

Mesocarnivore richness and relative distribution along riparian areas of Big Bend National Park.

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By

Lorna Hernandez-Santin

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Carnivores (Order: Carnivora) can be considered keystone species within their environments due to direct or indirect relationships which alter other species' distribution and abundance (Menge et al. 1994, Ripple and Beschta 2004, Soulé et al. 2005). Coyote (*Canis latrans*) removal in California increased the number of cats (*Felis catus*), which in turn decreased avian presence and abundance (Soulé et al. 2005). This example covers both direct (increase in cats) and indirect (decrease in birds) consequences of the removal of 1 mesocarnivore (coyotes). Another example addresses habitat deterioration, overgrazing alters landscape patterns and features in space and time (species composition and productivity, succession, etc.). It has also been documented that moose (*Alces alces*) density increased as a result of wolf (*Canis lupus*) removal in Yellowstone National Park, which led to highly browsed vegetation, affecting the whole ecosystem (Ripple and Beschta 2004). These examples reflect the importance of assessing mesocarnivore biodiversity (richness and abundance); as they may be indicative of the ecosystem health while controlling different species' populations.

There are many studies directed towards large carnivores inside the Big Bend National Park (BBNP): mountain lion (*Puma concolor*) and black bear (*Ursus americanus*); but, to my best knowledge, only one accounts for medium-sized carnivores. Carter (2002) analyzed mammalian landscape use, and found that landscape variables accounted for less than 40% of the variation of mammals' richness in the park. BBNP holds a mammalian checklist that dates back to 1973, authored by Easterla and last revised in 1997 by BBNP's employees (Easterla, 1973). However, most of the data for

presence and distribution are based on tourist and employee observations (Raymond Skiles and Vidal Davila, personal communication). Mesocarnivores that have been registered for BBNP include: coyote, swift or kit fox (*Vulpes velox*), gray fox (*Urocyon cinereoargenteus*), ringtail (*Bassariscus astutus*), raccoon (*Procyon lotor*), white-nosed coati (*Nasua narica*), long-tailed weasel (*Mustela frenata*), american badger (*Taxidea taxus*), western spotted skunk (*Spilogale gracilis*), hooded skunk (*Mephitis macroura*), striped skunk (*Mephitis mephitis*), hog-nosed skunk (*Conepatus mesoleucus*), and bobcat (*Lynx rufus*; Easterla 1973).

The objective of this study was to document and describe mesocarnivore diversity along riparian areas of the Big Bend National Park. More specifically, to document and describe species richness, relative periods of activity, relative distribution, and relative abundance along riparian areas of BBNP as well as compare within and between the selected riparian sites.

Most carnivores tend to be secretive (Dorazio et al. 2006), which makes it difficult to account for these objectives through direct observation. Thus, I used camera traps as an indirect method during one year. Camera trapping is becoming more popular because it is a non-invasive method which “captures” animals passing by; allowing proper species documentation and identification (Karanth and Nichols 1998, Nichols and MacKenzie 2004). Camera traps rely on infrared and (or) motion sensors triggered by the passing animal (Karanth and Nichols 1998, Trolle and Kéry 2003).

Study area

This study was conducted in BBNP located in the southernmost part of Brewster County, Texas, and belongs to the Chihuahuan Desert (Figure 1). Carter (2002)

characterized this area using 4 major patch types: riparian, Yucca-Ocotillo shrub, grassland, and other shrub.

The park area is approximately 324,360 ha. Elevation ranges from 550 m at the Rio Grande area, to 2380 m at the Chisos Mountains. Mean temperatures lie between 11°C and 26°C. The lowest recorded temperatures occur in January with an average of 1.67°C, while the highest are in June, with an average of 34.5°C. In general, riparian areas have temperatures 3-5°C higher than the park average. The largest river is the Rio Grande, and approximately 110 km of it runs through BBNP. (National Park Service – Big Bend–: <https://cms.imr.nps.gov/bibe/planyourvisit/bc-river-use.htm>).

