



**FINAL REPORT**

For the Manomet Bird Observatory and the Programme for Belize

**WILDLIFE INVENTORY OF  
THE RIO BRAVO CONSERVATION AND MANAGEMENT AREA  
PART I: UNGULATES AND PRIMATES**

by

Jose M. Fragoso, Damián I. Rumiz, Cynthia E. Hunter,

Gilberto Silva-López, Linda E. Grober,

and Susan K. Jacobson

Program for Studies in Tropical Conservation  
Department of Wildlife & Range Sciences  
118 Newins-Zeigler Hall, University of Florida  
Gainesville, Florida 32611 U.S.A.

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**PREFACE**

This report describes the results of a wildlife inventory of the Rio Bravo Conservation and Management Area in Belize conducted by the Program for Studies in Tropical Conservation, Department of Wildlife and Range Sciences, University of Florida in collaboration with the Manomet Bird Observatory and Programme for Belize. Part I, presented below, describes the results of a study on ungulates conducted by J. Fragoso, C. Hunter, and L. Grober, and a study of the primates by D. Rumiz and G. Silva-López. Part II will provide results of an inventory of carnivores by A. Novaro, S. Walker, and M. Suarez, and of small mammals by L. Smith, L. Wilkins, and M. Marquez. In Part III, J. Polisar will report on a survey of the turtle fauna of the Rio Bravo area. S. Jacobson, Assistant Director of the Program for Studies in Tropical Conservation, is the Project Director.

## INTRODUCTION

The Rio Bravo Conservation and Management Area (hereafter referred to as Rio Bravo) comprises 61,513 hectares of subtropical moist forest and related wetlands in northwestern Belize. It is managed by the Programme for Belize, a non-governmental organization that promotes research on the sustainable use and conservation of natural resources.

The Manomet Bird Observatory (MBO) began botanical and ornithological studies of the Rio Bravo Area in 1988 and compiled an account of its natural history (Brokaw and Mallory 1988). Wright et al. (1959) broadly described and mapped the vegetation of Belize including the Rio Bravo. Field studies of mammals have been conducted in other sites in Belize (Rabinowitz and Nottingham 1986, 1989; Konecny 1989, Fragoso in press a and b), but no work has been published for the Rio Bravo. Mammals are essential components of an ecosystem and can be greatly affected by land use practices. Plans to promote nature tourism in this region are dependent on improved knowledge of the abundance and distribution of mammal populations, particularly charismatic species which attract human interest.

In late 1989 a cooperative project was developed between the Programme for Belize/Manomet Bird Observatory and the University of Florida to conduct basic ecological research in the Rio Bravo area. A number of University of Florida graduate students proposed studies on the wildlife of the region, to provide baseline information for long-term resource management.

This report documents the results of a study on habitat, habitat use and relative abundance of ungulates and primates in the Rio Bravo. These results are compared to those of other studies of ungulates and primates in the Neotropics.

## METHODS

This study was conducted during January 1990. Rainfall in this region averages 155 cm/yr, less

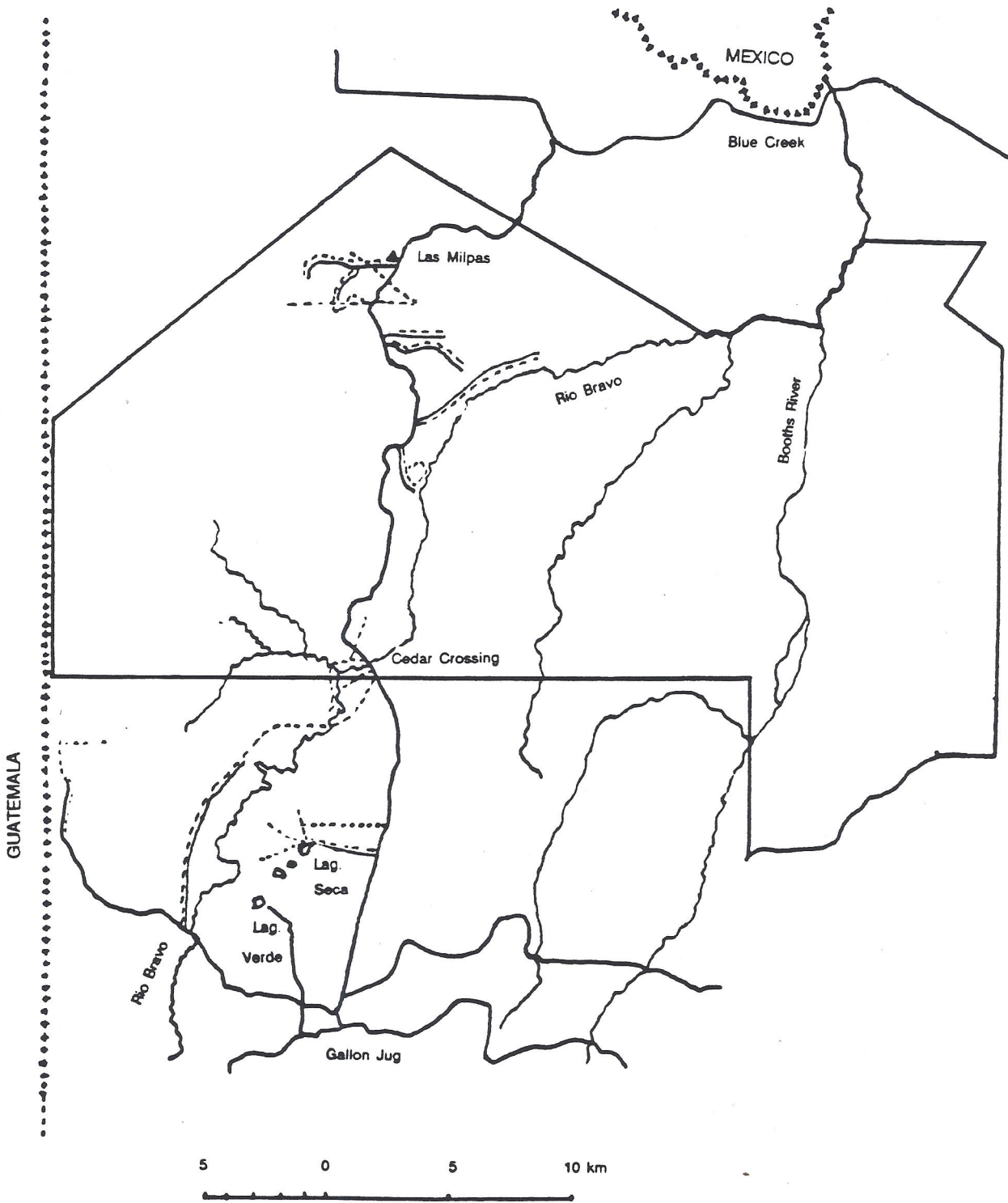


Figure 1: Location of trails cut (-----) and logging roads walked (.....) in Rio Bravo Area, January 1990.



