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for Alan Rabinowitz

# FINAL REPORT

For the Manomet Bird Observatory and the Programme for Belize

# WILDLIFE SURVEY OF THE RIO BRAVO CONSERVATION AND MANAGEMENT AREA BELIZE

## PART 2A: SMALL MAMMALS

Leslie Hay-Smith, Monica Marquez and Laurie Wilkins

## PART 2B: CARNIVORES

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**WILDLIFE SURVEY OF THE RIO BRAVO CONSERVATION AND MANAGEMENT AREA, BELIZE**

**PART II: SMALL MAMMALS AND CARNIVORES**

## PREFACE

This report documents the results of a mammalian inventory in the Rio Bravo Conservation and Management Area in northwestern Belize. The study was conducted by students from the Program for Studies in Tropical Conservation at the University of Florida, and funded by the Programme for Belize and Manomet Bird Observatory.

Part 1 presented the results of the primate and ungulate study conducted by J. Fragoso, D. Rumiz, C. Hunter, G. Silva-Lopez, and L. Grober. Part 2, presented here, documents the diversity, abundance and distribution of medium to small mammals (Part 2A) and carnivores (Part 2B), and includes an analysis of habitat characteristics. The small mammal research was conducted by L. Hay-Smith, M. Marquez, L. Wilkins, and J. Thomason. The carnivore research was conducted by A. Novaro, M. Suarez, and S. Walker. In Part 3, J. Polisar will report on the status of turtle species in the Rio Bravo area.

The director of the project is S. Jacobson at the University of Florida's Program for Studies in Tropical Conservation. Additional reports and information about the Rio Bravo Conservation and Management Area are available from the Programme for Belize (P. O. Box 385, Vineyard Haven, MA 02568 or P. O. Box 749, Belize City, Belize) or Manomet Bird Observatory (P. O. Box 936, Manomet, MA 02345).

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## GENERAL INTRODUCTION

The Yucatan Peninsula in Central America is geologically and biologically distinct. On the basis of geologic history and shared biotic relationships in the region, it has been referred to as the Yucatan biotic province (Goldman and Moore, 1945; Barrera, 1962). The peninsula is formed by a flat limestone shelf, composed of consolidated marine sediments, that extends from the Mexican states of Campeche, Yucatan, and Quintana Roo, southward into the northern part of El Peten, Guatemala and into northern Belize. That part of Belize north of the Maya mountain range and the Sibun River forms the southeast corner of the Peninsula (Wadell, 1938; Wright et al., 1959; West, 1964).

The Peten is an extensive tropical lowland forest that spans the Yucatan through southeastern Mexico, northeastern Guatemala and northern Belize. Deforestation resulting from development and human settlement activities has occurred throughout the Peten, but large tracts of forest remain in northwestern Belize (Hartshorn et al., 1984). Plans for sustainable development in this area are in progress, but if they are to succeed, proper management of natural resources must be implemented.

The Rio Bravo Conservation and Management Area (hereafter referred to as Rio Bravo) lies in the heart of the Belizean Peten. It is managed by the Programme for Belize, with the objectives of promoting ecological and archaeological research, developing environmental education and tourism, and extracting timber and forest by-products, while preserving biological diversity. Biological reports on Rio Bravo include vegetation and natural history accounts (Wright, et al., 1959; Brokaw and Mallory, 1989). Ecological studies are underway by staff scientists from the Manomet Bird Observatory (Programme for Belize, 1990). Very little information exists on the mammals of this region.

This report describes the results of research on small mammals and carnivores in the Rio Bravo Conservation and Management Area. The objectives were to document the presence of species, assess relative abundances, identify important habitat features, and analyze food habits of carnivore species. In Part 2A, we present results of the small mammal survey from live-trapping and mistnetting, and evaluate the major forest types of Rio Bravo. Part 2B presents the results of the carnivore survey based on indirect censusing methods, and carnivore food habits based on scat analysis.

These brief mammal surveys provide some base-line data for future studies. We hope this information will assist the Programme for Belize in planning and managing Rio Bravo as a conservation and multi-use area.

## STUDY SITE

Rio Bravo encompasses 61,513 hectares of land in the Orange Walk district of northwestern Belize. The topography ranges from low, flat, seasonally flooded lowlands to the undulating relief found in higher regions of the area. Several escarpments 30-60 meters high form the dominant physiographic features. Subtropical broadleaf deciduous forest is the dominant vegetation, although palm, swamp, and savanna/gallery forests as well as marshes are present. Calcareous soils of various types cover most of Rio Bravo and support the forest vegetation. Also of calcareous origin are deep clay soils that occur in the wooded, shallow depressions, termed "bajos". Siliceous soils in the northeast of Rio Bravo are associated with savanna vegetation. The clay soils of the bajos and the sandy soils of the savanna are considered to be relatively infertile (Wright et al., 1959; Browkaw and Mallory, 1989).

The rainy season occurs from June through December and in this region averages 1550 mm/yr. This is considerably less rainfall than the 4,500 mm/yr recorded from the southern-most coastal area of Belize (Wright et al., 1959).

We sampled all major habitat types in Rio Bravo except the marshes in the southeast which were inaccessible. The study was conducted during May 1990 primarily on Programme for Belize lands, but it extended onto the adjoining private property of Gallon Jug Agroindustries Ltd., which is located south of the reserve (Figure 1).

## PART 2A: SMALL MAMMAL SURVEY

Leslie Hay Smith, Monica Marquez, Laurie Wilkins

### INTRODUCTION

Although checklists exist of the mammals of Belize (Kirkpatrick and Cartwight, 1975; McCarthy, 1983; Hartshorn, et al., 1984), the most recent account of the small and medium mammmals of Belize totals 102 species (McCarthy, unpubl. ms.). Sixty-eight of these, or 66% of the total small mammal fauna, are bats. The balance are distributed among five orders of mammals and include species of marsupials, insectivores, edentates, rodents and lagomorphs. Although extensive field studies on small mammals have been conducted (Murie, 1935; Disney, 1968; McCarthy, 1987; McCarthy and Blake, 1987; Rabinowitz and Nottingham, 1989), the distributional limits of many species are not well known. Studies that have added to the knowledge of mammalian distributions in Belize have been conducted by Peterson (1966), McCarthy (1982), and Izor and McCarthy (1984).

Northern Belize is one of the most poorly documented regions in the country with regard to small mammals. As part of the Yucatan Peninsula, it would be expected to share part or all of the mammal fauna that has been recorded from the Mexican states of Campeche, Yucatan, and Quintana Roo (Jones et al., 1974 a,b; Young and Jones, 1983; Engstrom, et al., 1987; Dowler and Engstrom, 1988), as well as that of El Peten, Guatemala. While some records do exist for northern Belize, they are few (T.J. McCarthy, pers. comm.)

We identify mammals captured during this study only to species. Subspecies names have been intentionly omitted. Before determining subspecific status, it will be necessary to carefully examine specimens in the context of the morphologic variation that has been described in the literature.

## METHODS

### Habitat Analysis

Vegetation transects were established in six major forest types. These correspond to our trapping transects described below. Selection of the forest types was based on previously defined categories (Wright et al., 1959; Browkaw and Mallory, 1989); namely, upland broadleaf, seasonally flooded swamp forest (bajo), palm forest (cohune), savanna/gallery, and marsh. We subdivided the upland broadleaf forest into secondary broadleaf (SBL), riverine/SBL, and lacustrine/SBL, in order to represent rivers, lakes and their associated gradients in our sampling scheme.

We evaluated vegetation parameters every 45 meters, coinciding with every third trap station on each transect. We described vegetation characteristics within a 4-meter radius of each trap station. Data on vegetation height, type, abundance, form and density of four strata were collected.

Eleven parameters were used to describe habitat characteristics (Appendix 1, Burnham et al., 1989).

Data from our vegetation transects were first pooled to determine general trends, then separated by habitat for comparison.

Small Mammal Trapping and Mistnetting

We censused small mammals using live-traps placed along 1500-meter transects in the six habitat types described above. Traps were set 5-10 meters from the edge of existing logging roads and trails. We designed the study so that the number of trap nights in each habitat was proportional to the available habitat within the study area, as follows:

| Vegetation Type | % Total area | No. trap nights | (%) |
|---|---|---|---|
| Broadleaf/riverine/lake | 63% | 1,528 | (63%) |
| Swamp forest (bajo) | 20% | 503 | (21%) |
| Palm forest (cohune) | 8% | 100 | (4%) |
| Savanna | 2% | 314 | (13%) |
| Marsh | 7% | 0 | |

We deviated slightly from the study design by increasing our trap effort in the savanna since we were unable to sample in the marsh.

Three of our trapping transects, those in secondary broadleaf (1A, 1B, 3), and swamp (2A, 2B) forests were situated along old logging roads or trails perpendicular to the main north-south road. The savanna transect (4) was located in the northeast section of Rio Bravo. Two others, the lake broadleaf and palm forest transects, were located on Gallon Jug property at Laguna Seca (5) and the Mayan ruins at Punta de Cacao (6), respectively (Figure 2).

On each transect three sizes of live traps were used at 100 trap stations. These were placed every 15 meters in the following combination: 100 Sherman live traps(23 x 9 x 7.5 cm), one at each station; 50 squirrel-sized Tomahawk traps(61 x 17 x 17cm) at every other trap station; and 25 raccoon-size Tomahawk traps(66 x 25 x 24.5 cm) at every third station. Traps were alternately placed on the ground and up to 2 meters high in shrubs, vines or trees. In the savanna, cohune, and lake forests we deviated from this trapping regime by setting fewer sherman traps and eliminating the largest traps. In addition, we randomly sampled miscellaneous aquatic habitats such as ponds, mud-holes, and marshy areas. During the course of the study this trapping regime resulted in 1558 sherman trap nights, 678 squirrel-sized tomahawk trap nights and 251 raccoon-sized tomahawk trap nights for a total of 2487 trap nights.

Small traps were baited with a combination of rolled oats and wild bird seed flavored with vanilla extract. We baited the larger wire traps with dry dog food mixed with sardines. In the savanna where ants were a problem, traps were baited with cotton soaked with cod-liver oil (Kent Redford, pers.

comm.). This bait successfully reduced disturbance by ants without reducing trap success. Trap lines were opened for 24 hours and monitored at dusk and dawn.

Bats were censused using 15 and 30-meter mist nets placed at ground level. Two to four nets were set from dusk to 2300 hours. They were set along dirt roads and across rivers in four habitat types: SBL, riverine/SBL, savanna/gallery and in archaeological ruins where bats were reported roosting in looters' trenches (Figure 2).

All captured animals were weighed, measured, marked, and examined for sex, age, reproductive condition and ectoparasites. Females were classed as perforate or nonperforate, pregnant, or lactating; and males by the position of the testes (scrotal or abdominal). Most animals were released, but voucher specimens were taken for each of the rodent and bat species captured. Specimens were prepared as standard study skins with skeletons or as fluid preparations. Tissues were preserved in liquid nitrogen for genetic studies (M. Engstrom, ROM, pers. comm.). These voucher specimens are housed at the Florida Museum of Natural History, Gainesville, Florida and the Royal Ontario Museum, Toronto, Canada.

Additional information on species present in the reserve and their relative abundance was obtained by visual sightings and by analysis of carnivore scat indicating prey species (see Methods and Results, Part 2B).

## RESULTS

Habitat Analysis

The pooled data on habitat types illustrates a predominance of secondary forest (Table 1). The average base canopy height for all habitat types was nine meters, and the upper surface of the canopy was uneven. Gap presence was low with no gap at 64% of the vegetation stations, and with 27% of the stations exhibiting only 1/3 gap. All strata exhibited a medium-to-moderate density of vegetative cover. Grasses were only present in 39% of the plots. Vine densities were low, and where present, 58% of the vines were <1 cm in diameter. The average number of live trees with a DBH of 1-10 cm was much higher than any other size class. Palm species served as understory indicators of forest types. The cohune (Orbignya cohune), give-and-take (Crysophila argentea) and sabal (Sabal morrisiana) palms were most frequently encountered.

When habitats are compared, the four broadleaf forest types--cohune palm, riverine, lake, and secondary broadleaf--show similar structural characteristics. The base of the main canopy for these habitats range from 9-10 meters. Vegetation density at 1-3 meters was evenly low, with few grasses in all sites. Vine densities also were low; however, a greater percentage of vines occurred in the largest size class. Gap presence was low in all sites, with higher occurrences in the cohune and lake forests. The cohune palm and lake forests, when compared to SBL and Riverine/SBL, had higher numbers of large trees (50-100cm DBH, non-palm). Of these four broadleaf forest types, the cohune palm forest was lowest in canopy density, while the lake forest was highest in canopy density. The riverine/broadleaf forest was lowest in vegetation density at 0-1 meters, and had the highest average number of small trees (1-10 cm DBH). It also had the highest number of logs and brushpiles. The secondary broadleaf forest had the highest occurrence of grasses and the lowest numbers of brushpiles.

The bajo forest is exceptional in structural features when compared to other habitats. It exhibited the lowest canopy height (2 meters), with the highest representation of closed canopy. Vine densities, particularly in the small size class, were extremely high, as was the presence of grasses. The number of small live trees (DBH <10 cm) was higher than in all other forest types.

The savanna/gallery forest exhibits qualities typical of savanna/gallery regions (O'Connell, 1989). Average canopy height was only 5 meters, and vegetation density at 0-1 meters was extremely high. Sedges and grasses were present in 100% of the stations and vines were absent in 60% of them.

Small Mammal Survey

During the course of this study, we encountered 26 species of small mammals in 4 orders, representing 9 families. We documented a total of 219 observations of mammals through trapping, mistnetting, visual observations and scat and track analyses (Table 2).

Trapping

We captured a total of 64 animals of six species: two marsupials and four rodents (Table 2). This represents an overall trap success of 2.5%. Trap success varied considerably in different habitats. It was high in the savanna/gallery forest (40 captures, 311 trap nights, 12.9% trap success), and low in the other pooled forest habitats (22 captures, 2176 trap nights, 1% trap success). Sigmodon had the highest frequency of captures (1.53% trap success) for the savanna/gallery forest, (38 out of 40). Two other species with high capture frequency were Heteromys and Oryzomys, each with eight captures (0.32% trap success). In spite of low capture rates, some general habitat preferences can be discerned. The most evident preferences were exhibited by the cotton rat (Sigmodon) for the savanna, and the rice rat (Oryzomys) for tall grasses surrounding marshy areas (ponds, lake edge). The pocket mouse (Heteromys) had the most ubiquitous distribution, occurring in 5 of the 6 habitat types (Table 3). Ototylomys was captured in 3 broadleaf forest types. These results are consistent with Disney (1968) who recorded Heteromys from all habitats sampled, Ototylomys from strictly forest habitats, and Sigmodon occasionally from the "bush", but preferring grassy places. Data on capture weights and measurements are compiled in Table 4. The determination of Didelphis virginiana, rather than D. marsupialis, at Rio Bravo was based on characters described for Central American subspecies of both species (Gardner, 1973).

