Shepherdia canadensis: its Ecology, Distribution, and Utilization by the Grizzly Bear.

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March 4, 1985

Shepherdia canadensis (*L.*) *Nutt* is a berry producing woody shrub of wide distribution. Its common names include buffaloberry, Canadian buffaloberry, russet buffaloberry, soapberry, and soapolallie. It occurs throughout most of the range of the grizzly bear (*Ursus arctos*), including parts of Montana. It is frequently utilized by the bear as a key food source. Since *S. canadensis* has been little studied, this report has been undertaken to quantify the published data as well as report the findings of an experiment assessing *S. canadensis* density and relative productivity. This information can aid in grizzly-related management decisions pertaining to habitat improvement, forestry practices, erosion control, and land reclamation projects.

STUDY AREA

The study area occupies the extreme southeast corner of British Columbia (Figure 1). The Northfork of the Flathead River forms the west boundary. Middlepass Creek, a tributary to the Northfork, represents the northern border. The east boundary, another tributary of the Northfork, is formed by Elder Creek. The U.S.-Canadian border marks the southern boundary.

McClellan (1984) identifies the area as the Dry Engelmann Spruce-Subalpine Fir-Douglas-Fir zone, or the Dry Engelmann Spruce-Subalpine Fir-Whitebark Pine zone, within Krajina's Biogeoclimatic Classifications. According to Pfister et al. (1977), most of the area falls within the subalpine fir (*Abies lasiocarpa*) habitat types. Local habitat types include Engelmann spruce (*Picea engelmannii*) and Douglas-fir (*Pseudotsuga menziesii*). Lodgepole pine (*Pinus contorta*) is the dominate species in these dense coniferous forests. A severe infestation of mountain