than in the southern portion of the country (Mendez 1984). The rainy season usually occurs from June through December (Wright et al. 1959), and as it rained throughout the study, ground conditions were ideal for identifying animal tracks.

The site is traversed north-south by one maintained road. We collected data along old logging roads, preexisting trails and new transects which we cut (Fig. 1). Transects were used to describe major vegetation communities and were stratified within four geographic regions, three within the reserve and one in the wetlands adjacent to the southern end of the reserve. The wetlands on the eastern edge of the reserve remained inaccessible to this study. Transects began at a road or a lake edge and followed straight compass lines. We cut as little vegetation as necessary to provide a marked trail. Six transects, totalling 16.3 km, were cut and surveyed for vegetation and animal sign. Transect lengths of 4.2 km, 3 km, 3 km, 2.4 km, 2.2 km and 1.5 km were measured by pacing verified by two independent counters.

We described the vegetation qualitatively, characterizing the forest every 100 meters, using visually dominant plant species, plant growth types, and the following physical parameters: a) estimated canopy height, b) presence of trees >1 m in diameter at breast height (dbh), c) canopy broken or closed, and d) forest condition secondary (selectively logged) or primary. Secondary forest was identified by the presence of numerous gaps in the canopy, the presence of logging roads, skidlines, stumps, and the lack of trees greater than 1m dbh (Fragoso 1987, Johnson and Chaffy 1972).

Two to four researchers cut trails and collected data on habitat and animal sign. All researchers used the same methodology to identify mammals, tracks, trails, feeding sites, and plant communities. Nevertheless, to avoid inter-observer variation in recognizing more subtle differences among mammal signs, only sign quantified by one researcher (JMF) was used in the analyses.

Tracks, trails through brush with no tracks visible, scat, scrapes, and feeding evidence were used as indices of mammal presence. The signs used for identification varied among species. The Central American tapir (Tapirus bairdii) leaves obvious trails and three-toed footprints that cannot be confused with those of other species (Fragoso 1987). They create trails often used by other animals. Hence, tracks of the other ungulates were needed for identification, while a trail alone indicated tapir presence.

White-lipped peccary (Tayassu pecari) are almost twice the size of collared peccaries (Tayassu tajacu) (Eisenberg 1981), their footprints are consequently larger. In addition, white-lipped peccaries travel in larger groups, and turn up greater areas of soil when foraging, than collared peccaries (Fragoso 1989, Kiltie and Terborgh 1983, Sowls 1984). To discriminate between signs of peccary and cervids, we noted the abundance of tracks, their size, and gap size between toes. Peccary tracks usually occur in groups, and the gap between toe-prints is substantial. In contrast, white-tailed deer (Odocoileus virginianus) and brocket deer (Mazama americana) usually travel alone or in pairs. Large groups of O. virginianus are common in open grasslands but are not known in Central American forests (Mendez 1984). Deer hoof-prints are more rounded than peccary, and there is little space between the toe-prints. Brocket deer tracks can usually be differentiated from white-tailed deer by their smaller size and shallower imprint: M. americana weighs 15-60 kg and tracks average 30x25 mm, while O. virginianus in Central and South America weighs 50-120 kg and their tracks average 52x35mm (Aranda & March 1987). Mazama gouazoubira, if present in Belize, is even smaller than M. americana (Eisenberg 1981, 1989, Smith et al. 1986, Branan and Marchinton 1987). Of note, white-tailed deer vary less in size within a geographic region (Halls 1984) and those seen were estimated in the lower end of the weight range, so discrimination between brocket and white-tailed deer tracks was occasionally not possible.

We were aware that these methods do not sample all the species of interest equally. Signs of tapirs are more visible than those of other ungulates, and signs of primates are negligible. Sign occurrence in different habitats was analyzed by  $\chi^2$  and preference ratios (Crawley 1983) to determine species' preferred habitats. The preference ratio equation consists of dividing the proportion (%) of sign in a habitat, by the proportion (%) of that habitat in the area.

Transect censuses for direct animal encounters were conducted on the six vegetation transects, on 5 additional cut trails (7.2 km), and on preexisting logging roads and trails (Fig. 1). Censuses for ungulates and primates were conducted by walking quietly (3 or less people, <3 km/hr), scanning either the groundline or treetops. When searching for deer, the effective strip surveyed by two people was considered twice the area surveyed by one, since each person focused constantly to one side of the line.

Deer were censused on 146 km of trail and logging road, and primates on 140 km. In addition, approximately 142 km of main road were driven slowly searching for deer with a Q-beam after dusk. An additional 65 km of roads without recent vehicular traffic were searched from a slow vehicle or horseback during daylight hours. Upon sighting an animal we recorded the species, distance from the observer, and the angle from the transect line. In the case of encounters with monkeys we also recorded group size and composition by age and sex, main activity of the animals, response to the observer, height in the canopy, and type of clue (auditory or visual) that led to detection of the group. Criteria to distinguish spider (Ateles geoffroyi) and howler monkeys (Alouatta pigra) as well as characteristics of different age and sex classes are described in Appendix 1.

## RESULTS

### I. HABITAT

Logging and concomitant road preparation, hunting, chicle-tapping, milpa farming, and local settlement have influenced the biota of Rio Bravo. Since acquisition by the Programme for Belize and the installation of an entrance gate on the main road, we assume hunting and other human disturbances are decreasing.

