


FINAL REPORT

Why aren't there any Asiatic black bears in the Nepal Terai? Implications for sloth bear conservation

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Karine Pigeon, Bhupendra Yadav, Pooja Basnet, and Dave Garshelis

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About the Authors

Learn more at www.karine.pigeon.ca

Prepared by

Dr. Karine Pigeon, Principal Investigator, Research Associate, Geomatics and Landscape Ecology, Carleton University, IUCN Sloth Bear Expert Team Member, Ontario, Canada, 1-780-223-7317, karine.pigeon@gmail.com

Mr. Bhupendra P. Yadav, Asst. Conservation Officer, Department of National Parks and Wildlife Conservation Nepal (DNPWC), Babarmahal, Kathmandu, P.O. Box 860, Nepal, +977-9841507992, bhupendra.dnpwc@gmail.com

Ms. Pooja Basnet, Kathmandu Forestry College, Balkumari, Nepal, +997-9843411479, poohza005@gmail.com

Dr. David Garshelis, Minnesota Dept. of Natural Resources and Co-chair IUCN Bear Specialist Group, 1201 E. Hwy. 2, Grand Rapids, MN 55744 USA, 1-218-328-8874, dave.garshelis@state.mn.us

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This is a draft final report and the results presented here are therefore subject to revision. Any opinions expressed in this report are those of the authors, and do not necessarily reflect those of the organizations for which they work.

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Executive Summary

The geographic ranges of sloth bears and Asiatic black bears connect along the Terai Arc in Nepal. We collected habitat information to help explain the high densities of sloth bears and rare (but new) occurrence of Asiatic black bears there. In October 2017, we secured the necessary government permits, and commenced field work during January–March 2018. We obtained camera trap data of presence/ absence of bears as by-catch data from the Nepal National Tiger survey in 2013 and the Bardia and Banke Tiger surveys in 2016 to direct our field study. Based on these camera trap surveys, we identified 68 sites used by sloth bears and 3 sites used by Asiatic black bears in Bardia and Banke National Parks. We focused field investigations in these 2 parks because of the known presence of both bear species. We also assumed that Asiatic black bears were more prevalent in the Siwalik Range (Churia Hills) along the northern boundary of these parks, but sampling in this area was limited because the camera trapping focussed on tiger habitat (i.e. lowlands). We collected habitat and food-availability data at 51 camera trap sites (22 with presence of sloth bears, 3 with black bears, and 26 with no bear presence), 17 opportunistic sites (all with bear sign), and along 9600 m of 10-m wide transects (i.e. 9.6 ha). We also recorded presence of sign (claw marks, diggings, prints, or scats) of sloth bear activity (n = 26), Asiatic black bear activity (n = 7), and activity from either bear species (evidence that could not be distinguished to species; n = 7). The average density of termite mounds was highest in lowland Sal forests (*Shorea robusta*; 8.5 mounds/ha), and averaged less than half of that in other lowland habitats (3.8 mounds/ha), upland Sal forests (3.6 mounds/ha), and other upland habitats (2.3 mounds/ha). We recorded 96 fruiting tree or shrub species in sample plots; 7 were present in >50% of plots. Preliminary analyses showed that bear signs were more likely to occur at sites where at least one of 3 fruiting tree species occurred (*Careya arborea*, *Glochidron velutinium,* or *Catunaregan spinosa*). However, when looking at camera trap sites only, we did not observe the same preference. Tree species that were climbed by sloth bears were *Terminalia arjuna*, *Gmelina arborea*, *Alnus nepalensis*, *cleistocalyx operculatus*, *Lagerstroemia parviflora*, *schleichera oleosa*, *Careya arborea*, *Tidu (common name), and two other unknown tree species. Tree species that were climbed by Asiatic black bears were *Syzygium cumini*, *bauhinia purpurea*, *schleichera oleosa*, *Madhuca longifolia*, *Bombax ceiba*, and *Terminalia chebula*. Along with establishing successful and meaningful collaborations among researchers, governments, field staff, and local businesses and organizations, this project yielded invaluable site-level information on habitat characteristics and presence of bear food in these 2 protected areas of southwestern Nepal that should serve as a baseline for what appears to be a changing situation (increased use of the Terai Arc by black bears). The success of the first year of this project will allow us to continue meaningful collaborative work for a better understanding of the ecological requirements of sloth bears and Asiatic black bears in a landscape where they intersect.

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1. INTRODUCTION

1.1 BACKGROUND

The distribution and availability of resources, and behavioural differences among closely related wildlife species define the processes that enable species coexistence (i.e., niche differentiation; Krebs 2001). Most of the pressures that cause species to become endangered seem to be human-related, but there is growing awareness that competition among species can add pressure and influence persistence (e.g., DeCesare et al. 2010). Bears provide a unique opportunity to study the potential effects of competition on species persistence but few studies have examined how competition among bears affect their distribution and persistence (Mattson et al. 2005; Steinmetz et al. 2011, 2013).