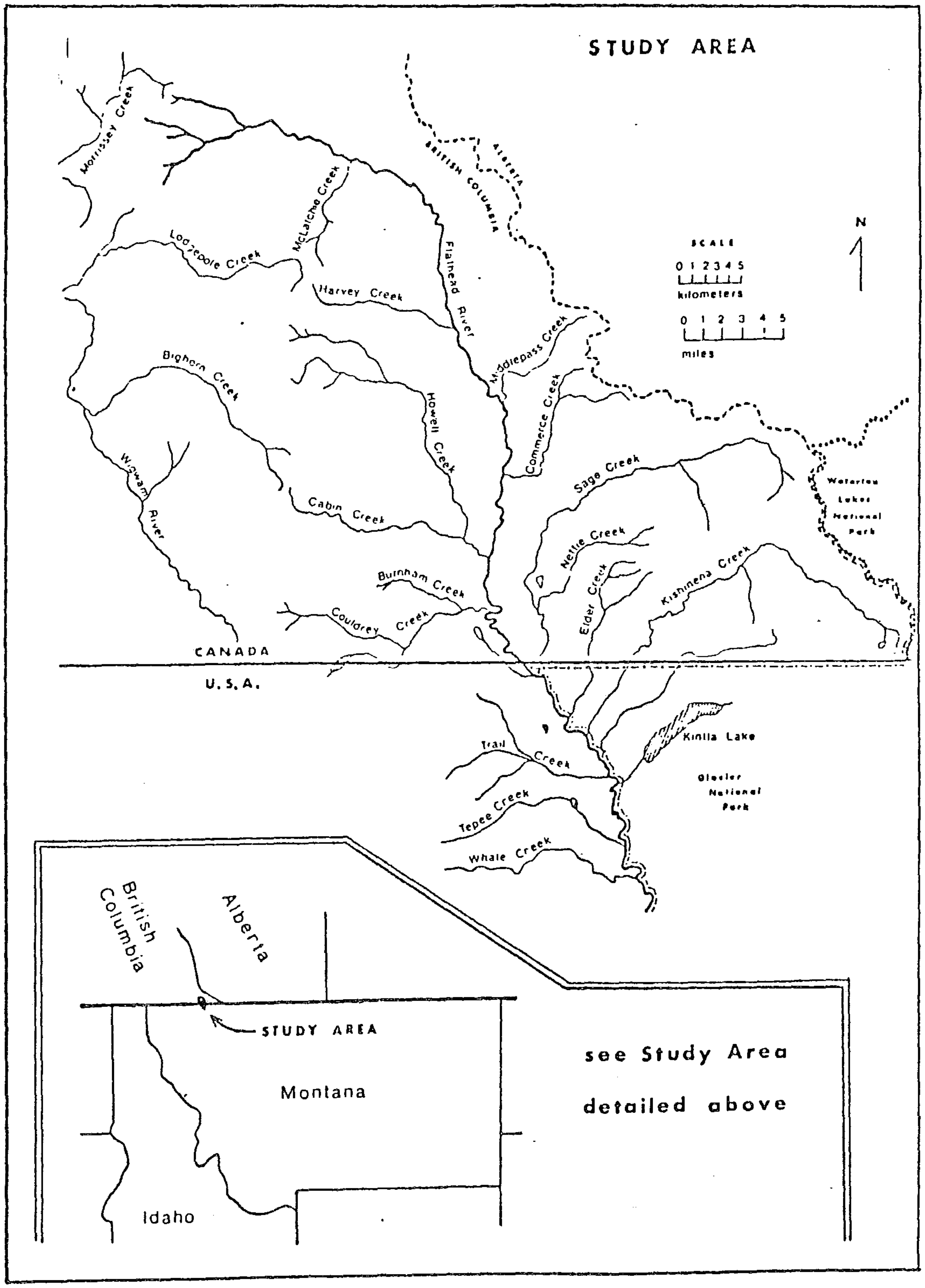

Fig. 1. Study area, adapted from McLellan 1984.

pine beetle (*Deudroctonus ponderosae*) has killed thousands of acres of *Pinus contorta* and continues to spread. Extensive clearcutting has resulted to salvage wood and control the potential for fire (Boyd 1982).

The region is under a maritime climate. Boyd (1982) reports snowfall occurring from September through May, with a mean annual snowfall of 123 in. (321 cm). Spring and autumn weather is usually cool with frequent rains, while summers are generally warm and dry.

Evidence of glaciation is apparent throughout the area, with U-shaped valleys, cirques, and jagged peaks being common (McClellan 1984).

DESCRIPTION

Shepherdia canadensis (*L*.) *Nutt* is a member of the family Elaeagnaceae. The *Shepherdia* genus is comprised of two other species, *S. argentea* and the rarer *S. rotundifolia*. *S. canadensis* is a small to medium shrub that grows 3-13 feet tall at maturity. The 2-3 in long leaves are opposite, entire, and deciduous. The leaves and young stems are covered with conspicuous brown scales. The small yellow flowers are born as axillary clusters. The entire genus is ~~dioceus~~ dioecious. It ranges from Alaska to Oregon, east to New Foundland, and down to New York. Its northern limits are within the Artic circle. In Alaska it is found along the north slope of the Brooks Range. It follows the Rocky Mountains south to New Mexico (Gardner and Bond 1957, Hitchcock and Conquist 1973, Lee and Pfister 1978, Thilenius 1974, Viereck and Little 1975).

S. canadensis is a non-leguminous, root-nodule bearing plant (Stewart 1967, Van Straten et al 1977). Nodulation is variable and appears to be most abundant in nutrient-poor, sandy soils. In soils with a humus layer, nodulation is reduced (Moore 1964). Nitrogen-fixation was recently discovered to occur through the symbiotic relationship with actinomycetes (Antibus 1984). Baker and Miller (1980) found evidence of this symbioses as early as the Pleistocene. They concluded S. canadensis and other nitrogen fixers played an important role in enriching the immature soils following the retreat of the glaciers. The Vaskon ice sheet retreated from southeast British Columbia in 13,000 BCE and pollen of S. canadensis has been dated there from about 12,000 BCE (Mathews 1973).

Across its range, S. canadensis flowers from April to June, and the fruits ripen June to August (Hitchcock and Cronquist 1973, Thilenius 1974). It is one of the earliest flowering plants in the Alaskan interior, blooming as soon as the snow melts in May (Viereck and Little 1972). Average phenological dates specific to Montana are presented in Table 1. The fruit, an achene with a fleshy perianth, contains a single nutlet (Hitchcock and Cronquist 1973, Viereck and Little 1972). The fruit is yellow to red and is very bitter tasting. Minimum seed bearing age is 4-6 years. Once mature it can produce good seed crops annually (Lee and Pfister 1978, Thilenius 1974).

The average ripe berry is 76.2% water and weighs 0.2g; dry weight equals 0.6486g (Pearson 1975). Carotenoids account for 0.97% of the dry weight (Kjøsen and Liaaen-Jensen 1969). The carotenoids provide a source of vitamins to the wildlife using the berries (Willard pers. comm.). Hamer et al. (1983) performed some nutrient analysis on S. canadensis while it was in the seed state (after flowering and before curing). The following represent percent chemical content:

Table 1. Phenological observations of *Shepherdia canadensis* in Montana, 1928-1937 (adapted from Schmidt and Lotan 1980).

Region		Leaf buds burst[a]	Leaves full grown[b]	Flowers start[c]	Flowers end[d]	Fruits ripe[e]	Leaves begin to fall[f]
S. canadensis east of the Continental Divide (and Yellowstone N.P.)	Ave. date	May 17	June 25	May 14	May 29	July 28	Sept. 10
	Range of dates	4/3-6/28	5/20-8/1	4/10-6/20	4/30-7/20	7/1-8/18	8/7-10/1
	Standard error	3	4	3	3	2	2
	Number of observations	35		33	33	26	29
S. canadensis west of the Continental Divide (and Northern Idaho)	Ave. date	May 19	June 14	May 15	June 3	July 9	Sept. 11
	Range of dates	5/8-6/3	6/2-6/30	5/1-5/28	5/26-6/11	7/7-7/12	8/7-10/5
	Standard error	6	4	7	5	1	8
	Number of observations	5	6	4	3	3	6

a. The date when bud scales open, leaves are visible but have not yet straightened out.
b. Leaves of plant have, on average, reached mature size (observer must know leaf size in advance).
c. When stamens and pistals are first exposed, or when anthers shed pollen.
d. When the majority of the flowers have faded or fallen.
e. Maturity of fruit indicates maturity of seed.
f. The date when a significant fall of leaves is noted, as differentiated from disease or injury.