## Mistnets

We captured 100 individuals representing 14 species of bats in 67.5 mist net hours (no. mist nets x no. of hours) (Table 5). We added an additional species, Lasiurus borealis, when a specimen was found hooked on a barbed wire fence. This was the only Vespertilionid bat encountered. The most common bats captured were Carollia brevicauda, Glossophaga soricina, Dermanura phaeotis, and Sturnira lilium. Of the total number of bats, 98 were netted in forest settings, while only two individuals, a Pteronotus parnellii and a Sturnira lilium, were netted in the savanna. A comparison of body weights and forearm measurements for captured bats are shown in Table 6.

Other records

The results of the carnivore scat analysis (see Part 2B) provided important new information regarding the presence, abundance and distribution of small mammals in the reserve. We recovered a total of 34 individuals of 9 species from carnivore scats which increases the robustness of our small mammal sample (Table 2). Two of these individuals, Marmosa and Tylomys represent new species records for Rio Bravo as neither had been previously captured during our study. The mouse opossum (Marmosa sp.) was clearly identifiable from partial dentaries with teeth. It was too fragmentary to determine the species, but its small size suggests M. mexicana. Based on distribution patterns, M. mexicana would be expected in this part of Belize (M. Engstrom, pers. comm.); however, M. robinsoni, known from south of the Belize River Valley, is also possible (T. J. McCarthy, pers. comm.). The identification of Tylomys nudicaudus (Peter's climbing rat), a large scansorial rodent, was based on the occurrence of a pelvis, a femur, and hair in carnivore scat. The bones are unique in size and structure in comparison with other small mammals expected to occur in Belize. Unfortunately, no post-cranial material was available to confirm the skeletal identification. However, there has been a documented record of Tylomys from Gallon Jug (collections of Louisiana State University--T. J. McCarthy, pers. comm.).

When observations are pooled for all species (Table 2), Heteromys desmarestianus was the most common forest rodent. This result is consistent with the relative abundances reported by Rabinowitz and Nottingham (1989). Three scats from the forested region of Rio Bravo Reserve containing Sigmodon remains were the first evidence of that species outside the savanna. Sigmodon is expected to be common in disturbed areas along roads and abandoned fields, sites we did not trap due to time constraints.

Three additional specimens were documented by visual observations (Table 2). A collared anteater (Tamandua mexicana) was seen mid-day in a tree at the Las Milpas ruins. Squirrels were occasionally seen in forested regions of the reserve and were identified as Sciurus deppei (Deppe's squirrel) based on the small size and reddish coloration of a single individual that was observed at close range. While on a night drive, we observed an Agouti paca (paca) crossing the main road in a forested region of the reserve. Data collected by the first survey team (Part 1) showed that paca/agouti trails (N=13) were found in closed canopy forests. They calculated preference ratios that express a high preference by paca for closed-canopy/high broadleaf and closed canopy/cohune/broadleaf forest (Fragoso, et al. 1990).

## DISCUSSION

### Vegetation

A natural phenomenon of tropical forests is a high degree of variation in composition and structure (Brokaw and Mallory, 1989). Six major vegetation types (Wright et al., 1959) were sampled in the Rio Bravo. Variation among and within the six types is extremely high which creates a characteristic patchiness. This variability instigated other researchers (Fragoso, et al., 1990) to subdivide the major forest types into nine categories. On our sampling sites, this variation did not appear as large, constituent forest patches, but rather as variability at each vegetation sampling point. Therefore, rather than creating new general categories, we chose to provide a quantitative description of the major vegetation types. Many factors may account for this ubiquitous patchiness, such as random variation in vegetation structure, varying levels of habitat disturbance, as well as sampling bias.

A comparison between our transects reveals the secondary nature of most of the forest types. The one exception is the bajo which has many unique characteristics. Structural features suggest the riverine, cohune palm and lake forests may be less disturbed. For example canopy height, diameter of trees, and vines were highest in the riverine, cohune, and lake forests. Logs and brushpiles were also abundant. These measurements of woody growth probably indicate older forests.

The secondary broadleaf forest has a greater number of characteristics which, when combined, suggest higher levels of disturbance. These include: abundance of gaps, higher levels of strata density (including grasses), lower canopy density, low vine density, and large numbers of fallen trees.

The most notable aspect of the forest types in Rio Bravo is the absence of primary forest, and the prevalence of various successional growth stages. We did not encounter any forest with the characteristic components of primary growth (i.e. larger woody growth forms, absence of stumps) as illustrated in the pooled and individual transect data (Table 1). Data were not collected on tree stump abundance. However, the presence of stumps and the notable absence of large trees (>50cm DBH) in all transects indicates the disturbed nature of the forests. Logging activities such as roads, skidlines, large stumps of valuable tree species, and other exploitative activities are evident in most habitat types of Rio Bravo. However, we did not encounter any recent signs of logging in this area.

We hoped to derive specific preferences by small mammals for these structural features of the forests based on capture localities. We were unable to do so because of extremely low capture rates. However, the data are instrumental in providing a general description of habitats with which the small mammals we captured are associated.

Small mammal survey

The majority of species recorded from Rio Bravo (Appendix 2), particularly the larger mammals, are characteristic of a mammalian fauna widespread throughout Belize and nuclear Central America. Although small mammals may have a less uniform distribution, those represented in our sample tend to be the more common and more widely distributed species. However, less than 40% of the total mammal fauna known from Belize (McCarthy, unpubl. ms.) has been recorded in Rio Bravo (Table 8). While the larger and more conspicuous species have been documented, many of the smaller, more cryptic, and difficult-to-trap species have not. Of the small mammals known to occur in Belize, 38% of the marsupials and 37% of the rodents have been documented from the Rio Bravo Reserve (Table 8). Sixty-eight species of bats have been documented from Belize (McCarthy, 1987), but only 15 (22%) were captured in Rio Bravo during the present study.

We did not expect to encounter all, or even most, of the small mammals that have been recorded from Belize, due to the limited duration of the study and the difficulty of capturing many of the small mammals. Further, Rio Bravo may be outside the distributional range of some species. Nevertheless, a number of additional species would be anticipated based on known distribution patterns. Other factors, such as seasonal, environmental, and community effects may be contributing to the low species richness and abundance of small mammals we recorded.

Bats are disproportionately represented in our sample by the predominantly frugivorous members of the family Phyllostomidae. The bats we captured in forest habitats were primarily frugivorous (fruiteaters) or nectarivorous (nectar feeders), except Trachops cirrhosus, the fringe-lipped bat, known to feed on frogs. Frugivorous bats are expected to be captured more often in tropical forests than in savannas, which accounts for the low capture rate in the latter habitat. Insectivorous bats are common in both forest and savanna, but are less often captured because they forage above net levels or are better able to detect the nets . Therefore, the three families of insectivorous bats--Emballonuridae, Vespertilionidae, and Molossidae--are poorly represented in our sample. A greater sampling effort and the use of other collection techniques will be required to document a large percentage of the bat fauna expected in Rio Bravo.

The low number of non-volant mammals captured during our study may reflect seasonal differences in rainfall. It appears that our 2.5% overall trap success was considerably lower than the 5.23% overall trap success reported for Cockscomb Basin by Rabinowitz and Nottingham (1989). Upon closer examination, however, their dry season captures of only nine animals compared to 70 during the wet season, represents an 85% reduction in captures that is similar to our own low capture rate. Disney (1968) recorded the lowest capture rates of the year for Ototylomys in April and May (<2%), while the highest was in January (7%). He also noted for Heteromys, "foraging appears to be curtailed during the dry season, and the species may aestivate."

Disney (1968) reported that most pregnant females of Oryzomys, Ototylomys and Heteromys were trapped in Belize during the dry and early wet seasons. Among these forest species in our study, 55.5% of all females were either pregnant or lactating, and 75% of the males were scrotal, signifying reproductive activity. By comparison, while 42% of the Sigmodon males were scrotal, none of the females appeared to be in reproductive condition (Table 7). We also encountered a large number of juvenile Sigmodon, indicating some recruitment had already occurred. Seasonality of rainfall influences reproductive patterns in didelphid marsupials as well. Breeding in Didelphis marsupialis, Caluromys and Philander is timed so that the young begin foraging in the wet season when food levels are higher (O'Connell, 1979). Little is known of reproductive cycles in D. virginianus in the tropics, but both adult female opossums we captured had 15 young in their pouches. Our extremely low trap success may be related to the reproductive cycles which are timed to the beginning of the wet season. Populations at the end of the dry season (the time of this study) would be at their lowest.

Several small and medium-sized non-volant mammals are noteworthy because of their absence. These are species that might occur at Rio Bravo but were not documented during our study. They are grouped into three categories: 1) Yucatan Peninsula endemics; 2) medium-sized conspicuous species; and 3) rare or difficult-to-capture mammals.

Four species of rodents endemic to the mainland of the Yucatan Peninsula are the Yucatan gray squirrel (Sciurus yucatanensis), Gaumer's spiny pocket mouse (Heteromys gaumeri), Yucatan vesper rat (Otonyctomys hatti), and the Yucatan deer mouse (Peromyscus yucatanicus) (Jones et al., 1974). All of these endemic species could potentially be found in Rio Bravo. Our record of Deppe's squirrel (Sciurus deppei) does not preclude the presence also of the Yucatan grey squirrel in Rio Bravo since they co-occur in some forest habitats, and both are recorded from northern Belize (Musser, 1968; Jones et al., 1974a). Likewise, two species of spiny pocket mice (Heteromys desmarestianus and H. gaumeri) have been reported from Orange Walk district (Izor and McCarthy, 1984; Engstrom et al., 1987; this report). They can be sympatric in distribution but occur in different habitats. Although we captured only H. desmarestianus, it is possible for both species to occur at Rio Bravo.

Perhaps the rarest of the Yucatan endemics is the vesper rat (Otonyctomys hatti). It is known only from a few records in Yucatan, Mexico (Hatt, 1938; Jones et al., 1974a), and El

Peten, Guatemala (Rick, 1965). The only record for Belize is that of a single young adult male found near Rockstone Pond (Peterson, 1966). The vesper rat is highly arboreal, but not necessarily habitat restricted, as it has been captured in thatched roofs as well as the top of a coconut palm tree. This arboreality accounts for its comparative rarity. A concentrated search for this species would undoubtedly show that it is more common than current records indicate (Peterson 1965). The Yucatan Deer mouse (Peromyscus yucatanicus) is the least likely of the endemic species to be found in Rio Bravo. There is no record of its presence in Belize, and the closest locatity from which it is known is north of Chetumal, Quintana Roo, Mexico (Young and Jones 1983). Where it does occur it is locally common, and therefore easily captured.

We were unable to document the presence of several medium-sized, relatively conspicuous species. Notably absent were the agouti (Dasyprocta punctata), 9-banded armidillo (Dasypus novemcinctus) and the rabbit (Sylvilagus sp.). The agouti is listed with the paca in Table 2 only because tracks or trails of the two species cannot be distinguished. The agouti and armadillo are widespread in the neotropics and considered to be common in Belize (Frost, 1977; McCarthy, unpubl. ms.). If they were present in Rio Bravo, we would expect to detect them in the scat analysis since they are found in carnivore diets in other tropical areas (Bisbal, 1986; Ludlow and Sunquist, 1987; Konecny, 1989; Sunquist et al., 1989). The absence of expected species in scat may be due to sampling bias at the level of predator selection or scat collection, and/or to low densities of prey species. For example, the harvest mouse (Reithrodontomys gracilis), another species expected in Rio Bravo, is reported to be eaten only by jagaurundi and margay (Konecny, 1989), but jagaurundi and margay scats are not well represented in our sample (part 2B). Out of 103 scats analyzed from four carnivores in the Cockscomb Basin in Belize, agouti remains were found infrequently and only in Ocelot scats (Konecny, 1989). This might suggest that agouti are less common than would be expected. Agouti populations may, in some cases, be kept at low densities as a result of predation pressure (Emmons, 1987). This might account for their scarcity at Rio Bravo since this is one of the few locations where all five felid species are sympatric. Human predation is another explanation for the apparent rarity of agouti in Rio Bravo. Because of its diurnal habit and relative ease of capture by dogs, it is one of the most sought after small mammals in Belize (J. Fragoso, pers. comm.).

We cannot account for the absence of the 9-banded armadillo at Rio Bravo, because it has an extensive range in North and South America, including the Yucatan of Mexico (Jones, et al., 1974b, Emmons, 1990). However, the northern naked-tailed armadillo (Cabassous centralis) has only been found in southern Belize (McCarthy, 1982).

There appears to be a hiatus in the distribution of the cottontail Sylvilagus floridanus, a grassland species, whose range is known to extend as far south as the state of Yucatan in Mexico, and the Brazilian rabbit (Sylvilagus brasiliensis). The few records that exist for rabbits in Belize are for S. brasiliensis in the southern regions of the country (McCarthy, pers. comm.).

The rare or difficult-to-capture species that would be expected to occur at Rio Bravo include the harvest mouse (Reithrodontomys gracilis), mouse opossums (Marmosa spp.), black eared rice rat (Oryzomys melanotis) and tentatively the wooly opossum (Caluromys derbianus). All of these have been recorded from the Yucatan of Mexico (Jones, et al., 1974a,b).

Environmental factors may influence species richness and distributional patterns. Lower species richness is the direct result of unfavorable environmental conditions (Emmons, 1984). The northern region of Belize represents a transitional zone from the drier regions in Quintana Roo, Mexico to more mesic environments in southern Belize. Over 4,500 mm of rainfall has been recorded from the southern coastal area of Belize, whereas less than 1,500 mm occurs in northern Belize (Walker 1973). Reduction of rainfall accompanied by a shift from alluvial soils to shallow calcareous soils, creates edaphic conditions that affect the composition and the structure of the vegetation (Wright, et al., 1959; various authors, in McCarthy, 1987). Soil type is a major environmental feature affecting species richness. Mammals may be absent in edaphically poor areas compared to areas containing richer soils and higher rainfall (Emmons, 1984). These factors in Rio Bravo may account for the absence of some expected species.

## CONCLUSIONS

Our study describes the secondary nature of the forests in Rio Bravo and documents the presence of 11 species of non-volant small mammals and 15 bat species. The low species abundance and richness we found in the Rio Bravo Reserve may be due to the timing and duration of this study, climatic or environnmental conditions, or community structure. We have discussed additional species that might be expected to occur in Rio Bravo. However, until we have better knowledge of the distributions and zoogeographical relationships of species throughout Belize, it is not possible to predict all the species that might be added to the existing faunal list.

Although preliminary, our findings provide some insight into the relative abundance and habitat associations of the species we did observe. Many are considered to be common species, representative of lowland tropical forest communities. The presence of these species, in addition to the other large mammals that have been documented during the course of this survey, suggest that the secondary nature of the forest may not have severely affected the faunal integrity of Rio Bravo.

A considerable commitment of time and effort will be required to further document the small mammals of Rio Bravo. This is a worthwhile endeavor because they are an integral part of the faunal assemblage. Small mammals provide the prey base for many predatory birds, mammals and reptiles and serve important functions in the plant community, as seed dispersers and plant pollinaters. Finally, the taxonomic and zoogeographic relationships represented by the mammals of this transitional zone must be better known in order to gain a greater understanding of the geographic region known as the Yucatan Peninsula.

