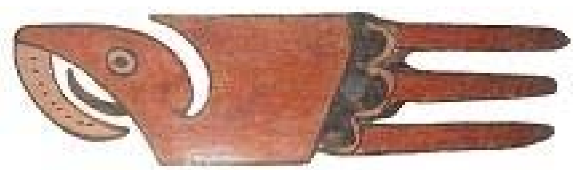
The Scarlet Macaw in Guatemala and El Salvador: 2008 Status and Future Possibilities

Findings and Recommendations from a Species Recovery Workshop
9-15 March 2008
Guatemala City and Flores, Petén, Guatemala



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Scientific name	***Ara macao*** **(subspecies *cyanoptera*)**
Scarlet macaw	**USA & Canada**
Guacamaya roja	**Guatemala & México**
Guara roja	**El Salvador & Honduras**
Lapa roja	**Nicaragua & Costa Rica**

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EXECUTIVE SUMMARY

The following proceedings are the outcome of a workshop held in Guatemala, during March 2008, to define conservation strategies for the northern Central American subspecies of the scarlet macaw (*Ara macao cyanoptera*). Participants from Guatemala, El Salvador, and the United States gathered for five days to evaluate possibilities for improving the plight of scarlet macaws in the lowland Maya Forest area, primarily focusing on the wild population clinging to existence in Guatemala's Maya Biosphere Reserve. Throughout the workshop, however, participants also assisted colleagues from El Salvador to evaluate the best ways to realize Salvadoran aspirations to reintroduce the species, and return the scarlet macaw to their national bird list.

Among the numerous strategies discussed, participants considered the persistence of existing wild macaw habitat to be the foundation of any successful conservation effort. The logic for this is straightforward: without viable habitat, other strategies eventually aimed at *in situ* conservation make little sense. A second point of agreement was that decreasing the frequency of macaw chick poaching across the entire range of Maya Forest macaws is critical for long-term success. Again, participants concurred that the logic of introducing birds without abating the loss of wild born chicks is questionable. But in Guatemala, recent advances in reducing poaching and in stabilizing habitat loss have poised macaw conservation at a new point, one of being able to re-evaluate lessons learned and look for new, safe ways to recover the species. For this reason, a significant part of the workshop focused on evaluating captive management techniques as a tool for ensuring, and possibly expediting, species recovery.

One of the most important questions addressed by workshop participants was "under which conditions should captive management, captive breeding, and *ex situ* strategies play a role in saving wild macaws?" A second, perhaps more intriguing question was "is the release of captive-bred macaws necessary to conserve the Maya Forest macaw population?" These questions were seen in a different light in the case of El Salvador, since conservationists there are also working to conserve the threatened yellow-naped parrot (*Amazona auropalliata*), and because captive breeding and reintroduction techniques constitute the only alternative for re-establishing a Salvadoran population of scarlet macaws.

To begin defining answers, workshop participants were largely informed by three main sources. The first consisted of extensive field data available for the wild population in Guatemala (Chapter 6). The second consisted of a collaborative pool of knowledge from avian health experts and aviculturists, many with extensive experience in macaw breeding and health issues (Chapters 5, 8, and 10). Finally, the third and perhaps most important source was a detailed, albeit imperfect[1] Population Viability Analysis (Chapter 7).

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[1] "Imperfect" due to the inevitable need to estimate parameters for which solid data do not exist; for example, it was necessary to estimate, among other variables: the probability of disease outbreaks as a result of introducing captive-

Inputs from these three key sources, combined with subsequent collaborative analysis and dialogue, helped workshop participants develop a set of comprehensive and ambitious conservation activities relevant to scarlet macaws in the greater Maya Forest. Among some of the more relevant conclusions, we highlight the following:

