Winter ecology of American black bears in a desert montane island

F. Scott Mitchell, Dave P. Onorato, Eric C. Hellgren, J. Raymond Skiles, Jr., and Louis A. Harveson

Abstract American black bears (*Ursus americanus*) have recolonized western Texas following extirpation in the mid-1900s. Knowledge of winter ecology of black bears is important for conservation and management because denning, parturition, and early cub development occur during this period. We monitored 13 radiocollared black bears for 22 den-years in Big Bend National Park (BBNP) during 1998–2003. All pregnant females (n=6), 2 females with yearlings, 7 subadults, and 1 adult male denned. Three females with yearlings remained active during winter 1998–1999. We located 4 cave dens, 5 ground dens, and 6 rock-pile dens. Volume and elevation of den sites averaged 2.00 m^3 (SD=1.51) and 1,800 m (SD=346), respectively. Mean (±SD) dates of den entrance and emergence for 5 pregnant females were 30 December±17 days and 27 April±21 days, respectively, producing a mean denning period of 118±29 days. Pregnant females exited dens later (P=0.003) and denned longer (P=0.02) than solitary females and males. Black bears in western Texas used den sites located in higher elevations that were remote and highly defensible. A den-habitat model described less than 56 km^2 of suitable denning habitat within and bordering BBNP. Resource managers should reduce visitor and management activities in and around potential denning areas during winter.

Key words American black bears, bear–human interactions, Big Bend National Park, Chihuahuan Desert, den model, denning habitat, denning period, *Ursus americanus*

Black bear (*Ursus americanus*) were common in the Chisos Mountains and other areas of west Texas in the early 1900s (Bailey 1905). Black bear populations declined during the early part of the century, primarily due to unregulated hunting and predator-control regimes (Onorato and Hellgren 2001). Since 1988 a resident population of black bears has returned to Big Bend National Park (BBNP; Hellgren 1993, Skiles 1995, Mitchell 2001, Onorato et al. 2003). Mitochondrial- and nuclear-genetic data indicate a mainland-island metapopulation of black bears in the larger western Texas–northern Mexico border region linked by male movements and structured by female philopatry (Onorato 2003, Onorato et al. 2004).

The reestablishment of black bears in BBNP poses new challenges for natural resource managers, especially in the area of bear–human interactions. On public lands bears are alternatively considered a species of special concern, a game animal, an indicator species, or a nuisance animal (Pelton 1982). Many national parks in northern latitudes and higher elevations that support populations of black bears, such as Yellowstone, Yosemite, Rocky Mountain, and Sequoia-Kings Canyon, have relatively low human visitation in winter. However, peak

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visitation at BBNP (Dec–Apr) coincides with denning behavior of black bears in this region (LeCount 1983, Doan-Crider and Hellgren 1996), and black bears are known to abandon dens following disturbance (Hellgren and Vaughan 1989). Thus, park visitors potentially could disturb denning bears in BBNP. Understanding black bear denning habits is essential to sound black bear management (Goodrich and Berger 1994). Knowledge of denning chronology, habitat, and site characteristics is necessary for managers to make informed management decisions, especially in a national park with approximately 500,000 visitors/year.

Knowledge of winter ecology can aid development of management strategies that will become increasingly important as the bear population in BBNP continues to increase. Our objectives were to locate and classify dens, record denning chronology, and classify microhabitat surrounding den sites. Additionally, we used data relating to physical characteristics at den sites to produce a den-habitat model depicting availability of suitable denning habitat in BBNP and adjacent ranges.

Study area

We conducted our research within the boundaries of BBNP, located approximately 122 km south of Alpine, Texas, in the southern portion of Brewster County (Figure 1). Big Bend National Park was established in 1944 and consists of approximately 324,291 ha of the Chihuahuan desert ecosystem (Skiles 1995). Elevations varied from approximately 2,385 m at the top of Emory Peak to 563 m near the Rio Grande. Big Bend National Park has a temperate climate, with precipitation and temperatures varying dependent on elevation. Monthly temperatures ranged from –5–22ºC in January, to 13–43ºC in July. Temperatures during the study ranged from –2–40ºC. Annual precipitation ranged from 5–50 cm, with averages from 35 cm in the upper elevations to 20 cm at lower elevations (BBNP, unpublished data).

