands of northerly exposure and at elevations below 4,000 feet (Table 6).

With one exception, mean density and importance values for all trees and shrubs combined were not significantly different ($P=.01$) between major study areas. The total tree shrub density (3,038 plants/ha.) of stands in the Missouri River Breaks was significantly greater than on the Fort Howes and Beartooth Game Range areas (Table 8).

Grass, Forb and Ground Cover Characteristics.--The typical "openness" of skunkbush stands was also evidenced by generally sparse ground cover. This consisted mainly of grasses with a mean total canopy coverage of 36 percent (Table 3), while bareground and rock accounted for 34 percent of the total area sampled. Forbs were prominent in only a few areas and had mean canopy coverage of 21 percent. About half of the area covered by live plants was underlain with litter. Mean canopy coverage for all grasses combined ranged from 25 percent among stands in the Fort Howes area to 46 percent for stands along the Madison River, while the mean for forbs ranged from 7 percent to 47 percent in the Beartooth and Big Timber areas, respectively (Table 3).

Bluebunch wheatgrass, an important plant in mountain foothills and badlands where soils are clayey, silty and shallow (Jeffries 1969) was the dominant grass, occurring in 22 of the 25 stands and in 50 percent of all plots with a mean 12 percent overall canopy coverage (Table 10). Sanford (1970) found little bluestem (Andropogon scoparius) and plains muhly (Muhlenburgia cuspidata) to be the major grasses associated with skunkbush in western North Dakota. Bluebunch wheatgrass was important

only on his top line position and, especially, on southwest exposures. Comparing bluebunch wheatgrass frequencies between sites indicated that the highest frequencies occurred significantly ($P=.05$) more often on slope gradients over 60 percent (Table 6). It also occurred with highest frequency on sites with west exposures, slope gradients over 60 percent, elevations less than 4,000 feet and with skunkbush dominant significantly more often than any other grass. In addition, bluebunch wheatgrass had the highest canopy coverage significantly more often than other grasses on southwest and north exposures, and had equal canopy coverage to cheatgrass on south and east exposures and on sites above 4,000 feet.

Other generally important grasses included cheatgrass, bluestem, Japanese chess and Junegrass with Indian ricegrass, Kentucky bluegrass (Poa pratensis) and Idaho fescue (Festuca idahoensis) dominant locally (Table 3). Cheatgrass was significantly more important than the others (Table 9, Table 19 in Appendix).

Among forbs, only fringed sagewort (Artemisia frigida), which occurred in 28 percent of all plots with 4 percent mean canopy coverage (Table 10), appeared to be of major importance ($P=.01$). Desert alyssum (Alyssum desertorum) had the second highest canopy cover, 2 percent, but was not significantly more or less important than any other forb in the stands. Western yarrow (Achillea millefolium), common salsify (Tragapogon dubius), desert alyssum, broom snakeweed (Gutierrezia

TABLE 9. SYNECOLOGICAL RELATIONSHIPS BETWEEN THE MAJOR STUDY AREAS AND STATISTICAL SIGNIFICANCE DETERMINED BY THE BEHRENS-FISCHER ANALYSIS OF VEGETATIVE DATA FROM FIVE SKUNKBUSH STANDS PER AREA.

Area	Skunkbush		Trees and Shrubs (24) 1/		Grasses (18)		Forbs (25)		Low Shrubs (5)	
	I.V.**	Density	Mean Species Density	Mean Species I.V.	Mean Species Canopy Cover	Mean Species Frequency	Total Mean 2/ Species Canopy Cover	Mean Species Frequency	Total Mean Species Canopy Cover	Mean Species Frequency
Fort Howes	1.461	355.6	39.04*	0.170	27.00 (1.50)	8.06	14.50 (0.58)	4.92*	5.00 (1.00)	7.0
Missouri Breaks	0.985	569.0	126.6 *	0.174	34.92 (1.94)	8.44	12.00 (0.48)*	3.48*	6.00 (1.20)	10.0
Beartooth Game Range	2.108	412.0	32.96*	.165	34.56 (1.92)	11.94	19.00 (0.76)	8.64	8.50 (1.70)	7.4
Big Timber	1.755	631.4	61.17	.165	40.50 (2.25)	13.00	42.50 (1.70)*	12.80*	2.00 (0.40)	4.4
Madison River	1.706	734.2	80.08	.169	46.44 (2.58)	14.28	21.50 (0.86)	6.92	0.0 (0.0)	0.0
F-calculated	2.179	0.482	3.939	0.010	0.376	0.883	3.476	3.542	1.345	1.358
F-tabled, P=.01	4.770	4.770	3.530	3.530	3.604	3.604	3.520	3.520	4.770	4.770

1/ The number of species involved in analysis.

2/ Total density, importance value, canopy cover or frequency per area obtained by multiplying the mean species value by (N).

* Indicates areas involved in significant differences at P=.01.

** Importance Value.

TABLE 10. CANOPY COVER AND FREQUENCY VALUES OF GRASSES, FORBS AND LOW SHRUBS COMPARED STATISTICALLY BY THE BEHRENS-FISCHER TEST.

Species <u>1/</u>	Canopy Cover Rank	Mean Percent Frequency	Closest Different Value	Mean Percent Canopy Cover	Closest Different Value
Grasses: <u>2/</u>					
Bluebunch wheatgrass	1	50	34	12	8
Cheatgrass	2	34	21	8	2
Bluestem	4	21	9	2	-
Japanese chess	4	17	5	2	-
Junegrass	3	17	5	2	-
Green needlegrass	6	11	-	2	-
Kentucky bluegrass	9	9	-	1	-
Blue grama	7	9	-	2	-
Needle-and-thread grass	8	9	-	1	-
Idaho fescue	11	5	-	1	-
Prairie sand reedgrass	10	4	-	1	-
Indian rice grass	13	4	-	tr <u>5/</u>	-
Side oats grama	12	4	-	1	-
Pennsylvania carex	13	2	-	tr	-
Red three-awn	15	2	-	tr	-
Carex species	16	1	-	tr	-
Sandberg bluegrass	18	1	-	tr	-
Hesperocloa	17	tr	-	tr	-
Forbs: <u>3/</u>					
Fringed Sagewort	1	28	17	4	1
Western yarrow	5	17	8	1	-
Common salsify	12	16	8	1	-
Desert alyssum	2	10	3	2	-
Brome snakeweed	4	10	3	1	-
American vetch	15	9	2	tr	-
Field chickweed	13	8	-	tr	-
Plains prickly pear	5	8	-	1	-
Aster species	8	8	-	1	-
Pale alyssum	9	8	-	1	-
Yellow sweet clover	3	7	-	1	-
Cudweed sagewort	5	7	-	tr	-
Golden-aster	9	6	-	1	-
Lupine species	9	6	-	1	-

(continued)

TABLE 10. (continued)

Species <u>1/</u>	Canopy Cover Rank	Mean Percent Frequency	Closest Different Value	Mean Percent Canopy Cover	Closest Different Value
Forbs (continued): <u>3/</u>					
Pale bastard toadflax	19	5	-	tr	-
Low ragweed	13	5	-	tr	-
Hooker sandwort	15	4	-	tr	-
Wild onion	19	3	-	tr	-
Winterfat	19	3	-	tr	-
Blue flax	16	3	-	tr	-
Wavyleaf thistle	16	3	-	tr	-
Northern bedstraw	24	3	-	tr	-
Narrow leaved collomia	19	2	-	tr	-
False-tarragon sagewort	19	2	-	tr	-
Microseris species	24	2	-	tr	-
Low Shrubs: <u>4/</u>					
Common snowberry	1	17	2	2	-
Prairie rose	3	5	-	tr	-
Skunkbush sumac	4	4	-	tr	-
Nine bark	2	2	-	1	-
Big sagebrush	5	1	-	tr	-

1/ Species listed by common name and ranked by mean percent frequency.

2/ Least significant difference for grasses (F_{17-68} , $P=.01$) was 11.4 and 2.5 for frequency and canopy cover, respectively.

3/ Least significant difference for forbs (F_{24-96} , $P=.01$) was 7.2 and 2.0 for frequency and canopy cover, respectively.

4/ Least significant difference for low shrubs (F_{4-16} , $P=.01$) was 13.4 for frequency. Canopy cover F value was not significant.

5/ tr: a value=.05.

sarothrae) and American vetch (Vicia americana) were other forbs of some importance (Table 9).