- **Insuring the persistence of an adequate expanse of viable habitat is essential to maintaining a wild population over the long-term.** As mentioned previously, great advances have occurred in the last 5 years in securing existing habitat and reducing poaching in Guatemala. Nevertheless, two key caveats also emerged as a result of the workshop and other information subsequently made available. The first is that the scarlet macaw subpopulations of Mexico, Belize, and Guatemala appear to be genetically homogeneous. This implies that historically, the populations have been connected, helping to ensure that inbreeding depression does not take its toll on the population. Scientists however, do not know the degree to which the subpopulations of the three countries remain in contact. This question is particularly relevant in terms of the linkage between macaws in Guatemala and those in Belize. As such, the relatively recent improvement in conditions for scarlet macaws in Guatemala probably does not hold true for those in Mexico[2] and Belize. Thus, a conservative approach to the conservation of the species in the lowland Maya Forest suggests an urgent need for improved protection efforts in Mexico and Belize. Second, although threats have receded somewhat in Guatemala, perhaps as much as 25% of the existing Guatemalan population is still subject to high levels of threat – including habitat loss and poaching. What's more, a recent satellite telemetry study of macaw movements in Guatemala indicated that macaws commonly move from "safe" areas into areas where threats remain high – especially after breeding season. Movements of up to 25 kilometers were detected with macaws entering into high threat zones, and apparently utilizing small areas (perhaps feeding on patchy resources) for up to a month. A similar study conducted in the lowland forests of the Peruvian Amazon by Brightsmith et al. (pers. comm.) also indicated that macaws tend to migrate seasonally out of their "home areas" for periods of a month or more. These findings help remind conservationists that while recent improvements in protection have served Guatemalan macaws well, more research should be conducted to better understand the threats on the species within the greater Maya Forest, as well as the dynamics of macaw habitat requirements over time. Finally, new information may eventually lead to the refinement and expansion of protection strategies currently underway in Guatemala, thereby highlighting the importance of continuing with investments in protection strategies as the most important activity for ensuring the persistence of existing populations.
- **Maya Forest macaw populations have decreased dramatically over the last 30 years, and the current population is far below the estimated carrying capacity of the habitat.** Despite the loss of habitat and the caveats previously mentioned, a preliminary and extremely conservative macaw habitat model developed for the lowland Maya Forest indicated that

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bred birds into a wild population; the percentage of successfully breeding females in any year; first year survival in the wild; and other key parameters. Despite the use of these "best guesses", the PVA was very helpful in evaluating the impact of any particular variable.

[2] Unfortunately, recent information on the state of macaws in Mexico was not available for the workshop.

scarlet macaws could likely increase their population by 76% (from 399 to 702), or perhaps far more[3] without surpassing their carrying capacity. Given the model's prediction of adequate habitat for more macaws than the number currently existing in the wild, we assume that extremely high levels of chick poaching in the past have taken a big toll on the population. As a result, if poaching can be reduced, a strong potential exists to improve macaw population viability in all three countries and propel a significant increase in the wild population. Workshop participants agreed that a multifaceted strategy should be pursued based on continuing to improve habitat management, and testing interventions designed to increase recruitment into the wild population. One clear need identified was the urgency of linking Guatemalan efforts to conservation practitioners and scientists working in Mexico and Belize.

- **The introduction of captive-bred juveniles to reinforce the existing wild population can have a positive effect on population recovery, and adequate protocols exist for minimizing the threat of introducing exogenous diseases into wild populations.** This statement is based on the key assumption that introduced macaws will eventually interbreed with wild born macaws. The best available estimate of the risk of introducing captive bred macaws indicated that a significant health risk was detected only when a large number (24+) of macaws was introduced each year. Given that the cost of introducing such a large number of macaws would be prohibitive, this possibility was discounted. If the release of captive-bred macaws is tested in the future, it is more likely that "soft releases" or "precision" releases" of smaller numbers will provide the best starting point for evaluating the efficacy of introduction. However, another key question was also considered: "does the cost/benefit ratio of introducing captive-bred juveniles outweigh the ratio of improving management at sites where macaws are currently exposed to threats?" In Guatemala, the response to this question is that the remaining unprotected population resides in areas so plagued by lawlessness that viable protection efforts are not currently feasible. Separate evaluations of the feasibility of improving management should be conducted in Belize and Mexico.
- **Experimentation with the diverse strategies for augmenting the wild population should be tested, compared, and documented to ensure a wider impact in the psittacine conservation community.** The introduction of captive-bred macaws was one of many possible interventions identified that could increase the number of wild ranging macaws. Yet other interventions such as improvements in field research, wild nest management, the management of wild hatched chicks, and the mitigation of natural predation were also considered. Many of these interventions have been tested successfully in other sites, such as Peru, Puerto Rico, and Costa Rica, among others. Participants in the workshop agreed that a diverse set of strategies would likely provide the best results for our shared goal of seeing wild ranging macaws recover as quickly as possible. The proceedings therefore detail a wide range of strategies that may offer positive results for the persistence of the species if the current amount of high quality, existing habitat can remain protected.

