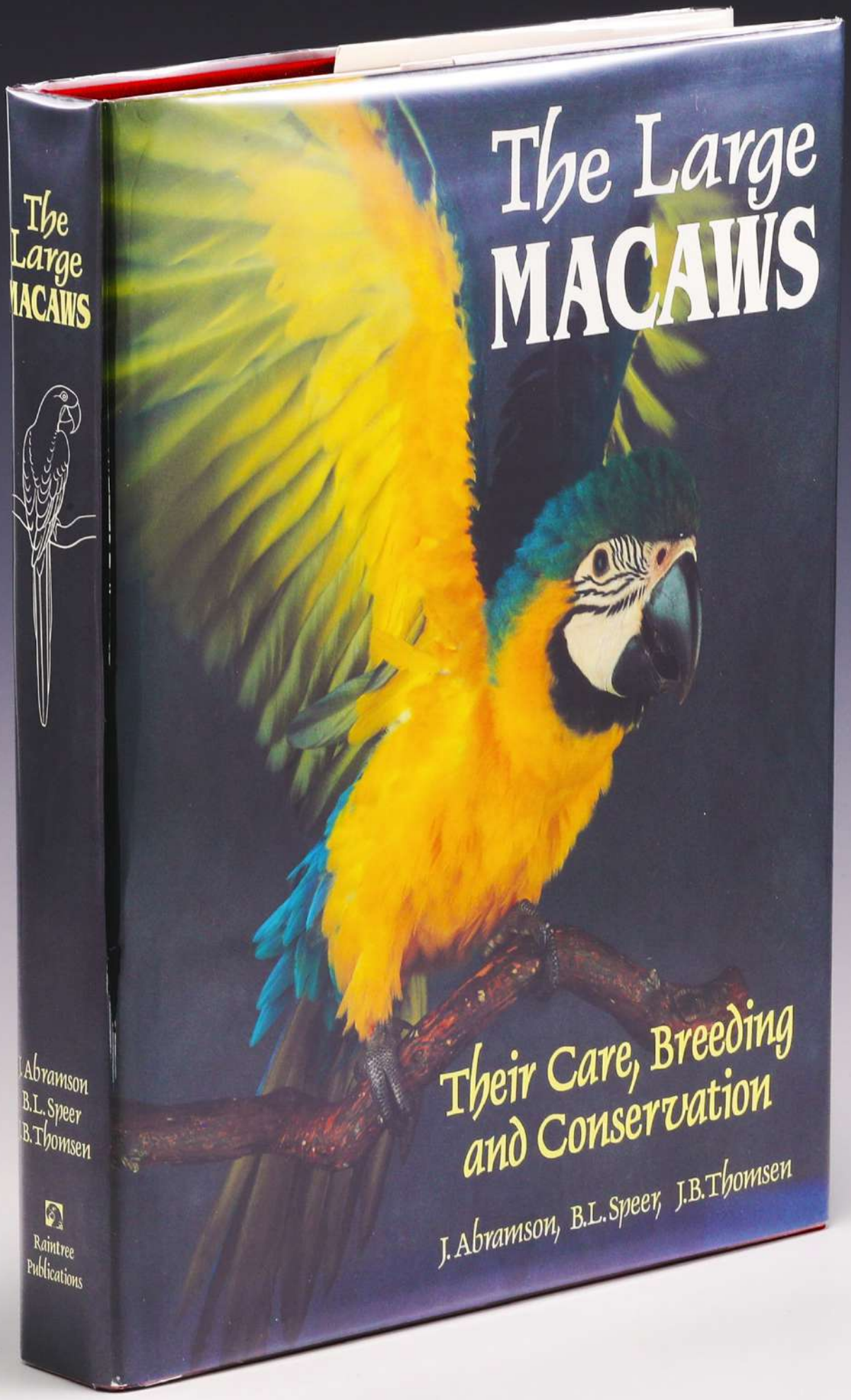
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MACAWS
Their Care, Breeding and Conservation
J. Abramson, B.L. Speer, J.B. Thomsen
The Large MACAWS
J. Abramson
B.L. Speer
J.B. Thomsen
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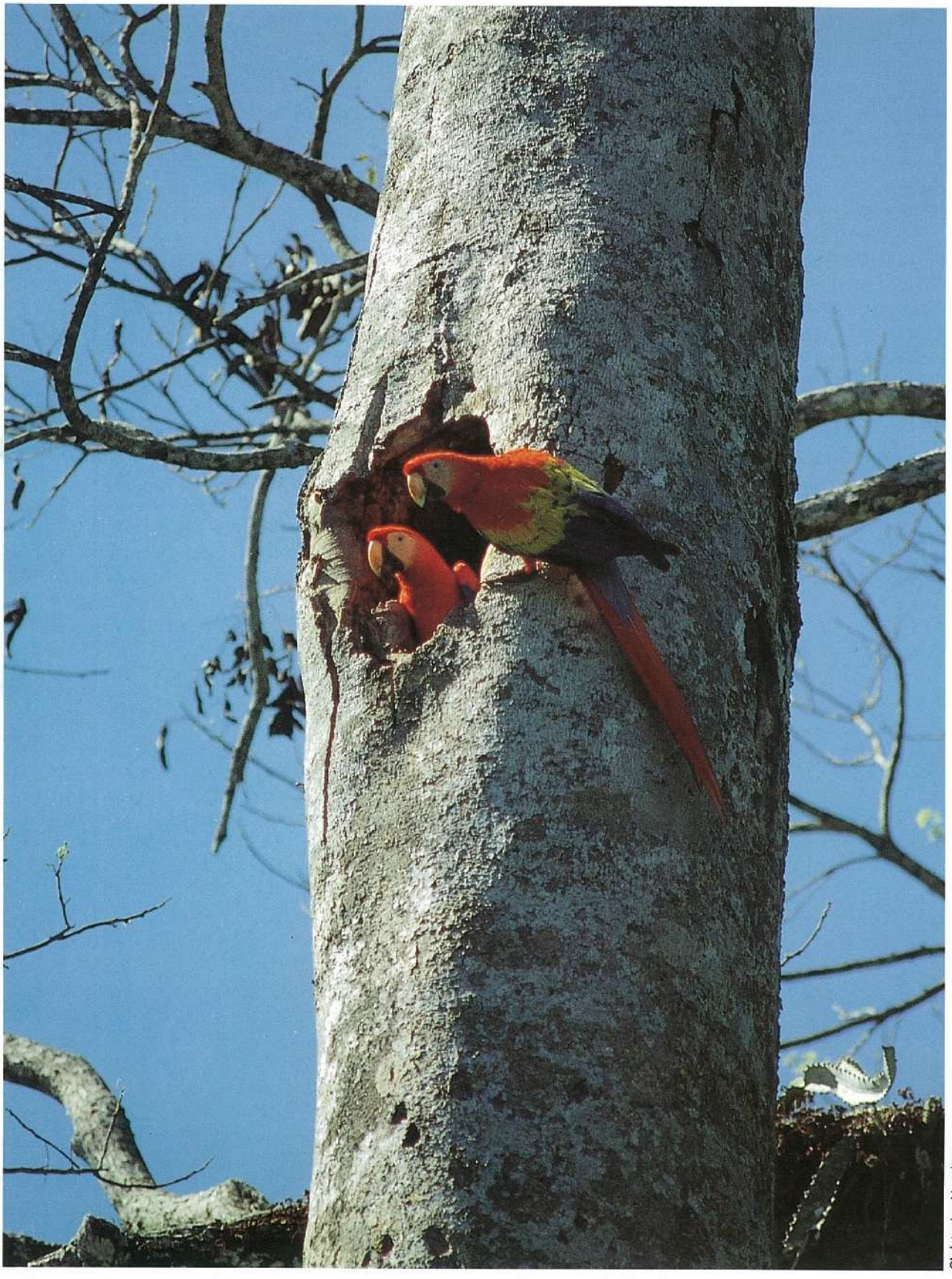
CHAPTER 22 Scarlet Macaws of Carara



Christopher Vaughan

Although the 140 species of New World psittacines are among the least known birds in the wild, no fewer than 42 species are considered at some risk of extinction (Collar *et al.* 1992). Most of these are threatened by wide-spread habitat destruction, several to supply the pet and aviculture trades and others by shooting for food or to protect crops; some are even threatened by all these factors. The great majority of the other 98 non-threatened parrot species are also declining in numbers. Timely biological information needed to develop management strategies is lacking, because parrots are difficult to study, have large home ranges (oftentimes in tropical forests) and nest in elevated tree cavities difficult to observe (Beissinger & Snyder 1992).

Socio-economic problems in neotropical countries threaten its high biodiversity. For instance, Central America (Guatemala, Belize, Honduras, El Salvador, Nicaragua, Costa Rica and Panama) contains among the world's most diversified terrestrial ecosystems and wildlife resources, including Scarlet Macaws *Ara macao.* Simultaneously, the human population in this region is expanding at one of the fastest rates worldwide, and is heavily dependent for economic development on the rich, renewable natural resources (Leonard 1987). The dynamic, yet fragile balance between human population, natural resources and economic development in Central America is causing a rapid deterioration of the natural resource base. In addition to accelerating deforestation, erosion and contamination rates in most countries, mass extinctions of wildlife species is occurring (Vaughan 1990). Throughout Central America, innovative programs in natural resource inventory, research, training and outreach are needed to promote intelligent utilization or restoration of the natural resource base, including wildlife. However, to be successful, these programs must incorporate local human communities so that they sustainably manage the resources surrounding them while receiving economic benefits (Vaughan 1993).

The Regional Wildlife Management Program for Mesoamerica and the Caribbean (RWMPMC), at the Universidad Nacional, Costa Rica was created in 1987 to promote the sustainable management of biotic resources. At present, RWMPMC has three regional objectives: 1) training Latin Americans at the graduate level *"in situ"* in wildlife management, 2) developing model wildlife-biodiversity projects and 3) conducting outreach through regional information and technology transfer. RWMPMC concentrates its activities in Mexico, Central America and the Caribbean, although it trains graduate students from almost every Latin American country (Vaughan & McCoy 1993). As part of its regional mandate, in 1990, RWMPMC began a long-term research project on a Scarlet Macaw population which lives in and around the Carara Biological Reserve (CBR) in Central Pacific Costa Rica. The overlying idea was to improve the macaw's conservation status by collecting sociological, economical and ecological information needed to promote management of the species and involve the local human community. The research team consists of scientists, graduate students and field assistants. The objective of this chapter is to present a summary of the ecological, social and economic information collected from the first three years of this study and discuss management strategies. In this way, we hope to contribute to the data base needed to manage the Scarlet Macaw and other neotropical psittacine species throughout their distribution.

Background

General distribution

Macaws are the most striking and best-known representative of the parrot family. The four macaw genera include 17 living species restricted to Middle and South America, and a few Caribbean islands. The Scarlet Macaw has the greatest latitudinal range which extends for 6,600 km almost continuously southward from central Mexico (Oaxaca) to Bolivia (Santa Cruz) (Forshaw 1977, Hoppe 1985). In Central America, it is found in fragmented habitats in all countries of the region except El Salvador, whose populations were extinguished in the last 50 years (Serrano 1978). It is considered an endangered species throughout Central America and is fully protected in most countries (Vaughan 1993).

