Activity patterns of urban American black bears in the San Gabriel Mountains of southern California

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Abstract: Both the American black bear (*Ursus americanus*) population in the San Gabriel Mountains of Los Angeles County, California, USA, and the human population at the base of these mountains have grown, and human–bear interactions are common. Little is known about the habits of urban bears in southern California. From July 1998 to December 1999, I studied the activity patterns of urban black bears in the foothills of the San Gabriel Mountains and described their use of adjacent cities. I trapped and radiocollared 2 female and 4 male bears and monitored their movements in forest and city habitats using ground-based and aerial radiotracking. The female bears used city habitat all seasons (spring, summer, fall, winter) of this study, with the exception of the second fall season by one female. Male bears used city habitat during summer, with little exception. Female bears used city habitat equally during 4 6-hr periods daily in summer 1998 and used the city heaviest from 1600–0359 hr in spring 1999 and from 2200–0959 hr in summer 1999. Male bears used city habitat most during the 2200–0359 hr period. Bears were most active in cities during late night when human activity was minimal. Public education efforts to inform residents about activities and behaviors to reduce bear attractants appeared to be successful, are supported by the Department's current black bear policy, and indicate that a focus on human education and enforcement of attractant containment and removal are necessary for minimizing bear–human conflict.

Key words: American black bear, black bear policy, nuisance bears, San Gabriel Mountains, southern California, urban bears, *Ursus americanus*

Ursus 16(2):255–262 (2005)

The American black bear (*Ursus americanus*) was introduced into the San Gabriel Mountains of southern California in 1933, when the California Department of Fish and Game (Department) relocated 11 bears from Yosemite National Park to an area near Crystal Lake. At the same time, 16 bears were released in the adjacent San Bernardino Mountains (Burghduff 1935). The San Gabriel bear population has since experienced little hunting pressure because the rough, steep terrain discourages most hunters. Bear hunters have reported taking an average 7 bears per year (Department bear harvest data for 1986–2001 hunting seasons, Los Angeles County, California, USA).

In the absence of natural predators and hunting pressure, the San Gabriel bear population has grown to approximately 250–300 bears (R. Stafford, California Department of Fish and Game, Sacramento, California, USA, personal communication, 1998). The human population at the base of the San Gabriel Mountains has also increased, resulting in urban and suburban sprawl. These population increases have created a situation where human–bear interactions are now common (D. Updike, California Department of Fish and Game, Sacramento, California, USA, personal communication, 1998), as bears include residential areas within their home ranges (Van Stralen 1998). Many residences have yards containing ornamental avocado and fig trees, while others contain small remnant avocado orchards. Bears frequently visit and obtain food from garbage cans and dumpsters, fruit trees, barbecues, and pet food bowls, and enter swimming pools.

Although the Department receives many nuisance complaints, few are related to serious damage or threats to humans (Davis and Brennan 1996). Residents of the interface communities do not wish harm to bears, but they do expect a response to increasing conflicts (C. Davis, California Department of Fish and Game, Ontario, California, USA, personal communication,

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1998). Although city councils have insisted on the relocation of the nuisance bears, the Department's current black bear policy prohibits such action.

Several black bear studies were conducted in the San Gabriel Mountains (Moss 1972, Braden 1991, Stubblefield 1992, Stubblefield and Braden 1994) and the adjacent San Bernardino Mountains (Boyer 1976, Siperek 1979, Novick et al. 1981, Novick and Stewart 1982, Hogan 1984), but none evaluated the habits of urban bears. The Department designed a 3-year study to address this issue (Davis and Brennan 1996). A preliminary feasibility study was conducted the first year of research from July 1997 to June 1998 (Van Stralen 1998). The second and third year of research (July 1998 to December 1999), I studied activity patterns of urban black bears in the foothills of the San Gabriel Mountains and described their use of adjacent cities.

Study area

The San Gabriel Mountains are located in Los Angeles County, California, USA, and are largely included in the Angeles National Forest. The mountains run east to west for approximately 113 km, encompassing an area of approximately 19,370 km^2. The mountains are bounded on the north by the Mojave Desert, on the west by the San Fernando Valley, on the south by the Los Angeles Plain, and on the east by the San Bernardino Mountains (Miller 1928).

