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RESEARCH ARTICLES

Tropical Rain Forest Conversion and Perspectives in the Conservation of Wild Primates (*Alouatta* and *Ateles*) in Mexico

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The original distribution of the tropical rain forest and of the populations of *Alouatta palliata*, *Al. pigra*, and the two subspecies of *Ateles geoffroyi* in southern Mexico have been reduced by at least 90% in the last 40 years as a result of conversion of natural habitat to pasture and agricultural fields. This dramatic conversion has been caused mainly by the rapid growth of the human population in the southern states of the country. In the region of Los Tuxtlas in southern Veracruz, where the only longitudinal populational and ecological studies of *A. palliata* and *At. g. vellerosus* have taken place, only 15% of the original extension of the tropical rain forest remains today. The intensive destruction of suitable primate habitat in this region has resulted in an accelerated process of extinction of the primate species. It is estimated that only about 200 *At. g. vellerosus* and about 1200 *Al. palliata* exist in the remaining small portion of their original habitat. Today, the distribution of the three primate species in Mexico is intensively and extensively fragmented, and only five potential foci for conservation exist in the country. Urgent action is required to protect the primate populations in the region of Los Tuxtlas and at the other four foci, as some of these populations may disappear by 1995.

Key words: howling monkeys, spider monkeys, deforestation

INTRODUCTION

The remnants of tropical rain forest in Mexico retain populations of the northernmost representatives of the Ceboidea in the Neotropics: two howler monkey species (*Alouatta palliata* and *Al. pigra*) and one spider monkey species (*Ateles geoffroyi*) represented by two subspecies (*At. g. vellerosus* and *At. g. yucatanensis*). *Al. palliata* in southern Mexico was originally distributed in rain forest areas in southern Veracruz, Tabasco, Campeche, Chiapas, and parts of Oaxaca. *Al. pigra* co-occurs with *Al. palliata* in the states of Tabasco and Campeche and possibly in northeastern Chiapas, and it is the only representative of the genus in the Yucatan peninsula [Smith, 1970; Estrada & Coates-Estrada, 1984b; Watts et al., 1986] (R. Horwich & E. Watts, personal communication). In the past, the spider monkey had a broader geographical distribution than did the howler monkey. *At. g. vellerosus*

Received June 17, 1987; revision accepted December 29, 1987.

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has been reported as far north as the Sierra Huasteca, where the states of Tamaulipas, Hidalgo, San Luis Potosi, and Veracruz border one another. The subspecies *yucatanensis* was apparently restricted to the Yucatan peninsula (Kellogg & Goldman, 1944; Konstant et al., 1985; Watts et al., 1986).

Unfortunately, the natural habitats of these primates have been disappearing very rapidly in the last few decades as a result of the rapid human population growth and of the implemented land management systems, which are incompatible with tropical rain forest conservation. This severe transformation coupled with illegal hunting and trafficking of animals has resulted in a significant depletion of the natural primate populations in the country.

Spider and howler monkeys currently inhabit forest fragments of various sizes and with different histories of isolation throughout southern Mexico. Very little quantitative information exists on the impact of the intensive and extensive fragmentation of the tropical rain forest and, consequently, on the stability and future of the wild populations.

The aim of the present study was to assess the impact of conversion of forest into pasture and agricultural fields on the survival of primate populations in southern Mexico in general and in the region of Los Tuxtlas in southern Veracruz in particular.

METHODS

Changes in the Original Distribution of Primate Habitats

Published documentation of the original distribution of tropical rain forest vegetation forms inhabited by *Alouatta* and *Ateles* were examined, and extensions of vegetation were quantified. The latter was accomplished by electronically digitizing vegetation maps and aerial photographs published by the Mexican federal government at 5–10-year intervals since 1960. In the region of Los Tuxtlas, this information was complemented with on-site surveys and low-flying air reconnaissance flights between 1981 and 1986.

Changes in the Size of the Human Populations

Published results of human population censuses were examined to evaluate the pressure exerted on primate habitat by human population growth in southern Mexico. Censuses have been conducted by both state and federal governments in the southern states at 10-year intervals since 1960. For the region of Los Tuxtlas, historical information [Andrle, 1964] was used to ascertain the distribution and growth of human populations before 1930. ●

Past and Present Distribution of *Alouatta* and *Ateles* in Mexico

Published sources [Hall, 1981] were examined to ascertain the original distribution of the two primate genera in Mexico. Surveys of populations of *Alouatta* and *Ateles* in the region of Los Tuxtlas were conducted yearly from 1981 to 1986 by the present authors. Once every 2 years selected sites in the states of Tamaulipas, Tabasco, Campeche, Chiapas, and Quintana Roo were surveyed. These surveys complement those conducted by Horwich & Johnson [1986] in Tabasco and Campeche and by Watts et al. [1986] in the Yucatan peninsula.

Impact of Forest Fragmentation on the Size and Structure of Populations of *Alouatta* and *Ateles* in Los Tuxtlas

Censuses of *Alouatta* and *Ateles* were conducted on segments of forests that had been protected for many decades either because they are part of the biological reserve "Los Tuxtlas" of UNAM or because they have remained relatively undis-