There were no significant differences in the occurrences or canopy coverages of individual forbs among stands on the various sites, probably due to the diversity of species and the generally small samples of each. Analyses of mean species canopy coverage and frequency values between major study areas (Table 8) suggested an inverse relationship between the relative occurrence of grasses and forbs in skunkbush stands. Where mean species canopy coverage and frequency of grasses were not significantly ($P=.01$) different between areas, forb values were. Analysis of data for the 25 most important forbs revealed that the Big Timber area had the highest frequency and canopy coverage per species, 12.8 percent and 17 percent, respectively, as well as total canopy cover, 43 percent. These values were significantly larger than those from the Fort Howes and Missouri Breaks areas. These areas also had the smallest canopy coverage and frequency values for forbs. The relative abundance of forbs in the Big Timber area may indicate extremely heavy utilization of those sites by domestic livestock resulting in relatively low grass and high forb densities as reported for the dry steppes region of Washington (Daubenmire 1970).

Growth Characteristics and Relationships

Growth Form

Skunkbush plants characteristically were low growing with dense

rounded crowns comprised of many twigs or "leaders". This species, unlike most deciduous shrubs, lacks true terminal growth leaders on mature branches. Among plants examined, lineal growth from terminal buds occurred only on branches less than about five years old and originating as resprouts from underground parts. Upon completion of annual growth, twigs of all other branches either developed a flower bud terminally or died back to the first vegetative bud located in the axil of the last formed leaf. The terminal portion of the flower bearing twigs similarly died back as flowers and fruits matured the following spring. As a result of this natural "hedging", new growth originated primarily from lateral buds on year-old twigs. From one to ten (usually two-four) shoots developed along each twig. There were no apparent differences among annual growth twigs with respect to which developed flower buds or died back immediately upon completion of growth. The percentages of "terminal" and total twigs which developed flower buds were similar (Figure 21) overall as well among plants on the different study areas. These general growth characteristics may represent adaptations to browsing and/or for survival of a species with a relatively inefficient means of reproducing from seed.

The 500 skunkbush plants measured averaged 23.5 decimeters in diameter and 7.9 decimeters in height (Figure 22). The mean corrected, or live, crown area was 3.5 m^2 per plant with an average 26 percent of the total crown area of each comprised of dead material. On the basis of

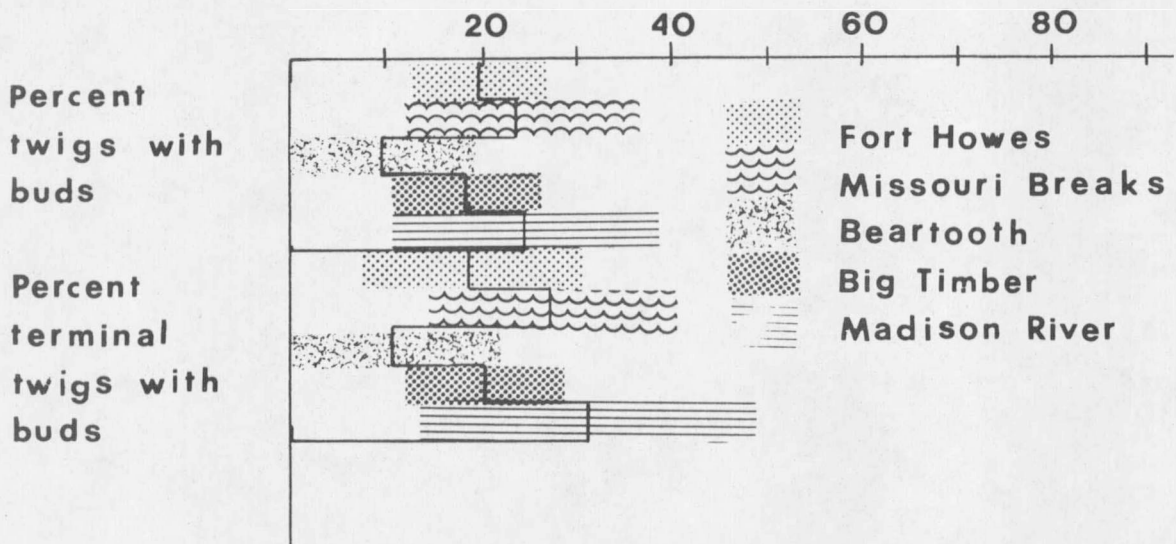


Figure 21. Mean percentage total and "terminal" twigs which developed flower buds on 10 plants per area in 1971 with 95 percent confidence intervals.

mean corrected crown areas, plants along the Madison River (4.7 m^2) and on the Beartooth Game Range (4.6 m^2) were significantly larger ($P=.05$) than those of plants in the Big Timber (2.7 m^2) and Missouri Breaks (2.2 m^2) areas. Mean diameters of plants in the stands along the Madison River were significantly ($P=.05$) larger than in the Missouri Breaks and generally, though not significantly, larger than in the Big Timber area. Although plants on the Beartooth Game Range were generally larger in diameter (28.0 dm) than those of all other areas, the differences were not statistically significant due to extreme variation in the size of individual plants. The tallest plants, 9.1 dm , were found near Fort Howes and along the Madison River, but the only significant ($P=.05$) difference in heights occurred between plants at Fort Howes and at Big

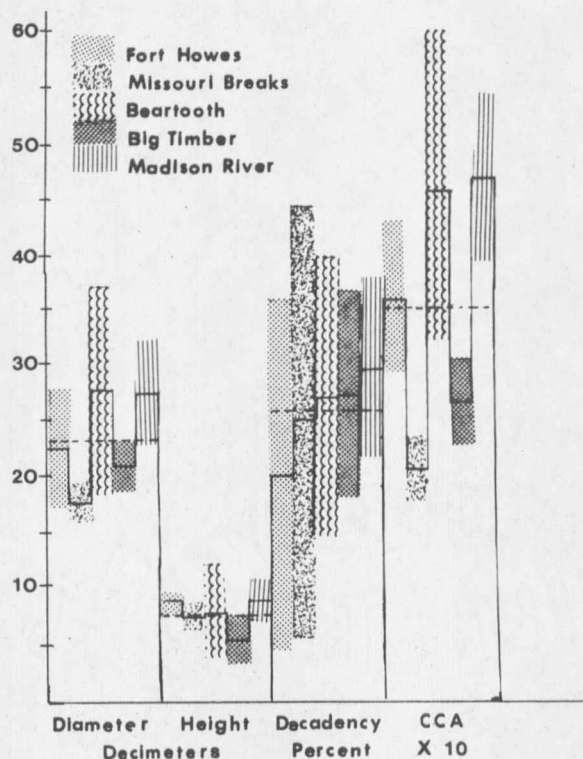


Figure 22. Mean diameter, height, decadency (percent dead crown area) and corrected crown area with 95 percent confidence intervals for 100 plants per area measured in 1971.

Timber where the shortest plants (average 5.6 dm) were found.

A substantial portion of dead crown was evident among plants of all areas. The mean percentages ranged from 20.2 percent for plants at Fort Howes to 29.8 percent on the Madison River with no significant differences between areas. Average decadency of 114 skunkbush plants collected throughout eastern Montana was 29.0 percent (Lonner 1972).

These differences in size and growth form doubtless reflect the influence of diverse environmental conditions. The tall, narrow plants

found in the Fort Howes area may be characteristic of skunkbush plants in fairly well developed ponderosa pine stands where an overstory reduces sunlight at ground level. The relatively low growth form of plants in the Big Timber area could reflect the relatively high elevation and short growing season of that area. Similarly, low spring precipitation and high spring temperatures may restrict the size of plants (Blaisdell 1958) as found in the Missouri River Breaks (Figures 19b and 22). Although browsing and/or trampling damage by big game and livestock apparently influence the size and growth form of plants in at least some areas, these effects probably are secondary. Mackie (unpublished data) found significantly larger skunkbush plants in two total exclosures as compared with plants on nearby browse utilization and condition trend transects. One of these units was located in the Big Timber area and the other near the Sun River about 60 miles northwest of the Beartooth Game Range.

The relative age of skunkbush stands also may be important. Lonner (1972) reported skunkbush plants to be relatively long-lived with size generally correlated with age. He also indicated that decadency may increase with age, but other factors, including browsing, may be more important. Mackie (unpublished data) found generally greater percentages of dead crown among browsed as compared to protected plants but differences were not significant ($P=.05$).

Annual Growth

Annual growth commenced with flowering in late April and early May in 1972, the approximate dates ranging from April 29 in the Missouri River Breaks to May 9 at Fort Howes (Figure 23). The first leaves appeared about 10 days after the first flowers in all stands. Most plants had completely leafed out by May 28. Twig growth generally began near mid-May varying from May 6 in the Missouri River Breaks to the 23rd of May in the Big Timber vicinity, progressed rapidly through late May and early June, and was essentially completed in all areas by mid-June. Fruiting generally began during the second week of June, after most leader growth was completed, with extreme dates of June 4 on the Bear-tooth Game Range and June 18 at Big Timber. The red or orange-red fruits matured in the Missouri River Breaks and elsewhere on some sites, mainly southeast exposures, by the end of June. Mature fruits were not observed in the Big Timber area until July 18. Thereafter skunkbush plants remained in a relatively static green condition, with only some leaf drying on the hottest, driest sites, until about the third week in September when photosynthesis ceased and the leaves turned a brilliant scarlet or orange color.

