



## WINTER RECREATION AND HIBERNATING BLACK BEARS *Ursus americanus*

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### Abstract

The increase of recreational activities in winter wildlife habitats is of concern because wildlife populations are under considerable stress during winter. To assess the effects of winter activities on black bears *Ursus americanus*, denning ecology was studied for three winters in the Sierra Nevada and Sweetwater Mountains in Nevada and California. Fourteen bears in the Sierra entered 31 dens earlier and were more selective in their choice of den sites than five Sweetwater bears using 10 dens. Bears at both sites abandoned dens and cubs in response to investigator disturbance, and all but one bear remained active after abandonment. High overlap between bear denning sites and potential winter recreation areas indicated a high potential for den abandonment due to human disturbance. Bear denning areas should be protected from human disturbance during winter.

**Keywords:** Sierra Nevada, black bear, *Ursus americanus*, Ursidae, recreational impacts.

### INTRODUCTION

Recreational impacts on wildlife are of great concern to wildlife managers and conservationists (Ream, 1980; Emanuelsson, 1985; Boyle & Samson, 1985; Cole & Knight, 1991; Knight & Cole, 1991), particularly in winter when disturbance may cause increased energetic expenditures at a time when food is of low nutritional value (Moen, 1976; MacArthur *et al.*, 1979). Both positive and negative effects of winter recreation have been suggested for many species, including white-tailed deer *Odocoileus virginianus* (Dorrance *et al.*, 1975), mule deer *O. hemionus* (Freddy *et al.*, 1986), bald eagles *Haliaeetus leucocephalus* (Stalmaster & Newman, 1978), and a variety of medium and small mammals (Bury, 1978). Most research has focused on the impacts of snowmobiles on wildlife (Bury, 1978; McCool, 1978;

Boyle & Samson, 1985). However, impacts of other forms of winter recreation, such as skiing, have received little attention, especially in high-altitude environments (but see Corn & Gorte, 1987).

The Sierra Nevada mountains are well suited for recreational impact studies because they are a very popular winter playground, especially in and adjacent to the Lake Tahoe basin, which receives about 3 million visitors per year (1985 estimates, Lake Tahoe Visitor Authority, South Lake Tahoe, California and Greater North Lake Tahoe Chamber of Commerce, Tahoe City, California, pers. comm.). Growth in the tourist industry is rapid, with a 156% increase in the number of visitors per year between 1975 and 1985 in the North Lake Tahoe area (Greater North Lake Tahoe Chamber of Commerce, Tahoe City, California, pers. comm.). The Basin has downhill ski resort densities of roughly 1 per 260 km<sup>2</sup> and snowmobiling, cross-country skiing, sledding and snowshoeing are also popular (Lake Tahoe Visitor Authority, South Lake Tahoe, California, pers. comm.).

Black bears are a good subject for human disturbance studies in high-altitude habitats because they are sensitive to disturbance and common in many mountain ranges throughout North America. Additionally, they are good ecological indicators because they require large expanses of relatively undisturbed habitat. In land use management plans, bears are often considered as a game animal, a species of special concern, an indicator species, or a nuisance animal (Pelton, 1982), and an understanding of bear denning habits is essential to sound management. For example, the importance of adjusting hunting seasons to denning chronology is well understood (Johnson & Pelton, 1979, 1980; O'Pezio *et al.*, 1983; Kolenosky & Strathearn, 1987) and several authors have recognized the importance of considering denning habitat and actual dens, such as trees, in land use planning (Johnson & Pelton, 1981; LeCount, 1983; Manville, 1987). However, few authors have recognized the potential impact of human winter activities on denning black bears (Johnson & Pelton, 1980; Tietje & Ruff, 1980; Manville, 1983; Nelson & Beck, 1984). Because of increasing human pressure on potentially sensitive high-altitude winter habitats, this study was designed, in

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part, to assess ecological status and conservation of black bears. We evaluate potential effects of human winter activities on denned black bears by comparison of populations in the Sierra Nevada and Sweetwater Mountains in Nevada and California.