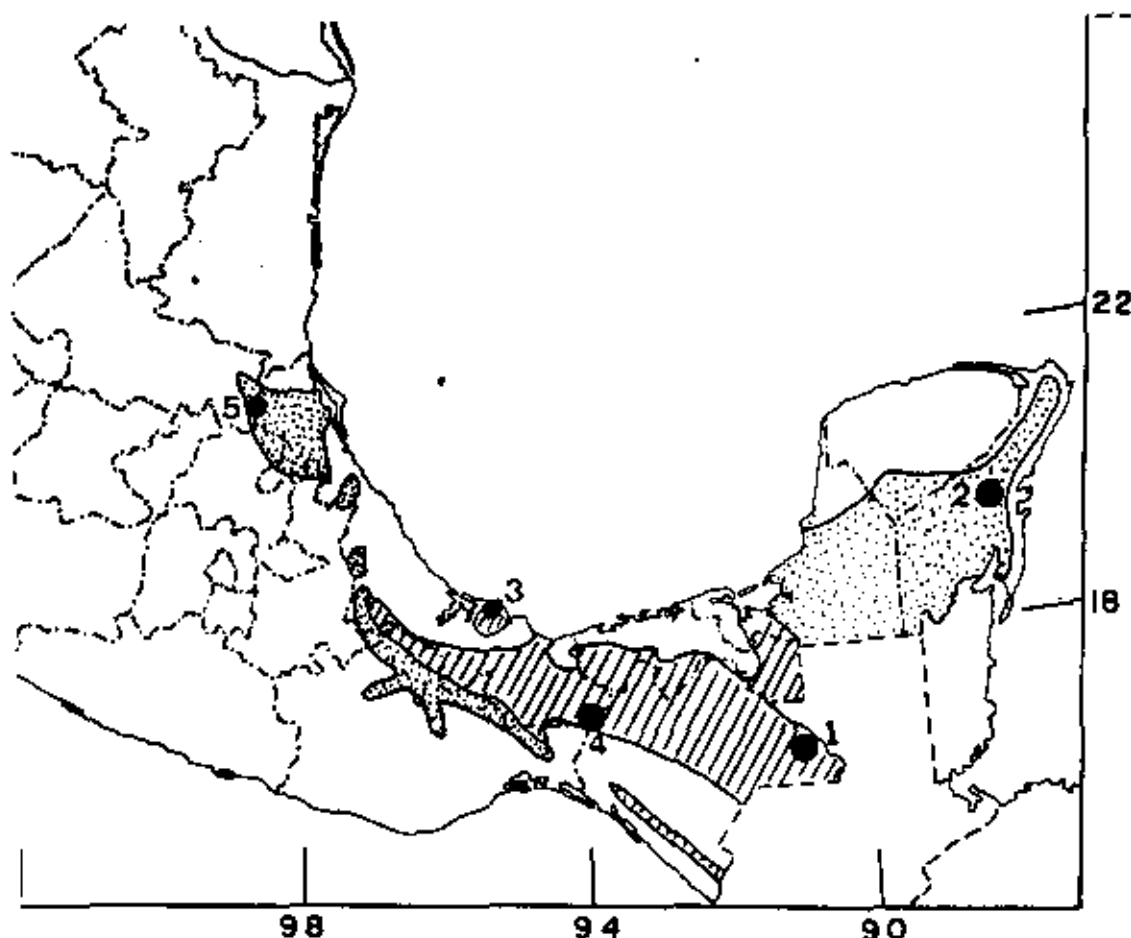


Fig. 1. Original distribution of the tropical rain forest (its two major variants are selva alta perennifolia [slashed pattern] and selva alta mediana subperennifolia [dotted pattern]) in Mexico. Only five loci of extensive tropical rain forest are currently available for conservation of viable populations of *Alouatta* and *Ateles* in Mexico: two already existing biosphere reserves (Montes Azules [1] and Sian Ka'an [2]) and three areas (Los Tuxtlas [3], Uxpanapa [4], and Sierra Huasteca [5]) that need to be converted immediately into national parks or ecological reserves.

turbed by humans as a result of their inaccessibility. Similar censuses were conducted in the same region in unprotected fragments of forests that have been undergoing attrition. In both cases, repeated "strip censuses" [see references in Estrada & Coates-Estrada, 1985] were conducted, and the number of troops contacted were recorded along with information on troop size, age, and sex/class structure.

RESULTS

Primate Habitats in Mexico

Even though 460,000 km² of the country are classified as tropical, only 24% of this area consists of vegetation that can be classified as tropical rain forest. This habitat is ecologically suitable for populations of *Alouatta* and *Ateles* (Fig. 1) [see Estrada, 1982; Estrada & Coates-Estrada, 1984b; Horwich & Johnson, 1986; Watts et al., 1986]. Two major types of tropical rain forest occur in Mexico: selva alta perennifolia (SAP) and selva alta-mediana subperennifolia (SAMSP). These rain forest types occur in the south and southeastern regions of the country, which originally encompassed 110,000 km² of vegetation or about 6% of the country's territory [Pennington & Sarukhan, 1968] (Fig. 1). Other variants of tropical vegetation in which *Alouatta* and *Ateles* have been reported (Table I) have a more restricted