The case of the Asiatic black bear (*Ursus thibetanus*) and sloth bear (*Melursus ursinus*) on the Indian subcontinent is particularly interesting. Sloth bears occur across much of peninsular India whereas Asiatic black bears occur in northern India. Their geographic ranges may overlap in one small area in the Indian state of Uttarakhand (Corbett and Rajaji National Parks, and Haldwani and Haridwar Forest Divisions; Bargali 2012) within the so-called Terai Arc, but anecdotal evidence suggests that they do not overlap at a fine scale (i.e., black bears use higher elevations). Moving eastward, their ranges diverge such that mostly sloth bears occur in the Terai Arc of Nepal. Although the Terai Arc of Nepal includes the Siwalik Hills that range above 1500m (typical elevations for Asiatic black bears), we found no historical evidence indicating that Asiatic black bears ever occurred in the region. Farther eastward, the ranges of sloth bears and Asiatic black bears rejoin and overlap in some parts of northeastern India, and possibly overlap with a third species, the sun bear (*Helarctos malayanus*). This area is the easternmost limit for sloth bears and westernmost limit for sun bears. Choudhury (2011, 2013) examined the historical and current status of all 3 species in this region based on written and verbal accounts, and concluded that Asiatic black bears are doing far better in this region than either sloth bears or sun bears, although the reasons are unknown. We hypothesize that as the habitat has been degraded and condensed into smaller patches, these 3 bear species have had to compete more with each other, and that black bears have been more successful.

As a more generalist species, it is plausible that Asiatic black bears are more resilient to human-caused or natural habitat alterations because of their adaptation to a wide range of habitats and foods. Conversely, sloth bears, a myrmecophagous specialist species that is mainly limited to lowlands, could be less resilient to habitat change (although they are found in scrubby degraded habitat with little forest cover). It is also possible that Asiatic black bears are more tolerant of people, or that people are more tolerant of black bears because they are less aggressive. The availability of food and suitable habitats, and the proximity of adjacent source populations could also explain why these 2 species seem to coexist in some areas of the Terai Arc but not in others. To better understand the dynamics of competition and coexistence, and niche differentiation between black bears and sloth bears, we first focus in the Nepal Terai Arc, where sloth bears are much more abundant than Asiatic black bears. This region offers a unique opportunity to assess habitat requirements of sloth bears, and Asiatic black bears, in an effort to disentangle the potential habitat-related drivers of their spatial separation (Terai of Nepal) versus possible co-existence (Terai of India, and NE India).

1.2 OBJECTIVES

Ultimately, we aim to understand the habitat preferences and complex interactions between Asiatic black bears and sloth bears. Specifically, this project aimed to gather information on habitat characteristics that favour sloth bears over Asiatic black bears. We hypothesize that mechanisms driving niche differentiation and abundance of Asiatic black bears and sloth bears are determined by some combination of the following: (1) availability of food and suitable summer and winter habitats, (2) adjacent source populations, (3) human-related pressures (poaching, disturbance, removal of cover, and human-bear conflicts), and (4) inter-species competition. For this project, we focused on gathering valuable information on fine-scale food availability, habitat characteristics, and evidence of human activity.

2. METHODS

To answer our objectives, we (1) conducted a review of the literature on sloth bear and Asiatic black bear distribution, ecology, and potential overlap in Nepal and India; (2) identified camera trap sites with recorded presence and absence of sloth bears in the Nepal Terai Arc in 2013 and 2016; and (3) conducted field work focused on assessing habitat, food, and human disturbances in protected areas of the Terai Arc (including lowlands and Siwalik hills) to examine habitat characteristics and habitat selection by sloth bears and black bears.

2.1 STUDY AREA

Geographically, Nepal is divided into 3 regions: the lowland Terai, the extensive central Middle Hills, and the Himalayas. The Terai includes the outer Terai (along the southern border with India), the Siwalik Range, and the inner Terai (so-called dun valleys north of the Siwaliks). In 2016, camera trapping aimed at tiger monitoring on the Terai obtained many photos of sloth bears, as expected, but also a few photos of Asiatic black bears in 2 adjacent national parks, Bardia NP (Lat: 28.43°, Long: 81.52°) and Banke NP (Lat: 28.19°, Long: 81.80°). Because of the documented interface of sloth bears and black bears in these 2 parks, we focussed our efforts there (combined area 1,437 km^2; Figure 1). These parks are primarily alluvial lowlands, bordered to the north by the crest of the Siwaliks (called Churia Hills in Nepal), although steep Siwalik Hills do occur within these parks (Figure 2). Lowlands are composed of Sal (*Shorea robusta*) forests, Khair-sissoo (*Acacia catechu, Dalbergia sissoo*) riverine forests, and grasslands (each in distinct patches), while the Siwaliks are composed of riverine forests, tropical deciduous forests / hill Sal, and tropical evergreen forests (*Chir pine, Pinus roxburghii*) at higher elevation (Dinerstein 1979, Bhuju et al. 2007). Elevation ranges from 100 to 1450 m above sea level.

Three seasons are recognized, which dictate the availability of food for bears: the subtropical monsoon (June to October), the dry season (October to February), and the hot season (March to June; Bhuju et al. 2007). We conducted this work during January–March 2018, which included the dry season and start of the hot season.

