

FACTORS INFLUENCING GLOBE HUCKLEBERRY FRUIT PRODUCTION IN NORTHWESTERN MONTANA

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Abstract: Globe huckleberry (*Vaccinium globulare*) fruit is a major food source for the grizzly bear (*Ursus arctos horribilis*) in northwestern Montana. A ranked-set sampling pattern was used to determine the effects of wildfires, timber harvest practices, and physical and vegetative site characteristics on globe huckleberry fruit production. Timber stands not disturbed within the last 60 years were among the least-productive sites sampled. Stands on mesic, northern or eastern aspects that were burned by wildfire 25–60 years ago, or clearcut and broadcast-burned 8–15 years ago, were the most productive sites. Wildfires or timber harvests on xeric, southern or western aspects reduced fruit production and percent cover of globe huckleberry plants, as did scarification of clearcuts on any aspect. The relationships between fruit production and vegetative site characteristics reflected the age and physical features of the stands, though fruit production was not related to the percent cover or height of the globe huckleberry plants. Crop failures were apparently related to meteorological events. Therefore, long-range planning to assure production of globe huckleberry fruit crops in the future is recommended for manipulation of grizzly bear habitat.

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Huckleberry fruits are a major component of both black bear (*Ursus americanus*) and grizzly bear diets from late July through September in northwestern Montana (Tisch 1961, Jonkel 1967, Schaffer 1971). Whether the bears are dependent on the berries for late summer nutrition, or just strongly prefer them, has not been investigated. Rogers (1977) noted marked declines in black bear cub production after 3 consecutive years of berry crop failure. Jonkel and Cowan (1971) found a positive correlation between abundant berry crops and black bear reproductive success, but said it may have been coincidental.

Generally, in mid- to late July, black bears and grizzlies in northwestern Montana and northern Idaho move to sites where huckleberry fruits ripen earliest (Jonkel 1967; Schaffer 1971; Amstrup and Beecham 1976; C. Martinka, Glacier Natl. Park, West Glacier, Mont., pers. comm.). They also shift their patterns of habitat use from year to year in relation to huckleberry crop failures (Jonkel 1967; R. Mace, Border Grizzly Proj., School of For., Univ. Montana, Missoula, pers. comm.). Thus it seems that the bears may be dependent on the berries for some aspect of nutritional or reproductive success, if not for long-term survival. This dependence may be especially important for the threatened grizzly. Accordingly, this study was undertaken to determine the effects of physical and vegetative site characteristics, and of logging and wildfires, on huckleberry

distribution and productivity in northwestern Montana.

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STUDY AREA AND METHODS

Most of the berry productivity plots were in known grizzly habitat in northwestern Montana, in the North Fork and South Fork drainages of the Flathead River (Fig. 1). Three plots were in northern Idaho where the status of the grizzly is unknown. Samples were collected during the summers of 1977 and 1978, and 10 plots were sampled in both years.

The sampling method was based on the ranked-set pattern developed by Halls and Dell (1966). Site selection was based on the presence of huckleberry plants, uniformity of physical and vegetative characteristics, and site history. Disturbed sites adjacent to undisturbed sites were sampled and compared as pairs. At least 3 representatives from each aspect, elevation, and topographic position were obtained. As many different slopes, habitat types (Pfister et al. 1977), site histories, and percentages of tree, shrub, and herbaceous cover as possible were included.

At each site, 9 plots 2.25 m² were arranged in a square with 10 paces between adjacent plots (Fig. 2). A random digit table was used to assign each plot to a low, medium, or high group, so

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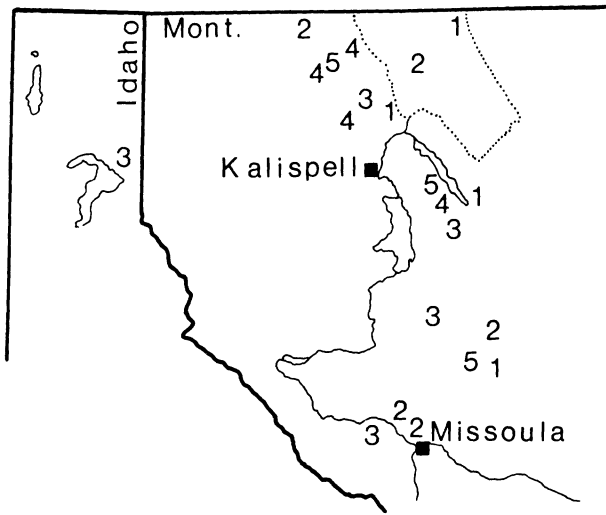