The Rio Bravo contains at least nine different forest types, six of which show signs of recent human disturbance (Table 1). The forest types, their successional stage, dominant understory vegetation, and subsequently used abbreviated titles are enumerated in Table 1. Various secondary broadleaf forests are the predominant habitat in the reserve, covering 67% of our sample. Most of the canopy was broken (x) but some closed canopy (/c) did occur. Cohune palm (Orbignya cohune) forest (C), either monotypically or mixed with broadleaves (BL/C), cover an additional 17% of the region, and milpas (M), abandoned within the last few years (estimate 1-5 yr), cover approximately 10% of the region. Sapling forest (SAP) consists of hardwood saplings <10 cm dbh and approximately 2-4 m in height. Lacustrine



Table 1: The forest types and dominant understory vegetation sampled by 6 cut transects in Rio Bravo Area.

FOREST TYPE	SUCCESSIONAL STAGE	CANOPY STATUS	UNDERSTORY VEGETATION	SAMPLES	
				N	%
HIGH BROADLEAF (HI-BL)	Secondary	Closed (/c)	Cohune/sabal/ star palm	42	29
			Sapling/vine/ shrub	2	1
			Sapling/shrub /sabal/cohune	9	6
		Broken (/x)	Sapling/vine/ shrub	10	7
			Shrub	1	-
Sapling/shrub/ sabal/cohune	5	3			
COHUNE (C)	Unknown	Closed (/c)	Star/cohune/ sapling	18	12
			Broken (/x)	<u>Desmoncus</u> sp.	1
BROADLEAF/ COHUNE (BL/C)	Secondary	Closed	Sapling/ star/cohune	6	4
SAPLING (SAP)	Secondary	Closed	Vines	4	3
BROADLEAF- LACUSTRINE (LAC)	Unknown	Closed	Cohune/sabal/ vines	9	6
LOW BROADLEAF (LO-BL)	Secondary	Broken	Shrubs/sabal/ cohune	4	3
ABANDONED MILPA (M)	Early Successional	Closed	Piper/ cecropia	15	10
BROADLEAF- RIVERINE (RIV)	Primary	Closed	Cohune	10	7
BROADLEAF- SWAMP (SF)	Unknown	Closed	Vines/star	7	5
TOTAL				145+	96*

\* Four percentage points lost due to omitting values less than one and rounding errors.

+ Vegetation data missing for some points.

broadleaf forest (LAC) is seasonally flooded and supports little or no understory plants. The riverine forests (RIV) were the least disturbed habitats we encountered, hence we termed them primary.

We identified 15 understory habitats (Table 1). The dominant plants common in the understory were similar in many of the forests. The species and growth types were: cohune, botan (Sabal morrisiana), star (Cryosophila argentea), and basket tie tie (Desmoncus spp.) palms, vines, saplings (stem un-branched near base), and shrubs (stem branching near base). Star palms were a frequent understory plant in all broadleaf forest types. The abandoned milpas consisted of dense Cecropia spp. and Piper auritum groves. One of the five milpa sites we located was still in use for marijuana and corn cultivation.

## II. UNGULATES

A. General. Actual encounters with ungulates were few (Table 2). Two tapirs, seven white-tailed, and three brocket deer are insufficient sample sizes for use of statistical density estimators (Burnham et al. 1980). However, we used these sightings to supplement the indirect information on habitat use. Table 3 quantifies ungulate sign by habitat type. Table 4 presents these signs as percentage of encounters by habitat. Some of the forest types were lumped based on biological criteria to facilitate statistical analysis. Only "tapir trails" and white-lipped peccary tracks occurred in high enough frequency for analysis using statistical tests of significance. The results of the preference ratio analysis are summarized in Table 5. They indicate that the three ungulate species, all browsers, preferred LO-BL and somewhat preferred C-BL/c. In contrast, collared peccary preferred HI-BL/c, and white lipped peccary preferred C-BL/c.

B. Tapirs. We observed tapir sign in all forest types, and in all but two understory habitats (Table 3). To obtain adequate sample sizes for a statistical analysis of tapir preferences using their sign (Table 5), forests at an early stage of succession (M and SAP) were grouped because their dominant plants were at similar growth stages, sharing structural characteristics. Seasonally and permanently flooded forests constitute a third group (Lacustrine/Swamp forest = LAC/SF). The Broken-canopy low-broadleaf forest (LO-BL) contained a highly significant majority of tapir evidence ( $\chi^2 = 17.7$ ,  $df = 6$ ,  $P < .005$ ). Cohune was the next most selected forest, the flooded forests (LAC, SF, and RIV) were avoided, and the other forests were used approximately in proportion to their availability by tapir. A



Table 2. Confirmed Independent Ungulate Sightings, January 1990, in Rio Bravo Area.

Species	Grp.size	Forest Type +	Details
<u>Tapirus bairdii</u>			
n=2			
	1		RIV: sec. bdlf. nr. streambed
	1		RIV: sec. bdlf. nr. streambed
<u>Odocoileus virginianus</u> (assumed race <u>truei</u> )			
n=7:			
	1		HI-BL/c: w/palm understory
	1		HI-BL/c: 10m from log. rd.
	1		HI-BL/x: w/sap. understory
	1		*RD: LO-BL edge of driven rd.
	2		RD: grassy edge of driven rd.
	1		RD: BL/x off driven rd.
<u>Mazama</u> (assumed sp.) <u>americana</u>			
n=3:			
	1		SAP: low forest w/palms
	1		RIV: closed BL near river
	1		SAP: crossed log RD.

+ Forest type symbols explained in Table 1.

\*RD: ecotone between dirt road or abandoned logging road and adjacent forest type listed

Table 3: The number of signs (sets of tracks, trails, or feeding evidence) of mammals encountered by JMF transect surveys in Rio Bravo Area.