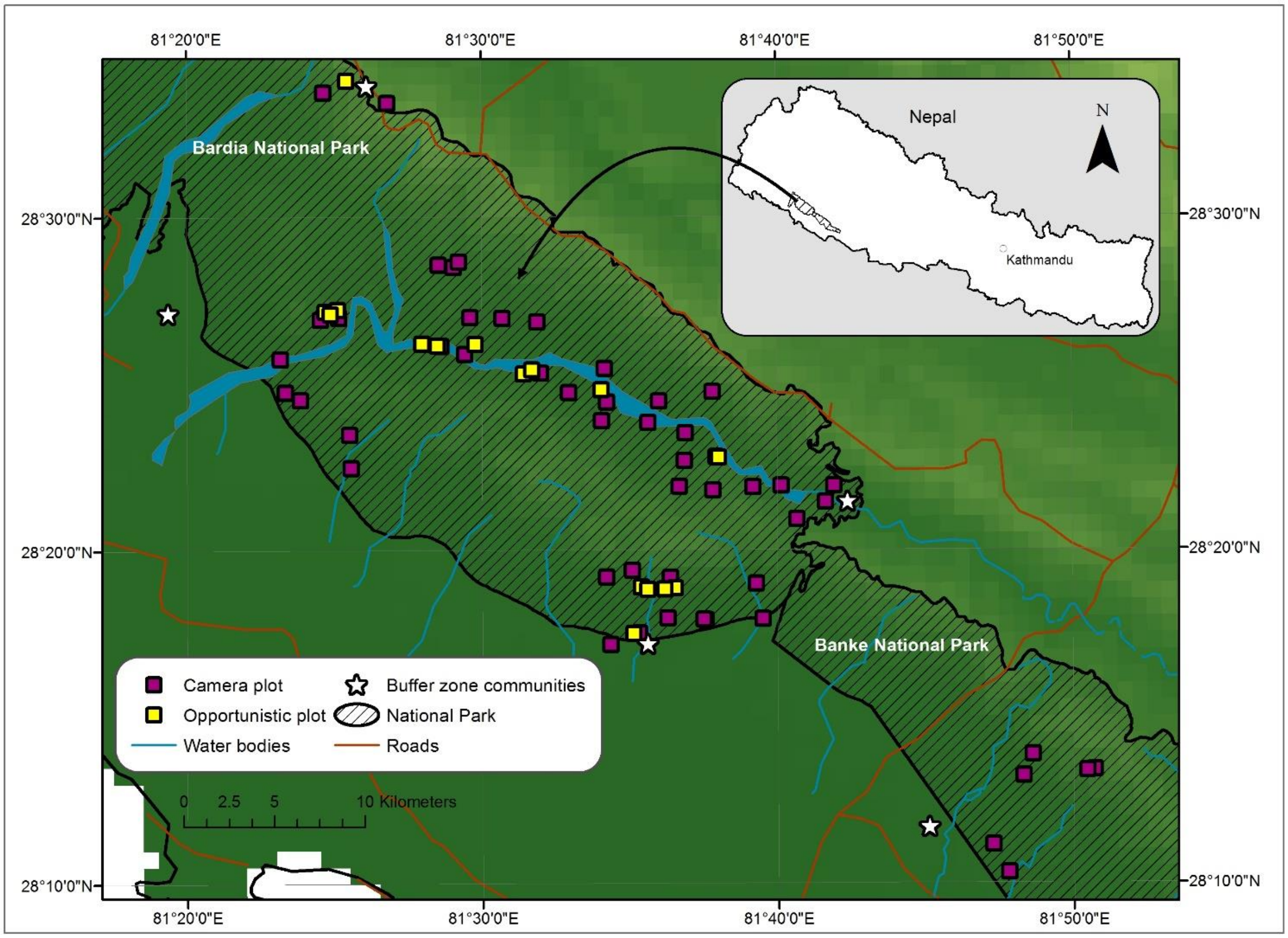

Figure 1. Sampling plots were surveyed at camera locations where bears had been photographed 2–5 years earlier, and opportunistic sites (while traversing to camera locations) within Bardia and Banke National Parks to discern habitat characteristics associated with presence of sloth bears and Asiatic black bears. Also shown are communities adjacent to the park (buffer zone communities).

Figure 2. Left: View of lowlands near the Babai River with a portion of the Churia Hills in the background at the centre of Bardia National Park. This finger of steep hills in the center of the park is surrounded by lowlands on all sides. Right: Churia Hills along the northern edge of Bardia National Park. These hills are connected to the higher elevation Middle Hills that continue towards the Himalayas further north.

2.2. Field Work

2.2.1. Terai Arc

We obtained presence / absence records of bears from 356 camera traps that were set to monitor tigers. Cameras were spaced in 2 x 2 km cells across Bardia and Banke National Parks in 2013 and 2016. Although most cameras were installed in lowlands (i.e., in valley bottoms or at the toe edge of hills generally associated with low elevations), cameras were also installed on hillslope (i.e., upland areas), and at elevations ranging up to 940m in Bardia NP and up to 720m in Banke NP. Mean ± SE (median) elevation of camera trap sites was271 ± 9m (221m) in Bardia NP, and 251 ± 10m (228m) in Banke NP respectively. Of 238 camera traps in Bardia NP, 31 and 18detected sloth bears in 2013 and 2016, respectively. Mean elevation of camera sites that detected sloth bears was 297 ± 22m in 2013 and 336 ± 39m in 2016 while mean elevation of camera sites that did not detect sloth bear was 267 ± 10m in 2013 and 274 ± 10m in 2016. In Banke NP, 16 out of 118 and 8 out of 57 camera traps detected sloth bears during 2013 and 2016, respectively. Mean elevation of camera sites that detected sloth bears in Banke NP was 302 ± 22m in 2013 and 260± 24m in 2016 while mean elevation of camera sites that did not detect sloth bears was 242 ± 10m in 2013 and 263 ± 16m in 2016.

The camera trap surveys recorded Asiatic black bears were at 1 site in Bardia (elevation: 263m) and 1 site in Banke in 2016 (392m), and a long time ago, another black bear photo from 2000 in Bardia (282m) was found in archived photographs. The recent occurrences of Asiatic black bears within the Terai Arc landscape of Nepal offered a new opportunity to examine a possibly changing dynamic between Asiatic black bears and resident sloth bears. Focusing on Bardia and Banke National Parks, we mapped camera sites with presence and absence of sloth bears and Asiatic black bears using ArcGIS 10.3 (Figure 3) to direct our field sampling.