Elevation ranges from approximately 152 m at the base of the foothills to over 2,743 m at a few peaks. Ridges generally have slopes of 20 to 40 degrees. The steep slopes combined with the presence of fractured basement rock contribute to frequent landslides (Morton 1973). Debris basins have been built at the base of the canyons for flood and debris control.

Climate varies with elevation. The average annual precipitation is 90.3 cm, and average annual temperature is 13.4°C. Winters are mild and wet with rainfall, while higher elevations receive occasional snowfall. Summers are typically dry and hot with occasional thunderstorms and windstorms (Western Regional Climate Center 2000). Climate on the south-facing side of the range is subject to coastal influences, while the north-facing side is subject to desert influences (Hanes 1976).

Lower elevation plant communities of the mountain range are coastal sage scrub (*Artemisia californica*), chamise chaparral (*Adenostoma fasciculatum*), and southern oak woodland (*Quercus agrifolia–Juglans californica*). The mid-elevation plant communities are sagebrush scrub (*Artemisia tridentata*), scrub oak chaparral (*Quercus dumosa*), desert chaparral (*Ceanothus greggii–Cercocarpus ledifolius*), pinyon–juniper woodland (*Pinus monophylla–Juniperus californica*), and Joshua tree woodland (*Yucca brevifolia*). The high-elevation plant communities are yellow pine forest (*Pinus ponderosa-Pinus jeffreyi-Pinus coulteri*), subalpine forest (*Pinus murrayana–Pinus flexilis*), and alpine fell-field dominated by *Eriogonum saxatile*. The riparian woodland plant community is found in different forms at low (*Platanus racemosa–Populus fremontii*), mid (*Alnus rhombifolia*), and high (*Pseudotsuga macrocarpa*) elevations (Hanes 1976).

My study area included the San Gabriel River Ranger District, as well as portions of the following cities: Arcadia, Monrovia, Bradbury, Duarte, Azusa, Glendora, San Dimas, La Verne, and Claremont. The human populations of these foothill cities range from 860 to 53,100 people, with an average population of 34,200 people. Population growth from 1990 to 2000 ranged from 3.0% to 10.4 %, with an average population increase of 5.6%. Population densities range from 174 to 1,940 people per km^2, with an average of 1,178 people per km^2 (City-data 2003, ePodunk 2003).

Methods

Capture and marking

Department personnel and volunteers attempted to trap bears from January to mid-August in 1998 and 1999 in urban areas that demonstrated consistent bear activity. Trapping was suspended during bear hunting season (mid-Aug through Dec) in accordance with Food and Drug Administration regulations.

Culvert traps (Piekielek and Burton 1975) were set in driveways, on lawns, or in small orchards of homes that experienced repeated bear problems. Baits included a variety of aromatic items such as cat food, canned tuna, sardines, bacon, or donated butcher scraps. The traps were set and baited at dusk and closed at dawn. Residents were instructed to page me or Department dispatch when they heard the heavy trap door close.

Once trapped, bears were chemically immobilized with tiletamine hydrochloride (Stewart et al. 1980, Burton and Schmalenberger 1995) using a Dan-inject jab stick (Wildlife Pharmaceuticals Incorporated, Fort Collins, Colorado, USA). Each bear was fitted with a radiocollar (Telonics, Mesa, Arizona, USA) equipped with a mortality switch (5.5 hr delay). The collars were marked with orange, red, yellow, or white reflective tape to allow easy visual identification of bears.

Standard morphometric measurements, condition of teeth (worn, broken, stained) and external parasite load were recorded. Each bear received a colored plastic tag, a metal numbered tag, or both in each ear. I assigned every captured bear an identification number beginning with an "F" for female or an "M" for male, followed by their unique 3-digit collar frequency.

When necessary, bears were released in the nearest undeveloped area to avoid immediate bear–human conflicts. Displacement did not exceed 400 m.

Monitoring

Beginning 15 July 1998 and continuing until 31 December 1999, I monitored movements of collared bears using discontinuous radiotracking (Harris et al. 1990). I located bears using standard methods of ground-based triangulation with a receiver attached to an Omni car-top antenna and a Yagi "H" hand-held antenna. I attempted to obtain at least 3 bearings per location within 30 min, but accepted locations based upon 2 bearings when bears were close (<250 m) to the receiver or when topography and road access precluded additional bearings. When possible, error polygons were constructed and locations associated with large polygons were censured.