In Costa Rica, the Scarlet Macaw originally occupied approximately 42,500 km^2 (national territory = 50,000 km^2) (Vaughan 1983). The species is distributed in dry and wet forests on both

Scarlet Macaws Ara macao *at the entrance to their nest. Notice their straight tails demonstrating that the nest cavity was sufficiently large not to cause damage to the tails.*

Atlantic and Pacific slopes from sea level to about 1,500 m elevation (Vaughan 1983, Vaughan *et al.* 1991). Due to deforestation, only 29% of the original habitat existed in 1977 and by 1993, 9,100 km² (20% of the original), all in protected areas (Marineros 1993). Today, in Costa Rica, the Scarlet Macaw is found principally on the Pacific slope, in three major areas. These are the Osa Peninsula with an estimated 200 to 400 individuals (Stiles & Skutch 1989), Carara Biological Reserve (CBR) and surrounding areas with at least 219 individuals (Vaughan *et al.* 1991), and Palo Verde and Barra Honda National Parks with 15 individuals (Slud 1964, Vaughan *et al.* 1991).

Study site

The study site is found in the Pacific Central region of Costa Rica and covers approximately 560 km² (Figure 22.1). According to Tosi (1969), there are four life zones in the region: tropical dry forest with transition to humid (from the north to the southern coast of the Tarcoles River), tropical humid forest (the Pacific coast to the Terraba River), premontane and montane forest (Turrubares, Altos de Aguacate Mountains) and tropical wet forest (Candelaria). Gomez (1986) classifies the vegetation types as: tropical rain forest, which occupies 90% of CBR, and lowland evergreen seasonal forests, which occupy 10% of CBR near the coastal highway and on the margins of the Tarcoles River.

Beginning in pre-Colombian times, man destroyed much of the forestry resources and wildlife in the region. It is difficult to find forest remanents larger then 40 ha in size, except in the Guacilillo Mangrove Reserve (GMR), the Turrubares Protected Zone (TPZ), and CBR (Cifuentes *et al.* 1983). Currently, the principal economic activities of the region include extensive livestock raising, subsistence agriculture and tourism at Guacalillo, Tarcoles, Herradura, Jaco, Esterillos and Quepos beaches (Direccion General de Estadisticos y Censos 1987, Vargas 1992).

The climate of the region is defined as humid and hot with the mean annual temperature oscillating between 25 and 30°C (Coen 1991). The region is protected from the trade winds and their drying effect by a high mountain chain to the north (Herrera 1986). As a result, the area is characterized by a moderate dry season from November to April and severe wet to torrential wet season from May to December with 90% of the annual precipitation. Annual precipitation varies between 2,487 mm (100 inches) in the lowlands to 3,299 mm (132 inches) in the higher elevations (Cifuentes *et al.* 1983).

The region is irrigated principally by the Tarcoles, Turrubares, Tarcolitos, Agujas, Tusubres, Tulin and Parrita Rivers. The most important mountains in the region are: Turrubares (1,756 m), Altos del Aguacate (1,634 m), Fila Negra (828 m), Lomas Pizote (399 m), Fila Cangreja (1,305 m), Fila Chires (307 m) and others of lower elevation (Figure 22.1).

Finally, the region has three nationally protected wildland areas: CBR, TPZ and GMR. In addition, the Pro-Green Iguana Reserve (GIR) is a private reserve (Figure 22.1). These areas recently became the Central Pacific Conservation Area. Scarlet Macaws are found in all of these areas, but the study was carried out principally in CBR.

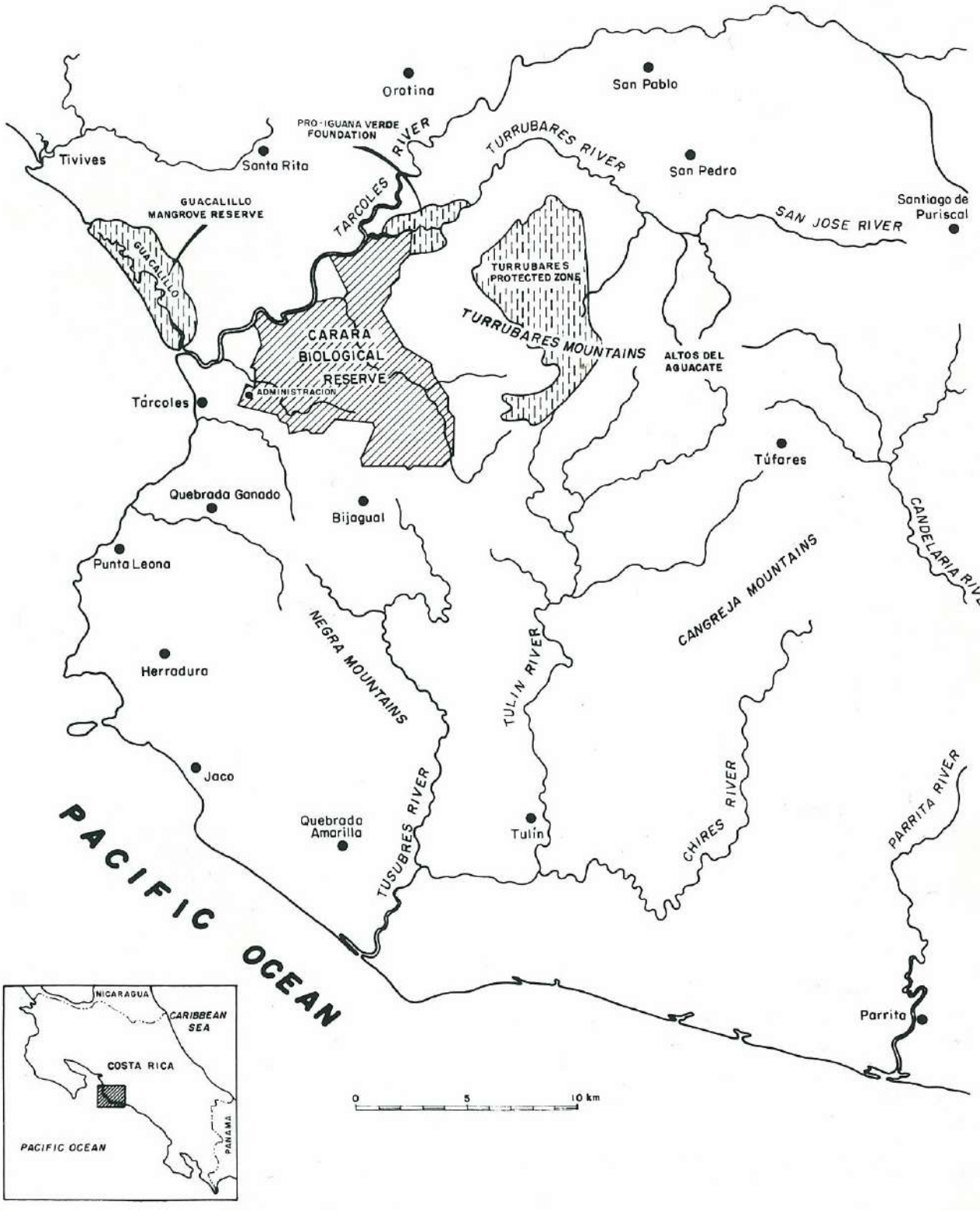
Leonel Marineros

The Turrubares River is very important for the Scarlet Macaw Ara macao *since both nesting and food trees are found along the river banks. The tallest tree in the photograph is a Ceiba* Ceiba pentandra *which is used by the Scarlet Macaw for nesting. This is nest number 11.*

Carara Biological Reserve

Carara Biological Reserve is found in the central part of the Pacific Region of Costa Rica (84° 35'W, 9° 47'N), between Puntarenas and San Jose Provinces, 40 km southwest of the city of Orotina. It is bordered on the north by the Tarcoles River and on the west by the Costanera Sur highway (which passes in front of the administration center of CBR). Carara Biological Reserve was created in 1978 by Executive Decree No. 8491-A. It is 4,700 ha in size and 95% is forested. Boza (1984) indicates that CBR has

Figure 22.1
The Central Pacific Study Area, Costa Rica



very diverse vegetation types, including swamps, oxbow streams, gallery forests and primary vegetation. Carara Biological Reserve is situated in an overlapping zone between tropical dry and wet forests and thus has tree species characteristic of both regions. The primary forests occupy the greatest area of the reserve, especially in the central area and to the west and southeast. They are generally found on soils which have between 20% to 60% slope (Boza 1984).

Scarlet Macaw population size and recruitment

Understanding population size and age structure is a necessary first step for wildlife management (Robinson & Bolen 1989). The Scarlet Macaw population at CBR perhaps presents a unique opportunity to study such aspects, as a major part of the population "migrates" daily between CBR (and surrounding areas) where they feed, court, reproduce and rest, and GMR where they roost at night. Between March, 1990 and October, 1993, an average seven monthly (morning from 5h00 to 7h00 and late afternoon from 15h00 to 18h00) counts have been carried out from a vantage point which permits observation of all flyroutes. Birds were recorded by flock size in relation to four basic categories: singles, pairs, trios or groups of four. The latter two categories are thought to represent a pair of adults accompanied by one or two offspring (Munn 1992). A Leopold 20x50 Spotting Scope with a tripod and Nikon 10x25 binoculars were used as well as a standard data sheet.

Flyroutes and population census

Three general flyroutes are chosen by the Scarlet Macaw population moving between CBR and GMR: 1) near and along the Tarcoles River, 2) over the Quebrada Bonita stream, and 3) close to the Pacific Ocean (Figure 22.2). A total of 304 morning and afternoon counts were made in 44 months (x = 6.9 counts/month), ranging from a single count in October of 1990 to 19 counts in April of 1990 (Marineros 1993). Highest monthly counts are presented in Table 22.1. In general, the yearly pattern represented is broken into three phases: 1)lowest numbers of individuals in January and February, including most single birds in the population; 2) gradually increasing numbers in March and April,

Table 22.1
Highest Population Counts Made of the Scarlet Macaw *Ara macao* Population (March 1990 - November 1993) Between Carara Biological Reserve and Guacalillo Mangrove Reserve, Costa Rica