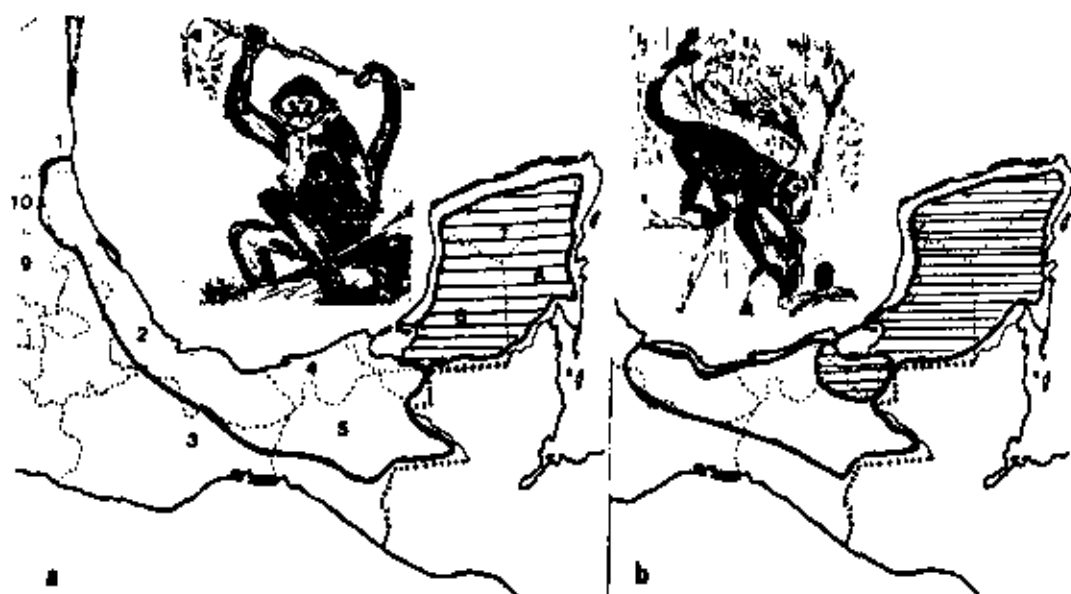


Fig. 2. The original distribution of the three primate species occurring in Mexico closely followed the original distribution of two major tropical vegetation types. a: *Ateles geoffroyi vellerus* and *At. g. yucatanensis* (shaded area). b: *Alouatta palliata* and *Al. pigra* (shaded area). States in which these primates have been reported to occur are 1. Tamaulipas; 2, Veracruz; 3, Oaxaca; 4, Tabasco; 5, Chiapas; 6, Campeche; 7, Yucatan; 8, Quintana Roo; 9, Hidalgo; 10, San Luis Potosi.

TABLE 1. Vegetation Types in Which *Alouatta* and/or *Ateles* Have Been Reported To Occur

Selva alta perennifolia
Selva alta-mediana subperennifolia
Selva baja perennifolia
Selva mediana subperennifolia
Selva baja subperennifolia
Selva baja-mediana subperennifolia
Selva mediana subcaducifolia
Selva baja inundable
Petenes

Data are based on Estrada & Coates-Estrada [1984], Watts & Rico-Gray [1986] Rico-Gray & Watts [in press], Horwich & Johnson [1986], and A. Estrada (unpublished data). For dominant vegetation formation throughout southern Mexico, see Figure 1.

distribution [Miranda & Hernandez, 1963; Rico-Gray & Watts, in press]. The original distributions reported for *Ateles* and *Alouatta* correspond rather well with the original distribution of these two major vegetation types (Fig. 2).

In the last four decades, tropical forests have undergone rapid destruction as the result of accelerated conversion to pasture lands and agricultural fields (Fig. 3). Today, the once semicontinuous corridor of tropical vegetation from southern Tamaulipas to the Guatemalan border consists of only a small collection of forest fragments of different sizes and with variable histories of isolation [see Estrada & Coates-Estrada, 1984b, 1986]. As a result of size, a few of these fragments still retain their original biological diversity. These fragments include 1) the Lacandon forest (Chiapas), an area that originally comprised 13,000 km²; 2) the Uxpanapa forest (the area where the states of Oaxaca, Veracruz, and Chiapas converge), with about 2,000

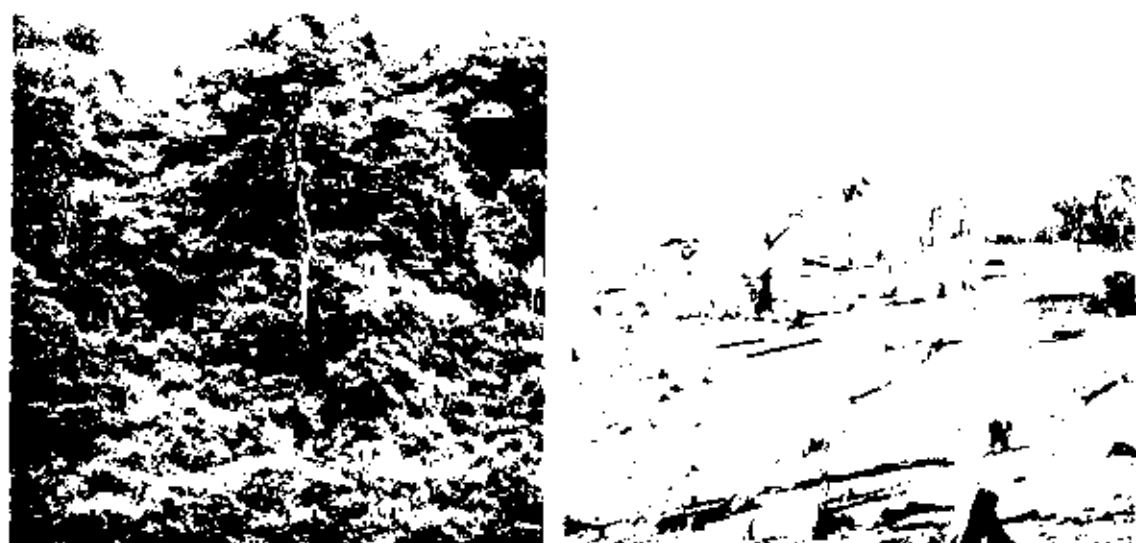


Fig. 3. Conversion of primate habitats by man in southern Mexico; rate of forest conversion to pasture lands and/or agricultural fields is 3 ha every 15 minutes.

TABLE II. Results of Censuses of *Alouatta* and *Ateles* Troops in Protected Fragments and Unprotected Fragments of Forests at Los Tuxtlas, Mexico

Areas	Troops	Mean no. of individuals per troops				Density (individuals per km ²)
		M ^c	F	J	I	
Protected fragments ^a						
<i>Al. palliata</i>	25	3.1	4.2	1.6	1.4	23.0
<i>At. geoffroyi</i>	6	2.0	3.0	2.0	2.0	1.0
Unprotected fragments ^b						
<i>Al. palliata</i>	17	1.0	1.5	1.0	1.0	3.6
<i>At. geoffroyi</i>	6	2.0	1.0	—	—	0.6

^aNumber of fragments is six, totalling 20 km².