Fig. 1. Distribution of globe huckleberry study plots. Figures indicate number of plots in that location. Dotted lines show boundary of Glacier National Park.

that there were 3 high, 3 medium, and 3 low plots per site. Each plot was divided into 9 sections 0.25 m² (Fig. 2). Three of the 9 sections in each plot were randomly chosen and ranked low, medium, or high, based on visual estimates of the amount of fruit in each section. If the 2.25 m² plot was in the “high” group, I picked all the fruit in the highest ranked of the 3 sections 0.25 m²; if it was in the medium group, I picked the fruit in the section that was ranked medium, and if it was in the low group, I picked the fruit in the least prolific section.

In each plot, I counted the number of berries picked, measured the height of the globe huckleberry shrubs, and estimated the percentage of globe huckleberry, shrub (other than globe huckleberry), and herbaceous canopy cover. The productivity of the site was determined by measuring the total volume of fruit with water displacement. Often, all of the fruit was not ripe, so I converted the sample volume to ripe volume with the following formulas of Minore et al. (1979):

1. (Volume of 100 ripe berries / 100) = Volume per ripe berry.
2. (Volume of 100 random berries / 100) = Volume per berry in sample.
3. (Volume per ripe berry / Volume per berry in sample) × Total volume of picked sample = Ripe volume of berry sample.

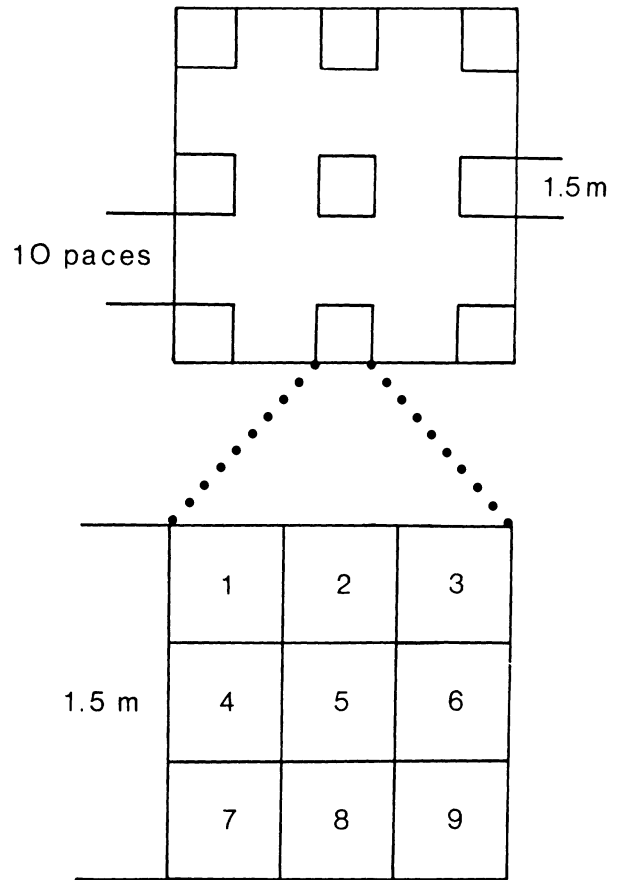


Fig. 2. Site sampling pattern with 9 plots 2.25 m², each divided into 9 sections 0.25 m².

The ripe volume (in ml) was converted to liters per hectare (l/ha) as follows:

$$l/ha = (\text{Total ripe volume (ml)} / 1000) \times 4444.4 \text{ plots per ha}$$

or

$$l/ha = \text{Total ripe volume (ml)} \times 4.444.$$

At each site, I recorded the date, location, aspect, percent slope, elevation, type and age of disturbance, habitat type (Pfister et al. 1977), primary and secondary understory components, the dominant tree species in the overstory, topographic position, soil pH, and the age of the tree stand (measured with an increment borer). Percentages of canopy and ground cover, the condition or vigor of the globe huckleberry shrubs, the number of berries per plant, and the average berry size were estimated. The data were analyzed with the University of Montana DECSYSTEM-20 computer and statistical programs in the Statistical Package for the Social Sciences (SPSS, Nie et al. 1975).