Methods

Trapping occurred throughout much of BBNP but focused in the Chisos Mountains (latitude 29º 15′N, longitude 103º15′W; Onorato et al. 2003). We captured bears using barrel traps during September 1998–December 1998, June 1999–December 1999, and June 2000–December 2000. We baited traps with deer (*Odocoileus* spp.) and javelina (*Tayassu tajacu*) furnished by BBNP employees from animals killed on park roads, and canned sardines. We injected Telazol (Fort Dodge Animal Supply, Fort Dodge, Ia.) intramuscularly via a jabstick at a rate of 5.5 mg/kg to immobilize captured bears (Doan-Crider and Hellgren 1996). We weighed, measured, sexed, and aged bears (Willey 1974) and fitted each with a radiocollar (Mod-500, Telonics, Mesa, Ariz.) with a mortality sensor.

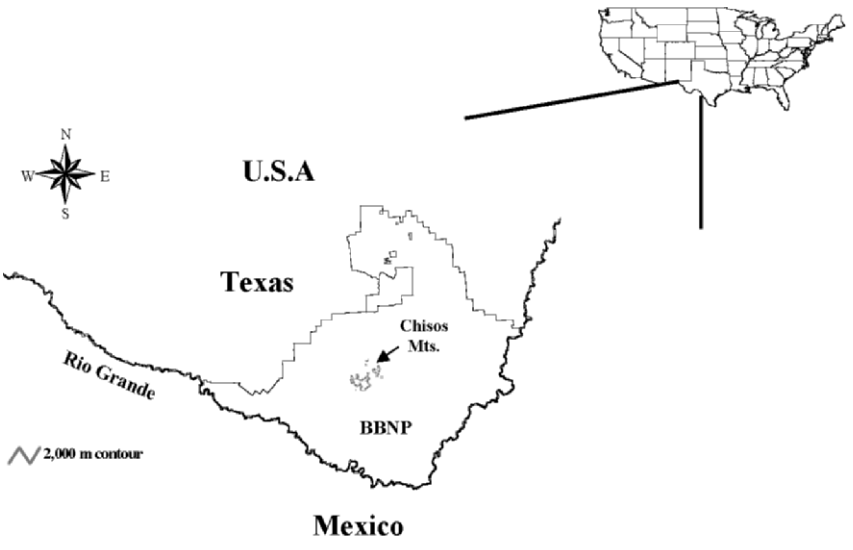

Figure 1. Location of Big Bend National Park (BBNP), Texas, along the United States–Mexico border. Black bear habitat was concentrated in the higher elevations of the Chisos Mountains located in the center of the park.

We located radiocollared bears weekly or biweekly during winter (15 Dec–30 Mar) by aerial or ground telemetry. Comprehensive den work during winters 1998–1999 and 1999–2000 was not repeated in denning seasons from 2001–2003, due to logistical constraints. Subsequently, sample sizes for analyses did not always correspond to the total number of dens that were located ($n = 15$). Additionally, 1 pregnant female was known to have denned in winter 2001–2002, but her den was never located. We estimated the general locations of

radiocollared bears based on signal strength and location. We obtained den locations by circling the signal until we observed bears or made a complete circle around the locations (Doan-Crider and Hellgren 1996). We plotted locations on a 7.5-minute topographic map obtained from a handheld Global Positioning System. We located dens without disturbing the bears. We recorded entrance and emergence dates for each denned bear and monitored den sites during the winter to determine reproductive status of adult females.

We used Mann-Whitney *U*-tests to compare den entrance, den emergence, and duration of denning between adult (≥4 years old) pregnant females and all other bears. We measured height and width of entrance, and height, width, and length of chamber after denning. We derived a relative volume estimate (RVE) from the chamber measurements (Beck 1991). Elevation, relief, den-entrance azimuth, and den type were recorded. We compared elevations of dens between adult and subadult bears using a Mann-Whitney *U*-test. We classified den-site locations according to BBNP habitat classification schemes described by Onorato et al. (2003).

We estimated vegetation characteristics surrounding the den site using 4 line intercepts (20 m) running in the 4 cardinal directions and originating at the den entrance. We measured all vegetation, rocks, and litter and calculated percent cover of each category (LeCount 1990). Some transects were not available for quantification due to steep slopes and inaccessibility. We surveyed transects at these sites as far as possible and calculated cover using weighted proportions of individual transects. We used a 20-m-diameter circular plot originating at the den entrance to obtain densities of trees and shrubs surrounding the den site. We classified trees and shrubs as deciduous or nondeciduous.