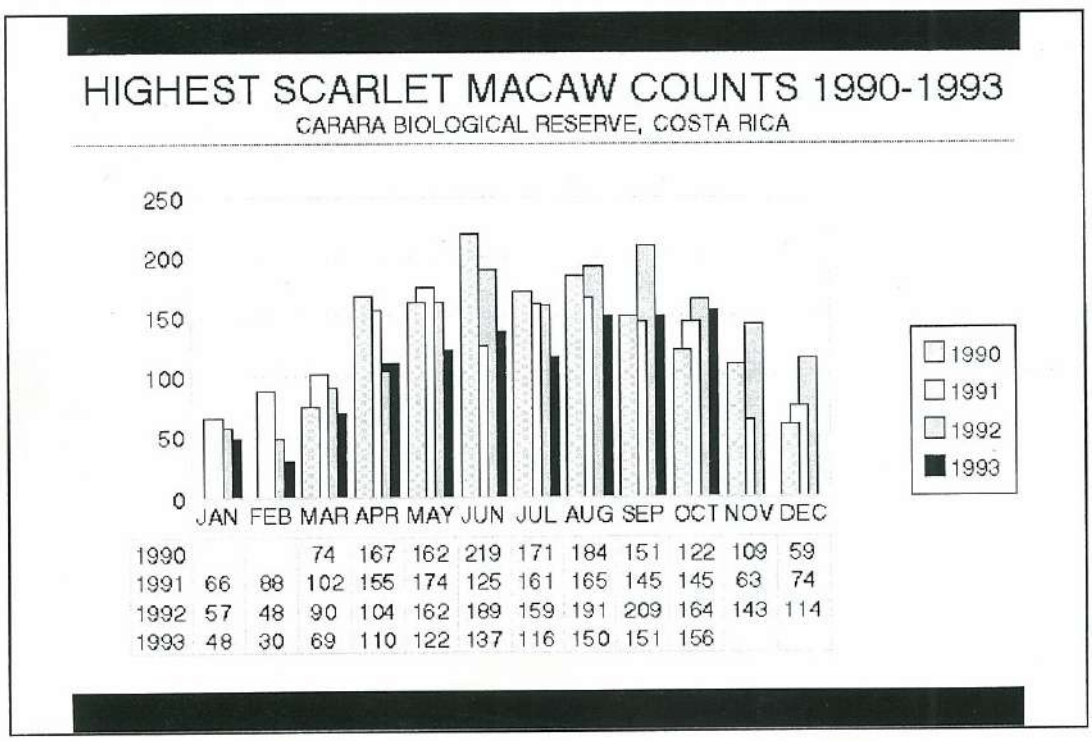
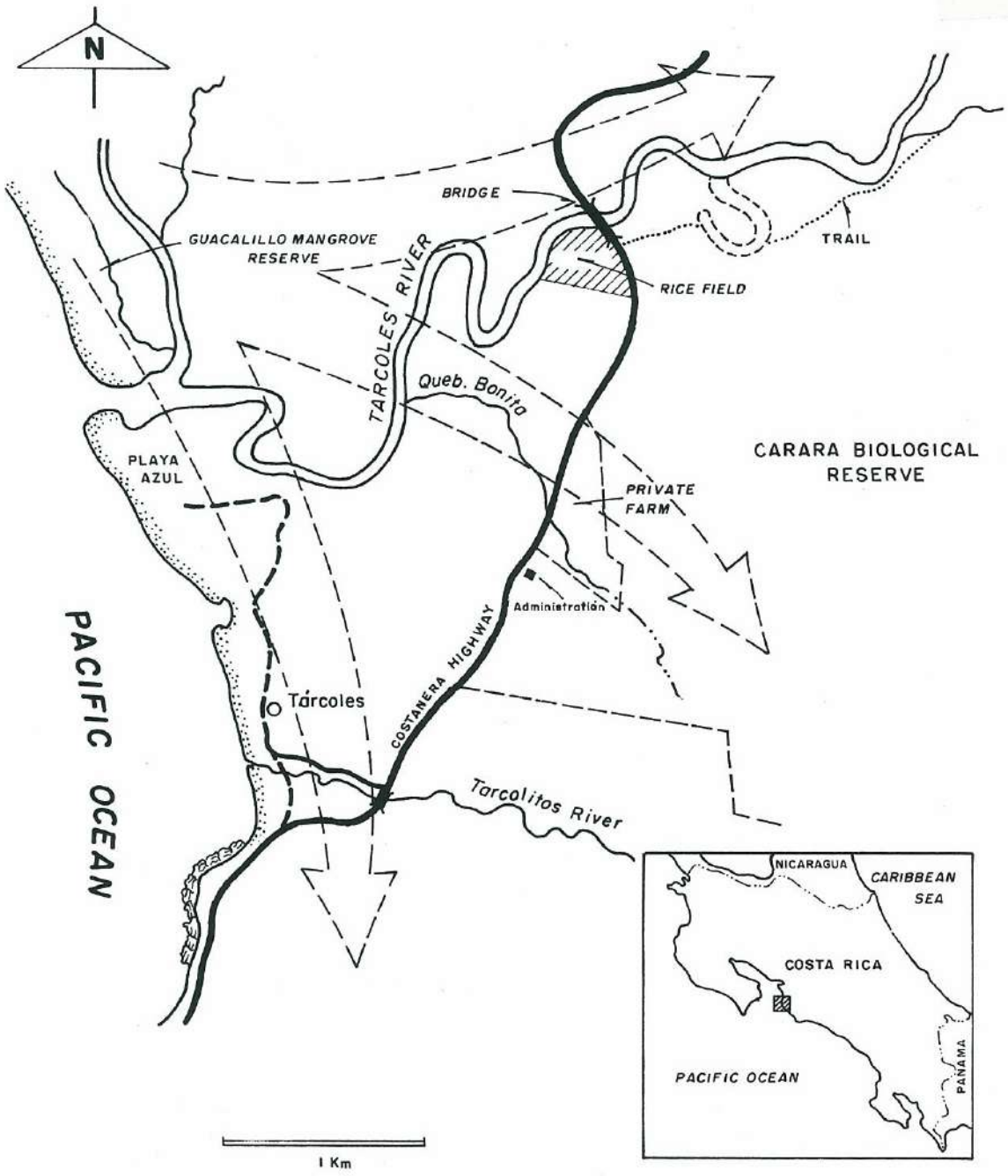


Figure 22.2
Flyroutes used by the Scarlet Macaw *Ara macao* between Carara Biological Reserve and Guacalillo Mangrove Reserve, Costa Rica



3) somewhat stable, and high (even maximum) counts in May, June, July, August and September, and 4) reducing numbers in October, November and December.

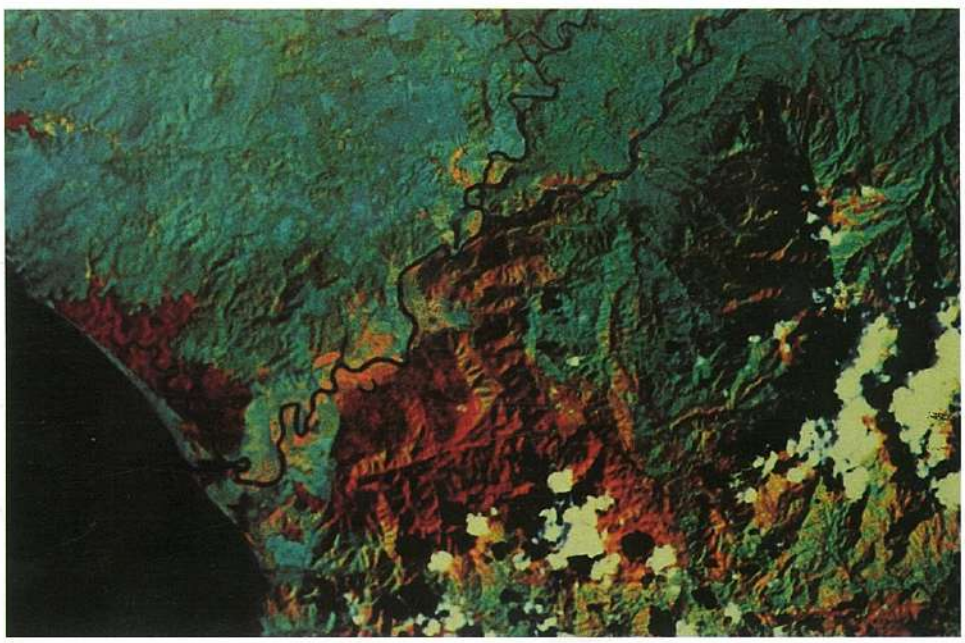
A possible biological explanation of the variance in monthly Scarlet Macaw census is the following:

- October, November and December coincide with the initiation of the nesting season (Vaughan *et al.* 1991) and the onset of the dry season, whereby some birds remain in CBR and the surrounding region to prepare the nesting site, the large number of loose groups and single birds seen can be either immature, single or unmated adults.
- In January and February, many birds are nesting and males may guard females during incubation, thus low numbers fly to roost in GMR.
- By March and April, unsuccessful nesting macaws are being reincorporated into the population and the first triplets or quadruplets of adult macaws with their young are observed (3-4 March 1992 and late April — Vaughan *et al.* unpubl.).
- In May, June, July, August and September, most birds have fledged and triplets and quadruplets (parents with one or two young) are observed.

Recruitment

Recruitment, or the number of new individuals added each year to a population (defined more strictly by Robinson and Bolen (1989) as those reaching breeding age), is one of the most important measurements of its general health or state (Bailey 1984). Monthly censusing of the Scarlet Macaw population provides an index of changes in population size. Young macaws with their parents annoted as triplets and quadruplets divided by the total number of macaws censused on any count would give a general estimate of recruitment (Munn 1992). Although young macaws flying with adults were recorded as early as 4-5 March (P. Herzog, pers. comm.) and late April (Vaughan *et al.* 1991), trios or quadruplets of macaws were highest during the months of July through October. Trios or quadruplets of macaws declined in December, probably coinciding with the beginning of the next nesting season, and were virtually absent from the population in January.

Recruitment rates were calculated from triplets and quadruplets data from the following dates: 30 June 1990, 219 individuals and 21 juveniles resulted in 9.5% recruitment; 26 July 1991, 161 individuals and 10 juveniles resulted in a 6.2% recruitment; 30 July 1992, 156 individuals of which 13 were juveniles resulted in a 10.2% recruitment rate (Vaughan *et al.* unpubl.). While all estimates are within the range of reproductive rates calculated by Munn (1992) for macaws, the Scarlet Macaws are very susceptible to the adverse effects of poaching, nest destruction and competition which reduce the current level of recruitment (Munn 1991). However, until poaching is controlled for the CBR Scarlet Macaw population and subsequent



A Geographic Information Systems (known as GIS) satellite photo of Carara and surrounding areas. In this photo of Costa Rica, the color infrared photography shows dense vegetation (such as tropical forests) as deep red. As the density diminishes, the color changes to shades of lighter reds and pink, green and even tan. Dead vegetation, such as dry grass, will appear as green or tan.

counts and recruitment estimates made for several years, it will be impossible to measure how much poaching impacts the population (see Poaching).

Scarlet Macaw food habits in CBR

No animal survives without food, and a complete understanding of CBR Scarlet Macaw yearly diet is necessary to manage habitat and population. Between 1990 and 1993, three methods were used to study Scarlet Macaw food habits. The first, employed between 1990 and 1991, consisted of walking the northern and western borders of CBR, listening for Scarlet Macaws inside the forest and searching for the birds. Although macaws are often very quiet while feeding, on occasion, birds were located, the tree species and parts being eaten were noted or unknown samples were taken for future identification (Vaughan *et al.* 1991). A second method used between 1992 and 1993 consisted of sitting on two hills and a rice field on the western border of CBR and observing Scarlet Macaws eating. The feeding tree was visited based on compass bearings and a general estimation of distance, and a sample was obtained for future identification. The third and fourth methods consisted of random observations of macaws feeding and through interviews, annotating where local inhabitants said they had seen the Scarlet Macaw feeding. All unknown identifications were made at the National Biodiversity Institute (INBio) in Santo Domingo de Heredia by Quirico Jimenez or Nelson Zamora. Finally, if local inhabitants annoted plant species which we did not observe, they were not included in our results.