RESULTS AND DISCUSSION

Year-to-Year Comparisons

Ten plots were sampled in both 1977 and 1978. Yearly data for the repeated plots are compared in Table 1. The total volumes produced, the average percent cover of globe huckleberry shrubs, and the average height of the shrubs within plots were not consistent between sample years. The 1977 starting point for the plots was marked with surveyor flagging. Some flags were missing in 1978, so the exact starting point may not have been the same for both years. However, because variations in coverage and height within plots in each year was high, the means for the 2 years were not significantly different, and I believe the samples were representative of the sites in both years (paired-sample *t*-test; $P < 0.05$).

Yearly productivity variations within sites emphasized how important weather is in determining fruit production. Crops on 3 of the 10 re-sampled plots failed in 1978. The reasons for the year-to-year variability were not evident, but a late snowstorm in one area (Plot A) on 24 May 1978 may have affected the huckleberry flowers or pollinators. Many shrubs on the plot had aborted, dry, white fruits, so the flowers formed but were not pollinated or did not mature. A 2nd failure occurred on Plot I at 1939 m, where 12 cm of snow fell on 7 July 1978, at the time the green fruits were starting to mature. The green fruits were still on the shrubs 29 August 1978, but had not matured noticeably since the July snowstorm.

Most of the berries on Plot D were ripe when it was sampled on 13 August 1977. Not even half were ripe on 17 August 1978, so the plot was repeated 2 September 1978 when 70% of the fruits were ripe. Plot H was done 10 days earlier in 1978 than in 1977, but was only 55% ripe. Time did not permit returning to the plot at a later date.

Only 2 plots (B and E) were not conspicuously influenced by weather, berry pickers, or animals, and were repeated in 1978 within 6 days of the date they were sampled in 1977. Total production for Plot E was equal in both years. It was lower in 1978 than in 1977 for Plot B; I could not explain the reason.

Minore et al. (1979) noted that weather influenced annual berry crops of the thin-leaved huck-

Table 1. Comparisons of plots sampled for globe huckleberry production in both 1977 and 1978.

Plot	Year	Date sampled	Total volume of berries in sample (l/ha)	Mean huckleberry shrub cover (%)	Mean huckleberry shrub height (cm)
A	1977	27 Jul	146	66	47
	1978	1 Aug	57(114) ^a	56	57
B	1977	12 Aug	186	19	36
	1978	18 Aug	89(133)	39	40
C	1977	12 Aug	556	21	50
	1978	18 Aug	431(791)	34	75
D	1977	13 Aug	236	21	33
	1978	2 Sep	124(177)	21	35
E	1977	13 Aug	155	12	45
	1978	17 Aug	93(155)	29	56
F	1977	26 Aug	253	8	39
	1978	27 Aug	36	27	57
G	1977	27 Aug	351	16	34
	1978	27 Aug	218	24	47
H	1977	28 Aug	226	14	55
	1978	18 Aug	111(204)	23	39
I	1977	31 Aug	204	21	41
	1978	29 Aug	0	7	36
J	1977	1 Sep	111	24	29
	1978	28 Aug	386	24	29

^a Numbers in parentheses represent ripe volume of berry sample [= (Volume per ripe berry/Volume per berry in sample) × Total volume of picked sample].

leberry (*Vaccinium membranaceum*) more than any site characteristic, and suggested that no conclusions about site production be based on samples from 1 or 2 years. The yearly variations in cover, height, and fruit production in this study seem to support their recommendation. The varied effects weather has in microclimates or on a major scale make comparisons of plots between years tenuous, at best. However, comparisons of plots within years in this study generally led to similar conclusions for both years. Therefore, conclusions about the influences of non-meteorological factors on fruit production can be made from samples obtained in 1 or 2 years. The conclusions are reinforced if results are similar in both years, even if actual numbers vary between years. The meteorological events determine yearly production, but the physical, vegetative, and historical site characteristics are the ultimate factors that affect presence or absence of the globe huckleberry on a site.