^bNumber of fragments is 25, totalling 38 km².

^cM = males, F = females, J = juveniles, I = infants.

km² [Marquez et al., 1981; Wendt, 1983]; 3) the Sierra of Los Tuxtlas (southern Veracruz), originally with 2,500 km² of natural vegetation [Andrle, 1964]; and 4) the Sierra Huasteca, with 1,000 km² (Fig. 1). Similar fragments occur throughout the Yucatan peninsula, the most significant, with a high diversity of ecosystems, being the Sian Ka'an Biosphere Reserve. This reserve has an extension of about 3,000 km², of which about one-half consists of tropical rain forest vegetation (SAMSP) in which populations of *Alouatta* and *Ateles* are reported to occur [Salazar, 1983].

The total extension of these fragments adds up to about 23,000 km² or only 20% of the original extension of the two major tropical rain forest variants in southern Mexico. If past and current attrition is considered, this figure is significantly reduced by at least one-half or more. For example, of the 2,500 km² of tropical rain forest originally occurring in the Los Tuxtlas region, only 15% remains; of the 13,000 km² of Lacandon forest, only about 23% remains; the original extension of the Uxpanapa and Sierra Huasteca forests has been reduced by at least one-half or more (Table II). All of these reductions have taken place in the last 30–40 years, with the result that the total extension of these combined areas is only 5% of the original 110,000 km²

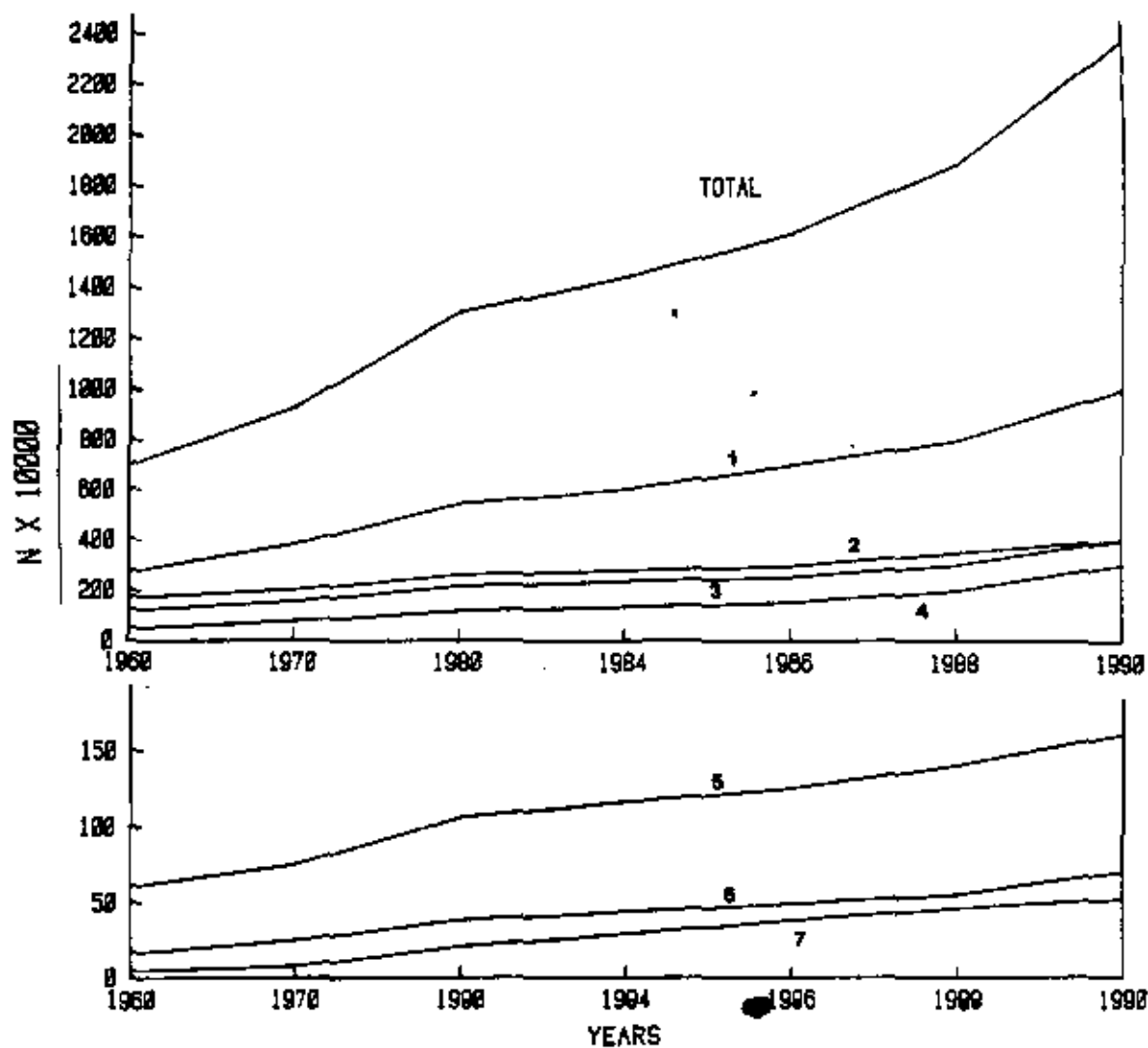


Fig. 4. Patterns of human population growth in southern Mexico, where primate populations were most intensively distributed in the past. 1, Veracruz; 2, Oaxaca; 3, Chiapas; 4, Tabasco; 5, Yucatan; 6, Campeche; 7, Quintana Roo. Data for the period 1986–1990 are projected data based on population growth rates for 1984–1986.