Since the study area is a desert environment, riparian areas offer a key component to the survival of living organisms: water. Thus, I focused my efforts on these riparian areas. I placed one trap-line near the Dog Canyon (DOG), one by the Fossil Exhibit area (FOS), one in the Terlingua Creek (TER), one in different creeks near Panther Junction (PNT), and two in the Rio Grande (one on the East and one on the West side: RGE and RGW; Figure 2).

Methods

Field surveys. I used camera-trap-lines to address carnivore biodiversity, species richness, and relative distribution, based on presence and absence data. Also, cameras were set to print the time to each photograph; this information helped to describe relative periods of activity.

The cameras were placed at 35cm off the ground to ensure capture of all mesocarnivores in the area, and were associated with sardines as an attractant to enhance their effectiveness (Carter 2002). In a camera-trap study directed towards tigers, Wegge

et al. (2004) found that it is possible to sample the same proportion of the population by combining space and time (i.e. you can sample the same proportion in 7 nights spacing the cameras 1 km, or in 25 nights with gaps of 2.5 km between cameras). I focused on medium-sized carnivores, which have relatively small home ranges, and used attractants; so I am confident that a distance of 2 km between cameras resulted in “capturing” a high percentage of animals. Due to logistic limitations (site accessibility, personnel, and economical), I selected 6 camera-trap-lines of 6 km each (using 3 cameras per trap-line), where the 9 cameras available were shifted between sites. I took coordinates of each camera in the field using a handheld GPS Megallan® Explorist 500, and then loaded them to ArcMap 9.1 (ESRI; Figure 2).

Data analysis. To achieve a daily time frame, each 24-hour day was divided into day, night, and crepuscular hours; observations were grouped accordingly. I used BioDiversity Pro (McAleece et al. 1997) to calculate relative abundances, Simpson’s diversity index (D), and rarefaction curves; per site, season, time of day, and species as appropriate. Using Simpson’s diversity index I calculated the evenness as: $E_{1/D} = (1/D) / S$, where $1/D$ = Simpson’s reciprocal index and S = species richness (Krebs 1998).

Results

A total of 128 days were sampled between Fall 2006 ($n = 72$) and Spring 2007 ($n = 56$). During this time, 142 pictures were taken; 3% were taken to Lagomorpha ($n = 5$), 6% to Rodentia ($n = 10$), 15% to Class Ave ($n = 23$), 25% to Artiodactyla ($n = 40$), and 51% to Carnivora ($n = 80$, all to medium-sized carnivores). Such non-target species were: collared-peccaries (*Pecari tajacu*), mule deer (*Odocoileus hemionus*), woodrat (*Neotoma sp.*), desert cottontail (*Sylvilagus audubonii*), mexican ground squirrel

(*Spermophilus mexicanus*), and various members of the Class Ave, including turkey vulture (*Cathartes aura*), roadrunner (*Geococcyx californianus*), scaled quail (*Callipepla squamata*), and sparrows and flycatchers (Family: Passeridae).

Of the 80 pictures taken to target species, 63 were considered to be different individuals (Table 1). Seven mesocarnivore species were documented: gray fox (48% of the mesocarnivore pictures), coyote (17%), bobcat (13%), western hog-nosed skunk (10%), striped skunk (8%), ringtail (3%), and raccoon (2%; Table 2). Gray fox was present at the most sites ($n = 4$) Panther Junction, Dog Canyon Area, Rio Grande east, and Fossil Exhibit area; followed by bobcat and coyote, both present at Terlingua Creek, Panther Junction area, and Dog Canyon area, and hog-nosed skunk present at Rio Grande east and west, and Dog Canyon area ($n = 3$); and finally striped skunk and raccoon were only present at RGW, and ringtail was only present at Panther Junction area ($n = 1$). Thus, the most diverse sites were Panther Junction and Dog Canyon area with 4 species recorded at each site, followed by Rio Grande west side ($n = 3$), Terlingua Creek and Rio Grande east side ($n = 2$ each), and finally Fossil Exhibit area with only one species (Table 1).