FOREST TYPE+	UNDERSTORY VEGETATION	n		n	
		TAPIR TRAIL	PECCARY WL* CL*	DEER WT* BT*	
HI-BL/c	Cohune, sabal, star palm	14	2 2	1	2
	Sapling, vine, shrub	1	0 0	0	0
	Sapling, shrub, sabal, cohune	9	4 2	0	0
HI-BL/x	Sapling, vine, shrub	0	0 0	0	0
	Shrub	1	0 0	0	0
	Sapling, shrub, sabal, cohune	4	0 0	0	0
LO-BL	Shrubs, cohune, sabal	6	0 0	1	1
COHUNE/c	Star, cohune, sapling	15	9 0	2	2
COHUNE/c	Bactris	1	4 0	0	0
BL/C	Sapling, star, cohune	5	3 0	1	1
MILPA	<u>Piper</u> sp., <u>Cecropia</u> sp.	7	1 0	0	0
SAP	Vines	2	0 0	1	1
RIV	Cohune	6	2 0	0	0
LAC	Cohune, sabal, vines	5	0 0	0	0
SF	Vines-star	0	4 2	0	0
<b>TOTAL</b>		<b>76</b>	<b>29 6</b>	<b>6</b>	<b>7</b>

+ Forest type symbols explained in Table 1.

\* WL=white-lipped, CL=Collared, WT=White-tailed, BT=Brocket.

Table 4: The percentage of tracks, trails, and feeding evidence of different mammals encountered in various forest types relative to the percentage availability of understory habitats in Rio Bravo Area.

FOREST TYPE+	% SAMPLE	% TAPIR	% PECCARY		% DEER	
			WL*	CL*	WT*	BT*
HI-BL/c	37	32	21	67	17	29
HI-BL/x	11	7	0	0	0	0
LO-BL	3	8	0	0	17	14
COHUNE, BL/C	17	28	55	0	50	43
M/SAP	13	12	3	0	17	14
RIV	7	8	7	0	0	0
SW/LAC	11	7	14	33	0	0
TOTAL **	99	102	100	100	100	101

+ Forest type symbols explained in Table 1.

\* WL=white-lipped, CL=Collared, WT=White-tailed, BT=Brocket.

\*\* Totals do not always equal 100% because of rounding error.

Table 5: Preference ratios of ungulates for different habitats in Rio Bravo Area.

FOREST TYPE+	PECCARY		DEER		PACA	AGOUTI
	TAPIR	WL*	CL*	WT*	BT*	
HI-BL/c	0.9	0.6	1.8	0.5	0.8	1.5
HI-BL/x	0.6	0	0	0	0	0
LO-BL	2.7	0	0	5.7	4.7	0
COHUNE/BL/c	1.6	3.2	0	1.9	2.5	2.2
M/SAP	0.9	0.2	0	1.3	1.1	0
RIV	1.1	1	0	0	0	0
SF/LAC	0.6	1.3	3	0	0	0.7

+ Forest type symbols explained in Table 1.

\* WL=white-lipped, CL=Collared, WT=White-tailed, BT=Brocket.

preference ratio analysis of the data supports this result (Table 5).

C. Peccaries. White-lipped peccaries move in large herds (Sowls 1984). A very recent large scale rooting area and a large bedding area were found nearly 30 km apart, suggesting that at least two herds roam the Rio Bravo region. This estimate is supported by an interview with Mr. Carl Tahan, resident manager of Gallon Jug, who observed two large herds (about 50 peccaries one time and about 90 at another) in the region. To determine the habitat preferences of white-lipped peccary we compared the amount of sign in different forests. We omitted M/SAP and LO-BL from the analysis because no white-lipped peccary sign was seen in the latter, and only one set of tracks were in the former. In addition to the aforementioned groups of forest types, we lumped HI-BL/c and HI-BL/x forest into one group, and two flooded forests (LAC/SF and RIV) in another group to obtain an adequate sample size. White-lipped peccary showed a highly significant preference for cohune dominated forests. They used the flooded forests in proportion to its occurrence, and avoided the HI-BL forest ( $\chi^2 = 22.92$ ,  $df = 2$ ,  $P < 0.000001$ ). These results are supported by a preference ratio analysis of the data (Table 5). No confirmed sightings of collared peccaries were obtained. However, preference ratio analysis of the sign data revealed a high preference for SF/LAC, and a slighter preference for HI-BL/x (Table 5). Their tracks were not seen in other forests.

D. Deer. Deer sign occurred in all forest types (HI-BL/C, LO-BL, C, BL/C, AND M/SAP). Both deer genera preferred LO-BL and Cohune forests (Table 5). Independent observations suggested that deer also used HI-BL/closed-canopy forests when there was chicle fruitfall in these areas. Three brocket deer and three white-tailed deer were seen in 146 km of walking/searching on previously cut or preexisting trails. This small sample yields a relative abundance of 0.02 deer (each species) per km walked, all habitats combined. Three white-tails (two groups) were encountered at night during searches from vehicles. No deer were seen during daylight driving. The roadside habitat (RD) is an artificial one and composes a small percentage of the total reserve, but often is preferred by white-tailed deer for the new growth on cut browse species. It can serve as one index of white-tailed abundance. Note that 57% of the white-tailed sightings occurred within 10m of road/forest ecotones (Table 2).

Brocket deer are usually more shy, cryptic, and solitary than white-tailed deer, and less often found in 'edge habitats' like roadsides. They are known to use all the habitat types found at Rio Bravo (Walker 1975, Eisenberg 1989). Two of the three sightings of brockets occurred in dense sapling forest



(Table 2), suggesting a preference for denser cover over more open forests. Inconclusive evidence of the presence of the smaller species M. gouazoubira was gathered.

### III. PRIMATES

We recorded 17 encounters with primates: 10 with spider monkeys (Ateles geoffroyi) and 7 with howler monkeys (Alouatta pigra). Group composition is shown in Table 6, and location of encounters in Figure 2. Differences in visibility and in the experience of the observer resulted in the recording of incomplete sex/age information for some primate groups.

The color pattern of the spider monkeys more closely resembled the Mexican subspecies (A.g. vellerosus) than the Yucatan subspecies (A.g. yucatanensis), contrary to what has been previously reported for Belize (Kellogg and Goldman 1944). There was some inter-individual variation in color making it difficult to assign individuals to a particular subspecies. Some showed intermediate patterns between the subspecies descriptions and drawings from Konstant et al. (1985).