## PART 2B: CARNIVORE SURVEY

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### INTRODUCTION

Kirkpatrick and Cartwright (1975) and McCarthy (1983) list sixteen species of the order Carnivora which are known to occur in Belize. Rabinowitz (1983) surveyed different regions of the country to assess relative abundance of jaguar (Panthera onca), and concluded that the Gallon Jug area had the highest density of big cats in Belize. The only ecological studies of carnivores in Belize have been done in the Cockscomb Basin (Konecny, 1989; Rabinowitz, 1986; Rabinowitz and Nottingham, 1986; Watt, 1987).

The purpose of this study was to assess the presence, relative abundance, and food habits of carnivore species in the Rio Bravo area. Descriptions of the study area and vegetation types are presented in Part 2A. We refer to only two categories of habitat type in this section, the broadleaf forest, which includes all five of the broadleaf forest types mentioned in Part 2A, and the savanna.

### METHODS

Presence and relative abundance of carnivores were assessed using indirect methods and sightings. Food habits were

Roads currently in use and abandoned logging roads were surveyed for carnivore tracks, scrapes, and scats in Rio Bravo and in the Gallon Jug Agroindustries lands (Figure 3). Ninety kilometers were walked and 73 kilometers were driven at 10 km/hr (Koford, 1978) in the broadleaf forest, and 36 kilometers were driven at 10 km/hr in the savanna. Because the survey was conducted during the dry season, most of the roads were hard and dry or covered with leaves, providing poor substrate for tracks. Those roads or portions of roads with good track substrate were surveyed at least twice (Figure 4).

Tracks were measured and identified to species whenever possible (Aranda and March, 1987; Murie, 1974). Number of individuals was determined by size and relative position of tracks. Scrapes were measured and classified as big or small cat scrapes. Sightings of all carnivores which occurred during the study period and reliable cat sightings reported from the previous four months were recorded.

For each species, the minimum number of individuals detected in the area was estimated using the signs and sightings as mentioned above and information on home range sizes obtained from the literature. Signs or sightings which were not clearly of different individuals were only considered to be so if they occurred at a distance greater than the diameter of reported home range sizes.

For big cats, the number of tracks encountered per kilometer travelled was calculated for comparison to a previous survey done in the broadleaf forest portion of the area (Rabinowitz, 1983). That survey was conducted in the rainy season, when the road surface provided good substrate for tracks. Detection of tracks in the present survey was possible on a very small proportion of the total distance travelled (Figure 4), and therefore the distance used in the calculation was limited to the number of kilometers travelled along roads with good track substrate.

In the third week of the study, we set lines of scent stations (Linhart and Knowlton, 1975; Roughton and Sweeny, 1982) along five logging roads on which detection of tracks had not been possible previously. Each line consisted of five stations spaced 300 meters apart. Track surfaces one meter in diameter were created with sand, and fermented powdered egg was used as an odor attractant. Stations were operated on three consecutive nights, but each night early rains washed them away and no data could be collected.

Scats were measured and collected for later identification and analysis of content. Contents were identified by comparisons with collections at the Florida Museum of Natural History. Predator species were identified by association with fresh tracks and by the presence in the scat of hair ingested while grooming (Emmons, 1987). Scats of cats were distinguished from other carnivore scats by general appearance. They were considered to come from small cat species (margay, jaguarundi, or ocelot) or big cat species (puma or jaguar) when their diameters were less or more than 2 cm, respectively (B. Ackerman, pers. comm.; Murie, 1974; S. Walker, unpubl. data). When predator species could not be identified, the scats were classified as unknown non-felid carnivore scats, and could include scats from any of the non-felid carnivores present in the area. Comparisons of frequencies of occurrence of food items were done using G-tests and Bonferroni confidence intervals (Byers et al., 1984).

## RESULTS

### Carnivore Survey

The presence of five species of felids, one species of canid, three species of procyonids, and three species of mustelids was confirmed in the study area. Three additional species of mustelids were suspected to occur in the area based on unconfirmed tracks and sightings and known ranges of those species (Appendix 3) (Emmons, 1990; Kirkpatrick and Cartwright, 1975; McCarthy, 1983).

Felids: The presence of jaguar (Panthera onca), puma (Felis concolor), ocelot (F. pardalis), and jaguarundi (F. yagouaroundi) was confirmed by sightings. The presence of margay (F. weidii) was confirmed by tracks (Table 9). During the study period, a juvenile margay was captured a few miles south of Gallon Jug by loggers who chased its mother and a sibling from their den.

Based on the sightings reported, the signs encountered, and home range size information obtained from other studies, we estimated that there was evidence of at least five jaguars, six pumas, three ocelots, two jaguarundis, and one margay in the area (Table 9; Figures 3 and 4).

In the broad-leaf forest portion of the study area, only 4.3 kms of the total distance travelled had substrate where detection of tracks would be possible. Tracks of eight big cats were encountered along roads, giving an index of 1.8 tracks/km. In the savanna, 19.9 km of the distance travelled was along roads where detection of tracks would be possible, and tracks of seven big cats were found, giving an index of 0.4 tracks/km.

Canids: Gray fox (Urocyon cinereoargenteus) was the carnivore species sighted most frequently during the study period. All sightings occurred in the daylight hours. Tracks and scats were also frequently encountered. These sightings and signs indicated that there was evidence of at least 40 individuals in the area (Table 9; Figure 5).

Procyonids: The presence of coati (Nasua nasua) and kinkajou (Potos flavus) was confirmed by sightings during the study period. There were three sightings of single coatis and one of a group of three. Two kinkajous were seen together at the same place on several occasions. Raccoons (Procyon lotor) were not sighted, but their tracks were frequently encountered. Sightings and signs indicated evidence of at least 13 raccoons, five coatis, and two kinkajous (Table 9; Figure 6). No evidence of the presence of cacomistle (Bassariscus sumichrasti) was found, although the area is included in its known range (Emmons, 1990; McCarthy, 1983).

Mustelids: Presence of tayra (Eira barbara) and river otter (Lontra longicaudis) was confirmed by sightings. Skunk odor was detected on several occasions, but it was not possible to determine the species responsible. The presence of striped hog-nosed skunk (Conepatus semistriatus) was confirmed by tracks, and although the study area is included in the known range of the spotted skunk (Spilogale putorius) (Emmons, 1990; McCarthy, 1983), we did not find evidence of its presence. Mustelid tracks the size of grison (Galictis vittata) tracks were encountered (Table 9; Figure 7), but we could not rule out the possibility that they were small tayra tracks. The known range of the long-tailed weasel (Mustela frenata) also includes the study area (Emmons, 1990; McCarthy, 1983). There was one unconfirmed sighting, but no other evidence of its presence was found.

Signs and sightings provided evidence of a minimum of four tayras, one otter, and one hog-nosed skunk (Table 9; Figure 7).

## Carnivore Food Habits

We collected 564 carnivore scats during the study period, 27 in the savanna and the remainder in the broadleaf forest. About half (293) of the scats were found along the roads and logging roads surveyed. The other half (271) were found in 25 gravel quarries along the main road, from which gravel to repair the road was extracted. The group from the University of Florida that surveyed ungulates and primates collected 11 additional scats in January, 1990.

The scats collected in January, and 183 of the scats collected in May, were analyzed in detail, whereas the remaining 378 scats were analyzed only for broad categories of food items (Tables 10 and 11). Two big cat scats collected in January and two collected in May contained only mammalian prey. One from January contained three prey items: a big-eared climbing rat (Ototylomys phyllotis), a mouse opossum (Marmosa sp.), and a four-eyed opossum (Philander opossum). The other three scats contained one prey item each, which were medium to large sized mammals (Tables 11 and 12).

Six small cat scats collected in May contained birds, mammals, and arthropods in similar proportions. Mammals consumed were a mouse opossum (Marmosa sp.), and two species of rodents, Sigmodon hispidus and Tylomys nudicaudus (see Part 2A of this report) (Table 12). No small cat scats were collected in January.

Five gray fox scats collected in January contained fruit, arthropods, and birds, but no mammals (Table 11). Of the 183 scats collected in May and analyzed in detail, 103 were from gray fox. Fruit was the most common food item found in fox scats, followed by arthropods. Fifty-one percent of the scats contained vertebrate prey, including mammals (20%), birds (18%), reptiles (7%), and amphibians (2%). Mammal prey included one species of opossum (Didelphis sp.) and three species of rodents (Sigmodon hispidus, Heteromys sp., and Agouti paca) (Table 11).

One mustelid and four raccoon scats were found in May. The mustelid scat, which was associated with grison-sized tracks, contained only arthropods of the order Coleoptera. All of the raccoon scats contained fruit. Arthropods were the next most common item, and snails, reptiles, and birds were also found (Table 12). No mustelid or raccoon scats were collected in January.

There were four unknown non-felid carnivore scats found in January, which contained fruit, arthropods, reptiles and birds (Table 11). The major food item in the 67 unknown non-felid carnivore scats collected in May was fruit (87%), followed by vertebrate prey (66%), and arthropods (58%). Vertebrate prey included mammals (27%), birds (22%), and reptiles (17%) (Table 12).

Comparison between 14 non-felid (fox, raccoon, mustelid, and unknown) scats from the savanna and 161 from the broadleaf forest indicated a significant difference in proportions of food items ($G=40.35$; $p < 0.001$) (Table 13). A comparison of proportions of individual food items using Bonferroni confidence intervals indicated that in the savanna, arthropods were consumed less often ($p < 0.05$) and mammals were consumed more often ($p < 0.05$) than in the broadleaf forest.

## DISCUSSION

### Carnivore Survey

Carnivore diversity (12 species confirmed and three suspected) was similar to that reported for the Cockscomb Basin

(14 species), a subclimax moist tropical forest in southern Belize (Konecny, 1989), and higher than that reported for Hato Masaguaral (8 species), a mosaic of open grasslands and forest in the central Venezuelan llanos (Eisenberg et al., 1979; Sunquist et al., 1989). Signs found in the broadleaf forest and savanna indicate that big cats were distributed throughout the study area, using the forest habitat type more intensively. Rabinowitz (1983) encountered 1.1 tracks/km in his rainy season survey, over the entire distance he travelled. Our index of 1.8 tracks/km is probably an overestimate because we excluded distances travelled on roads with hard compacted surfaces, on which tracks would not be visible. Even though our higher index might not indicate an increase in numbers, it provides evidence that big cat numbers have not declined.

Scrapes and other marking behaviors have been frequently observed in areas where jaguar densities are high (Rabinowitz, 1983), but they are found during brief periods when animals come into close proximity to one another (Rabinowitz and Nottingham, 1986). Only one scrape was found in this survey, and although this could be an indication of low density, it is probably due to the short duration of the study.

If densities in the Rio Bravo and Gallon Jug areas were comparable to those found in other studies, the area could support from 45 to 126 jaguars (Eisenberg et al., 1979; Rabinowitz and Nottingham, 1986; Schaller and Crawshaw, 1980), and 14 to 103 pumas (Eisenberg et al., 1979; Schaller, 1984).

The higher figures for jaguars are based on data from the Cockscomb Basin, Belize, and a semi-deciduous tropical forest in Venezuela, habitat types more similar to the broadleaf forest in the study area. The lower figures for jaguars and both figures for pumas are from the Pantanal in Brazil, which includes marsh, grassland, and deciduous forest habitats, and Hato Masaguaral in Venezuela, habitats more similar to the savanna in the Rio Bravo area.

Previous studies have shown that where jaguars are common, pumas are rare (Rabinowitz and Nottingham, 1986; Schaller and Crawshaw, 1980). Although we found evidence of an almost equal minimum number of individuals of the two species at Rio Bravo, this is not enough data to conclude that their actual densities in the area are similar.

Although a greater number of species was represented, fewer sightings and signs of small cats than of big cats were recorded. This could be the result of a less intensive use of roads by small cats (Rabinowitz, 1983; Watt, 1987) and does not necessarily indicate low densities. The small amount of data we collected on small cats precluded us from estimating the relative densities of individual species.

The gray fox was the most abundant carnivore species in the study area. Signs and sightings were evenly distributed in the Rio Bravo area, and relative density was lower in the Gallon Jug area. Although studies in the temperate zone indicate that this species is primarily nocturnal or crepuscular (Fritzell and

Haroldson, 1982), the frequent sightings in the daytime indicate that the species is more diurnal in this area.

Because cacomistles and kinkajous are primarily nocturnal and arboreal (Eisenberg, 1989; Emmons, 1990), their presence could not be detected by our methodology. The presence of kinkajous was confirmed by chance sightings, but no information about distribution or relative density in the area was obtained.

Raccoons and coatis were found in the broadleaf forest and in the savanna. They were in lower densities in the Gallon Jug area than in the forested part of the Rio Bravo.

The low number of signs and sightings of all mustelids could be explained by actual low densities, their infrequent use of roads, or a combination of both. Scent stations would have provided more information about mustelid presence and relative abundance, but, as mentioned above, this technique failed. We were also unable to survey the river for otter signs, due to the closed understory in the gallery forest and the muddy bottom of the Bravo River.

## Carnivore Food Habits

Big cat scats consumed a wide range of mammalian prey. Sizes of prey varied from rodents of less than 100 g to peccaries (*Tayassu pecari* or *Dicotyles tajacu*). Although the sample size is small, our data are consistent with findings of other studies of jaguar and puma diets (Emmons, 1987; Rabinowitz and Nottingham, 1986; Watt, 1987). The three smallest species were all found in the same scat, and were all semi-arboreal. One of those species (Philander opossum) has been reported in jaguar and puma diets previously (Rabinowitz and Nottingham, 1986), and Emmons (1987) reported that jaguars occasionally take arboreal species. Other studies have suggested that pumas take smaller prey, including small rodents, in areas where pumas and jaguars co-occur (Emmons, 1987; Rabinowitz and Nottingham, 1986).

Varying proportions of arthropods, fish, amphibians, reptiles, birds, and small mammals have been reported in analyses of small cat diets (Bisbal, 1986; Emmons, 1987; Konecny, 1989; Sunquist et al., 1989), but our sample included only arthropods, birds and small mammals. Small cat diets differed from big cat diets because they included arthropods and birds in addition to mammalian prey. They differed from other small carnivore diets in that they did not include fruits.

Mendez (1970) claims that gray foxes in Panama eat rodents, rabbits, birds, lizards, bird eggs, insects and fruits, but there have been no systematic studies of their diets in the tropics. In the temperate zone, gray fox diets vary between locations and seasons, and include plant foods, invertebrates, birds, and mammals (Fritzell and Haroldson, 1982). We found items from all of these categories in gray fox scats, and also frogs and reptiles. The rainy season (January) scats differed from the dry season (May) scats because they did not contain mammals, but the sample size was too small to conclude that mammals were not part of the rainy season diet.

Raccoons in other habitats consume a wide variety of foods, including fruits, invertebrates, and vertebrates, although consumption of mammals is rare (Eisenberg, 1989; Emmons, 1990; Lotze and Anderson, 1979). Our sample included items from each of these categories. Vertebrate prey included birds and reptiles, but no mammals.

