Chapter 20

Macaw abundance in relation to human population density in the western Amazon basin

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Abstract: We assess whether macaw population size varies with human population density in the western Amazon basin. Several factors, including collecting baby macaws for the pet trade, increase dramatically in areas with higher human population densities in the Amazon basin. We use a 'quasi-experimental' design to determine population size variation of four *Ara* macaw species in two regions of the Peruvian and Colombian Amazon, each having a low human population density site (~7 - 12 villages, 100 – 150 people per village) and high human population density site (30 - 50 villages each) for comparison. In region one, the abundances of all four species of *Ara* macaws were negatively related to human density. However, this trend held for only two of the four *Ara* species in region two. We discuss the relative importance of various factors (seasonal fruit abundance, overharvest of macaws for protein or the pet trade, and palm tree harvest) to the patterns observed, as well as the policy and management implications of these patterns.

1.   INTRODUCTION

As human populations grow, they affect bird populations. The quality and magnitude of these impacts are contemporary issues in avian

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conservation. One dimension of this topic concerns the variation in bird abundance with human population density. Studies of birds in sparsely inhabited Neotropical areas can provide interesting insight into how urbanization affects birds. The western Amazon basin proves an ideal testing ground for this topic because there have been colonies and villages of people in some regions (e.g., Francisco de Orellana, Departamento Loreto, Peru) for ~450 yr.

The human population in rural Amazonia is composed of mestizo (mixed ethnic background), indigenous tribes, and the detribalized descendants of the indigenous people that are known in Peru as ribereños or river people (Egoavil 1992). The origin of the ribereños can be traced to the exploitation of the Peruvian Amazon during the 19th century. The transformation of Amazonian people from tribal groups to ribereños began with the earliest European immigration and continued with the detribalization process imposed by missionaries, expansion of the slave trade, and influx of immigrants during the rubber boom. Because of the need for labor and the promise of prosperity, rubber exploitation attracted people from the Peruvian coast, the Andean region, Brazil, Europe, North America, Asia, and detribalized Amerindians (Dourojeanni 1990). Hence, the non-native population increased from 18,000 in 1876 to 120,000 in 1920 (San Roman 1975). After the abrupt ending of the rubber exploitation, many immigrants returned to their place of origin, but others established themselves in the Peruvian Amazon where they turned their attention to other extractive activities (San Roman 1975).

Currently, ribereños greatly exceed indigenous people. Data from a 1981 census revealed that 280,000 nontribal people live in the rural sector of Departamento Loreto, comprising 85% of the entire rural population. The remaining 15% are mainly indigenous people with a population of 50,000 (Egoavil 1992). Ribereño villages are located at the margins of major rivers and some are more than a century old (FPCN 1994). Indigenous groups and ribereños practice agriculture, fishing, hunting, small-scale lumber extraction, and collection of minor forest products. However, ribereños are more involved in market economies, at both the regional and international level, than are indigenous groups (Padoch 1988). Psittacids, especially *Ara* macaws (Munn 1992), are highly threatened in several areas of their range due to over-collecting for the pet trade, among other factors (Collar and Juniper 1992). Such over-collecting is one of several factors exacerbated by an ever-expanding human population (Begazo 1999). Our objectives herein are to determine whether macaw population size varies with human population density in the western Amazon basin.

2.   METHODS

2.1   Habitat and History of Human Use

Regional habitats have been overviewed elsewhere (e.g., Brooks 1997), but will be described here briefly. The habitats sampled are primarily situated along water, within forest, or a transition/edge situation between these habitats. Regions along the immediate edges of water (e.g., marshes, lakes, streams and rivers) are often dominated by sawgrass (*Spartina spp.)* or cane, followed by thick undergrowth further inland from the water. Island edge vegetation is similar, unless the island is young, in which case it is monocultured with rapidly colonizing plant species that are primary successional island specialists (e.g., *Cecropia* spp., *Gynerium* spp., and *Heliconia* spp.).   Aquatic edge vegetation is separated from interior rainforest by dense forest with thick undergrowth, with canopy height often not exceeding 10 - 15 m. The exception is floodplain, which is characterized by continuous short stems and grasses (e.g., *Tridescantia* spp.) and tall, leafy trees with trunks spaced 5 - 20 m apart. Primary, interior rainforest is high in plant diversity, is characterized by a dark understory due to few penetrable light gaps, and contains tall trees that form part of the canopy, buttresses, or canopy emergents (e.g., *Cedrela* spp., *Ceiba pentandra*, *Ficus insipida* and *Inga* spp.), often exceeding 35 m.   Other tall trees in the region include palms (e.g., *Euterpes prectoria*, *Mauritia flexuosa*, *Scheelea* spp., *Socratea* spp.), often occupying a gradient of habitats from river edge to interior forest.