The onset, as well as, the rate and duration of growth of skunkbush plants among the various stands and study areas appeared to be strongly influenced both by overall weather conditions prior to and during the growth period and by local microclimates as influenced by elevation,

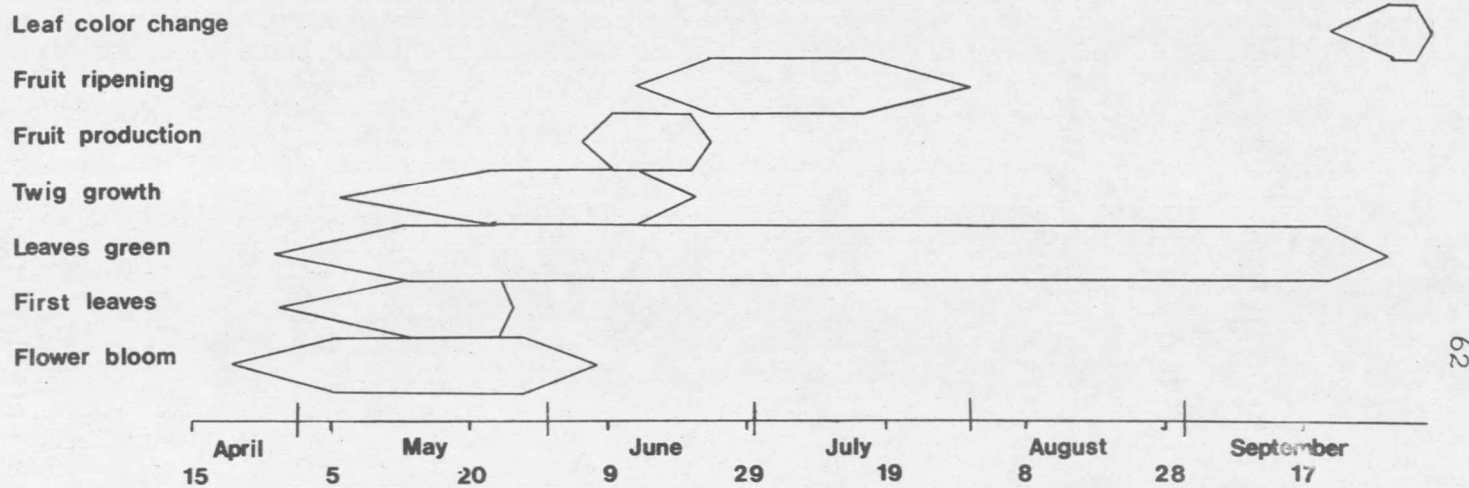


Figure 23. Chronological phasic development and growth of skunkbush in eastern Montana (1972) as determined by six direct observations of 25 stands and continuous general observations.

slope and exposure. The chronology of plant growth (Figure 23) in the spring of 1972 was more than two weeks ahead of that listed by Sanford (1970) for skunkbush in western North Dakota where leader growth began in late May, was 45 percent complete by June 3 and reached maximum length by July 9. This suggested that my findings may represent unusually early growth, possibly influenced by abnormally high temperatures in all areas during February and March 1972 (Figure 19). Blaisdell (1958) found early phasic development and growth of native plants on the upper Snake River in Idaho caused mainly by high temperatures. Plants in stands on steep southeast facing slopes at low elevations were the first to flower, develop leaves and show leader growth while those at highest elevations were the last to begin growth. These sites were also representative of the extremes in frost-free periods within which skunkbush occurs.

Characteristics of leader growth among skunkbush plants on the five study areas are shown in Figures 24 and 25. Although these data indicate somewhat higher growth rates for plants in the Fort Howes and Madison River areas, as compared with other locations, the difference may not be real because of different times of measurement in relation to duration of growth. If earlier or more continuous measurements had been made on plants in the Missouri Breaks, Beartooth and Big Timber areas, where growth had apparently ceased some time prior to measurement in early June, it seems likely that growth rate curves might have been similar for all areas.

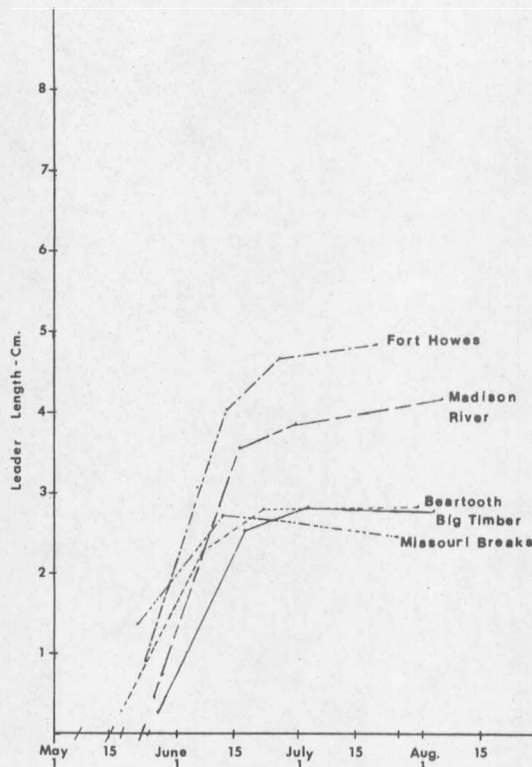


Figure 24. Growth curves of the five major study areas, Fort Howes, Missouri River, Beartooth Game Range, Big Timber and Madison River, as determined by the mean length of 400 twigs per area at three measurements from mid-May through June and one near the end of July 1972.

Although a few twigs continued to grow until the end of June in some areas and into July in one stand along the Madison River, most had completed growth by the end of the second week of June. Mean twig lengths from successive measurements at approximately two week intervals in all stands were significantly ($P=.005$) different only between the first two measurements in all areas. Differences between mean lengths at second, third and fourth measurement were not significant in any area.

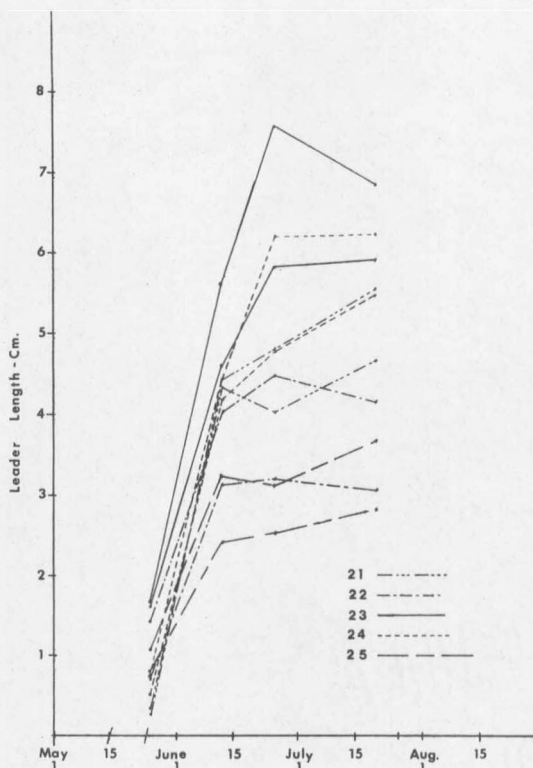


Figure 25. Growth curves of two plants per stand on the five major study areas as determined by mean length of 40 twigs per plant at four measurements in 1972. a. Fort Howes area—stands 21 to 25.

Sanford (1970) reported some skunkbush branches losing up to 20 percent of their original growth between June 26 and July 31, 1968. I found a reduction in the length of twigs only in the Missouri Breaks area amounting to 10 percent from June 11 to July 24, 1972 (Figures 24 and 25b). This retrogression may have been caused by desiccation as a result of above average temperatures during the second half of June (Figure 19b).

Twig growth varied considerably on and among the study areas, apparently in relation to local site characteristics and conditions.