	Protein	Ca	P	Nitrates
leaf	18.9	0.96	0.17	0.00
shoot	13.9	1.24	0.12	0.00
fruit	12.7	0.17	0.16	0.09

The presence of harmula alkaloids and tryptamines, both of which show psychotomimetic activity, have been identified in the roots (Ayer and Browne 1970). Lotan et al. (1978) states that S. canadensis is rhizomatous with relatively deep underground parts. It has also been reported to have fibrous, shallow roots (Van Dersal 1938) and to be "a species without rhizomes, but has a taproot" (McLean 1969). Lyon and Stickney (1976) reported it as "capable of resprouting from its rootcrown/ candex."

In propagation experiments in Alaskan (Holloway and Zasada 1980), stem cuttings did not sprout. However, 24% of the root cuttings immediately planted (in a greenhouse after fall collection) produced roots and shoots. None of the cuttings undergoing vernalization produced any sprouts.

Econmics

S. canadensis has, at best, a low forage value for cattle. It has limited to fair value for sheep (Lee and Pfister 1978, Van Dersal 1938, Willins et al. 1980). Sheep may make limited use of it before the frosts hit in Idaho and Montana (Lommasson et al. 1937).

Lommasson also claims S. canadensis provides good forage for deer (Odocoileus spp.) and wapiti (Cervus elaphus) in the Pacific Northwest. This may be an exaggeration, however, for other authors list limited or moderate use by mule deer (Odocoileus hemionus) and white-tailed deer

(O. virginianus) (Klebenow 1965, Lovaas 1958, Van Dersal 1938). Willins et al. (1980) reported mule deer fawns selected for S. canadensis during July and August. I have seen deer tracks leading to a number of S. canadensis bushes in January. It appeared the deer were seeking out successive patches. Despite snow being knocked off the shrubs, very little actual feeding appeared to take place. Other species identified as using S. canadensis for food includes several species of grouse, various passerines alpine chipmunks (Eutamias alpinus) and other rodents (McLellan pers comm, Van Dersal 1938).

Though of limited horticultural importance (Hitchcock and Cronquist 1973), it has been planted by wildlife managers for habitat improvement, and used in watershed management (Thilenius 1974).

Direct use by traditional cultures included both medicinal and culinary preparations. The Salish and Kootenai tribes boiled debarked branches and used the solution as an eyewash (Hart 1974). The Sioux would boil the roots, strain them through cloth, and use the tea to cure diarrhea (Oka 1955). The fruits were gathered and eaten fresh (Hart 1955) or dried for winter use (Viereck and Little 1972). Variations included whipping the berries into a froth for a dessert, or used atop other foods like whipped cream (Hart 1974, Oka 1955). The indians of Alaska pressed the fruits into cakes, smoked, and then ate them (Viereck and Little 1972). One of the early European encounters with S. canadensis came from a fur trapping expedition in the 1820's. Hugh Glass was severely mauled after jumping a grizzly sow with two offspring. He was abandoned by the expedition and literally dragged himself 100 miles-surviving in part on buffaloberries (Craighead 1971).

A study in British Columbia (Tisdale and McLean 1957) determined S. canadensis to be indifferent to the particular canopy species and having a "ubiquitous distribution". Studies in Montana, Alaska, Alberta, and British Columbia have identified S. canadensis as either dominant or abundant in a total of at least 13 different community types. Dominant overstory species include: Abies lasiocarpa and Pinus ponderosa in Montana (Pfister et al. 1977, Zager 1980); Abies lasiocarpa, Picea glauca (white spruce), Psuedotsuga menzeseii, and Populus tremuloides (quaking aspen) in southern British Columbia (Tisdale and McLean 1957); Picea glauca, Pinus contorta, and Populus tremuloides in Alberta (LaRoi and Hnatiuk 1980, Moss 1953). Picea glauca in the Yukon (Pearson 1975); and Populus tremuloides in interior Alaska (Viereck and Little 1972, Viereck et al. 1983). It can be found along riparian zones (Gardner and Bond 1957, Jonkel 1982, Murie 1944) and valley bottoms (LaRoi and Hnatiuk 1980, Pearson 1975) where it forms dense thickets, dominating shrubfields (Pearson 1975, Van Straten et al. 1977) and steep slopes (Van Straten et al. 1977, Viereck et al. 1983) and at or above timberline (Porsild 1974).