[3] The Population Viability Analysis presented in Chapter 7 estimated carrying capacity (K) to be 1200 birds in the tri-national area, probably a more realistic assessment. A lack of adequate natural history information has precluded a more precise estimation of current carrying capacity across the range, but we strongly believe that they are not limited by food resources or the availability of nesting sites.

- **Social support for scarlet macaw persistence is fundamental if they are to survive into the future.** One final outcome of the workshop was that a broad alliance of actors is now engaged to strengthen macaw conservation in the Maya Forest. A strong potential exists for continuing this alliance, such that diverse strategies advance across Maya Forest sites with information being shared to the benefit of all practitioners. Possibilities include, among other actions, the eventual reintroduction of a “managed population” into El Salvador, improved threat mitigation and monitoring in Belize, Mexico, and Guatemala, and experimentation with nest management and predator mitigation in Guatemala. And yet another possibility is the introduction of captive–bred macaws into the wild. One often overlooked, clear benefit of testing and refining introduction methods in Guatemala was also identified, being the massive social support likely to emerge as the result of such a process. Any effort to introduce captive-bred macaws into Guatemala would imply a collaborative effort between aviaries, government, local communities, NGO’s, researchers, and leading donor organizations. A high profile effort of this nature would likely help focus public opinion on the plight of the species, and galvanize resolve to protect macaw habitat for the future. This intangible benefit should not be underestimated when considering the costs and benefits of testing such strategies in the future.

The following summaries of the chapters of these proceedings will help the reader to better understand the contribution of each section to the development of an updated strategy for the conservation of the macaws of the Maya Forest. For more detailed information, we urge the reader to consult the individual chapters of these proceedings. Chapter 1 provides a general introduction to our joint endeavors seen through the lens of the current state of macaw conservation. Chapter 2 consists of the workshop agenda, and Chapter 3 summarizes the specific goals of the workshop. Chapter 4 details the potential for the reintroduction of scarlet macaws in El Salvador, and Chapter 5 recounts information obtained during visits to two Guatemalan aviaries with scarlet macaws, Aviario Mariana and ARCAS. Chapter 6 reviews the state of the scarlet macaw in Guatemala’s Maya Biosphere Reserve, and Chapter 7 provides a detailed population viability analysis (PVA) of the extant Maya Forest scarlet macaw population. Chapter 8 addresses best management practices for mitigating the threat of disease in the context of psittacine (re)introduction projects, and Chapter 9 reviews *in situ* management considerations. Chapter 10 provides detailed recommendations on the best management practices during the liberation of captive-bred and fostered macaws. Chapter 11 describes the diverse range of possibilities for macaw-related conservation activities, including research, protection, development of social support, and population enhancement, among other possible activities. Chapter 12 concludes with a set of activities selected by Guatemalan partners that will be implemented during the next two nesting seasons (2009, 2010) as an outcome of this workshop. Finally, the Appendix on recent findings on the genetic characteristics of scarlet macaws in Mexico, Guatemala, and Belize provides important guidelines, highlighting the need to expand activities to include conservation partners in Belize and Mexico.

CHAPTER SUMMARIES

Chapter 1: Introduction

Chapter 2: Workshop Agenda

Chapter 3: Workshop Introduction

Since 2002, the Wildlife Conservation Society has been working to conserve the last remaining population of scarlet macaws (*Ara macao cyanoptera*) in the country of Guatemala. After six years of engagement, WCS is now working to build a broad alliance with local, national, and international institutions to increase the number of wild flying macaws in Guatemala's last safe haven for the species, the Maya Biosphere Reserve (MBR). As part of this ambitious goal, with the help of national and international partners we convened this workshop to evaluate the viability of a pilot program to reinforce[4] scarlet macaw populations in the Maya Biosphere Reserve. We also hope to compare this intervention with other interventions that may contribute to the recovery of the species, and build alliances that permit greater collaborations on all aspects of scarlet macaw conservation in Guatemala.

Workshop objectives included: gathering experts to evaluate and develop a protocol for reinforcing the scarlet macaw population in the Maya Biosphere Reserve; defining a consensus on minimal health criteria for the release of captive-bred juveniles; visiting national aviaries to evaluate their potential for contribution to a captive breeding program; visiting a macaw nesting site; and developing a network of researchers and institutions willing to help strengthen Maya Forest psittacine conservation efforts.