## MATERIALS AND METHODS

### Study area and time period

The locations of the Sierra and Sweetwater study sites are shown in Fig. 1. We focused on two separate areas in the Sierra: one in Little Valley 4 km west of Washoe Lake and 2 km east of Lake Tahoe and another 10 km west of Reno. Data from these areas were combined. The Sweetwater site, located 130 km south of the Sierra site, was subjected to little human disturbance in winter, while the Sierra had high potential for disturbance from winter recreation activities. Parts of two ski resorts fell within the boundaries of the Sierra study area and construction of a third has been proposed. Four additional ski resorts bordered or were within 4 km of seasonal home ranges outside of the Sierra study area.

Elevations ranged from 1890 to 3463 m at the Sweetwaters and from 1564 to 2944 m at the Sierra. Both areas were characterized by steep, rugged topography with high peaks and ridges and deep canyons. General vegetation and climatic descriptions of the study sites were described by Goodrich (1990).

The study was conducted over three winter denning periods from 1987 to 1990.

### Data Collection

Bears were captured in culvert traps and Aldrich foot snares during summer and immobilised with a mixture of ketamine hydrochloride and xylazine (200 mg/ml to 40 mg/ml, respectively). Age was estimated from cementum annuli (Stoneberg & Jonkel, 1966) and animals were classified as cubs (<1.5 years), juveniles

(1.5–3.5 years) or adults (>3.5 years). Selected animals were fitted with radio-collars or intraperitoneal transmitter implants (Telonics, Mesa, Arizona) and those in dens were located from a Cessna 182 fixed-wing airplane, or from the ground. Since reports of den abandonment due to investigator disturbance are common (LeCount, 1983; Manville, 1983; Smith, 1986; Kolenosky & Strathearn, 1987; Hellgren & Vaughan, 1989), we attempted to minimise disturbance when approaching dens from the ground by advancing quietly and from downwind.

Den entry and emergence dates were estimated during the winter of 1988–89 as midway between the first location at the den and the previous location, and the date midway between the last location at the den and the following location. The time period between these locations never exceeded two weeks.

Percent slope, aspect of slope, elevation, and den type were recorded for each den to determine if bears selected specific sites that might be subject to human disturbance. Percent slope and elevation were measured from 1:24000 scale United States Geological Survey (USGS) topographic maps with 12.2 m (40 foot) contour intervals. The aspect of slope on which dens occurred and the frequency that dens were found on slopes as opposed to level areas was compared to 100 random coordinates (hereafter referred to as 'random dens') to examine whether slopes and slope aspects were utilised according to their availability.

Data collected on the same individual during different years were treated as independent random events and pooled. Therefore, statistical conclusions must be treated with caution because pooling of data inflates sample sizes and may increase the true Type I error rate above the stated alpha level (Machlis *et al.*, 1985). However, large samples of different individuals are often logistically impossible to obtain from secretive animals, such as bears, that occur in low population densities.