Human Populations in Southern Mexico

The persistently high birth rate in Mexico (3.4% annually from 1960 to 1974) and the reduction in general mortality indices (from 10.4% in 1964 to 8.8% in 1974) have resulted in a recent population explosion. Today, Mexico's population is 80 million, and according to government predictions the population will be doubled in the next 14 years [*Todo Mexico*, 1985]. Population growth in the southern states of the country has been particularly accelerated during the last three decades, creating a heavy demand for agricultural and cattle ranching land and resulting in massive destruction of the original vegetation (Fig. 3). Veracruz leads the southern states in population growth, followed by Oaxaca and Chiapas. The states with the lowest population growth are Tabasco, Campeche, Yucatan, and Quintana Roo (Fig. 4). Unfortunately, the first three, Veracruz, Oaxaca, and Chiapas, contain the largest remnants of tropical rain forest existing in Mexico (Fig. 1). In the remaining states, tropical rain forest formations are less extensive as a result of topographic, orographic, and edaphic characteristics.

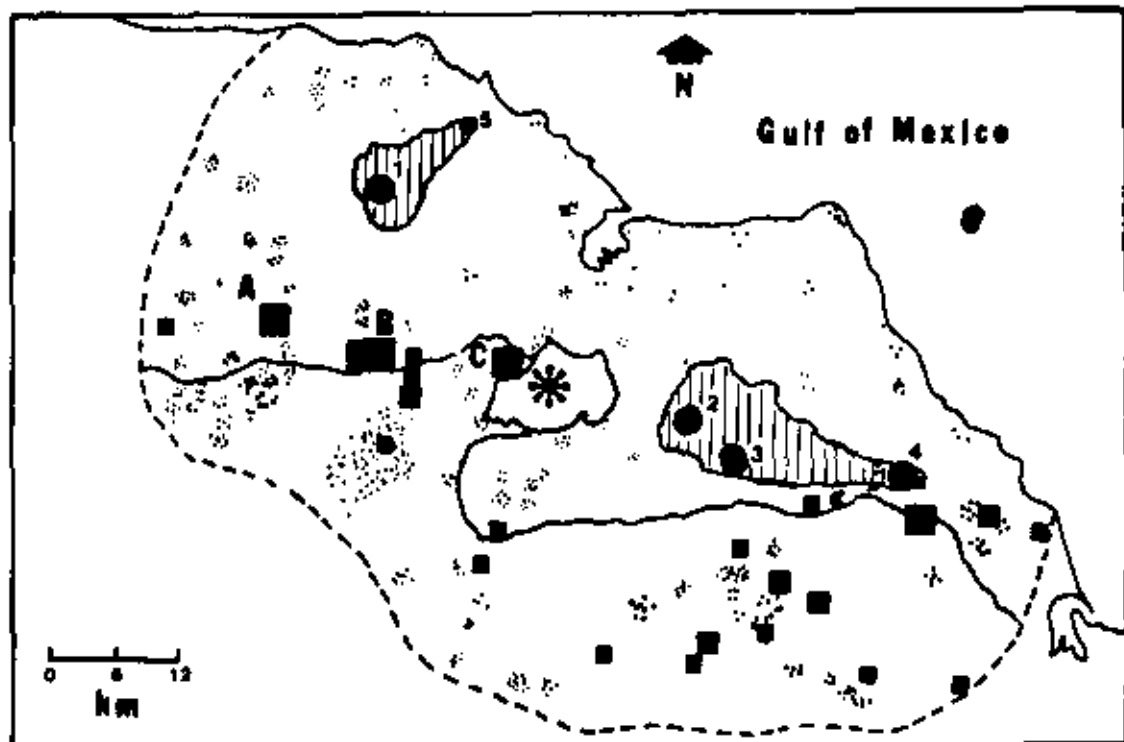


Fig. 5. Mountainous region of Los Tuxtlas in southern Veracruz limited to the north and northeast by the Gulf of Mexico and to the northwest, west, and southwest by lowlands with savannas (dotted line). The solid line indicates the original limits of the distribution of the tropical rain forest (2,500 km²). The solid lines around the volcanos (1, San Martin Tuxtla; 2, Santa Marta; 3, Cerro Campanario; 4, San Martin Pajapan), including the biological station Los Tuxtlas (5), show the current extension of the forest today (15% of the original distribution). Also shown are major urban centers (A, Santiago Tuxtla; B, San Andrés Tuxtla; C, Catemaco, with >50,000 inhabitants) and numerous human settlements throughout the Sierra (smaller squares, 5–20,000 people; and dots, >500 people). Asterisk indicates Lake Catemaco.

Rain Forest Conversion at Los Tuxtlas

Los Tuxtlas comprises about 4,500 km², of which at least 2,500 km² were dominated by *selva alta perennifolia* [Andrie, 1964]. This mountainous area has an altitudinal gradient ranging from sea level to 1,660 m above sea level. The landscape is dominated by four volcanos: San Martin Tuxtla (1,660 m), Santa Marta (1,550 m), San Martin Pajapan (1,270 m), and Cerro Campanario (1,180 m). A dominant feature in the area is Lake Catemaco, originally a volcanic caldera (Fig. 5).

Human settlements have been documented in the area since 1500 BC, but the majority of the population then and throughout the colonial period until the early 1900s was concentrated in the lowlands at the western edge of the Sierra. After 1930, population growth was rapid, and the colonization at higher elevations was especially intensive and extensive as a result of the implementation of colonization and land reform laws established in 1921 and since promoted by the Mexican government [Andrie, 1964]. These latter reforms resulted from the transformation of land tenure systems introduced by the Mexican revolution of 1910 in which large private land holdings involving thousands of hectares were converted to much smaller community holdings ("ejidos" and "colonias"). Today, the only government land remaining is located in the most inhospitable areas of the Sierra around each of the four major volcanos.