Most of the primate sightings occurred in HI-BL forest, probably because it was the dominant habitat in the sampled area. A group of howlers was found in riverine forest, calling from cohune palms. In other habitat types no monkeys were seen. It is not possible to draw conclusions about habitat preferences based on our few encounters, but they suggest a preference for high closed canopy forests. Six encounters with spiders and two with howlers, including the largest group sizes recorded in this survey, took place around two Mayan ruin sites where we found many chicle, ramon (Spondias sp.) and fig (Ficus sp.) trees. It seems that monkey groups are not evenly distributed throughout the area and that particularly rich food sources can concentrate groups of both species.

Thirteen of the seventeen monkey sightings (8 spider and 5 howler groups) took place during actual transect censuses along a total of 140 km walked. Sighting distances for spider monkeys varied between 15 and 100 m ( $\bar{x} = 39.6$ ) and for howler monkeys between 12 and 27 m ( $\bar{x} = 16$ ). Perpendicular distances varied between 6 and 22 m for spiders ( $\bar{x} = 12.4$ ), and between 1 and 17 for howlers ( $\bar{x} = 9$ ). As these were too few encounters to estimate density by line transect methods (Burnham et al. 1980), we are only able to provide a range of densities based on minimum and maximum distances. Considering that the censused area covered 140 km by two times the sighting distance, population density estimates for spiders is between 0.57 and 3.80 groups per km<sup>2</sup> and for



Table 6: Composition of primate groups encountered at the Rio Bravo Area (see Figure 2 for location of groups).

<u>Ateles geoffroyi</u>			<u>Alouatta pigra</u>		
Location	Composition*	total	Location	Composition*	total
UF2W	2 ?	2	M.Road	2 ?	2
Ruins	13 ?	13	L.Seca	1 AM, 1 AF, 1J	3
UF2E	2 SAM, 1 JF	3	7.4 Rd	1 AM, 1AF, 1 inf	3
L.Seca	6 ?, 1 inf	7	M. Road	1 AM	1
L.Seca	3 ?	3	CC-SC	1AM, 1AF, 1J, 1inf	4
L.Seca	1 AF, 1 JF, 1 inf	3	CC	1 AM, 1AF, 1J,	3
Ruins	2 AF, 2 JF, 1 inf	5	Ruins	4 AM, 3AF, 2JF,	
Ruins	2 AF, 1 J, 2 inf	5		1 JM, 1 inf	11
P.Cacao	7 ?	7			27
L.Seca	3 ?	3			

51

mean group size 5.1 ind.

mean group size 4.3 ind.  
(without counting solitary M)

\* AF: adult female; AM: adult male; SAM: subadult male;  
 JF: juvenile female; JM: juvenile male; inf: infant;  
 ?: age/sex unknown.

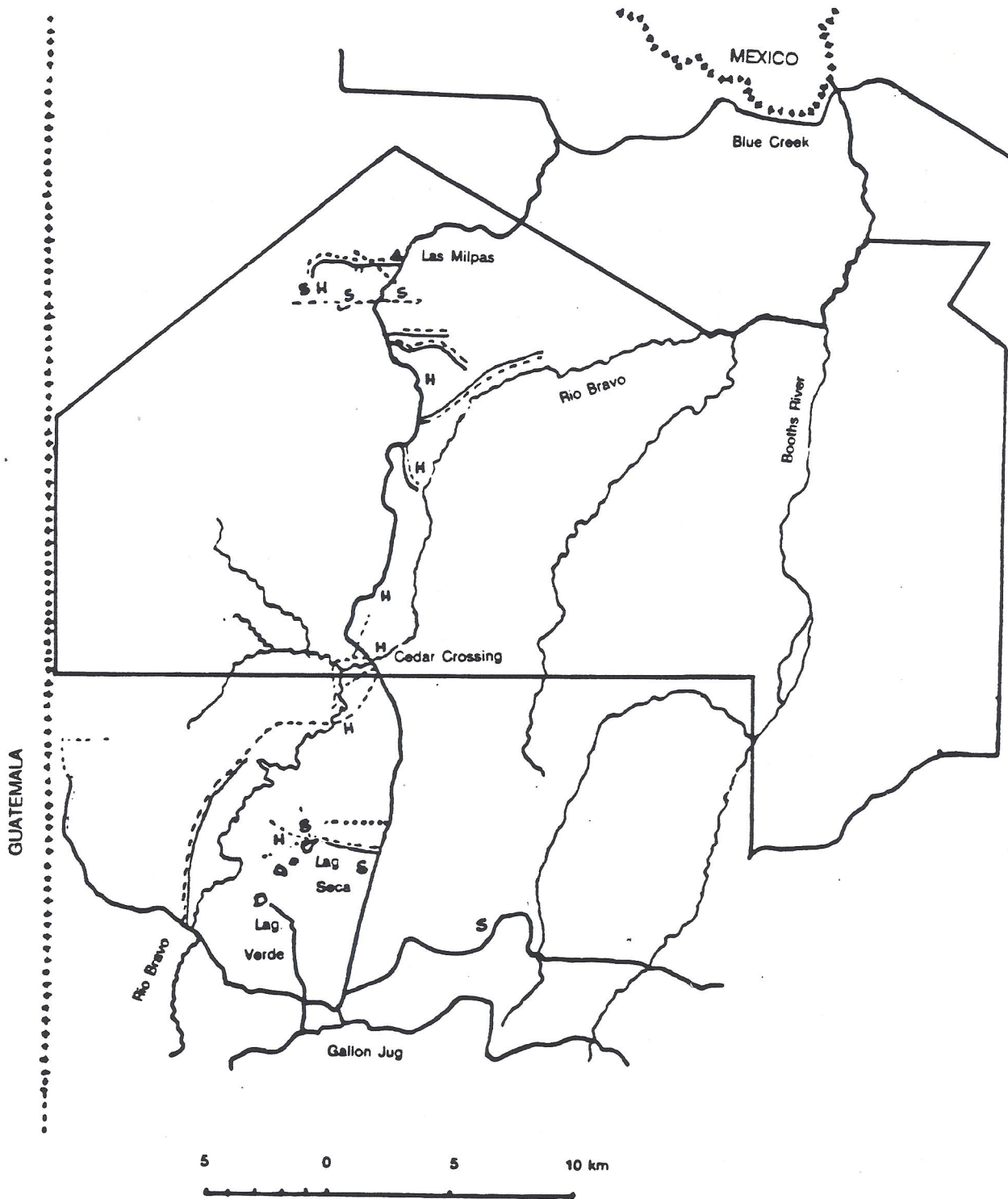


Figure 2: Location of howler (H) and spider (S) monkey encounters in Rio Bravo Area, January 1990.

howlers between 1.32 and 2.97 groups per km<sup>2</sup>. The rate of encounters per km walked was low, 0.057 spider groups/km and 0.036 howler groups/km.