S. canadensis has been described as mesophilic and occurring on (moist) north-slopes (Pfister et al. 1977, Thilenius 1937, Van Dersal 1938). S. canadensis has also been reported as dominating dry, rocky sites in the Mission and Rattlesnake Mountains of Montana (Servheen pers comm). It also dominates the most xerophytic communities in Banff and Jasper National Parks, Alberta (LaRoi and Hnatiuk 1980), and the driest site conditions for tree growth in interior Alaska (Viereck et al. 1983). S. canadensis can thrive in nutrient poor, sandy or gravelly soils (Baker and Miller 1980, Moore 1964, Viereck and Little 1972, Viereck et al. 1983). In tests of seedling survival, *S. canadensis* had survival rates of 42-100% over a variety of sand and clay regimes (Fedkenheuer et al. 1980). Interestingly, seedlings achieved higher results in unfertilized rather than fertilized replications.

Fire

Martin (1979) found that post-fire disturbance sites 25-60 years old increased berry production in huckleberries (*Vaccinium globulare* and *V. membranacea*). Fire may have a similar effect on *S. canadensis*. Moss (1953) described as locally abundant on *Pinus contorta* stands burned 25 years previously. Hamer et al. (1983) reported 100% of their grizzly feeding records on *S. canadensis* were from 47-92 year old fire regenerated stands of *Pinus contorta* and *Picea engelmannii*. This suggests fire improves berry production. Whether the improvement was nutritional or an increase in total production was not mentioned. Viereck and Little (1972) found *S. canadensis* locally common on old burns. Recurrent, low-intensity ground fires are closely linked to maintaining *S. canadensis* density and vigor in stands with *Pinus contorta* and *Populus tremuloides* overstories and dry upland meadows where *S. canadensis* dominates the shrub layer (Hamer et al. 1983, LaRoi and Hnatiuk 1980).

To address *S. canadensis* response to burning on sites less than 25 years old the physical parameters of the burn itself need to be addressed. In terms of shrub response, the severity of the burn on specific microsites needs to be examined (Miller and Stickney 1982). The quantity, condition, and distribution of fuel loads as well as the seasonality of the burn are strong determining factors of shrub survival (Miller 1977, Ryan pers comm, Stickney pers comm). Miller (1977) found a strong correlation between duff and soil moisture and rhizome survival in Vaccinium globulare (Globe huckleberries). Stickney (1980) stated S. canadensis was absent from previously occupied sites in western Montana nine years after fire. Zager (1980) reported a decline of S. canadensis on his northwestern Montana study area following disturbance. He speculated this related to its infrequent occurance before the burn. S. canadensis has also been described as being "relatively moderately resistant to fire" (McLean 1969). Gruell (1980) found it to be among the shrubs favored by fire in Pseudotsuga menziesii and Pinus contorta habitat types, as well as spruce-fir communities. Gruell did state (pers comm) that in the first 10 years there was an apparent reduction in S. canadensis, but that "in time" fire enhanced the shrub. When the smoke clears it, appears the length of time since burning is a critical factor in dampening the numerous effects that cloud S. canadensis fire ecology. As fire suppression culminates in closed-canopy, old growth forests (Zager 1980), burns can, in general, be expected to improve S. canadensis production. The benefits, however, may not be realized for at least 25 years.

Grizzly Use

S. canadensis berries are utilized throughout most of the grizzlies range (Table 2). In June they feed on dried berries from the previous season. Generally, feeding occurs upon berry ripening in late summer to early fall. This is a critical period of weight gain for the bears in preparation of winter den-up. This dramatic increase in weight is correlated to the seasonal increase in food quality and availability. In seasons of berry failures grizzlies turn to roots, greens, or other, less abundant berries. Under these conditions the animal does not amass

Table 2. Studies identifying Shepherdia canadensis as a key food item during late summer/early fall.

Source	Study area
Craighead and Sumner (1980)	Scapegoat wilderness, Montana
Hamer and Hererro (1983)[a]	Waterton N.P., Alberta
Hamer et al. (1983)	Banff N.P., Alberta
Husby and McMurray (1978)	Northwestern Montana
McLellan (1984)	Southeast British Columbia
Murie (1944)	Mount McKinley, Alaska
Pearson (1975)	Southwestern Yukon
Schallenberger and Jonkel (1980)	Rocky Mountain East Front, Montana
Servheen (1983)	Mission and Rattlesnake Mountains, Montana
Zager (1980)	Northwestern Montana

a) in Craighead, J.J. and J.A. Mitchell (1982) further weight gains (Craighead and Mitchell 1982, Hamer et al. 1983, Jonkel pers comm, Pearson 1975, Zager et al. 1980).