Land use before the arrival of the Europeans consisted of shifting agriculture combined with hunting and fishing. After the Spanish conquest, sedentary agricultural practices and cattle raising became the *modus vivendi*. Today 90% of the land

TABLE III. Major Areas of Tropical Rain Forest Remaining in Mexico and in Which Viable Populations of *Alouatta* and/or *Ateles* Still Occur

Areas	Vegetation type	Species	Extension (km ²)		
			Original	Current	% Remaining
Huasteca	SAMSP	<i>A. g. v.</i>	3,000	1,000	33
Los Tuxtlas	SAP	<i>A. p.</i> , <i>A. g. v.</i>	2,500	363	15
Uxpanapa	SAMSP	<i>A. p.</i> , <i>A. g. v.</i>	2,000	1,000	50
Lacandon	SAP	<i>A. p.</i> , <i>A. g. v.</i>	13,000	3,000	23
Sián Ka'an	SAMSP	<i>A. pigra</i>	3,000	1,450	50
		<i>A. g. y.</i>			
Total			23,500	5,813	

Estimates are based on examination of aerial photos (see text). The current extension of these areas represents only 5% of 110,000 km² of selva alta perennifolia (SAP) and selva alta mediana subperennifolia (SAMSP) vegetation originally found in the country. *A. g. v.*, *At. g. vellerosus*; *A. p.*, *At. palliata*; *A. g. y.*, *At. g. yucatanensis*.

is used for cattle ranching, and agriculture (corn, coffee, cacao, citrus, and so forth) is practiced on a small scale in the lowlands of the Sierra. However, rapid erosion of the soil is common in these converted parts of the Sierra as a result of the abrupt terrain (80% of the land is between 300 and 1,600 m above sea level). Raising cattle for beef and milk products has deemphasized the importance of agricultural practices and increased the demand for pasture land. This increased demand, together with timber exploitation, contributes to the destruction of the remaining tropical rain forest.

The history of land use in the region shows that between 1500 and 1943 only 15% of the original vegetation had been converted to pasture and agricultural fields; deforestation rates were only 90 ha/year. After 1943, as a result of intensive colonization, population growth, and the opening of new access roads, rain forest conversion was much more rapid, with the result that between 1943 and 1960 deforestation rates were 6,141 ha/year. In 1986 only 15% of the original vegetation remained untouched, with deforestation continuing at a rate of 4,000 ha/year. Today, only about 7,000 ha of the original vegetation exists around the San Martín volcano, and about 25,000 ha exists around the Santa Marta and Cerro Campanario volcanos. Both areas total about 320 km², or only 10–15% of the original extension (Figs. 5, 6). The current deforestation rate of 4,000 ha/year suggests that unless these natural areas are immediately protected, they will disappear by 1995. Even if deforestation rates are reduced by one-half, the entire original vegetation cover will have disappeared by the year 2,000 (Fig. 6).

Impact of Forest Fragmentation on the Primate Populations

The reduction of tropical rain forest in Los Tuxtlas corresponds with the drastic reductions in original vegetation that have been occurring elsewhere in the country and with a reduction in the primate populations inhabiting these forests.

Our censuses of *At. palliata* troops in protected forest fragments such as those of Los Tuxtlas indicated an ecological density of 23 individuals/km². Censuses of *At. geoffroyi* in the same protected areas showed densities of 1.0 individual/km². In unprotected fragments, densities were 3.6 individuals/km² for *At. palliata* and 0.6 individual/km² for *At. geoffroyi*.

With the lower density figures for both species, we extrapolated, as a function of suitable available primate habitat, the size of each primate population in the past and projected, based on the rate of habitat destruction, the size of each population in