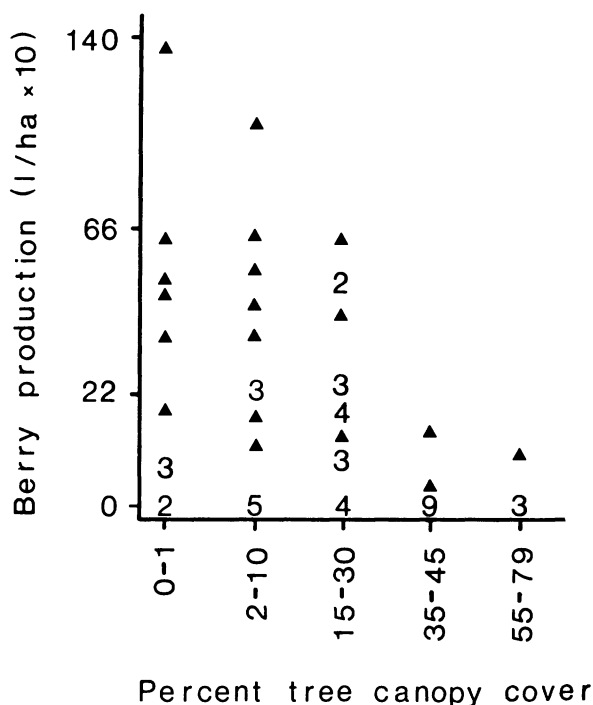


Fig. 3. The relationship between percent tree canopy and fruit production of the sampled sites ($r^2 = 0.13$). (Numbers indicate multiple data points; triangles indicate individual productivities.)

Aspect and Tree Canopy Density

Statistical analysis of the data was difficult because huckleberry fruit production was the result of interactions between several site characteristics, so the coefficients of linear correlation (r^2) for individual variables were usually very low (e.g., $r^2 < 0.30$). The relationship between aspect and fruit production was not particularly strong, but was similar in both years. I believe the most important point is that production on mesic aspects (northwest through east) was significantly higher than that of xeric aspects (southeast through west) (paired-sample t -test; $P < 0.01$).

Fruit production was less than 134 l/ha, irrespective of aspect, when the estimated tree canopy exceeded 30%, presumably because shading prevented flower formation (Fig. 3). The most productive plots were on mesic aspects with light tree canopies. The unproductive plots with tree canopies less than 30% were either in scarified clearcuts or in disturbed stands on xeric aspects.

Table 2. Site history, aspect, and huckleberry productivity for the 61 sampled plots.

Aspect	Productivity (l/ha)	Aspect	Productivity (l/ha)
Stands not visibly disturbed within the last 100 years		Stands burned by wildfire 25-60 years ago	
NW	13	N	622
NW	13	N	124
N	0	E	1399
E	0	E	1111
SE	0	E	644
S	4	E	467
S	4	E	387
W	27	E	218
		E	236
		E	98
		E	18
Stands partially cut less than 20 years ago		S	209
NE	133	S	80
S	440	SW	200
W	36	SW	36
Bench	587		
Stands partially cut more than 20 years ago		Stands burned by wildfire 61-100 years ago	
NE	444	N	0
NE	138	N	58
NE	116	NE	0
E	204	NE	0
SE	338	SE	84
W	129	S	36
		S	0
		S	0
		S	0
Stands clearcut and scarified		SW	124
N	0	SW	44
E	0	SW	31
SE	0	SW	0
		SW	0
		Bench	0
Stands clearcut and broadcast-burned 8-15 years ago			
NW	783		
N	502		
N	378		
NE	520		
NE	200		
NE	67		
E	0		
SE	0		
S	0		
SW	0		
Bench	67		

Site History

Recency and type of disturbance significantly influenced site productivity (Table 2). The 11 most productive plots sampled were all in timber stands that were disturbed in the last 50 years. Eight of the 11 were burned, 5 in wildfires and 3 in controlled, broadcast burns of clearcuts. Productivity in old-growth stands not noticeably disturbed within the last 100 years was low (0-27 l/ha), and, in contrast to other situations, was not affected by the density of the old-growth tree canopy. Old-growth stands with tree canopies less than 35% were not more productive than

those with more dense canopies. On the other hand, trees on the most prolific, old-growth plot (27 l/ha) were over 300 years old. Fruit production in this stand was limited to places where old trees had fallen. I believe that as the stand aged and the trees in the canopy died or fell, local huckleberry fruit production in the understory improved slightly. If the fallen trees are continually replaced, the local increase in fruit production may be short-lived. If they are not replaced, productivity should continue to increase, especially if the vigor of the shrub layer increases and inhibits tree replacement.