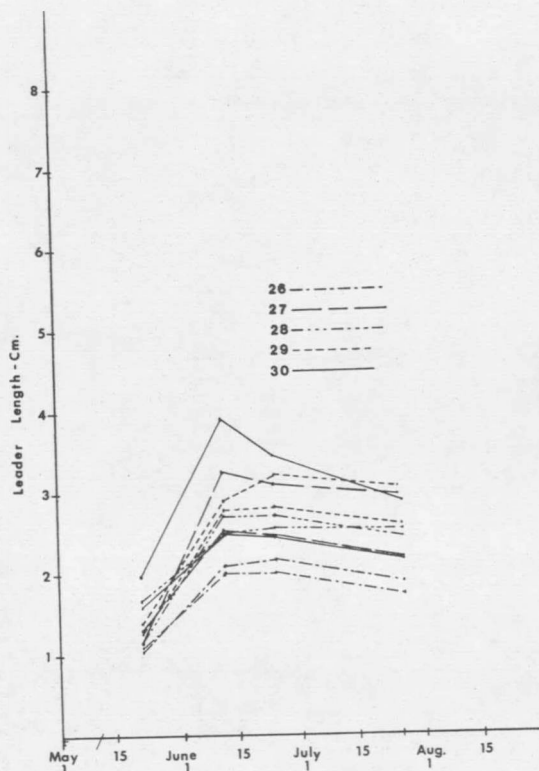


Figure 25. (continued) b. Missouri Breaks area—stands 26 to 30.

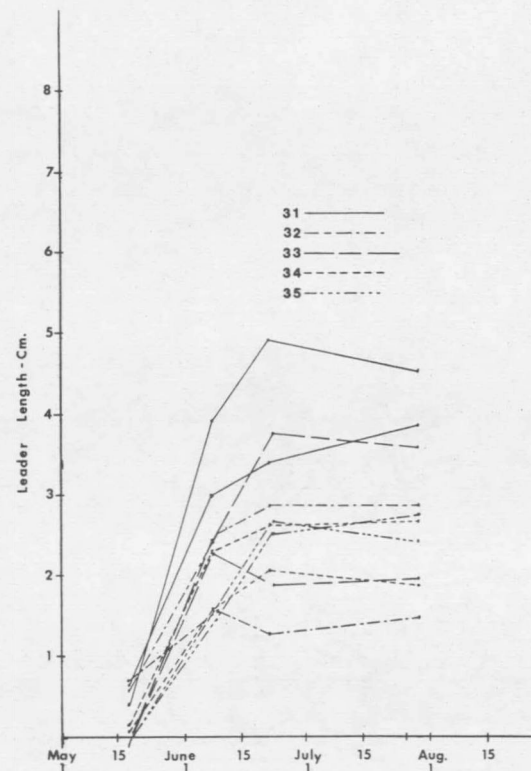


Figure 25. (continued) c. Beartooth Game Range area—stands 31 to 35.

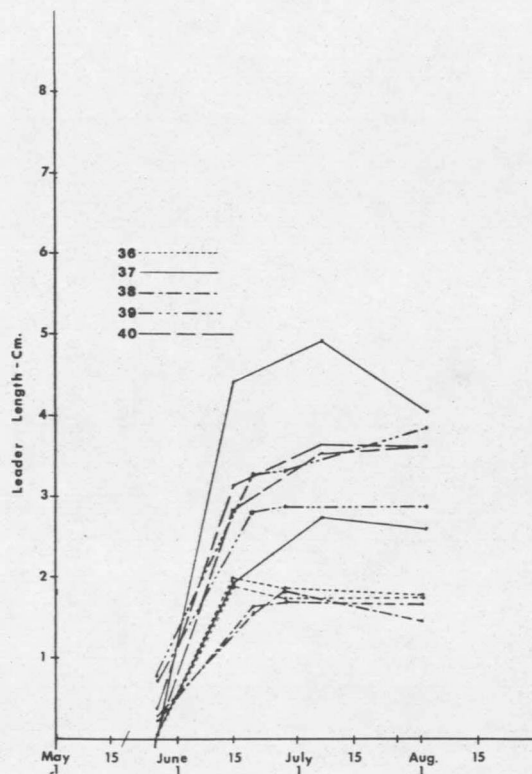


Figure 25. (continued) d. Big Timber area—stands 36 to 40.

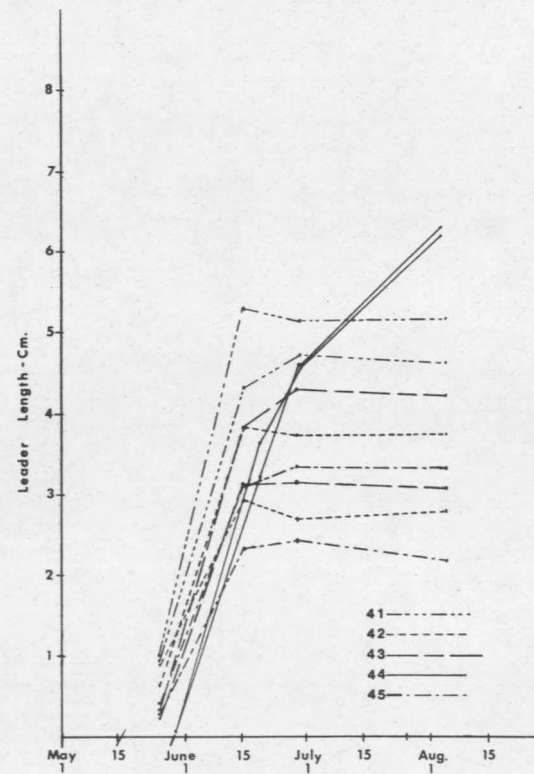


Figure 25. (continued) e. Madison River area—stands 41 to 45.

Comparisons of mean twig length between the stands of each study area showed that plants in stand 23 at Fort Howes produced significantly ($P=.01$) longer twigs than those in stand 25 (Figure 25b). In the Big Timber area, plants in stand 40 produced significantly longer twigs than those in stands 36 and 38. Plants in stand 37 also produced twigs significantly longer than those on stand 38 (Figure 25d). Along the Madison River, significantly longer twigs occurred in stand 41 as compared with stand 45 (Figure 25e). In each of these cases, as well as generally, the longest twigs were produced in stands on sites that were open, dominated by skunkbush, south and east facing, and/or at lower elevations with relatively long growing seasons. The shortest twigs were produced on diametrically opposed sites—relatively mesic north or, occasionally, west exposures, dominated by ponderosa pine and/or Rocky Mountain juniper, or at relatively high elevations.

The Fort Howes and Madison River areas had significantly longer ($P=.01$) mean twig lengths than the other three areas (Table 11). These differences may be at least partially related to weather conditions during the spring and early summer. Precipitation prior to the growing season, by assuring adequate soil moisture during the period of active growth, appears to be the dominant climatic condition affecting twig growth (Blaisdell 1958). Fort Howes was the only area with above average precipitation in May (Figure 19a). Although the Madison River area received less than normal rainfall in May, skunkbush sites may have

TABLE 11. LONGEST MEAN TWIG LENGTH FOR FIVE MAJOR STUDY AREAS WITH ESTIMATED VARIANCE, DEGREES OF FREEDOM AND SIGNIFICANT DIFFERENCES.

Area	Mean Length (centimeters)	Estimated <u>1</u> / Variance	Degrees of Freedom
Fort Howes	5.01*	.201	9
Missouri Breaks	2.79	.033	9
Beartooth Game Range	2.92	.102	9
Big Timber	2.91	.118	9
Madison River	4.21*	.194	9

1/ Statistical analysis of independent samples with unequal variances prepared by Dr. Martin A. Hamilton, Montana State University.

* Significantly different from others at $P=.01$.

obtained needed moisture from ground water because of their relatively close proximity to the river. Blaisdell (1958) also found that highest plant yields were associated with cool growing seasons. This phenomenon may explain why plants in Missouri River Breaks, which had the longest growing season (Figure 18), had the shortest mean twig length. It was the only area with above average temperatures throughout the growing season (Figure 19b).

Browse Production

Skunkbush plants are extremely prolific producers of annual growth twigs. Production indices (Figure 26) indicates that an average of 1.34

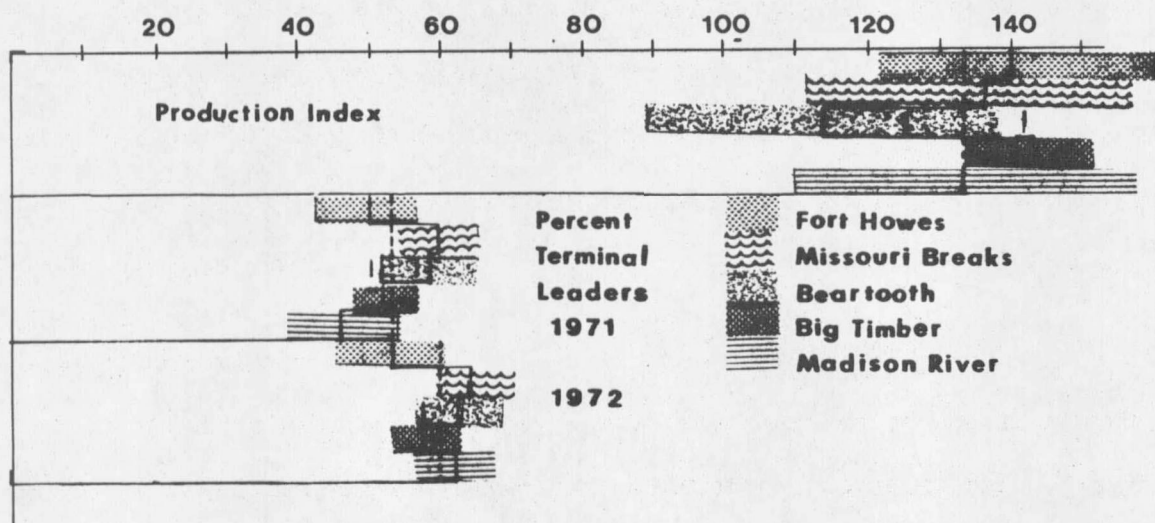


Figure 26. Percentages of "terminal" current annual growth twigs, 1971 and 1972, and production index, 1972, for major study areas along with 95 percent confidence intervals.

new "leaders" developed from each year-old twig with only slight variation between areas. The range was from 1.17 on the Beartooth Game Range to 1.42 at Big Timber. This was considerably lower than reported by Sanford (1970) who found annual branch increments ranging from 1.44 to 2.65 (mean 1.85) twigs for four plants over a nine-year period.

