A CASE STUDY OF THE EFFECTS OF LAND USE ZONING BY THE COFAN INDIANS ON THE CONSERVATION OF THREATENED CRACIDS (CRACIDAE) IN THE CUYABENO RESERVE, ECUADOR

by

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ABSTRACT

A Case Study of the Effects of Land Use Zoning by the Cofan Indians on the Conservation of Threatened Cracids (Cracidae) in the Cuyabeno Reserve, Ecuador (December 1993)

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Chair of Advisory Committee: Dr. Timothy Moermond

Program for Conservation Biology and Sustainable Development

A study of the effect of land use zones on the conservation of viable populations of threatened cracids (Family Cracidae), was conducted in the Cofan territory of Zábalo in the Cuyabeno Reserve of eastern Ecuador . Salvin's curassow (*Mitu salvini*), a cracid which exhibits high sensitivity to overharvest, was used as the subject from which to conduct the analysis. The objectives of the study were to (i) determine the relative frequency and density of Salvin's curassow in three land use zones; (ii) record sex and age-specific harvest of cracids; (iii) assess hunting protocol and community incentives for adoption of land use zones; (iv) calculate a minimum viable curassow population size which has a 99% probability of persistence for 50 years; (v) estimate a sustainable harvest and examine the impact of hunting, rates of curassow dispersal and zone size on curassow population trends.

Results suggest that a Salvin's curassow population which contains 300 breeding individuals has a 99% probability of persistence for 50 years. The conservation zone, with its current curassow population density, is of sufficient size to contain a viable curassow population for the next 50 years if the guidelines of the current land use plan are maintained. As such it can serve as an important source population for the adjacent hunted zones. The current curassow harvest exceeds this study's recommendations, which estimates that approximately twenty Salvin's curassows could be sustainably harvested annually from the hunted zones. The assurance of secure land use rights and economic return from ecotourism and scientific investigation are important factors affecting the adoption and continued enforcement of land use zones by the Zábalo community.

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I would like to express my gratitude to the members of the Zábalo community who were instrumental in providing orientation and assistance at the study site. They include Randy Borman, Anibal and Miriam Criollo, Toribio Aguinda, Carlos Gigoguaje, Oscar Machoa, Eduardo Gigoguaje, Silvio Chapal and Roberto Aguinda. Field work was carried out with the invaluable assistance of Betty Trujillo, Ruth Garcéz and Joanie Robinson. A special thanks to Michael Hedemark for his encouragement and help throughout the duration of the study.

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CONTENTS

Introduction

The objective of this study was to examine the potential of land use zones to conserve viable populations of threatened cracids (Family Cracidae), in the Cofan territory of Zábalo in the Cuyabeno Reserve of eastern Ecuador. Cracids are large turkey-like birds (Order Galliformes) which are distributed throughout the Neotropics. Six species are found in the tropical moist forest of Amazonian Ecuador and include wattled curassow (*Crax globulosa*), Salvin's curassow (*Mitu salvini*), nocturnal curassow (*Nothocrax urumutum*), Sphix's guan (*Penelope jacquacu*), common piping guan (*Pipile pipile cumanensis*) and speckled chachalaca (*Ortalis guttata*). Of these, the wattled curassow is considered endangered and the Salvin's curassow is listed as threatened (WCMC 1990). The cracids represent a group of large avian frugivores whose decline is associated with habitat loss and over-exploitation for human food consumption (Strahl 1990, Amadon and Gilbert 1981). In addition to being an economically important food source, cracids can also be important seed dispersers, playing a critical ecological role in regeneration of tropical forests (Redford 1992, Strahl and Grajal 1991). As habitat "islands" are carved out of tropical forests, large game birds are some of the first to face extirpation (Leck 1978, Thiollay. 1989, Simberloff 1986). Even in remote forests that seem visually intact, the numbers of popular game animals such as curassows can be severely reduced by human harvest (Redford 1992, Silva and Strahl 1991, Vickers 1991). Within the cracid group, the curassows exhibit characteristics of species vulnerable to extinction such as rarity, small clutch size and slow rate of maturity (Delacour and Amadon 1973). The wattled curassow has not been reported in any major ornithological survey or known native hunting kill for ten years in eastern Ecuador (Borman 1993, Hedemark 1990). The Salvin's curassow continues to be a sought after game bird in areas where it still occurs. It ranks highest in meat contribution among all the birds harvested in selected Siona-Secoya and Huaorani indigenous villages in eastern Ecuador, preceded in caloric value by only five large mammals (Vickers 1980, Yost and Kelly 1983). It is identified by Vickers

(1991) as the game animal which exhibits the greatest sensitivity to overharvest in forests along the Aguarico river within the Cuyabeno Faunistic Reserve.

The documented decline of cracids has prompted a call for the evaluation of the management of protected areas in the Neotropics (Strahl and Grajal 1991) and the identification of parameters for sustainable harvest (Silva and Strahl 1991). In Ecuador, all flora and fauna in natural forests are under the official jurisdiction of the state (Hicks 1990) who has issued no quantitative guidelines to govern harvest of game animals (Figueroa 1992). Although the country has legally established six protected areas in the Amazon region (Hicks 1990), colonization, deforestation and petroleum development take place within the designated reserves (Kimerling 1990, Nations 1990, Coello 1992). This is attributed to contradictory legislation regarding national priorities for management and utilization of the area's natural resources (Hicks 1990). Consequently, cracids can be categorized as an "open access resource", meaning that their exploitation is currently regulated only by access to the forests which they inhabit (Bromley and Cernea 1989). This implies that the resource is currently available on a first-come first-serve basis, which encourages short term individual gain at the expense of long term public conservation (Blaike and Brookfield 1987).

In an attempt to creatively deal with management challenges, the Reserva de Producción Faunistica Cuyabeno (Cuyabeno Faunistic Reserve) has enlisted the cooperation of indigenous residents to maintain zones of use in return for special regimes of land tenure within the reserve (FECODES 1992). In response to this incentive, the Cofan community of Zábalo has divided a territory of 81,000 hectares into three land classes described as zones of intensive use, moderate use and conservation (MAG 1992). The stated objective of the reserve plan is to limit activity to subsistence hunting by residents only, with the use of endangered and threatened species to be agreed upon with the reserve's area supervisor (FECODES 1992). In an agreement with the Ministry of Agriculture, the Zábalo community has stated that they will limit game exploitation to a subsistence level until specific sustainable rates of harvest can be determined (MAG 1992). The reserve plan calls for research which will determine rates of sustainable harvest and outlines plans for long-term monitoring.

Study site

The Cuyabeno Faunistic Reserve encompasses 655,780 hectares in the northeastern corner of Ecuador (Figure 1) and is considered one of the most biologically diverse areas of the world (Coello 1992). As a faunistic reserve, the area is dedicated to the production of wildlife and intended for sustainable use by indigenous residents. The reserve personnel include one supervisor and four rangers who live at the western border of the reserve. Large petroleum reserves were identified and have been developed in the in the western portion of

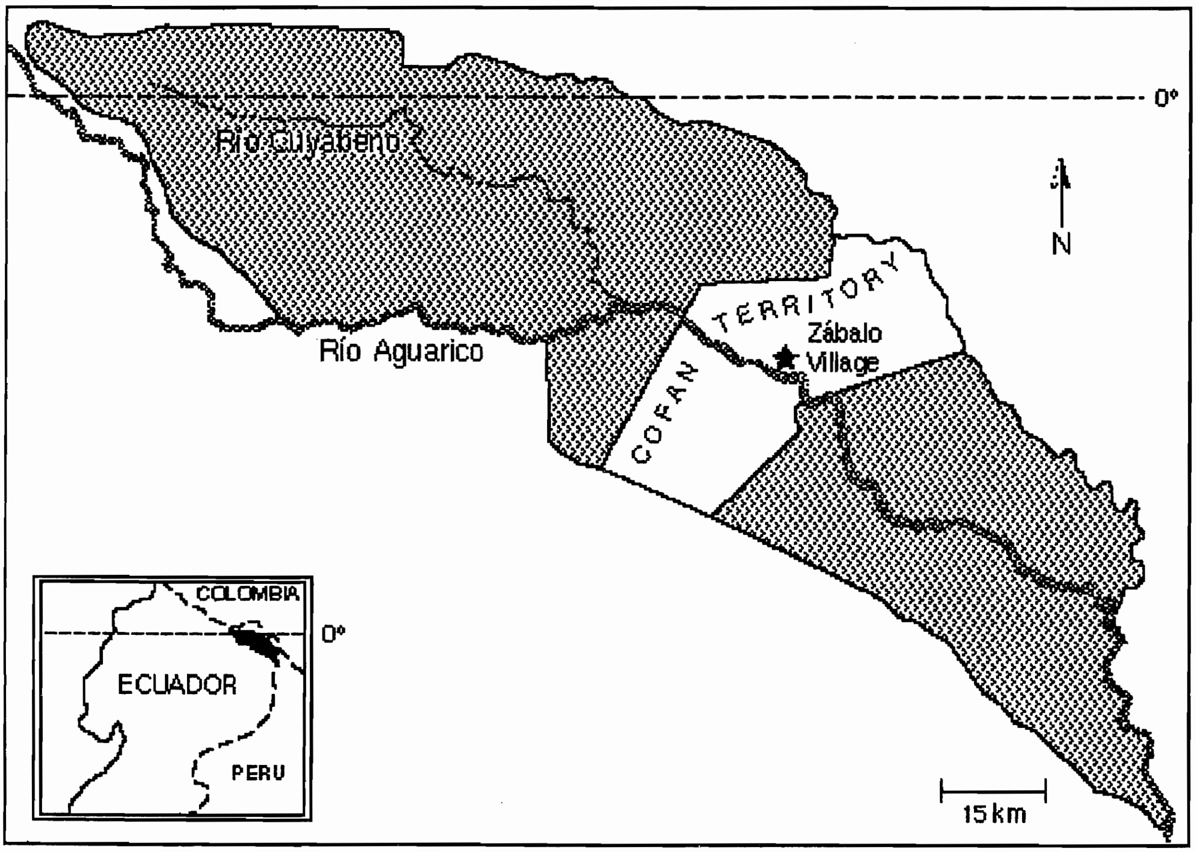

Figure 1. Map of Cuyabeno Faunistic Reserve in northeastern Ecuador, which includes the Cofan territory of Zábalo

the reserve. Intensive colonization occurred along petroleum pipeline roads such that the boundaries of the reserve were modified in 1991 to include 150,00 hectares which encompassed the territory then occupied by the Cofan community of Zábalo (MAG 1992). Today, a total of 1000 families live in the reserve with the major concentration still in the western half (Coello 1992). The reserve was administered by the Division of Parks within the Ministry of Agriculture until 1992 when institutional reorganization took place. Today, INEFAN, the Ecuadorian Forest Institute of Wildlife and Natural Areas, directed by a board of public and private officials, oversee the national protected areas.

