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Abstract: Black bear can inflict severe negative impacts on timber stands in the northwestern United States. A supplemental feeding program to provide bears an alternative food source during spring is practiced in the stat e of Washington, and to a lesser extent in other states. We initiated concurrent studies to assess characteristics of bear that forage at feeding stations, the interactions of bears around feeders, and impacts of the program on bear territories. Numerou s bears fed at stations, including females with and without cubs, yearlings, and males. Bear feeding bouts at stations were generally short, less than 15 minutes. Bears generally fed alone, although we observed 2 to 3 adult bears at a feeder simultaneously and feeding partners were not consistent. There was little antagonistic behavior observed around the feeders, and no evidence that this behavior inhibited foraging opportunities for long. On the rare occasion a bear was driven from a feeder it returne d later that same day to feed. Bear territories that included feeding stations were similar in size to territories of bears without access to feeders. However, there may be more overlap of territories at feeding sites, and during the spring bears with fe eders do not visit some parts of their territory as frequently as those without feeders.

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Black bears (*Ursus americanus*) commonly forage on Douglas-fir (*Pseudotsuga menziesii*) trees during the spring (Ziegltrum and Nolte 1997). They strip the bark to feed on the newly forming vascular tissue which may contain 4 to 5% free floating sugars (Kimball et al. 1998). These vascular tissues are dietary staples for some bears (Noble 1993). Bears feed on the vascular tissue by removing the bark with their claws and scraping the sapwood from the heartwood with their incisors. Bears generally feed on the lower bole of trees in stands between 15 and 30 years of age (Ziegltrum 1994). Any age tree, however, is vulnerable and bears occasionally strip an entire tree. Damage within a stand can be extensive as a single foraging bear may peel bark from as many as 70 trees per day (Schmidt and Gourley 1992). Damage inflicted through this behavior can be extremely detrimental to the health and economic value of a timber stand (Ziegltrum and Nolte 1997). Complete girdling is lethal, while partial girdling reduces growth rates and provides avenues for subsequent insect and disease infestations (Kanaskie et al. 1990). The severity of timber loss is compounded because bears tend to select for the most vigorous trees within the most productive stands or where stand improvements (e.g., thinning) have been implemented (Mason and Adams 1989, Kanaskie et al. 1990, Schmidt and Gourley 1992).

Historically, management to protect timber resources from bear damage generally required lethal removal of bears. Control agents or professional hunters were hired to trap and hunt bears throughout the counties where damage was occurring (Poelker and Hartwell 1973). Private timber mangers began investigating alternative damage control techniques, particular non-lethal methods, during the mid-1980s. The first directed effort to provide bears with an altemative food to reduce bear girdling of trees was attempted in 1985 (Ziegltrum 1994). During the first year, approximately 2,250 kg of pellets were provided through 10 feeders. Since its inception the program has continued to grow. During 1999 approximately 288,500 kg of pellets were offered through approximately 900 feeders spread across western Washington, with a few feeders in Oregon and California.

The supplemental feeding program appears to be an effective means to reduce bear damage in select timber stands (Ziegltrum and Nolte 1997). Bears generally reduce their tree peeling once they begin eating pellets. Some anecdotal evidence, however, suggests that success of the feeding program declines as population densities increase. This decline in the program's efficacy may occur because of competition among bears or through efforts by bears to avoid antagonistic encounters, particularly females with cubs.

The impact of the supplemental feeding program on bear behavior is largely unknown. Interest in possible long-term consequences has increased as supplemental feeding of bears has grown and become more widespread across western Washington. Questions raised by timber and wildlife managers led

to a series of studies being conducted through the National Wildlife Research Center's Olympia (Washington, USA) Field Station to assess the effects of supplemental feeding on nutritional status and behavioral characteristics of black bears. This paper presents information pertaining to the characteristics of bears which forage at feeding stations, interactions of bears around feeders, and the impacts of the program on bear territories. The effect of the supplemental feeding program on the bear territories also was presented at the International Bear Conference in Romania (Fersterer et al. 2001).

METHODS

Study Area

The study area was approximately 80 km southwest of Olympia, Washington (USA) between 123°37'30"-123°00'00" longitude and 46°42'30"-47°02'00" latitude. Elevation ranged from 30 m along the Chehalis River to 798 m on Larch Mountain. Bears with access to supplemental feed were located on timber stands of the Weyerhaeuser Company. The supplemental feeding program had been practiced in these stands for several years, and physical characteristics of the stands were similar to state owned timber stands where supplemental feeding had not been practiced. Non-feeding areas were located on the Capitol State Forest and the Lower Chehalis State Forest.