Based on our studies, the Scarlet Macaw population in CBR and surrounding areas feeds on fruits, flowers, bark, leaves and shoots of 28 plant species (Marineros 1993). These species include trees, bromeliads and orchids which were observed being eaten by Scarlet Macaws (Vaughan *et al.* 1991, Marineros 1993) (Table 22.2). Fourteen of 28 species were also reported by local inhabitants (Table 22.2). Some tree species such as *Hura crepitans, Brosimum alicastrum, Ceiba pentandra, Schizolobium parahybum* and *Scheelea rostrata* are utilized by Scarlet Macaws both in the wet and dry seasons and therefore are an important food source for their constancy. *Hura crepitans* has also been reported as a food source for the Scarlet Macaw in Brazil (Kainer 1991) and Peru (Munn 1988), although

Leonel Marineros

The fruit of the Jabillo Hura crepitans *tree is considered an important component of the Scarlet Macaws'* Ara Macao *diet at Carara Biological Reserve.*

the bark is used by local people as a fish poison in local rivers (Hartshorn 1983). In CBR and surrounding areas, the Scarlet Macaw feeds on both fruits and bark of *Hura crepitans* between November and August. The fruits of *Cedrela odorata* and *Bursera simarouba* are also said to be toxic to wildlife (Janzen 1991), but Scarlet Macaws from CBR were observed feeding on them. Munn (1988) observed the Scarlet Macaw feeding on *Cedrela odorata, Spondias mombin* and *Terminalia oblonga* in Manu National Park, Peru. Tree species such as those mentioned above and in Table 22.2 are important to conserve in macaw habitat and to include in reforestation projects because they provide necessary Scarlet Macaw food sources. Some species, such as *Scheelia rostrata* may be keystone plant species for the Scarlet Macaw in CBR as it was found to be for some primate species in Manu National Park, providing an important food source at certain critical times of the year of food shortage (Terborgh 1986). Knowledge of Scarlet Macaw food habits throughout its distribution is in the early stages. Long-term phenology studies of known food species, food habit studies, food quality and Scarlet Macaw movement patterns in CBR and surrounding areas have just begun. These studies will add to the increasing data

base on diet, an important aspect to consider in any habitat enhancement or reintroduction effort (Wiley *et al.* 1992). Likewise, it is very important for conservation purposes to note that the Scarlet Macaw population in CBR feeds outside of the reserve.

Table 22.2
List of Tree Species Eaten by the Scarlet Macaw *Ara macao* in the Carara Biological Reserve and Surrounding Areas, Costa Rica (Information is presented by month and season)

Plant species	Reference	Part	Observation months dry season / wet season											
			J	F	M	A	M	J	J	A	S	O	N	D
Anacardium excelsum	O,C,V	fr/s	▬	▬	▬	▬	▬							
Aspidosperma spuceanum	O	l				▬								
Bernoullia flammea	O,C	fr/s			▬									
Bursera simaruba	O	fr				▬								
Bravaisia intergerrima	O	?				▬								
Bromelia sp.	V	?			▬									
Brosimum alicastrum	O,C,V	fr/s			▬			▬	▬					
Brosimum utile *	C	fr/s			▬									
Cedrela odorata	O	s											▬	
Ceiba pentandra	O	fr/s,b		▬	▬	▬								
Clarisia biflora	O	?	▬											
Enterolobium cyclocarpum	O,C,V	fr/s		▬	▬									
Epidendrum sp.	O	?												▬
Erythrina sp.	O,C	fl	▬	▬										
Ficus sp.	O,C,V	fr		▬										
Hura crepitans	O,C,V	s,b	▬		▬	▬	▬							
Inga vera	V	?					▬							
Licania platypus	O	l							▬					
Lonchocarpus acuminatus	O	?							▬					
Ochroma pyramidale	O,C	fl	▬											▬
Pithecellobium saman	O,C	fr/s												▬
Pouteria sp.	O	?									▬			
Sapium jamaicense	O	?									▬			
Scheelea rostrata	O,C,V	fr				▬	▬		▬	▬				
Schizolobium parahybum	O,C,V	l	▬	▬	▬	▬	▬	▬		▬			▬	
Spondias mombin	C,V	?												
Tabebuia rosea	O	fr/s	▬		▬									
Terminalia oblonga	O,C,V	s		▬										

KEY:
* Fruits and Scarlet Macaw feathers were found under the tree in March of 1993.

O = observed in this study
C = commented by local people
V = Vaughan *et al.* 1991
fr/s = fruits or seeds
fl = flowers
b = tree bark
fr = fruits
s = seeds
l = leaves
? = unknown

Scarlet Macaw local movement patterns

Before beginning this research, it was assumed that the Scarlet Macaw "migrated" daily between CBR and GMR. Research was performed by interviewing local inhabitants in a 1,360 km² area around CBR about their knowledge of Scarlet Macaw presence and annotating earlier information collected by the researchers (Marineros 1993). Human communities interconnected by roads and highways were visited using a Yamaha DT 175 cc motorcycle and an informal structured interview, annotating the answers afterwards. People were randomly sampled, without paying attention to age, sex or occupation. They were asked three questions: 1) if they had seen Scarlet Macaws fly in the area, 2) if so, with what frequency (daily, monthly, yearly, infrequently), and 3) had they seen macaws fly in other areas? The responses were later placed on a 1:50,000 scale topographical map, each with a specific symbol which identified its frequency. The interview was considered qualitative, and was not analyzed statistically, because a representative percentage of the human population in each area visited, was not interviewed. Over 447 km of roads and highways were covered during the study and 395 persons interviewed in 133 sites in the CBR region.

Results indicate that the Scarlet Macaws around CBR are found in an area of approximately 560 km², bordered by the following communities: north (Guapiles), south (Tulin), east (Paso Agres) and west (Salitrales) see Figure 22.3.

Leonel Marineros

Leonel Marineros counting Scarlet Macaws Ara macao *at Carara Biological Reserve.*

The map has been divided into three zones, depending on likelihood of seeing Scarlet Macaws:

Zone 1: Of high Scarlet Macaw frequency covering about 160 km². The zone of high Scarlet Macaw frequency, includes CBR, GMR and areas in between. This zone is probably the major feeding, nesting, roosting and courting area for the population.

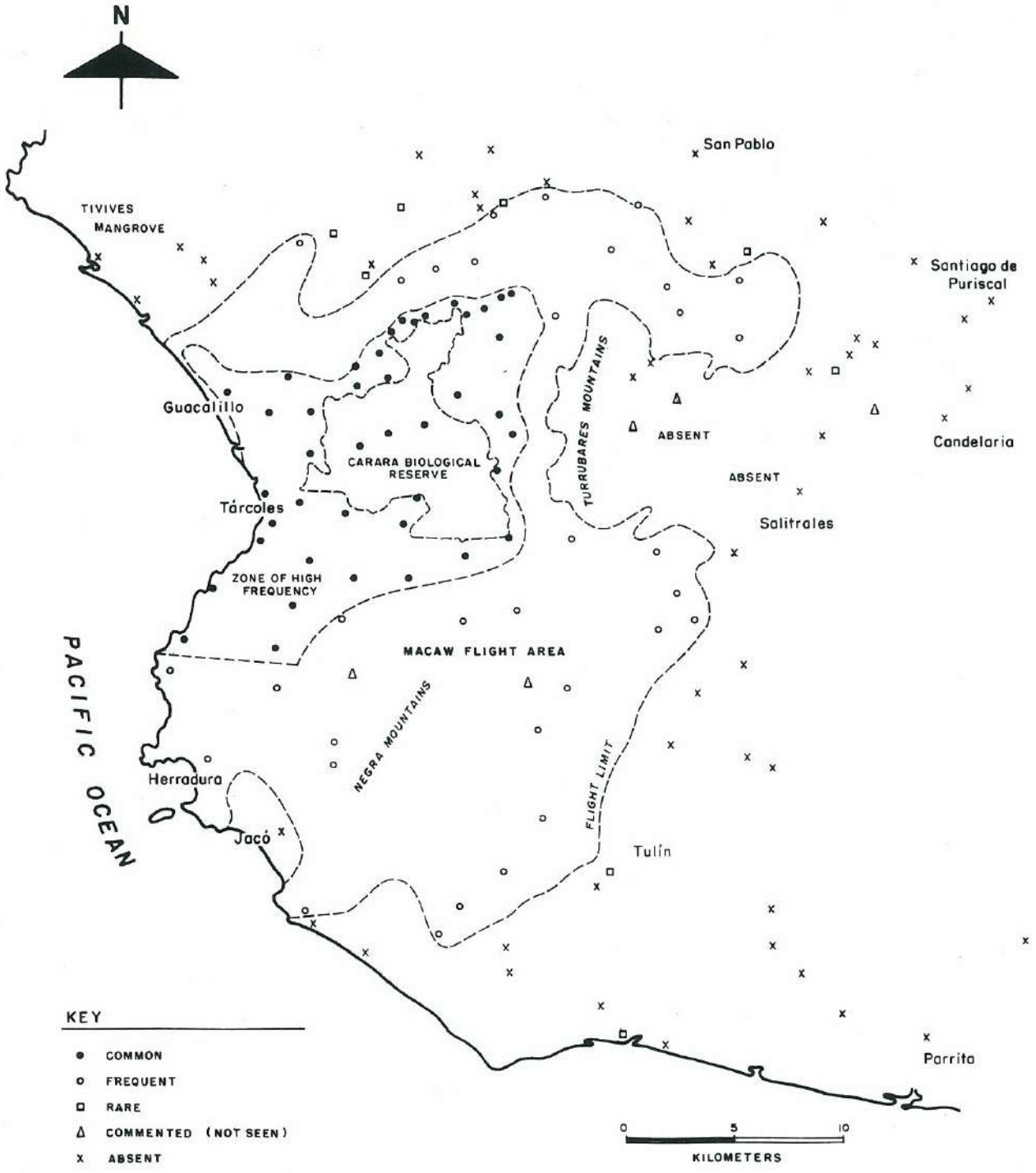
Zone 2: Of lesser Scarlet Macaw frequency which covers about 400 km². Several nests have been found in this zone.

Zone 3: Where Scarlet Macaws are absent. The best vantage points to observe Scarlet Macaws are from farms which border the Tarcoles River from Bajo Capulin to the Guacilillo Mangrove and all the Costanera highway which borders CBR, including the bridge over the Tarcoles River.

The Scarlet Macaw population in the Central Pacific region of Costa Rica has a density of approximately 0.4 individuals per km². The highest nest reported was nest N28, found at 600 m elevation (Figure 22.4). Although interviews were conducted at Potenciana Arriba (1,300 m elevation) and Llano Caite (1,700 m elevation), located in the upper regions of the TPZ (1,756 m highest point elevation), Scarlet Macaws were not reported. Stiles and Skutch (1989) and Vaughan *et al.* (1991) affirm that the Scarlet Macaw distribution can reach 1,500 m, although the CBR Scarlet Macaw population probably does not go higher than 700 to 800 m in the region. In Candelaria, the western slope of the Tarcoles River, people interviewed commented that the Scarlet Macaw was present up to the 1960s, but that it had disappeared.

In general, the Central Pacific region where the Scarlet Macaw was reported is dominated by pastures with forest patches. The exceptions are the forests legally protected as wildland areas, which vary in size from several hundred ha at GIR to 4,400 ha at CBR. The GMR and TPZ are intermediate in size, yet forested and legally protected. In addition, the forested regions of the fila Aguacate and the upper regions of the Tulin River probably constitute important Scarlet Macaw habitat, but are unprotected. Although the Scarlet Macaw can feed and nest in trees in forest fragments, the six abovementioned areas are important for the survival of the Scarlet Macaw in this region. The fila Aguacate and Tulin River should be included as protected areas. Most of the above mentioned

Figure 22.3
Area Occupied by the Scarlet Macaw *Ara macao* in the Central Pacific Region, Costa Rica
Based on 395 Interviews in 133 Localities



areas have recently been joined as a Regional Conservation Area, to conserve its biodiversity and sustainable use by local communities. This has also occurred in other parts of Costa Rica (Lara 1992, Garcia 1993).