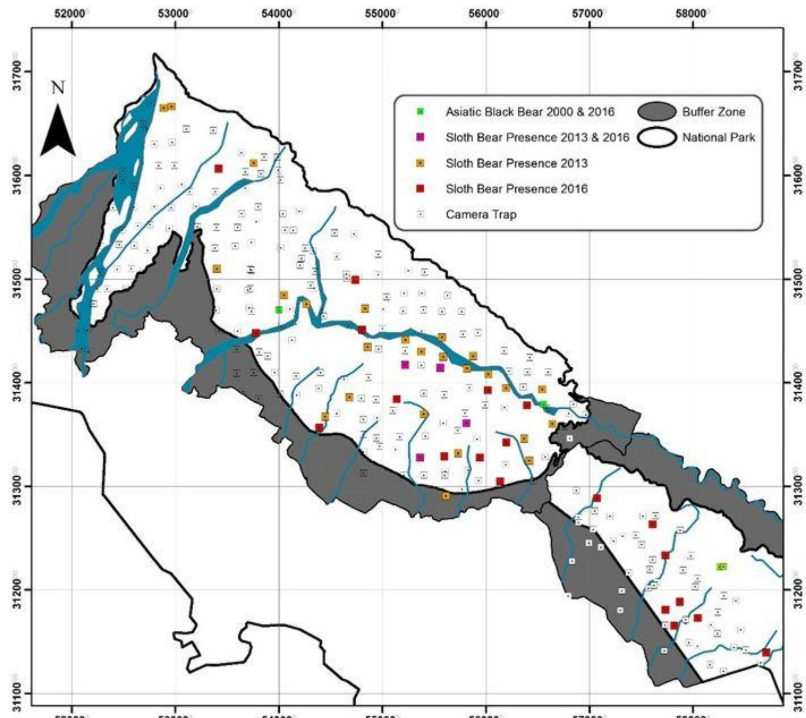

Figure 3. National tiger survey sites in Bardia and Banke National Parks, 2013, and Bardia and Banke tiger survey sites, 2016. Cameras were spaced in 2 x 2 km cells. Records of sloth bears were obtained at cells colored orange (2013), red (2016) and pink (2013 and 2016). Records of Asiatic black bears were obtained at green cells. White cells represent camera traps that did not photograph bears.

2.2.1.1. Habitat characteristics

We conducted habitat surveys to assess the potential links between occurrence of each of the bear species with food availability, habitat characteristics, and human activity. We quantified the presence and abundance of food, measured habitat characteristics, and recorded signs of anthropogenic features and human disturbances at camera trap sites where bears were present, camera sites where bears were not present, and at opportunistic sites where evidence of either bear species was observed. We established plots that consisted of 3 sampling subplots (30m x 30m) and 2 sign transects (10m x 100m). Figure 4below shows an outline of the sampling scheme. Within each subplot (3 subplots within each plot), we recorded the dominant habitat type (sal forest, riverine forest, mixed forest, or grassland) along with comments on the general stand ecology. We ranked the relative level of human activity inside each of the 3 subplots (zero, light, moderate, heavy, or very heavy), and whether the activity was recent or old. We estimated the distance from each subplot to the nearest anthropogenic features such as trails, fire roads, roads, park or army posts, fields and crops, and villages based on our observations while reaching each plot. We accessed each plot on foot using local knowledge and maps to optimize access and therefore assumed that our estimate of proximity to anthropogenic features in the vicinity of each subplot was reasonably accurate. To assess specific habitat characteristics that might be preferred by sloth bears or Asiatic black bears, we measured a number of other variables within each subplot: we used a folding hiding cover board (Figure 5) to quantify horizontal concealment; we counted the number of live and dead trees along a 1m wide x 15m length transect placed at the centre of each of the 3 subplots; we evaluated the seral stage of the forest stand (establishment, immature, vs. mature); we identified the dominant and codominant tree species, and the dominant and co-dominant shrub species; we visually estimated the height and diameter at breast height (DBH) of these dominant and co-dominant tree and shrub species; we visually estimated the percentage of canopy cover at fixed 0m, 15m, and 30m intervals within the 3 subplots; and we recorded the distance of each subplot to the nearest creek. To quantify the presence and abundance of food, we recorded the presence of any fruiting tree or shrub species within each of the 3 subplots, and we also recorded the number of ant hills and termite mounds within the 3 subplots and along the 2 sign transects linking the 3 subplots.