Previous studies reported that grison diets consisted exclusively of vertebrate prey (mostly mammals), and tayra diets consisted of vertebrates, fruits, and insects (Bisbal, 1986; Konecny, 1989; Sunquist et al., 1989). As we found only one mustelid scat, we cannot draw any conclusions about their diets in this area.

Four of the scats found in the savanna were identified as gray fox scats. Because the only signs of non-felid carnivores found in the savanna were of gray fox, raccoon, and coati, the ten remaining scats analyzed from that habitat are most likely from those species. All of these species are opportunistic feeders (Fritzell and Haroldson, 1982; Lotze and Anderson, 1979; Russell, 1982). The higher proportion of mammals in scats from the savanna may be attributed to the higher density of small mammals in this habitat during the dry season (see Part 2A of this report). The lower proportion of arthropods may be related to a lower abundance in the drier environment of the savanna at the end of the dry season, as compared to the broadleaf forest.

## CONCLUSIONS

The Rio Bravo and Gallon Jug areas support a diverse carnivore community. Even though the study was of short duration and surveying efforts were hindered by the difficulty of detecting tracks on the hard road surfaces at the end of dry season, we established the presence of 12 of the 16 species of carnivores reported to occur in Belize. The survey provides preliminary evidence that population levels of big cats and gray foxes are relatively high, and densities of raccoons are locally high. Insufficient data and limitations of surveying methods prevent us from making conclusions about the relative abundance of other species.

This unique community provides many opportunities for further research. The species which co-occur in this area do not occur in the same combination and proportions in any tropical carnivore community described in the literature. In particular, the high density of gray foxes found here has not been reported elsewhere in the tropics. Some of the species (gray fox, raccoon, and puma) have been well-studied in North America, but little is known of their ecology in the tropics. Recent studies have focused on jaguars and ocelots, but most of the other species remain relatively unstudied. In light of the relatively high abundance of some carnivore species and the apparent cyclical nature of the small mammal populations (see Part 2A of this report), the impact of predators on the prey species merits investigation. It has been suggested that carnivore predation might have a strong influence on the relative abundances of prey species in a tropical rainforest community (Emmons, 1987).

Because so little is known about most of these species, it is difficult to assess the potential impact of the multiple use management plan elaborated by the Programme for Belize (1990). We suggest that in order to meet the Programme's stated objectives, the following factors pertinent to the carnivore community be considered:

1. Many of the species, even the smaller ones, have relatively large home range sizes (Konecny, 1989), or occur naturally at low densities (Emmons, 1990), so large areas of land are required to maintain viable populations. Because the big cats generally have the largest land requirements, any actual or effective reduction in the size of the preserve and/or in the forested or undeveloped lands in the surrounding area could jeopardize the apparently healthy population levels which exist now. In the proposed division of the preserve into areas of different levels of use, corridors between low-use areas in different parts of the preserve and in the surrounding lands should be maintained.

2. Management practices which protect and foster diversity and abundance of prey and plant food species are essential. Strategies outlined in the management plan (Programme for Belize, 1990), such as regulating use of pesticides and herbicides, wood harvesting methods, introduction of exotic species, and

preventing hunting and unauthorized logging, are important in this regard.

3. One of the plans presented in the management proposal is to re-open old logging roads for use by researchers to monitor wildlife. Monitoring of carnivore populations could be facilitated if suitable surfaces for tracks were maintained on some of these re-opened roads, particularly in parts of the preserve which currently have no cleared roads where tracks can be detected (Figures 3 and 4).

4. The carnivore community of the Rio Bravo area is composed of a mixture of temperate and neotropical species not found in areas further south in the country, such as the Cockscomb Basin Jaguar Preserve. The nature of this unique community could be exploited to reach the stated objective of promoting "natural history tourism" and utilized in environmental education.

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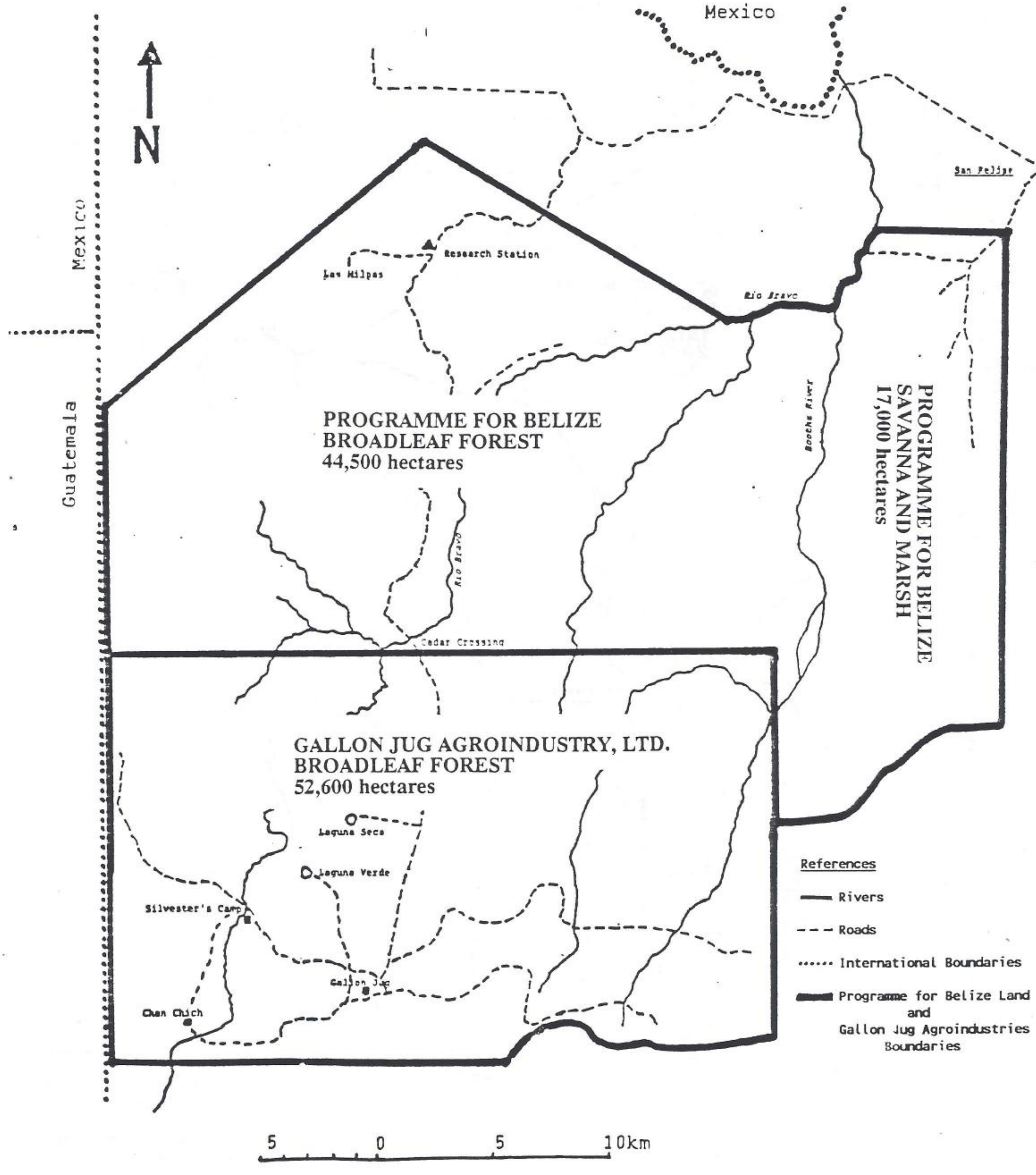


Figure 1. Map of Rio Bravo region illustrating area ownership and major habitat types.

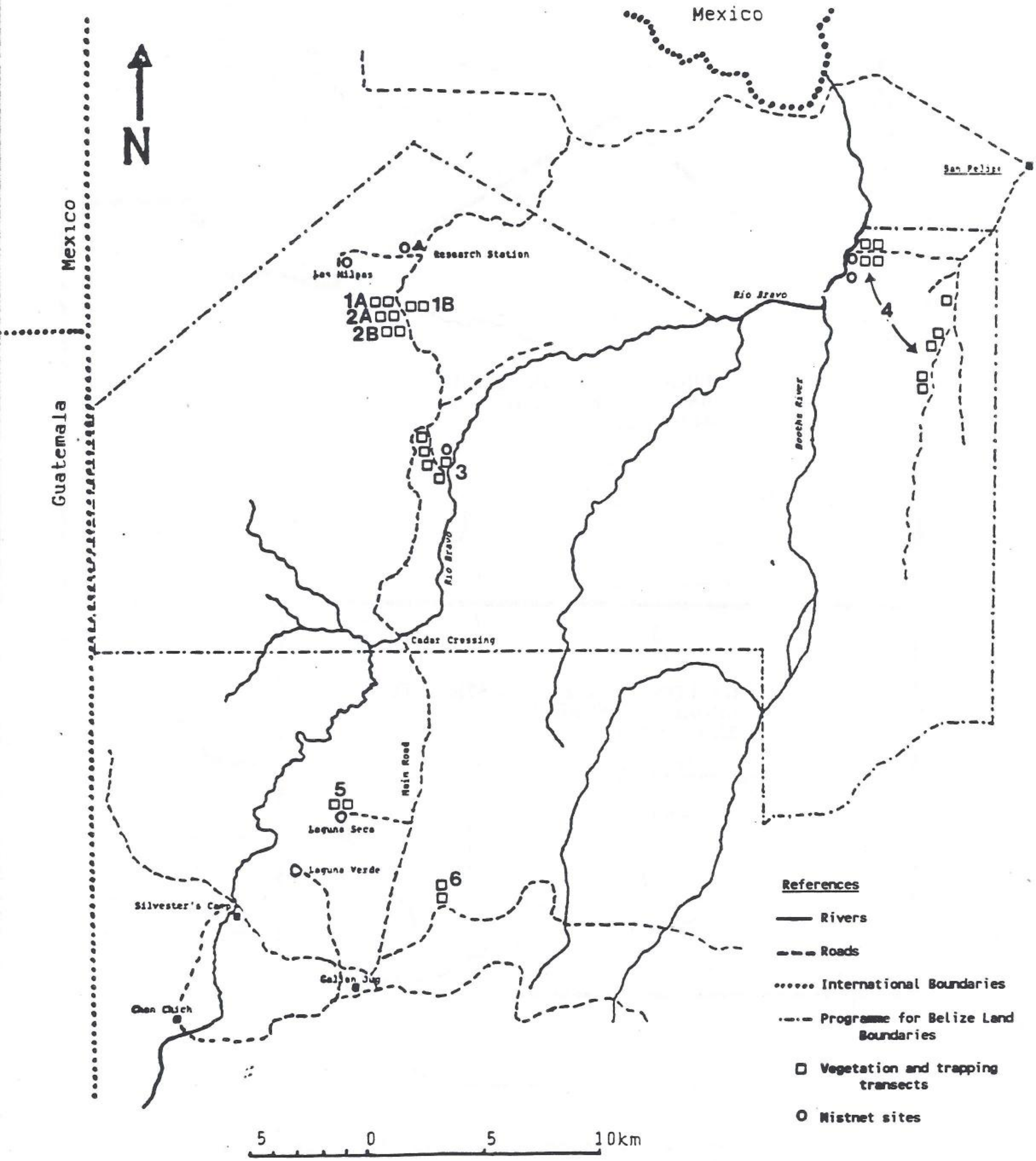


Figure 2. Location of vegetation and trapping transects 1 through 6 and mistnet sites in the Rio Bravo and Gallon Jug areas in May, 1990.

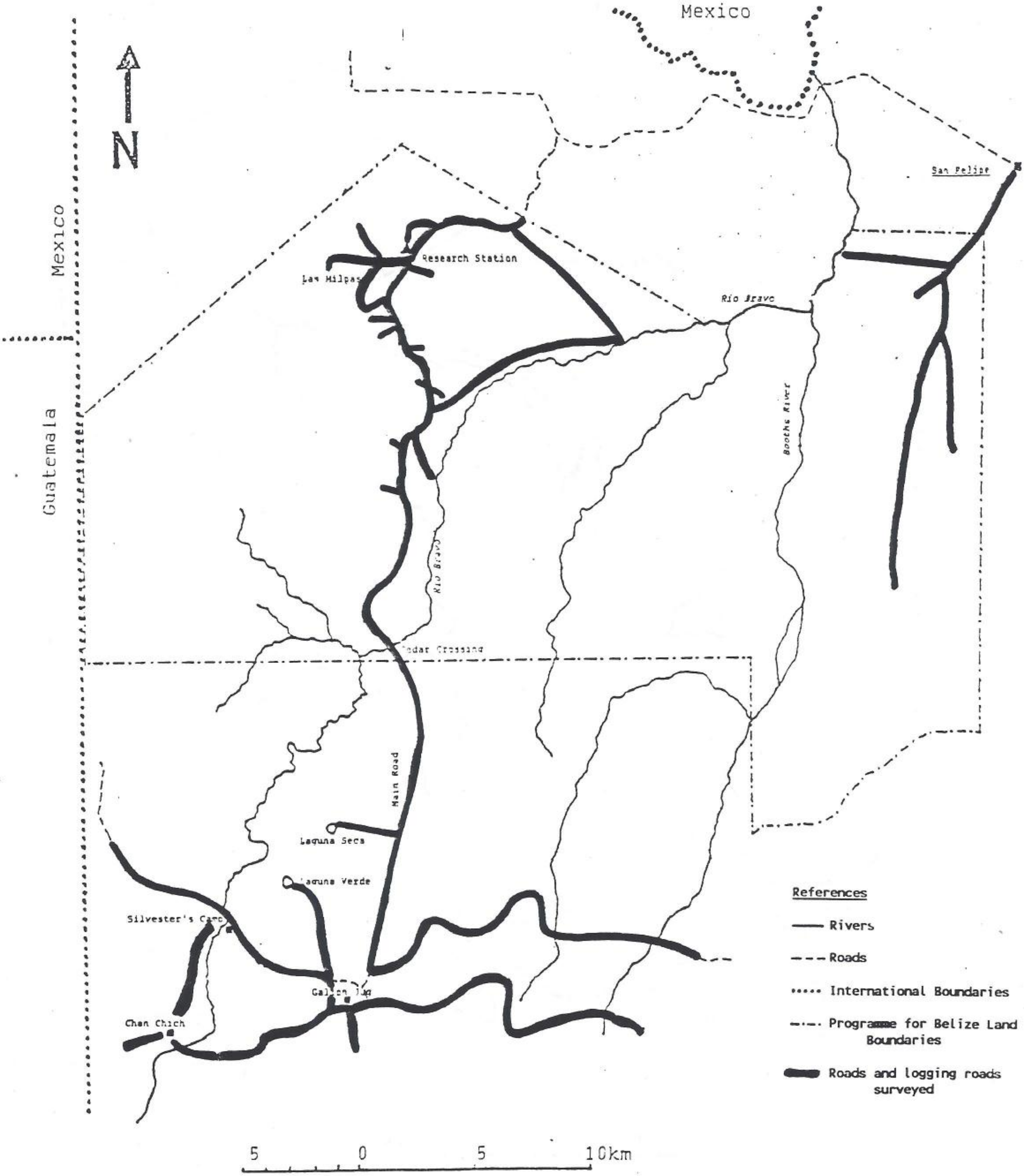


Figure 3. Roads and logging roads surveyed in the Rio Bravo and Gallon Jug areas in May, 1990.