Forest fragments north of the Turrubares river and GMR are scarce, and the Scarlet Macaw population is uncommonly reported. The Tivives Mangrove Reserve is found only 4 km north of GMR, but is not being used by the species. Interviews from the town of Bajamar, located only 1 km north of GMR, does not report Scarlet Macaws, although up to several hundred Scarlet Macaws roost in GMR.

During the study, two reports of Scarlet Macaws outside of the study area, Manuel Antonio National Park (S. León, pers. comm. 1992) and Dominical (G. Wong, pers. comm. 1992) may be from isolated individuals from the Osa Peninsula or from the CBR population. Manuel Antonio National Park and Dominical are about equidistant between the Osa Peninsula and CBR. This dispersion could be important for preventing genetic inbreeding between these two isolated populations (Wiley *et al.* 1992).

Scarlet Macaw reproduction

For a threatened species, such as the Scarlet Macaw in Central America, an understanding of those factors influencing reproduction are extremely important and form a cornerstone in any management program. Cover, water and food form the three components of habitat for a wildlife species. Quality of nesting sites is an important part of cover for Scarlet Macaw reproduction. The Scarlet Macaw population at CBR nests between November to December and May to July. Courtship begins in November and nest occupation in a tree cavity usually begins in December. Young are fledged between April and June (Vaughan *et al.* 1991). Two techniques were used to find nests of Scarlet Macaws in the study area. One technique involved interviewing local inhabitants and macaw poachers, paid to inform about nest location. A second technique was inspecting different parts of CBR from outside the Reserve and observing trees where macaws were frequently seen. Once a nest or potential nesting tree was located, the following data was taken: height to the nest, direction of the nest, nesting activity, evidence of poaching, owner of farm (if located on a farm) and names of people who knew the whereabouts of the nest. Tree species were identified at INBio from samples taken or by references from macaw poachers. Unknown dead trees were labeled as unidentifiable. Chi-squared tests were performed on nests in living and dead trees and on nest orientation.

A nest was classified as:

- High Risk of Poaching: if it was low in height, had signs of past poaching (climbing spurs, ladders or other signs); it was close to a road or houses; or known by local inhabitants.
- Medium Risk of Poaching: even though it was near human communities, it was very high (30 to 40 m) and did not show signs of poaching.
- Low Risk of Poaching: if it was found in an area of difficult access, far from a road or dwellings, was only observed with aid of the spotting scope and it was impossible to reach by the research team (Marineros 1993).

Thirty-four nests were found in the study site, nine within CBR and the rest outside the reserve (Figure 22.4). Table 22.3 describes each nest in detail. The majority were found in *Schizolobium parahibum* (n = 8), *Ceiba pentandra* (n = 5) and *Rhizophora mangle* (n = 3) with six other species used. Of the 24 trees identified, *Schizolobium parahybum* and *Ceiba pentandra* were significantly more often used than the other species ($x2 = 17.7$, $p = 0.02$, $gl = 8$). Ten trees were unidentified, and of these, six were dead. The Scarlet Macaw in CBR makes its nest at an average height of 21 m, with a maximum of 40 m and a minimum of 8.5 m (Table 22.4). There was no significant difference between nest height, according to the chi-squared test. Scarlet Macaws do not build nests and are thus dependent on the existence of trees with holes that have sufficient height and dimensions for rearing young. It was impossible to determine which nests were natural and which were made by other animals. Also, it was difficult to determine if some trees were used more frequently because the wood was softer and permitted construction of an inner chamber nest. The majority of the holes where nests were found was in living trees, perhaps because dead trees decompose and lose their branches or fall quickly for some natural reason (wind, rain, rotting, etc.). Holes found in branches did not have much duration, because the branches break from the tree as occurred in June 1993 when the branch holding nest N5 with two chicks fell. The young were apparently un-

Table 22.3
Characteristics of Nests Utilized by the Scarlet Macaw *Ara macao* in the Carara Biological Reserve and Surrounding Areas, Costa Rica (N = 34)

Nest	Tree Species	HN	CO	DR	RP	NE
N1	*Zanthoxylum setulosum*	9, 8	Alive	NE	High	Trunk
N2	?	?	Dead	S	High	Trunk
N3	?	?	Dead	S	High	Trunk
N4	*Ceiba pentandra*	20	Dead	A	High	TB
N5	*Schizolobium parahybum*	15	Alive	A	Low	BB
N6	*Schizolobium parahybum*	15	Alive	A	Low	Knot
N7	*Ceiba pentandra*	35	Alive	NE	Medium	BB
N8	*Ceiba pentandra*	15	Dead	A	High	TB
N9	?	18	Dead	A	High	TB
N10	*Ceiba pentandra*	30	Alive	NE	High	BB
N11	*Ceiba pentandra*	35	Alive	N	Medium	BB
N12	*Sterculia apetala*	40	Alive	SW	High	BB
N13	?	25	Alive	E	Low	Knot
N14	?	?	?	?	?	?
N15	*Schizolobium parahybum*	20	Dead	A	High	BB
N16	*Schizolobium parahybum*	18	Dead	S	High	BB
N17	?	10	Alive	E	High	Trunk
N18	*Sterculia apetala*	13	Alive	N	High	Trunk
N19	*Schizolobium parahybum*	36	Alive	W	High	Knot
N20	*Astronium graveolens*	30	Alive	N	Medium	Trunk
N21	*Schizolobium parahybum*	18	Alive	N	High	Knot
N22	*Astronium graveolens*	21	Alive	E	High	Knot
N23	*Avicenia germinans*	11	Alive	S	High	BB
N24	*Rhizophora mangle*	23	Alive	NE	Medium	BB
N25	*Rhizophora mangle*	10	Alive	N	High	Knot
N26	*Rhizophora mangle*	8, 5	Alive	S	High	Trunk
N27	*Schizolobium parahybum*	27	Alive	W	High	BB
N28	*Schizolobium parahybum*	14	Alive	N	High	Knot
N29	*Hura crepitans*	26	Alive	E	Medium	BB
N30	*Terminalia oblonga*	9	Alive	N	High	Trunk
N31	?	17	Alive	W	?	Trunk
N32*	?	28	Dead	NE	?	BB
N33*	?	32	Dead	A	?	BB
N34*	?	32	Dead	S	?	BB

KEY:
? = Unidentified
HN = Height to Nest
CO = Tree Condition
DR = Direction Nest Facing
RP = Risk of Being Poached
NE = Where Nest is Found on Tree
A = Looking Upwards
TB = Upper Part of Trunk Broken
BB = Branch Broken
* C. Potter pers. comm. 1991

injured. An additional problem was that these nesting cavities are also sought by owls, hawks, ants, wasps and other animals, reducing their availability for the Scarlet Macaws in and around CBR.

The cardinal orientation of the hole apparently does not influence nest selection for the Scarlet Macaw. However, most utilized nests have no vegetation around the entrance and all are free of obstacles, because the macaw does not have the ability to maneuver its arrival to a branch, as other birds do.

Ecotourism vs. poaching: non-consumptive vs. consumptive uses

Tourism

Tourism has recently become the top source of foreign exchange in Costa Rica, replacing the traditional export crops of coffee, banana and cattle. In 1992, 610,093 tourists visited Costa Rica and generated US$421.1 million for the economy. Many of these tourists are ecotourists or nature tourists, and the number of visitors to national parks and equivalent reserves of Costa Rica to see Costa Rica's biodiversity increased from 205,640 to 639,753 tourists between 1982 and 1992 (Damon & Vaughan *in press*). Costa Rica is perhaps the country with the highest biodiversity for its size in the world and has an estimated 500,000 species distributed in a wide diversity of habitats. Most are protected by a world-famous wildlands system (Umana & Brandon 1992, Boza 1993, Vaughan 1994). However, lack of understanding amongst visitors, few restrictions on visitors, and the "urge" for guides to satisfy tourists by showing them wildlife species, are causing scientists to question if tourism and wildlife are compatible without in-depth research and controls (Damon & Vaughan *in press*).

Tourists visiting CBR are an example of this dilemma. The relative proximity of CBR to San Jose (1.5 hours) by car, exuberant tropical vegetation and abundant Scarlet Macaws and American Crocodiles *Crocodylus acutus* attracted 12,000 foreign tourists in 1990; 19,000 in 1991; 24,600 in 1992; and over 40,000 in 1993. However, the economic contribution tourists visiting CBR make in general to Costa Rica and especially to the Central Pacific region was not well

Table 22.4
Frequency of Scarlet Macaw *Ara macao* Nest Heights Found in Carara Biological Reserve and Surrounding Areas, Costa Rica (N = 34)