The village of Zábalo is located in the eastern half of the reserve, (0^{o}, 21' S; 75^{o}, 40' W). The nucleus of the village is composed of 9 thatched houses with 9 more homes dispersed to the northwest along a 15 kilometer stretch of the Aguarico River (Figure 2, MAG 1992). Due to its location in relatively remote forest, the community is able to engage in more traditional hunting, gathering and subsistence horticulture typical of the Cofan culture than the remainder of the Ecuadorian Cofan nation (~600 individuals) who live closer to developed settlements which now harbor less game to hunt. Access to Zábalo is by motorized canoe and to the forest interior by foot. The territory claimed by the community is bisected by the Aguarico river and encompasses 81,000 hectares which is divided into three zones of use. The area labeled as Zone One is the intensive use zone where house construction, agriculture practices and harvest of any necessary resources is conducted . Zone Two is a moderate use zone in which sustainable fishing, hunting and collection of plant products for construction, medicine and firewood is to take place. Hunting is conducted with 16-gauge shotguns as the use of the blowgun has declined over the last ten years (Borman 1993). Zone Three is an area of conservation where only limited subsistence fishing and low impact ecotourism is permitted (MAG 1992). My analysis includes all zones except for the 17,000 ha. in the southern area labeled Zone Three. This zone was not included because 1) the habitat, monotypic palm forest of *Mauritia flexuosa* , is very different from the censused forest in the other zones (FECODES 1992) and 2) the Zábalo community currently does not frequent this zone and are less able to monitor if hunters enter the zone via access from the south border near the Napo river.

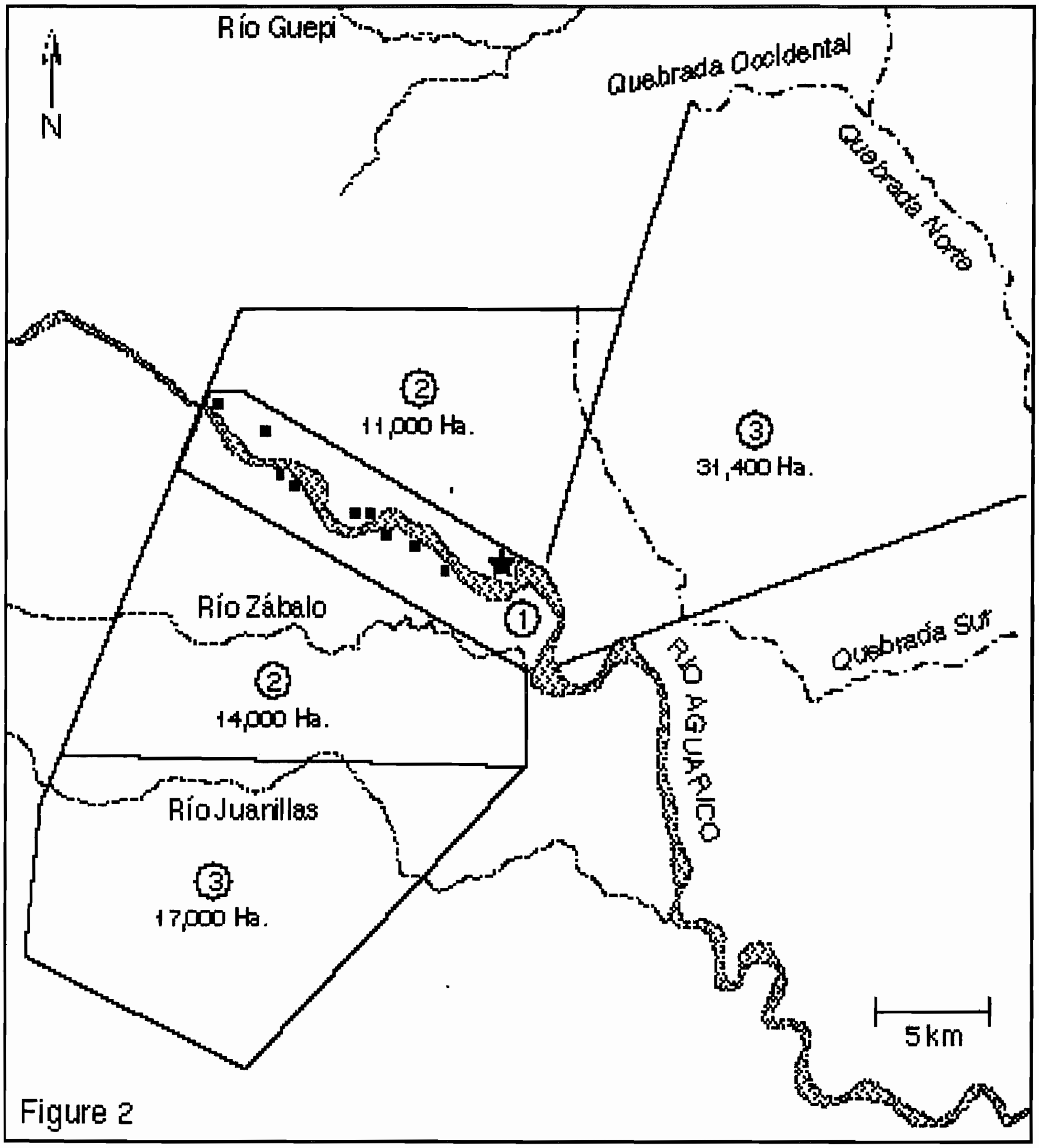

Figure 2. Territory of the Cofan community of Zábalo inside the Cuyabeno Faunistic Reserve. ★ Zábalo village (9 households), ■ Cofan households away from central village, ① Zone One composed of 7,000 hectares

The village site has a history of game exploitation which dates back to the 1930s (Borman 1993) (Figure 3). The Cofan established a temporary camp at Zábalo in 1979 with 1984 considered the official founding date of the village although there were still weeks when the site was unoccupied (Borman 1993). 1989 is recognized as the year of formal organization of the community which today consists of 105 members. The elevation of the area ranges from 180 to 250 meters (FECODES 1992). The landscape varies from well-drained hill forest to flat seasonally flooded forest. The hilly areas support a diverse flora while low regions are dominated by palm forest . The mean annual rainfall is 3500 millimeters with precipitation heaviest from May to July. The average temperature is 25 degrees Celsius.

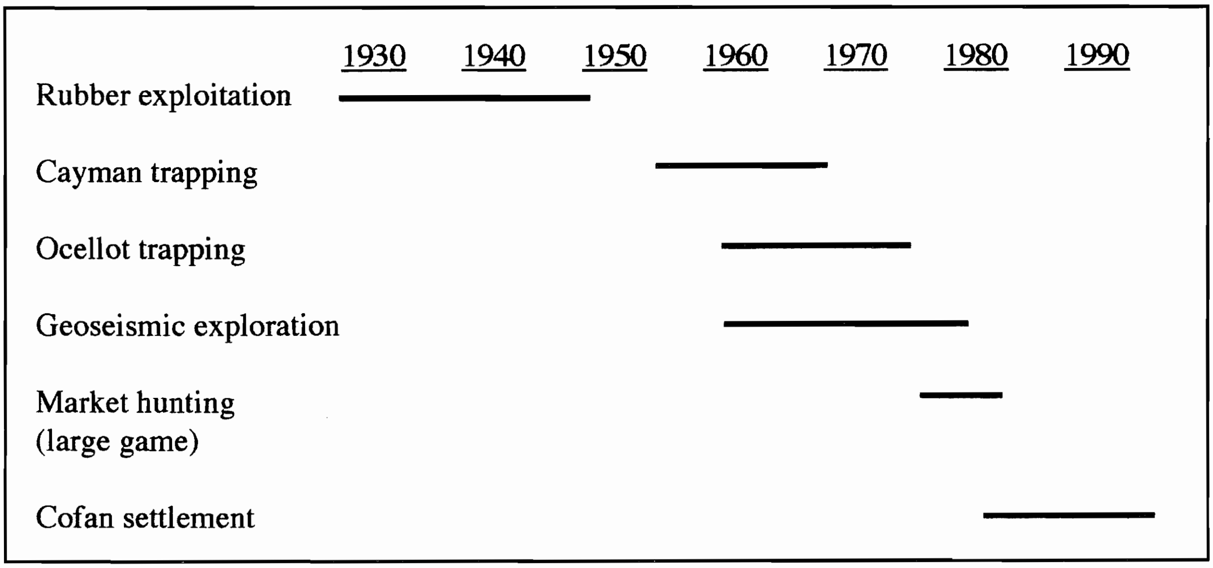

Figure 3. Periods of game exploitation in the area of the current Zábalo site

Methods

The case study was conducted by employing conventional systems analysis which required a variety of methodologies. Estimates of relative cracid abundance were obtained by line transects. Cracid harvest was documented by trained informants who completed standardized report forms for each hunting trip conducted in the village. Hunting practices were recorded by an Ecuadorian field assistant who conducted standardized interviews with hunters on preselected topics. In-depth interviews were done with individuals who were most active in land use regulations at the site. The population viability analysis for Salvin's curassow employed models of genetic, demographic and environmental stochasticity to assess probability of survival over a 50 year period. Stochasticity signifies an unpredictable event which may have catastrophic impact on a population's persistence.

Cracid population census

A census methodology for cracid populations (Silva and Strahl 1991) was utilized to estimate a relative frequency and density for each cracid species. Frequency simply represents the number of birds *heard* and *seen* per kilometer of transect walked. The results are expressed as individuals of each species per kilometer.

Density is determined by use of the formula

$$D = \frac{Z}{2\ \text{xcrit} \sum L}$$

where Z = the sum of individuals of a given species *seen* on all transects. Xcrit is a critical perpendicular distance determined for each cracid species by plotting each individual sighting against its own perpendicular distance to determine a maximum detection distance. The critical value of x is equal to the distance that corresponds to the drop in the frequency distribution of sighting distances. For the Salvin's curassow, xcrit was determined to be 10 meters (Figure 4). $\sum L$ is the sum of lengths of all transects. The results are expressed as individuals of each species per square kilometer.