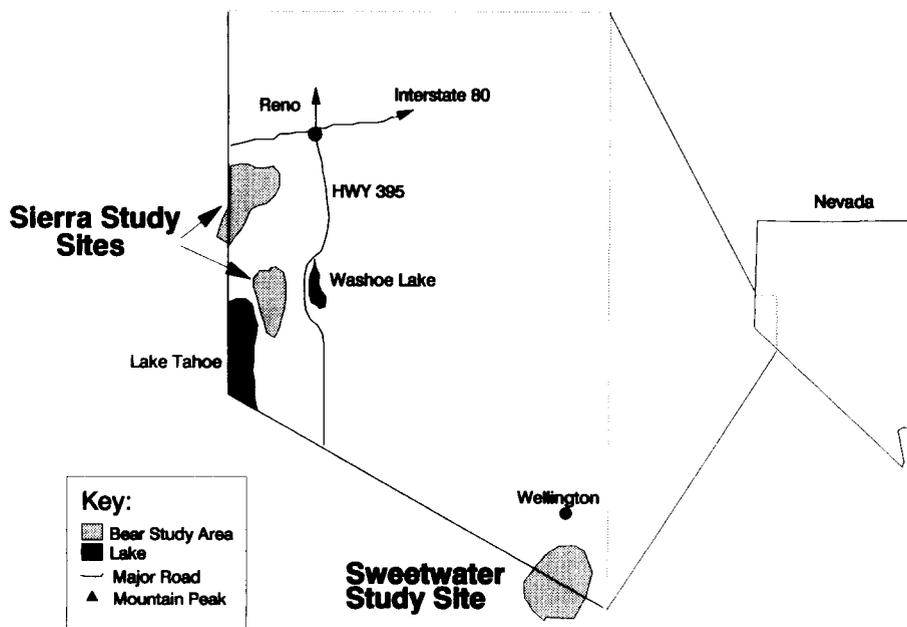


Fig. 1. Location of black bear study areas in the Sierra Nevada and Sweetwater Mountains, Nevada and California.

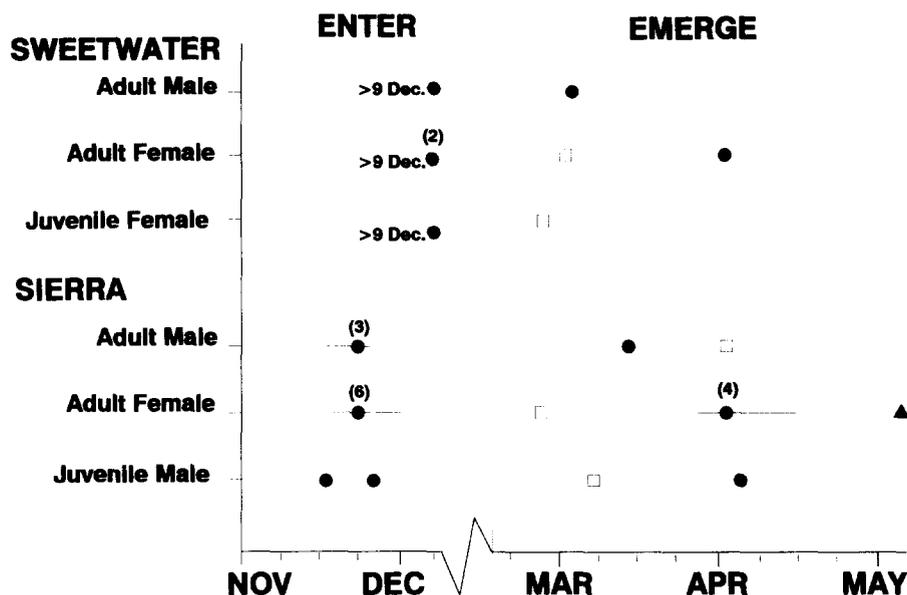


Fig. 2. Den entry and emergence dates for radio-collared black bears in the Sierra Nevada and Sweetwater Mountains in Nevada and California for winter 1988–89. □, abandoned dens; ▲, presence of new-born cubs; ●, normal denning instances; —, ranges. Sample sizes greater than one are in parentheses.

**RESULTS**

Thirty-one dens belonging to 15 different bears were located in the Sierra. These dens were occupied by four adult males (seven dens), three juvenile males (three dens), and eight adult females (21 dens). During the winter of 1987–88, an eight-year-old adult male and a three-year-old adult female used the same den (Goodrich & Stiver, 1989). Ten dens of five different bears were located in the Sweetwaters belonging to three adult females (five dens), two adult males (three dens) and one juvenile female (two dens). The juvenile female became adult during the study, thus the apparent discrepancy in the number of bears in the Sweetwaters.

**Chronology of denning**

Bears in the Sweetwaters entered dens significantly later than in the Sierra ( $G_{adj} = 10.315$ , d.f. = 1,  $p < 0.05$ ) (Fig. 2). There was no difference in emergence dates between the Sierra and Sweetwaters ( $t = 1.76$ , d.f. = 12,  $p > 0.05$ ), but these data may have been confounded by den abandonment and small sample sizes.