Chapter 4: Psittacine Conservation in El Salvador

In 2007, SalvaNATURA began a study to assess the feasibility of reintroduction of Scarlet Macaws (*Ara macao*) to El Salvador, initially funded for three years. The ultimate goal is to establish a wild, self-sustaining population of the Scarlet Macaw. The project area is approximately 300 km^2 in the Department of Ahuachapán, southwestern El Salvador—the El Imposible National Park to Barra de Santiago Corridor. Initial objectives are to evaluate if the reintroduction site is within the historic distribution of the species, if there is sufficient habitat to support a macaw population, if the causes of the macaw's extirpation have been identified and addressed, and what may be the potential impacts of the reintroduction on local biodiversity. We will assess macaw stock for reintroduction based on best available phylogenetic data for *A. macao*, and genetics, availability, and quality of stock in existing breeding facilities. We are

[4] According to the "Guidelines for Re-introductions" of the IUCN/Species Survival Commission's Re-introduction Specialist Group (1998), four strategies for *in-situ* population augmentation exist: *"**1) Re-introduction:** an attempt to establish a species in an area that was once part of its historical range, but from which it has been extirpated or become extinct (Re-establishment is a synonym, but implies that the re-introduction has been successful); **2) Translocation**: deliberate and mediated movement of wild individuals or populations from one part of their range to another; **3) Reinforcement/Supplementation:** addition of individuals to an existing populations of conspecifics; and **4) Conservation/Benign Introductions:** an attempt to establish a species, for the purpose of conservation, outside its recorded distribution but within an appropriate habitat and eco-geographical area. This is a feasible conservation tool only when there is no remaining area left within a species' historical range".*

generally following guidelines of the IUCN Reintroduction Specialist Group to insure well-planned, thorough preliminary evaluations which, with our anticipated support of the project from local communities, will facilitate government authorization and have the best chance of reintroduction success.

As part of an evaluation of the species' historic distribution, we conducted an initial assessment of the status of extant coastal Pacific Scarlet Macaws in Nicaragua and Honduras which are the closest in proximity (~250 km) and habitat to conditions for macaws that once occurred in El Salvador and for which there was little information. In April 2008, we made an expedition to the Cosigüina Peninsula, Nicaragua and Isla Zacate Grande, Honduras which were reported to have a population or flock of free-living Scarlet Macaws. Our field observations confirmed that Scarlet Macaws still exist in the wild in the Cosigüina Volcán Nature Reserve, Nicaragua, and we roughly estimated the population to be 20 to 50 birds. The small population size and reports of ongoing poaching of both chicks and adults suggests that the population's continued existence is extremely threatened. Reintroduction of Scarlet Macaws at Isla Zacate Grande Biological Station, Honduras began in about 1996-97 when an interested private party was given 4 confiscated chicks; a few years later they received and released another 5 macaws (adults and chicks), also confiscations of unknown origin. The released birds are provided daily supplemental food and they also feed on wild fruits. Although the project has not been formally documented, nesting has been observed in artificial nests and natural cavities, and there are now believed to be ~20 free-flying macaws. Some of these birds range outside the reserve to nearby communities and the adjacent island of Amapala. Isla Zacate Grande is only ~35 km (over-water) from the Cosigüina Peninsula, an overland flight distance within documented range for Scarlet Macaws, and therefore contact between the reintroduced Zacate Grande flock and wild Cosigüina birds is within the realm of possibility.

To evaluate the capacity of the existing foraging habitat in the project area to sustain a population of reintroduced Scarlet Macaws throughout their annual cycle, we are conducting an analysis to determine what natural food resources occur in the area, where and when they are available, and in what quantity. In April 2008, monitoring began of over 2000 individually-marked trees in sampling sites in forested lands distributed among 3 elevation zones (0 - 600 m). Tree species were selected based on their potential to serve as food resources for macaws; the marked trees are observed monthly to document timing of fruiting and abundance of fruit. We will use these data, interpreted with respect to tree species' density and extent of forest, to estimate potential food resources for Scarlet Macaws throughout the study area and throughout the annual cycle.