Wildfires.—Thirteen sites burned by wildfires 60–100 years ago did not produce much fruit (Table 2), even though mean huckleberry shrub cover was moderately high (31%). In contrast, the mean production for 15 plots of wildfire-burned sited 25–60 years old was significantly higher than that of plots with other site histories (paired-sample *t*-test; $P < 0.01$). The most obvious difference between recent and old wildfire-burned plots was the density of the tree canopy. It averaged 30 % in the old burns, significantly higher than the mean of 5% for the recent burns (paired-sample *t*-test; $P < 0.05$). The mean percent coverages of herbaceous plants, shrubs (other than globe huckleberry), and globe huckleberry shrubs were almost equal for the 2 conditions, so apparently the more dense tree canopy limited fruit production in the older burns.

The 2 most prolific plots sampled were burned by wildfire 25–60 years ago, but 5 of the 15 plots burned 25–60 years ago produced less than 125 l/ha. One of the 5 was on a very steep slope (71%) at 2120 m, near the upper elevational limit of the species in northwestern Montana. Two unproductive wildfire plots were on xeric aspects, and the absence of a duff layer and predominance of grasses in another indicated an intense fire. I could not explain the lack of fruit production on the 5th plot. In general, however, fruit production on the mesic-slope sites burned 25–60 years ago was higher than on the other sites, and this will probably continue until a tree canopy of 30% or more develops. Conditions that retard or inhibit the development of a tree canopy should prolong the productive life of wildfire-burned sites.

Logging.—All sampled clearcuts were logged within the last 25 years. Fruit production in

clearcuts was dependent on the site aspect and post-logging treatment. No fruit was present on huckleberry shrubs in the 3 dozer-scarified clearcuts sampled, and the mean percent huckleberry shrub cover was significantly lower than on sites with other treatment histories (paired-sample *t*-test; $P < 0.01$). Scarification apparently destroyed the rhizomes of the huckleberry shrubs and thus prevented vegetative propagation. Since seedling propagation of huckleberries is extremely rare in western Montana (P. Stickney, For. Sci. Lab., Missoula, Mont., pers. comm.), widespread rhizome destruction reduces the percent cover of huckleberry plants. Recovery to predisturbance coverages from the limited shrubs that survive the scarification is delayed until a layer of sapling trees develops (S. Arno, unpubl. rep., Intermountain For. and Range Exp. Stn., U.S. For. Serv., Missoula, Mont., 1979). Therefore, I believe that scarification eliminates the fruit production phase of the globe huckleberry recovery cycle, as the saplings would probably inhibit fruit production.

Eleven plots were in stands that were clearcut and broadcast-burned 8–15 years ago. Three were on xeric south or west aspects and produced no fruit. Fruit production in the 8 clearcut, broadcast-burned plots on mesic north or east aspects varied from 0 to 791 l/ha; the less productive of these were in spots where the burn was apparently very hot. Grasses were the only vegetation present, and the duff layer had been almost completely burned. However, the percent huckleberry cover and fruit production in most mesic-aspect, broadcast-burned clearcuts were significantly higher than those of adjacent, undisturbed stands (paired-sample *t*-test; $P < 0.01$). The adequate moisture, minimal soil disturbance, reduced tree canopy, and a light fire stimulation of the rhizomes were apparently responsible for the increase.

How long the broadcast-burned plots had been productive was a matter of conjecture. Berry production of the similar thin-leaved huckleberry in Oregon was very poor the first 3 years after clearcut, broadcast-burn treatments, but diesel fuel was used to carry the fire and could have had detrimental effects on shrub recovery (Minore et al. 1979). No wildfire-burned plots in my samples were less than 25 years old, but it seemed that shrubs in mesic broadcast-burned clearcuts

in northwestern Montana were productive earlier than those in sites burned by wildfires. Perhaps the fire was less intense, and the depth of rhizome destruction less extensive. The shrubs in the cutting units should continue to produce fruit as long as the tree canopy does not limit light penetration.