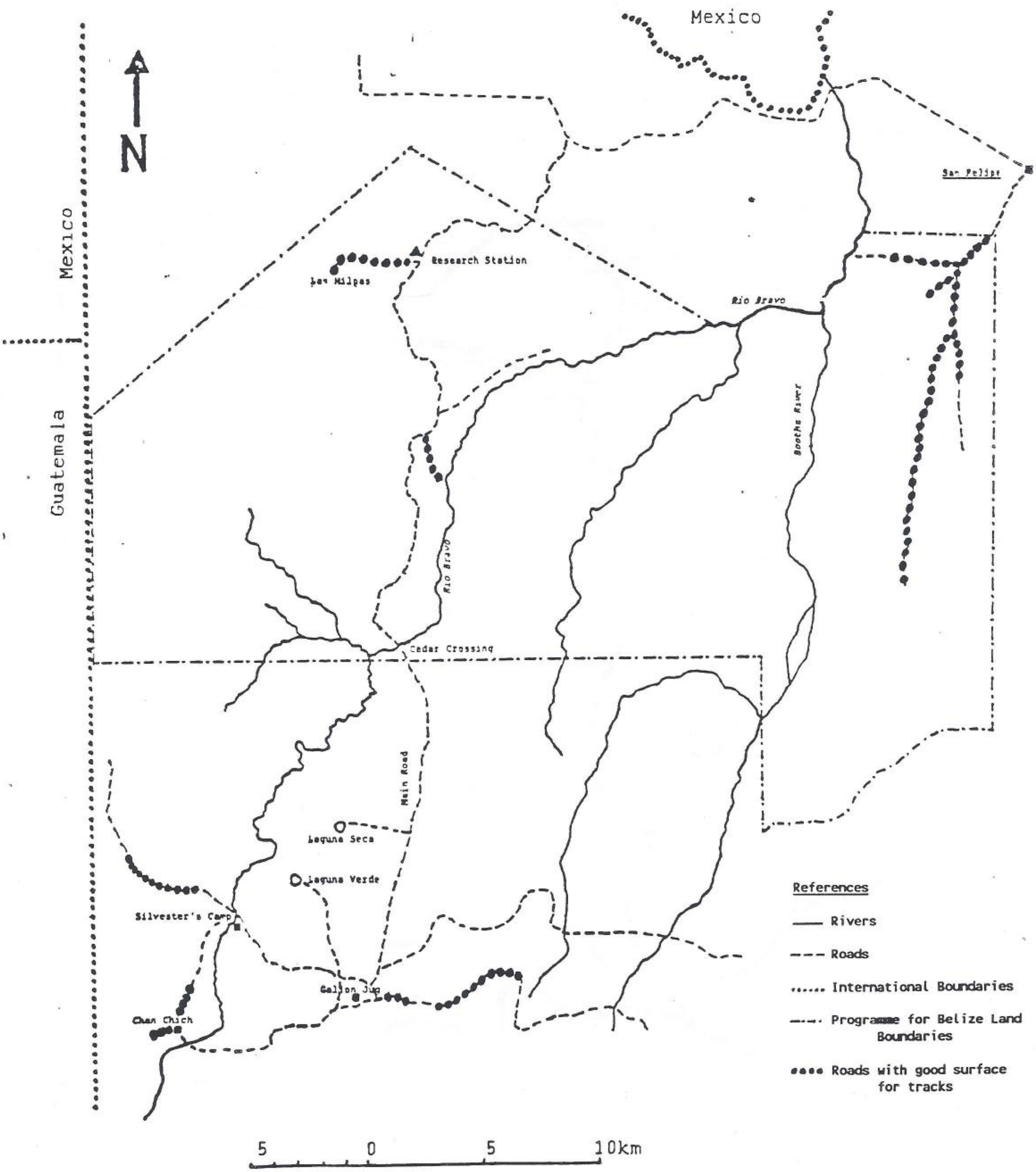


Figure 4. Portions of roads surveyed with surfaces on which tracks were detectable in the Rio Bravo and Gallon Jug areas in May, 1990.

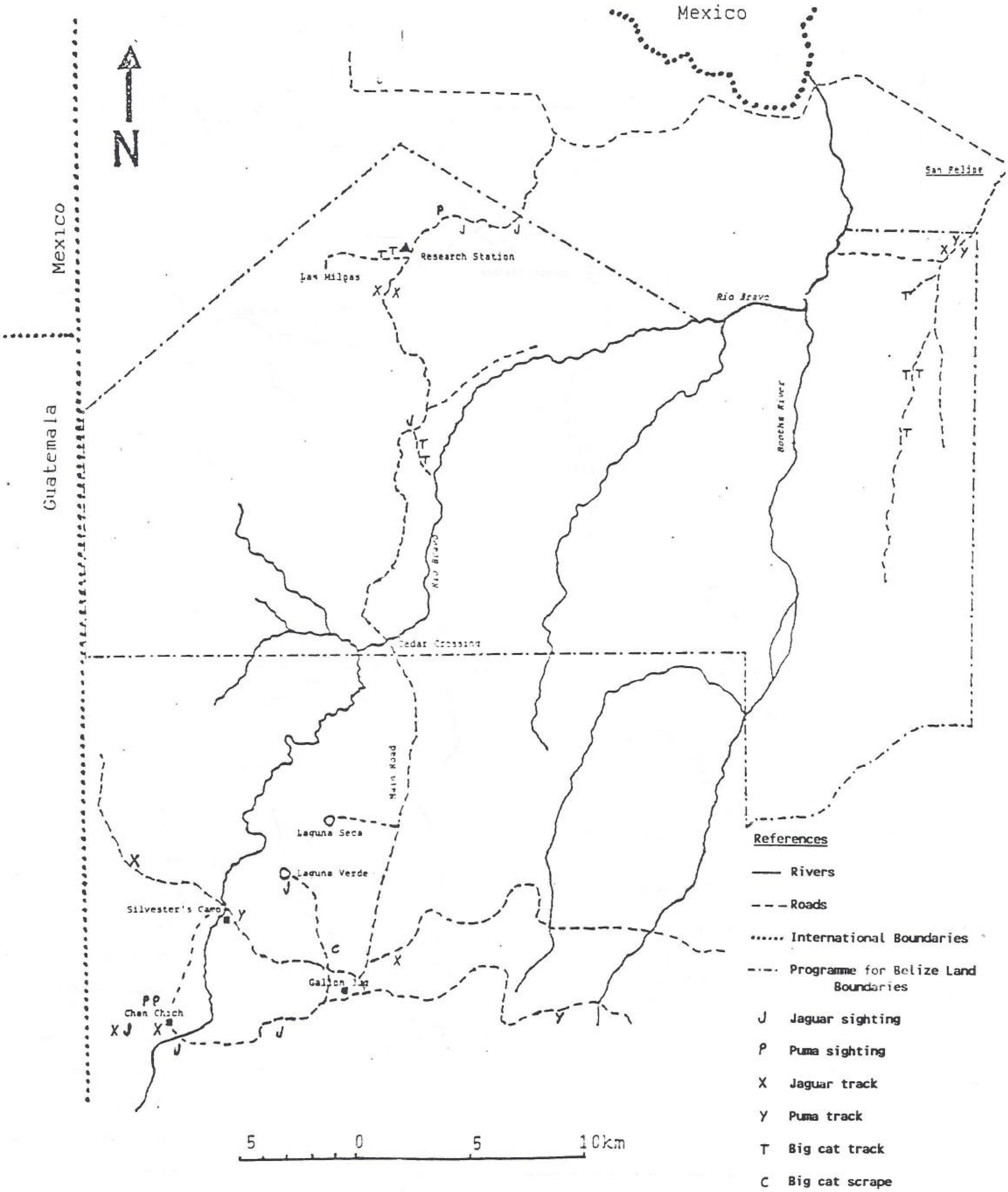


Figure 5. Big cat sightings from February to May, 1990, and big cat signs found in May, 1990, in the Rio Bravo and Gallon Jug areas.

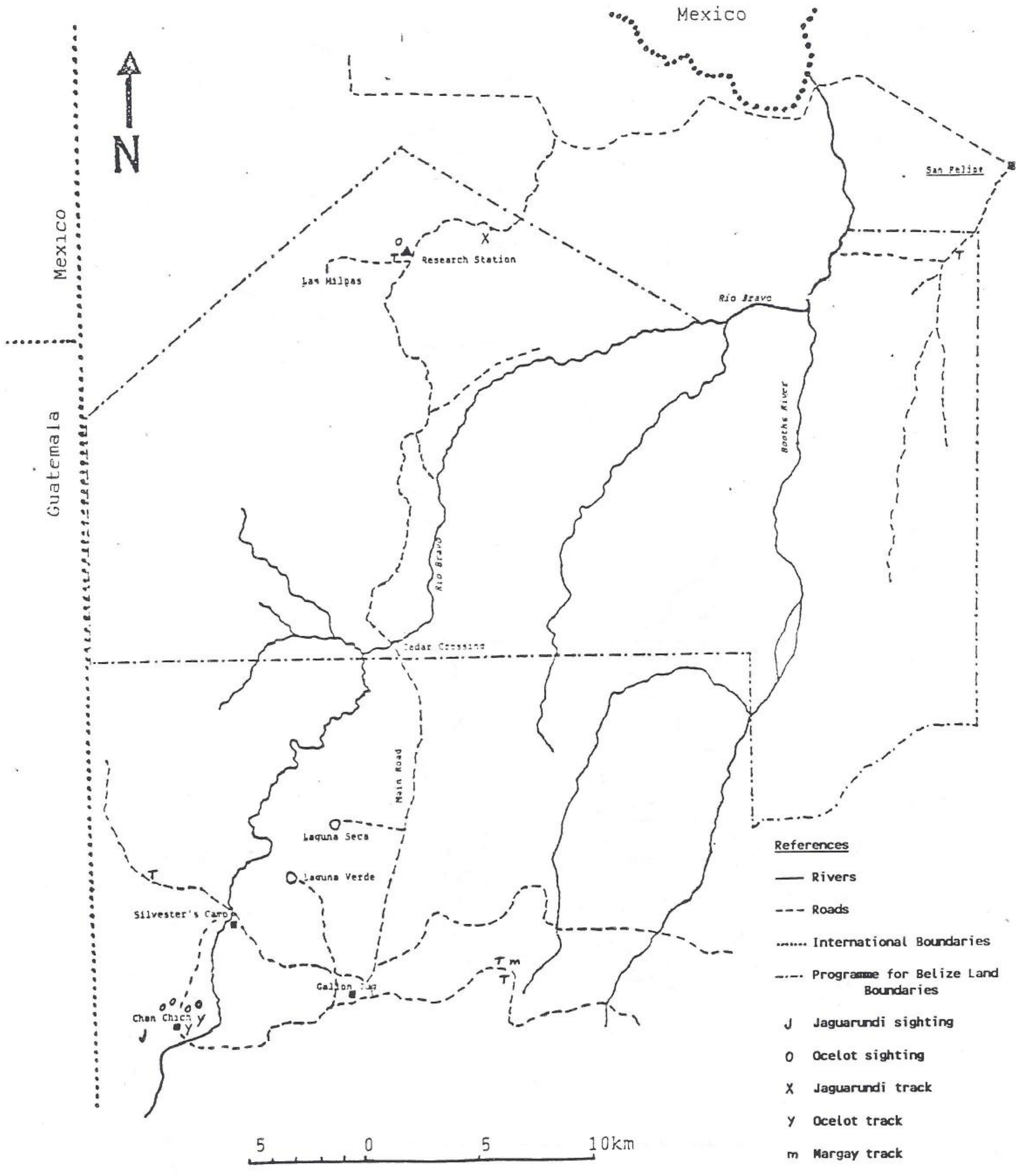


Figure 6. Small cat sightings from February to May, 1990, and small cat signs found in May, 1990, in the Rio Bravo and Gallon Jug areas.

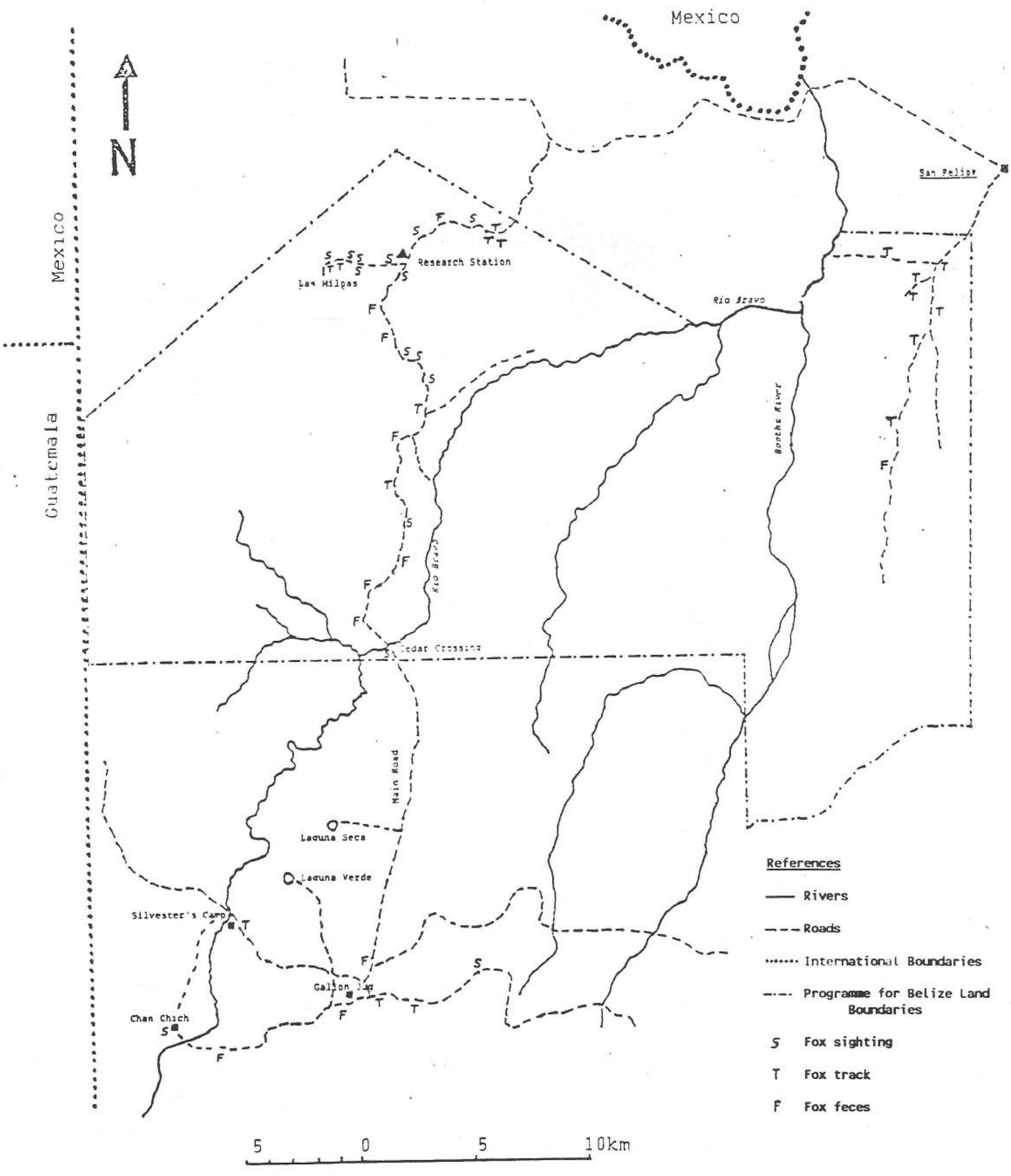


Figure 7. Gray fox sightings and signs recorded in the Rio Bravo and Gallon Jug areas in May, 1990.