We chose the Yellow-naped Parrot (YNPA; *Amazona auropalliata*) as an element of biodiversity in the project area to be among the most likely to exhibit effects—both positively and negatively—from the reintroduction of Scarlet Macaws. The YNPA inhabits mangroves and lowland forest patches in the project area, and there is high likelihood for resource overlap—and potentially competition—with Scarlet Macaws. Beginning in December 2008, we will initiate research on the population (population size, diet, habitat use), erect artificial nests and monitor reproductive activities in natural and artificial nests, and include the species in our education outreach. From what we know about the needs of Scarlet Macaws and what we learn about those of YNPA, we can assess potential impacts of the reintroduction and monitor for predicted impacts if the reintroduction proceeds.

Critical to the success of this project is the securing of local community support and participation in the project. Public outreach and grade school education is the primary means by which we will approach this challenge. We are working with key players in environmental education from the local community, protected areas, and government to gain a better understanding of the state and needs of environmental education in the rural areas, and determine the best means to strengthen and incorporate themes relevant to psittacine conservation and macaw reintroduction into existing programs.

The next phase of the project will involve defining a reintroduction strategy or strategies for El Salvador based on our habitat evaluation and the availability of birds. We will identify potential locations for reintroduction facilities considering availability of macaw food resources and forest connectivity throughout the corridor, security issues, land tenure and availability, human density, and educational opportunities. Acceptability of likely sources of birds for reintroduction relative to health, genetics, and personal histories will be evaluated. We will then present our final analysis to the Ministry of the Environment and Natural Resources for their approval, followed by confirmation of a source of birds for reintroduction and procurement of necessary national and international permits.

Chapter 5: Breeding Aviaries and Genetic Considerations

One of the conservation interventions being considered for the Maya Forest macaws is captive breeding and release of juveniles to strengthen the wild population (Guatemala) or to reintroduce the species to a country from which it has been extirpated (El Salvador). Two breeding aviaries exist in Guatemala but apparently none exist in El Salvador. The facilities in Guatemala are Aviarios Mariana in the southwestern part of Guatemala near the border with El Salvador and the ARCAS Rescue Center near Flores, in the Department of Petén.

Aviarios Mariana contains 219 scarlet macaws. It was founded in 1983 by Nini de Berger and over the ensuing 25 years has bred a total of 115 F1 and F2 generation birds. No breeding has taken place since 2002, due to lack of space for additional birds. Work by Kari Schmidt of Columbia University indicates most of the birds have the same genetic signatures as wild macaws in the Maya Biosphere Reserve, although some F1 and F2 individuals are descended from a founder imported from Panama. This aviary has the potential to begin breeding again and produce significant numbers of juveniles (6-12 per year) for a release program, although probably only after 3-5 years. Genetically suitable pairs would need to be established.

The ARCAS Wildlife Rescue Center has 54 scarlet macaws, but many are not readily suitable for breeding. Most originate from the Petén region of Guatemala and are likely to be genetically suitable for providing juveniles for release. ARCAS has set up 4 pairs for breeding and have had some success in producing chicks. They plan to set up additional breeding pairs.

With these two aviaries the possibility definitely exists for a long term (e.g., 10 year) captive breeding program. To implement such a program, a number of steps would need to be taken. The birds would need to be tested to verify no serious disease exists. Biosecurity procedures would need to be established to ensure no diseases enter the breeding population. In the case of ARCAS, the macaws in the breeding program would need to be kept isolated from any new psittacines received. Additional genetic analysis by Kari Schmidt would need to be examined so that genetically suitable pairings (both pair members possessing only northern Central American genetic profiles) could be verified or established in the aviaries. A few additional flight cages would need to be constructed to allow flocking and socialization of the juveniles intended for release. While a number of steps need to be taken before using juveniles from one or both aviaries for population augmentation in the Petén, a captive breeding for release program is quite feasible.

Chapter 6: WCS Guatemala Scarlet Macaw Conservation Program

The Wildlife Conservation Society's Guatemala Program is focused on the conservation of the eastern Maya Biosphere Reserve (MBR), in the northern half of the Guatemalan Department of Petén. The MBR was established by the Guatemalan government in 1990 and is part of the largest tract of intact tropical forests remaining in Central America, the tri-national *Selva Maya* of Belize, Mexico, and Guatemala. Unfortunately, the reserve faces many threats; in particular, illegal colonization, illegal conversion of land to ranching and agricultural activities (often fueled by money from the illegal drug trade), uncontrolled fire, unsustainable natural resource extraction, looting of archaeological sites, and weak governance.