Although I did not attempt to measure total numbers of twigs produced by individual plants, the number of current annual growth twigs on a single branch often exceeded 100. Mackie (unpublished data) found an average of more than 2,200 twigs per plant among 20 skunkbush plants collected equally from two exclosures and adjacent transect sites in westcentral and southcentral Montana during September 1971. This represented an average of more than 540 twigs/m² of live crown. One plant, 35.5 decimeters in diameter and 8.0 decimeters high, produced 7,197 twigs, nearly 1,000 twigs/m² live crown. Nearly 60 percent of the twigs were at least 1 inch (2.5 cm) long. His data also showed that skunkbush greatly exceeded three other important browse species including antelope bitterbrush, curl-leaf mountain mahogany, and western serviceberry (Amelanchier alnifolia) in mean numbers of twigs produced per plant and all but mahogany in production per unit crown area (Table 12). Both total numbers of twigs and numbers of twigs greater than one inch in length were very high correlated with crown area, the linear correlation coefficients ranging from .90 to .99 for the two areas and for plants inside and outside the exclosures.

TABLE 12. CURRENT ANNUAL GROWTH TWIG PRODUCTION OF FOUR MAJOR BROWSE SPECIES;
SKUNKBUSH SUMAC, ANTELOPE BITTERBRUSH, CURL-LEAF MOUNTAIN MAHOGANY AND
WESTERN SERVICEBERRY.

Species	Number of Plants	Mean CAGT <u>1/</u> Per Plant	Mean CAGT Per M ² CCA <u>2/</u>	Percent CAGT Greater than 1 Inch
Skunkbush	20	2,262	575	60
Antelope bitterbrush	50	400	329	79
Curl-leaf mountain mahogany	20	198	743	74
Western service- berry	30	29	127	49

1/ CAGT=current annual growth twig.

2/ M²CCA=square meter of corrected crown area.

3/ Data gathered by Dr. Richard J. Mackie, Montana State University, from plants collected equally from exclosures and nearby browse utilization and condition trend transects.

Reproductive Characteristics and Relationships

My observations and data generally substantiated the findings of Sanford (1970) that skunkbush only rarely reproduces from seed, but relies heavily on resprouting from an extensive underground root system to perpetuate itself. Among stands examined, I found only one plant, about 10 years old which appeared to have originated from seed. Lonner (1972) reported that only 4 (8.3 percent) of 48 transect locations (stands) in eastern Montana had plants less than 5 years old, and the youngest plants at more than 60 percent of the sites were 15 years old or older.

Sanford (1970) attributed the scarcity of seedlings in skunkbush stands in western North Dakota to low seed production and high seedlings mortality. Seed production also seemed to be extremely low among plants observed during this study (Figure 27). More than half (mean 57.6 percent) did not produce seeds in each of the two years, and flower to fruit success was generally quite low in 1972 (Figure 28).

There was some evidence to suggest that the low percentage of plants producing seed may be attributable to skunkbush being dioecious, though the literature is not clear on this point. A total of 384 (77 percent) of the 500 plants observed during 1971 and 1972 either had or did not have seeds both years (Figure 29). Those which produced no seed either year, possibly male plants, comprised 45.6 percent of the total, while those which produced seeds in at least one year, the female

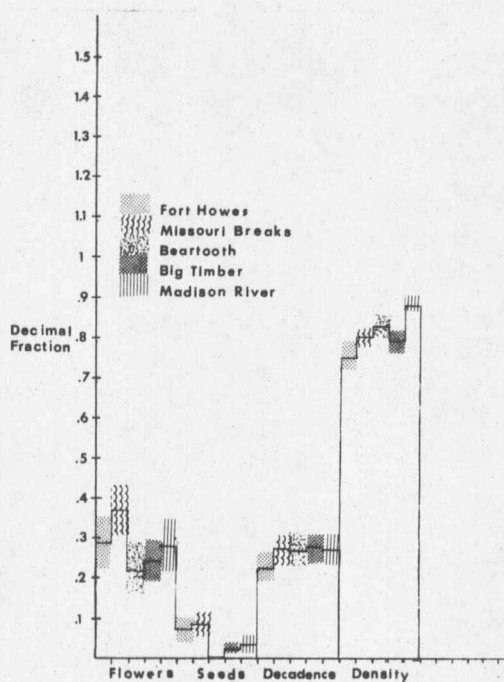


Figure 27. Percentages of twigs with flowers and seeds (including mature fruits), percentages of crown area comprised of dead material and percent density for major study areas in 1972 along with 95 percent confidence intervals.

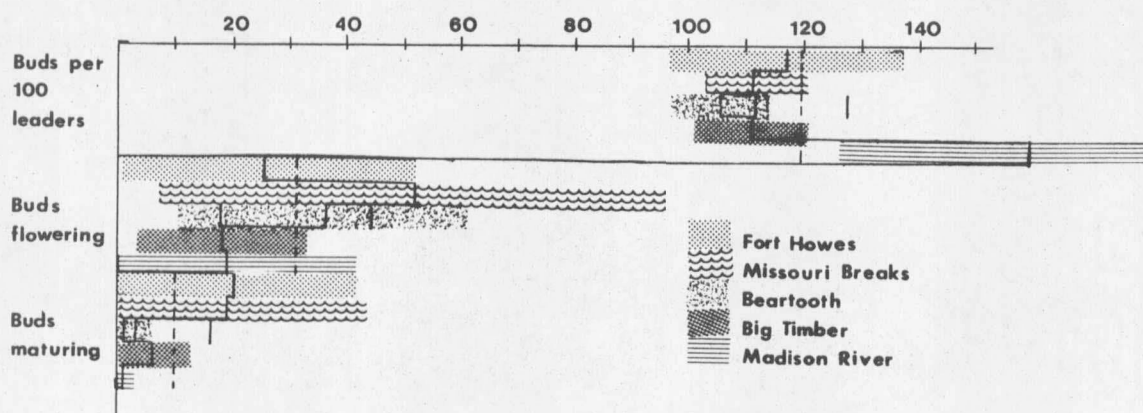


Figure 28. Flower buds per twig, percentage of buds, flowering, and percentage of buds producing mature fruits and/or seeds on major study areas in 1972 along with 95 percent confidence intervals.

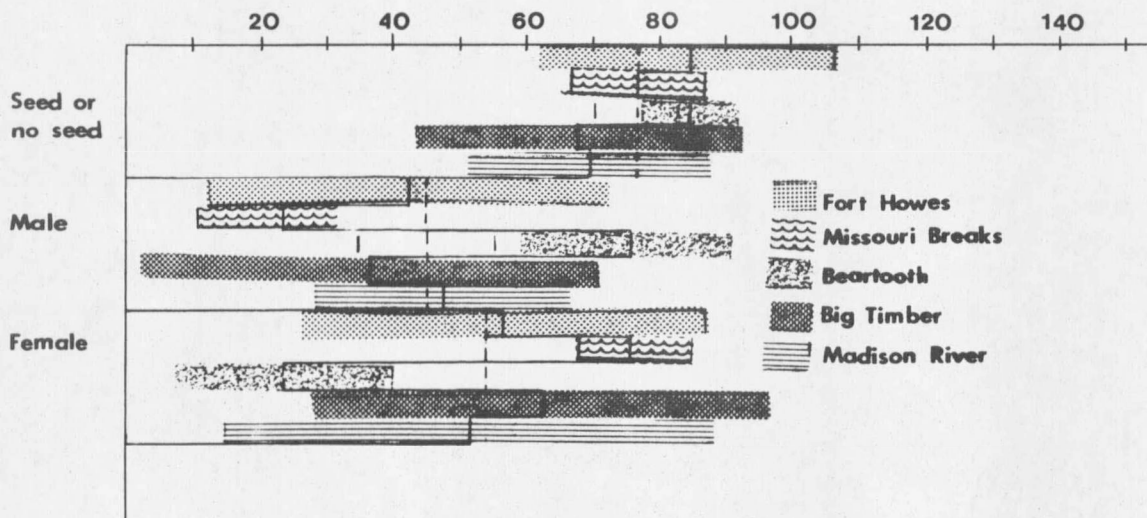


Figure 29. Percentage of skunkbush plants on major study areas producing no seeds in 1971 and 1971 (male plants), percentage producing seeds in at least one year (female plants) and percentage which either produced seeds or produced no seeds both years along with 95 percent confidence intervals.

plants, comprised 54.6 percent.