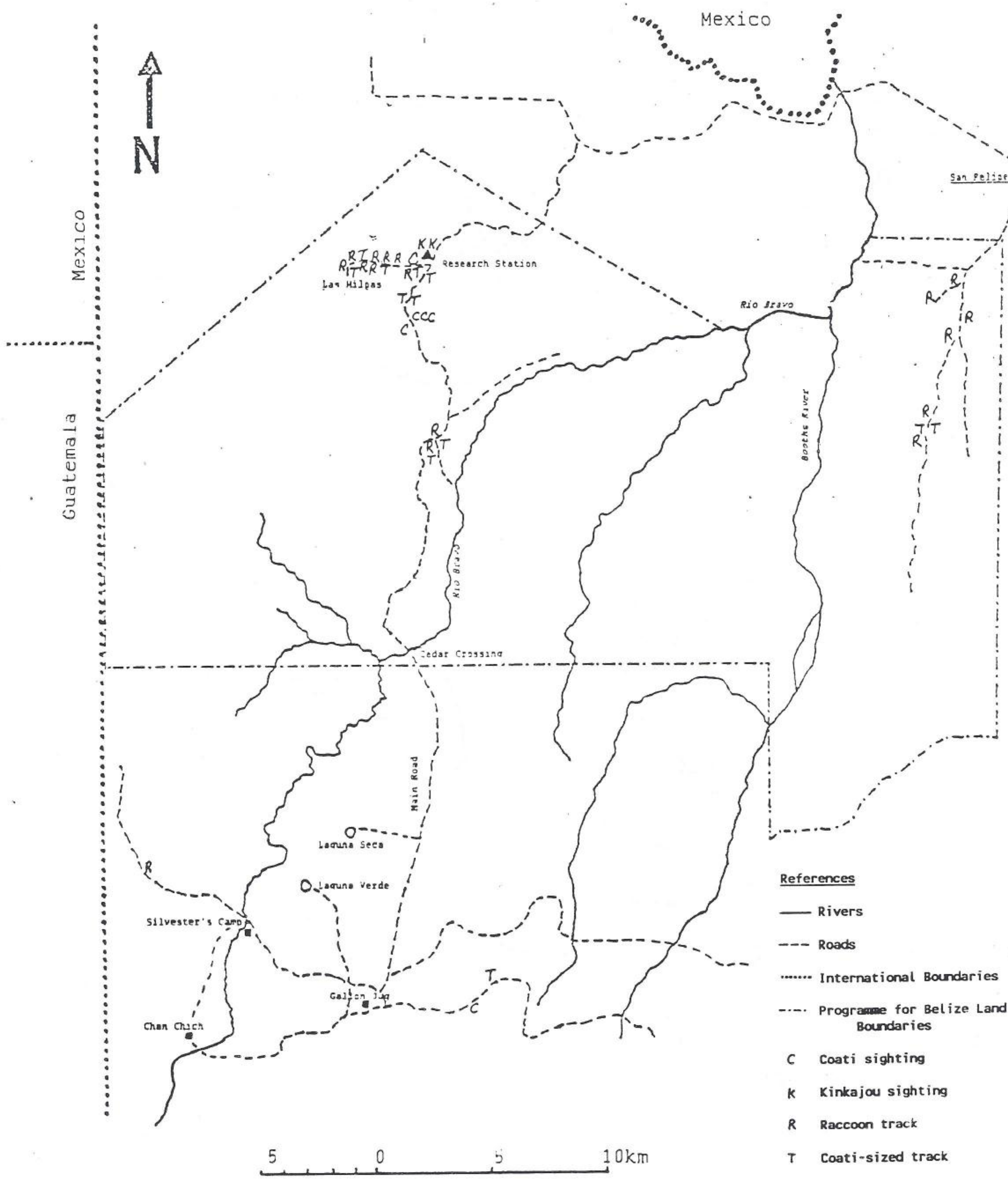


Figure 8. Procyonid sightings and tracks recorded in the Rio Bravo and Gallon Jug areas in May, 1990.

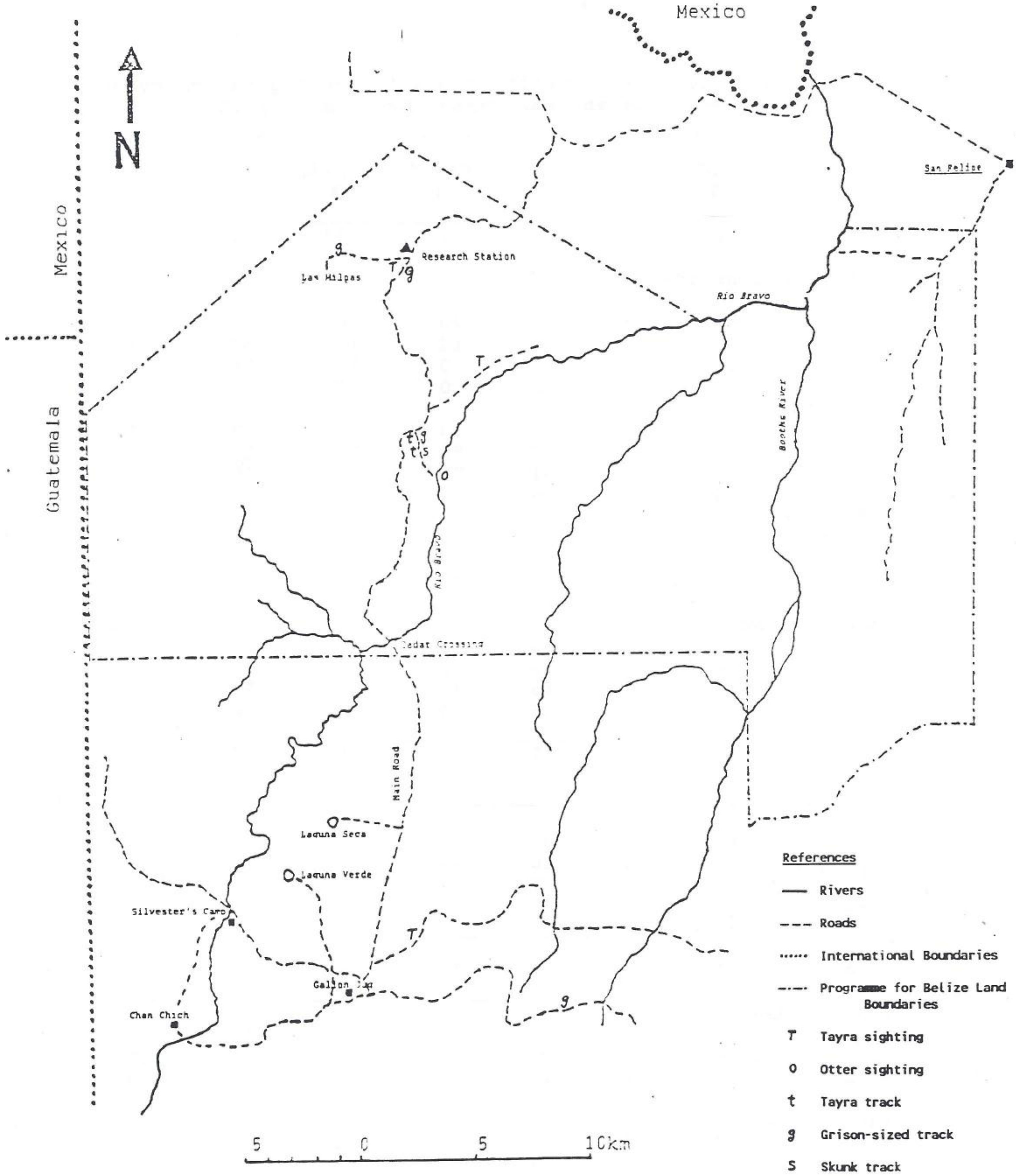


Figure 9. Mustelid sightings and tracks recorded in the Rio Bravo and Gallon Jug areas in May, 1990.

**Table 1. Summary of six habitat types in the vegetation survey from Rio Bravo Conservation and Management Area, May, 1990.**

| | SBL % | BAJO % | RIV % | SAV/G % | LAC/BL % | COHUN % | POOLED SITES % |
|---|---|---|---|---|---|---|---|
| N= | 27 | 16 | 31 | 10 | 14 | 14 | 113 |
| Vegetation Density* | | | | | | | |
| 0-1 meter | | | | | | | |
| A | 55 | 6 | 4 | 90 | 0 | 0 | 9% |
| B | 0 | 44 | 35 | 10 | 14 | 57 | 40% |
| C | 44 | 50 | 61 | 0 | 86 | 36 | 50% |
| D | 0 | 0 | 0 | 0 | 0 | 7 | 1% |
| 1-3 meter | | | | | | | |
| A | 0 | 0 | 0 | 10 | 0 | 7 | 2% |
| B | 33 | 50 | 39 | 50 | 29 | 14 | 35% |
| C | 67 | 50 | 61 | 30 | 71 | 79 | 62% |
| D | 0 | 0 | 0 | 10 | 0 | 0 | 1% |
| 3-10 meter | | | | | | | |
| A | 4 | 0 | 7 | 20 | 14 | 15 | 6% |
| B | 48 | 50 | 67 | 50 | 79 | 64 | 57% |
| C | 48 | 50 | 26 | 30 | 7 | 22 | 35% |
| D | 0 | 0 | 0 | 0 | 0 | 0 | 2% |
| Canopy >10 meter | | | | | | | |
| A | 26 | 0 | 0 | 0 | 14 | 21 | 11% |
| B | 44 | 18 | 39 | 0 | 86 | 0 | 37% |
| C | 26 | 44 | 55 | 30 | 0 | 79 | 42% |
| D | 4 | 38 | 6 | 70 | 0 | 0 | 10% |
| Average canopy height (meters) | 10 | 2 | 9 | 5 | 9 | 10 | 9 |
| Gap Presence | | | | | | | |
| No gap | 63 | 88 | 67 | 60 | 50 | 50 | 64% |
| 1/3gap | 22 | 6 | 26 | 40 | 43 | 43 | 27% |
| 2/3 gap | 19 | 6 | 7 | 0 | 7 | 7 | 8% |
| All gap | 4 | 0 | 0 | 0 | 0 | 0 | 1% |
| Grass Presence | 41 | 75 | 29 | 100 | 14 | 0 | 39% |
| Vines: Presence and Size | | | | | | | |
| | 0 | 0 | 6 | 0 | 0 | 21 | 9% |
| <1cm diameter | 26 | 94 | 55 | 30 | 50 | 21 | 58% |
| 1-5cm diam. | 74 | 6 | 45 | 10 | 50 | 57 | 12% |
| Vine Density | | | | | | | |
| None | 74 | 0 | 0 | 60 | 0 | 21 | 9% |
| Few | 19 | 31 | 48 | 40 | 71 | 71 | 57% |
| Moderate | 7 | 19 | 39 | 0 | 21 | 8 | 21% |
| Dense | 0 | 50 | 13 | 0 | 8 | 0 | 13% |

**Table 1. continued**

| | SBL % | BAJO % | RIV % | SAV/G % | LAC/BL % | COHUN % | POOLED % |
|---|---|---|---|---|---|---|---|
| **Average Number Live Trees** | | | | | | | N |
| 1-10cm DBH | 15 | 96 | 48 | 44 | 16 | 18 | 39(4397) |
| 10-50cm DBH | 4 | 3 | 6 | 1 | 3 | 4 | 4(438) |
| 50-100cm DBH | 0 | 0 | 1 | 0 | 2 | 2 | 1(80) |
| **Canopy Surface*** | | | | | | | |
| Even | | X | | X | X | | |
| Uneven | X | | X | | | X | |
| Very broken | | | | | | | |
| BrkN-emergents | | | | | | | |
| **Presence of Brushpiles** | | | | | | | |
| <10 cm diameter | | | | | | | |
| 0 | 48 | 38 | 3 | 30 | 0 | 7 | 5 |
| <5 | 52 | 62 | 42 | 50 | 86 | 93 | 44 |
| >5 | 0 | 0 | 55 | 20 | 14 | 0 | 65 |
| **Presence of Logs** | | | | | | | |
| >10 cm diameter | | | | | | | |
| 0 | 22 | 44 | 17 | 50 | 29 | 15 | 16 |
| <5 | 78 | 56 | 35 | 50 | 71 | 64 | 37 |
| >5 | 0 | 0 | 48 | 0 | 0 | 21 | 61 |

Dominant Palm Species (%)

| | SBL | BAJO | RIV | SAV/G | LAC/BL | COHUN |
|---|---|---|---|---|---|---|
| 1. | GT(80) | GT(80) | GT(85) | PM(85) | CH(45) | CH(95) |
| 2. | SB(15) | SB(18) | SB(10) | PP(10) | GT(45) | SB(4) |
| 3. | CH(5) | CB(2) | CB(5) | SB(5) | SB(10) | GT(1) |

Palm Species:

G&T=Give-and-Take
CH=Cohune
SB=Sabal
CB=Cabbage
PM=Palmetto
PP=Spiny palm

*-refer to Appendix 1

**Table 2. Small mammals (marsupials, bats, edentates, rodents) recorded from Rio Bravo Conservation and Management Area, May 1990.**

| Species | Capture | Sighting | Scat[1] | Other | Total |
|---|---|---|---|---|---|
| MARSUPIALIA | | | | | |
| Didelphis virginiana | 3 | 3 | 1 | | 7 |
| Philander opossum | 1 | | 1 | | 2 |
| Marmosa (mexicana?)[2] | | | 2 | | 2 |
| **Subtotal (3 species)** | **4** | **3** | **4** | | **11** |
| EDENTATA | | | | | |
| Tamandua mexicana | | 1 | 2 | | 2 |
| **Subtotal (1 species)** | | **1** | **2** | | **2** |
| CHIROPTERA | | | | | |
| Pteronotus parnellii | 7 | | | | 7 |
| Trachops cirrhosus | 3 | | | | 3 |
| Glossophaga soricina | 14 | | | | 14 |
| Carollia brevicauda | 29 | | | | 29 |
| Carollia perspicillata | 5 | | | | 5 |
| Sturnira lilium | 11 | | | | 11 |
| Uroderma bilobatum | 1 | | | | 1 |
| Vampyrops helleri | 3 | | | | 3 |
| Vampressa pusilla | 1 | | | | 1 |
| Artibeus jamaicensis | 2 | | | | 2 |
| Artibeus literatus | 8 | | | | 8 |
| Artibeus intermedius | 3 | | | | 3 |
| Dermanura phaeotis | 11 | | | | 11 |
| Centurio senex | 2 | | | | 2 |
| Lasiurus borealis | 1 | | | | 1 |
| **Subtotal (15 species)** | **101** | | | | **101** |
| RODENTIA | | | | | |
| Sciurus deppei | | 5 | | | 5 |
| Heteromys desmarestianus | 8 | | 10 | | 18 |
| Oryzomys couesi | 8 | | | | 8 |
| Tylomys nudicaudus(?)[3] | | | 1 | | 1 |
| Ototylomys phyllotis | 4 | | 1 | | 5 |
| Sigmodon hispidus | 38 | | 10 | | 45 |
| Agouti paca | | 2 | 6 | 1[4] | 9 |
| Agouti paca/Dasyprocta punctata | | | | 1[5], 13[6] | 1[4] |
| **Subtotal (7 species)[7]** | **58** | **7** | **28** | **15** | **105** |
| **TOTAL (26 species)** | **163** | **11** | **34** | **15** | **219** |