Most of the mesocarnivore pictures were taken during the night ($n = 57$), followed by daylight hours ($n = 4$), and finally during crepuscular hours ($n = 2$). However, most of non-target species pictures were taken during the day (Table 1).

Most of spring's data was lost due to flooding. Although Simpson's diversity and evenness indices were measured per season, they should be considered only as a trend; as it may not reveal real values. Diversity was higher in Fall ($D = 0.390$) than in Spring ($D = 0.185$) while evenness was higher in Spring ($E_{1/D} = 0.900$) than Fall ($E_{1/D} = 0.513$).

The overall species accumulation curve based on observations reached an asymptote (Figure 3). Still, the rarefaction curve indicated that higher species richness was expected in Spring ($ES(n) = 5.74$ when $n = 21$ individuals) than in Fall ($ES(n) = 4.68$ when $n = 21$; Figure 4).

Discussion

Fifty-one percent of the pictures were taken to target subjects; the rest was distributed between non-target Classes Ave and Mammalia (Orders: Artiodactyla, Rodentia, and Lagomorpha). Artiodactyla, which was the most abundant non-target Order, represented 25% of the total pictures taken. However, those were mostly represented by groups of collared peccaries that stayed near the camera for extended periods of time, resulting in a high number of pictures taken. Thus, methods used during this study were appropriate, where the camera traps successfully attracted the target Order: Carnivora. However, their secretive nature and low density numbers were also reflected during this study. Most of the mesocarnivore individuals were recorded during the night, where only 4 were recorded during the day (2 gray fox and 2 bobcat) and 2 individuals were recorded during crepuscular hours (a bobcat and a coyote). Conversely, most of the non-target pictures were recorded during the day.

Nevertheless, during this study I encountered many setbacks. Such include those that are inherent to the methods I used: low number of sample sites, wind triggering cameras due to moving vegetation, and animals crossing too fast to appear on the picture. Other problems include a triggering cable cut at one site and the losing most of spring's data due to flooding. Data lost makes it inappropriate to compare seasons or sites. However, some inferences can be made.

Five 5 species were recorded during Fall and 6 species were recorded in Spring. The rarefaction accumulation curve reveals that higher species richness was expected during Spring (Figure 4). Moreover, Spring was more homogenous in terms of diversity and evenness ($D = 0.185$ and $E_{1/D} = 0.900$) than Fall ($D = 0.390$ and $E_{1/D} = 0.513$); however, those results could be different if all data were available. In addition, mesocarnivores were mostly active during night on both seasons (46% of the pictures taken to target species). The most relatively abundant species was fox on both seasons (Table 2).

Considering all data, gray fox, which is thought to be “common” (Easterla, 1973), had the highest relative abundance with 48% of the pictures taken to mesocarnivores ($n = 30$); and was also recorded at the most sites (75%, $n = 4$). Although bobcats are reported to be “uncommon”, Easterla (1973) acknowledge that this might be due to their secretive nature, being more common than they seem. This is supported by my findings, where the “uncommon” bobcats and the “common” coyotes were documented on the same number of sites ($n = 3$), with relative abundances of 13% and 17% respectively. Moreover, I also recorded the “rare” hog-nosed skunk on 3 sites with a relative abundance of 10%.

