Home range and habitat use of American black bears on a desert montane island in Texas

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Abstract: American black bears (*Ursus americanus*) have recolonized Big Bend National Park (BIBE), Texas, in the past 15 years from adjacent habitat in northern Mexico. Range expansion by the Big Bend bear population across the Chihuahuan Desert landscape has considerable consequences for the recolonization of areas north of BIBE in western Texas (Glass, Del Norte, and Davis Mountains). We studied black bear ecology from 1998 to 2001 in BIBE. Thirty bears were marked (15 with radiocollars) during the study, including newborn cubs. Home ranges of bears (males $\bar{x} = 97.7$, SE = 35.8 km^2, females $\bar{x} = 32.1$, SE = 4.3 km^2) were larger than in southwestern populations in Arizona and northern Mexico, but smaller than those in the nearby Black Gap Wildlife Management Area (BGMWA). Bears were mainly restricted to the Chisos Mountains and their foothills, with 65% of radiolocations in the pinyon (*Pinus cembroides*)–oak (*Quercus* spp.)–juniper (*Juniperus* spp.)–talus–meadow-grass vegetation association. Habitat selection analyses indicated that bears used oak-dominated vegetation types more than expected based upon availability. Bears were more likely than random to be <100 m from anthropogenic features (e.g., roads, trails), but that effect was much stronger in summer when visitor use was low. These data provide predictive capability to managers regarding recolonization of other montane islands north of BIBE and provide information that will help managers ensure the persistence of the small island population of black bears in BIBE.

Key words: American black bear, Big Bend National Park, Chihuahuan Desert, habitat selection, home range, metapopulation, Mexico, recolonization, Texas, *Ursus americanus*

American black bears were once prevalent throughout parts of the Trans-Pecos region of western Texas (Onorato and Hellgren 2001). Bears in the Chihuahuan Desert landscape historically survived on chains of montane islands surrounded by a sea of inhospitable desert. As anthropogenic activity (cattle and goat ranching) increased in western Texas during the late 1800s and early 1900s, extermination of several large carnivores became a top priority. By the 1940s, black bear and Mexican wolf (*Canis lupus baileyi*) were extirpated from the Trans-Pecos due to predator control regimes and unregulated hunting (Onorato and Hellgren 2001).

However, black bears survived in large remnant populations in the mountain ranges of northern Coahuila, Mexico (Fig. 1). Populations in the Sierra del Carmen and Serranias del Burro Mountains apparently served as reservoirs for bear reproduction and dispersal into the Trans-Pecos region (Doan-Crider and Hellgren 1996, Onorato and Hellgren 2001, Onorato et al. 2004). Dispersal from these ranges into the Chisos Mountains of Big Bend National Park (BIBE), Texas, resulted in natural recolonization during the mid-1980s, and reproduction within BIBE was verified in 1988 (Skiles 1995). This recolonization process was corroborated by historical records of visitor observations of black bears in BIBE from the early 1900s until 2000 (Onorato and Hellgren 2001).

Range expansion as the BIBE population of black bears grows has important consequences for resource managers

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in BIBE and for assessing prospects for recolonization of other habitats former-ly occupied by black bear north of BIBE. The Glass, Del Norte, and Davis Mountains (Fig. 1) are known to have supported bear populations in Post-Columbian times. Knowledge of seasonal bear distribution and spatio-temporal range use can facilitate man-agement and conservation initiatives.

Our objectives were to describe landscape use and home range charac-teristics for black bears in a portion of their distribution that had not been intensively sampled. Additionally, we compared bear range use to visitor use and the associated effect of human-related landscape features. These data will be instrumental in preventing negative bear–human interactions fre-quently observed in other national parks. They also will allow park managers to implement appropriate measures to ensure that natural recolo-nization can proceed in the Chisos Mountains.
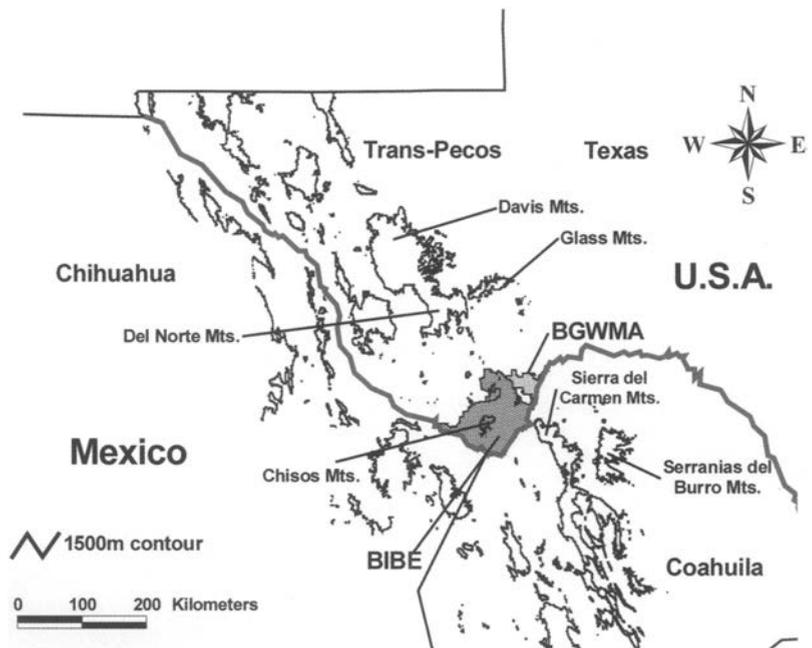