The census was carried out from October 1992 - January 1993. These months overlap the breeding season of the cracids in the area and assured the maximum number of visual

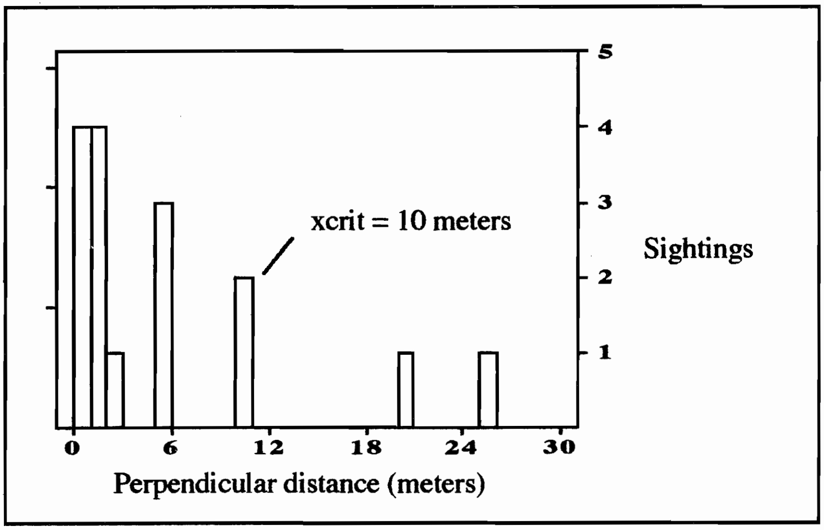

Figure 4. Perpendicular distance of Salvin's curassow sightings

and auditory cues by which to detect their presence. A total of seven transects were identified. They varied from 2 to 2.5 km. in length and were marked every 250 meters. Transects were walked between 0600 and 0900 by one observer. Table 1 presents the censusing regime and transect totals in the hunted and non-hunted zones. The trails in Zone One were used for hunting regularly on a weekly basis. Many had been used before the establishment of Zábalo (Figure 3) and "reopened" when the Cofan arrived in the 1980s. Trails in Zone Two were hunted seasonally and with less regularity than those in Zone One. Trails in the conservation zone experienced no hunting and had all been created in 1992 by members of the Zábalo community. All trails are located in rolling terra firme forest. This is characterized by humid, mature forest with little forest floor undergrowth. Ridges are well-drained, dissected by numerous small rivines which are not subject to inundation.

Harvest monitoring

To monitor cracid harvest in the village, we used both direct observations of hunting kills and more often, posthunt interviews with the hunter as utilized by Vickers (1980). For each hunting trip recorded, an individual hunting card was completed which documented the

Table 1. Censusing regime and transect totals for hunted and nonhunted zones

Zone	Month/Year	No. of transects	Total length of transects(km)
One	Oct. 1992	7	14
	Nov. 1992	10	21
	Dec. 1992	9	18
Two	Nov. 1992	2	5
	Dec. 1992	2	5
	Jan. 1993	8	20
Three	Nov. 1992	11	18
	Dec. 1992	20	44
	Jan. 1993	8	20
	Total	77	165

hunters in the party, the location, the number of cracids observed or harvested as well as other factors. Each harvested cracid was identified by sex and age (juvenile or adult) based on development of gonads.

To obtain a total picture of hunting effort, we attempted to record all hunting trips made by the village whether cracids were harvested or not. Since the community was dispersed along the river and we could not reach each home on a daily basis, we expanded our coverage by training four Cofan informants to assist with the completion of hunting cards with bi-weekly monitoring of informants to assure data accuracy. Hunting cards (n=159) were completed from November 1, 1992 to April 1, 1993. They compose a sample of 234 hunter days.

Hunter interviews

The Cofan live in extended-family households where it is the responsibility of men to provide meat for the household. We interviewed 21 of the 22 adult hunters in the village to determine the relative importance of wild game in their diet, document hunting protocol, and hunter attitudes regarding cracid decline and conservation. The interview followed a format utilized by Silva and Strahl (1991) and included twenty two questions in six categories.

1. Hunter background: Age and sex, years of residence at Zábalo, size of family and level of education
2. Food consumption: Preference for and consumption of wild and domestic meat, other foods cultivated or purchased, source of monetary income for food purchased
3. Hunting rights: Areas hunted, who else has access and if /how use is controlled
4. Cracid hunting: Which species are hunted, estimated number per year, hunting method, habitat, seasonality and rarity
5. Cracid conservation: Changes in hunting behavior if and as cracids diminish; if cracid harvest should be limited and if so, how, and by whom
6. Curassow sightings: Sightings and habitat of Salvin's curassow nests or chicks, sightings and habitat of wattled curassow

The interviews followed a standardized format and were conducted in Spanish by an Ecuadorian field assistant over the eleven weeks that we were living in Zábalo. In three interviews, a Cofan teacher in the village served as a translator for hunters that spoke little Spanish. In-depth interviews were conducted with the presidents of the Zábalo community and the Cofan Indigenous Association (ACOINCO). To establish credibility and trust between ourselves and the community members, the community president introduced and endorsed the interview activity at a community meeting at which time we were able to explain the components and goals of the study. Before the interviews were conducted, the questions were reviewed with the community president to avoid or modify any that would be inappropriate or elicit confusion. Questions to determine distance to a hunting site or number of cracids shot per year were most subjective. All distances were recorded in hours walking, the scale of the Cofan, and the estimated harvest could be later measured against actual harvest monitoring.

Population viability analysis of Salvin's curassow

I used Salvin's curassow as the subject of my population viability analysis since it represents the cracid which is most sensitive to overharvest in the area (Vickers 1991). The range of this species is confined to eastern Ecuador, northeastern Peru and southern Colombia (Delacour and Amadon 1973). It is associated with riparian vegetation within primary humid forest (Silva and Strahl 1991). Although it is likely subject to isolation in remaining forest fragments in cleared areas (e.g., colonization zones) it is probable that subpopulations can become isolated even in contiguous forest that is "fragmented" by centers of human population (e.g., indigenous villages, military camps, oil exploration sites) from which hunting consistently takes place (Redford 1992, Delacour and Amadon 1973).

Because of the lack of specific details of genetic, demographic and environmental factors which affect curassow populations, I utilize the literature available to date, along with conservative assumptions to conduct the viability analysis. Should subpopulations be reduced to low numbers, I assumed that inbreeding depression and loss of alleles could threaten genetic viability (Shaffer 1987). I adopted Soulé's (1987) recommendation that an effective population size (Ne) of at least 50 individuals is necessary to avoid genetic complications due to inbreeding coefficients greater than 0.01.

I used a modification (Reed et al. 1986) of Hills's (1972) estimator of an effective population size to determine the number of curassows needed to provide an effective population size of 50 which would avoid genetic stochasticities. The formula for monogamous species is

$$Ne = L \times Nbr \times k \times l$$

where L is the mean age of all individuals that reproduce in a population with a stable age distribution, Nbr is the number of breeding individuals to be determined, k is the number of offspring per pair per year and l is the probability that an individual survives to the mean age of reproduction and breeds. A stochastic simulation model which annually varies fecundity and survival was utilized to estimate the probability that various initial population sizes would have of persisting for 50 years, considering environmental and demographic stochasticities. To test the ability of the current Cofan land use plan to maintain a viable population size, I constructed a demographic simulation model (Figure 5) which illustrates variations in population trends in the zones of hunting and non-hunting due to changes in the parameters of curassow harvest, dispersal and zone size. A ceiling on population size was set for each simulated population and hunting was assumed to be additive.

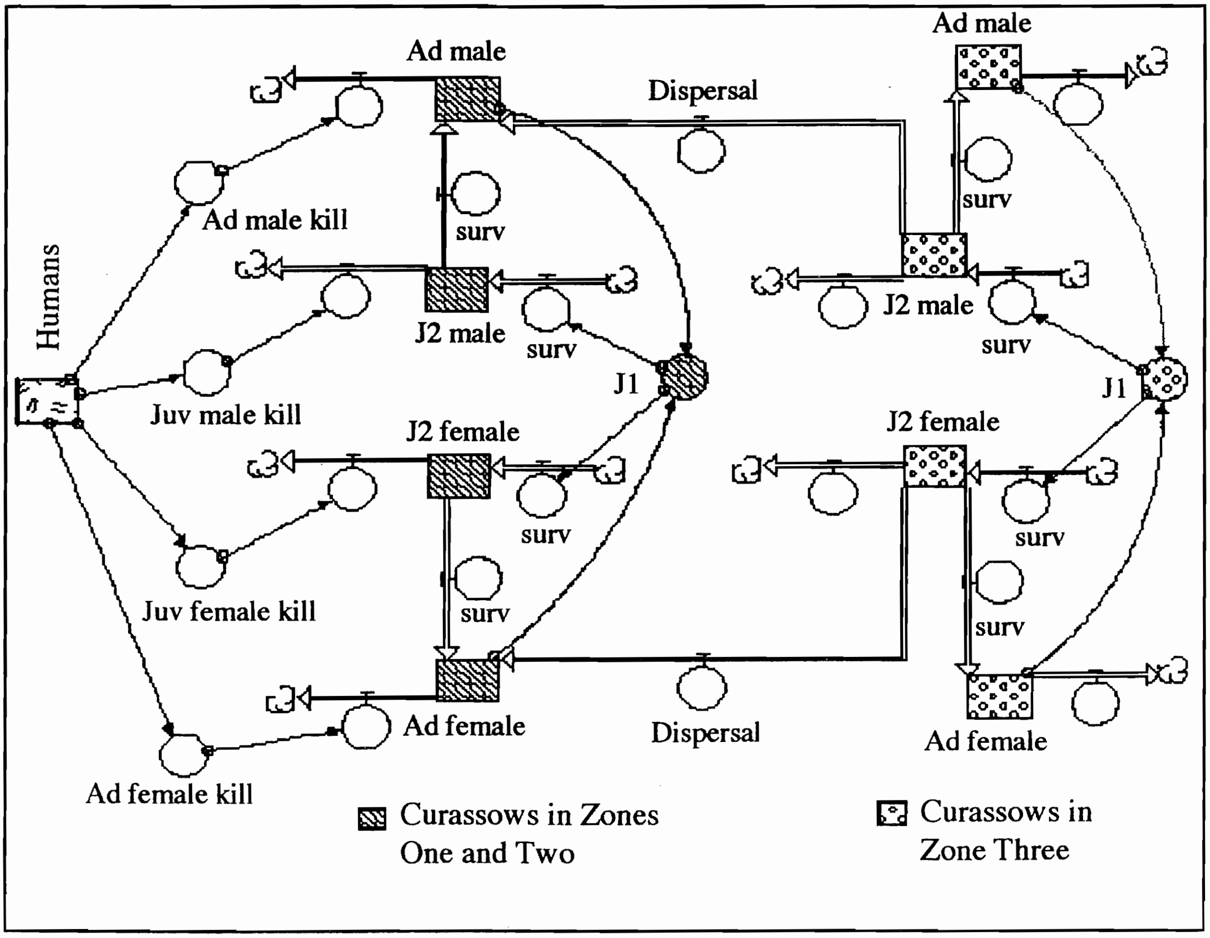

Figure 5. Demographic simulation model of the Salvin's curassow population in hunted and non-hunted zones.