The official list which dates back to 1973 has relative abundances in terms of how common species are throughout BBNP; where “common” species are those seen >100 times per year, “uncommon” species have been sighted <100 per year, “rare” species are spotted <10 times per year (on average), and those “extremely rare” are those sighted <10 times in the past 10 years (Easterla 1973). Although BBNP’s list was revised in 1997, records are still based on sightings. Out of the 13 medium-sized carnivores registered in BBNP, I recorded 7 while Carter (2002) recorded 10. This could be explained because

Carter (2002) conducted her surveys on roads throughout BBNP, and used camera traps, scats, and tracks; whereas I restricted my efforts to camera-traps along 6 riparian areas. However, out of the 10 mesocarnivores found by Carter (2002), one was only recorded through scats (long-tailed weasel) and one through tracks (raccoon). Although targeted to all mammals, Carter (2002) recorded 3 mesocarnivores I did not. However, those 3 are thought to be “rare”: badgers, long-tailed weasels, and spotted skunks. Moreover, according to Easterla (1973), badgers may be found in lowlands which I did not target, and long-tailed weasels are very secretive. Accordingly, Carter camera-trapped badgers on 2 out of her 70 sites; long-tailed weasels on 4 sites based solely on scats, and spotted skunks on 5 sites based on scats and photographs. Finally, of the species that neither study successfully recorded, swift fox is thought to be “rare” and confounded with gray fox, while hooded skunk (recorded once in recent years) and coati (not seen in recent years) are “extremely rare” (Easterla 1973, revised 1997).

Benefits and implications

National Parks throughout the United States lack of reliable and complete inventories of the organisms that live within their boundaries; and those available are poorly maintained (Stohlgren et al. 1995). BBNP is not an exception, where most of their data for presence and distribution are based on tourist and employee observations (Raymond Skiles and Vidal Davila, National Park Service, personal communication). Furthermore, there have been few studies that take into account medium-sized carnivores. This project helped to document the presence of mesocarnivores in the BBNP.

Recently, Carter (2002) recorded mammals in 70 points throughout the park, whereas I had 6 sites or 9 points (considering the individual camera points). It is obvious

that sampling effort was different between both studies. However, the only difference between studies, considering mesocarnivore richness, includes only 3 “rare” species. This study provides evidence research conducted with limited resources may be very useful to adequately record mesocarnivores by concentrating efforts on riparian areas. Therefore, small studies like this could help improve the status of biodiversity inventories throughout the United States, and could even allow finding community and population trends by standardizing the methods used between them.

Moreover, Texas is 98% privately owned, which makes it difficult to have access to wildlife communities. Given that the BBNP is a protected area, the results from this study might give insight in the natural characteristics of these medium-sized-carnivores, and their interactions; this in turn may allow us to estimate the community’s health of this area and those with similar conditions.

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Tables and Figures

Table 1. No. of individuals of each species found according to season, site, or time of day obtained for Big Bend National Park in Texas during the study conducted in Fall 2006 and Spring 2007. DOG = Dog Canyon area, FOS = Fossil exhibit area, TER = Terlingua Creek, PNT = Panther Junction area, and RGW and RGE Rio Grande West and East respectively, and PNT = Panther Junction area.

	Season		Site						Time of day			Overall
	Spring	Fall	RGW	TER	PNT	DOG	RGE	FOS	Crepuscular	Night	Day	
<i>Lynx rufus</i>	3	5	0	1	5	2	0	0	1	7	0	8
<i>Canis latrans</i>	6	5	0	1	4	6	0	0	1	8	2	11
<i>Urocyon cinereoargenteus</i>	9	21	0	0	23	3	3	1	0	28	2	30
<i>Canis mesoleucus</i>	4	2	4	0	0	1	1	0	0	6	0	6
<i>Procyon lotor</i>	1	0	1	0	0	0	0	0	0	1	0	1
<i>Bassaricus astutus</i>	0	2	0	0	2	0	0	0	0	2	0	2
<i>Mephitis mephitis</i>	5	0	5	0	0	0	0	0	0	5	0	5
Total	28	35	10	2	34	12	4	1	2	57	4	63

Table 2. Percent relative abundance of each species found according to season, site, or time of day obtained for Big Bend National Park in Texas during the study conducted in Fall 2006 and Spring 2007. DOG = Dog Canyon area, FOS = Fossil exhibit area, TER = Terlingua Creek, PNT = Panther Junction area, and RGW and RGE Rio Grande West and East respectively, and PNT = Panther Junction area.