Fig. 1. Big Bend National Park (BIBE) in the Big Bend Ecosystem, location for a 1998–2001 study of black bears in the Chisos Mountains. The Serranias del Burro and Sierra del Carmen ranges in northern Coahuila, Mexico, constitute large, contiguous areas of black bear habitat. BGWMA = Black Gap Wildlife Management Area, Texas, USA.

Study area

We conducted fieldwork between September 1998 and December 2001 in Big Bend National Park, Texas, which encompasses 320,000 ha of northern Chihuahuan Desert in the Trans-Pecos of western Texas (Fig. 1). Climate of the Big Bend Ecosystem is arid, and elevation ranges from 550 m to 2,385 m. Average annual precipitation totals 30.5 cm, with most falling during thunderstorms in July, August, and September. Rainfall accumulations generally increase with elevation within BIBE (Powell 1998). Plumb (1987) described 28 vegetation associations in BIBE and subsequently digitized them into a geographic information system (GIS) data layer. We reclassified these 28 associations into 10 based on recommendations from specialists in BIBE (Table 1; an 11th category is for areas with no data).

Methods

Trapping and handling

We captured black bears using barrel traps baited with sardines and fish oil. Traps were made of two 55-gallon drums bolted together and outfitted with a sliding door

at one end and heavy wire mesh at the other. A trigger arm, on which the bait was placed, activated the sliding door. These traps can capture bears ≤ 140 kg (H. Black, Department of Zoology, Brigham Young University, Provo, Utah, USA, personal communication, 1999), which was likely the maximum mass attained by BIBE black bears (Maehr et al. 2001).

We concentrated trapping in 2 major zones. The low-country trapping zone (LCZ) encompassed elevations from 1,000 to 1,800 m and the high-country trapping zone (HCZ) included sites in the high Chisos >1,800 m. Trapping in both zones simultaneously was not feasible due to logistical constraints; therefore, trapping was con-ducted in either zone depending on time of year, bear sightings, and weather.

We used Telazol (tiletamine hydrochloride and zolazepam hydrochloride, A.H. Robins Company, Richmond, Virginia, USA) to anesthetize bears in barrel traps at a dosage of 5.5 mg/kg (250 mg/ml at 0.02 ml/ kilogram of estimated body weight) via jabstick. Upon immobilization, we recorded vital signs (heart rate, respi-ration, rectal temperature) immediately while ophthalmic ointment was applied to the eyes. We rechecked vital signs periodically during the immobilization period.

Table 1. Reclassification scheme used for vegetation associations derived by Plumb (1987) in Big Bend National Park, Texas. Vegetation classifications were combined according to criteria relating to botanical and bear natural history. Numbers designate codes that are periodically used in text for simplicity.

Plumb (1987)	Onorato et al. (2002)
Bare	Bare (1)
Cottonwood (*Populus* spp.) grove	Cottonwood–desert willow (2)
Desert willow (*Chilopsis lineaus*)	
Creosote (*Larrea divaricata*) flats	Creosote–lechuguilla–prickly pear–grass–mesquite (3)
Creosote grass	
Creosote–lechuguilla (*Agave lecheguilla*)–prickly pear (*Opunita* spp.)	
Creosote–lechuguilla	
Creosote–tarbush (*Flourensia cernua*)	
Creosote–yucca (*Yucca* spp.)–grass	
Lechuguilla–grass	
Lechuguilla–grass–candelilla (*Euphorbia antisyphilitica*)	
Lechuguilla–grass–hechtia (*Hechtia texensis*)	
Lechuguilla–grass–viguiera (*Viguiera* spp.)	
Mesquite (*Prosopis* spp.) thicket	
Sotol (*Dasylirion leiophyllum*)–lechuguilla–grass	Sotol–yucca–lechuguilla–grass (4)
Sotol–nolina (*Nolina* spp.)–grass	
Yucca–sotol	
Pinyon (*Pinus cembroides*)–juniper (*Juniperus* spp.)–grass	Pinyon–oak–juniper–talus–meadow–grass (5)
Pinyon–oak (*Quercus* spp.)–juniper	
Pinyon–talus	
Forest meadow	
Mixed scrub	Mixed scrub–oak scrub (6)
Oak scrub	
Oak–ponderosa pine (*Pinus ponderosa*)–cypress (*Cupressus*)	Oak–ponderosa pine–cypress (7)
Mixed riparian	Mixed riparian–reed grass (8)
Reed grass (*Phragmites australis* and *Arundo doxax*)	
Mixed oak	Mixed oak (9)
Water	Water (10)
No data	No data (11)