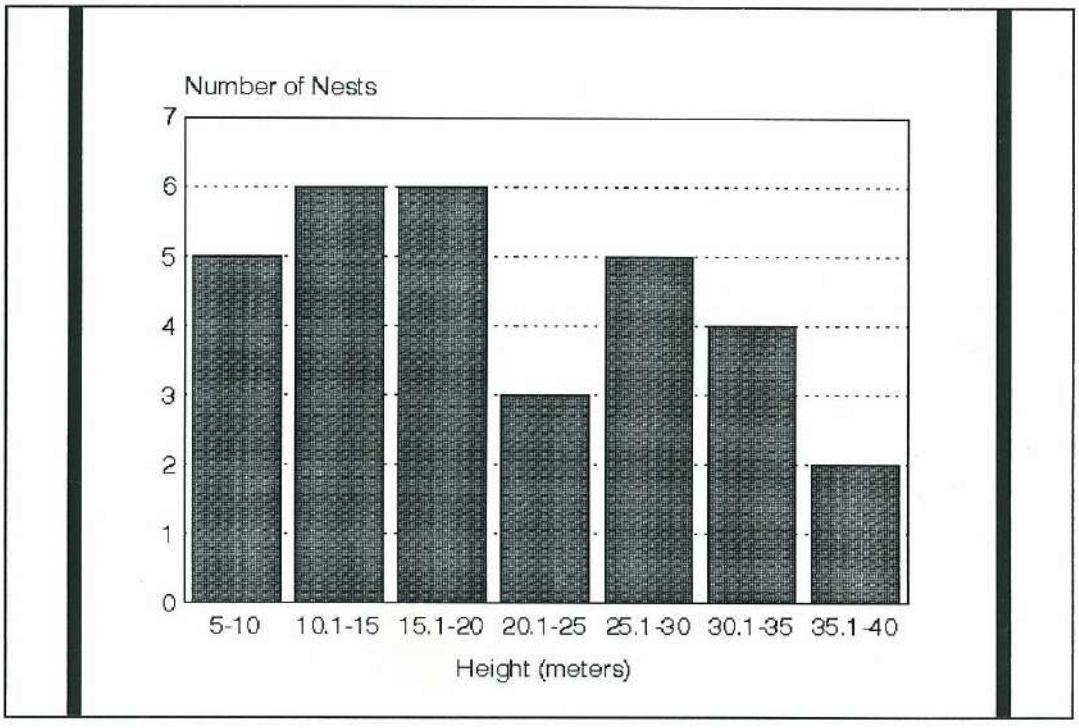
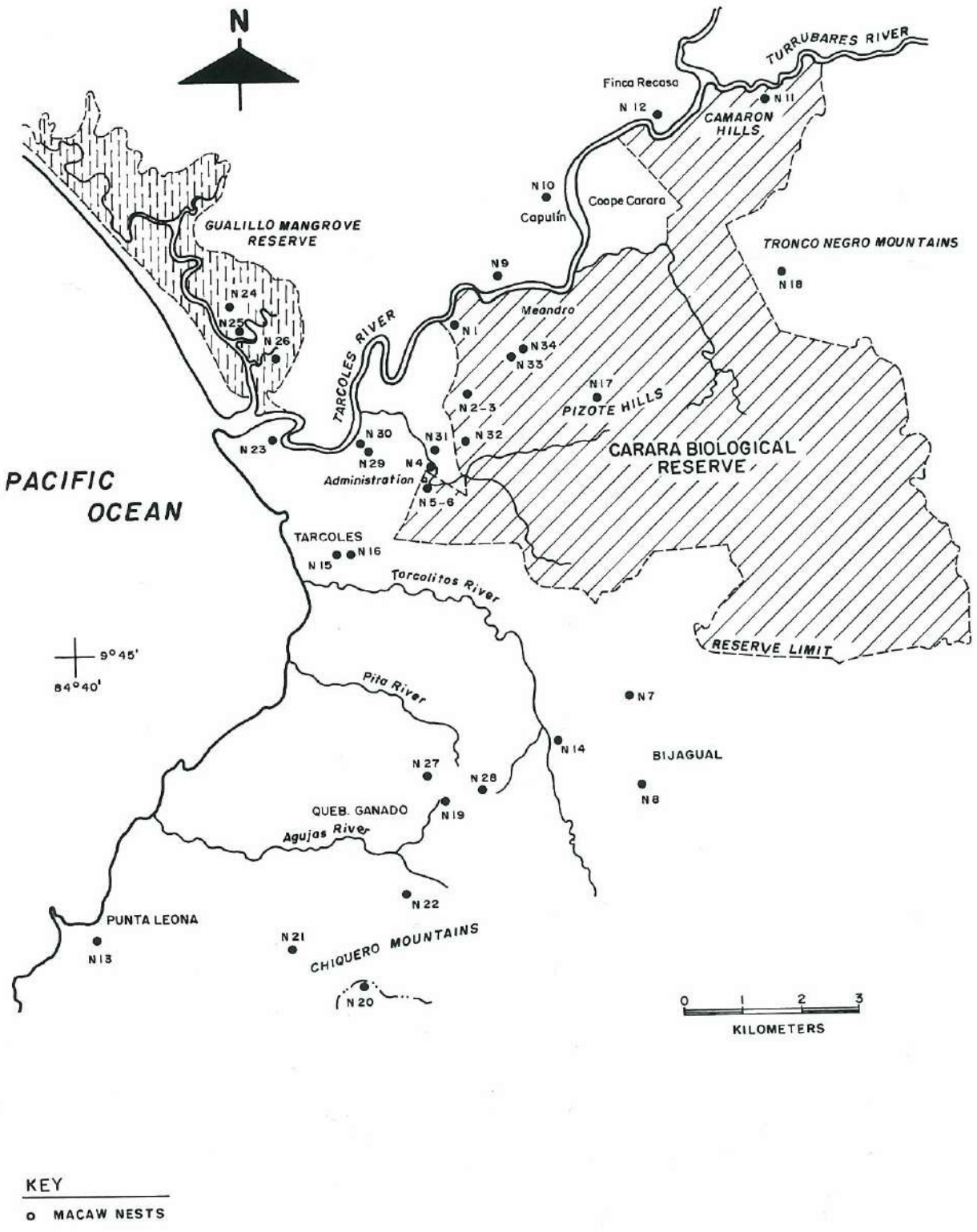


Figure 22.4
Location of 34 Scarlet Macaw *Ara macao* Nests in Carara Biological Reserve and Surrounding Areas



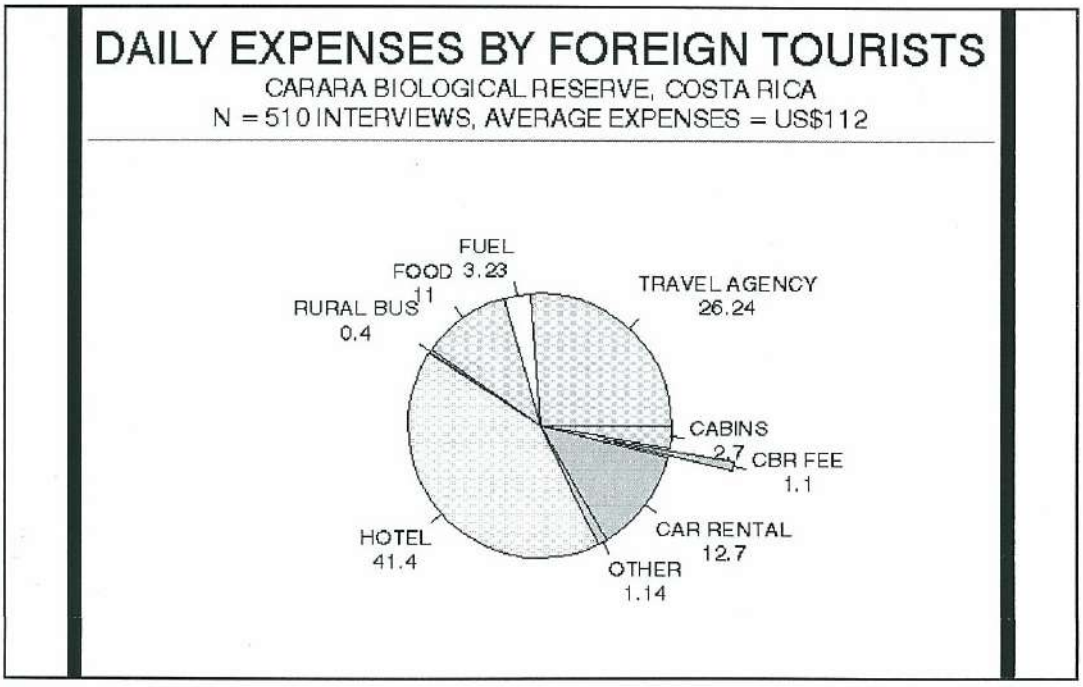
understood (Vaughan & Liske 1991). Therefore, 595 foreign tourists visiting CBR were interviewed between September 1992 and March 1993. Typical questions asked included: 1) why were you visiting CBR, 2) how much money did you spend on this trip, 3) would you be interested in talking or being guided by local people, and 4) did you enjoy your visit. In addition, prices of 12 tourist agencies travelling to CBR, hotels, restaurants, car rental agencies, and fuel were consulted. Finally, informal interviews were conducted among 41 families of local inhabitants to determine their economic status, knowledge of Scarlet Macaws, and their interest in working with ecotourism and Scarlet Macaw conservation in the region.

Based on the tourist interviews, the majority of the visitors to CBR were between 25 and 50 years of age, with about 12% between 26 and 30 years old. About 50% of the visitors came from the United States. Canadians (15.7%), Costa Ricans (12.4%) and Germans (9.8%) were also important. About 46.2% of the interviewed people arrived with a travel agency, while 26.0% came in rented cars, 17.4% used their own car and the rest visited CBR by other means. Over 35% of the visitors commented they came to CBR principally to see the Scarlet Macaw, although 44.8% said that their main interest was to observe monkeys. Over 39% of the foreigners interviewed said that they knew about the existence of Scarlet Macaws in CBR before arriving in Costa Rica, while 47% said that they were not aware. The remaining 14% did not answer the question or were Costa Ricans.

Christopher Vaughan

Scarlet Macaws Ara macao *are frequently used as logos in ecotourism-related ventures in the Pacific Central region of Costa Rica.*

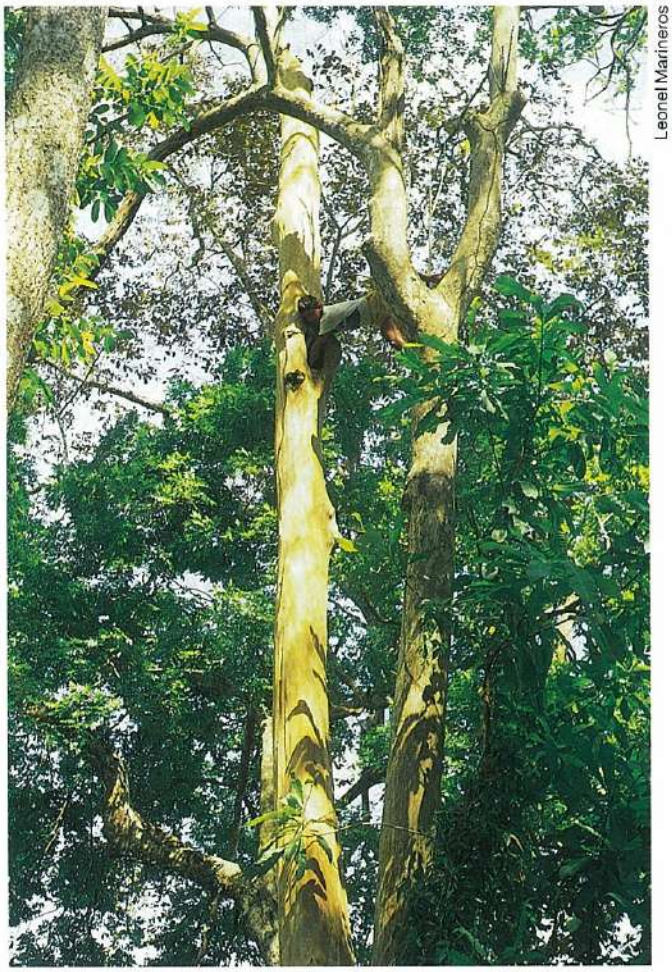
Table 22.5
Daily Expenses by Foreign Tourists that Visit Carara Biological Reserve, Costa Rica (N = 510). Average Expenses = US$112 per Person.



The visitors spent an average US$112 per person a day enroute to CBR, this included hotel, meals, tour agency and/or car rental, reserve entrance fee, etc. (Figure 22.5), and amounted to about US$4,480,000 in foreign revenue in 1993 for Costa Rica from CBR foreign visitors. The hotels (41.4%) and travel agencies (26.2%) receive the majority of the economic benefits from ecotourism. Many hotels and tour agencies in Costa Rica are owned by foreigners. It has been estimated that up to 55% of developing countries tourism profits return to developed countries (Boo 1990). However, Costa Ricans who own hotels, restaurants, gas stations and stores and work in these establishments are the ones benefitting most from tourism to CBR.

Two Scarlet Macaw nests found along the main nature trail of CBR may have 30 or more tourists from different travel agencies observing them at any one time. Apparently this level of activity is not causing major problems as the nest continues to be occupied. If they are the only macaws seen by the tourists, their economic value would be very high, perhaps close to the more than US$4.5 million generated. However, given that the Scarlet Macaw population of CBR is at most 219 birds, dividing the 1993 figure of US$4,480,000 by the known Scarlet Macaw population would give US$20,457 per bird per year. A Scarlet Macaw can live approximately 30 years and if tourism to CBR remained stable in numbers and expenditures, each bird would be worth US$613,710 for ecotourism in its lifetime. Munn (1992) studied macaws in Peru and, based on tourists expenditures in 1990 around Manu National Park, concluded that a macaw can generate between US$750 and US$4,700 a year as a tourist attraction, and between US$22,500 and US$165,000 in its lifetime.