Berry production in partially-cut stands was erratic and inconsistently related to the parameters considered in this study. Fruit yield in the 10 partially-cut stands ranged from 36 to 587 l/ha. The productive, partially-cut stands had high percent coverages (\bar{x} = 40%) of tall (\bar{x} = 59 cm) of huckleberry shrubs. Huckleberry shrubs in the unproductive plots were either dense *or* tall, but none were dense *and* tall. No other differences were identified between productive and unproductive partially-cut plots.

Characteristics of the Globe Huckleberry Shrubs

Plant Height and Percent Cover. — Fruit production was not correlated with the percent cover of huckleberry shrubs. Though both variables responded similarly to changes in tree canopy cover and aspect, they did not respond in unison. Some sites had moderate to high coverages (25–40%) of huckleberry shrubs, but produced no fruit. It seemed the shrubs on disturbed sites had to reach a certain age or physiological state before they could produce fruit (P. Stickney, pers. comm.), so the recovery of production lagged behind that of coverage. Other unproductive stands also had moderate to high coverages (25–40%) of huckleberry shrubs, but had not recently been disturbed, so the tree canopies were dense enough (> 30%) to limit flower formation.

Fruit production was also not correlated with the average height of the huckleberry shrubs, suggesting that fruit production and vegetative growth responded to different environmental influences. Unlike fruit production, huckleberry shrub height was positively correlated with the tree canopy density. The shaded environment that limited fruit production and reduced coverage did not eliminate the huckleberry shrubs in stands over 100 years old. The shrubs that remained, continued to grow. Such growth habits in old-aged stands suggest that the globe huckleberry is a late-seral or climax species (Pfister et al. 1977) with a meso-seral reproductive phase.

Size and Quantity of Berries. — Not surprisingly, the more berries there were per plant, the larger the average volume of each berry, the higher the site's production was. The most prolific plot had many small berries (\bar{x} volume = 0.28 ml), and several plots had scattered, large berries, but the positive relationship between size and total production was generally constant. Forty-eight percent of the site-to-site variation in fruit production was associated with the size and number of berries per plant.

Average berry volume was calculated by dividing each sample's total volume by the number of berries in that sample. The average berry volume for 1977 was 0.34 ml; it was 0.35 ml in 1978. The number of berries per plant was subjectively estimated as none, rare, few to common, common, common to abundant, or abundant. The values of both variables decreased significantly in stands where the tree canopy was more dense than 30% (paired-sample *t*-test; $P < 0.01$). Site aspect was not correlated with the number of berries produced, but the average berry volume was higher on mesic than on xeric aspects (paired-sample *t*-test; $P < 0.01$). Globe huckleberry flowers develop in early spring when adequate moisture on most aspects is provided by snow melt and precipitation. Lingering snow packs on mesic aspects could delay flower formation, so frosts that were fatal in open areas would have no effect on plants covered by, or near, the snow (Minore and Smart 1975). In contrast, the fruit develops in late July through September when moisture differences among aspects are at a maximum.

Elevation and Percent Slope

Fruit production was low on steep slopes (> 70%) and on gentle slopes (0–10%). In general, however, the percent slope did not significantly influence globe huckleberry fruit production.

The elevation range of the sampled berry plots was 820–2120 m. Fruit production was limited at the low and high extremes, but within a certain range (1300–1850 m), other factors were more influential than elevation, or they obscured the effects of elevation (D. Minore, For. Sci. Lab., Corvallis, Ore., pers. comm.). However, the 6 most prolific plots sampled in 1978 had a significantly higher mean elevation (1810 m) than any other group of less productive plots

(paired-sample *t*-test; $P < 0.01$). Mean shrub (other than globe huckleberry) and herbaceous coverages were low for the high-elevation plots, so inter-specific competition between undergrowth species was also low.

MANAGEMENT RECOMMENDATIONS

The most productive sites sampled were disturbed areas on mesic, northern, or eastern aspects that were burned by wildfire 25–60 years ago, or clearcut and broadcast-burned 8–15 years ago. Grizzly bear use of clearcuts seems to be limited, but in the fall they prefer wildfire-burned areas (Zager 1983). The current practices of controlling wildfires and clearcutting timber in the western Montana could have detrimental effects on the major food source of grizzlies in the future. Therefore, I recommend long-range plans that allow wildfires to burn, particularly at higher elevations, in grizzly bear habitat.

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