Bears generally select their favorite berry and then feed primarily on that species. Huckleberries (Vaccinium globulare and V. membranaceum) are key food items in parts of the grizzlies range, including Montana. Over most of their range, however, they utilize S. canadensis as a key food source during the critical late summer/early fall season (Hamer et al. 1983, Schallenberger and Jonkel 1980, Servheen 1981). Individual bears frequently have their "favorite" berry-patch when producing shrubs will be locally abundant. When in a productive area a bear may spend hours meandering from bush to bush in a seemingly random fashion. They sometimes appear very selective as to which berries are suitable. Conversely, they may settle before a bush, lifting individual branches and using their prehensile lips to feed (Murie 1944). Pearson (1975) observed a grizzly sprawled in the middle of a bush, stripping berries from the surrounding branches. After 10-15 minutes he leisurely moved into the center of another bush.

Grizzlies feed almost continually from early morning until late evening. Periodically through the day they may stop for short naps (Mace pers comm, McLellan pers comm). Pearson (1975) totaled the average number of berries in 24 feces and observed that over 10 feces were voided per day. He weighed the berries and calculated 6,205g of digestible S. canadensis matter was consumed per grizzly per day. This totaled over 202,000 berries per bear per day. He also noted that when a bear fed at a specific bush, many berries were knocked to the ground. Also, the bears never completely consumed all the berries on a single bush.

METHODS

Eight transects (Figure 2) of three plots each were sampled for a total of 24 different plots. Four of the transect locations were chosen because of known grizzly use, as determined by radio-telemetry. The remaining four locations were randomly chosen. This was largely determined by where I happened to be when I had time to conduct a transect. The plots, about 100m apart, were divided into four quadrats and sampled with the point-centered quarter method (Barbour et al. 1980). Measurements were taken from plot-center to the nearest S. canadensis bush, and also to the nearest berry-producing S. canadensis as this shrub can reproduce vegetatively, selecting "one bush" was occassionally a subjective decision. However, I tried to maintain consistent standards to minimize the bias.

The three most berry laden branches were selected at each producing shrub. Each berry was counted within a standard length of 12 in, as measured from the branch tip. Any side branches within this span were examined and included in the total.

The original intention of choosing the branches randomly was changed to a subjective choice due to the scarcity of berries on many of the sites. Several branches were recorded as having zero berries. This was not always the case. Instead, the branch may have simply produced berries below 12 in. from the branch tip. Although this selected against shrubs that were more productive lower in the bush, an overall relative ranking was still obtained.

The following physical parameters were recorded: canopy and S. canadensis coverage classes (using Pfister's et al.(1977) standards), aspect, percent slope, and elevation were all estimated based on 1/10-acre samples at