While the sites chosen may have been heavily influenced by humans, it is unlikely that this influence was significant in the 1600's, let alone more recently. While extraction of rubber and animal pelts may have influenced human habitation throughout Amazonian macaw habitat, the forest was still intact at the more pristine sites. The main forms of threats to macaw populations are more apparent at sites with more permanent civilization and higher human population densities. These threats increased after rubber extraction was no longer profitable, with people in higher populated areas turning to extraction of live animals for biomedical research and pets. The increase in human population density coupled with better transportation, availability of firearms and ammunition, and the destruction of Palm trees (e.g., *Mouritia flexuosa* and *Euterpe* spp.) are factors that are likely to decrease macaw abundance.

2.2   Study Sites

We use a 'quasi-experimental' design to estimate the impact of human density on macaw abundance in two remote, continuously forested regions of the Peruvian and Colombian Amazon (for more detailed description see Brooks 1997, 1998; Brooks et al. 1999; Begazo 1997, 1999). Within each region, we selected a site with high human density (~30 - 50 villages each, with approximately 100 - 150 people per village) and a site with low human density (7 - 12 villages) yielding a total of four study sites. Regions 1 and 2 are located north and south of Iquitos, Peru, respectively. We refer to sites by their human population density (high or low) and the region in which they occurred (1 or 2). High 1 is where the Napo River drains into the Amazon River in Peru (~$2^{\circ}45$'S; $72^{\circ}55$'W; Fig. 20.1A). Low 1 is along the main river stems of the eastern Peruvian and Colombian Amazon (~$2^{\circ}45$'S; $72^{\circ}55$'W - $2^{\circ}15$'S; $70^{\circ}00$'W; Fig. 20.1B). High 2 (~$4^{\circ}22$'S; $73^{\circ}08$'W) and Low 2 (~$4^{\circ}31$'S; $72^{\circ}24$'W) are located near Tamshiyacu, and Javari-Mirim, respectively. Note that differences in human population density and, potentially, corresponding habitat quality are not apparent from satellite imagery (Miller et al. 2001). Mean annual temperature in the western Amazon basin is 26° C and annual rainfall exceeds 2500 mm (Gorchov et al. 1995).

2.3   Sampling

Three one-week repeated surveys took place at High 1 in May 1995, May 1996 and May 1998. Low 1 was surveyed for a week in June 1996. High 2 was sampled for 13 days in February 1997, and Low 2 was sampled for two weeks in June 1997. We used strip transect sampling methods at each site, recording birds that could be accurately detected visually using unlimited distance contacts (Ralph 1981). We covered 89, 75, 62, and 69 km week^{-1} by boat and foot at High 1, Low 1, High 2, and Low 2; respectively. All abundance estimates were weighted by converting the total number of individuals observed into individuals per week.