We modeled landscape-vegetation characteristics to determine the amount of potential denning habitat available to black bears in the Big Bend region. Slope, elevation, and aspect were determined from field data collected at den sites or using United States Geological Survey digital-elevation models (DEM's) with the grid tools extension in ArcView. We utilized a modified Rayleigh's Test (Zar 1999) to determine mean aspects of den entrances and whether the azimuths were significantly different from 180. We entered ranges for slope, elevation, and aspect into the map calculator as a series equation to determine the proportions of the BBNP landscape that met those criteria.

Results

We monitored 13 radiocollared bears for 22 den-years (5 F in 1998–1999, 6 F and 4 M in 1999–2000, 2 F and 2 M in 2000–2001, 1 F and 1 M in 2001–2002, 1 F in 2002–2003). During 5 winters all pregnant females ($n=6$), subadult bears ($n=7$), 1 adult male, and 2 females with yearlings denned. One solitary adult female briefly denned in winter 2000–2001. In winter 1998–1999, 3 females with cubs did not den.

One adult male bear (1999–2000) used 2 separate dens, of which only 1 was successfully located. Four dens were in caves, 5 in the ground, and 6 in rock piles. Three ground dens were totally excavated, and 2 were partially excavated or under rock formations. Den volumes ($n=12$) averaged 2.00 ± 1.51 m^3 (range: 0.32–5.9), and elevations of den sites ($n=15$) averaged $1{,}800 \pm 346$ m (Table 1). Distances from den sites to the nearest road or trail averaged 562 m (range: 23–1,930).

Den entry dates ranged from 4 December–1 February, and emergence dates ranged from 8 March–17 May. The denning period ranged from 35–151 days (Table 2). Pregnant females exited dens later ($P=0.003$) and denned longer ($P=0.02$) than solitary nonpregnant bears, but there was no difference ($P=0.462$) in den entrance dates. We documented 1 case of repeat den use, where a female gave birth to 3 cubs in winter 1998–1999 and returned to the same den with her 3 yearlings the following winter.

Eleven of the 15 dens were located in a pinyon (*Pinus* spp.)–oak (*Quercus* spp.)–juniper (*Juniperus* spp.)–talus–meadow–grass association at higher elevations of the Chisos Mountains (Onorato et al. 2003). Remaining dens were located in either the sotol (*Dasylirion leiophyllum*)–yucca (*Yucca* spp.)–lechuguilla (*Agave lechuguilla*)–grass ($n=3$) or creosote (*Larrea tridentata*)–lechuguilla–prickly pear (*Opuntia* spp.)–grass–mesquite (*Prosopis* spp.) ($n=1$) associations at lower elevations. We found rock–bare ground was the dominant cover type (30.5%) surrounding den sites ($n=10$), with herbaceous (24%) and shrub (27.4%) cover being secondary. We recorded an average of 15.9 (SE = 7.5) nondeciduous trees and 22.5 (SE=8.1) deciduous trees within a 20-m radius of the dens. Additionally, an average of 10.6 (SE=4.0) nondeciduous and 16.7 (SE=3.8) deciduous shrubs were located in the same area.

Aspect values for den entrances were not uni-

Table 1. Dimensions, elevations, and distances of black bear dens from roads and trails in Big Bend National Park, Texas, 1998–2003.

			Entrance		Chamber					
Bear ID	Age group	Den year	Height (m)	Width (m)	Height (m)	Width (m)	Length (m)	Volume (m^3)	Elevation (m)	Distance from trail/road (m)
F01[a,b]	Adult	1998–1999	0.99	0.94	1.15	1.22	2.13	2.99	1,919	1,092
F01	Adult	2000–2001	N/A[a]	N/A	N/A	N/A	N/A	N/A	2,024	665
F02[b]	Adult	1999–2000	0.54	0.66	0.77	1.64	1.47	1.86	1,783	687
F03[b]	Adult	1999–2000	0.52	0.61	1.54	1.48	2.59	5.90	2,196	23
F04	Subadult	1999–2000	0.66	1.38	0.77	1.77	1.25	1.70	1,767	292
F05[b]	Adult	1999–2000	0.52	0.82	0.81	1.52	1.54	1.90	1,952	900
F06[b]	Adult	1999–2000	0.72	0.63	0.96	1.66	1.88	3.00	1,922	1,842
F29	Subadult	2000–2001	1.36	1.23	0.72	0.89	0.50	0.32	813	708
F29	Adult	2002–2003							1,582	1,930
M08	Subadult	1999–2000	0.22	0.38	0.61	1.12	1.44	0.98	1,830	101
M09	Subadult	1999–2000	0.52	0.61	0.65	1.03	1.50	1.00	1,378	786
M10	Subadult	1999–2000	0.67	1.72	0.66	1.22	2.11	1.70	1,738	897
M11	Adult	1999–2000	0.75	0.59	1.05	1.42	1.55	2.31	2,209	109
M14	Subadult	2000–2001							1,918	951
M28	Subadult	2000–2001	0.51	0.57	0.83	0.58	0.80	0.39	1,970	1,062