**Table 2, continued**

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[1]Scat collected and analyzed as described by Novaro, Suarez, Walker (in Part 2B attached)
[2]Species expected to be present (M. Engstrom, ROM, pers. comm).
[3]pelvis and femora found in scat, identification tentative, see comments in results section
[4]Road-killed specimen found on main road through reserve
[5]Tracks per Novaro, Suarez, Walker, pers. comm.
[6]Tracks noted by J. Fragoso, D. Rumiz, C. Hunter, G. Silva-Lopez and L. Grober (survey team No. 1), pers. comm.
[7]Dasyprocta punctata not counted as observation, see discussion

**Table 3. A comparison of the diversity and distribution of nonvolant mammals by habitat type and trapping success during May 1990 in the Rio Bravo Conservation and Management Area.**

| Species | Number of Individuals | Habitat[1] | Trapping Success (%) |
|---|---|---|---|
| Heteromys desmarestianus | 8 | SG,L,SBL,B,R | 0.32 |
| Oryzomys couesi | 8 | SG,P,L | 0.32 |
| Ototylomys phyllotis | 4 | R,C,B | 0.16 |
| Didelphis virginiana | 3 | R,L | 0.12 |
| Philander opossum | 1 | B | 0.04 |
| Sigmodon hispidus | 38 | SG | 1.53 |

[1]Habitats: SBL = Secondary Broadleaf Forest
R = Riverine/SBL
L = Lake/SBL
B = Bajo (Seasonally flooded)
SG = Savanna/Gallery Forest
C = Cahune Palm Forest
P = Pond

**Table 4. A comparison of body weight, hind foot, and ear length for nonvolant mammals live-trapped during May 1990, Rio Bravo Conservation and Management Area.**

| Species | #Body Wt (g) Ave. | #Body Wt (g) Range | RHF[1] (mm) Ave. | RHF[1] (mm) Range | RE[2] (mm) Ave. | RE[2] (mm) Range |
|---|---|---|---|---|---|---|
| *Heteromys* | 64.2 | 33.0-96.0 | 33.3 | 32.0-35.0 | 15.8 | 14.0-18.0 |
| *Oryzomys* | 44.6 | 30.5-67.0 | 29.4 | 28.0-31.0 | 14.3 | 13.0-16.0 |
| *Ototylomys* | 62.1 | 34.0-84.5 | 25.0 | 21.0-29.0 | 20.0 | 17.0-23.0 |
| *Didelphis* | 1009.3 | 205-1450 | 52.3 | 39.0-60.0 | 45.7 | 33.0-51.0 |
| *Philander* | 680 | --- | 44.0 | --- | 35.0 | --- |
| *Sigmodon* | 64.3 | 9.0-110.5 | 26.4 | 19.0-31.0 | 15.1 | 6.0-17.0 |

[1]RHF = right hind foot
[2]RE = right ear

Table 5. The diversity and abundance of bats according to habitat type in the Rio Bravo Conservation and Management Area, May 1990.

| Species | Number of Indivs. | Habitat[1] | MNH[2] | Bat/MNH |
|---|---|---|---|---|
| Artibeus intermedius | 3 | R | 54 | 0.06 |
| A. jamaicensis | 2 | R | 54 | 0.04 |
| A. literatus | 8 | R,RU | 60 | 0.13 |
| Dermanura phaeotis | 11 | R,RU | 60 | 0.18 |
| Carollia brevicauda | 29 | R,LMR,RU | 61.5 | 0.47 |
| C. perspicillata | 5 | RU | 6 | 0.83 |
| Centurio senex | 2 | R | 54 | 0.04 |
| Glassophaga soricina | 14 | R,RU | 60 | 0.23 |
| Lasiurus borealis | 1 | fence[3] | | |
| Pteronotus parnellii | 7 | R,LMR,SG | 61.5 | 0.11 |
| Sturnira lilium | 11 | R,LMR,RU,SG | 67.5 | 0.16 |
| Trachops cirrhosus | 3 | R,RU | 60 | 0.05 |
| Uroderma bilobatum | 1 | RU | 6 | 0.17 |
| Vampressa pusilla | 1 | R | 54 | 0.02 |
| Vampyrops helleri | 3 | R,RU | 60 | 0.05 |

[1]Habitats: R = Riverine/Secondary Broadleaf Forest
RU = Ruins
LMR = Las Milpas Road
SG = Savanna/Gallery Forest

[2]MNH = Mist-Net Hours

[3]fence in an open pasture

Table 6. A comparison of body weight, ear, and forearm length for bats mist-netted during May 1990, Rio Bravo Conservation and Management Area.

| Species | Body Wt (g) | | Ear (mm) | | Fore arm (mm) | |
|---|---|---|---|---|---|---|
| | Ave. | Range | Ave. | Range | Ave. | Range |
| Artibeus intermedius | 48.0 | - | 23.0 | - | 63.0 | 62.0-64.0 |
| A. jamaicensis | 40.0 | - | 21.0 | - | 61.5 | 61.0-62.0 |
| A. literatus | 65.5 | 63.0-68.0 | 22.0 | 21.0-23.0 | 70.0 | 63.0-75.0 |
| Dermanura phaeotis | 12.0 | - | 16.0 | - | 38.7 | 37.0-41.0 |
| Carollia brevicauda | 19.3 | 15.0-23.5 | 17.0 | 14.0-22.0 | 40.2 | 38.0-46.0 |
| C. perspicillata | 20.3 | 20.0-20.5 | 19.5 | 19.0-20.0 | 44.5 | 44.0-45.0 |
| Centurio senex | 15.0 | - | 15.0 | - | 44.3 | 43.0-45.0 |
| Glassophaga soricina | 9.0 | - | 14.0 | - | 35.9 | 35.0-38.0 |
| Lasiurus borealis | 10.0 | - | 90.0 | - | 39.5 | - |
| Pteronotus parnellii | 19.6 | 17.5-22.5 | 18.2 | 17.0-21.0 | 57.4 | 53.0-62.0 |
| Sturnira lilium | 15.0 | 14.0-16.5 | 14.4 | 12.0-18.0 | 38.0 | 34.0-40.0 |
| Trachops cirrhosus | 26.0 | - | 32.0 | - | 62.0 | - |
| Uroderma bilobatum | 16.5 | - | 19.0 | - | 44.0 | - |
| Vampressa pusilla | 7.0 | - | 15.0 | - | 31.0 | - |
| Vampyrops helleri | 12.5 | - | 16.0 | - | 38.7 | 38.0-39.0 |

**Table 7. Reproductive condition of non-volant mammals live-trapped, Rio Bravo Conservation and Management Area, May, 1990,**

**FEMALES**

| Species | Pregnant | Lactating | Non-Reproductive | Percent Reproductive |
|---|---|---|---|---|
| Didelphis[1] | 0 | 2 | 1 | 100 |
| Heteromys | 2 | 0 | 3 | 40 |
| Ototylomys | 1 | 2 | 0 | 100 |
| Oryzomys | 0 | 0 | 1 | 0 |
| Sigmodon | 0 | 0 | 10 | 0 |

[1]The non-lactating individual was sub-adult; 100% of adults were in reproductiive condition

**MALES**

| Species | Scrotal | Non-Scrotal | Percent Reproductive |
|---|---|---|---|
| Heteromys | 3 | 1 | 75 |
| Oryzomys | 3 | 1 | 75 |
| Sigmodon | 12 | 14 | 42.8 |

Table 8. **Total number of species[1] recorded from Belize compared to species recorded in Rio Bravo Reserve and Cockscomb Basin**

| Order | Family | NUMBER OF SPECIES | | | |
|---|---|---|---|---|---|
| | | Total Belize[2,3] | Rio Bravo[4] | Cockscomb Basin[5] | per cent unrecorded Rio Bravo |
| MARSUPALIA | Didelphidae | 8 | 3 | 4 | 62% |
| INSECTIVORA | Soricidae | 2 | 0 | 0 | 100% |
| CHIROPTERA | Emballonuridae | 8 | 0 | 1 | |
| | Noctilionidae | 1 | 0 | 1 | |
| | Mormoopidae | 4 | 1 | 0 | |
| | Phyllostomidae | 37 | 13 | 11 | |
| | Natalidae | 1 | 0 | 0 | |
| | Thyropteridae | 1 | 0 | 1 | |
| | Vespertilionidae | 9 | 1 | 2 | |
| | Molossidae | 7 | 0 | 0 | 78% |
| PRIMATES | Cebidae | 2 | 2 | 1 | 0% |
| EDENTATA | Myrmecophagidae | 2 | 1 | 1 | 75% |
| | Dasypodidae | 2 | 0 | 1 | 100% |
| LAGOMORPHA | Leporidae | 1 | 0 | 0 | 100% |
| RODENTIA | Sciuridae | 2 | 1 | 2 | |
| | Geomyidae | 1 | 0 | 1 | |
| | Heteromyidae | 2 | 1 | 1 | |
| | Muridae[6] | 11 | 4 | 7 | |
| | Erethizontidae | 1 | 0 | 1 | |
| | Dasyproctidae | 2 | 1 | 2 | 63% |
| CARNIVORA | Canidae | 1 | 1 | 1 | |
| | Procyonidae | 3 | 3 | 3 | |
| | Mustelidae | 6 | 3 | 4 | |
| | Felidae | 5 | 5 | 5 | 20% |
| PERISSODACTYLA | Tapiridae | 1 | 1 | 1 | 0% |
| ARTIODACTYLYA | Tayassuidae | 2 | 2 | 2 | 0% |
| | Cervidae | 2 | 2 | 2 | 0% |
| **TOTALS** | | **124** | **45** | **54** | **62.5%** |

[1]excluding orders Cetacea and Sirenia
[2]McCarthy, 1983 and ms. in prep.
[3]Weyer, D. in Hartshorn et al., 1984
[4]Numerous authors, this study (Parts A&B), 1990
[5]Rabinovitz and Nottingham, 1989
[6]Formerly family Cricetidae; introduced Rattus and Mus not listed

**TABLE 9. Number of tracks and sightings, home range sizes (from the literature), and estimated minimum numbers of carnivore species in the Rio Bravo and Gallon Jug areas in May, 1990.**

| SPECIES | TRACKS | SIGHTINGS | HOME RANGE ($km^2$) | REFERENCE | MINIMUM NUMBER |
|---|---|---|---|---|---|
| JAGUAR | 7 | 7 | 10-90 | 1,2 | 5 |
| PUMA | 4 | 3 | 82 | 3 | 6 |
| BIG CAT | 9* | | | | |
| OCELOT | 2 | 3 | 0.8-14.7 | 3,4,5,6 | 3 |
| JAGUARUNDI | 1 | 1 | 12.9-100.0 | 6 | 2 |
| MARGAY | 1 | 0 | 10.9 | 6 | 1 |
| SMALL CAT | 6** | | | | |
| FOX | 17 | 18 | 2 | 7 | 40# |
| RACCOON | 17 | 0 | 0.5 | 8 | 13 |
| COATI | 12+ | 6 | 0.3-3.0 | 9,10 | 5 |
| KINKAJOU | 0 | 2 | -- | -- | 2 |
| TAYRA | 2 | 3 | 2.1-24.4 | 6,11 | 4 |
| OTTER | 1 | 1 | -- | -- | 1 |
| GRISON | 4++ | 0 | -- | -- | -- |
| SKUNK | 1 | 0 | -- | -- | -- |

*Unconfirmed jaguar or puma tracks; includes one big cat scrape
**Unconfirmed jaguarundi or margay
#Known fox scats also used in calculation of minimum number of individuals
+May also include some small raccoons
++May also include some small tayras
1. Rabinowitz & Nottingham, 1986; 2. Schaller & Crawshaw, 1980; 3. Schaller, 1984; 4. Emmons, 1988; 5. Ludlow & Sunquist, 1987; 6. Konecny, 1989; 7. Fritzell & Haroldson, 1982; 8. Lotze & Anderson, 1979; 9. Kaufmann, 1962; 10. Lanning, 1976; 11. Sunquist et al., 1989.