Results and Discussion

Cracid frequencies and densities

The relative frequencies for Cracidae in the hunted and non-hunted zones are presented in Figure 6. Results indicate that even in the non-hunted forest, Salvin's curassow occur with much lower frequency than the guans. The relative density of Salvin's curassow

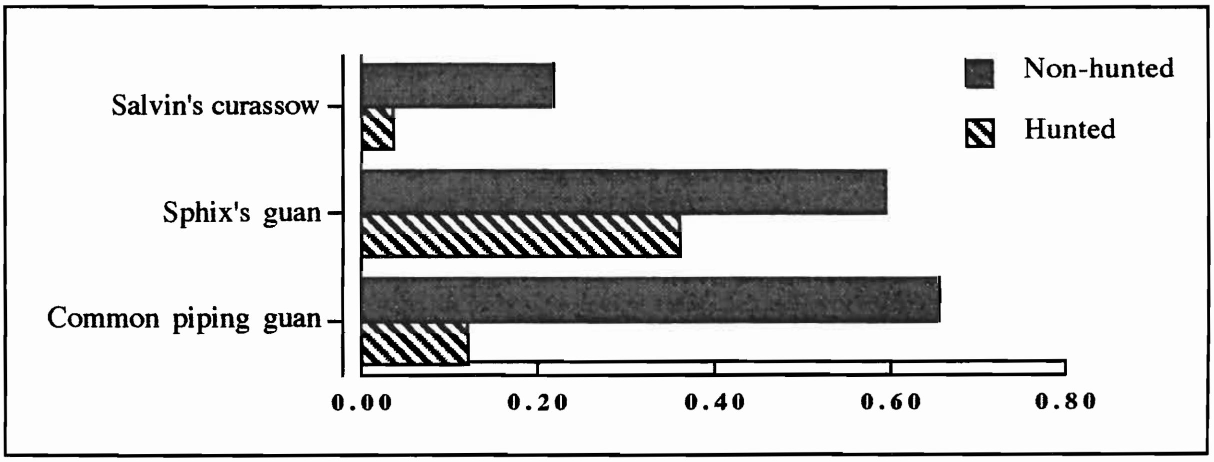

Figure 6. Relative frequencies of cracids in hunted and non-hunted zones

in the hunted and non-hunted zones is shown in Table 2. The density in the non-hunted zone is 2.5 times higher than those found in in any habitat in other censused areas of eastern Ecuador (Johnson and Hedemark 1989). This supports the assumption that the non-hunted zone has not been exploited in recent years (Borman 1993) and suggests that some feature of the habitat may be particularly appropriate for the production of this species. The significant

Table 2. Relative population densities of Salvin's curassow in hunted and non-hunted zones

Zone	Z (# of ind. seen)	Birds/ sq. km.
One	1	0.94
Two	2	3.33
Three	18	9.15

impact of hunting on curassow densities is consistent with censuses conducted in French Guiana, Venezuela and other sites in Ecuador (Thiollay 1989, Silva and Strahl 1991, Vickers 1991).

Age and sex specific cracid harvest

The age and sex specific harvest of three cracid species is presented in Figure 7. Only occasionally were nocturnal curassow (n=2) and speckled chachalaca (n=2), harvested.

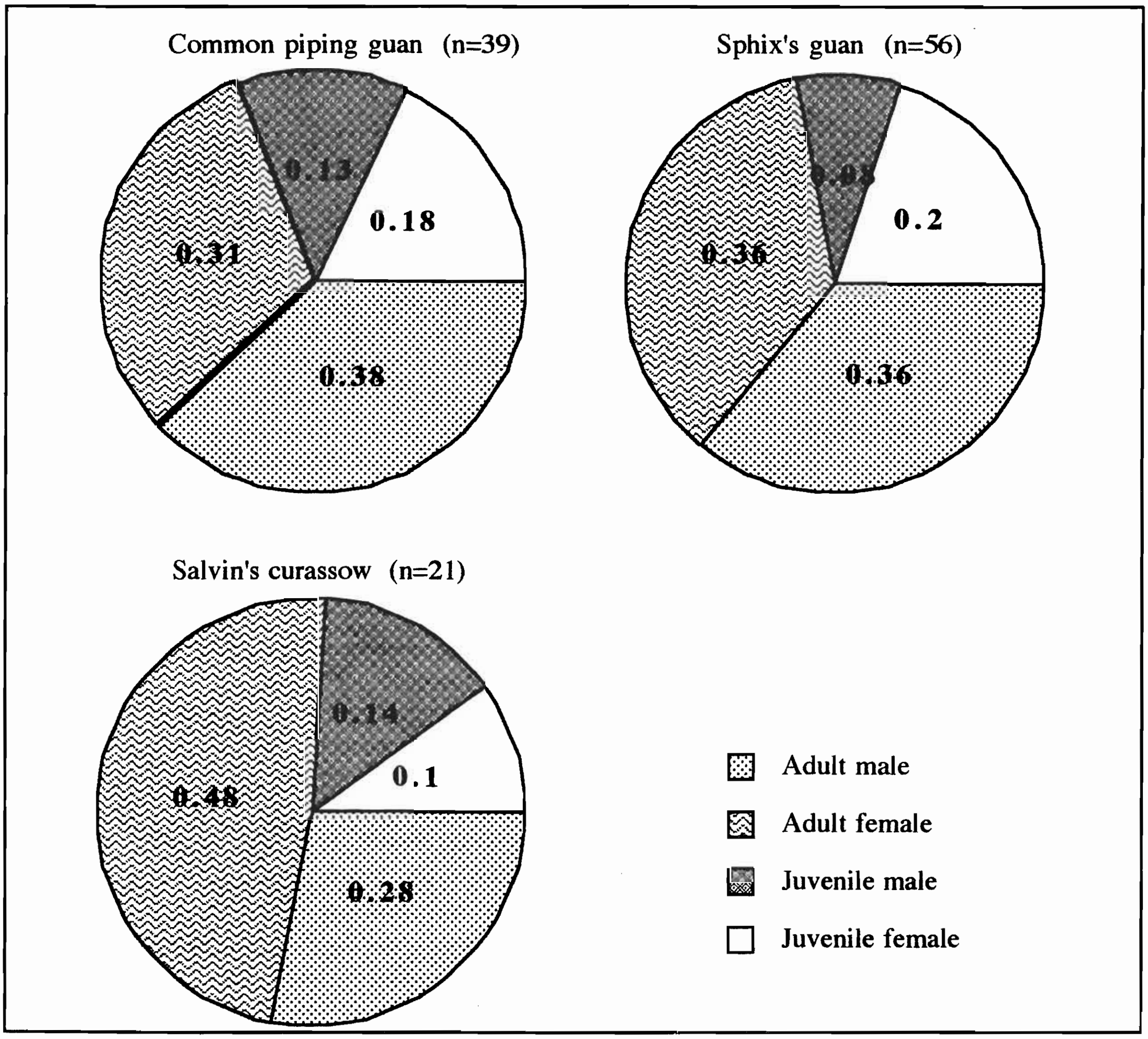

Figure 7. Cracid sex/age mortality. Percent of total individuals harvested (n) in each sex/ age class, November 1, 1992 - April 1993.

If harvest remained constant throughout the year, the harvest rate of each species (total annual harvest divided by the number of consumers) would be .48 Salvin's curassow (*Mitu salvini)*, 1.28 Sphix's guan (*Penelope jacquacu)* and .89 common piping guan (*Pipile pipile cumanensis)* per consumer year. When compared to a survey of harvest in other indigenous and colonists settlements in the Amazon basin (Redford and Robinson 1987), the average annual harvest of *Mitu sp.* was greater in other areas, 0.64 *Mitu sp.* (n=6 settlements). Less *Penelope sp.*, 0.706 (n=13 settlements) and *Pipile sp.*, 0.654 (n=6 settlements) were harvested on average at the other sites.

Hunter interviews

The population of Zábalo is one hundred and five individuals which consists of twenty couples and their children. The average hunter is thirty four years old which signifies a relatively young community with capacity for further population growth. To control growth, immigration of families from outside of Zábalo is being limited by the community. Levels of education in the community rank from zero to thirteen years of school enrollment with approximately four years being the average. Tourism is the principle source of economic income followed by scientific investigation. Each household sells craft items to tourists, some men work as tourist guides and others have recently begun to assist scientists with research projects that are based out of the Zábalo community. Within the last year, some community members have formed their own ecotourism business and have recently begun to provide wilderness trekking trips into the Zábalo conservation zone .