**Den types and site selection**

In the Sierra, trees were the most commonly used (53%) den type (Fig. 3). Of tree dens, 11 (69%) were in the bases of hollow, yet usually live, trees, three (19%) were in elevated tree dens (i.e. the cavity was above ground level), one (6%) was in the base of a hollow stump, and one (6%) was in a hollow log. Rock dens, including natural caves and dens dug out under large boulders were also commonly used (37%). Two bears (7%) in the Sierra denned in log or brush piles and one (3%) denned in a hole excavated in the ground.

In contrast, rock dens were most frequently used (56%) in the Sweetwaters. Two bears (22%) in the Sweetwaters wintered in trees and two on the ground in ‘nests’ constructed at tree bases. Stands containing tree

species growing large enough to support bear dens made up less than 1% of the available habitat in the Sweetwaters (Goodrich, 1990).

Average den elevation was significantly lower ( $t = 4.063$ , d.f. = 39,  $p < 0.005$ ) in the Sierra (2310 m, range 1799–2713 m) than in the Sweetwaters (2656 m, range 2256–3001 m), possibly due to elevation differences between study sites. That is, denning habitat below 1900 m did not exist in the Sweetwaters, while habitat above 3000 m did not exist on the Sierra study site.

Bears in the Sierra selected north- to east-facing slopes at a greater proportion than those slopes were available ( $G_{adj} = 10.42146$ , d.f. = 3,  $p < 0.025$ ) (Fig. 4), but no selectivity was detected in the Sweetwaters ( $G_{adj} = 1.56$ , d.f. = 3,  $p > 0.10$ ). Tree dens occurred on a greater variety of slope aspects than other den types; however, the difference was not significant when tree

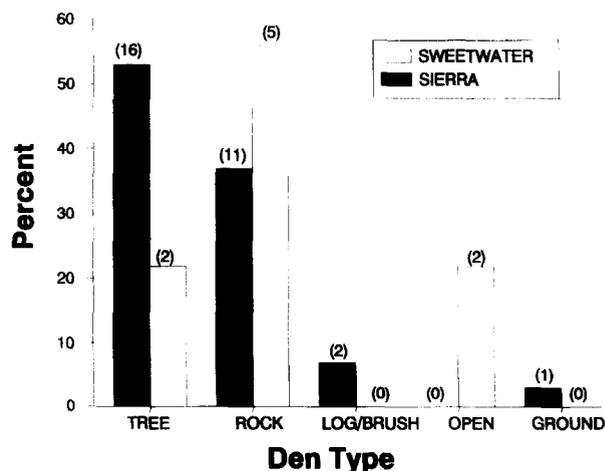


Fig. 3. Den types used by bears in the Sierra Nevada and Sweetwater mountains in Nevada and California during the winters of 1987–88, 1988–89 and 1989–90. Sample sizes are in parentheses.

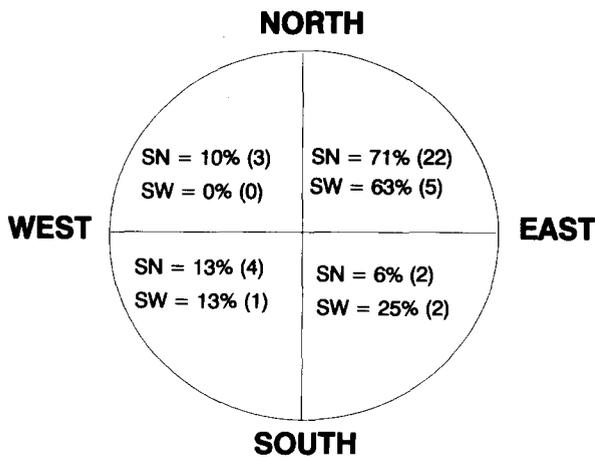


Fig. 4. Slope aspects on which bears denned in the Sierra Nevada (SN) and Sweetwater (SW) Mountains in Nevada and California during the winters of 1987–88, 1988–89 and 1989–90. Sample sizes are in parenthesis.