	Season		Site						Time of day			Overall
	Spring	Fall	RGW	TER	PNT	DOG	RGE	FOS	Crepuscular	Night	Day	
<i>Lynx rufus</i>	11%	14%		50%	15%	17%			50%	12%		13%
<i>Canis latrans</i>	21%	14%		50%	12%	50%			50%	14%	50%	17%
<i>Urocyon cinereoargenteus</i>	32%	60%			68%	25%	75%	100%		49%	50%	48%
<i>Conepatus mesoleucus</i>	14%	6%	40%			8%	25%	0%		11%		10%
<i>Procyon lotor</i>	4%		10%							2%		2%
<i>Bassaricus astutus</i>		6%			6%					4%		3%
<i>Mephitis mephitis</i>	18%		50%							9%		8%

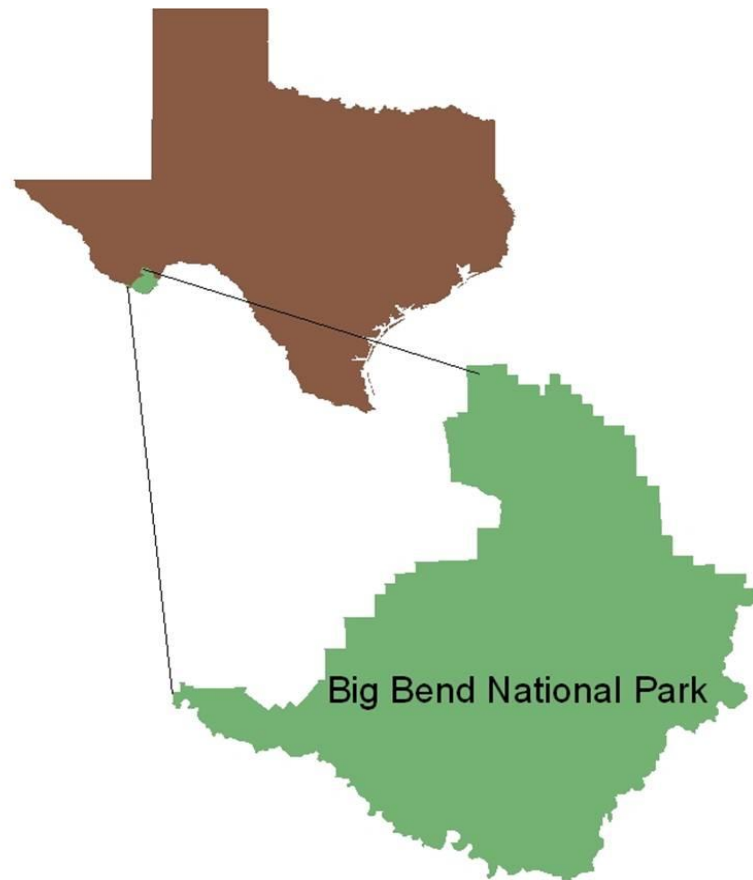


Figure 1. Study area for the mesocarnivore study conducted in Big Bend National Park, Texas during the study conducted in Fall 2006 and Spring 2007.