However, through admission fees, CBR receives only about 1% of what a visitor spends in a day (Marineros *et al.* 1993). In 1993, the Costa Rica National Chamber of Tourism funded salaries of three park guards for CBR, mostly to attend tourists, but discontinued this policy in 1994. As a result, in what amounts to perhaps the first conflict between the tourism industry and the understaffed and underbudgeted National Parks Service, the Minister of Natural Resources, Energy and Mines has threatened to close CBR to tourists in 1994 unless the tourism agencies assist in providing personnel for CBR (Harris 1994).



Leonel Marineros

A macaw poacher searching for young macaws in a nest found in a Sura tree on a farm located outside of Carara Biological Reserve.

Poaching

Perhaps the only direct benefit several local inhabitants receive from the Scarlet Macaw population at CBR is by stealing an undetermined number of young macaws from nests in and around CBR and selling them as pets to Costa Ricans and foreigners (Vaughan & Liske 1991). The Scarlet Macaw trade in Costa Rica is not well understood. However, of 34 nests found, 56% showed signs of being poached yearly, leaving only nests along the CBR nature trail and in areas of difficult access to CBR or not yet discovered by macaw poachers. The low recruitment rate is an indicator that there is low reproductive success, and poaching is suspected as a major factor.

The poaching and sale of macaws is against the Costa Rican Wildlife Law (No. 7317), which stipulates that commercialization of endangered wildlife species (such as the Scarlet

Macaw) is illegal and violators will be fined up to US$325 and/or imprisoned. Poaching macaws at CBR is not a necessity, but an opportunity to add to income (Vaughan 1993). The chicks are generally lowered from the nest with several people working together. The tree climber is normally the youngest person and gets paid least for the dangerous job of climbing up to 40 m to a nest. Most chicks are robbed in March and April, when they are feathered and able to leave the nest. This period usually coincides with Easter Week, when tourism is highest in the region and some macaw chicks may be purchased. The macaw poachers are paid between US$154 and US$384 per chick (Marineros *et al.* 1993).

Local inhabitants

A number of authors (Rovinski 1991, Vaughan & Liske 1991, Lara 1992, Marineros *et al.* 1993) recommend that local inhabitants receive some of the economic benefits from natural areas, such as CBR. It is important that tourist guides from local communities be trained; 88% of families interviewed had at least one member interested in becoming a guide. Also, 65% of the visitors interviewed showed interest in being guided by a local person, and 70% were interested in purchasing local crafts (Marineros *et al.* 1993). Although, these services do not presently exist in CBR, tourism in other Costa Rican areas such as Monteverde, La Selva and Guayabo National Monument have benefitted local communities (Rovinski 1991). An innovative approach might be to charge tourists for observing macaw nests near local communities. The community at Tarcoles knows the whereabouts of over a dozen Scarlet Macaw nests which visitors could observe; at Bajo Capulin there are two Scarlet Macaw nests, crocodiles in the Tarcoles River and a beautiful view to the valley. Lookout and restaurant facilities could be constructed.

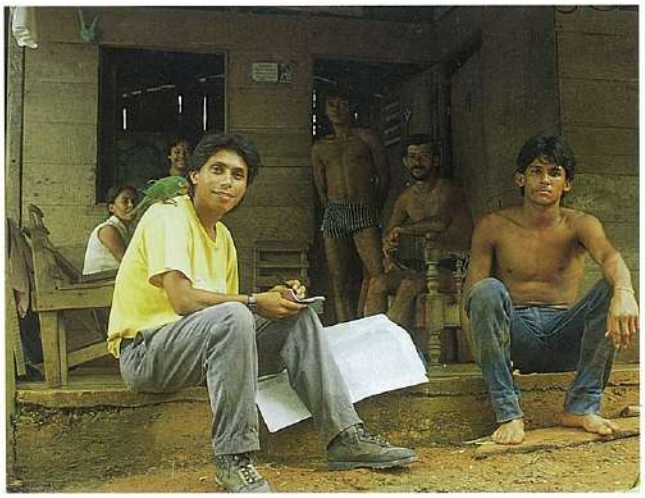
Scarlet Macaw management at CBR and surrounding areas

The CBR Scarlet Macaw population is threatened and could soon begin a downward trend leading to extinction. This is based on the following information:

- CBR Scarlet Macaw population monitoring data collected between 1990 and 93 indicate low recruitment rates, probably related to high nestling poaching and perhaps nesting failure.
- With low recruitment rates and a small "founder" population of unknown genetic characteristics, it is probable that according to minimum viable population size (MVP) theory, the CBR Scarlet Macaw population does not have a high probability of long-term survival (Shaffer 1981).
- The local community around CBR presently shows no interest in stopping the poaching of Scarlet Macaw chicks.
- The wildlife and park officials have not been successful in stopping this illegal trade.
- Ecoturism agencies have never demonstrated interest in sharing their profits with local inhabitants or CBR.
- Economic conditions have been steadily deteriorating for the lower classes throughout Central America and poaching offers an economic incentive (Vaughan 1990, 1993).

If the CBR Scarlet Macaw population is to survive well into the next century, management must be based on socioeconomic and ecological (population and habitat) programs. A summary of management and outreach programs planned or in execution are described below.

Management of the Scarlet Macaw can be divided into the social, economic and ecological areas, with the understanding that one cannot function without the other (Primack 1993). A general description is provided for each area (Marineros 1993).



Leonel Marineros

Leonel Marineros interviewing local campesinos from the San Gabriel area as part of his research on the local distribution of the Scarlet Macaw Ara macao.

Socioeconomic

The socioeconomic outreach program is slowly taking shape, coordinated by CBR employees. It consists of several sub-programs:

Education programs for local communities (grade schools, high schools and adults) have begun which teach the importance of the Scarlet Macaw and other species within their ecosystem. This includes a general educational plan such as booklets, audiovisual aids, radio programs, posters and visits to CBR. The initiation of an innovative program in the Tarcoles grade school is planned, where the students will "adopt" several active Scarlet Macaw nests in their community and try to ensure that the birds fledge in 1994. Though several students and their families earn extra money by climbing trees to poach macaws, our plan is to "reward" their school for nest protection by purchasing library books, pencils and other supplies. The Scarlet Macaw must become a symbol of CBR and the local county of Jaco to give it more educational, touristic and conservation importance.

Christopher Vaughan

A typical dwelling from the Pacific Central region of Costa Rica.

Education programs for the visiting public teach about the biology of the Scarlet Macaw and its survival problems. This is presently done in an informal way with tour guides. In 1994, a visitors center will be installed in CBR to highlight the tropical forest ecosystem and its biota, especially the Scarlet Macaw. Interpretation is also planned at selected macaw nesting trees along the nature trail near the present administration building.

Education program for park guards although presently carried out informally, will provide basic training about legislation and rules within CBR related to making arrests, first aid, human relations, basic Scarlet Macaw biology, in order to protect the visitors and the biota.

Public relations and community development are providing the infrastructure for the local community to become confident with CBR and its conservation, and involved in and benefit from the tourism arriving at CBR.

This could include:

- Courses to train local guides.
- How to make arts and crafts.
- Setup and administration of a tourist shop at CBR by the local communities.
- A protection campaign for the Scarlet Macaw nests on farms (such as school children "adopting" a nest).
- Promotion of participation of hotel owners and tour agencies to collaborate in Scarlet Macaw protection and conservation.

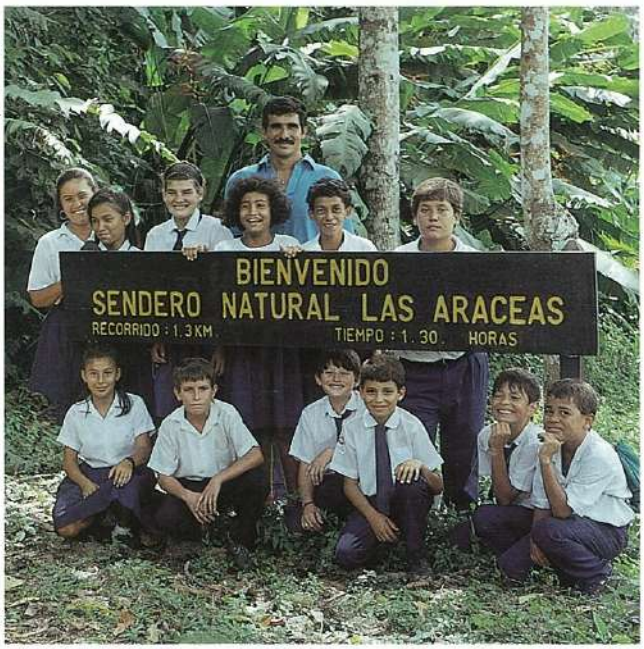
Without local community interest and involvement in Scarlet Macaw conservation, the Scarlet Macaw population will decline and eventually become extinct. Preservation will happen only if the local communities perceive an economic incentive for themselves. Fortunately, CBR generates millions of dollars yearly for Costa Rican businesses (hotels, restaurants, airlines, tour agencies) through ecoturism. These businesses must share their profits with CBR and the local communities. Purchasing local arts and crafts, paying to see macaw nests, eating at local restaurants all helps the local community development. This sort of interaction will insure a positive local community attitude towards CBR so the tropical rainforest environment and its biota (including the Scarlet Macaw) will continue to exist and tourists will visit it. The CBR director and staff must ensure that this is carried out in an intelligent and equitable manner. It will not be an easy task, but it is the only solution.

Ecological research, monitoring and management program

The key to learning more about the status of the Scarlet Macaw population and its habitat over time and conserving it involves continuing and expanding on several subprograms which include:

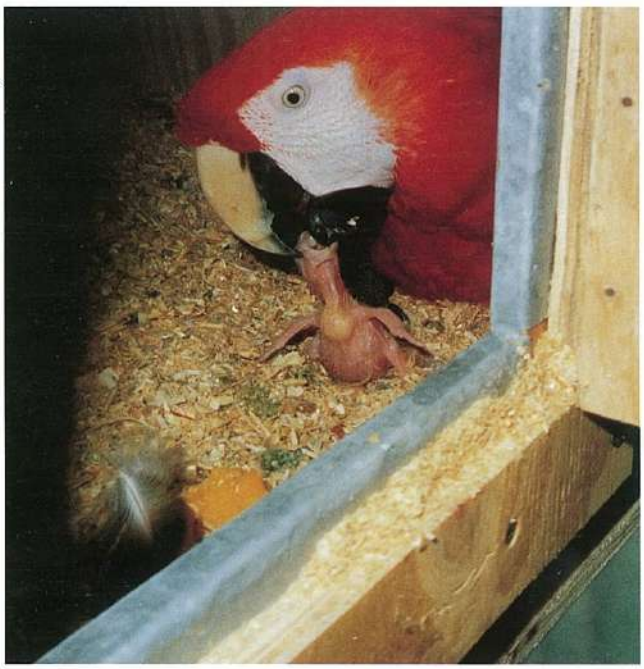
- Monitoring the CBR Scarlet Macaw population at monthly intervals over the next decade

Christopher Vaughan



Local school children and their teacher receiving environmental education in CBR.