dens were compared to all other den types combined ( $G_{adj} = 3.51$ , d.f. = 2,  $p > 0.10$ ). Bears selected slopes as opposed to level areas in a greater proportion than slopes were available in the Sierra ( $G_{adj} = 4.18$ , d.f. = 1,  $p < 0.05$ ), but no preference was detected in the Sweetwaters ( $G_{adj} = 0.01$ , d.f. = 1,  $p \gg 0.10$ ). The average percent slope denned on by bears was 42% (range 21–66%) in the Sierra and 36% (range 0–73%) in the Sweetwaters.

#### Abandonment

Despite precautions to minimise disturbance, two types of den abandonment occurred in response to our activities: (1) flight as the field crew approached; and (2) departure after immobilisation (Fig. 5). New-born cubs were abandoned in the Sierra in two cases: one after immobilising and handling the mother in her den and the other as we approached, but were still approximately 75 m away. In another case, a Sweetwater female abandoned a one-year-old cub when we approached to

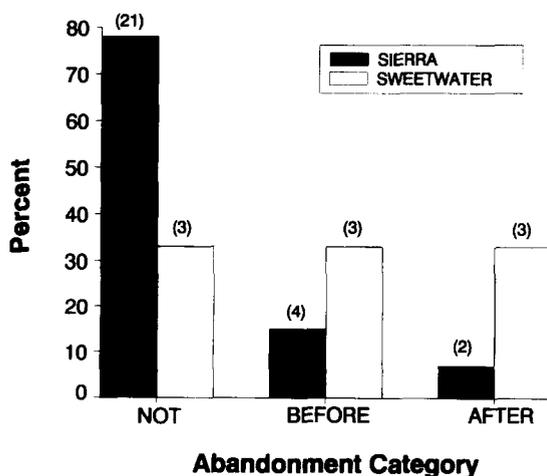


Fig. 5. Frequency of bear den abandonment in the Sierra Nevada and Sweetwater mountains in Nevada and California during the winters of 1987–88, 1988–89 and 1989–90. 'Before' refers to bears that fled as the field crew approached, and 'after' to bears that fled after visitation to the den site.

within 1 m of the den entrance. Abandonment frequencies did not differ between the two study sites ( $G_{adj} = 5.414$ , d.f. = 2,  $p > 0.05$ ). Abandonment was highest for the first category, but estimates for the second were conservative because removal of radio-collars from denned bears in 1990 made follow-up impossible.

#### DISCUSSION

We obtained direct evidence that hibernating bears are sensitive to human disturbance by examining den abandonment rates in response to our activities at den sites. Since the quiet approach of investigators sometimes causes abandonment of dens and cubs (this and other studies; LeCount, 1983; Manville, 1983; Smith, 1986; Kolenosky & Strathearn, 1987; Hellgren & Vaughan, 1989), skiing and other recreational activities could have the same or more heightened effects. This would adversely affect individual fitness and reduce physical condition. For instance, in Alberta, bears that abandoned dens experienced greater overwinter weight loss than those that did not (Tietje & Ruff, 1980). In addition, disturbance of bears during the transition into hibernation may cause death from starvation and urea poisoning (Lundberg *et al.*, 1976). Although other studies (Kolenosky & Strathearn, 1987; Hellgren & Vaughan, 1989) have found that bears often select new dens after abandonment, only one bear in this study was known to do so; the rest moved to lower elevations and remained active.