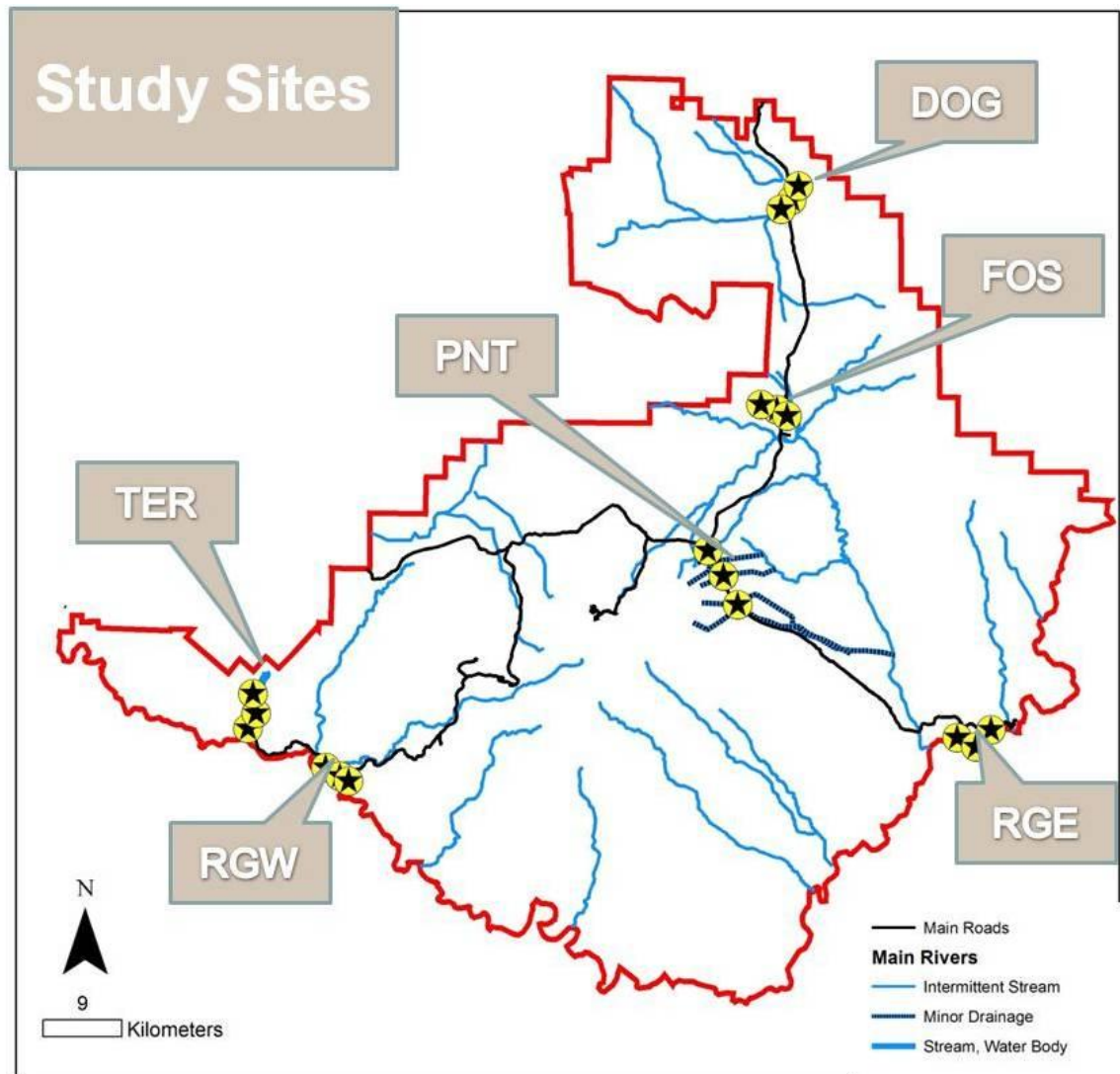


Figure 2. Study sites for the mesocarnivore study conducted in Big Bend National Park, Texas during the study conducted in Fall 2006 and Spring 2007. DOG = Dog Canyon area, FOS = Fossil exhibit area, TER = Terlingua Creek, PNT = Panther Junction area, and RGW and RGE Rio Grande West and East respectively, and PNT = Panther Junction area.