Food consumption is summarized in Figure 8. As indicated, the principle components of the diet utilized in almost every household are wild game, bananas, manioc and rice. When asked which type of wild game they preferred, avian or mammalian, the majority responded that their hunting choice was dictated more by seasonal availability and amount of meat return per shotgun shell expended than preference. For example, a hunter with a very

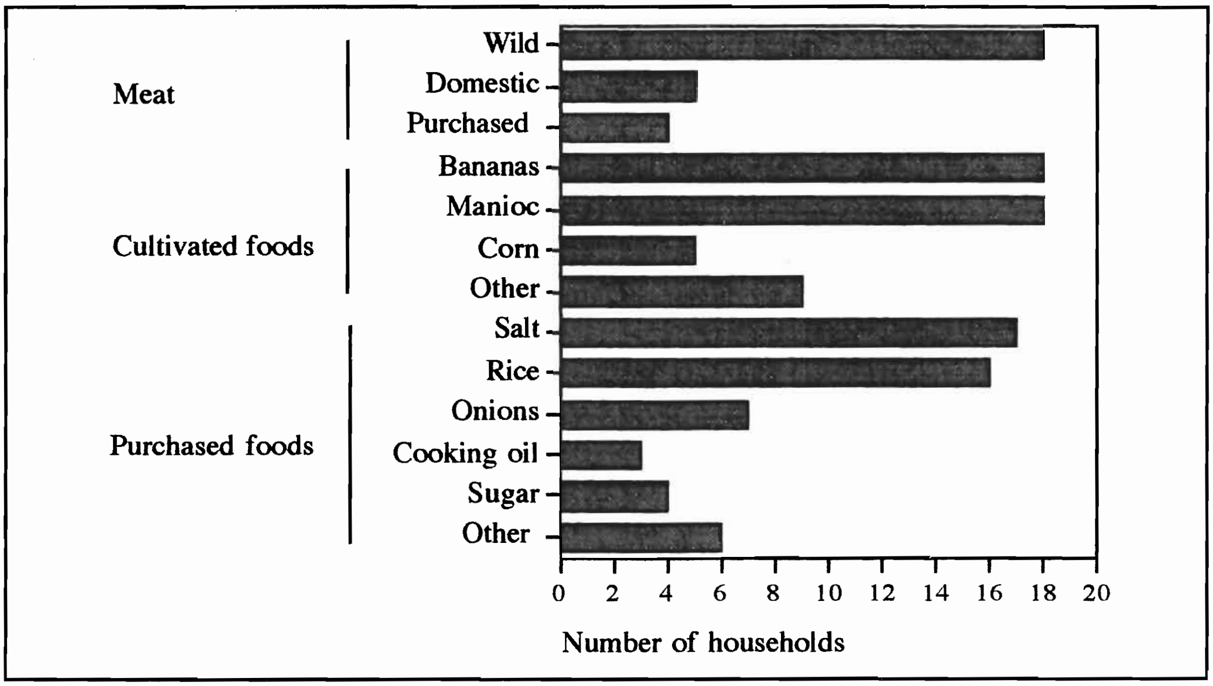

Figure 8. Principle foods utilized in the eighteen households in Zábalo village (average of six individuals per household).

large family chose to expend energy in white-lipped peccary kills because they yielded access to more meat for shells shot. Others harvested many common piping guan in November and December when the "tamaricho" tree (*Brosimum guianense)* was in fruit and guans were readily found feeding there. The estimated annual cracid harvest (Table 3) is consistent with the distribution of cracid kill registered in the hunting cards (Figure 7) as well as with the relative occurrence of cracid species indicated by forest census (Figure 6).

Table 3. Estimated annual cracid harvest for 1992 (Source: hunter interviews)

Species	Harvest (individuals)
Salvin's curassow	51
Sphix's guan	145
Common piping guan	118

Table 4. Summary of hunter response to questions regarding hunting rights and cracid management (sum of hunters interviewed = 21)

- Ownership of Cofan land is considered comunal (n=21).
- Only Cofans and permitted guests are considered to have rights to hunt (n=18). Anyone can enter and hunt (n=3).
- Access to hunt is controlled by the community presence along the river(n=14). No control is necessary (n=3). Unsure (n=4)
- The number of curassows and guans have declined since the hunters' youth (n=21).
- As cracids have declined in number, hunters have switched to hunt other species (n=10), hunters go farther to hunt(n=3), hunters have switched to other species *and* go farther for the same species (n=6). Unapplicable (n=2)
- Hunting of curassows and guans should be limited in some way (n=18). Hunting should not be limited or unsure (n=3).
- The community should be in charge of cracid protection (n=12). Protection is the responsbility of reserve guards (n=3). Unsure (n=6).

Responses to questions regarding cracid decline and conservation are summarized in Table 4. Most hunters felt that they were able to currently restrict hunting access to only the Cofan. Many indicated that they, rather than park guards, were best able to provide for the protection of the conservation zone since they lived at the site. The president of the Zábalo community cites three incentives which have influenced the adoption of land use zones by his community. They are 1) the need to adhere to land use guidelines outlined in the plan for settlements in the Cuyabeno Reserve, such that secure rights to land access and use is attained; 2) the economic income which can be gained by the community through ecotourism and scientific investigation in an ecologically intact forest; and 3) the augmentation of game supply in the hunted area from a conservation zone . The most critical incentive is the desire to obtain secure land rights such that the latter two benefits are assured to the Zábalo community who now maintains the conservation zone (Borman 1993). It was clear that should the current arrangement of land access and use be threatened and if the Zábalo community needed the game supply, that there would be much less incentive to continue with the current protection plan.

Population viability analysis

Minimum viable population

Observations suggest that Salvin's curassow exhibits characteristics which are typical of species with a monogamous mating system (Santamaria and Franco 1993, Johnson and Hedemark 1989, Buchholz 1990). Based on these observations, the operational sex-ratio is assumed to be 1:1 males to females. Throp (1964) indicates that clutch size ranges from 2, to occasionally 3 eggs. Silva and Strahl (1991) suggest that an assumption of 1.5 offspring annually per pair is a liberal fecundity estimate based on Skutch (in Buckley et. al. 1985). Observations (n=11) by Cofan hunters of curassow pairs with chicks reported an average of 1.55 chicks per pair. Since this does not account for pairs who fledge no chicks, I will assume a more conservative mean number of curassows fledged per nest to be 1.25. Throp (1964) and Olson (1971) say that successful breeding of Salvin's curassows is not to be expected until birds are two years old. Estudillo (1985) reports that birds are fertile in their third year of age. I utilized a reproductive age of 2 with the assumption that some infertility is already reflected in the reduced fecundity rate of 1.25. The number of males and females produced by each breeding female is assumed to be equal. A generous annual survivorship estimate for juvenile and adult curassows is considered to be 0.80 (Silva and Strahl 1991). I conducted my calculations with more conservative survivorship figures of 0.75 for adults, 0.70 for second year juveniles and 0.60 for first year birds. While these rates of survival remain high as compared to other gamebirds, they are also consistent with the observation that other large-bodied gamebirds experience rates of survival which are higher than smaller game species (Dobson, Carper and Hudson 1988). The oldest Salvin's curassow known from a captive population was 24 years old (Delacour and Amadon 1973). Given an adult survivorship of 0.75, an average age of 6 was assigned to the reproducing adults in the population. Given these parameters, the probabilities of a newly hatched Salvin's curassow surviving to breed at age 6 is 0.13. Following the equation presented for monogamous species (Reed et. al.), an actual population size of 50 breeding individuals, plus the nonbreeders, would be sufficient to maintain an effective population size of 50.

This calculation only suggests that a breeding population of 50 Salvin's curassows can likely avoid genetic stochasticities, but does not consider the threats of population fluctuation due to demographic and environmental stochasticity (Goodman 1987). While little is known about the sensitivity of curassows to such phenomena, we can speculate that both skewed sex ratios and isolated breeding individuals seem possible in areas where hunting has severely fragmented the population. To simulate the impact of possible stochastic events, I used an age-structured simulation model to run 250 replications in which annual fecundity and survival varies to estimate likelihood of a population surviving for 50 years. The variables included in this model were those obtained from the sources used to calculate a minimum viable population. For lack of more accurate data, generous coefficients of variation are utilized. The proportion of females in the population is assumed to be 50%. Females breed at 2 years of age, and the number of young produced per female averages 1.25 (CV = 0.40). Annual survival of first year juveniles is 0.60 (CV=0.25), of second year juveniles is 0.70 (CV=0.20) and of adults is 0.75 (CV=0.20). To determine the impact of initial population size on probability of extinction, I conducted six simulations, each with a different starting population size. The initial populations contained 50, 100,200, 300, 400 and 500 adults, respectively, with an equal number of juveniles in each population which is based on the estimated stable age distribution for the population. With an instantaneous rate of increase (r) of 0.01, the probability that any of these populations will fall below a specific threshold some time during a 50-year period is depicted in Figure 9. Only when the initial number of breeding individuals approached 300, was a 99% probability of curassow persistence for 50 years achieved.

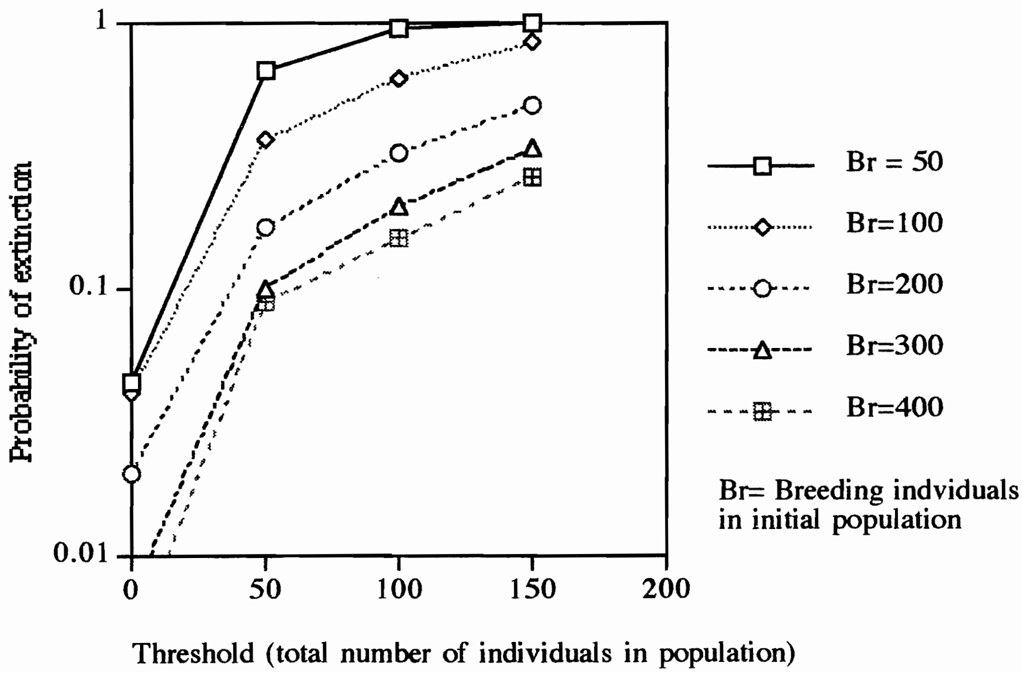

Figure 9. Log of probability that Salvin's curassow populations with differing numbers of breeding individuals in the initial population will fall below a specific threshold of individuals some time during a 50-year period.