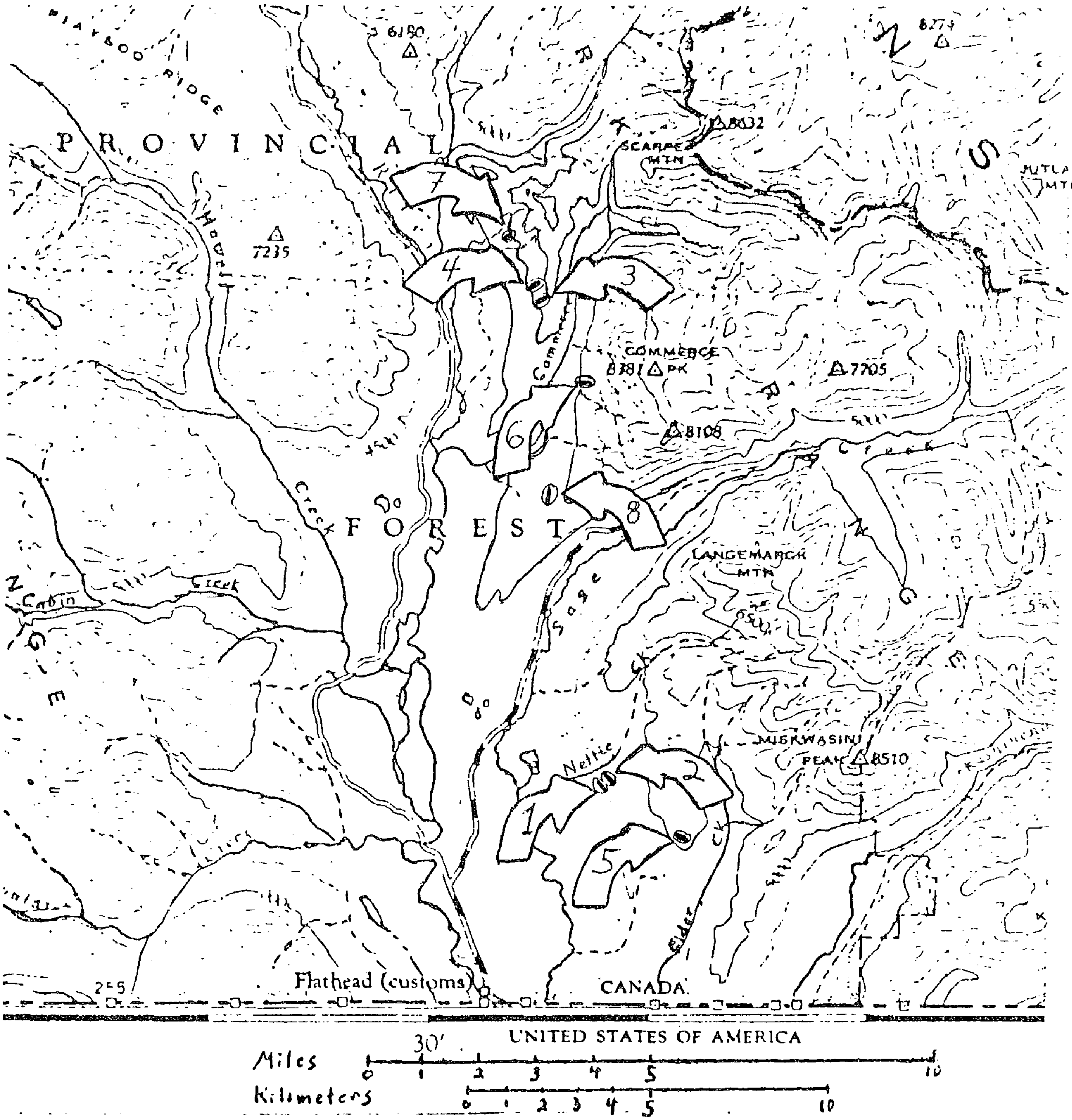

Fig. 2. Transect locations adapted from the National topographic system map series: Fernie 1:250000. Canada Dept of Energy, Mines, and Resources, Ottawa.

each plot center (Table 3). The present stand age was determined either with an increment borer or by consulting a Provincial Forest timber harvest map. Densities and confidence intervals were calculated according to Greig-Smith (1957).

The number of berries produced was determined for each transect (Table 4). A ranking of berries per acre was calculated by multiplying the average number of berries per transect times the average number of producing shrubs per acre. A relative production ranking was established by dividing the highest transect value into the other transect's berry values.

The following gives a brief description of the eight transects:

Transect 1 (T-1): Lower Nettie Creek; clearcut.

This site was cut 8-10 years ago and was broadcast burned with scattered *Larix occidentalis* left as seed trees. This location was essentially flat with only minor perturbations.

Transect 2 (T-2): Lower Nettie Creek; timber.

This paired stand to T-1 was doghair *Pinus contorta* with *Abies lasiocarpa* and *Picea engelmannii* regenerating. A 65-year-old *Larix occidentalis* was aged with an increment borer.

Transect 3 (T-3): Middlepass ridge; clearcut.

This area was winter-logged and broadcast burned 12 years ago. In late summer and early fall, both grizzly and blackbears congregate here to feed on the abundant *S. canadensis* berries. The entire ridge burned in 1928.

Transect 4 (T-4): Middlepass ridge; timber.

This transect was paired with T-3. Fire scars were evident on old *Larix occidentalis* snags and stumps. A 29-year-old *Picea engelmannii*

Table 3. Values of the plot variables measured along each transect*. Coverage classes according to Pfister (1977).

Transect	% Slope	Aspect (in degrees)	Canopy cover[a]	*S. canadensis* cover
T-1 Lower Nettie Cr. Clearcut	6,.6, 6	280,280,280	1,2,2	1,2,3
T-2 Lower Nettie Cr. Timber	6, 6, 6	280,280,280	4,5,5	2,2,2
T-3 Middlepass Ridge Clearcut	15,23,25	237,254,264	0,0,0	2,2,3
T-4 Middlepass Ridge Timber	14,24,38	228,256,257	3,3,4	T,2,3
T-5 86km Hilltop, Flathead Rd. Clearcut	8, 8, 8	180,180,180	T,T,T	1,1,1
T-6 Between 76 and 77km markers, Flathead Rd. Timber	13,20,24	262,270,286	3,4,4	3,3,3
T-7 Middlepass Ridge Burn	22,40,45	236,242,262	0,T,1	3,4,4
T-8 78km marker Flathead Rd. Clearcut	15,18;18	120,126,136	0,T,T,	2,2,2

*Note: Elevational measurements were not complete. However, all transects were between 4300-4400 ft.

Table 4. Shepherdia canadensis density and productivity values.

Transect	Bushes/acre	Berry producing bushes/acre	Average berries/bush	Average berries/acre	% of highest berries/acre values
T-1	41.13	12.24	11.67	142.84	0.46
T-2	117.55	7.84	22.50	176.40	0.57
T-3	181.96	73.57	112.50	8276.63	26.84
T-4	77.59	62.27	33.50	2186.55	7.09
T-5	59.82	3.53	3.38	11.93	0.04
T-6	692.69	112.84	10.25	1156.61	3.75
T-7	966.04	587.37	52.50	30836.93	100.00
T-8	887.50	14.81	20.50	303.61	0.98

and a 37-year-old Pinus contorta were aged.