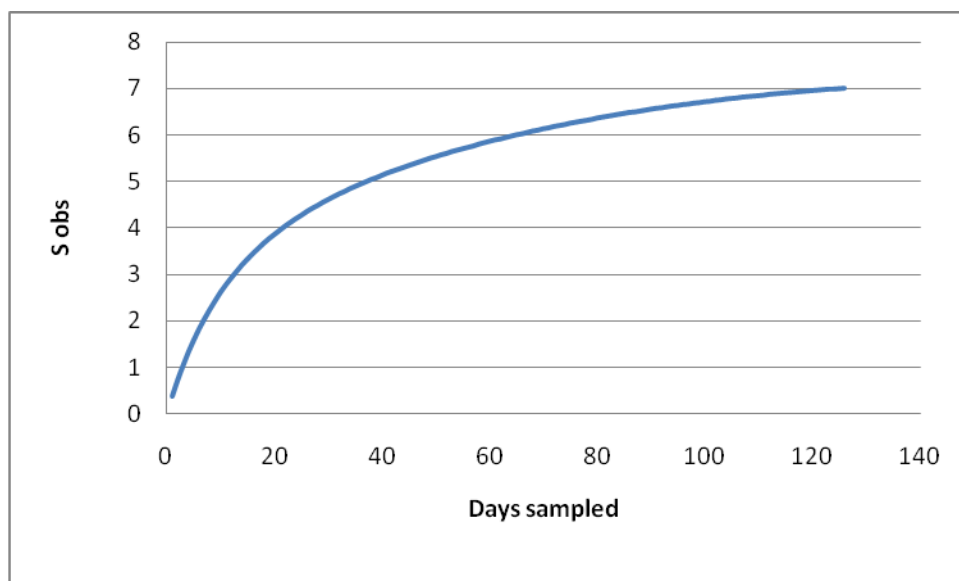


Figure 3. Accumulation curve of observed species richness obtained for Big Bend National Park in Texas during the study conducted in Fall 2006 and Spring 2007.

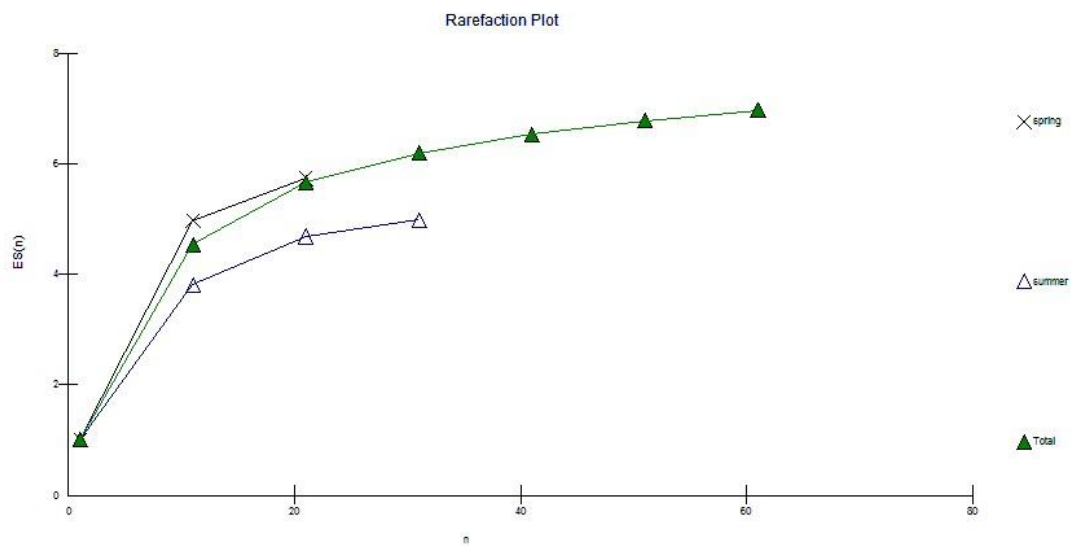


Figure 4. Rarefaction curved per season obtained for Big Bend National Park in Texas during the study conducted in Fall 2006 and Spring 2007.