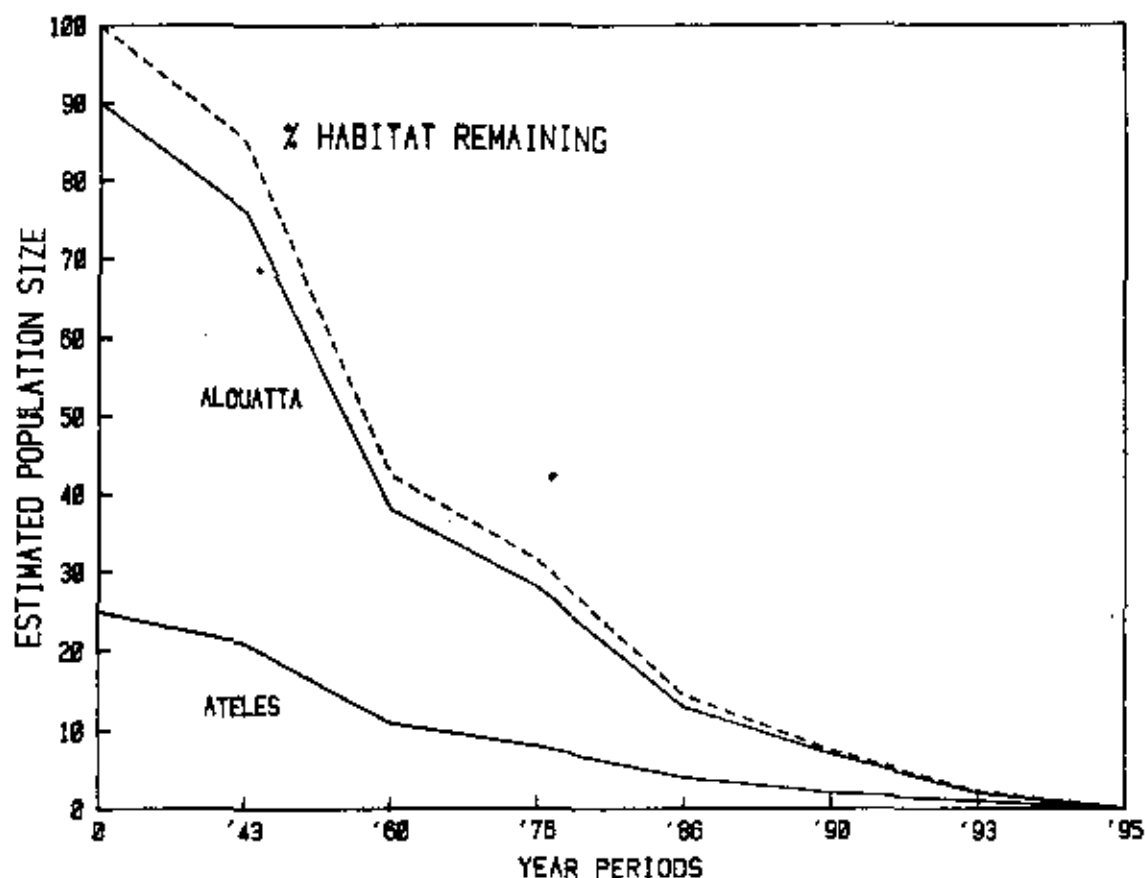


Fig. 6. Loss of primate habitat and estimated decline in population size ($N \times 100$) of *Al. palliata* and *At. g. vellerosus* in the Los Tuxtlas region (original extension of rain forest was 2,500 km²). Deforestation rates for each period were 1900–1943, 90 ha/year; 1944–1960, 6,141 ha/year; 1961–1976, 3,500 ha/year; 1977–1986, 4,000 ha/year; 1987–1995, 4,000 ha/year. Data for 1986 through 1995 are projected data based on deforestation rates for 1976–1986.

the near future. The result showed a clear tendency toward extinction in the very near future (Fig. 6). This finding is even more significant if we consider that no evaluation was made of the impact of natural causes of death (e.g., predation, diseases, and so forth) in the population. The situation can be easily verified in the field. Although local accounts indicate the former presence of these primates, many of the remaining fragments no longer contain representatives of *Ateles* and/or *Alouatta*. Even in some fragments of considerable size (e.g., 250 ha), *Ateles*, for example, has been extinct for 20 or more years.

Extinction

Habitat destruction has had a severe impact on both primate species. Our assessment revealed that no more than 200 *Ateles* and about 1,200 *Alouatta* exist in the 320 km² remaining of original vegetation in the Los Tuxtlas region. While *Al. palliata* seems to survive under disturbance a little better than *Ateles*, probably as a result of different energetic requirements and different resource exploitation strategies, *At. geoffroyi* is in immediate danger of extinction in the Los Tuxtlas region.

In addition to the danger of extinction, the structure of these populations is being seriously altered as a result of fragmentation of natural habitats, illegal hunting, and the pet trade. These structural changes have important consequences for breeding potential. For example, our censuses of *Al. palliata* under unprotected conditions showed not only that density was significantly reduced but also that

mean troop size was only 2.8 individuals as compared to 9.5 individuals in protected forests. The age and sex/class structure of the censused troops showed significant reductions in the mean number of individuals in each (Table II). In addition, as a result of the isolation caused by fragmentation, biologically and socioecologically important events such as emigration and immigration of individuals among troops, which contribute to gene flow within the population, cannot occur.

Current Distribution of Primates in Mexico

The rapid disappearance of forested areas in southern Mexico has reduced the original distribution of the three wild primate species by at least 90%. The few remaining populations of these primates exhibit a fragmented distribution that corresponds to the current fragmented distribution pattern of tropical vegetation in the country (Fig. 1; Table III) (see also Fig. 1 in Estrada & Coates-Estrada [1984b] and Fig. 1 in Watts & Rico Gray [1986]). These populations are endangered by continuing high rates of conversion of their natural habitat and by lack of a national conservation program.

In Mexico, conservation of *Al. palliata* and *At. g. vellerosus* results from the existence of the Montes Azules Biosphere reserve (ca. 2,000 km²) in the Lacandon forest in Chiapas. *Al. pigra* and *At. g. yucatanensis* remain in the Sian Ka'an Biosphere Reserve in Quintana. However, no systematic population surveys, ecological studies, or conservation evaluations have been conducted until now on these populations. Further, the future protection of these reserves needs to be ensured.

Three other areas of habitat suitable for primate conservation exist in Mexico and are in need of urgent protection by creating either national parks or ecological reserves. These strategically important areas are 1) the two large fragments in the Los Tuxtlas region comprising about 320 km²; 2) about 1,000 km² of the Uxpanapa forest where the states of Oaxaca, Veracruz, and Chiapas converge; and 3) 100 km² in the Sierra Huasteca, a rugged mountainous area at the border of the states of Hidalgo, San Luis Potosi, Veracruz, and Tamaulipas (Table III; Fig. 1). Populations of *Al. palliata* and *At. g. vellerosus* occur in the first two areas, and the existence of populations of *At. g. vellerosus* was confirmed in 1984 in the last area. In sum, only five foci occur in Mexico for the potential conservation of the two species of howler monkeys and the two subspecies of spider monkeys (Table III), a real loss considering the original wide distribution of these primates and the important ecological role they play [Estrada & Coates-Estrada 1984a, 1985, 1986].

DISCUSSION

In Mexico, the fundamental problems associated with the preservation of natural areas and viable populations of *Alouatta* and *Ateles* are rapid human population growth and current land management systems. The conservation of Mexican primates is the conservation of the tropical rain forest ecosystem. Unfortunately, the rain forest is almost totally gone. Unless we act immediately to preserve the five foci recommended earlier, extinction of Mexican primates will occur in the very near future. In some cases, such as in the Los Tuxtlas region, extinction will occur by the end of the century.