Probability of extinction in the non-hunted zone

The northern Zone Three contains 314 square kilometers with a censused density of 9.15 Salvin's curassows per square kilometer. This represents a relative density determined by line transects which may result in an underestimate of actual densities due to undetected birds and over-looked parts of home ranges (Thiollay 1989) resulting in a conservative population estimate. Based on a stable age distribution, I estimate that the population would contain approximately 1437 adults, 545 second year juveniles and 891 first year juveniles.

According to the population viability analysis, this zone, with its current population density, is of adequate size to currently support a viable population of Salvin's curassow with a very low probability of extinction (Figure 9).

Probability of extinction in the hunted zone

Zone One contains 70 square kilometers with a censused density of 0.94 Salvin's curassows per square kilometer. Based on a stable age distribution, the population would contain approximately 33 adults, 12 second year juveniles and 21 first year birds. According to my calculations, this area of the hunted zone with its current population density, does not support a viable population of Salvin's curassow which is capable of withstanding demographic, environmental or even genetic stochasticity.

Zone Two is made up of 250 square kilometers and has a censused density of 3.33 curassows per square kilometer. Based on a stable age distribution, the population would contain approximately 415 breeding adults. This zone, with its current population density, does contain a population of Salvin's curassow that show a very high chance of persistence for the next 50 years (Figure 9). The entire hunted area, composed of Zones One and Two has a censused density of 2.81 curassows per square kilometer.

Maintaining a viable curassow population

The population viability analysis suggests that the sum population of curassows in Zones One, Two and Three is sufficient to avoid genetic, demographic and environmental stochasticity over the next 50 years. Can viable curassow populations be maintained if current rates of harvest and human population growth continue? To assess the viability of the Salvin's curassow population at the site, I constructed a model (Figure 5) which simulates the current curassow population and examines the impact of human population levels, zone size, rates of curassow dispersal and harvest on curassow population trends.

The variables included in the model were those obtained from the sources used to calculate a minimum viable population. Females breed at 2 years of age, and the number of young produced per female averages 1.25. Annual survival of juveniles is 0.60 for first year birds and 0.70 for second year individuals and of adults is 0.75. In Zone Three, the initial population size used for this model included 1436 adults, 545 second year juveniles and 891 first year juveniles based on censused density calculations and a stable age distribution. In the hunted zone, the initial population size was composed of 448 adults, 170 second year juveniles and 279 first year juveniles. Based on Cofan interviews (Table 3) and harvest measurements I assume an annual curassow harvest of 50 individuals which is double that which was measured at Zábalo in five months from November 1, 1992 - April 1, 1993 (Figure 7). This is consistent with Yost and Kelly (1983) who demonstrated that hunting yields of Salvin's curassow are not constant throughout the year, being slightly less from April through August. A harvest of 50 individuals is equivalent to 0.48 Salvin's curassow per consumer year (total annual curassow kill divided by the village population) which is only slightly less than the average of 0.64 *Mitu sp.* (range .007-2.26) taken per consumer-year in six other Amazonian settlements (Redford and Robinson 1987). In the model, the percentage of the population of curassows harvested from each age and sex class remain the same each year and are distributed according to that observed in Zábalo from November 1, 1992-April 1, 1993. Given the calculated initial population of the hunted zone, the annual harvest of adult males from the hunted zone is 6%, of adult females is 11% and of juvenile males and females respectively, is 8% and 6%.

<u>Importance of curassow dispersal from a source population</u>

No studies have yet examined dispersal distances for Salvin's curassows. Based on observational accounts, it is assumed that they are interior forest species, frequent the edge of the forest only for water during the dry season and are poor fliers (Delacour and Amadon

1973). While this behavior may impede movements between subpopulations divided by clearings, it gives no information about their movements through contiguous forest. Since curassow chicks do not reach adult size and plumage until they are from 7-10 months, I made the assumption that young are affiliated with their parents at least until this time (pers. observation) and begin to disperse in their second year, prior to adult breeding. To examine the potential impact that this variable has on the Zábalo population, I conducted a sensitivity analysis in which dispersal of second year juveniles from Zone Three to the hunted zone varied from 0 to10% of the second year juvenile population in Zone Three.

The results of the dispersal sensitivity analysis are shown in Figure 10. At the current rates of harvest, with no migration from Zone Three to the hunted zone, the growth rate

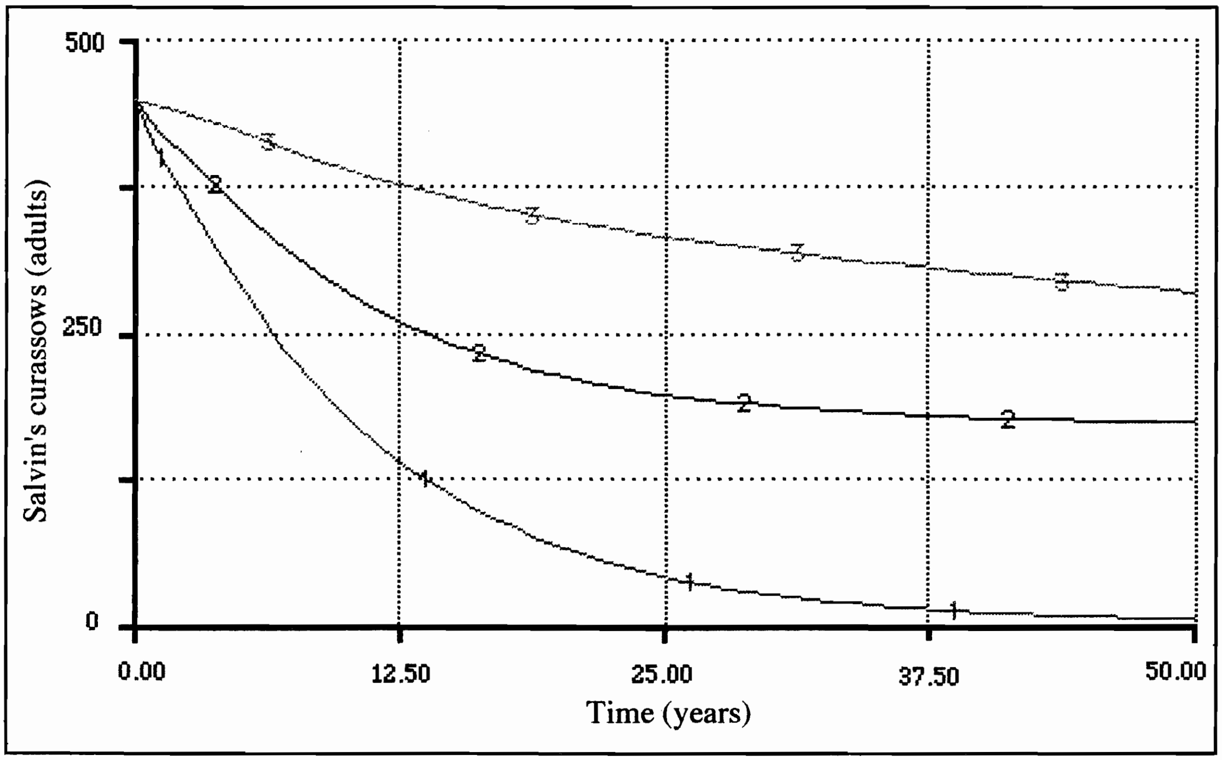

Figure 10. Abundance of adult Salvin's curassows in the hunted zone with three different percentages of juvenile dispersal from the non-hunted zone. The percentage of second-year juveniles in the non-hunted zone which annually disperse to the hunted zone is 1) 0.00, 2) 0.05 and 3) 0.10.

declines (r= -0.10). The number of breeding adults in the hunted zone (Zones One and Two) at the end of a 50 year simulation is approximately 3 individuals, well below the viable population recommendations. At rates of juvenile dispersal from 5% - 10%, population growth rates decline less drastically (r = -0.02 to -0.01) in the hunted zone, although population densities are low, ranging from 0.02 - 1.70 curassows per square kilometer. A 5% migration rate results in approximately 170 breeding individuals in Zones One / Two at the end of the 50 year simulation with approximately a 95% probability of persistence (Figure 9). The model indicates that when second year juvenile dispersal rates are as great as 10%, the current rates of harvest in Zones One and Two begin to exceed population growth in Zone Three such that Zone Three begins to exhibit negative growth rates (r = -0.01). This impacts juvenile dispersal and results in a slow down in population growth in the hunted zone. It is questionable whether this would actually occur since we are yet unsure of the exact mechanism which determines dispersal in curassows. Studies have suggested that some curassow species perform seasonal movements (Thiollay 1989, Leopold 1972). If this is is the case for Salvin's curassow, such movements could precipitate population declines in Zone Three if individuals are over-harvested while present in Zone One/Two.

This exemplifies the potential importance of a source population to compensate for harvest of a normally slow growing population in the hunted zone such as that suggested by Thiollay (1989). If no such source population were available or if dispersal is not taking place, harvest rates certainly must be reduced to maintain the population in a hunted zone. In the case of Zábalo, my model is conservative since additional dispersal of curassows from contiguous forest to the west and east of the hunted zone, outside of Cofan territory, may currently be serving as additional sources of curassow dispersal which augment the hunted population. As human settlement in these adjacent "unprotected" forests takes place, Zone Three may become the only source population. To assess the impact of such a scenario, I conducted an additional simulation in which curassows from Zone Three were dispersed to all areas surrounding the zone. Using the parameters of the previous scenario, I assumed that 5% of the second year juveniles in Zone Three would disperse to Zones One / Two. One-quarter of the perimeter of Zone Three abuts Zones One / Two. Assuming that an equal number of curassows will disperse in other directions, another 15% of the second year juveniles in Zone Three were annually removed from the model. This resulted in an annual decline (r= -.03) of curassows in the source population. After 50 years, a total of approximately 300 adults remained in Zone Three. Although the population would still retain a high probability of persistence at that time (Figure 9), further declines would increase risks of extirpation.

Effects of increasing rates of harvest

With some dispersal from a nearby source population, the previous simulation suggests that a population of approximately 150 curassows could be expected in the hunted zone in 50 years. Traditionally, as the game in an area declined, indigenous Amazonian settlements dissolved and moved to new sites before the game was decimated, allowing for resource renewal (Vickers 1980). It is unlikely that indigenous groups within the Cuyabeno Faunistic Reserve can do this as all lands along the Aguarico river up to Peruvian border are now claimed and/or occupied by some human settlement (FECODES 1992). Foreseeing this problem, Zábalo is currently limiting the number of families which can enter the community (Borman 1993, Aguinde 1992). They are doing this to protect their ability to continue a traditional hunting lifestyle and to honor the wishes of the INEFAN who wants to restrict human population growth inside reserve boundaries. Even without immigration, if the population of the village continues to experience birth and death rates similar to the national average of 0.032 and 0.007 respectively (World Bank 1990), the Zábalo population will grow to 360 individuals in 50 years.