Transect 5 (T-5): Hilltop north of the 86 km marker, Flathead road; seedtree cut.

This was the only management site dozerpiled, and it received no fire treatment. It also represents the oldest cut with a Pinus contorta aged at 54 years. S. canadensis was so low that in two of the quadrats none was encountered. In these instances, measurements were taken to the edge of the quadrat. The figures presented in Table 2 thus represent maximum density estimates for the transect. These two quadrats were omitted when the data were clumped and when the average number of berries was calculated.

Transect 6 (T-6): Between km markers 76 and 77, east of the Flathead road; timber.

This site is of known bear activity. One grizzly in particular was regularly located here during the berry season. A 44-year-old Pinus contorta and a 37-year-old Pseudotsuga menziesii were aged.

Transect 7 (T-7): Middlepass ridge; burn.

Approximately two miles north of T-3, this site burned in 1928. It had the largest percent slope (Table 3). A 17-year-old Pinus contorta was aged here.

Transect 8 (T-8): 0.5 miles east of 79.5 km, Flathead road; clearcut.

This broad, flat area was about 2 miles east of the Flathead river. This extensive clearcut was the largest observed (from both air and ground reconisssance). No fire treatment occurred on this 10 year old cut.

RESULTS

The average number of berries per acre is presented for each transect in Table 2. These values represent the relative numbers as defined by the sampling technique, not actual per acre estimates. T-7 had nearly four times the number of berries per acre (30,839.93) as the next most productive site. Conversely, T-5, the lowest value (11.93), and only 0.04% of T-7.

Transects 1 and 2 are a matched pair. T-1 was measured in a clearcut and T-2 in a representative timbered stand nearby. Both were relatively poor sites for S. canadensis production (T-1=142.84 and T-2=176.4 berries per acre). Transects 3 and 4 were another clearcut-forest matched pair. In this case the clearcut, T-3, had more than double the producing bushes per acre, and more than triple the amount of berries per bush. The total berries per acre was nearly quadruple that of T-4 (8,276.63/acre for T-3; 2186.55/acre for T-4).

DISCUSSION

A serious lack of data prohibits an indepth analysis of the results. However, examining the data can provide some observations - although not generalization. It is interesting to note that the four most productive transects are also the sites of known bear feeding activity. Two of these sites are forested (T-4 and T-6), one is clearcut (T-3), and one is burned (T-7). Three of these transects are along the Middlepass Ridge (T-3, T-4, and T-7). One element they have in common is the major fire of 1928. The fourth transect, T-6, is less than two miles from the ridge. It, like T-7, had numerous fire scarred snags, logs, and stumps. They appeared to be of similar size and condition as T-7, although the actual age of the burn is unknown, a 44-year-old Pinus contorta was aged at T-6. A 37-year-old Pinus contorta was aged at the timbered T-4 on Middlepass Ridge. If they burned in different fires the time since disturbance may be close enough to be similarly affecting production in all three sites. These four "productive" sites ranged from 1,156.61 (T-6) to 30,836.93 (T-7) berries per acre. The remaining four "unproductive" sites ranged from 11.93 (T-5) to 303.61 (T-8) berries per acre.

Statistically unfounded inferences are as follows: Aspect and elevation were similar for all eight transects. The two measured variables that differed the most were slope and canopy coverage. The four productive sites also had the largest percent slope. The most productive site was also the steepest site. The two most productive sites (T-3 and T-7) both had very low canopy coverage.

T-3 and T-4 were a matched pair. T-3 was winter-logged and subsequently broadcast burned. T-4 was in a neighboring timber stand. T-3 had more shrubs per acre, more producing shrubs per acre, and more berries per shrub. Zager et al. (1980) found S. canadensis decreased in unscarified clearcuts, but also stated that S. canadensis overall response to disturbance was unclear. An important factor here may be the winter logging, which presumably decreased the impact on the understory. The effects of canopy removal certainly deserves further investigation in regards to total berry production.

While T-7 had such a relatively exaggerated abundance of berries, T-5 was equally exaggerated in its lack of berries. As stated earlier, the estimate for berries per acre on T-5 is a maximum value based on 10 rather than 12 plots. T-5 was clearcut, dozer-piled, and received no fire treatment. Zager (1980) found a consistent decline in S. canadensis canopy coverage on clearcut, dozer-piled sites. He concluded that heavy scarification can destroy rhizomes and root crowns. It also exposes the mineral soil. This increases the colonization rates of r-selected species (Zager 1980). A developed grass/forb cover reduces woody seedling survival (Fedkenhuer et al. 1980) and in Vaccinium spp., reduces berry production (Martin 1979). Castrale (1982) also discovered an inverse relationship between grass and shrub cover after a disturbance, while investigating sagebrush control.