An average of 12 buds formed per leader on skunkbush plants in the summer of 1971 (Figure 28). Only 31.3 percent and 10.2 percent, respectively, blossomed and produced mature fruit or seeds in the spring and summer of 1972. These values differed significantly ($P=.05$). The 19.2 percent of inflorescences producing seed was within the range of the 2.2 to 27.4 percent flower to fruit success reported by Sanford (1970) for skunkbush branches 4 and 10 years old, respectively; however, the actual

flower to fruit ratio may have been lower as many inflorescences produced only one seed.

The percentage of leaders bearing flowers in 1972 (Figure 27) was significantly ($P=.05$) higher than the percent bearing fruits in all areas. The percentages of flowers producing seeds (Figure 30) were significantly higher in the Missouri Breaks and at Fort Howes than in the Beartooth and Big Timber areas. These differences may reflect the

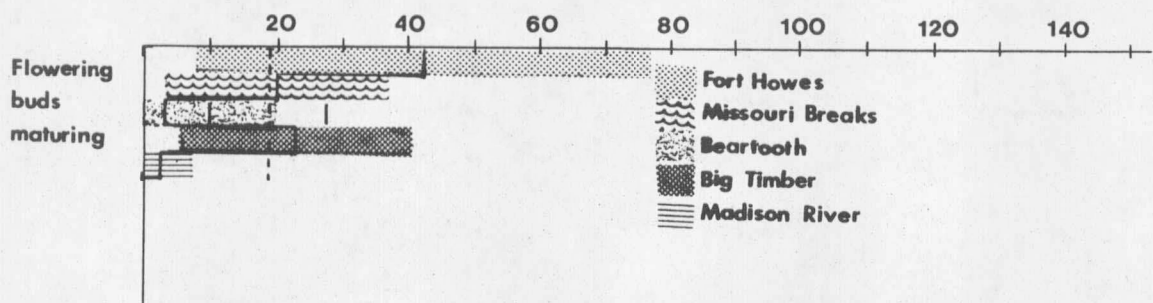


Figure 30. Percentage of buds flowering which produced mature fruits and/or seeds on major study areas along with 95 percent confidence intervals.

effect of soil characteristics. Soils in the Fort Howes area rated very low in phosphorus and medium in potassium content, with both values among the lowest for the study areas; but the pH was relatively high at 8.24 (Table 2). Those of the Missouri Breaks rated low in phosphorus content and high in potassium, with both values the highest among the five areas, while the pH was relatively low at 7.00. Both combinations would seem to provide more favorable soil conditions for plant reproduction (Buckman and Brady 1960) than existed in other areas. The two areas of lowest seed production had soils very low in phosphorus, high in potassium and with mildly alkaline pH values; a combination generally unfavorable to reproduction.

Although the number of resprouts per plant varied from 2.4 at Fort Howes to 10.3 along the Madison River (Figure 31), extremely large individual plant variances negated any statistical significance. However, the variation itself reveals the ability of skunkbush to vegetatively maintain itself. Undisturbed plants seemed to have generally few resprouts while those subjected to some stress, e.g., browsing, trampling, or burning, produced many resprouts. All the branches of one plant on the Wall Creek Game Range (stand 44) died during the winter of 1971-1972, possibly due to extensive girdling by small mammals. By the end of July 1972, the underground portion of that plant had produced more than 50 resprouts, all over 100 centimeters in length.

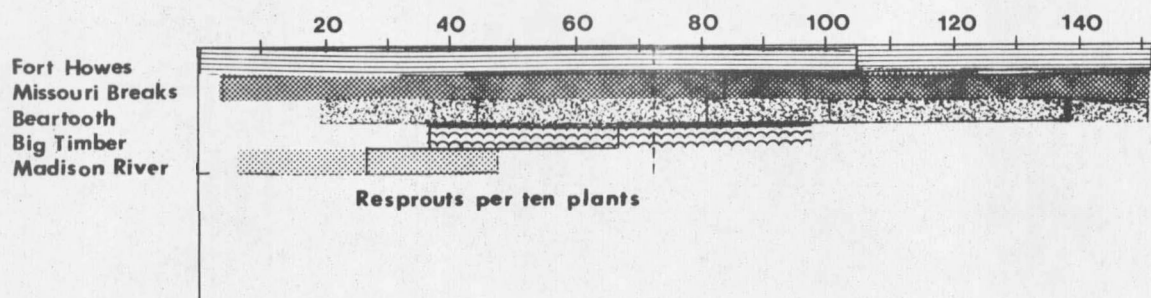


Figure 31. Number of resprouts (X10) per plant in 1972 on major study areas along with 95 percent confidence intervals.

Browse Utilization Characteristics and Relationships

Numerous studies of the food habits of ungulates on rangelands in eastern and southwestern Montana indicate that skunkbush is primarily important as a forage plant only to mule deer. The only reports of use by other species are those of Mackie (1970), who found minor use of skunkbush by elk and cattle throughout the year, and Mackie (1966) who found skunkbush among the rumen contents of a domestic sheep in the same area during summer.

Utilization of skunkbush by mule deer is highly variable between range areas as well as between years on any one area. Two general patterns of use are apparent. In most of eastern Montana, the species is important mainly as summer and fall forage with relatively little or no use during winter (Trueblood 1960, Mackie 1970, Dusek 1971, Eustace 1971a, and Knapp 1972). On foothill ranges in west and southcentral Montana,

use occurs primarily in winter with little or no use during the summer months. Mean percentages of annual growth twigs utilized by late fall were significantly higher ($P=.05$) at Fort Howes and in the Missouri Breaks, both in eastern Montana, than those of other areas (Table 13, Figure 32). Spring utilization estimates were significantly higher ($P=.10$) than fall measurements on the Beartooth Game Range and in the Big Timber area. Although total utilization varied considerably among the five areas, from 3.4 percent on the Beartooth area to 27.0 percent in the Missouri River Breaks, the differences were not significant. All of the recorded use of skunkbush in the Madison area occurred in one stand on the Wall Creek Game Range, a wintering area for mule deer and elk. This stand received the heaviest use (60 percent) of any area, while other stands in the Madison received little or no use at any time.

Seasonal differences in use of skunkbush by mule deer in eastern Montana as compared to the other areas appeared to reflect seasonal distributions of the deer, seasonal changes in nutritional characteristics and forage values of skunkbush, and the relative availability of other, more preferred or higher quality forage plants.

Deer on the eastern Montana ranges were nonmigratory and yearlong residents of these areas. Eustace (1971b), in a comparative study of the nutritional characteristics of five important mule deer browse species in the Garfield (Missouri Breaks) and Rosebud Counties, Montana, found skunkbush to be an excellent summer forage but of only marginal

TABLE 13. PERCENTAGES OF BROWSE UTILIZATION FOR MAJOR STUDY AREAS DETERMINED BY ACTUAL COUNT AND BY OCULAR ESTIMATE DURING FALL (1971) AND SPRING (1972) STATISTICALLY COMPARED BY ONE WAY ANALYSES OF VARIANCE.

Area	Fall		Spring	
	Count	Estimate	Count	Estimate
Fort Howes	3.5	9.4+	3.6	7.8
Missouri Breaks	16.0	29.4+	14.7	27.0
Beartooth Game Range	0	0.2	1.1	3.4*
Big Timber	1.0	1.7	11.9	23.2*
Madison River	-	0.3	0	12.2

+ Estimates significantly different between areas, $P=.01$.

* Estimates significantly different at different times within areas, $P=.10$.

quality during the fall and relatively poor in winter. Protein levels were high in summer, 12.4 percent and 11.0 percent for the two counties, respectively, but dropped to about 6 percent or less in fall and winter. Fats and NFE were also highest during summer and fall while crude fiber was relatively low. Calcium:phosphorus ratios were within the desirable range during summer but developed a wide spread during fall and winter. Other browse species including rabbitbrush, silver sagebrush and big sagebrush, which characteristically are important in the diets of mule deer during fall and/or winter, maintained high nutritional qualities during those periods.