Auditory clues helped us to detect monkey groups. Two howler groups were noted due to their loud calls, and five spider groups were detected during censuses because of their vocalizations and the noise they produced while moving in the foliage.

Group sizes of spider monkeys ( $\bar{x}$  = 5.1 ind.; range = 2-13; n = 10) agreed with other studies and the "fusion-fission" nature of their social organization (van Roosmalen and Klein 1988). Small foraging groups usually consist of a mother and her offspring and often forage separately from males. However, individuals congregate at night and in trees with large fruit crops. Group sizes of howler monkeys were small ( $\bar{x}$  = 4.3 ind.; range 2-11; n = 6 plus a solitary male), similar to reports for other places in Central America (Bolin 1981, Horwich and Gebhard 1983).

## DISCUSSION

The Rio Bravo Conservation and Management Area supports a diversity of vegetation types. Most have been disturbed, primarily by selective logging. Our vegetation analysis incorporates the influence of human disturbance. These disturbances affect structure and species composition of broadleaf forests, impacting mammalian species long after the disturbance has ceased (Johns 1986). We suggest that Brokaw's and Mallory's (1988) vegetative classes, derived from a vegetation map produced in the 1950s by Wright et al. (1959), could be enhanced by sub-division to reflect post-Mayan human disturbance and the successional stage of the vegetation. Specifically, we divided their upland broadleaf forest into five types: HI-BL/c, HI-BL/x, LO-BL/x, M, and SAP (Table 1), and found these to be used differentially by the mammals surveyed. Similarly we split the swamp forest into a number of "flooded" categories, e.g., Broadleaf Swamp forest (found in depressions with the water table at ground surface), and lacustrine and riverine forests. Our estimated extent of "flooded forests" (18%) was similar to Brokaw and Mallory's swamp forest (20%) as were our percentages of various broadleaf forests. In our study, cohune dominated forest was slightly more extensive than that described by Brokaw and Mallory (12% vs. 8%), but this could be due to sampling and/or vague boundaries. We differentiated

broadleaf/cohune (BL/C) from other BL because it may be important in terms of mammalian use. We were unable to reach the "marsh area" described by Wright et al. (1959).

Tapirs were widely distributed throughout the Rio Bravo area, but not abundant. We encountered an average of four tapir trails per km of transect line, whereas Fragoso (in press a) averaged 52 per km in the Chiquebul Forest Reserve and 12 per km in the Rio Grande regions of Belize. The low tapir abundance at Rio Grande was due to population reduction caused by human hunting (Fragoso in press b). The low tapir densities at Rio Bravo may also have resulted from hunting, which occurred in the Rio Bravo Area until 1987, and still occurs around the reserve. The regions we surveyed did not support prime tapir habitat, such as herb dominated floodplains (Fragoso in press a and b). Thus, the low tapir population may also reflect a generally lower quality habitat. Selective logging at low levels improve tapir foraging habitat (Fragoso in press b), but this activity at high intensity can negatively impact them.

The Rio Bravo region supports a population of white-lipped peccaries. Their preference for Cohune forests during January is probably due to the occurrence of cohune nuts on the ground, since this species consumes the nuts of related palm species in other areas (Kiltie and Terborgh 1983). Harvesting forest resources in the Rio Bravo Conservation and Management Area may be detrimental to white-lipped peccary populations, since they require large tracts of land for their survival (Sowls 1984). They disappeared from Santa Rosa National Park, Costa Rica, when this 10,700 ha area became isolated from other forested regions, and from Barro Colorado when it became a 1500 ha island. Increased human activity at Rio Bravo, coupled with the isolation of the area from contiguous forest, could cause the extirpation of the species. White-lipped peccary populations at Rio Bravo should be closely monitored.

Collared peccaries are tolerant of human activity and can withstand high levels of hunting (Sowls 1984). However, we found few sign of collared peccaries. This may be because they avoid areas occupied by white-lipped peccaries (Sowls 1984). At Rio Bravo it appears that the two peccary species co-exist by foraging in different forest types. Peccaries in Peru also appear to coexist by using different habitats (Bodmer 1989). Collared peccaries may eventually become more common at Rio Bravo, if white-lipped peccary populations decline.

Our low track counts of deer are partially due to their small track size and solitary social



structure: we probably missed many tracks during searches. All these cervids are both diurnal and nocturnal, but we were unable to census them at night. Given these sampling problems, the following conclusions are made regarding deer densities in the Rio Bravo.

The low frequency of white-tailed deer encounters by all methods indicates low densities relative to other secondary broadleaf forests. The frequency of white-tail sightings on roads was also low. The white-tailed population may be concentrated in the limited savannah habitat, which is the preferred habitat in Suriname (Branan and Marchinton 1987), but which we were unable to census. We suggest that the carrying capacity of the various broadleaf habitats to support white-tailed deer is not currently met, and given their reproductive plasticity (Verme and Ullrey 1984) the population probably will increase with continued control of hunting. Our rate of encounter with brockets and brocket sign indicate population densities similar to other regions. The brocket density suggested from our data is not much lower than that of Branan and Marchinton (1987) in Suriname's broadleaf closed forest, or those reported by Emmons (1984) (*Mazama americana* figures of 0.02, 0.04, and 0.05 deer per km walked at night) for various tropical forests.