[a] Bear F01 made a ground den with no entrance or chamber in winter 2000–2001.
[b] Pregnant females.

formly distributed ($U=1.831$, $P<0.05$). The mean azimuth value of 163 (range: 82–348) was not significantly different from 180, demonstrating selection of south-facing slopes by black bears in BBNP. Adult dens typically were at higher elevations ($n=8$, ±SD=1,948±206 m) than those of subadults ($n=7$, 1,631±408 m; $U=11.0$, $P<0.05$). The den habitat model (Figure 2) described 55.16 km^2 of suitable denning area out of 4,635.26 km^2 that were analyzed (including BBNP and adjacent ranges bordering the Park [Christmas Mountains, Rosillos Mountains, and Dead Horse Mountains]). Modeled den habitat was concentrated in the higher elevations of the Chisos Mountains (Figure 3), and some of those areas were in close proximity to roads and trails. Adjacent ranges bordering the park also were predicted to contain areas with suitable denning habitat.

Discussion

Our observations on black bear denning support previous studies indicating that black bears in southern latitudes den for shorter time periods than bears in northern latitudes (Smith 1985, Hellgren and Vaughan 1989). Denning chronology for pregnant females in BBNP was similar to that of other southern black bear populations (Smith 1985, Hellgren and Vaughan 1989, Wooding and Hardisky 1992, Doan-Crider and Hellgren 1996, Oli et al. 1997). Differences in denning among years suggested black bears in this region could remain active during the winter, as demonstrated by females with yearlings remaining active during 1998–1999. Winter-active bears have been reported in other southern populations including the southeastern Coastal Plain (Hamilton and Marchinton 1980, Hellgren and Vaughan 1989, Wooding and Hardisky 1992, Oli et al. 1997) and Coahuila, Mexico (Doan-Crider and Hellgren 1996). Certain cohorts, especially females with yearlings and males, commonly are winter-active in southern latitudes (Doan-Crider and

Table 2. Denning chronology for American black bears in Big Bend National Park, Texas, 1998–2003.

		Entry		Emergence		Period	
Cohort[a]	*n*	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
PF	5	30-Dec	17 days	27-Apr	21 days	119 days	28 days
NPB	10	1-Jan	13 days	24-Mar	8 days	80 days	23 days
M	6	28-Dec	16 days	24-Mar	10 days	79 days	31 days

[a] Cohort abbreviations refer to pregnant females (PF), non-pregnant bears (NPB), and male bears (M).

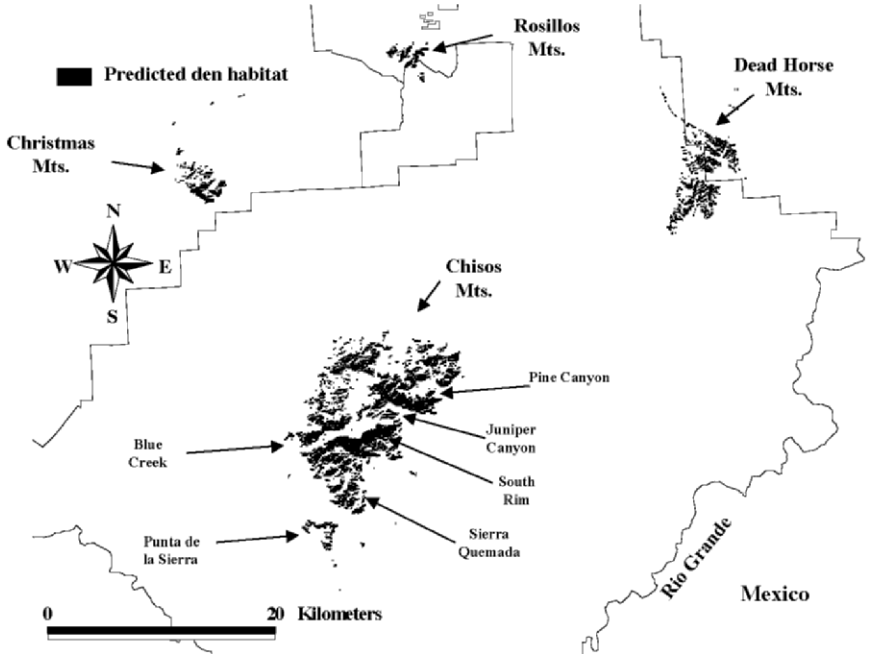

Figure 2. Predicted black bear den habitat in Big Bend National Park (BBNP) described using a Geographic Information System den model. Suitable habitat was concentrated in the Chisos Mountains, but additional habitat was estimated to be located in mountain ranges on the periphery of BBNP. Geographical names of locations pertaining to denning habitat in the text are labeled throughout the Chisos range.