Data points were gathered daily per bear on as many bears as possible during active periods, but only once or twice per week per inactive bear during denning. I continued to search for each bear until I located it, ensuring that I had the same potential to register a location in the forest as in city habitat.

I also located bears once or twice per month through aerial radiotracking (White and Garrott 1990) with the assistance of a Department fixed-wing aircraft. Additional data points were gathered from reported positive identification of bears provided by homeowners or police departments.

I located bears by searching for them with equal intensity during each of 4 6-hr periods that represented morning (0400–0959 hr), mid-day (1000–1559 hr), evening (1600–2159 hr), and late night (2200–0359 hr). Each location was accompanied by descriptive data including latitude, longitude, elevation, time of day of the location, and location relative to city or forest.

Activity patterns

I defined "forest" as areas within the Angeles National Forest and vegetated, undeveloped areas surrounding cities. I defined "city" as developed areas within city limits. For each bear, I divided the number of telemetry locations gathered within the forest boundary by the total number of telemetry locations. The same calculation was performed for the number of telemetry locations gathered within city boundaries. I used these calculations to report percent use of city and forest habitats on a monthly and seasonal basis. I defined seasonal ranges (Novick and Stewart 1982) as: spring (1 Apr–30 Jun), summer (1 Jul–30 Sep), fall (1 Oct–31 Dec), and winter (1 Jan–Mar 31).

I compared the distribution of telemetry locations gathered within city habitat over the 4 daily periods described above to determine if bear activity was equally distributed among periods. I summarized number of bear locations within cities by period to compare activity inside city limits within and among seasons using a chi-square goodness-of-fit analysis (Zar 1984). When observed use differed from expected, I divided the chi-square analysis to determine which period was used disproportionately.

I was unable to analyze daily activity among periods for individual bears because >20% of the expected frequencies were <5 for most individuals (Zar 1984). Instead, I pooled data from the 2 females for one analysis and pooled data from 3 of the 4 males for the other analysis (the fourth male was not included because he stopped frequenting the city 2 weeks after capture).

Results

Capture and marking

Despite nearly continuous trapping effort during January–August, bears were only captured during July and August in 1998. Two bears captured during the preliminary study (1997) had been fitted with drop-off collars. Both were recaptured during the second year of study and fitted with new collars. One bear was captured free-ranging in a neighborhood, 3 bears were trapped, and 2 were darted and removed from trees in residential areas during daylight hours. Bears were captured in Monrovia, Bradbury, Glendora, and Claremont. In all, 2 adult female and 4 adult male bears were collared.

Monitoring

I gathered 2–3 bearings consecutively on each bear ($\bar{x}$ = 2.3 bearings/usable location). Over 92% of the bearings were gathered within 15 minutes of the previous bearing. Elapsed intervals between consecutive fixes were 2–27 minutes ($\bar{x}$ = 7.2 min).

During winter months, 3 male bears (M025, M265, and M290) retreated into the forest above the snow line and became inactive; the fourth male (M545) retreated to a chaparral area just above and behind the city, where

Table 1. Use (% of time) of forest and city habitat by 2 female black bears in the San Gabriel Mountains, Los Angeles County, California, USA, on a monthly and seasonal basis, July 1998–December 1999.

	Bear F225		Bear F375	
Time	Forest	City	Forest	City
1998				
Jul	50	50	n/a	n/a
Aug	43	57	36	64
Sep	70	30	72	28
Summer	56	44	59	41
Oct	65	35	94	6
Nov	83	17	100	0
Dec	93	7	100	0
Fall	79	21	87	13
1999				
Jan	90	10	100	0
Feb	93	7	100	0
Mar	75	25	90	10
Winter	88	12	98	2
Apr	68	32	69	31
May	37	63	58	42
Jun	39	61	61	39
Spring	48	52	67	33
Jul	57	43	67	33
Aug	50	50	82	18
Sep	31	69	55	45
Summer	48	52	67	33
Oct	100	0	69	31
Nov	100	0	86	14
Dec	100	0	100	0
Fall	100	0	78	22

he also became inactive. Consequently, I tracked male bears only weekly during winter. Both females remained active throughout the winter months; I therefore continued to track them daily.