All deer species are preferred game throughout Central America, and overhunting has diminished populations over much of Belize (Frost 1977). The white-tailed deer is reportedly the number one meat source to subsistence hunters in Belize as in other countries (Bindernagel 1988). Brocket deer are less popular for sport hunting and less profitable for subsistence but are still heavily utilized in other parts of Belize (Bindernagel 1988). Brockets exhibit lower reproductive potential than white-tailed deer (Branan and Marchinton 1987) and thus are more severely impacted by overhunting. The signs of hunting we detected lend support to the hypothesis that deer densities are presently low in the Rio Bravo.

The reserve fosters two primate species, and given its relatively large area, could become an important stronghold for their long term conservation. However, frequency of group encounters (0.09 groups/km) was low. Hubrecht (1986) found spider monkeys at a rate of 0.16 groups/km in the Chiquebul forest, which provided a density estimate of 4.4 groups per km<sup>2</sup>. In Tikal, only 80 km from our study site, Cant (1978) found the density for spider monkeys to be 6.5 groups per km<sup>2</sup> with a rate of encounters of 0.5 groups per km walked. For further comparison, censuses of primates in Uganda yielded an average of 1.7 groups per km for three species (Struhsaker 1975), and in Malaysia averaged



0.8 groups/km for four species (Marsh and Wilson 1981). Our density estimate of spider monkeys based on sighting distances (0.57 to 3.80 groups/km<sup>2</sup>) was lower than the above mentioned ones for Chiquebul and Tikal, whereas our density of howlers (1.32 to 2.97 groups/km<sup>2</sup>) seems similar to the one reported for a nearby area on the Belize River (1.85 groups/ km<sup>2</sup>; Bolin 1981). Due to our small sample size we should be cautious in drawing conclusions from this comparison. Density estimation depends on frequency of encounters as much as on distances of the encounters. If our estimation of effective strip width base on distances was substantially shorter than the "real" width, actual population densities would be even lower than our estimates.

Although population densities appeared to be low, we perceived that monkeys were not evenly distributed throughout the reserve. Habitat characteristics primarily determine animal populations, and the concentration of monkey groups around former Mayan sites with abundant food trees is an example of this, but other factors may also be important. Logging has modified the forest, indirectly affecting food availability and shelter for arboreal mammals in a way that we can not evaluate. Disease outbreak has been mentioned as an explanation for population crashes of howler monkeys in Central America (Collias and Southwick 1952, Trapido and Galindo 1956). This could have occurred in Belize (Hubretch 1986), but no recent evidence of it has been found for the Rio Bravo Area. Considering reports of local people, hunting is also a detrimental pressure in the area. Monkeys may not be shot for food, but they may be used as bait for hunting large cats and as pets.

Longer studies of the ecology of all the mammals of the Rio Bravo area are needed to evaluate population status and trends due to the influences of hunting, logging, or other human disturbance. Human activity in forests often decreases mammal populations (Myers 1986). We report here evidence suggesting that these six ungulate and primate species are impacted by recent disturbances in Rio Bravo. Although low intensity selective logging can sometimes benefit folivores and browsers (Crawford 1984, Johns 1986, Fragoso in press a), the mammals surveyed here are susceptible to forest degradation and may be easily extirpated. If agricultural development occurs and selective logging begins again in the Rio Bravo Area, the impact of various human activities on animal populations should be closely monitored. This report should provide a basis for initial management decisions regarding ungulates and primates.

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REFERENCES

- ARANDA, M., and I. MARCH. 1987. Guía de los mamíferos silvestres de Chiapas. Inst. Nac. de Inv. de los Recursos Bióticos, Xalapa, Mexico. 149 pp.
- BINDERNAGEL, J.A. 1988. Wildlife conservation in Belize: status, utilization, and management requirements of important wildlife species. U.N.F.A.O. Development Programme (Draft).
- BODMER, R.E. 1989. Frugivory in Amazon Ungulates. Unpubl. Ph.D. Thesis, University of Cambridge, England.
- BOLIN, I. 1981. Male parental behavior in black howler monkeys (Alouatta pigra) in Belize and Guatemala. *Primates*, 22:349-360.
- BRANAN, W.V. and R.L. MARCHINTON 1987. Reproductive Ecology of White-tailed and Red Brocket Deer in Suriname. In C.M. Wemmer (ed). *Biology and Management of the Cervidae*. Washington, DC. Smithsonian Institution.
- BROKAW, N.V. and E.P. MALLORY. 1988. Natural history of the Rio Bravo Resource Management and Conservation Area. Unpubl. Report. Manomet Bird Observatory, Manomet, Mass.
- BURNHAM, K.P., D.R. ANDERSON and J.L. LAAKE. 1980. Estimation of density from line transect sampling of biological populations. *Wildlife Monographs* 72.
- CANT, J.G. 1978. Population survey of the spider monkey Ateles geoffroyi at Tikal, Guatemala. *Primates*, 19:525-535.
- CRAWFORD, H.S. 1984. Habitat Management. In *The white-tailed deer: Ecology and management*. (L.K. Halls, ed.) Stackpole Bks. Harrisburg, Pa.
- CRAWLEY, M.J. 1983. *Herbivory: the dynamics of animal-plant interactions*. University of California Press, Berkeley, California. 437 pp.
- COLLIAS, N. and C. SOUTHWICK. 1952. A field study of population density and social organization in howling monkeys. *Proceedings of the American Philosophical Society* 96:143-156.
- EISENBERG, J.F. 1981. *The Mammalian Radiations*. University of Chicago Press, Chicago.
- 1989. *Mammals of the Neotropics: The Northern Neotropics*, vol.1. University of Chicago Press, Chicago.
- EMMONS, L.H. 1984. Geographic variation in densities and diversities of non-flying mammals in Amazonia. *Biotropica* 16:210-222.
- FRAGOSO, J.M.V. 1983. The ecology and behavior of Baird's tapir in Belize. B.S. Thesis, Trent Univ., Peterborough, Canada.
- 1987. The habitat preferences and social structure of tapirs. M.S. Thesis, Univ. of Toronto, Toronto, Canada.
- 1989. The white-lipped peccary on Maraca Island, Brazil. Pp. 34-42 in *Maraca rainforest project preliminary report: mammals (part 1)* (J.A. Ratter and W. Milliken eds.). Instituto Nacional de Pesquisas da Amazonia, Royal Geographic Society, and Secretaria Especial do Meio Ambiente, (RGS) London, England.
- In press a. The effect of selective logging on the Central American tapir in Belize. In *Latin American Mammals: Their Conservation, Ecology and Evolution* (M.A. Mares and D.J.