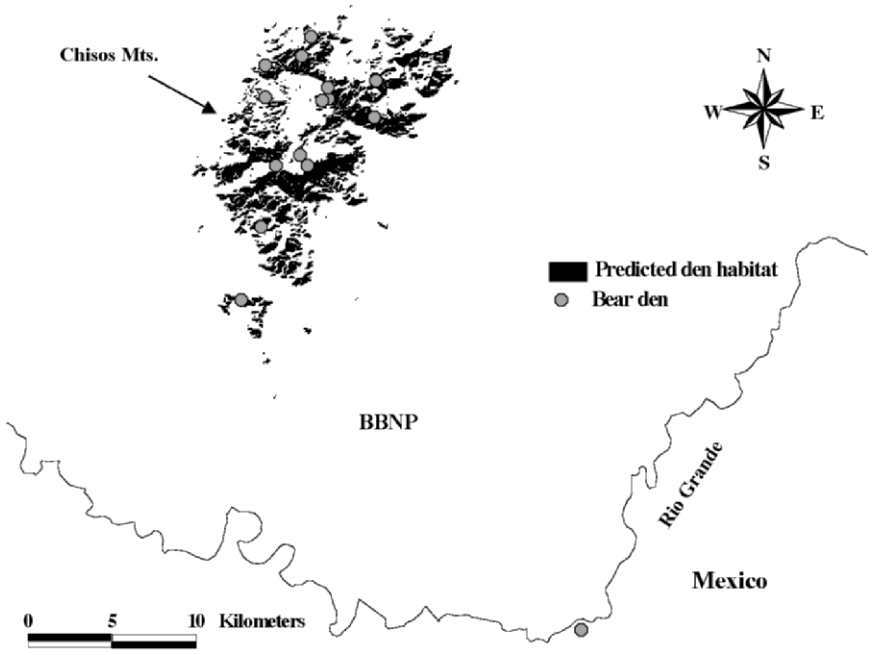

Figure 3. Location of 15 black bear den sites in Big Bend National Park (BBNP). Den locations were concentrated in the higher elevations of the Chisos Mountains but also occurred in the Sierra Quemada and Punta de la Sierra (see Figure 2). Note the den site located on the Mexican side of the Rio Grande.

Hellgren 1996). Black bears that remain active during the winter also have been documented in a concurrent study conducted by Texas Parks and Wildlife Department on Black Gap Wildlife Management Area located on the northeast border of BBNP (Texas Parks and Wildlife Department, unpublished data).

Yearly differences in denning patterns may be tied to food availability and associated bear nutritional condition or weather patterns. Johnson and Pelton (1980) hypothesized that bears have evolved an endogenous, circannual rhythm as the ultimate denning mechanism, with environmental cues providing the stimuli to den and hibernate. Variation in these cues can change timing of the rhythm. For example, several conditions associated with southern latitudes are correlated with winter activity in black bears. These conditions include mild temperatures, lack of snow cover, moderate food availability, and relatively long winter photoperiod (Hellgren and Vaughan 1987). The Big Bend region exhibits these climatic and ecological characteristics, which may lead to a circumvention of denning behavior. The occurrence of intermittent activity during winter (brief periods of denning interspersed with periods of activity) is more difficult to docu-

Radiocollared American black bear (*Ursus americanus*). Black bears have naturally recolonized Big Bend National Park.

ment and explain. We did not observe intermittent denning activity in monitored bears, although it may have occurred beyond the scale of our monitoring.