Of 1,064 data points gathered, 77% were obtained using ground telemetry, 17% using aerial telemetry, 3% from reported sightings by residents or law enforcement officers, 2% from researcher sightings, and 1% from capture and recapture locations.

Activity patterns

Forest versus city use. Bear F225 used city habitat for 15 consecutive months from July 1998 through September 1999. Bear F375 used city habitat August through October 1998 and March through November 1999 (Table 1).

Bear M025 used city habitat only in August of 1998. Bear M265 used city habitat during July and August in both years. In September of 1999, he used the city only minimally. Bear M290 used city habitat during July and August in both years, and used the city to a lesser extent

Table 2. Use (% of time) of forest and city habitat by 4 male bears in the San Gabriel Mountains, Los Angeles County, California, USA, on a monthly and seasonal basis, July 1998 to December 1999.

	Bear M025		Bear M265		Bear M290		Bear M545	
Time	Forest	City	Forest	City	Forest	City	Forest	City
1998								
Jul	n/a	n/a	40	60	17	83	100	0
Aug	71	29	70	30	8	92	64	36
Sep	100	0	100	0	61	39	70	30
Summer	75	25	76	24	42	58	72	28
Fall	100	0	100	0	86	14	90	10
1999								
Winter	100	0	100	0	100	0	100	0
Spring	100	0	78	22	100	0	n/a	n/a
Jul	100	0	63	37	67	33	91	9
Aug	100	0	71	29	60	40	56	44
Sep	100	0	94	6	n/a	n/a	40	60
Summer	100	0	76	24	62	38	60	40
Fall	100	0	100	0	n/a	n/a	100	0

in September of 1998 (data are incomplete for this bear because it was killed by a hunter at the end of summer 1999). Bear M545 used city habitat in August and September of both years, and used the city minimally in October of 1998 and July of 1999 (data are incomplete for this bear because he dropped his collar at the end of winter 1999 and was not recaptured until summer 1999; Table 2).

Daily activity within the city. The 2 female bears consistently used city habitat during summer 1998, spring 1999, and summer 1999. Female daily activity patterns differed between summer 1998 and summer 1999 ($P < 0.025$), and between summers and spring 1999 ($P < 0.025$).

Female activity in the city was equally distributed across the 4 daily periods during summer 1998 ($P > 0.75$), but not during spring and summer 1999 ($P < 0.005$). In spring 1999, females were more active than expected during the 1600–2159 hr and 2200–0359 hr periods. In contrast, during summer 1999, female bears were more active than expected during 2200–0359 hr and 0400–0959 (Fig. 1).

The 3 male bears consistently used the city only during summer 1998 and summer 1999, and their 4 daily activity patterns were consistent between summers ($P > 0.95$). However, during summer, males moved actively within the city more during 2200–0359 hr than during the other 3 periods (Fig. 2), as reflected in a change to significant χ^2 values ($P < 0.01$) when this period was included in the analysis.

Discussion

Capture and marking

I experienced unexpected difficulties while trapping. Many residents in the foothill areas enjoyed watching and photographing bears and became angry when they discovered that I was going to trap and collar the bears. Despite efforts to inform them about the study, I experienced several incidents of trap sabotage. Consequently, I was forced to monitor the trap when it was set, dramatically reducing trapping effort. Trapping efficiency was also lowered by several instances of bears escaping from traps, the capture of a domestic dog, and the abundance of foods, namely avocados and garbage, available to bears in the cities. Perhaps trapping success would have improved if attractants in the surrounding area were removed or secured before the trap was baited and set.