Monitoring Bear Activity Near Feeding Stations

We videotaped bear activity in the vicinity of 4 feeding stations from May 1 until July 10, 1999. Feeders were located within approximately 5 km of each other. Three other feeders also located within the vicinity of the study area were not monitored. Video cameras were mounted on tree stands within 10 m of feeding stations. Camera limitations prohibited nighttime monitoring. Batteries and videotapes were replaced every 2 - 3 days. Platforms were constructed at least 3 weeks prior to videotaping to ensure bears were familiar with their presence. We saw no indication (e.g., bears leaving an area immediately prior to our arrival) that human activities to maintain cameras impacted bear behavior. Our ability to recognize an individual bear was enhanced because several bears had been captured and ear-tagged during another study.

The indicator we used to assess wariness of bears while at feeding sites was the number of times a bear exhibited 3 specific behaviors: 1) Looking Away; 2) Walking Around; and 3) Standing Up. *Looking away* was defined as remaining at the feeder but staring at something off camera for several seconds. *Walking Around* was defined as leaving the feeder and walking to the edge of the feeding site and staring at something off camera for several seconds. *Standing up* was defined as a bear raising on its hind legs and appearing to look around the feeding area.

Equipment used in the study included Panasonic WV-BP310 (black and white series) video-cameras with a fixed-iris lens (Broadcast and Televisions Systems Company; Secaucus, New Jersey), Pelco (MD2001) single channel analog video motion detectors (Pelco; Clovis, California), and Panasonic (model AG1070) direct current time lapse recorders (Broadcast and Televisions Systems Company; Secaucus, New Jersey). All equipment was powered by marine 205-minute reserve capacity batteries. Platforms (2.5 x 2.5 m) were built around a Douglas-fir tree at least 4 m above ground with crossed support beams covered with plywood. All branches below platforms were removed.

Monitoring Bear Movements

The approach used to monitor bear movements was described in Fersterer et al. (2001). Briefly, bears were captured and collared during the spring months of 1998 and 1999. Bears in stands with feeders were captured near feeding stations. Non-feed bears were captured in stands being damaged by bears that had similar timber characteristics. During summer and fall of 1998, movements of 4 bears within feeding areas and 5 bears outside known feeding areas were monitored after feeding had been concluded for the year. An additional 16 bears were incorporated into the study during the spring of 1999 for a total of 17 bears within feeding areas and 8 outside the supplemental feeding sites. Movements were monitored throughout the period when bears were actively feeding at stations (TRT), as well as outside this period (PRE).

Bear locations were identified by triangulating telemetry points. Attempts to locate bears were repeated until all points were within a 35 x 35 m area. The home ranges were estimated using the minimum polygon method with a 5% reduction of area (Kenward 1987). A 3-factor analysis of variance was used to compare home range size differences among bears with treatment (supplemental feed, no supplemental feed), gender (male, female) and period (feeding period, outside feeding period) as factors. Feeding period was defined as the time between May 1 and June 30 when there was high activity around feeders inside the study area.

RESULTS

Bear Use of Supplemental Feeding Sites

Numerous bears fed at stations, including females

with and without cubs, yearlings, and males. Overall, 20 bears visited at least 1 feeder. Most bears visited at least 2 feeders and several were observed at all 4 feeders (Table 1). Bears generally fed at stations every 2 or 3 days (Table 2) and their visits were usually short, less than 15 minutes (Table 3). Occasionally, adult males walked through feeding sites without stopping to eat. Bears also used numerous feeding sites, often moving from 1 feeder to the next within a single day. While at feeding sites, bears spent most of their time sitting in front of the feeder. However, the amount of time bears spent with their head inside a feeder, an indicator of eating, was fairly short. The mean for all bears was approximately 1.5 min (Table 3). Cubs played in the feeders. Therefore, they were recorded having their heads in the feeders considerably longer than other bears. Bears spent approximately 25% of their time walking around feeding sites (Table 3).

Feeders were used by bears throughout the study period. Mean hourly activity was calculated for each of 7 consecutive 10-day periods. Bear activity, particularly early in the spring, was greatest early in the morning and then again during late afternoon or early evening. Bears, however, were recorded visiting stations at all hours of the day. There was no indication that 1 class of bears (e.g., females) avoided feeders during times of high use by another class of bears (e.g., large males). Use of feeders declined toward the end of the feeding period, and feeders were removed from the field on July 10.

Alert Activity Exhibited by Bears Near Supplemental Feeding Sites

Alert activities were exhibited by lactating females more frequently than by other bears, while there was a tendency for adult male bears to demonstrate these behaviors the least (Table 4).