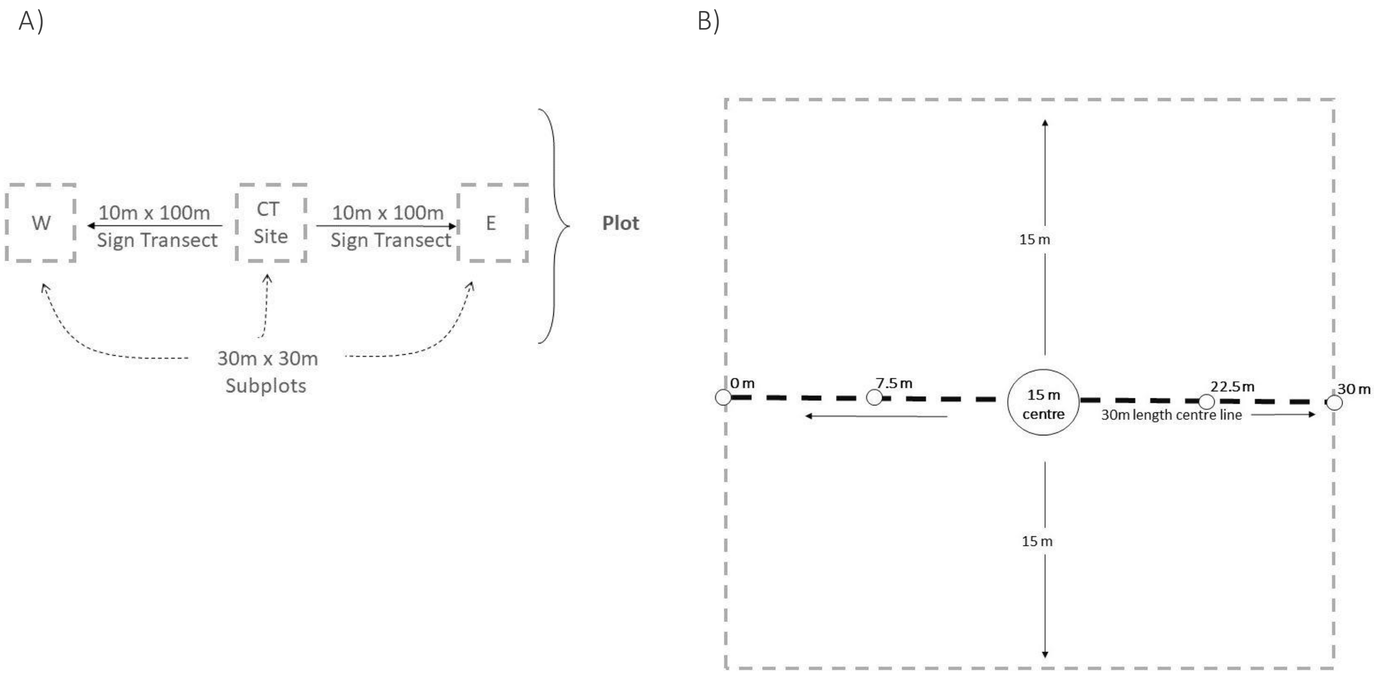

Figure 4. A) Design of sampling plots used to assess presence of sloth bear and Asiatic black bear signs (claw marks, diggings, scats, and print), quantify the density of termite mounds, and assess food availability and habitat characteristics in Bardia and Banke National Parks during winter 2018. Each plot consisted of 2 transects (10m x 100m) and 3 subplots (30m x 30m) with the camera site centered in the middle (within the middle subplot). B) Details of the subplots established (3 per plot) to measure habitat characteristics and presence / absence of fruiting tree species.

Figure 5. Karine Pigeon (left) and Birendra Adikari (right) holding a folding cover board used to quantify horizontal concealment within 30x30m subplots. The cover board was held at 0-1m above ground, and again at 1-2m above ground while standing at the 0m and 30m mark on a 30-m length line transect inside each subplot. A second person standing at the centre of the subplot, at the 15m mark on the line transect, estimated the percentage of the board obscured by vegetation.

2.2.1.2. Sloth bear and Asiatic black bear signs

We searched for evidence of sloth bear and Asiatic black bear signs by investigating the presence of claw marks on any tree within the 10m x 100m transects joining the 3 subplots, and we also determined whether each ant hill or termite mound observed showed any sign of being disturbed by a bear. We considered all digging into termite mounds to be from sloth bears and classified other types of ground digging as "unknown". We considered claw marks on climbed trees without any evidence of sliding as Asiatic black bear sign and considered claw marks on trees with at least some evidence of sliding as sloth bear sign (Figure6). We also recorded the height and decay status (recent mound vs. old mound), and whether termites or ants were still present for each mound. We categorized sites as being either "lowland" or "upland" sites based on topographic location: sites in flat areas, floodplains, creek and river beds, and at the toe-edge of hills were categorized as lowland sites while sites located on mid-to-high hillslopes were categorized as upland sites.

Figure 6. Left: Typical claw marks observed on trees climbed by sloth bears. Right: Typical claw marks observed on trees climbed by Asiatic black bears, Bardia National Park 2018.

2.2.2. Siwalik Range (Churia Hills)

Camera trapping occurred in 2017-18 in the Churia Hills north of Bardia NP but results were not available in time for our field sampling. Processing of data are currently underway. As our next step, we plan to sample camera sites with known presence and absence of each bear species in this area to match the sampling scheme conducted so far. We expect that this area should have a higher proportion of Asiatic black bears than the lowlands and uplands sampled within Bardia and Banke NP because Asiatic black bears are generally found at higher elevation than sloth bears, and the Siwalik Hills north of Bardia NP connect with the known, higher elevation, Asiatic black bear range.

2.2.3. Covariates and statistical analyses

We provide an overview of variables that will be further considered for general Linear Models (GLMs) following Resource Selection Function (RSF; Manly et al. 2002) to distinguish fine scale patterns of sloth bear and Asiatic black bear use in Bardia and Banke National Park. We considered the importance of environmental variables related to topography, habitat characteristics, and food availability. We also assessed the influence of different levels of anthropogenic features and human disturbances. Using logistic regression, we conducted preliminary analyses to investigate potential differences in the presence or absence of the more common fruiting tree or shrub species (species that occurred in at least 15 sites overall). We conducted all preliminary analyses and summary statistics in R using RStudio (R Development Core Team 2015, RStudio Team, 2016).