- Schmidly, eds.) Univ. of Oklahoma Press, Oklahoma.
- In press b. The effect of hunting on tapirs in Belize. In The Utilization of Wildlife in the Neotropics (J.G. Robinson and K.H. Redford, eds.). Univ. of Chicago Press, Chicago.
- FROST, M.D. 1977. Wildlife management in Belize: program status and problems. *Wildlife Soc. Bull.*, 5:48-51.
- HALLS, L.K., ed. 1984. *The White-Tailed Deer: Ecology & Management*. Stackpole Bks. Harrisburg, Pa. 870 pp.
- HORWICH, R.H., and K. GEBHARD. 1983. Roaring rythms in the black howler monkey (Alouatta pigra) of Belize. *Primates*, 24:290-296.
- HUBRECHT, R.C. 1986. Operation Raleigh primate census in the Maya Mountains, Belize. *Primate Conservation* 7:15-17.
- JOHNS, A.D. 1986. Effects of selective logging on the behavioral ecology of West Malaysian primates. *Ecology*, 67:684-694.
- JOHNSON, M.S. and D.R. CHAFFY 1972. An inventory of the Chiquebul Forest Reserve, Belize. Land Resources Division, Colonial Publ., Suributon, England.
- KELLOG, R. and E.A. GOLDMAN 1944. Review of the spider monkeys. *Proceedings of the U.S. National Museum*, 96:1-45
- KILTIE, R., and J. TERBORGH. 1983. Observations on the behavior of rain forest peccaries in Peru: why do white-lipped peccaries form herds? *Z. Tierpsychol* 62: 241-55.
- KONECNY, M.J. 1989. Movement patterns and food habits of four sympatric carnivore species in Belize, Central America. Pp. 243-264 in *Advances in Neotropical mammalogy* (K.H. Redford and J.F. Eisenberg, eds.) Sandhill Crane, Gainesville, Fl.
- KONSTANT, W., R.A. MITTERMEIER and S.D. NASH. 1985. Spider monkeys in captivity and in the wild. *Primate Conservation*, 5:82-109.
- MARSH, C.W. and W.L. WILSON. 1981. A survey of primates in Peninsular Malaysian forests. *Universiti Kebangsaan Malaysia and Cambridge University, Cambridge*.
- MENDEZ, E. 1984. Mexico and Central America. In: *The white-tailed deer: Ecology and management*. (L.K. Halls, ed.) Stackpole Bks. Harrisburg, Pa.
- MYERS, N. 1986. Tropical deforestation and a mega-extinction spasm. Pp. 349-409 in *Conservation Biology: The Science of Scarcity and diversity* (M. Soule, ed.) Sinauer Assoc., Sunderland, Mass.
- RABINOWITZ, A.R., and B. NOTTINGHAM, Jr. 1986. Ecology and behaviour of the jaguar (Panthera onca) in Belize, Central America. *J. Zool. Lond. (A)* 210:149-159.
- \_\_\_\_\_. 1989. Mammal species richness and relative abundance of small mammals in a subtropical wet forest of Central America. *Mammalia* 53(2):217-226.
- SMITH, M.H., W.V. BRANAN, R.L. MARCHINTON, P.E. JOHNS, and M.C. WOOTEN. 1986. Genetic and morpohologic comparisons of red brocket, brown brocket, and white-tailed deer. *J.Mamm.*, 67(1):103-111.
- SOWLS, L.K. 1984. *The Peccaries*. University of Arizona Press, Tucson.
- STRUHSAKER, T.T. 1975. *The red colobus monkey*. University of Chicago Press. Chicago.

- TRAPIDO, H., and P. GALINDO 1956. The epidemiology of yellow fever in Middle America. *Experimental Parasitology* 5:285-323.
- van ROOSMALEN, M.G.M., and L.L. KLEIN 1988. The spider monkey, genus Ateles. Pp.455-537 in *Ecology and behavior of neotropical primates vol. 2* (R. Mittermeier, A. Rylands, A.Coimbra-Filho, G. Fonseca, eds.)
- VERME, L.J., and D.E. ULLREY 1984. Physiology and Nutrition. In *The white-tailed deer: Ecology and management.*(L.K. Halls, ed.) Stackpole Bks. Harrisburg, Pa.
- WALKER, E.P. 1975. *Mammals of the World v.II.* 3d ed. Johns Hopkins Press. Baltimore, MD.
- WRIGHT A.C.S., D.H. ROMNEY, R.H. ARBUCKLE and V.E. VIAL. 1959. *Land in British Honduras: a report of the British Honduras Survey team.* Land Resources Division, Colonial Publ., Suributon, England.



APPENDIX 1Criteria used to identify, sex, and age primates at Rio Bravo.

Alouatta pigra  
Black howler monkey  
or Guatemalan howler.

Ateles geoffroyi  
Spider monkey  
A.g. vellerosus Mexican spider  
A.g. yucatanensis Yucatan spider

All black

Dorsally brownish-black, ventrally whitish, sides of the back brownish.

**Quadrupedal locomotion.** Almost always four limbs attached to the substrate.  
Leaps uncommon.

**Brachiation.** Fore limbs and tail used in fast travelling.  
Leaps common.

Adult males: large, long beard. They howl.  
Large **white-pink hanging testicles**.

Adult males: dark testicles, not very obvious.  
Same size as females.

Adult females: less robust, pink vulva, no obvious clitoris, long nipples. Only ones that carry infants.

Adult females: **long, pink hanging clitoris**.  
Noticeable nipples. Carrying infants.

Juveniles: smaller size. Males with pink testicles; females with thin clitoris (hard to see)

Juveniles: smaller size, more playful (or "threatening") than adults. Testicles or clitoris noticeable but smaller than adults.

Infants: being carried, ventrally if < 3mo. old, dorsally if older. Up to 1 yr. old.

Infants: being carried by the mother. Distinctive pink and black face mask.