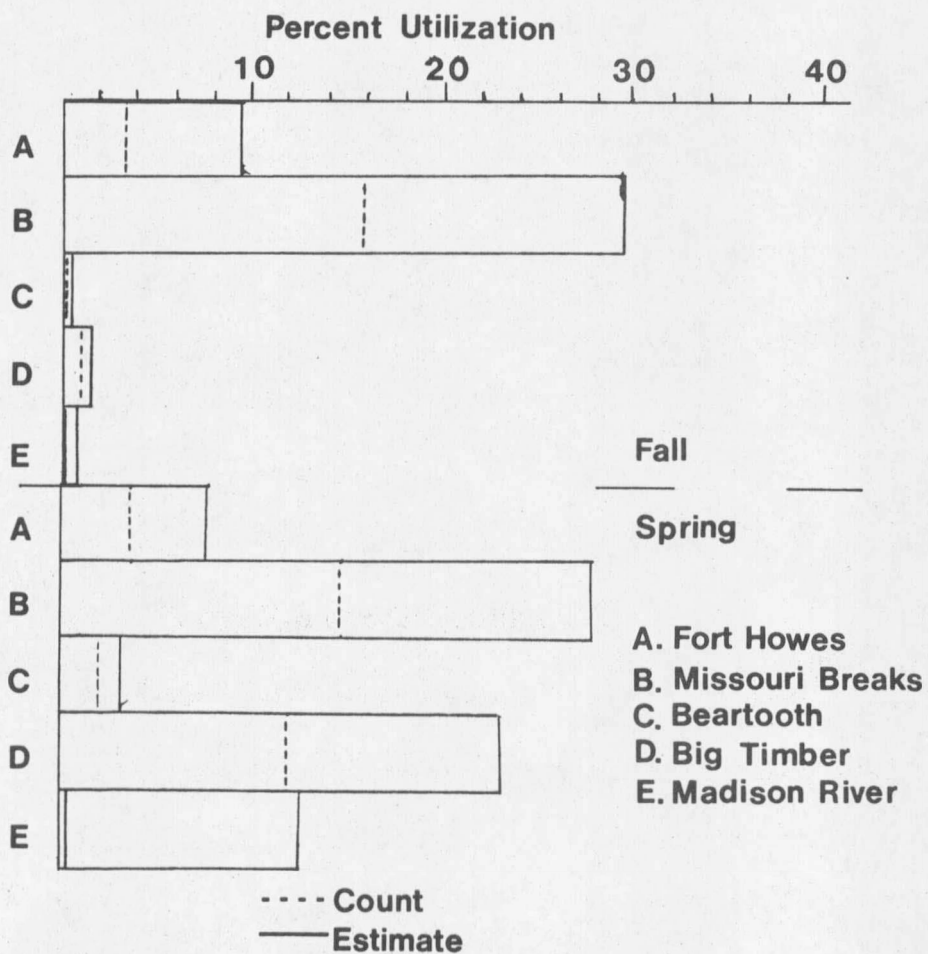


Figure 32. Utilization (percentage of twigs eaten) of skunkbush plants by mule deer in fall (1971) and spring (1972) on major study areas determined by ocular estimation and actual counts.

Skunkbush stands on foothill ranges in the western and southern portions of the state east of the Continental Divide were utilized primarily by migratory mule deer moving onto these areas as winter snows and weather conditions force them down from higher elevations. Where total forage supplies, especially of higher quality or more preferred plants are limited, as they frequently are relative to numbers of animals on these ranges, the deer may be forced to utilize skunkbush as a winter food source. Stands along the lower Madison River generally included bitterbrush, mountain mahogany, and serviceberry in relative abundance (Table 4), plants which characteristically are important in the fall and winter diets of mule deer in western and southwestern Montana.

The general similarity in twig production indices for the five study areas combined with broad difference in utilization between areas suggested that browsing had only minimal if any influence on the numbers of annual growth twigs produced by skunkbush plants, at least at utilization levels experienced in this study.

Trends in skunkbush utilization on Fish and Game Department transects on or near the four major study areas where these sample units have been established are shown in Table 14. Considerable variation between years is evident for all areas, as well as a general decline in percentages of twigs used annually on transects in the Fort Howes and Missouri Breaks areas. The annual fluctuations and to some extent the

TABLE 14. AVERAGE SKUNKBUSH UTILIZATION PERCENTAGES ON FISH AND GAME TRANSECTS IN OR NEAR THE FIVE MAJOR AREAS FROM 1960 TO 1971. ^{2/}

Year	Fort Howes (8) ^{1/}	Missouri Breaks (12)	Beartooth Game Range (1)	Big Timber (8)	Madison River
1960	-	72	53	-	-
1961	42	72	3	-	-
1962	57	73	24	29	-
1963	32	39	43	43	-
1964	52	58	58	-	-
1965	36	27	30	33	-
1966	23	52	3	23	-
1967	21	30	47	42	-
1968	15	20	47	27	-
1969	26	20	27	27	-
1970	-	21	-	41	-
1971	20	21	-	36	-

^{1/} Number of transects used near each area of which at least three different transects were read each year.

^{2/} All data from files of the Montana Fish and Game Department Research Section, Bozeman, Montana.

general decline in use of skunkbush in eastern Montana may have been influenced by the relative availability of other, more preferred, forage plants and supplies, especially during summer and fall. Eustace (1971b) found an inverse correlation between utilization on browse plants, mainly skunkbush, and spring rainfall and a direct correlation between rainfall and fawn production in southeastern Montana for the years 1957-1970 and 1960-1970, respectively. He concluded that increasing spring precipitation led to increasing growth and utilization of forbs and grasses, which provided a higher nutritional plane, and ultimately resulted in greater fawn survival. Similarly, Mackie (1970) found that intensities of browsing, including use of skunkbush, varied inversely with availability and use of forbs in the Missouri Breaks from 1960 to 1964. Extreme drought conditions prevailed in much of southeastern Montana from 1959 through 1961 (Eustace 1971b) and in the Missouri Breaks from the early spring of 1960 through April 1962 (Mackie 1972), the years when utilization levels were generally highest for skunkbush. Normal or above average precipitation has generally prevailed in these areas since the summer of 1962. During the hot, dry summer of 1971 in the Missouri Breaks (Figure 19b), some skunkbush plants had 25 to 50 percent usage of annual growth twigs by July 21; while no plants had received as much as 25 percent use by August 26 of 1972, a relatively cool and wet summer when forbs were available and persisted in abundance. Mackie (1970) reported similar patterns of use of skunkbush during the

dry and wet summers of 1961 and 1962, respectively. The early intensive summer use in 1961 was reflected in high mean utilization on transects by the spring of 1962, whereas utilization recorded in the spring of 1963 was relatively light. Annual variations in skunkbush utilization on the Beartooth and Big Timber areas apparently reflected the relative severity of winter conditions and snow depths in adjacent mountains and/or on these winter ranges.

Comparisons of "leader" use estimates with actual counts of current annual growth twigs browsed among plants on four different areas resulted in correlation coefficients of .94 ($t=11.3$) for the fall of 1971 and .93 ($t=10.7$) in the spring of 1972. If actual count estimates had been based only on leaders longer than one inch, the percentages would have been approximately equal.

APPENDIX

TABLE 15. EXPOSURE, SLOPE, ELEVATION AND DRAINAGE OF 25 SKUNK-BUSH STANDS IN MONTANA, EAST OF THE CONTINENTAL DIVIDE.

Area	Stand	Exposure		Slope	Elevation	Drainage
		Direction/Degrees				
(percent) (feet)						
<u>Fort Howes</u>						
	21	ENE	60	70	3480	South Fork Taylor Creek
	22	SSE	150	85	3580	South Fork Taylor Creek
	23	WSW	235	90	3980	O'Dell Creek
	24	WNW	280	60	3720	Branch Creek
	25	NNW	355	80	3450	Horse Creek
<u>Missouri Breaks</u>						
	26	WNW	280	60	2720	Sand Creek
	27	S	180	30	2990	Carrol Coulee
	28	ENE	70	80	2750	Missouri River
	29	NNE	10	70	2720	Sand Creek
	30	WSW	250	50	2750	Missouri River
<u>Beartooth Game Range</u>						
	31	ENE	60	50	3820	Willow Creek
	32	SSE	150	35	3720	Lower Cottonwood Creek
	33	SSW	210	60	5040	Upper Elkhorn Creek
	34	W	270	40	4210	Cottonwood Creek
	35	W	270	75	4700	Upper Cottonwood Creek
<u>Big Timber</u>						
	36	ESE	110	40	5550	Big Timber Creek
	37	SSE	160	80	5700	East Boulder River
	38	NNW	330	40	4400	Lower Deer Creek
	39	NNE	70	25	4280	Lower Deer Creek
	40	SSW	200	55	5180	Mission Creek
<u>Madison River</u>						
	41	ESE	110	75	4620	Madison River
	42	SSE	160	40	4600	Cherry Creek
	43	WSW	250	50	5130	Hot Springs Creek
	44	ESE	100	60	5680	Madison River
	45	WSW	230	45	5350	Hot Springs Creek

Table 16.