Den placement was most common on rock outcrops and on steep (>70%) canyon walls, consistent with characteristics reported for black bears in Arizona (LeCount 1990). Doan-Crider and Hellgren (1996) also reported that den sites were located in large boulder piles on hillsides, on cliff ledges, and in narrow rock caves. Most dens (80%) were located in remote areas of BBNP. Visitation by tourists and hikers to a majority of dens (especially dens selected by pregnant females) is highly unlikely due to the general inaccessibility and extreme topography associated with routes to these den sites. Although the highest density of roads and trails in BBNP occurs in the Chisos Mountains, only 1 den was found <100 m from a trail. Additionally, this den (selected by a pregnant female) was located on the edge of the South Rim in the upper elevations of the Chisos. It was positioned on a steep cliff face 23 m from the edge and bordered by a >750-m cliff dropping to lower elevations in the Chihuahuan Desert.

The most common characteristic shared by black bear dens was the small entrance. Regardless of the volume, entrances were considerably smaller than the chamber. Four of the 5 den entrances of pregnant females were not much larger than minimally necessary to permit a full-grown bear to enter. In total, small entrances that allowed for easy defense characterized 11 of 15 dens. The only den site that was vulnerable from >1 direction was the den of an adult male. Beck (1991) suggested that den-site selection was associated with the fact that it could be defended from predators.

Our den model notes the small amount of available denning areas in BBNP. A caveat is necessary when interpreting these results due to small sample size ($n = 15$) in our den model. Nevertheless, the model illustrates the concentration of denning areas in the high-elevation areas of the Chisos Mountains (>1,800 m) and also portrays the proximity of some of these areas to hiking trails. The Chisos Mountains are the most heavily visited part of the Park and contain the highest concentration of hiking trails in that range. Although direct contact between denning bears and visitors is unlikely, noise associated with heavily traveled hiking trails could disturb denning bears.

Large portions of the south-facing slopes in the high elevations of the Chisos are estimated to be good denning habitat. These areas encompass portions of the South Rim, Blue Creek, Pine Canyon, and Juniper Canyon (Figure 2). The latter 3 areas are not intensely used by hikers, even in the busy winter season (Dec–Apr). The South Rim is one of the most popular destinations for hikers in the high Chisos due to the scenic views it provides. Coincidentally, large portions of the South Rim are closed to Park visitors from February–May for the peregrine falcon (*Falco peregrinus*) nesting season. This closure limits human access during a busy visitor period and indirectly benefits hibernating bears in the area by reducing the probability of disturbance.

The northern section of the Chisos Mountains is not estimated to contain as much suitable black bear denning habitat. Four of the 15 located dens were in the northern section of this range. This part of the Chisos contains no marked hiking trails and is very remote. Bears that den in this area are unlikely to be disturbed by park visitors. Denning habitat estimated to be located in the extreme southern portion of the Chisos (e.g., Sierra Quemada and Punta de la Sierra) also is remote and infrequently used by hikers.

Management implications

The presence of potential denning habitat in ranges bordering the Park has important implications. These areas are either not used by the public (because they are on private land) or in very

Scott Mitchell weighs a black bear cub extracted from a den at Big Bend National Park while Dave Onorato records data.

remote parts of the northern portion of BBNP. Suitable denning habitat in these ranges also may indicate the presence of small "populations" of bears in these areas that have remained undocumented. Habitat in these ranges is similar to the Black Gap Wildlife Management Area, which supports a small population of black bears approximately 40 km northeast of BBNP.

The return of black bears to BBNP after an absence of >40 years has returned a sense of wildness to the park that attracts a multitude of visitors from winter through late spring. The knowledge provided by research on the winter ecology of black bears will inevitably be important for the continuation of the recolonization process. The combination of sound human management and bear reproductive success in the Chisos should facilitate successful return of black bears to BBNP and nearby ranges.

The cross-border movement of black bears documented during research in BBNP (Onorato et al. 2003) reveals the importance of international cooperation and management of black bears in the Big Bend ecosystem. Mexican and United States protected areas (BBNP, Big Bend Ranch State Park, Black Gap Wildlife Management Area, Canon Santa Elena, and Maderas del Carmen) represent >1 million ha and provide the framework for improved cooperation. Additionally, an international Letter of Intent to Cooperate between United States Department of Interior's National Park Service, Texas Parks and Wildlife Department, and Secretaria de Medio Ambiente y Recursos Naturales of Mexico is in place, along with annual cooperator planning meetings that serve as a forum for formal adoption of projects and goals.

To improve international cooperation, a better understanding of dispersal routes and habitats is necessary, and a long-term mast monitoring and modeling strategy would improve predictability and preparedness for food-stress-related migration episodes that represent risk to the Chisos Mountains black bear population. Finally, a mechanism for outreach, education, and conflict resolution is required to enhance further recolonization of black bears to the Big Bend region.

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