WCS engagement in scarlet macaw conservation issues began in 2002, when WCS began efforts to monitor nesting success and identify the nesting distribution of the species across the reserve. Since that time, four main threats affect the Guatemalan scarlet macaw population have been identified: habitat destruction, poaching, natural predation, and competition for nesting cavities.

The distribution of active macaw nests is concentrated in the eastern section of the Laguna del Tigre ecosystem, including the national park of the same name, an adjacent Biological Corridor located within the reserve's Multiple Use Zone, and community managed forest concessions. A small nesting subpopulation occurs outside of the extreme southwestern part of the reserve at Pipiles. A total of 29 active nests were reported for the 2008 nesting season in Guatemala, a slight decrease from the 31 nests reported during 2007.

A preliminary model of macaw habitat in the lowland Maya Forest areas of Belize, Guatemala, and Mexico has been developed based on the distribution of known nests, habitat type, and the availability of surface water. The model currently predicts a carrying capacity (K) of 702 macaws in all three countries, and a current population of 399. Per country estimates for the current number of wild macaws is 103 in Belize, 159 in Guatemala, and 137 in Mexico. The model also predicts that the greatest positive impact on the population can be obtained by consolidating protection and management efforts at the site of El Perú in Guatemala, and in the Maya Mountains of Belize.

WCS Guatemala has been monitoring nesting success at 7 sites across northern Guatemala, including El Perú, Peñon de Buena Vista, El Burral, La Corona, AFISAP, La Colorada, and Pipiles. In 2007, 29% of all chicks in wild nests fledged, and in 2008 50% of chicks fledged.

The rate of fledging success varies widely among sites where adequate monitoring occurs, ranging from 0-100% in 2008 (Peñon de Buena Vista and AFISAP, respectively). Reasons for this include natural predation by forest falcons, and human impacts at unguarded sites.

Chapter7: Vortex modeling

A population viability analysis (PVA) for the northern subspecies of scarlet macaw (*Ara macao cyanoptera*) was conducted in association with a workshop to evaluate the feasibility of augmenting the existing population in Guatemala with captive produced birds. The following report presents the results of 31 scenarios created using Vortex v9.72. The baseline scenario assumes a single population of 354 across Mexico, Guatemala and Belize with an unstable age distribution (biased towards older birds), equal sex ratios, age at first breeding at six years and maximum age of reproduction at 25 years, an average of 30% of breeding age females successfully breeding (across all regions), 76% of successful nests producing one chick, 23% of successful nests producing two chicks, 1% of successful nests producing three chicks, a 1% frequency of a catastrophic disease (one event every 100 years), no inbreeding, no change in carrying capacity (K = 1200) and no supplementation. Modifications of the baseline scenario examined the effects of population size, age structure, metapopulation structure, life history characters, reproductive success, changes in disease risk and carrying capacity, and population augmentation. Further information on scenarios and justification of all values are contained in Chapter 7.

The baseline model suggests that scarlet macaw populations are probably—at best—holding their own and have a probability of extinction of at least 10% within the next 100 years. The current near-zero projected population growth rate is probably largely a result of recent efforts by CONAP (with support from WCS and local partners) that have reduced poaching rates in parts of Guatemala. Prior to 2001 it is likely that the population was experiencing a significant rate of decline. The major factor influencing population growth rates and trajectories is the percentage of females that breed successfully. In a stochastic model that accounts for environmental variation and random events, an average annual success rate of roughly 37% is necessary to maintain a stable population.

Guatemala is believed to have a success rate of 40% under current management activities, but success rates in Mexico are almost certainly lower and rates in Belize are in question. Although genetic data suggest that a single population model is appropriate, we recommend using a three-population model because of the likelihood of a source/sink dynamic between countries with different levels of reproductive success. At present, Guatemala is the only documented source population and movement of birds from Guatemala into sink populations in other areas has the potential to prevent recovery in Guatemala and possibly even deplete it. Because of the relatively small difference between the level of breeding success needed for population stability (37%) and the level of breeding success achieved by protected nests (52%) even moderate levels of poaching could result in population declines. Therefore, acquiring more accurate data on poaching rates—the primary factor reducing breeding success—in Mexico, Belize, and other parts of Guatemala is essential for predicting the future of the local and global populations of this subspecies.