The other matched pair, T-1 and T-2, were relatively flat locations. Cut in 1975-1977, T-1 was subsequently broadcast burned. T-1 and T-2 produced 0.46% and 0.57% respectively, of T-7's berries/acre total. Due to this suppression in berry production, a comparison of forested versus clearcut sites (using the two matched pairs of transects, T-1 through T-4) was not conducted. The high production at Middlepass sites (T-3 and T-4) combined with the low production of the Lower Nettie sites (T-1 and T-2) indicated strong variables not addressed in this paper. However, T-1 and T-2 had average slopes of 6%. The Middlepass transects averaged slopes of 21% and 25%. The effects of slope on berry production would be an interesting question in future S. canadensis work. Numerous descriptions of S. canadensis fields in the literature refer to it being abundant on mountain slopes (Hamer et al. 1983, Viereck et al. 1983) as well as in the flatlands (Jonkel 1982, LaRoi and Hnatiuk 1980, Pearson 1975). However, reports of specific percent slope values were not discovered.

A literature search again failed to reveal any clear patterns with canopy coverage. Hamer et al. (1983) reported that, of 3,889 grizzly feeding records on S. canadensis, 10.6% occurred under 0% forest cover, 44.2% occurred under 1-25% cover, and 25.0% of the feeding records were in 25-100% forest cover. The study was conducted in Banff National Park, which would conceivably minimize disturbance factors. Hence it may be safe to assume that these sites were chosen due to productivity. Other studies have reported S. canadensis dominant in shrub fields and also occurring above timberline (Pearson 1975, Porsild 1974), suggesting minimal canopy coverage. As reviewed earlier it is abundant in 13 different community types under a variety of overstory species. Unfortunately, no consistent cataloguing of percent canopy coverage or productivity was discovered. Martin (1979) found canopy coverage greater than 30% a limiting factor in production of Vaccinium spp. In addition, mature stands were determined to be unproductive. Although Hamer et al. (1983) attributed 25% of their S. canadensis feeding observations to 25-100% forest cover sites, no reference was made to stand maturity.

MANAGEMENT IMPLICATIONS

Broadly categorizing bear foods masks the individuality of these animals. In much of their range up to 100% of their feeding activity will, for some period of time, be devoted to S. canadensis. Within these populations individual tastes can vary. In northwest Montana Vaccinium globular is frequently the most preferred late summer/early fall food item. Nevertheless, within these Vaccinium populations exist "Shepherdia bears". In the years where Vaccinium spp. crop fails (as in the summer of 1984) most of the Vaccinium bears have to seek alternative foods. In many cases they will primarily select one or two other berry species (Jonkel pers comm, McLellan pers comm, Servheen 1983). In the Northfork of the Flathead River these alternatives include S. canadensis as well as Cornus stolonifera (red osier dogwood) and Rhamnus alnifolia (buckthorn).

Whether primarily or secondarily sought after, S. canadensis represents a key bear food during a critical period. Very little work has been done specifically on S. canadensis, and none that I know of on S. canadensis productivity. To stress this important gap in the "common knowledge" is one of the goals of this paper. Research on native tree and shrub survival in relation to oil sand tailings reclamation was done in Canada (Fedkenhuer et al. 1980). Jonkel (1982) concluded careful propagation and management of S. canadensis may be of vital importance to the grizzlies survival. Propagation could not only enhance the existing S. canadensis food base, but also supplement the alternate berry species used as key food items. This could help dampen some density-independent variables on the already stressed grizzly.

Within about two miles of the productive Middlepass Ridge a major coal mine has been proposed which calls for the removal of 1.5 M tons of coal from two open pit mines (Boyd 1982). Shell Oil of Canada has been conducting extensive seismic testing in the Northfork valley. They have proposed investing another $600 million in resource exploration and development (Lamb 1985). Much of the impact on the habitat itself could be moderated through active S. canadensis management. Watershed management and logging activities could also use S. canadensis to achieve specific goals. Just as Forest Service crews now replant tree seedlings, S. canadensis (and other key shrubs) seedlings could potentially be replanted. S. canadensis in particular holds potential, given its wide site tolerance and nitrogen-fixing capabilities.

Viereck et al. (1983) described it dominating shallow, stony, well drained silt loams. This stand was situated on steep south-facing slopes making the soil very warm and dry. Pfister et al. (1977) described it occurring on acidic gravelly silt loams. Root nodulation was found to increase in acidic soils (Gardner and Bond 1957). Moss (1953) summed up S. canadensis as "indicative of poor site quality". The above edaphic conditions frequently result with resource development. This again points to S. canadensis suitability in management use.

Additional research, however, is needed. The variables discussed in this paper have been treated in a simplistic fashion. Data gathering needs to account for the dynamic interactions of each community. Particular attention should be placed on phenotypes. A large degree of plasticity is suggested by the wide range of suitable habitats. Genotypic variation may also be responsible for its remarkably adaptive abilities.

In terms of wildlife specifically, the wide range of both site selection and environmental variability needs to be related to berry production. "Shepherdia management" may well prove to be an important tool available to managers in mitigating the increasing pressure placed on wildlife populations.

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