3. Results

3.1.1 Sampling plots & line transects

We surveyed 51 camera trap sites and 17 opportunistic sites, including 9600 m of 10-m wide transects (i.e. 9.6 ha) and 168 subplots. Twenty-two of the camera sites that we visited showed photo evidence of having been visited by sloth bears (mean elevation ± SE: 264 ± 16m), 3 of Asiatic black bears (elevation: 312 ± 40m), and 26 recorded no photos of either bear species (elevation: 302 ± 40m; Table 1). During field investigations, we recorded evidence of sloth bear activity (n = 26, mean elevation ± SE: 253 ± 11m), Asiatic black bear activity (n = 7, elevation: 443 ± 158m), and activity from either bear species (evidence that could not be distinguished to species; n = 7, elevation: 326 ± 46m) based on the presence of claw marks, diggings, prints, or scats (Table 1). At one camera site with recorded presence of an Asiatic black bear in 2016, we observed signs (in 2018) from both bear species, along with signs that could not clearly be identified to one particular species. Field-based evidence of bear signs from either species did not match with recorded presence at camera trap sites (Table 1).

Table 1. Number of visited camera sites in Bardia and Banke National Parks, Nepal, during January–March 2018with and without bear photos (2–5 years before) and associated evidence of claw marks on trees, diggings, or scats from either a sloth bear (SLB), Asiatic black bear (ABB), or an unknown bear species. We searched for evidence of bear signs at all visited camera trap sites by investigating three 30 x 30m subplots and two 100-m transects linked to each other with the camera trap site in the centre subplot (see Figure 4 above). "Species" refers to the bear species associated with the recorded evidence of claw marks, diggings, and/or scats. At some sites, more than 1 type of sign was found (e.g., claw marks and digging). We considered all digging into termite mounds to be from sloth bears and classified other types of ground digging as "unknown". *Out of the three camera sites with Asiatic black bear photos, we recorded the sloth, Asiatic, and unknown bear signs at only one site (i.e., all 3 signs associated with ABB photo are from the same site).

Species	SLB photo (n = 22)	ABB photo (n = 3)*	No bear photo (n = 26)
SLB sign	5	1	11
ABB sign	0	1	3
Unk bear sign	1	1	1

Out of 168 sites (including camera trap sites and opportunistic sites), we categorized 97 sites as 'lowland sites' and 71 sites as 'upland – Churia / Siwalik sites'. Within these sites, we observed 19 signs of sloth bears in lowlands and 7 in upland areas, whereas 5 of the 7 Asiatic black bear signs were recorded in uplands and 2 in lowlands (Table 2). We observed sloth bear signs and Asiatic black bear signs at 20% and 2% of the lowland sites respectively, and at 10% and 7% of upland sites. Among the bear sign that we could not attribute to species, 3 were in the lowlands and 4were in upland areas (Table 2). The average elevation for sites where we observed sloth bear signs was 252m (range: 161–380m), whereas the average for Asiatic black bear signs was 443m (range: 192–1224m). Slope was slightly steeper for sites with recorded presence of Asiatic black bear (average = 13°) than sloth bear (average = 7°), but both also occurred on steep slopes (max ABB: 32°; max SLB: 44°). We also recorded bear sign not attributed to species at slopes of up to 70°.We found no difference in distance to nearest water source for sites with signs of either bear species (SLB mean = 197m, range = 0–700m; ABB mean = 117m, range = 0–500m). The average density of termite mounds was highest in lowland Sal forests (8.5 mounds/ha), and averaged less than half of that in other lowland habitats (3.8 mounds/ha), upland Sal forests (3.6 mounds/ha), and other upland habitats (2.3 mounds/ha). The level of human activity recorded at sites with bear signs did not vary by species; we found no bear sign at sites with high human activity (Table 3).

Table 2. Number of sites and associated transects where we recorded evidence of claw marks on trees, diggings, or scats from a sloth bear, Asiatic black bear, or unknown bear species in Bardia and Banke National Parks, Nepal, during January–March 2018. %Lowland is the percentage of species-specific signs observed in lowland sites over the total number of sites where we observed signs of that species. Lowland sites are flat areas, floodplains, creek and riverbeds, and toe-edge of hills while upland sites are located on mid-to-high hillslopes. At some sites, more than 1 type of sign was found (e.g., claw marks and digging). We considered all digging into termite mounds to be from sloth bears and classified other types of ground digging as "unknown".

Species	Claw marks	Digging	Scat	%Lowland
Sloth	16	17	4	73%
Asiatic black	7	NA	NA	29%
Unknown	2	4	2	42%
TOTAL	25	21	6	NA

Table 3. Level of human activity (None to High) recorded within plots containing sign of bears in Bardia and Banke National Parks, Nepal, during January–March 2018.

Species	None	Low	Moderate	High
Sloth	18	7	1	0
Asiatic black	4	1	2	0
Unknown	7	0	0	0
TOTAL	29	8	3	0