We fitted all adult bears and selected subadults with radiocollars possessing a mortality switch and either breakaway cotton spacers (Hellgren et al. 1988) or expandable rubber tubing inserted between the ends of the collars (Telonics, Mesa, Arizona, USA). We extracted the first upper premolar of each bear with a dental elevator and extractor tools. A commercial laboratory (Matson's Laboratory, Milltown, Montana, USA) estimated age via cementum annuli analysis (Willey 1974). Each bear also was implanted with a passive integrated transponder (PIT) tag for permanent identification. The alpha-numeric code on the PIT tags could be read using a Destron-Fearing mini-portable reader (Destron-Fearing Corporation, St. Paul, Minnesota, USA). After aseptically treating the injection site, PIT tags were implanted subcutaneously with a large gauge syringe into the area between the scapulas. Ear tags were not attached to captured bears.

Home range

We attempted to locate radiocollared bears opportunistically using aerial or ground telemetry. A majority (92%) of telemetry locations were collected during daylight hours (0700–1900 hrs). We obtained ≥ 2 azimuths in ≤ 20 minutes to estimate bear locations. Estimated locations of collared bears were assigned UTM (universal transverse Mercator) coordinates via triangulation on 7.5-minute topographic maps. We formatted data for compatibility with GIS databases used by other BIBE researchers. We estimated mean telemetry error at 172.6 m using test collars ($n = 13$) in our study area. We estimated home ranges using 95% minimum convex polygon (MCP) and 50% fixed kernel estimator models with the Animal Movement extension (Hooge and Eichenlaub 1997) in ArcView 3.3 (Environmental Systems Research Institute, Redlands, California, USA). We used the least-squares cross-validation

(Silverman 1986) smoothing parameter when calculating the 50% fixed kernel core areas. We used a nonparametric Wilcoxon rank-sum test to compare MCP home ranges between sexes and age (adults vs. subadults–yearlings) groups. Animals included in the home-range analyses were monitored for >50 days and had ≥25 relocations. We compared MCP home ranges of bears in BIBE to bears from the low-elevation population in the BGWMA (Black Gap Wildlife Management Area; McKinney and Pittman 2000) using the same nonparametric analysis.

Habitat selection

We determined variation in spatial use of the landscape by merging UTM coordinates of bear radiolocations with digitized vegetation data for BIBE (Plumb 1987). We assessed habitat selection by black bears at second- and third-order levels (Johnson 1980) using the compositional analysis technique (Aebischer et al. 1993) and 11 vegetation associations (Table 1). If habitats were used in a nonrandom manner (i.e., selection occurred), they were ranked according to use. We assessed differences between ranks to qualify habitat selection. We determined second-order selection by comparing proportions of vegetative associations within a bear's 95% MCP (use) to proportions found within a composite 95% MCP calculated for all bears (availability). We determined third-order selection by comparing proportions of vegetative associations found at radio-location points within a bear's 95% MCP (use) to proportions of vegetative associations found within the entire 95% MCP for that specific bear (availability).

We examined the effect of human activity on bear distribution using bear locations ($n = 711$) in the North Chisos and High Chisos Management use-areas. These management areas encompass a majority of the Chisos range and include the most intensively visited part of BIBE. We determined the frequency of bear relocations that were within 0–100 m, 100–250 m, and 251–500 m buffers of areas with anthropogenic activity (dirt and paved roads, trails, backcountry and campground campsites, housing areas, waste dump sites). We compared those values to the frequency of an equal number of randomly distributed points (within the management use-areas) that occurred in the same buffers. Comparisons between observed and randomly generated data were completed using chi-square analysis to determine if bears avoided areas with anthropogenic activity. Comparisons were made for periods in which visitor use of BIBE was heavy (Nov–May) and light (Jun–Oct). We also tested for

Table 2. Comparison (Wilcoxon rank-sum test) of 95% minimum convex polygon home range sizes for American black bears in Big Bend National Park (BIBE), Texas, 1998–2001. Bears from Black Gap Wildlife Management Area (BGWMA) included 5 males (3 adults and 2 subadults) and 3 females (2 adults and 1 subadult).

Group	n	Mean (km^2)	P
Males	7	97.7	0.165
Females	7	32.1	
Adults	8	86.5	0.282
Subadults	6	36.2	
BIBE	14	64.9	0.017
BGWMA	8	152.7	

a difference in the distribution of bear locations across buffer zones for high- and low-use seasons ($n = 335$ and $n = 376$, respectively).