LOCATION OF 25 SKUNKBUSH STANDS BY QUARTER SECTION,
SECTION, TOWNSHIP AND RANGE.

Stands	Quarter Section	Section	Township	Range
<u>Fort Howes Area</u>				
21	NE	4	7S	46E
22	SW	7	7S	47E
23	NW	6	6S	45E
24	NW	1	6S	44E
25	NE	1	7S	45E
<u>Missouri Breaks Area</u>				
26	NE	24	21N	24E
27	SE	32	21N	26E
28	NW	15	21N	25E
29	SE	9	21N	24E
30	NW	15	21N	25E
<u>Beartooth Game Range Area</u>				
31	SW	6	13N	2W
32	SE	26	14N	3W
33	NE	36	14N	2W
34	NW	31	14N	2W
35	SW	15	14N	2W
<u>Big Timber Area</u>				
36	NE	13	3N	12E
37	NE	34	3S	12E
38	SW	11	1S	15E
39	SE	11	1S	15E
40	NW	21	2S	11E
<u>Madison River Area</u>				
41	SW	9	3S	1E
42	NW	36	2S	2E
43	SW	6	3S	1E
44	NE	23	9S	1W
45	NE	8	3S	1E

TABLE 17. LATITUDE, LONGITUDE AND ELEVATION OF U. S. DEPARTMENT OF COMMERCE WEATHER STATIONS NEAREST THE FIVE STUDY AREAS.

Area	Station	Latitude	Longitude	Elevation (feet)
Fort Howes	Birney 15N	45° 32"	106° 31"	4,121
Missouri Breaks	Roy 24 NE Mobridge	47° 37"	108° 42"	2,310
Beartooth Game Range	Holter Dam	47° 00"	112° 01"	3,487
Big Timber	Big Timber	45° 50"	109° 57"	4,100
Madison River	Norris-Madison PH	45° 29"	111° 38"	4,745

TABLE 18. TAXA WITH LESS THAN 0.5 PERCENT CANOPY COVERAGE AND 5 PERCENT FREQUENCY AS DETERMINED BY EXAMINATION OF 2 X 5 DECIMETER PLOTS ON EACH OF FIVE SKUNKBUSH STANDS PER AREA.

Taxa	Beartooth				
	Fort Howes	Missouri Breaks	Game Range	Big Timber	Madison River
GRASS AND GRASSLIKE PLANTS:					
<u>Carex filifolia</u>	X				X
<u>Danthonia unispicata</u>	X				
<u>Elymus cinereus</u>	X				
<u>Festuca scabrella</u>			X		
<u>Muhlenbergia cuspidata</u>		X			
<u>Phleum alpinum</u>				X	
<u>Phleum pratense</u>			X		
<u>Poa spp.</u>				X	
Unknown			X	X	
FORBS:					
<u>Artemesia campestris</u>				X	X
<u>Asclepias verticillata</u>	X	X	X		
<u>Astragalus miser</u>	X				
<u>Astragalus purshii</u>					X
<u>Astragalus striatus</u>				X	
<u>Balsamorhiza sagittata</u>	X		X		
<u>Calochortus nuttallii</u>	X			X	
<u>Cardus nutans</u>	X			X	
<u>Camelina microcarpa</u>			X		
<u>Cerastium arvense</u>				X	
<u>Chaenactis douglasii</u>	X	X		X	
<u>Commandra pallida</u>		X	X		
<u>Crepis acuminata</u>					X
<u>Cryptantha bradburia</u>	X			X	X
<u>Eriogonum multiceps</u>	X				
<u>Eriogonum ovalifolium</u>					X
<u>Euphorbia spatulata</u>					X
<u>Fragaria virginiana</u>	X		X		
<u>Gaillardia aristata</u>	X				
<u>Grindelia squarrosa</u>	X		X		
<u>Lactuca pulchella</u>		X			
<u>Lepidium densiflorum</u>					X
<u>Lithospermum incisum</u>					X
<u>Lithospermum ruderales</u>				X	
<u>Lomatium cous</u>				X	
<u>Lomatium macrocarpum</u>			X		

(continued)

APPENDIX 18. (continued)

Taxa	Howes	Missouri Breaks	Beartooth		
			Game Range	Big Timber	Madison River
<u>Microsteris gracilis</u>	X				
<u>Orthocarpus luteus</u>	X				
<u>Oxytropis bessevi</u>					X
<u>Oxytropis sericea</u>	X		X	X	X
<u>Oxytropis spp.</u>			X		
<u>Penstemon cyaneus</u>	X				
<u>Penstemon nitidiis</u>	X				
<u>Petalostemon candidus</u>			X		
<u>Petalostemon purpureum</u>	X		X	X	
<u>Phacelia leocophylla</u>				X	X
<u>Phlox alyssifolia</u>	X				
<u>Phlox hoodii</u>		X	X	X	
<u>Polygala alba</u>	X				
<u>Ratibida columnifera</u>	X		X		
<u>Sisymbrium altissimum</u>					X
<u>Smilacina stellata</u>	X				
<u>Solidago missouriensis</u>	X				
<u>Stephanomeria runcinata</u>		X	X	X	X
<u>Taraxicum officinale</u>	X				
<u>Thlaspi arvense</u>			X		
<u>Triodanis leptocarpa</u>					X
<u>Verbascum thapsus</u>					X
SHRUBS:					
<u>Artemisia cana</u>			X	X	
<u>Chrysothamnus nauseosus</u>	X				X
<u>Juniperus scopulorum</u>	X				
<u>Prunus virginiana</u>	X		X	X	X
<u>Ribes cereum</u>	X				

TABLE 19. SPECIES WHICH HAD THE HIGHEST CANOPY COVER, FREQUENCY OR IMPORTANCE VALUE ON AT LEAST ONE OF 25 SKUNKBUSH STANDS OR ONE OF 17 SKUNKBUSH DOMINANT STANDS.

Taxa	All Stands				Skunkbush Dominant Stands 1/			
	Importance Value				Importance Value			
	No.	%	No.	%	No.	%	No.	%
TREES AND TALL SHRUBS:								
<u>Rhus trilobata</u>	17	68*	2/		-	-		
<u>Juniperus scopulorum</u>	3	12			2	12		
<u>Pinus ponderosa</u>	2	8			2	12		
<u>Purshia tridentata</u>	2	8			-	-		
<u>Chrysothamnus nauseosus</u>	1	4			3	18		
<u>Artemesia tridentata</u>	-	-			3	18		
<u>Symphoricarpos albus</u>	-	-			2	12		
<u>Artemesia cana</u>	-	-			1	6		
<u>Chrysothamnus viscidiflorus</u>	-	-			1	6		
<u>Prunus virginiana</u>	-	-			1	6		
<u>Ribes cereum</u>	-	-			1	6		
<u>Rosa arkansana</u>	-	-			1	6		
LOW SHRUBS:								
	Frequency		Canopy Cover		Frequency		Canopy Cover	
<u>Symphoricarpos albus</u>	10.5	42*	10	40	7	41+	6	35+
<u>Rosa arkansana</u>	4	16*	3	12	25	85	2	12
<u>Artemesia cana</u>	1	4	1	4	1	6	1	6
<u>Physocarpus malvaceus</u>	1	4	1	4	-	-	-	-
<u>Rhus trilobata</u>	1	4	1	4	1	6	1	6
<u>Chrysothamnus nauseosus</u>	0.5	2	1	4	0.5	3	1	6
<u>Artemesia tridentata</u>	-	-	1	4	-	-	1	6
GRASS:								
<u>Agropyron spicatum</u>	9	36+	13	52*	6	35°	9	53*
<u>Bromus tectorum</u>	75	30*	6	24°	5	29°	4	23°
<u>Bromus japonicus</u>	4	16°	1	4	4	23°	1	6
<u>Agropyron smithii</u>	1	4	1	4	1	6	1	6
<u>Koeleria cristata</u>	1	4	1	4	-	-	1	6
<u>Oryzopsis hymenoides</u>	1	4	1	4	-	-	-	-
<u>Poa pratensis</u>	1	4	1	4	1	6	1	6
<u>Festuca idahoensis</u>	0.5	2	1	4	-	-	-	-

(continued)

TABLE 19. (continued)

- 1/ Includes only those stands on which skunkbush had the highest importance values.
- 2/ Statistical differences determined by one way analysis of variance at significance levels ($P_{*} = .01$, $P_{+} = .05$ and $P_{o} = .10$).

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