Some relict populations will remain at the Sian Ka'an Biosphere Reserve, Quintana Roo, and at Montes Azules Biosphere Reserve in Chiapas. However, it no longer will be possible to study these primates under varying and sometimes contrasting ecological conditions, and the contribution these studies could provide to our understanding of the behavioral adaptability of both genera and of the dynamics of basic biological and ecological processes will be lost. In addition, we will lose the northernmost representatives of Ceboidea on this continent.

Conservation of *Alouatta* and *Ateles* in situ requires selection of natural areas where conservation can be carried out effectively. Such selection requires careful evaluation of the demographic trends of the human populations and of local and regional land management systems. The demographic data examined in the present study indicate that there are states in Mexico where conservation still can be carried out with little pressure from human population expansion, mainly in the Yucatan peninsula. However, even here population growth has accelerated in the last 10–20 years, and measures to ensure the further protection of already protected natural areas must be developed now.

The only information available on the primate populations of the Yucatan peninsula consists of the presence or absence surveys reported by Watts et al. [1986]. Such information, however, suggests where intensive field efforts ought to be directed to obtain enough data to provide recommendations for conservation. One priority site for intensive evaluation should be the Sian Ka'an Biosphere Reserve, which has reported populations of *Ateles* and *Alouatta* and a considerable extension (ca. 1,500 km²) of apparently suitable primate habitats (selva alta mediana subperennifolia; selva baja subperennifolia). Other potential sites in the peninsula are the areas with networks of Petenes, which by their very nature have been protected from human colonization [Watts et al., 1986, Rico-Gray & Watts, in press].

Conservation in Veracruz, Tabasco, Oaxaca, and Chiapas will be more difficult as a result of their larger sizes and rapid growth of the human populations. However, the existence of the Montes Azules Biosphere Reserve in Chiapas will ensure, if its permanent protection is implemented, the conservation of *Al. palliata* and of *At. g. vellerosus*. Unfortunately, here also are lacking extensive and intensive surveys of population distributions, sizes, and state of conservation.

For the Uxpanapa, one of the least known tropical rain forest areas of Mexico, practically nothing is known about the existing primate populations. Recent surveys by the authors in the spring of 1987 indicated the presence of *Alouatta* and *Ateles* in the most remote areas of the Sierra of Chimalapa (state of Oaxaca) and their recent extinction (during the last 20 years) in the lower parts (300–700 m above sea level) of the range.

In the Los Tuxtlas region, the only quantitative surveys that provide enough information to make assessments of the locations and states of the populations are those of the authors [Estrada, 1982; Estrada & Coates-Estrada, 1984b; present study]. These surveys have been concentrated in the area of the Los Tuxtlas Biological Reserve, the forest around the San Martin volcano, and some segments of the central sections of the Sierra Santa Marta in the same region. The recently confirmed existence of populations of *At. g. vellerosus* at their northernmost limit in Mexico (Sierra Huasteca) demands intensive surveys to evaluate the exact locations and sizes of these populations.

Fewer data are available on spatial arrangements of the troops within a population and on patterns of forest resource use. Only in Los Tuxtlas have data been collected [e.g., Estrada, 1984; Estrada & Coates-Estrada, 1984a, 1985, 1986] and in enough detail only for *Alouatta*. No information of this nature is available yet for *Ateles* at Los Tuxtlas or for *Alouatta* and *Ateles* at other localities in southern Mexico.

Effective ex situ conservation is taking place at only one site in southern Mexico: the zoological park Miguel Alvarez del Toro in Tuxtla Gutierrez City, Chiapas. Here, the only known successful translocation of an *Al. palliata* troop has been conducted since 1983, and successful semicaptive breeding of *At. g. vellerosus*, *Al. pigra*, and *Al. palliata* has been achieved with small colonies (about 10–15 animals each) (A. Cuarón, personal communication).

The present speed at which the natural habitats of the three primate species are disappearing in southern Mexico demands a faster and more significant action toward conservation. This concern resulted in the organization of a national symposium in March 1987 at Los Tuxtlas Biological Station on the use of Mexican nonhuman primates in the basic and applied sciences (A. Estrada [in press]). The participants expressed concerns about the well-being of the native populations and decided that urgent and coordinated actions would be required to stop their near extinction. In this direction was the creation of the Mexican Association of Primatology (Asociación Mexicana de Primatología) and the generation of a nationwide conservation campaign, which is presently being implemented.

CONCLUSIONS

1. The three primate species occurring in Mexico are in immediate danger of extinction as a result of extensive and intensive destruction of their natural habitats by humans.

2. The major causes of habitat destruction for the three primate species are rapid human population growth and land management systems. Pasture lands and agricultural fields are incompatible with conservation of genetically viable populations of the three species.

3. Only five potential sites for effective conservation of the three species exist in Mexico. Two are officially recognized Biosphere Reserves, but there are no data on the exact locations and sizes of existing populations within these areas. Three sites can be converted into national parks or reserves: two fragments at Los Tuxtlas, totalling about 320 km² of forest; a section of the Uxpanapa forest at the border of the states of Oaxaca, Veracruz, and Chiapas, totalling about 1,500 km² of forest; and a segment of the Sierra Huasteca forest, with about 500 km² of original vegetation.

5. Los Tuxtlas is the only locality in Mexico where we have detailed knowledge of the spatial and temporal distribution of primate populations and of their basic foraging ecology and behavior.

6. Urgent conservation measures need to be undertaken within the next 10 years to protect the remaining populations of the two *Alouatta* species and the two *Al. geoffroyi* subspecies, or they will become extinct in the country by the end of the century.

ACKNOWLEDGMENTS

We thank G. Herrera for his assistance in the field and Drs. E. Watts, V. Rico-Gray, J. Erwin, R. Horwich, J. Contreras, and the primatology group of the AMP for stimulating discussions during the primatology symposium at Los Tuxtlas in March 1987.

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