Results

Trapping success in BIBE during the entire study was low (2.4%; 42 captures in 1,763 trap-nights), and capture rates were similar between the LCZ (2.3%; 35 in 1,502) and HCZ (2.7%; 7 in 261). We marked 11 cubs in dens, and 23 bears were captured in traps (including 2 marked cubs). A total of 30 bears were marked in BIBE; an additional 2 bears were captured but not marked. In addition, the skeletal remains of a yearling were found in the HCZ in July 1999.

Home range

We radiotracked 14 bears from October 1998 to December 2001. Minimum convex polygon home-range sizes varied from 5.1 km^2 to 288.5 km^2. Home-range sizes for males did not differ from females (Wilcoxon rank sum, $S = 41.0$, $P = 0.165$), although the mean of 7 male home ranges was 3 times larger than that of 7 females (Table 2). Average home range size of adult and subadult black bears in BIBE was not significantly different ($S = 36.0$, $P = 0.282$). Average home-range size for black bears in BGWMA was larger ($S = 21.0$, $P = 0.017$) than those recorded in BIBE. There was a high degree of overlap in MCP home ranges for both sexes and age groups (Fig. 2). At the 50% level, overlap in core areas occurred in males and females, although some separation was evident (Fig. 3).

Habitat selection

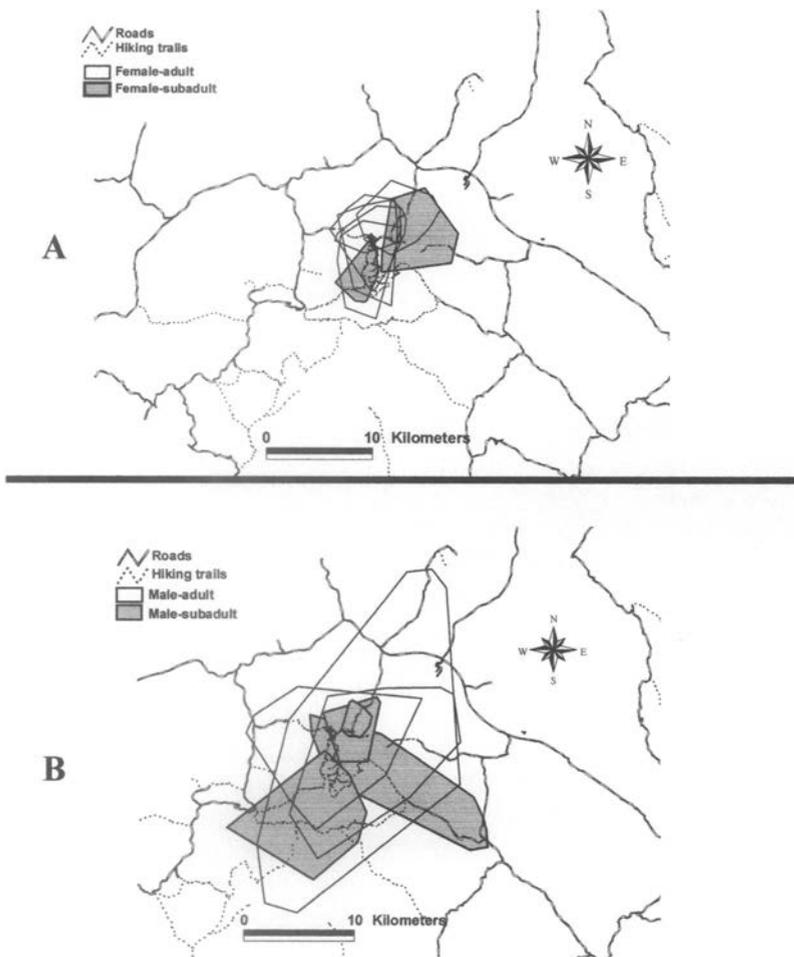Female bears clearly restricted their range to the Chisos Mountains and its foothills. Second-order

Fig. 2.   Female (A) and male (B) home ranges (95% minimum convex polygon) of subadult (≤3-yr old) and adult black bears in the Chisos Mountains of Big Bend National Park (1998–2001).

selection revealed that only 12.3% of the overall composite 95% MCP was classified as pinyon–oak–juniper–talus–meadow-grass, yet 60.3% of the female composite home range contained this association (Table 3). Males made more frequent use of low-country areas, especially the creosote (*Larrea divaricata*)–lechuguilla (*Agave lecheguilla*)–prickly pear (*Opuntia* spp.)–grass–mesquite (*Prosopis* spp.) and sotol (*Dasylirion leiophyllum*)–yucca (*Yucca* spp.)–lechuguilla–grass associations (Table 3, second order selection). Analyses at the third-order level showed 65.1% of all bear relocations occurring in the pinyon–oak–juniper–talus–meadow-grass association.