3.   RESULTS AND DISCUSSION

3.1   Human Population Density and Macaw Abundance

During three weeks of surveys at High 1, we observed two *Ara arauna* (mean = 0.6 birds week^{-1}), zero *A. macao* (0.0), four *A. severa* (1.3), and seven *A. manilata* (2.3). During one week of surveys at Low 1, we observed
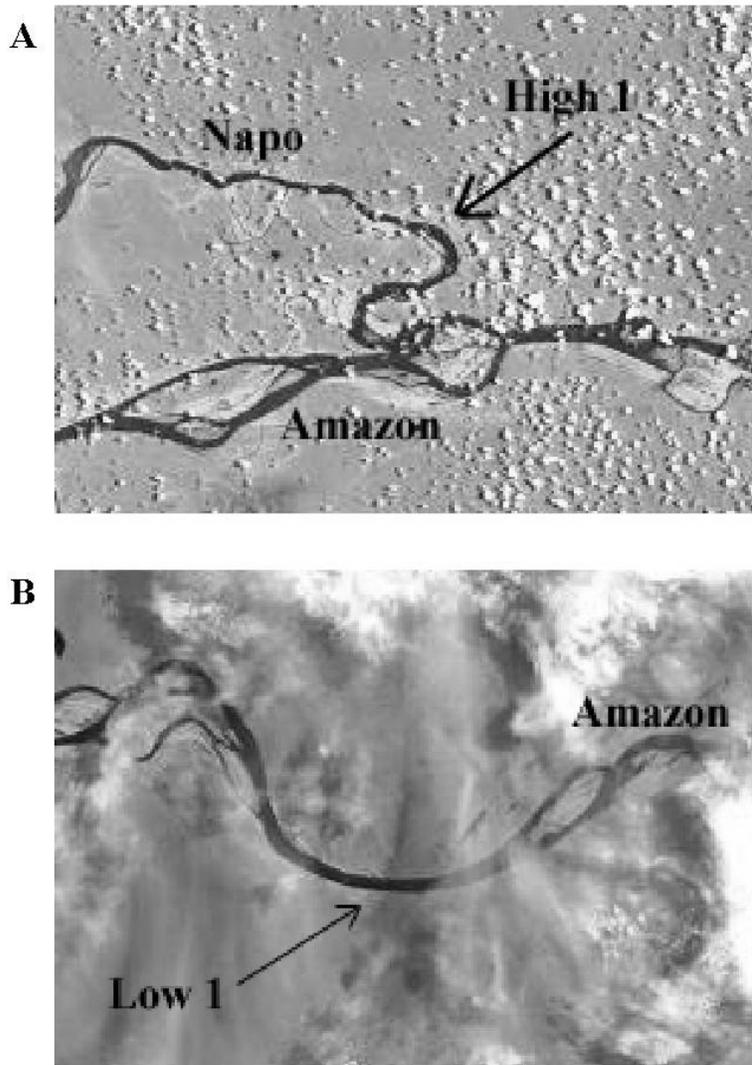
Figure 20.1. (A) Study site with high human population density (High 1) just upstream of the confluence of the Napo and Amazon Rivers. (B) Study site with low human population density (Low 1) on the Amazon River. Both images have some cloud cover (spotty in A, wispy in B), were taken by Landsat in 1999, and cover ~4800 ha. Variation in human population density is not evident in these images.

nine *A. arauna*, two *A. macao*, six *A. severa*, and four *A. manilata*. During 13 days of surveys at High 2, we observed 16 *A. arauna* (8.6), seven *A. macao* (3.7), nine *A. severa* (4.8), and zero *A. manilata* (0.0). During two weeks of surveys at Low 2, we observed 32 *A. arauna* (mean = 16 birds week^{-1}), six *A. macao* (3), five *A. severa* (1.5), and three *A. manilata* (2.5).

The differences between the average density of all four species is strong between High 1 and Low 1 (Fig. 20.2). Thus, *Ara* macaw abundance appears to be negatively correlated with human population densities at these sites. In Region 2, a similar trend holds for *A. arauna* and *A. manilata* between the High and Low sites; however, the opposite pattern occurs for *A. macao* and *A. severa*; the former is slightly higher and the latter dramatically higher at the high human density site. (Fig. 20.2).