We did not document den abandonment due to recreational disturbance, but indirect evidence of the problem exists. Bears were sighted on ski runs bordering the Sierra study area on at least two occasions in early February 1989 and two bears were reported at another ski area in late December 1988. Because these activities occurred several weeks before any radio-collared bears had emerged from their dens, it seems likely that the uncollared bears abandoned their dens, possibly the result of human recreational disturbance. Evidence of human-caused den abandonment is available from other areas. Tietje and Ruff (1980) indicated that oil drilling activities may cause den abandonment, while Manville (1983) noted that two bears moved to new dens when their original dens were 0.15 km from an active oil well and 0.09 km from a snowmobile trail. Brown bears *U. arctos* may also abandon dens when disturbed by humans and usually select den sites in isolated areas, presumably to avoid human activity (Craighead & Craighead, 1972b; Buchalzyk, 1980; Jonkel, 1980 in Interagency Grizzly Bear Committee, 1987).

Some animals, including bears (Harms, 1980; Zardus & Parsons, 1980), may become habituated to human disturbance, especially in national parks and other areas where animals are not hunted (Dorrance *et al.*, 1975; Schultz & Bailey, 1978). The lack of a difference between abandonment frequencies in the Sierra and the relatively undisturbed Sweetwaters suggests that Sierra bears have not habituated to human disturbance.

However, small sample sizes may have failed to detect a difference and the data suggest a trend towards higher abandonment frequencies in the Sweetwaters (Fig. 5).

Novick *et al.* (1981) suggested that bears in southern California selected den sites with minimal human disturbance. This could explain why Sierra bears were selective in their choice of den sites while Sweetwater bears were not. However, Sierra bears often denned in areas where high human disturbance was expected (e.g. three bears denned within 75 m of seasonally used dirt roads), indicating that they did not select sites with minimal disturbance. It is more plausible that Sierra bears selected sites with deep snow, while Sweetwater bears were not selective because snow depths were not sufficient to cover dens.

There was increased potential for den abandonment in the Sierra due to similarities between the sites selected by black bears for dens and those selected by ski resorts for ski runs. For example, snow accumulation was greatest on slopes with aspects most often selected by bears (i.e. north to east) due to decreased sunlight and prevailing winds; these sites are also selected for ski runs for the same reason. Bears may select slopes with higher snow accumulations because of the insulating properties of snow. Beecham *et al.* (1983) found similar results in Idaho and grizzly (brown) bears have been noted to select north-facing slopes in some cases (Craighead & Craighead, 1972a), but south-facing slopes where snow depth did not vary with slope aspect (Serveen & Klaver, 1983).

Further overlap between denning areas and ski resorts occurred because the range of percent slope and elevation of the ski areas was well within the range on which dens were located. For example, the two ski areas bordering the Sierra site ranged from nearly level to 58% slope and from 2012 m to 2926 m in elevation. In addition, bears preferred to den on slopes rather than level areas. Denning on slopes may be important for maintaining insulating snow cover at the den entrance while minimising snow in the den chamber, as has been described for grizzly bears (Vroom *et al.*, 1980). These similarities between den sites and ski areas increase the potential for high human winter activity in important black bear denning habitat which may result in high den abandonment rates.

Our data imply that protecting black bear denning areas from human disturbance in winter is important to minimise cub abandonment and needless energetic expenditures by increased winter activity. Future land use planning in the Tahoe Basin should be geared toward diminishing human winter activities in important black bear denning areas. Since den site characteristics vary between regions, data on black bear denning ecology is necessary for each population or region where black bear management and conservation is a concern in land use planning in North America.

The conservation of bear species has become a worldwide concern as populations decrease under the pressure of increasing human populations. Although

black bears occur exclusively in North America, the above discussion may apply to other species that face more immediate threats to their survival. For example, brown or grizzly bears have similar denning habits to black bears (e.g. Vroom *et al.*, 1980) and are very sensitive to human disturbance, including recreational activities (Zunino & Herrero, 1972; Elgmork, 1978; Interagency Grizzly Bear Committee, 1987). This species has been reduced to small isolated populations in many parts of its range in Europe, Asia, and North America (Cowan, 1972; Curry-Lindahl, 1972) and minimising human disturbance in important habitats, including denning areas, is essential to their conservation.

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