Compositional analysis of habitat use by black bears via second-order selection was nonrandom ($\chi^2 = 48.43$,

$P < 0.001$). Habitat rankings revealed that black bears selected the pinyon–oak–juniper–talus–meadow-grass and oak–ponderosa pine (*P. ponderosa*)–cypress (*Cupressus* spp.) associations more than all other habitat associations (Table 3). The most prominent desert vegetation associations (classes 3 and 4) were used less within bear home ranges than all habitats except water (10). Third-order selection also illustrated that bears used home ranges in a non-random manner ($\chi^2 = 44.41$, $P < 0.001$). Based on radiolocations, the mixed scrub–oak scrub and pinyon–oak–juniper–talus–meadow-grass associations ranked the highest (Table 3).

Frequencies of bear relocations within buffer zones encircling anthropogenic disturbance differed from random points during low-use ($\chi^2 = 32.87$, 3 df, $P < 0.001$) and high-use ($\chi^2 = 17.57$, 3 df, $P < 0.001$) periods (Table 4). During both periods, bears were found more often than expected in the buffer zone ≤100 m of anthropogenic features. However, during the low-use period, bears were less likely to be found >500 m from anthropogenic features, whereas during the high-use period, bears were less likely than random to be in the 251–500-m zone. Frequencies of bear locations relative to anthropogenic features also differed ($\chi^2 = 35.98$, 3 df, $P < 0.001$) between the 2 periods, with bears more likely to be close (<100 m) to those features during the low-use period (Table 4).

Discussion

We preface our discussion with comments about our sampling regime. Only 3 bears (2 males and 1 female) were captured below 1,300 m in elevation, and it could be argued that our analyses and results are biased toward the Chisos Mountains in BIBE. Most traps in the LCZ were in the foothills and lower slopes of the Chisos. Our trapping effort in low-elevation desert habitats was minimal; more effort in these areas may have captured males that were dispersing or moving across the desert from other montane islands. Several reports of uncollared

bears in 1999 and 2000 attested to the fact that not all bears were collared, but the high number of visitor sightings of collared animals suggested that we had captured most resident bears (J.R. Skiles, unpublished data). In addition, visitor sightings of bears and observations of bear sign in desert habitats were rare, and trapping efficiency in these areas would be impractical given other objectives of our work.

Further, we trapped at 8 locations that were considered low-elevation sites (<1,300 m), and only 1 of 3 bears captured in these traps during >160 trap-nights was not previously captured at higher elevations. Additionally, we frequently surveyed the lowland areas of BIBE during the evening and night-time hours and continually monitored the area during these forays with telemetry equipment. Although bears were sporadically located in the lowland vegetation associations, we do not believe that our results under represented the use of these regions of BIBE (D.P. Onorato, unpublished data). Therefore, although we recognize that our sampling was biased toward high-elevation habitats, we believe that we sampled bears where they occurred and avoided sampling where they did not.

Resident bears, especially males, made forays into the Sierra Quemada south of the Chisos and other low-country areas. Use of these non-woodland areas (which were not included as suitable habitat by Hellgren [1993]) indicated the presence of seasonally important areas away from the Chisos and likely justify a higher carrying capacity for BIBE than the 16–22 estimated by Hellgren (1993). The density estimate for bears based on the entire area of BIBE (0.9 bears/100 km^2; Onorato et al. 2002) was as low as any reported in the literature (Garshelis 1994) and illustrated the vast amount of desert habitat in BIBE that is unsuitable for black bears. Bear density in the Chisos Mountains alone was much greater (23 bears/100 km^2; Onorato et al. 2002).

Home range

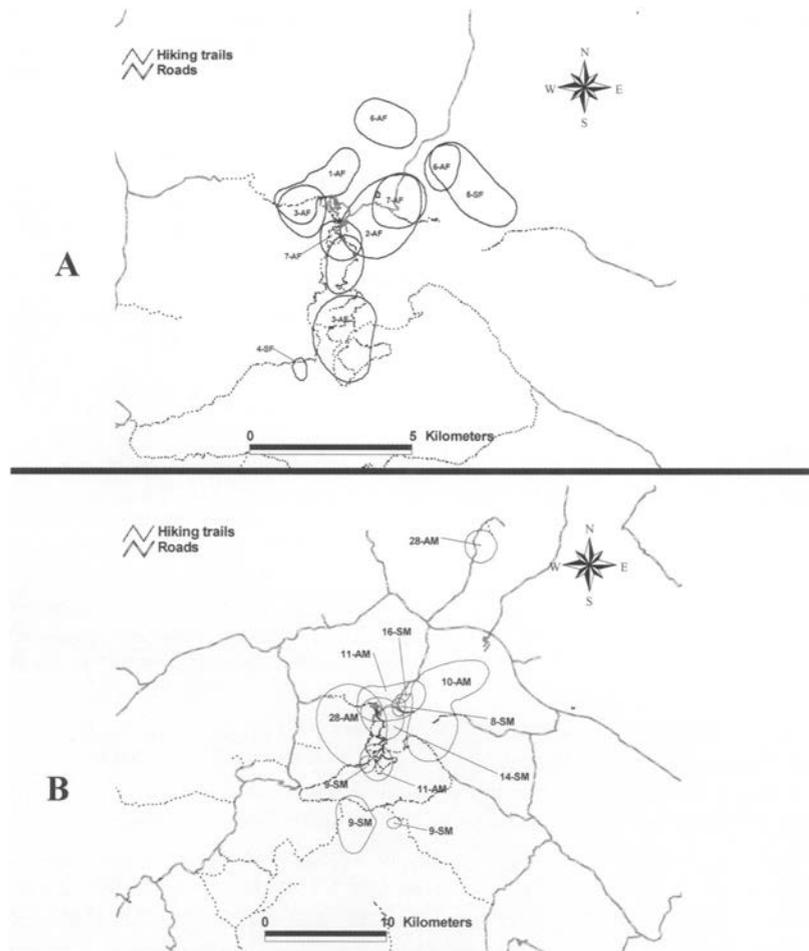Estimates of home range size based on MCPs for adult females in BIBE were in the middle of estimates for