These results must be interpreted cautiously considering their preliminary nature. While more intensive sampling is desired, this is often difficult, because macaws travel great distances on a daily basis (e.g., Terborgh 1986, Munn 1992). In light of this, we consider the relative affects of seasonal and annual fluctuations in fruit abundance (c.f. Terborgh 1986) as well as harvesting rates (c.f. Begazo 1997) as additional factors explaining the
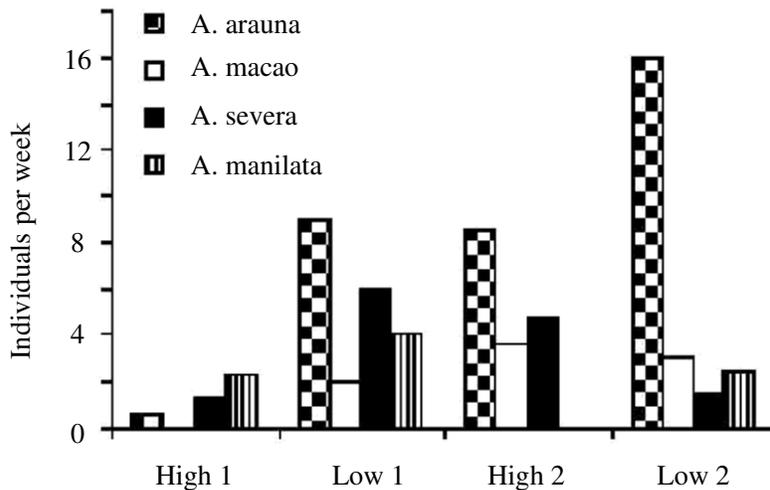

Figure 20.2. Relative abundance of macaws at sites with high and low human population density.

differences in the density of macaws between sites of high and low human population density.

3.2   Variation in Macaw Abundance

Seasonal fluctuations in fruit abundance may partly explain the reversed pattern for *A. severa* (and *A. macao*) between High 2 and Low 2; these two sites were sampled during high water (February) and low water (June) seasons, respectively.   Alternatively, annual fluctuations in fruit crop abundance (c.f., Terborgh 1986) may influence population abundance, because *Ara* macaws are moderate to strong specialists on specific fruits (e.g., Roth 1984). However, seasonal or annual fluctuations in fruit crop are weak explanations, considering the strong pattern shown for the other species (*A. arauna* and *A. manilata*) and other cases (i.e., High 1 vs. Low 1) when comparing sites of high versus low human population density. Moreover, large parrots typically do not fluctuate in seasonal abundance (e.g., Galetti 1997, Brooks 1998).

Rather, the main factor dampening macaw population levels in regions of higher human population density is likely overharvest, perhaps due to the pet trade rather than for a protein source. Multiple visits to the local markets by both authors in Iquitos (the large market town and central city in Amazonian Peru) failed to reveal macaw carcasses for sale. In contrast, baby macaws are often available locally as pets. Additionally, data from a number of Amazonian sites (Table 20.1) suggest that less than eight large macaws (i.e., *A. arauna* and *A. macao*) are harvested per site for meat each year on average. Moreover, macaws ranked in the lower 50% of all species taken per site (mean = 20th prey item consumed out of 38 species) and of only bird species taken for food (mean = 7th prey item consumed out of 15 species) (Table 20.1). For most rural Amazonians, macaw trapping appears to be opportunistic, but is likely an important activity during parts of the year in at least some Amazonian villages (Gonzalez 1999). Macaw trapping is likely to be more pervasive in villages located near large expanses of *M. flexuosa,* that are nesting areas mainly for *A. arauna*. This may partly explain the strong difference between populations of *A. arauna,* a species popular with the pet trade (Thomsen and Brautigam 1991)*,* at High 1 and Low 1 ($X^2_{(1)}$ = 7.35, $P < 0.01$). This corroborates the data of Gonzalez (1999) from Region 2, where 1718 psittacids (*Amazona* and *Ara*) were harvested from nests over a 4 year period (range = 166 – 680 birds year^{-1}) from 3890 ha of *M. flexuosa* palm swamps.

4.   POLICY AND MANAGEMENT IMPLICATIONS

Although laws may be established to prevent wildlife trade, the same laws, especially when not properly enforced, may actually exacerbate the effects of wildlife harvesting (Bodmer et al. 1997). For example, Thomsen and Mulliken (1992) indicated that Peru established laws restricting export of certain species, requiring a trapping license, and establishing a quota system in 1983, with trade being restricted to Amazonian species (i.e., those east of the Andes). Despite this, trade levels increased dramatically from <20,000 birds exported in 1983 to >50,000 exported in 1984 (the year after the law was passed; Thomsen and Brautigam 1991), and trade levels did not return to <20,000 birds exported yr^{-1} until 1986. Indeed, Peru was listed as one of the top five exporters of psittacids (Thomsen and Brautigam 1991).