To estimate the impact of increasing curassow harvest rates as a result of rising human population, I modified my model such that the current percent of harvest from each curassow age/sex cohort is multiplied by the annual percentage increase in human population (humans at time *t* / human population now). The annual harvest of adult males from the hunted zone is 6%, of adult females is 11% and of juvenile males and females respectively is 8% and 6%. Values for survival and fecundity parameters are the same as those used earlier. An annual dispersal rate of 0.05 second year juveniles from Zone Three to the hunted zone was utilized. This assumes that curassow harvest does not increase in direct proportion to increases in human population. Instead, hunting success is based on curassow abundance in each cohort and, as stated in the hunter interviews, that hunters will switch to other game as curassows become scarce.

Under this simulation, the results indicate that the number of breeding adults is reduced to approximately 50 individuals after 50 years ($r= -0.04$)). Kill rates of Salvin's curassow decline from the present 0.48 curassows per consumer year to 0.05 per consumer year. The decline is consistent with, but less severe than that shown by Vickers (1991). He documented kill rates (individuals harvested per man hour of hunting) of Salvin's curassow that declined steadily (approximately $r = -0.35$), suggesting severe depletion of the curassow population within nine years, which took place in a territory approximately three times larger with three times as many people and on the same river system as Zábalo. Hunter interviews indicate that fishing is a frequent activity in Zábalo. If fishing is a productive pastime in villages,the extent to which they hunt in the forest is proportionately reduced (Ross 1978). If this is not the case, my model may underestimate the impact of increased harvest on curassow populations due to rising human population at the site.

<u>Determining sustainable rates of harvest</u>

Even if curassow populations are decimated in the hunted zone, my analysis suggests that a viable population for conservation purposes will continue to exist in the area encompassed by Zone Three. Yet this does not resolve the problem of the lack of a sustainable supply of curassows for the Cofan to harvest in Zones One and Two. Using my existing model, I conducted a sensitivity analysis to determine the impact of restricted hunting based on a relative curassow density in the hunted zone. In the analysis, the current rates of harvest were exercised only if the total population density in Zones One and Two was greater than a prescribed density threshold. The density thresholds ranged from 0.50 - 2.50 curassows per square kilometer. Values for annual harvest, survival and fecundity parameters are the same as those used in the initial model. A annual dispersal rate of 0.05 second year juveniles from Zone Three to the hunted zone was utilized.

The results of the sensitivity analysis in Table 5 indicate that a 20% difference in the average number of birds harvested per year, 20 individuals instead of 25, over a 50 year

Table 5. Total kill of Salvin's curassow over 50 years when hunting is conducted only when curassow population density in Zones One and Two is above a specific threshold

Density threshold (ind./sq. km.)	Total kill (ind.)	Annual average kill (ind.)
0.5	1240	25
1.0	1215	24
1.5	1130	23
2.0	1026	21
2.5	1006	20

period would maintain five times as many curassows (a density of 2.50 instead of 0.50 individuals per square kilometer) in the hunted zone (Figure 11) . Based on the current ratio of age and sex specific harvest, a density of 2.5 curassows per square kilometer would assure a seemingly viable population of 411 breeding individuals in the hunted zone while providing a moderate harvest of 20 curassows each year.

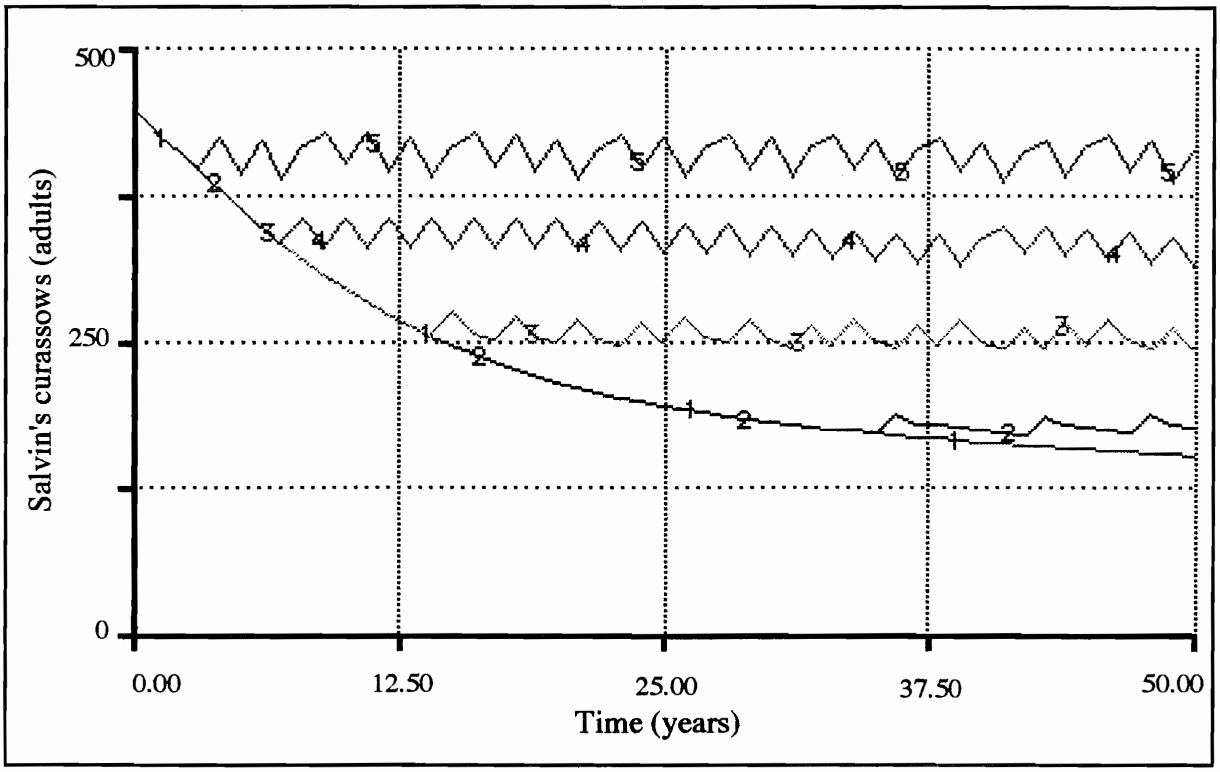

Figure 11. Abundance of adult Salvin's curassows after 50 years under five different harvest regimes based on censused curassow density in Zones One and Two. Density thresholds (curassows per square kilometer) were 1) 0.50, 2) 1.00, 3) 1.50, 4) 2.00 and 5) 2.50.

Minimum area requirement of a conservation area

The population viability analysis suggests that habitat such as that found in Zone Three, with a current censused density of 9.15 curassows per square kilometer, is of adequate size to maintain a viable population of Salvin's curassow. Until specific details of genetic, demographic and environmental factors which affect curassow populations are available, it is obviously important to maintain the entire conservation area. In the event that institutional circumstances change and it becomes impossible to do this, what may be the impact on the curassow population? I tested the viability of different size reserves as a source population for the surrounding hunted territory by using my initial model and reducing the size of Zone Three from 50% to 100% of its current area. Accordingly, the curassows that existed in that portion of Zone Three were available for harvest. All other model parameters remained constant.

The results (Table 6) reflect a large increase in the number of curassows harvested in the first five years of the simulation, an average of 110 to 177 individuals; two to three times higher than the current harvest. While this seems dramatic, harvests of this size have been recorded in other settlements. Vickers (1980) estimated that the mean annual kill of Salvin's curassow was *310* individuals during the first two years of a Siona-Secoya settlement on the Aguarico river. As such, this simulation gives a very somber picture of the potential impact that unrestrained harvest could have in the currently protected zone and consequently on the number of curassows available for harvest in Zone One/Two.

Table 6. Salvin's curassow adults in hunted and non-hunted zones after 50 years with area reductions in Zone Three

Zone	50% reduction	75% reduction	100% reduction
Hunted	82	48	14
Non-hunted	564	284	0

Based on estimated extinction probabilities (Figure 9), the most conservative approach is to maintain a population with a minimum of 300 breeding pairs. Given the current density of 9.5 individuals per square kilometer in Zone Three, this suggests that this zone should not be reduced to less than approximately 70% of its current size, approximately 10,000 hectares. If forests surrounding Zone Three outside of Cofan jurisdiction are eventually settled and hunted as modelled on page 25, then the minimum of 300 curassow adults may only be maintained by conserving the entire 31,400 hectares in Zone Three.

On a national scale, this analysis does not realistically address the long-term viability of Salvin's curassow unless we consider the possibility that any curassow population may be vulnerable to local extirpation due to rare catastrophic events such as severe weather, disease or predation. In that event, it is advisable to have several viable populations spaced far enough apart such that they are not all subject to the same local catastrophes (Goodman 1987). This may be accommodated by a single large non-fragmented reserve of at least one million hectares as suggested by Thiollay (1989). In Ecuador, it is more likey that smaller fragments will be preserved. Of course, size recommendations depend on the habitat and the extent of hunting that has already taken place once a conservation zone is established. We know from preliminary baseline census in other areas of eastern Ecuador (Johnson and Hedemark 1989), that a density of 9.5 Salvin's curassow per square kilometer is relatively high and that conservation zones in these other habitats would likely have to be larger to compensate for lower curassow densities.

Management considerations

Potential of land use zones to maintain viable populations of Salvin's curassow

This paper has addressed the potential for maintaining viable populations of Salvin's curassows within the parameters of the current land use plan of the Cofan community of Zábalo in the Cuyabeno Reserve. Based on that objective, and within the parameters of my model, preliminary calculations indicate that the area encompassed by Zone Three will likely contain a viable curassow population for the next 50 years. Without greater dispersal from non-hunted areas than what my model includes, it is likely that the curassow population in the hunted area of Zones One and Two will fall below the recommendations for a viable population within that same time period. This does not take into account additional influx of dispersing curassows from non-harvested lands which still surround the Cofan territory nor increased harvest due to human immigration from other areas outside the community. My analysis suggests that, conservatively, at least 20 curassows could continue to be harvested annually on a sustainable basis from the hunted zone. The results are meant to provide only preliminary guidelines for land managers and planners. It is critical that models such as this continue to be tested and refined with new data annually on a regional basis (Silva and Strahl 1991). I suggest that a national biologist work closely with trained "parabiologists" in the village (See methodology of Hedemark 1993) to continue documentation of hunting kills and monitoring of annual cracid densities, fostering a sense of coinvestigation and management cooperation between Zábalo and the scientific community (FECODES 1992).