**TABLE 10. Number and proportion (%) of food items found by two kinds of analysis of carnivore scats collected in the Rio Bravo and Gallon Jug areas in May, 1990.**

| Food Items | Analyzed in detail | Categorized |
|---|---|---|
| Fruits | 161(44) | 239(58) |
| Arthropods | 116(31) | 121(30) |
| Reptiles | 19(5) | 3(1) |
| Birds | 39(11) | 12(3) |
| Mammals | 34(9) | 35(9) |
| Number of scats | 183 | 378 |
| Number of items | 369 | 410 |

**TABLE 11. Number and frequency of occurrence (%) of food items in carnivore scats collected in the Rio Bravo and Gallon Jug areas in January, 1990.**

| Food item | Fox | Big cat (1) | Unknown (2) |
|---|---|---|---|
| Fruits | 4(80) | | 4(100) |
| Arthropods | 4(80) | | 2(50) |
| Reptiles | | | 1(25) |
| Birds | 3(60) | | 1(25) |
| Marsupials: | | | |
| *Philander* | | 1(50) | |
| *Marmosa* | | 1(50) | |
| Rodents: | | | |
| *Ototylomys* | | 1(50) | |
| Edentates: | | | |
| *Tamandua* | | 1(50) | |
| Number of scats | 5 | 2 | 4 |
| Number of food items | 11 | 4 | 8 |

(1) Unidentified jaguar or puma
(2) Non-felid carnivore species not identified

**TABLE 12. Number and frequency of occurrence (%) of food items in carnivore scats collected in the Rio Bravo and Gallon Jug areas in May, 1990.**

| Food item | Fox | Small Cat (1) | Raccoon | Big cat (2) | Mustelid (3) | Unknown (4) |
|---|---|---|---|---|---|---|
| Fruits | 98(95) | | 4(100) | | | 58(87) |
| Arthropods | 69(67) | 3(50) | 3(75) | | 1(100) | 39(58) |
| Snails | | | 1(25) | | | |
| Frog | 2(2) | | | | | |
| Reptiles* | 6(6) | | 1(25) | | | 5(8) |
| Snakes | 1(1) | | | | | 6(9) |
| Birds | 19(18) | 4(67) | 1(25) | | | 15(22) |
| Marsupials: | | | | | | |
| <u>Didelphis</u> | 1(1) | | | | | |
| <u>Marmosa</u> | | 1(17) | | | | |
| Rodents: | | | | | | |
| <u>Sigmodon</u> | 6(6) | 1(17) | | | | 3(5) |
| <u>Heteromys</u> | 6(6) | | | | | 4(6) |
| <u>Tylomys</u> | | 1(17) | | | | |
| <u>Agouti paca</u> | 1(1) | | | 1(50) | | 4(6) |
| Unidentified small mammal | 6(6) | | | | | 7(10) |
| Artiodactyla: | | | | | | |
| <u>Tayassu</u> or <u>Dicotyles</u> | | | | 1(50) | | |
| Unidentified vertebrate | 4(4) | | | | | |
| Number of scats | 103 | 6 | 4 | 2 | 1 | 67 |
| Number of food items | 219 | 10 | 10 | 2 | 1 | 156 |

(1) Unidentified ocelot, margay, or jaguarundi
(2) Unidentified jaguar or puma
(3) Grison or small tayra
(4) Non-felid carnivore species not identified
* Unidentified lizards or snakes

**TABLE 13. Number and proportion (%) of food items in all non-felid carnivore scats collected in the broadleaf forest and savanna habitats of the Rio Bravo and Gallon Jug areas in May, 1990.**

| Food item | Broadleaf forest | Savanna |
|---|---|---|
| Fruits | 148(46) | 12(40) |
| Arthropods | 106(33) | 7(23) * |
| Reptiles | 17(5) | 2(7) |
| Birds | 31(10) | 4(13) |
| Mammals | 22(7) | 5(17) * |
| Number of scats | 161 | 14 |
| Number of food items | 324 | 30 |

* Differences between broadleaf forest and savanna proportions significant at $p < 0.05$

**Appendix 1. List of Vegetation Sampling Criteria (Burnham, et al. 1989)**

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A. Density of ground cover from 0 to 1 meters in height

B. Vegetation density from 1 to 3 meters in height

C. Vegetation density from 3 to 10 meters in height

D. Main canopy density from 10 meters to the surface

E. Gap presence

 1: 1/3 gap
 2: 2/3 gap
 3: All gap

F. Grasses present

G. Presence and Size of Vines

 0: None
 1: Vines <1 cm in diameter
 2: Vines 1-5 cm in diameter

H. Density of vines
 0: None
 1: Few
 2: Moderate
 3: Dense

I. Number of live trees 1-10 cm DBH

J. Number of live trees 10-50 cm DBH

K. Number of live trees 50-100 cm DBH

L. Average height of base of main canopy

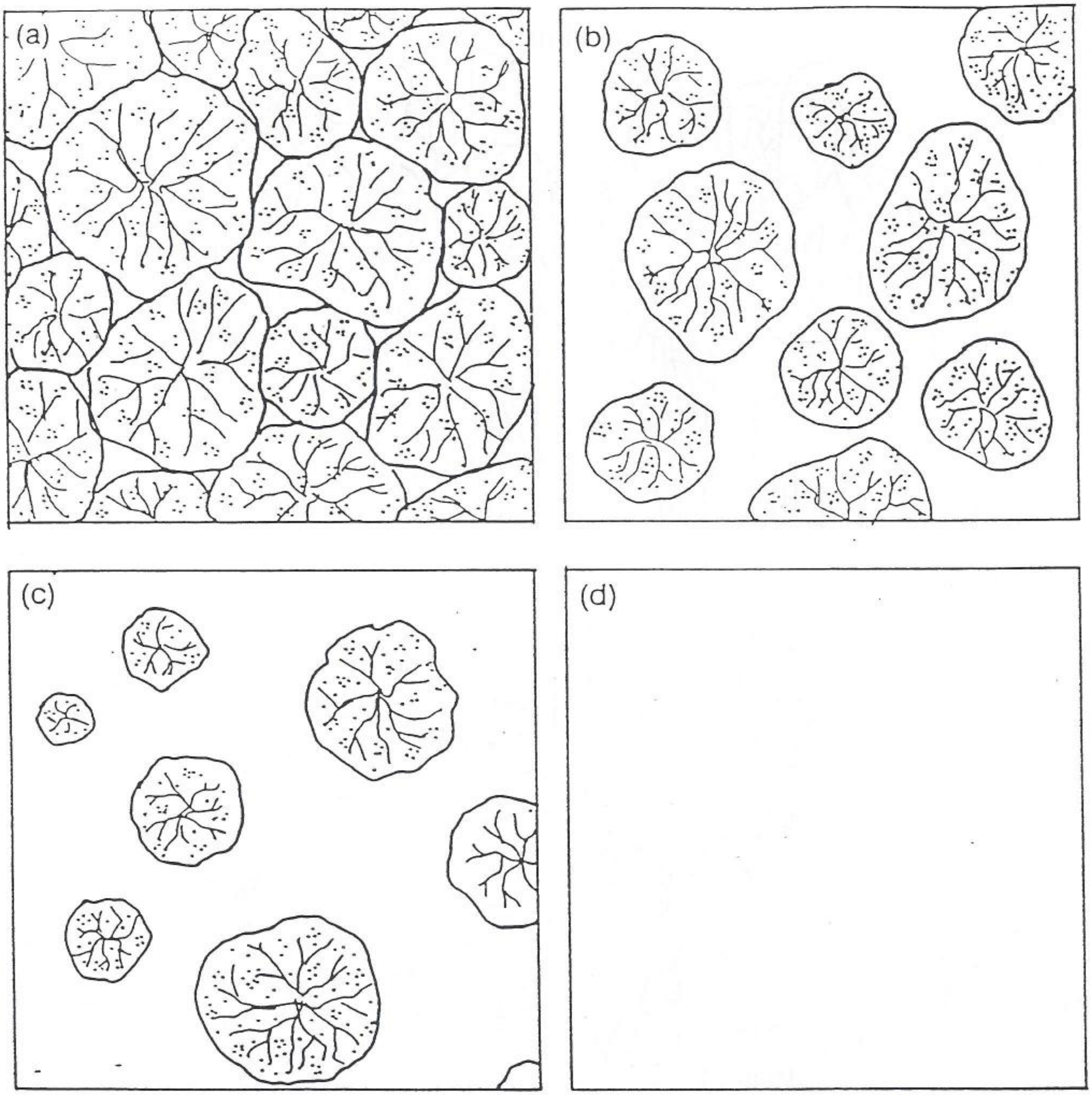
M. Upper surface of canopy

 0: More or less even
 1: Uneven
 2: Even
 3: Broken with emergents

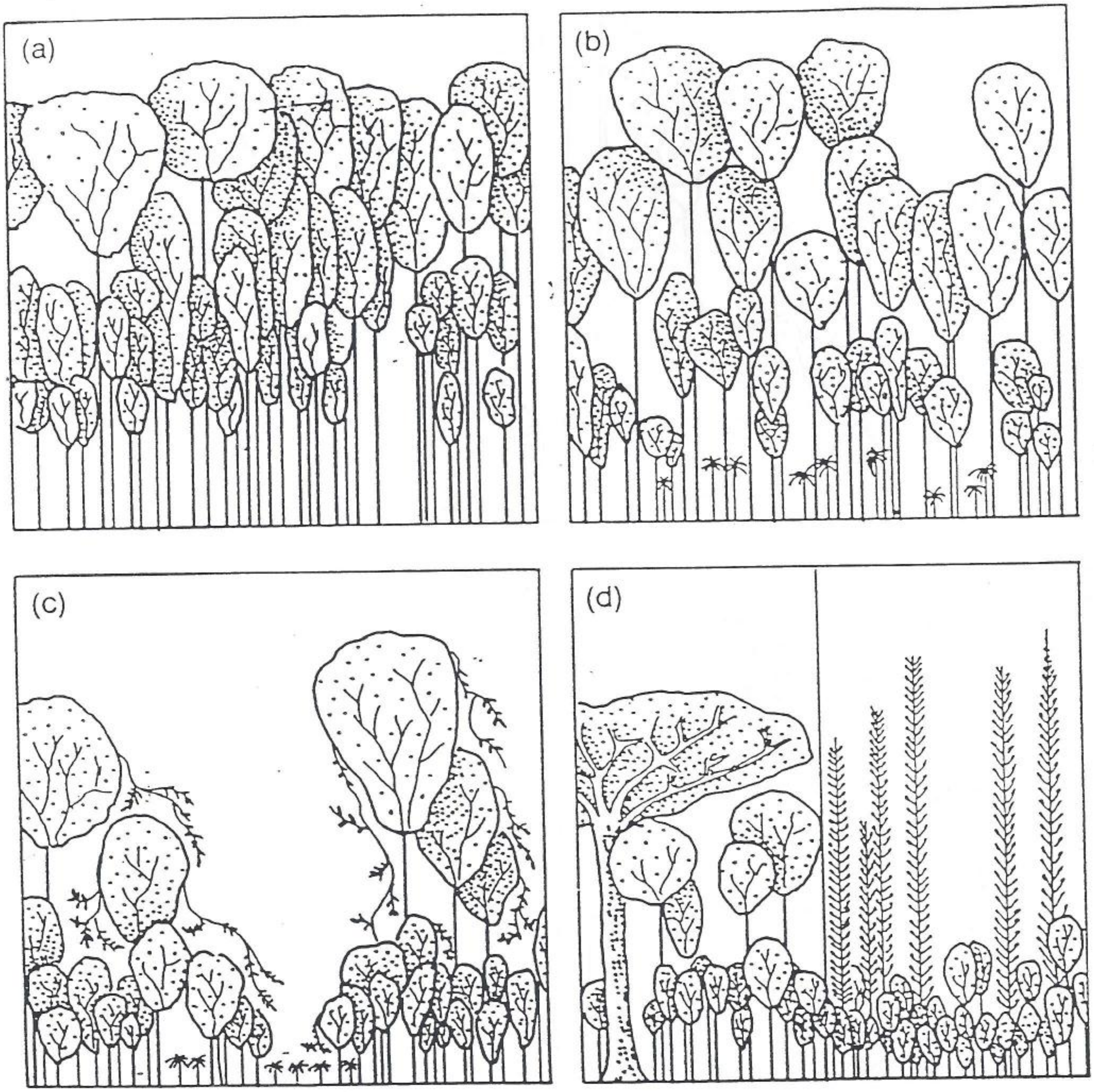
N. Presence of brushpiles <10 cm DBH

O. Presence of logs >10 cm DBH

P. Dominant palm species (%)




Appendix 1A. Definition of vegetation density: (a) dense; (b) medium; (c) open; (d) no canopy




Appendix 1B. Definition of canopy surface types: (a) more or less even; (b) uneven; (c) very broken; (d) with emergents

**Appendix 2. List of mammals recorded from Rio Bravo Conservation and Management Area during mammal survey conducted January and May, 1990.**

| Species | Common Name |
|---|---|
| **MARSUPIALIA - Marsupials** | |
| **DIDELPHIDAE - Opossums** | |
| Didelphis virginiana | Virginia Opossum |
| Marmosa sp. | Mouse Opossum |
| Philander opossum | Four-eyed opossum |
| **CHIROPTERA - Bats** | |
| **MORMOOPIDAE - Leaf-chinned Bats** | |
| Pteronotus parnellii | Parnell's mustached bat |
| **PHYLLOSTOMIDAE - Leaf-nosed Bats** | |
| Trachops cirrhosus | Fringe-lipped bat |
| Glossophaga soricina | Pallas' long-tongued bat |
| Carollia brevicauda | Short-tailed bat |
| Carollia perspicillata | Seba's short-tailed bat |
| Sturnira lilium | Yellow-shouldered bat |
| Uroderma bilobatum | Tent-making bat |
| Vampyressa pusilla | Yellow-eared bat |
| Vampyrops helleri | Heller's broad-nosed bat |
| Artibeus jamaicensis | Jamaican fruit-eating bat |
| Artibeus lituratus | Big fruit-eating bat |
| Artibeus intermedius | Big fruit-eating bat |
| Dermanura phaeotis | Gervais' fruit-eating bat |
| Centurio senex | Wrinkle-faced bat |
| **VESPERTILIONIDAE - Plain-nosed Bats** | |
| Lasiurus borealis | Red bat |
| **PRIMATES - Monkeys** | |
| **CEBIDAE - Howler and Spider Monkeys** | |
| Alouatta pigra | Black howler monkey |
| Ateles geoffroyi | Spider monkey |
| **EDENTATA - Anteaters and Armadillos** | |
| **MYRMECOPHAGIDAE - Anteaters** | |
| Tamandua mexicana | Tamandua, Collared Anteater |
| **RODENTIA- Rodents** | |
| **SCIURIDAE - Squirrels** | |
| Sciurus deppei | Deppe's squirrel |
| **HETEROMYIDAE - Pocket rats** | |
| Heteromys desmarestianus | Desmarest's spiny pocket mouse |
| **MURIDAE (Cricetinae) - New World Rats and Mice** | |
| Oryzomys couesi | Coues' rice rat |
| Tylomys nudicaudus[2] | Peters' climbing rat |
| Ototylomys phyllotis | Big-eared climbing rat |
| Sigmodon hispidus | Hispid cotton rat |
| **DASYPROCTIDAE - Agoutis and Pacas** | |
| Agouti paca | Paca, gibnut |

**Appendix 2 continued**

| | |
|---|---|
| | **CARNIVORA - Carnivores** |
| **CANIDAE - Foxes** | |
| Urocyon cinereoargenteus | Gray fox |
| **PROCYONIDAE - Rintails,raccoons, coati mundis, kinkajous** | |
| Procyon lotor | Raccoon |
| Nasua nasua | Coati mundi |
| Potos flavus | Kinkajou |
| **MUSTELIDAE - Weasel, skunks, otters** | |
| Eira barbara | Tayra |
| Connepatus semistriatus | Striped hog-nosed skunk |
| Lontra longicaudis | Southern river otter |
| **FELIDAE - Cats** | |
| Panthera onca | Jaguar |
| Felis concolor | Puma |
| Felis pardalis | Ocelot |
| Felis weidii | Margay |
| Felis yagouaroundi | Jaguarundi |
| | **PERISSODACTYLA - Horses, tapirs** |
| **TAPIRIDAE - Tapirs** | |
| Tapirus bairdii | Baird's tapir |
| | **ARTIODACTYLA - Peccaries, deer** |
| **TAYASSUIDAE - Peccaries** | |
| Dicotyles tajacu | Collared peccary |
| Tayassu pecari | White-lipped peccary |
| **CERVIDAE - Deer** | |
| Odocoileus virginianus | White-tailed deer |
| Mazama americana | Red brocket |

[1]Based on currently accepted nomenclature and recommendations by T. J. McCarthy, pers. comm.; subspecies excluded since names would depend on distribution rather than morphology.

[2]species to be verified; I.D. based on pelvis and femora found in scat