Fig. 3. Female (A) and male (B) core areas (50% fixed kernel) of subadult (≤3-yr old) and adult black bears in the Chisos Mountains of Big Bend National Park (1998–2001). Scales differ between A and B.

other areas in southwestern North America. Our estimates were larger than those observed in Arizona chaparral ($\bar{x}$ = 17.9 km^2, n = 5; LeCount et al. 1984) and northern Coahuila, Mexico ($\bar{x}$ = 19.6 km^2, n = 12; Doan-Crider 1995), similar to south-central New Mexico ($\bar{x}$ = 43.1 km^2, n = 25; Costello et al. 2001), and much smaller than those in the BGWMA ($\bar{x}$ = 89.8 km^2, n = 3; B.R. McKinney, Texas Parks and Wildlife, Alpine, Texas, USA, unpublished data). Larger home ranges in BGWMA may indicate a lower density of food resources (bears cover large areas to obtain food). The smaller home ranges of bears in BIBE and New Mexico were due to the concentration of good bear habitat at higher elevations than existed in BGWMA.

Differences in range dynamics of American black bears residing in BIBE compared to those in BGWMA

Table 3. Proportion of vegetation associations available in Big Bend National Park, Texas (1998–2001) within the composite home range (95% minimum convex polygon) of all black bears, male and female black bears, and at relocations (*n* = 866) of monitored bears. Home range data were collected between October 1998 and December 2001.

Vegetation associations	2nd order selection[a]				3rd order selection
	Proportion of BIBE	Proportion within composite 95% MCP	Mean proportion within male 95% MCP	Mean proportion within female 95% MCP	Proportion of relocation points
Bare (1)	0.015	0.003	0.004	0.010	<0.001
Cottonwood–desert willow (2)	0.017	≪0.001	0.000	0.000	0.000
Creosote–lechuguilla–prickly pear–grass–mesquite (3)	0.773	0.472	0.202	0.034	0.062
Sotol–yucca–lechuguilla–grass (4)	0.156	0.351	0.331	0.243	0.180
Pinyon–oak–juniper–talus–meadow–grass (5)	0.017	0.123	0.389	0.603	0.651
Mixed scrub–oak scrub (6)	0.018	0.048	0.067	0.096	0.089
Oak–ponderosa pine–cypress (7)	<0.001	<0.001	0.001	0.002	<0.001
Mixed riparian–reedgrass (8)	0.003	0.000	0.000	0.000	0.000
Mixed oak (9)	<0.001	0.003	0.005	0.009	0.010
Water (10)	0.001	<0.001	0.000	<0.001	0.000
No data (11)	<0.001	<0.001	<0.001	0.002	<0.001

[a]Rankings of vegetation associations using second-order habitat selection 7 = 5 > 1 = 11 = 6 = 9 = 4 > 10 = 3; using third-order habitat selection 5 = 6 > 4 = 3 = 10 = 9 = 7 = 11 = 1. A > denotes significant differences ($P \leq 0.05$) between ranked habitats left and right of the symbol. Rankings were assessed via compositional analysis using data pooled by sex.

are important in predicting the progress of bear recolonization in this region. Due to higher availability of water and quality food sources in higher elevations of the Chisos, we believe black bears will achieve higher densities with smaller home ranges in BIBE than in BGWMA. Important mast-producing species such as Texas madrone (*Arbutus xalapensis*), weeping juniper (*Juniperus flaccida*), alligator juniper (*J. deppeana*), and nine species of oak are prevalent in the Chisos Mountains (Powell 1998). Conversely, these species were either rare or did not occur in the lower elevations of the Chihuahuan Desert in BGWMA. The BGWMA contained over 42,800 hectares of predominantly xerophytic desert scrub–grassland associations (McKinney and Pittman 2000). Thus, bears travel farther in BGWMA to obtain the necessary resources to survive. Consequently, as bears move north to other low-elevation ranges, they will require larger expanses of habitat to survive. Any proposed reintroduction of black bears in western Texas should consider this.