The results of the viability analysis exemplify the necessity of indigenous land claims to be sufficiently large (Vickers 1991) such that relatively low human population densities exist if sustainable harvest of rarer game species such as Salvin's curassow is to occur. It illustrates that the current pattern of linear strips of contiguous 50 hectare plots in the colonization zone in the western end of the Cuyabeno Reserve (Canaday 1991) is inadequate for maintaining curassow populations. This is especially true given the current colonization laws which encourage even hopeful squatters to deforest at least half of an untenured parcel as evidence of productive use (Southgate and Runge 1990). Cracid census carried out in the western half of the reserve have found densities of Salvin's curassow to currently range from only 0.29 to 0.70 individuals per square kilometer (Garcéz 1991).

On a national scale, it is advisable to have several Salvin's curassow populations spaced far enough apart such that they are not all subject to the same local catastrophes. Populations must contain a sufficient number of breeding individuals such that the probability of extinction is reasonably low which will likely require over 300 breeding individuals (Figure 9). Based on this concern, it is critical that other settlements in the Cuyabeno Reserve and in the Ecuadorian Amazon be encouraged to adopt the Zábalo model of a non-hunted conservation zone and / or that very large parks be maintained (Vuilleumier 1988) to encompass these well-spaced curassow populations.

Community incentives to maintain a conservation zone

The Zábalo president identified secure land use rights, economic income through ecotourism / scientific investigation and game augmentation as the incentives which have influenced his community to adopt and maintain land use zones. It was clear that should the current arrangement of land access and use be threatened and if the Zábalo community needed the game supply, that there would be little incentive to continue with the current protection plan. In the case of Zábalo, secure land access and use is interpreted as the exclusive right to harvest necessary resources from designated use zones for community subsistence (MAG 1992). It is felt that the persistence of value which the culture places on the forest is dependent on their recognized need of the resource, in this case in the form of food supply via hunting or perhaps in future years, as monetary income via ecotourism and scientific investigation (Borman 1993). In either case, a commitment to forest conservation will allow the community to live a traditional Cofan lifestyle and/ or become modern entrepreneurs. Having the option may help this group avoid the pitfalls of fragmented indigenous communities who have been expected to serve only as traditional forest guardians and forgo opportunities for modernization (Redford and Stearman 1993).

While the proposal of clear legal status as a means of resource conservation is an argument presented by many indigenous, as well as colonist groups in the Amazon region (Nations and Coello 1989, Bodmer et.al. 1991, Vickers 1991), there is justified hesitation that indigenous land rights do not exclusively equate to protection of biodiversity (Redford and Stearman 1993, Redford and Robinson 1985). Bromley and Cernea (1989) state that the prerequisites for successful transition from open access regimes to those of common property are locations where the "size of the user group is small, the users are reasonably homogeneous in important socioeconomic characteristics, and the users reside in close proximity to the resource", a description which fits the current Zábalo community. Common property is defined as private property for a group of individuals who are co-equal in their rights to use the resource and agree to limit their individual use with the expectation that others will do the same. While this does not equate to protection of biodiversity either, it outlines some of the necessary characteristics of groups who exhibit potential to effectively implement and enforce their own resource use restrictions if such behavior is recognized as a goal by the community. If no incentive for conservation exists, even these groups may not undertake resource use restrictions as illustrated by the comments of the Zábalo leader. If local communities are not involved in wildlife conservation and exploitation pressure continues to increase, it then becomes necessary to administer more sophisticated strategies of management which require complex regulations at a higher economic cost (Rose 1991). Complex controls currently seem unrealistic with a reserve staff of five individuals who must patrol a remote reserve with a human population of 1,000 people.

It has been suggested that indigenous land rights be recognized in areas that are not currently contained in parks (Redford and Stearman 1993). Past history of colonization in the Cuyabeno Reserve suggests that it may be an even greater management necessity within some parks to assess a resident group's ability to provide for resource protection (FECODES 1991) and then grant appropriate ongoing incentives (Vickers 1991) such as special regimes of land tenure. As in the case of Zábalo, their covenant with the Ministry of Agriculture, specifies continued land access and use contingent upon the adherence to zones of use (MAG 1992) with the Ministry having the ultimate voice (FECODES 1991). The continued success of the covenant implies the need for ongoing evidence that the community is adhering to land use guidelines and likewise, evidence that the government continues to honor the specified land use rights.

Evidence of resource conservation should be collected by systematic long-term monitoring (see suggestion above) of cracid kill and population density. Evidence of continued support of Cofan land use rights by the government can be determined by monitoring evidence of endorsement of conflicting land use practices. Among these are 1) road development for petroleum exploitation which has historically brought colonist settlements into Amazonian Ecuador (Hicks 1990) and 2) efforts to resettle Ecuadorians from other provinces into the eastern lowlands (Hicks 1990). National and international NGOs can be instrumental in aiding monitoring efforts by promoting technical and financial support as well as serving in a watchdog capacity.

Potential to limit harvest of threatened species outside of the conservation area

My analysis suggests that a sustainable harvest of at least 20 curassows per year from the hunted zone may be possible. Further analysis (see below) suggests that population growth may be most sensitive to the survival of adult curassows, and that harvest of these individuals should be restricted. This is problematic since juveniles attain adult size and plumage at seven to ten months of age (Ollson 1971, Estudillo 1985) such that second year juveniles cannot be safely told from adults. That which can be easily measured on a yearly basis is the relative density of the population using the methods described in this paper. If the relative density of the hunted zone was consistently above a specified threshold, in this case 2.5 individuals per square kilometer, the harvest may even be increased. Because the Zábalo territory maintains a conservation zone as a safeguard, experimentation with sustainable harvest in the hunted zone seems possible without endangering long-term survival of Salvin's curassow in the area.

The Zábalo community is actively involved in considering candidates for hunting bans. They currently recognize a ban on hunting large macaws (*Ara sp.*), and all river otters (*Lutra longicaudis* and *Pteronura brasiliensis*) throughout their entire territory (MAG 1992). They restrict the use of barbasco, a plant product which stuns fish, in flowing rivers and streams. Other species considered for protection by the community are river turtles (*Podocnemis spp.*), hawks, eagles, and ocelots (Borman 1993). Although hunters identified the decline in curassows as well as the need to have a system of protection, they also rated guans and curassows as their preferred game birds. This traditional preference is consistent with other Amazonian settlements, both colonist and indigenous (Redford and Robinson 1987), where the highest harvest rates of birds is of the guans and curassows. Because of such popularity, the village president felt it unlikely that hunters could presently restrict harvest of curassows in Zones One and Two (Borman 1993). It is felt that only the designation of Zone Three as an area where no hunting is permitted can presently curtail exploitation of cracids. While this will probably not provide a sustained curassow harvest for the community, it will likely maintain a viable population of curassows within the conservation zone. Borman (1993) suggested that access to solar freezers may allow hunters to better regulate and store their kill such that moderate rates of harvest of vulnerable species such as Salvin's curassow would be acceptable.

Guidelines for future field studies

With the assumptions of my population viability model (adult survival=0.75, second year juvenile survival = 0.70, first year juvenile survival = 0.60 and fecundity = 1.25), the curassow population is capable of growing at a sustained rate of 1% per year (lambda = 1.01). To guide the emphasis of future field studies, it is pertinent to determine which of the specified demographic parameters have the greatest influence on population growth such that the most critical data be collected to improve the accuracy of the viability model. In Table 7, I summarize the changes observed in the population growth rate as a result of modifying each demographic parameter one set at a time. I first increase the mortality of each age class by 50% and then decrease fecundity by 25% and 50% as demonstrated by Starfield and Bleloch (1986). The results of these experiments suggest that fecundity of adults as well as the degree of adult survival are parameters which may have large impacts on overall population growth followed by the rate of survival of first year juveniles.

The question of curassow movements within contiguous forest is key to understand-

Table 7. Sensitivity analysis on the sustained growth rate of the modelled Salvin's curassow population

Parameters that differ from standard run	Sustained growth rate (%)
None (i.e. standard run)	1.0
Survival rate of first year juvenile age class reduced from 0.60 to 0.40	-6.3
Survival rate of second year juvenile age class reduced from 0.70 to 0.55	-3.6
Survival rate of adult age class reduced from 0.75 to 0.675	-8.8
Fecundity of adult age class reduced from 0.625 to 0.468	-4.4
Fecundity of adult age class reduced from 0.625 to 0.3125	-10.4

ing the dynamics that exist between source and sink populations such as that believed to occur between hunted and non-hunted zones. It is critical to determine if Salvin's curassow exhibits seasonal movements such as that described for other large game birds (Leopold 1972, Thiollay 1989). The extent of these movements may jeopardize a seemingly viable source population if overharvest occurs while individuals are outside of a protected zone. Studies of population survival rates and movements will likely take much time and effort. In the interim, it will be critical to use basic population and harvest monitoring to continue evaluation of the current zones of use in their stated purpose of long-term conservation of even the most endangered and rare species.

Conclusions

This preliminary study has illustrated the importance of the Zábalo conservation zone in maintaining viable populations of the threatened Salvin's curassow with the Cofan territory of the Cuyabeno Faunistic Reserve of eastern Ecuador. Based on the results, the following conclusions may be drawn:

1. The conservation zone, with its current curassow population density, is likely of sufficient size to contain a viable curassow population for the next fifty years if the guidelines of the current land use plan are maintained. As such, the conservation zone may serve as a critical source population of Salvin's curassow for the adjacent hunted zones.
2. The harvest of Salvin's curassow in the hunted zones currently exceeds the recommendations for sustainable harvest of this study, which estimates that approximately twenty Salvin's curassows can be sustainably harvested annually from the hunted zones over the next fifty years.
3. The actions of the Zábalo community indicate that they are capable of adapting to the Cuyabeno Reserve mandate of establishment of land use zones. They are aware of natural resource declines and are active in enacting management guidelines within their jurisdiction. The assurance of secure land use rights and economic return from ecotourism and scientific investigation are important factors affecting the adoption and continued enforcement of land use zones by the Zábalo community. Continued national recognition of these rights could foster a promising scenario in which maintenance of cultural identity and socioeconomic development by the Cofan of Zábalo is achieved as well as the conservation of the most threatened cracids.

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