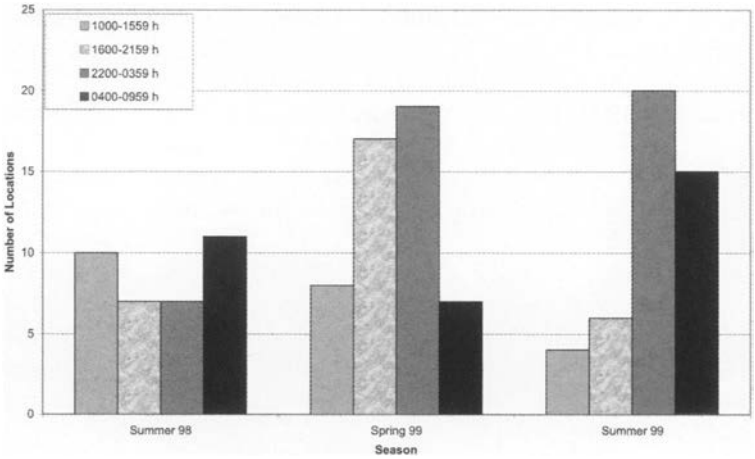

Fig. 1. Number of telemetry locations in city habitat for 2 female bears within each of 4 daily periods during an urban black bear study in the San Gabriel Mountains, Los Angeles County, California, USA.

Activity patterns

Forest versus city use. Both females had cubs in 1998 and remained active year-round, but they traveled alone during the second fall and were relatively inactive as they prepared for hibernation. Bear F225 used city habitat to some extent in every month of the first year of study, but retreated to the forest in October 1999. During summer 1999, F225 spent most nights feeding in a small avocado grove, whereas F375 visited various areas within the city limits. I believe the constant supply of a fattening food allowed F225 to achieve a threshold condition for denning and reproduction earlier than F375, which may explain F225's lack of use of city habitat in fall 1999.

The 3 male bears using city habitat did so consistently throughout both summers, but they did not use the city in fall, winter, or spring, with the exception of minimal use preceding or following summer. Their lower incidence of location within the city than females may be related to the larger home ranges of males, which potentially expose them to more and varied sources of foods. For example, bear M545 visited a 40-acre avocado orchard outside of the city during both summers and traveled far into the mountains during early fall 1998 to a fruit orchard, where he remained for a short time before returning to an area just above the city. It is also possible that the females used the city for a longer period due to the higher energetic demands of lactation or gestation.

Daily activity within the city. In summer 1998, both female bears had young cubs with them and they were equally active throughout the day, which may result from the energetic demands of the young

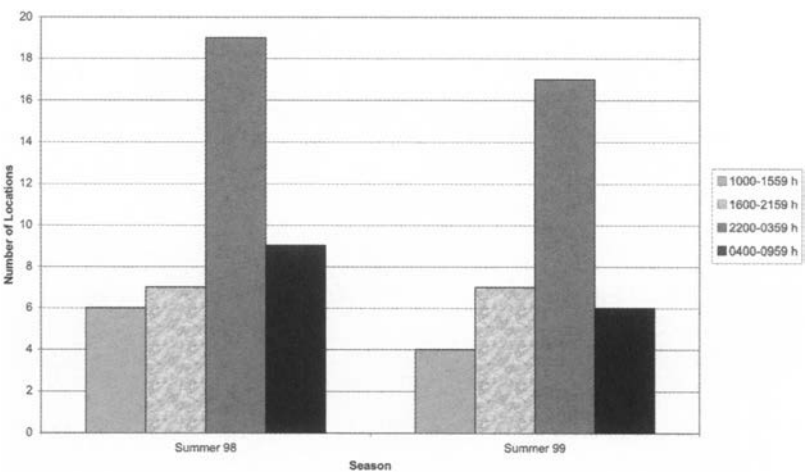

Fig. 2. Number of telemetry locations in city habitat for 3 male bears within each of 4 daily periods during an urban black bear study in the San Gabriel Mountains, Los Angeles County, California, USA.

(Ayres et al. 1986). The two females' use of city habitat shifted from 1600–2159 hr and 2200–0359 hr periods in spring 1999 to 2200–0359 hr and 0400–0959 hr periods in summer 1999. This shift in activity may have been in response to a change in human activity, as human activity typically continues later into the evening during summer months due to a later sunset and warmer temperatures.

The 3 males displayed identical daily activity patterns during both summers. In summer, they were most active in the city late evening to early morning (2200–0359 hr). This pattern of activity within the city was also displayed by the 2 female bears in spring and summer 1999.