The presence of a small black bear population in the BGWMA indicates that other low-elevation ranges (few peaks >1500 m) such as the Glass and Del Norte mountains could be recolonized. Reproduction has been documented in BGWMA, and 3 females denned in the area in 2000 (McKinney and Pittman 2000). Two bears translocated to BGWMA (a male and female) subsequently traveled north or northeast in an attempt to return to the areas from which they were removed. One

male dispersed >120 km in 3 days from BGWMA to the Del Norte Mountains from which he had been removed. Such movements by both sexes demonstrate the potential for BIBE and BGWMA to serve as sources of recolonizers to other ranges in western Texas.

The Davis Mountains, >170 km northwest of the Chisos Mountains, contain vegetation associations similar to the Chisos. Most importantly, this range contains about ten times as much high-elevation (≥1,800 m) habitat as BIBE. The Davis Mountains have the potential to serve as an important island habitat for black bear in western Texas and would function as a critical subpopulation within the northern portion of the black bear metapopulation in the Big Bend Ecosystem.

Habitat selection

Analyses at both second- and third-order scales demonstrated strong selection of the pinyon–oak–juniper–talus–meadow-grass association by black bears. Some of the primary autumnal foods upon which bears heavily depend—oak acorns, juniper berries, pinyon nuts, and berries of Texas madrone and littleleaf sumac (*Rhus microphylla*)—were found within this association. LeCount et al. (1984) recorded similar habitat selection by black bears in the Four Peaks region of central Arizona. Bears in this southwestern population preferred Emory oak (*Quercus emoryi*)–scrub oak (*Q. turbinella*), ponderosa pine–manzanita (*Arctostaphylos*

Table 4. Comparison of bear relocations to random points within buffer zones encircling anthropogenic disturbances (dirt and paved roads, trails, campsites, housing developments, dump) in Big Bend National Park, Texas, 1998–2001. Random points were derived by obtaining a similar number of randomly located points in the 2 most heavily used management zones during periods of low use (Jun–Oct) and high use (Nov–May) within the park.

Use period	Buffer zone	Observed locations	Random locations
Low	≤100 m	109	55
	101–250 m	71	66
	251–500 m	79	70
	>500 m	117	185
High	≤100 m	60	41
	101–250 m	63	48
	251–500 m	39	77
	>500 m	173	169

pungens)–oak, and scrub oak–mountain mahogany (*Cercocarpus montanus*)–sugar sumac (*R. ovata*) vegetation associations. Even within these similarities, there was a difference between the Arizona population and bears in BIBE. Sixty-five percent of bear relocations in BIBE were the pinyon–oak–juniper–talus–meadow-grass association that composed only 1.7% of BIBE. Conversely, the Emory oak–scrub oak vegetation association in Arizona contained a seasonal average of 38% (males) and 53.4% (females) relocations while comprising >38% of the Four Peaks study area (LeCount et al. 1984). The strong selection for montane vegetation associations in the Chisos Mountains of BIBE demonstrated their importance to bears recolonizing BIBE.

Rankings for low-elevation desert associations (e.g., creosote–lechuguilla–prickly pear–grass–mesquite and sotol–yucca–lechuguilla–grass) in BIBE were low at the second-order level but fairly high at the third-order selection level. If bears had these associations in their individual home ranges, they used them, especially during summer when prickly pear and Texas persimmon (*Diospyros texana*) fruits began to ripen. Although more prevalent in the composite home range of males, female bears also used these associations periodically, especially the sotol–yucca–lechuguilla–grass association. Our trapping was concentrated in the higher elevations of the Chisos, and the observation of selection of high-elevation vegetation associations by black bears could be a result of sampling bias.

Comparisons of our data with the nearby population in BGWMA were revealing. Bears in BGWMA relied on low-elevation (500–1,500 m) plant assemblages for

survival. Food sources used by bears in this region included sotol, Spanish dagger (*Yucca torreyi*), and mesquite beans (McKinney and Pittman 2000). Mesquite beans are comparable to sandpaper oak (*Q. pungens*) in percent fat, fiber, and protein (McKinney and Pittman 2000), suggesting they may supplement bear diets in low-elevation areas of the Chihuahuan Desert with sparse acorn patches. Although these food items have been found in some scat samples in BIBE, they appear to be used far less frequently by BIBE bears than bears in BGWMA (D. P. Onorato, unpublished data). Nevertheless, bears in BGWMA concentrated in scattered oak groves and persimmon patches at higher elevations (1,500–1,700 m) during the fall to take advantage of those food sources (McKinney and Pittman 2000).