The greatest impact of human activity on A*ra* macaws may be the harvest of palm trees and the resulting loss of nesting sites. At Manu in the southern Peruvian Amazon, the availability of nest sites appears to limit macaws (AJB, unpubl. data). The few natural nests available were fiercely defended by pairs that guarded them well before the breeding season began. When artificial nestboxes were erected in *Mauritia flexuosa* stands and in other places, these boxes were sometimes occupied by macaws within a few hours, and fights over the newly available nests were common. Additionally, it was common to see pairs patrolling the occupied cavities, apparently in search of an opportunity to seize a nest.

Palm trees are often cut to harvest and sell the fruit (Bodmer and Brooks 1997, Galetti and Aleixo 1998). Thousands of 25 – 30 year old palm trees are cut every year to sell the fruit for a value of $10 - 20 per tree. Consequently, both macaw food, in the form of palm fruits, and nesting sites

Table 20.1. Macaw harvest at various sites in the Amazon.

References	Location	# Macaws harvested yr^{-1}	Rank[a] / all sp.	Rank[a] / all birds
Hames 1979	Venezuela	6.4 *macao*	25 / 64	9 / 25
Vickers 1991	N. Ecuador	4.8 *macao*	19 / 48	7 / 20
Vickers 1991	N. Ecuador	0.8 *arauna*	38 / 48	12 / 20
Yost and Kelly 1983	E. Ecuador	16.0 *macao*	24 / 36	9 / 14
Begazo unpubl.	C. Peru	9.3[b]	-	-
Ayres 1991	S. Brazil (1978)	14.0[b]	6 / 26	3 / 9
Ayres 1991	S. Brazil (1980)	1.0[b]	7.5 / 8	1 / 2
	Mean	7.47[b]	20 / 38	7 / 15

[a]These data refer to the number in a ranked list where macaws were consumed (average) divided by the number of all vertebrates (all species) or birds (last column) consumed. For example 1 = most frequently consumed, maximum number = least frequently consumed.
[b]Data for *A. arauna* and *A. macao* combined.

are diminished. Additionally, any tree with a cavity containing baby macaws, parrots or toucans is also cut down to obtain the chicks.

Abating the impact of human activities near human settlements is an extremely difficult task. The conservation of Amazonian diversity will more likely be successful if strategies operate within the traditional exploitation system of rural Amazonians. Hunting patterns of ribereño people include frequent searches for wildlife in the areas surrounding the human settlements (short trips) to procure meat for the day's meal, and less frequent searches farther away from the human settlements (long trips) to procure larger wildlife. Given the socio-economic realities of rural Amazonians, it is unlikely that they will refrain from shooting large birds that are easy to procure, or refrain from cutting palm trees near settlements.

A strategy that considers both socio-economic and biological factors may help conserve Amazonian birds. This strategy includes the concept of a functional refuge (McCullough 1987, Joshi and Gadgil 1991). A functional refuge is the area or circumstance that protects resident animal species from being hunted to extinction. Functional refugia take advantage of spatial characteristics, such as being distant from human settlements, or comprised of habitats that humans find difficult to access, or they depend on human characteristics such as being located near areas where humans lack motivation to access those areas (McCullough 1987). Behavioral and biological attributes of Amazonian birds suggest that a functional refuge for tinamous can be realized in proximity to human settlement, while functional refugia for large cracids, trumpeters, and macaws may need to be located very far from human settlements (Begazo 1999, DMB pers. obs.). Hunters in the study site for which the macaw data were obtained took game within a 25 km radius of their settlement (Begazo 1999). Therefore, functional refuges that abate population decline and local extinction of macaws needs to exclude settlement within 25 km of their borders. Such distant areas are not subject to hunting or removal of chicks due to the impracticality of such activities.

In conclusion, our data suggest that overall, populations of *Ara* macaws are higher in regions with lower human population densities. While we hypothesize various cause and affect relationships, future studies of longer duration are needed to test our hypotheses. The studies of Gonzalez (1999) are more quantitative, and more adequately assess how chick harvest affects macaw abundance. Studies correlating variation in macaw populations with palm harvest and natural variation in resource abundance, especially fruit, would further our knowledge of how humans impact macaws.

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