We found no obvious difference between habitat types associated with presence of sign from sloth bears vs. Asiatic black bears, although we note that because our sampling occurred mainly at camera trap sites that were chosen to target tigers, our sampling ended up being skewed towards lowland areas. Over 70% of sloth bear and Asiatic black bear signs were recorded in Sal forests (73% of sloth bear signs, 71% of Asiatic black bear signs, and 53% for unknown bear species). We identified 96 fruiting tree or shrub species (although 29 of these species were only recorded at single sites). The most abundant fruiting species were *Terminalia arjuna* (n = 57 of 168 sites), *Shorea robusta* (n = 55), *Lagerstroemia parviflora* (n = 52), *Bauhinia vahlii* (n = 49), *Syzygium cumini* (n = 45), *Mallotus philippinesis* (n = 41), *schleichera oleosa* (n = 38), *Buchanania latifolia* (n = 31), *Semecarpus anacardium* (n = 29), *Glochidron velutinum* (n = 28), *Cassia fistula* (n = 28), *Careya arborea* (n = 26), *woodfordia fruticosa* (n = 25), *Murraya koenigii* (n = 25), *phoenix* humilis(n = 23), *Grewia optiva* (n = 23), *Phyllanthus emblica*(n = 21), *Holarrhena pubescens* (n = 21), *Himalyacalamus falconeri* (n = 21), *Bauhini purpurea* (n = 21), and *Acacia catechu* (n = 21). Seven of these species occurred within >50% of all sites, regardless of the presence of bear sign (*Terminalia arjuna*, *Shorea robusta*, *Lagerstroemia parviflora*, *Bauhinia vahlii*, *Syzygium cumini*, *Mallotus philippinesis*, and *schleichera oleosa*), 23 species occurred within >25% of all sites, and 45 species occurred in at least 10% of all sites. We recorded 74 fruiting species in sites where sloth bear signs were observed, and 51 fruiting species where Asiatic black bear signs were observed, although we do not know when these species typically fruit, and which species produced fruit consumed by bears. *Shorea robusta*, *Terminalia arjuna*, *Lagerstroemia parviflora*, *Syzygium cumini*, and *Bauhinia vahlii* were abundant at sites with signs of sloth bears and Asiatic black bear. *Tetrastigma serrulatum*, *Murraya koenigii*, and *Mallotus philippinensis* were abundant at sites with sloth bear signs but rarely at sites with signs of Asiatic black bears (Table 4).

Table 4. Tree or shrub species present at sites where we recorded sign (claw marks on trees, diggings, or scats) from sloth bears or Asiatic black bears in Bardia and Banke National Parks, Nepal, during January–March 2018.Tree or shrub species in bold were present in >10% of sites associated with only 1 species of bear. Common names of tree or shrub species marked with an asterisk(*)have not yet been associated with a scientific name.

Tree / Shrub species associated with signs of both bear species	% sites with SLB sign	% sites with ABB sign	Tree / Shrub species associated with signs of ABB only	% siteswith only ABB sign	Tree / Shrub species associated with signs of SLB only	% sites with only SLB sign
Aclina cordifolia	1.3%	2.0%	*Anogeissus latifolus*	2.0%	*Acornus calamus*	1.3%
Garuga pinnata	1.3%	2.0%	*callicarpa macrophylla*	2.0%	*Anagalis arensis*	1.3%
Glochidion velutinium	1.3%	2.0%	*Ligustrum confusum*	2.0%	*Astilbe rivularis*	1.3%
Ichnocarpus frutescens	1.3%	2.0%	*Pinus roxburghii*	2.0%	*Baleti	1.3%
Aegle marmelos	2.7%	2.0%	*Pyrus pashia*	2.0%	*Bauhinia malabarica*	1.3%
Aesandra butyracea	2.7%	2.0%	*Sangraino	2.0%	*Bidu	1.3%
Madhuca longifolia	2.7%	3.9%	*Sarato	2.0%	*Buchania latifolia*	1.3%
Trema cannabina	2.7%	2.0%	*Sunna	2.0%	*Ficus auriculata*	1.3%
Bauhinia variegata	4.0%	5.9%	*Trewia nudiflora*	2.0%	*Indigofera atropurpurea*	1.3%
Litsea monopetalia	4.0%	2.0%			*Kachari	1.3%
*Rukh gayo	5.3%	3.9%			*lantana camara*	1.3%
Acacia catechu	5.3%	2.0%			*Mallotus philippensis*	1.3%
Bridelia refusa	5.3%	2.0%			*Mangifera sylvatica*	1.3%
Cleistocalyx operculatus	5.3%	2.0%			*Parijat	1.3%
*Kurumkhaja	5.3%	5.9%			*Poganatrierum crinitum*	1.3%
phoenix humilis	5.3%	7.8%			*Sidda	1.3%
Pogostemon benghalensis	5.3%	3.9%			*Spatholobus roxburghii*	1.3%
*Banbayer	6.7%	2.0%			*Zizyphus retundifera*	1.3%
Catunaregan spinosa	8.0%	2.0%			*Alnus nepalensis*	2.7%
*Kalam	9.3%	5.9%			*Padulo	2.7%
Bauhinia purpurea	10.7%	2.0%			*Tidu	2.7%
Woodfordia fruticosa	10.7%	9.8%			*Albizia procera*	4.0%
Buchanania latifolia	12.0%	9.8%			*Dellinia pentagyna*	4.0%
Himalyacalamus falconeri	12.0%	3.9%			*Diospyros melanoxylon*	4.0%
Holarrhena pubescens	12.0%	3.9%			*Gmelina arborea*	4.0%
Semecarpus anacardium	12.0%	5.9%			*Mangifera indica*	5.3%
Cassia fistula	13.3%	3.9%			*sapium insigne*	5.3%
Grewia optiva	13.3%	5.9%			*Paan	6.7%
***Pipiri**	13.3%	2.0%			*piper betle*	6.7%
***Ficus* spp.**	14.7%	2.0%			*Bombax ceiba*	8.0%
Glochidron velutinum	14.7%	9.8%			*Terminalia chebula*	8.0%
Murraya koenigii	16.0%	2.0%			***Tetrastigma serrulatum***	14.7%
Phyllanthus emblica	16.0%	3.9%				
Schleicher aoleosa	16.0%	5.9%				
Careya arborea	17.3%	5.9%				
Bauhinia vahlii	20.0%	11.8%				
Mallotus philippinesis	**22.7%**	**3.9%**				
Syzygium cumini	22.7%	13.7%				
Lagerstroemia parviflora	24.0%	11.8%				
Terminalia arjuna	29.3%	13.7%				
Shorea robusta	30.7%	9.8%				