We believe that a regular, fall mast source (acorns, juniper, Texas madrone) is necessary to maintain small populations in low-elevation ranges in western Texas. Studies of food habits of black bears in BGWMA and BIBE have demonstrated the importance of mast in both habitats (Hellgren 1993, McKinney and Pittman 2000, Mitchell 2001). Mitchell (2001) found that acorns were present in >60% of the scats analyzed in BIBE, yet may have been underrepresented in the diet due to low levels of precipitation in 1998 and 2000 (Mitchell 2001). We believe mast failures in 1999–2000 and subsequent infestation by variable oakleaf caterpillars (*Lochmaeus manteo*) resulted in a large-scale migration and dispersal event in which 13 of 15 collared bears left the Chisos for northern Mexico (Mitchell 2001, Onorato et al. 2002).

Analyses of bear locations within buffer zones surrounding anthropogenic disturbances in the Chisos Mountains provided 2 findings of management interest. First, throughout the year, bears were more likely than chance to be located close (≤100 m) to human-related features. Many trails and campsites in this area border stands of pinyon pines, Texas madrone, juniper, and a variety of oak species. The mast and berries from these trees make up a majority of the diet of BIBE black bears during autumn (Mitchell 2001), when bears are trying to gain mass prior to winter hibernation (or limited movement).

Additionally, comparisons between visitor-use periods (low vs. high) showed that bears were more likely to be close to these features during periods of low visitor use. Whether this shift was caused by human disturbance was difficult to interpret. Similar findings have been noted in relation to bear habitat use and roads (traffic volumes and location) in the Pisgah National Forest in North Carolina and central Cascades of Oregon (Brody and Pelton 1989, Heyden and Meslow 1999).

Chi and Gilbert (1999) reported that a higher proportion of black bears restricted their fishing activities to 2 waterfalls on Anan Creek, Alaska, with lower human activity compared to falls that were open to the general public. We suggest that visitor use in BIBE may reduce use of these areas (trails, roads, campsites) by bears during the late autumn and winter, which may negatively impact bears in the Chisos Basin.

A majority of our relocations were obtained from either roads or hiking trails during daylight hours. These factors may have biased our disturbance analyses. Collection of radiolocations from roads and trails may have resulted in the prevalence of bear location estimates that were near anthropogenic features. Nevertheless, we supplemented our ground telemetry location estimates with aerial locations when bears were not located from roads and trails. We feel that this protocol reduced but did not eliminate the bias. Additionally, nocturnal activities of bears in BIBE were not intensely monitored in our sampling scheme. However, data collected during several 6-hour monitoring sessions (day and night) within the developed region of the Basin in the Chisos Mountains demonstrated that bears rarely ventured into campgrounds or housing developments (D.P. Onorato, unpublished data). Even in nocturnal monitoring sessions, bears typically avoided close contact with these human features. Although bears in BIBE were active during portions of the night, we believe that the population in BIBE was generally diurnal as noted in other natural environments in North America (Larivière et al. 1994). The staff at BIBE has been proactive in preventing bear–human conflicts with visitors by implementing camper awareness programs, providing bear-proof waste containers and food storage boxes, and supporting research. Big Bend National Park has benefited from the nuisance bear lessons learned in other, more heavily visited national parks (Yosemite and Great Smoky Mountains) and has not experienced major problems to this date.

Due to the limitations of our data, conclusions concerning avoidance and use could be considered speculative. Additional studies are necessary to determine the exact effects anthropogenic disturbances have on BIBE bears. Park officials should note bear activity near development during these months and respond appropriately. Managers should also be aware of these potential impacts when planning future hiking trails or other development in the Chisos.

The black bear in the Trans-Pecos of Texas has endured periods of persecution, extirpation, and recolonization in the last century (Onorato and Hellgren 2001). Data presented herein and collected during concurrent research using genetic markers (Onorato et al. 2004) has established a link between black bears in BIBE and Coahuila, Mexico. The black bear population in BIBE always will be limited by suitable bear habitat available (<100 km^2, primarily in the Chisos Mountains) because preferred foods in adequate quantities only occur at high elevations. Nevertheless, this population is an important stepping-stone to natural recolonization of other areas of western Texas from Mexico. An increase in the number of complaints by private landowners to the Texas Parks and Wildlife Department involving black bears (Taylor 1999; B.R. McKinney, Technical Wildlife Coordinator, El Carmen Project, CEMEX, Coahuila, Mexico, personal communication, 2000) attest to slow recolonization. Several ranges north of BIBE, including the Del Norte, Glass, and Davis mountains, once harbored populations of black bears (Onorato and Hellgren 2001). Most of this habitat is still undeveloped and could support small bear populations.

We recommend that managers use these data to predict effects of management decisions involving new development on bears in BIBE and other areas in western Texas with suitable habitat for recolonization. Our data also can be used to select suitable sites for, and predict trajectories of, future reintroductions and natural recolonizations of black bears to montane islands in the desert southwest.

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