Table 2. Mean number of days between visits by bears of different status at four feeders video-taped for activity between May 1 and July 10, 1999.

Bear Status	Mean Number of Days
Females	2.5
Females with cubs	2.1
Cubs (sets)	2.2
Adult Males	2.6
Sub-adult Males	3.1
Yearling	0.9

Bear Encounters Near Supplemental Feeding Sites

Bears generally fed alone, though we observed 2 to 3 adult bears at a feeder simultaneously and feeding partners were not consistent (Table 5). We observed little antagonistic behavior around feeders, and found no evidence that this behavior inhibited foraging opportunities for long. On the rare occasion a bear was driven from a feeder it returned later that same day to feed.

Bear Movements

Home range size varied among bears (Table 6). The home ranges of bears in feeding areas, however, were not different ($P > 0.35$) than the home range of bears in non-feeding areas (Table 7). Male bears had larger ($P = 0.0002$) home ranges than female bears, and this difference was consistent across treatments ($P > 0.35$). Bear movements also were reduced ($P = 0.0286$) during the feeding period relative to the non-feeding period (Table 2), but again this difference

Table 1. The status and number of bears visiting four feeders video-taped for activity between May 1 and July 10, 1999.

Bear Status	Number of Bears Monitored				
	Feeder #1	Feeder #2	Feeder #3	Feeder #4	All Feeders
Females	2	2	2	2	4
Females with Cubs	2	1	1	0	2
Cubs (sets)	2	1	1	0	2
Adult Males	5	5	5	5	5
Sub-adult Males	4	5	2	2	6
Yearling	1	1	1	1	1
Total	16	15	11	9	20

Table 3. Mean number of minutes different status of bears spent at feeding sites, mean time spent sitting in front of feeders, mean time their head was inside a feeder, and mean time spent within the vicinity but not directly in front of a feeder.

Mean Number of Minutes for Bears at Feeding Sites				
Bear Status	Total	Front of Feeder	Head in Feeder	Away from Feeder
Females	14:44	9:53	1:19	4:27
Females with Cubs	13:24	10:36	2:50	3:07
Cubs (sets)	14:05	10:40	5:00	3:25
Adult Males	14:02	11:08	1:02	3:20
Sub-adult Males	14:03	11:14	1:55	2:36
Yearlings	20:13	14:02	0:38	6:05
All Bears	14:50	10:52	1:38	3:49

Table 4. Mean number of times bears exhibited three alert behaviors at four feeders videotaped for activity between May 1 and July 10, 1999.

Frequency of Alert Activity[a]			
Bear Status	Looking Away	Standing Up	Walking Around
Females	5.3	0.1	1.1
Females with Cubs	8.4	3.4	2.7
Cubs	0.4	0.3	0.6
Adult Males	2.7	0.1	0.6
Subadult Males	5.4	0.0	0.9
Yearlings	4.9	0.4	0.8

[a] Looking away was defined as a bear remaining in front of a feeder but staring at something off camera. Standing up was defined as a bear raising on its hind legs and looking around the feeding site.. Walking around was defined as a bear leaving the feeder and walking to the edge of the feeding site and staring at something off camera for several seconds.

did not relate to feeding (P =0.2614). There was no interaction between periods and gender (P = 0.1121). The 3-way interaction among treatments, periods and gender also was insignificant (P = 0.0984).

DISCUSSION

Our efforts to videotape bears in the vicinity of supplemental feeding stations was restricted to a single area. Therefore, these results need to be interpreted as a case study rather than a replicated experiment. Although lack of replication restricts our ability to extrapolate these findings across western Washington, the study does provide a glimpse of bear use of supplemental feed and their behavior at these sites.

Table 5. Total number of times multiple bears visited a feeding site at the same time, total number of times an aggressive bear chased another bear from the feeding site (Aggressive) and number of times bears remained at the feeding site together (Non-Aggressive).

Interaction	Total	Aggressive	Non-Aggressive
Female/Female	0	0	0
Male/Male	6	0	6
Male/Female	17	2	15
Male/Female/Male	1	0	1
Female/Male/Female	1	1	0
Total Encounters	25	3	22

We were surprised at the limited amount of time bears spent at feeding sites. They only visited feeders every 2 or 3 days, and then on average remained at feeding sites for only about 15 minutes per visit. These findings were contrary to opinions expressed by several persons familiar with the feeding program who thought large boars probably remained near feeders and dominated use of the pellets. In retrospect, however, reproductive males are normally exploring for partners during this period (Pelton 1982) and perhaps it should have been expected that they would not restrict their movements.