Preliminary analyses investigating potential differences in the presence of fruiting species between sites with and without signs of bears showed that bear signs were more likely to occur at sites where *Careya arborea (β ± SE: 0.3 ± 0.07)*, *Glochidron velutinium (β ± SE: 0.2 ± 0.07)*, or *Catunaregan spinosa* (*β ± SE: 0.3 ± 0.1)* were present. However, when looking at camera trap sites only, we did not observe the same preference for these species at sites with recorded evidence of either bear species when compared to sites without recorded evidence from camera traps: *Careya arborea (β ± SE: -0.07 ± 0.2)*, *Glochidron velutinium (β ± SE: -0.1 ± 0.2)*, and *Catunaregan spinosa* (*β ± SE: -0.2 ± 0.3)*. When considering only camera sites with or without sloth bear presence (there were only 3 records of Asiatic black bear), we found that sites with at least one photo of a sloth bear were less likely to contain *Terminalia arjuna (β ± SE: -0.4 ± 0.17)*, *Bauhinia vahlii* (*β ± SE: -0.3 ± 0.1), or Woodfordia fruticose* (*β ± SE: -0.3 ± 0.15)* compared to camera sites without sloth bear presence. Hence, although *Terminalia arjuna* and *Bauhinia vahlii* were common at sites with sloth bear signs, both tree species were even more common at sites without recorded evidence of sloth bears from camera traps. Tree species that were climbed by sloth bears were *Terminalia arjuna*, *Gmelina arborea*, *Alnus nepalensis*, *cleistocalyx operculatus*, *Lagerstroemia parviflora*, *schleichera oleosa*, *Careya arborea*, *Tidu (common name), and two other unknown tree species. Note that *Alnus nepalensis* is not a fruiting species. Tree species that were climbed by Asiatic black bears were *Syzygium cumini*, *bauhinia purpurea*, *schleichera oleosa*, *Madhuca longifolia*, *Bombax ceiba*, and *Terminalia chebula*.

4. Discussion

Using recorded presence / absence data of camera traps that was generated as by-catch data from tiger surveys conducted in 2013 and 2016 in Banke and Bardia National Parks, we were able to target specific areas to conduct fine-scale habitat assessments and sign surveys to further our understanding of habitat characteristics used by sloth bears or Asiatic black bears at the edge of their respective geographic distributions in the Terai Arc landscape of Nepal. We focused our field investigations in Bardia and Banke National Parks after recent evidence of Asiatic black bears in these parks. We collected data associated with habitat characteristics, human activity, and food-availability at camera trap sites, opportunistic sites, and along line transects.

Consistent with current knowledge of sloth bear and Asiatic black bear habitat, we found high densities of termite mounds (a preferred food for sloth bears) in lowland Sal forests (Garshelis et al. 1999), and a high occurrence of fruiting tree species associated with sites used by both species (Garshelis and Steinmetz 2016).Preliminarily, our results suggest that 1) "by-catch" camera trap data generated for other target species have the potential to be useful, not only to understand species distribution, but also to gain insight into species-specific habitat associations, 2) field surveys targeted at quantifying species-specific habitat associations offer complementary, and valuable, information that can be added to information gathered via camera traps, and 3) although the area encompassed by Bardia and Banke National Parks is occupied largely by sloth bears, food is available for Asiatic black bears. Further analyses are required to disentangle potential associations between habitat characteristics, food availability, human activity, and presence of sloth bears and Asiatic black bears in these protected areas.

Sloth bear populations in the Terai of Nepal appear to be stable based on anecdotal reports (including records of their presence in new areas. Despite being the northern edge of their geographic range, the habitat in this region appears to be highly suitable for this species. The Terai of Nepal, however, is disconnected from larger sloth bear populations in India. Conversely, a large continuous area of Asiatic black bear habitat stretches across central Nepal. The recent, previously-undocumented reports of Asiatic black bears in the Terai Arc are yet to be explained. We believe that understanding the ecological and biological dynamics of these 2 species in the Terai Arc will be important to future conservation efforts since potential competition among Asian bears is poorly understood (Steinmetz et al. 2011, 2013). For example, in North America it appears that high densities of American black bears (*Ursus americanus*) stifle the expansion of brown bears (*U. arctos*; Mattson et al. 2005). Accordingly, it may be that the comparatively high sloth bear densities in the Terai Arc of Nepal have kept Asiatic black bears from expanding into this area. If this is true, then it may follow that as sloth bear densities are reduced in some parts of their range (i.e, in NE India), black bears have been able to displace them. Understanding the respective habitat needs of sloth bears and Asiatic black bears could therefore be key to their conservation.

Future analyses using information gathered during our field survey will further investigate the relationships among food availability (presence of fruiting tree species and densities of termite mounds and ant mounds), habitat characteristics, and habitat use by sloth bears and Asiatic black bears in the region. Moving forward, we hope to continue fine-scale and broad-scale investigations within Nepal and India that will allow for a better understanding of 1) specific ecological characteristics associated with potential competition between these 2 species, possibly including exclusion of 1 over the other, and 2) how habitat degradation at the boundaries of protected areas might change the dynamic of these 2 species. Further research focusing on the Siwaliks (where Asiatic black bears are expected to be more prevalent than in the lowlands) will complement these findings and help disentangle the specific habitat requirements of these 2 species.

This collaborative project allows for a better understanding of where future conservation actions aimed at reducing habitat degradation outside of protected areas should be focused, thereby addressing a conservation issue identified by the IUCN SSC Bear Specialist Group. It is particularly intriguing that the geographic range of these species may be in flux, with Asiatic black bears being documented on the Terai of Nepal for the first time. The data collected now may therefore serve as an important baseline for monitoring change.

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