Laney Rickman



Scarlet Macaw Ara macao *feeding a two day old nestling.*

to provide continued information about population size, fluctuations and recruitment rate.

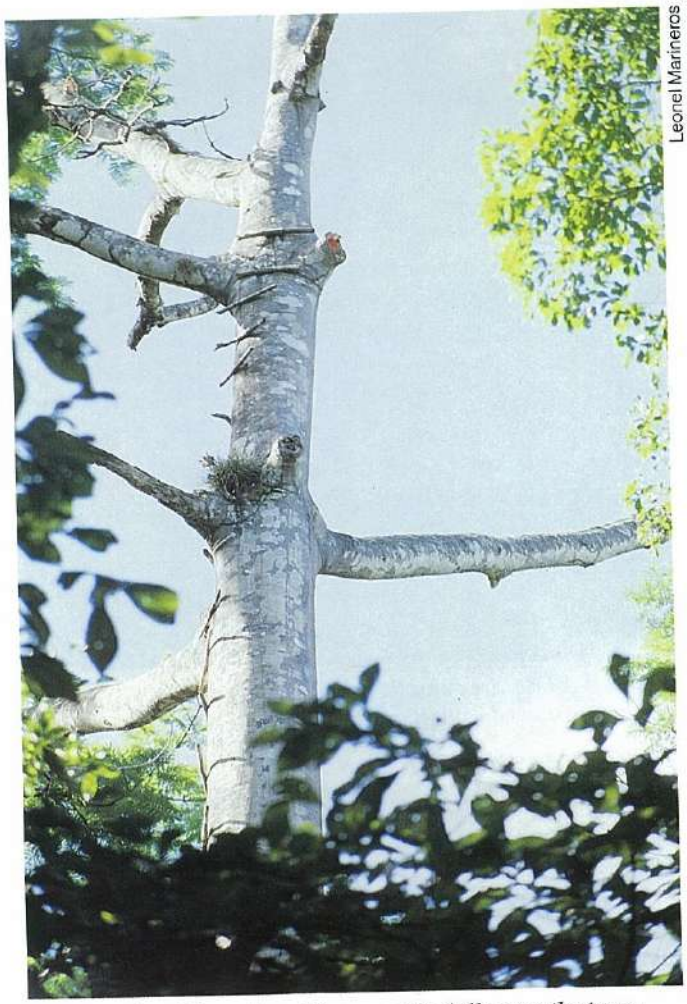
- Researching and monitoring Scarlet Macaw food habits. The following studies have begun or are planned for 1994:
  - Determining new plant species in the Scarlet Macaw diet.
  - Beginning a long term phenology study on the CBR vegetation, focusing on plant species eaten by the Scarlet Macaw and determining the flowering, fruiting and leafing periods.
  - Initiating biochemical assays of Scarlet Macaw flower, fruit, leaves, and seed eaten by Scarlet Macaws to determine their nutritive value.
- Continuing research of Scarlet Macaw local movement patterns by initiating radio-telemetry studies to compliment the data gathered by interviews on local Scarlet Macaw movements. This will commence in January, 1995 with RWMPMC personnel.
- Researching Scarlet Macaw local movement patterns by evaluating location, size and floristic components of forest fragments found in the CBR region. This will be carried out using aerial photographs and satellite imagery in early 1994 with professors and graduate students from RWMPMC. Results should indicate utilization of forest fragments by Scarlet Macaws, depending on distance from CBR, size, and flora found within. An innovative idea is to establish corridors to other wildland and forested areas in the Pacific Central Region and initiate a private wildlife refuge system in the CBR region (M. Rojas pers. comm. 1993). The information generated from this forest fragment study will support this idea. It will also provide valuable information when the radio-telemetry work is initiated.
- With the knowledge that at least 28 trees are used by macaws for food and nesting, and the fact that they feed outside of CBR, key forest fragments outside of CBR must be protected

Christopher Vaughan

Cebu cattle and pastures have replaced the native wildlife and forests throughout much of the neotropics.

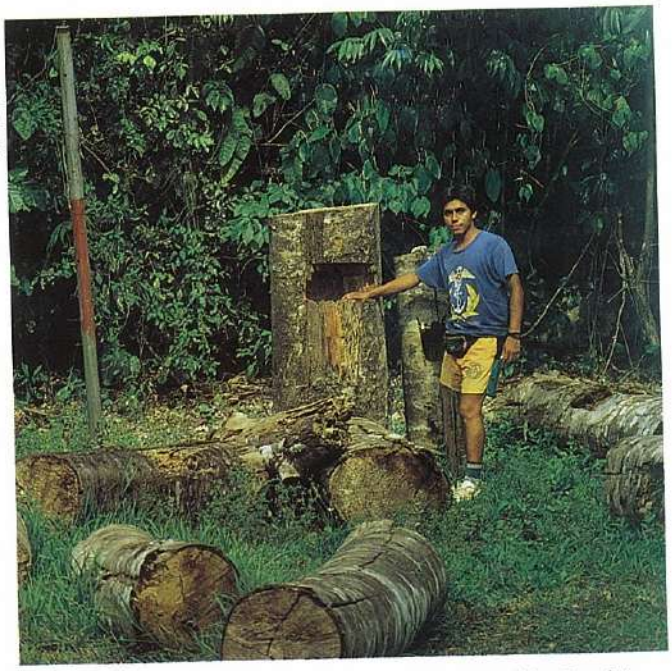
due to their important plant species that supplement the Scarlet Macaws diet and provide nesting and roosting sites. This could include advising land owners as to which tree species are important, establishing nurseries for important tree species, and proposing to include lands adjacent to CBR within the reserve or as private wildlife refuges.

- Researching and monitoring Scarlet Macaw reproduction at natural and artificial nesting sites in CBR and surrounding areas. To date, information on characteristics and vulnerability of 34 Scarlet Macaw nests has been collected. We will continue to collect data on nests, especially nesting success. Additionally, monitoring hatching success on the nest following incubation, and examining and weighing chicks until they fledge is planned, to initiate in early 1995 when macaws begin nesting. A nesting program would also involve protecting and improving natural and artificial nesting sites in and around CBR as proposed by Munn *et al.* (1991) and Munn (1992) at Manu National Park in Peru. Artificial nesting boxes have been attempted in CBR without success (Marineros 1993), but the design (wooden nests) was probably the major problem. Artificial plastic tubes will be installed near CBR guard stations in late 1994 to provide additional nesting options for the Scarlet Macaws and added protection.



Leonel Marineros

Nest number 27 was found in one of the hills near the town of Quebrada Ganado. The tree has an improvised ladder which the local inhabitants use yearly to extract Scarlet Macaws Ara macao.



Leonel Marineros

Semi-artificial nests like these have not been used by Scarlet Macaws Ara macao *in CBR.*

Additional studies must be initiated, but will require more time, economic and human resources. This would include a long-term study of CBR Scarlet Macaw population structure and population dynamics by marking chicks and following their life cycle over a number of years. Additionally, it is important to determine genetic variability of the CBR Scarlet Macaw population. This could be done by taking blood samples and tissue samples when handling chicks or adults.

Recently a plan to use confiscated Scarlet Macaw chicks and those "purchased" from macaw poachers, then breeding and raising them under captive conditions and finally releasing them or their progeny at sites considered appropriate for the species has been proposed (E. Muller pers. comm. 1994). This confuses the local community as macaw poaching has been condemned by the CBR and govern-

mental wildlife authorities. The Association for Parrot Conservation (APC) has expressed reservations on captive breeding as a "panacea" and suggests careful scientific evaluation of conservation alternatives for maintaining wild populations and their habitats.

There are few reintroduction projects for parrots, such as the Thick-billed Parrot *Rhynchopsitta pachyrhyncha* reintroduction in Arizona (Snyder *et al.* in press) to learn from. However, releases of captive-reared birds have not been encouraging, with almost all individuals lost within a few days of release because they lacked the basic survival skills. Snyder *et al.* (in press) estimate that thousands of captive-reared birds and "formidable" logistical and financial investments would be required in such an effort. Likewise, these projects could bring many detrimental impacts upon the native population (such as disease spread) if captive-bred birds are "accidentally" or intentionally released into the CBR Scarlet Macaw population, or return to the CBR population from release sites (B. Beck pers. comm. 1992).

On 28 March, 1994, the Costa Rican Wildlife Service denied permission to the Green Iguana Foundation to capture or collect young macaws from CBR and surrounding areas (J. Rodriguez pers. comm. 1994). Their reasoning included the following:

Kazuya Nahoki

Nest number 9 is found in a cattle pasture near the town of Bajo Capulin. Although the nest was guarded by local inhabitants, it was poached by other members of the same community during Easter week in April 1993. The nest had two young Scarlet Macaws Ara macao.

- Reintroductions of young macaws raised or bred in captivity should be the last management alternative to consider for the CBR population because it is potentially dangerous to the existing population and in general has not been proven successful elsewhere.
- The Green Iguana Foundation must prove that the reintroduction program will not negatively impact either the macaw population or ecosystem.

With the CBR Scarlet Macaw population, habitat and population research and monitoring only began in 1990 and has been limited by lack of funding. Population, habitat and human management is being initiated on a limited scale, based on only three years of work. The future of the CBR Scarlet Macaw population will be based on:

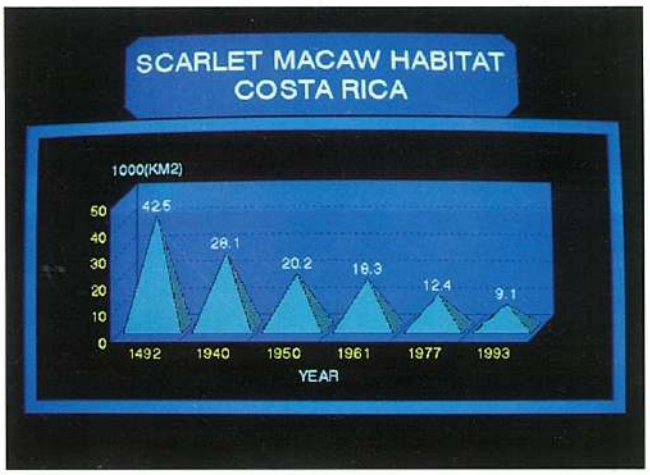
- a successful outreach program which educates and benefits the local community and
- habitat and population management and monitoring.

In general, captive breeding should not be used to augment an existing population unless all other attempts to protect the population have failed (Wiley *et al.* 1992).

Conclusion

Based on 43 months of research on the Scarlet Macaw population at CBR and surrounding areas, important ecological information has been documented about population size, food habits, local movements and reproduction. In addition, socioeconomic aspects related to the local human community and visiting ecoturists is better understood. But understanding this threatened population has just begun, and has been limited by financial restrictions.

For successful conservation of the CBR Scarlet Macaw population, CBR and local human communities must identify themselves with macaw conservation and benefit from ecoturism in the area. The population and habitat research and monitoring program must be continued and expanded to incorporate new information which will aid in understanding long-term population and habitat trends. Management of this threatened species is possible, but will require a much larger human and economic investment and commitment of all parties involved; scientists, local people, businesses, tourists, CBR personnel and donors.



Acknowledgements

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