These patterns of activity are most likely related to the urban setting. Wild black bears are mostly diurnal (Amstrup and Beecham 1976, Lindzey and Meslow 1977, Garshelis and Pelton 1980, Ayres et al. 1986, Lariviere et al. 1994). However, black bears have been known to shift to nocturnal activity in areas where human activities are prevalent during the day (Reimchen 1998). Activity budgets when bears were within city habitat reflect the period of minimal human activity, a response observed in other studies of bears that used human food sources (Ayres et al. 1986, Mattson 1990).

Management implications

Major attractants within cities (garbage, pet food, and avocados) are available year-round. Yet the 6 bears in this study used these areas only during summer. Similarly, Boyer (1976) found that despite a year-round garbage supply at a study site in the San Bernardino Mountains, bears ate less garbage as natural foods became more available from spring to fall.

In studies of seasonal elevation use in the San Bernardino Mountains, Novick (1979) and Hogan (1984) found that centers of activity for black bears occurred at low elevations in spring and summer. The bears then traveled to higher elevations in the fall, and even higher elevations in the winter. Novick (1979) speculated that this movement to higher elevations in fall reflects the phenological progression of berry producing plants and acorns.

It is conceivable that the bears of the present study travel to lowest elevations within home ranges during spring and summer and consequently end up on the edge of cities. Once there, they are drawn inside city limits by numerous attractants during a time when natural food sources are scarce and caloric intake requirements are high. During this time of scarcity of natural foods, the bears may also be more tolerant of human disturbance in order to obtain the abundant food resources within the city.

Removal of attractants

The Department's current black bear policy is intended, in part, to minimize bear–human conflicts. The policy recognizes improper storage of garbage as a major cause of interactions between bears and humans and stresses the need to reduce or eliminate attractants in the city. For the duration of the study, I distributed the Department's "Living with California Black Bears" brochure to residents in neighborhoods that had regular visits from bears or were adjacent to areas of high bear activity. Several community meetings were jointly organized by Department personnel and local police to educate the public about removal of attractants. Several residents followed our advice to secure garbage cans and place them out on the street only on the morning of pick-up (rather than the night before), bring pet food inside, clean barbecue grills, and remove ripened and dropped fruit from trees and on the ground; they reported to me that bear activity declined or ceased in their area. However, this strategy only seemed to work when all residents of an area complied. Some residents admitted that they left out attractants because they enjoyed seeing the bears; this caused neighbors to continue having bear problems.

Residents with avocado groves or similar fruit producing trees (attractants which are not removable) were given guidelines for constructing bear-proof electric fencing. To my knowledge, this suggestion was not implemented by any residents. The cities of Monrovia and Bradbury considered upgrading public garbage cans to bear-proof models. However, the local waste management company concluded that the cost of altering their garbage trucks to enable the pick-up of bear-proof cans was prohibitive (C. Davis, California Department of Fish and Game, Ontario, California, USA, personal communication, 2000).

Future management strategy

The Department's current black bear policy is appropriate for the urban black bear population in the foothill cities of the San Gabriel Mountains. More intense efforts toward public education and enforcement of the removal of attractants should be the focus of a future management plan for all bear populations inhabiting the urban–wildland interface in California. Individual cities can enforce county codes that enable law enforcement to cite residents who live in areas of high bear activity if they do not properly contain and

secure garbage, do not bring in pet food bowls, or purposely feed bears. This shift from correcting the behavior of the bears to correcting human behavior has been adopted by other cities experiencing urban bear problems (Peine 2001), and in most cases has led to the requirement of bear-proof garbage containers for residents. Future studies should address the effectiveness and possible implementation of this strategy.

Acknowledgments

Funding was provided by the Los Angeles County Fish and Game Commission and the California Department of Fish and Game's Black Bear Program. My sincerest thanks to C. Davis, D. Updike, R. Stafford, M. Jeter, T. Evans, G.R. Stewart, G.R. Trapp, the Department's game wardens, local police officers, K. Bosell, K. Argent, and numerous volunteers who assisted this study. I thank G.R. Stewart, F. Wernette, and D. Updike for editing an early draft, as well as R. Harris, C. McLaughlin, J.D. Peine, and an anonymous reviewer for comments and suggestions.

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Received: 25 February 2004
Accepted: 16 January 2004
Associate Editor: C. McLaughlin