The only bear that made daily visits to a feeding station was a yearling male. Early in the spring this particular bear appeared at feeding stations with his mother and later came to the station alone. Meanwhile the mother began coming to the stations accompanied by different males. While at the station the yearling also remained longer (20 min) than most bears, but spent little time eating from the feeder (38 seconds per visit). Thus, it is probable the yearling was visiting feeder sites because the sites were familiar to him and to locate his mother, rather than solely as a place to feed.

Although single bears at feeding stations were most common, there were 25 occasions when multiple bears were present. Most often these multiple visits consisted of a male and female (17),

Table 6. Mean home range size (Km^2) for male and female bears monitored in feed and non-feed areas, either during (TRT) or (PRE) periods of high feeding activity.

Treatment	Feed Area				Non-Feed Area			
Gender	Male		Female		Male		Female	
Period	Pre	Trt	Pre	Trt	Pre	Trt	Pre	Trt
(n)	(2)	(3)	(2)	(10)	(3)	(1)	(2)	(2)
Km^2	33.05	11.93	7.90	7.49	23.47	20.00	7.20	3.30
(s.e.)	8.75	3.78	2.40	1.64	5.35	0.00	1.90	0.60

Table 7. Mean sizes (Km^2) and statistical comparisons of home ranges for all male and female bears; for home ranges for all bears monitored in feed and non-feed areas, and the home ranges for all bears during (Trt) and outside (Pre) the period when there was high feeding activity at supplemental feeding stations (Fersterer et al. 2001).

		(n)	Km^2	(s.e.)	*p* values
Treatment	Feed	(17)	11.33	2.43	$p > 0.35$
	Non-Feed	(8)	13.92	3.79	
Gender	Male	9)	21.37	3.66	$p = 0.0002$
	Female	(16)	6.98	1.11	
Period	Pre	(9)	18.52	4.28	$p = 0.0286$
	Trt	(16)	8.58	1.53	

less frequent were 2 males (6), and twice we recorded 3 bears at a station (2 males with 1 female, and 2 females with 1 male). Partners at stations were not consistent. One female appeared at a feeding station on separate occasions with 3 different males. During 22 of these multiple encounters bears ignored each other, or 1 bear waited its turn to eat. We observed little antagonistic behavior around the feeders. We could attribute a bear leaving a site to the aggressive behavior of another bear only 3 times. This limited aggression did not appear to inhibit feeding opportunities for long. On the rare occasion a bear was driven from a feeding site it was observed returning later the same day to feed.

Bear behaviors exhibited in the vicinity of feeding stations suggest that bears were not competing with each other for this nutritional resource. We observed no bears remaining at the resource to protect it from intruders, and dual visits were generally non-aggressive. We speculate that the reason a dominant bear does not restrict access to the resource is because feeders provide an unlimited amount of food. Food is always available, regardless of the number of bears that feed at a station or how much each consumes. Therefore, this food source is different than an animal carcass or even a berry patch containing a finite resource. The mechanism by which bears learn to modify their behavior to be less competitive is unknown, although this response is similar to multiple bears feeding adjacent to each other along a stream with abundant trout (Reinhart and Mattson 1990). Perhaps the time required to acquire this behavior is why the efficacy of providing supplemental feed improves over time if used repeatedly in the same area, provided bear populations do not expand.

Radio telemetry data suggested that the supplemental feeding program was not impacting the movement of bears (Fersterer et al. 2001). Bear home ranges were fairly consistent whether they were located in areas with or without ready access to supplemental feed. Males exhibited larger home ranges than females, which is consistent with prior studies (Amstrup and Beecham 1976, Lindzey 1976, Young and Ruff 1982, Koch 1983).

Bear movements were less extensive during the feeding period. However, this response was consistent on areas with and without feeders. The corresponding reduced movements on non-feeding areas suggest that bears were not merely remaining

close to feeders. Increased bear movements coincided with the onset of additional food items. For example, 1 male more than doubled his movements during the first few weeks of July. This particular bear moved to an adjoining area to feed on ripening berries and returned only once to a feeder during the last 2 weeks supplemental feed was available.

MANAGEMENT IMPLICATIONS

The efficacy of a supplemental feeding program would be compromised if there were continuous conflicts among animals trying to eat from the feeders. This study suggests that aggressive interactions among bears at feeding stations are minimal and that access to feeders is available to most if not all bears. The results, however, also suggest that numerous bears are probably being encouraged to frequent timber stands that are most vulnerable to damage. This may be problematic if the feeding program is interrupted while trees within these areas remain vulnerable to bear damage, or if bear populations continue to increase until they exceed a threshold where damage levels are likely to increase regardless of the availability of supplemental feed. The supplemental feeding program generally becomes less effective as bear populations increase (Ziegltrum 1994).

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