Because of the recent history of severe poaching that has reduced recruitment into the population, it is likely that the current population has an unstable age structure with many older birds. If this is true, then the population could decrease over the next five to ten years. This is a demographic artifact resulting from previous poaching and would occur regardless of current nest protection efforts but any decrease in nest protection efforts would exacerbate this trend. Results suggest that *in situ* management actions that address breeding success should have the greatest conservation impact and further, that at least some level of *in situ* management is necessary for the population to recover. Average levels of breeding success achieved at protected nests in Guatemala (52%) produced sufficiently robust growth rates that other management actions (including other *in situ* actions such as those that attempt to reduce natural sources of mortality or increase the number of fledglings per nest) may not be necessary. Continued data collection on causes of nest failures will help to understand the relative importance of non-anthropogenic factors affecting breeding success.

The primary questions surrounding the issue of *ex situ* management (population augmentation) are: 1) what is the risk, and 2) what is the need. Generally speaking, the risk of disease introduction is probably low and manageable, but it is important to note that the benefits of population augmentation could be negated and population status could worsen if proper biosecurity is not observed during reintroduction. Population augmentation has the potential to minimize a short term population decrease and to increase population size if the current assumptions of an unstable age structure and a population growth rate near zero are valid; if the population is performing significantly better or significantly worse, population augmentation at the level that is suggested as feasible (a maximum of 18 birds per year) would have little impact.

Working with partners in Mexico and Belize to evaluate poaching levels and breeding success in advance of, or in concert with, any attempts at reintroduction, will be important in part because these data are needed for determining the utility of reintroduction, but also because connectivity among populations means that these countries will likely share both the benefits and the risks associated with reintroduction efforts. Finally, it is important to note that population augmentation is strictly a short term solution and does not address the cause of decline nor ultimately prevent it. Introductions in Guatemala could buy additional security for a fragile population, but will have little meaning if released individuals simply disappear into unmanaged sink populations elsewhere.

Chapter 8: Disease Issues and Testing Recommendations

Introducing animals from outside into a population always carries with it some risk of introducing disease. Some diseases can be disastrous. Before captive bred scarlet macaws are introduced into Guatemala or El Salvador, they must be verified as uninfected with serious psittacine diseases. An avian virologist and veterinarian from the Schubot Exotic Bird Health Center/US Department of Agriculture and a zoo veterinarian from the Wildlife Conservation Society in New York led a discussion that identified the serious diseases for which testing needs to be performed. In most cases PCR testing must be used and not serology testing. PCR testing must be performed for polyoma, Pacheco's disease (avian herpes), psttacine beak and feather disease (PBFD), and, when available, psittacine dilatation disease (PDD). PCR testing for Chlamydophyla/chlamydia is recommended. Serology testing until negative results are obtained should be considered for Exotic Newcastles's Disease (END), and *Salmonella pullorum* because these diseases may have been transmitted from domestic poultry. Of course, if multiple serology tests are all positive, the bird should be further examined.

Chapter 9: Scarlet Macaw *In-situ* Management
On March 12-13, workshop participants visited the Maya Biosphere Reserve scarlet macaw nesting site of El Perú to familiarize themselves with the natural conditions, visit the modest WCS Guatemala facilities, and evaluate the possibilities of promoting a macaw reinforcement project in the area. During the January – August breeding season, WCS field personnel locate nests and monitor scarlet macaw breeding success in the area, and use El Perú as a springboard for monitoring further north at the site of El Burral.

After traveling into the site, WCS personnel provided presentations on their scarlet macaw environmental education program, followed by presentations on nest monitoring, anti-poaching activities, and other field activities. Subsequently, the group discussed ways to increase the number of chicks fledging from wild nests. Dr. Don Brightsmith shared his observations from the Tambopata macaw research project in the Amazonian lowlands of Peru, highlighting the relevance of their efforts to evaluate chick nutrition and growth. Finally, Dr. Darryl Styles detailed important information from the avicultural perspective, focusing on macaw chick growth rates and feeding among other aspects relevant to monitoring and husbandry. The final day, participants visited wild nests and a tower observatory that holds potential for developing a point count system to evaluate macaw population trends over time.

The main product of this section of the workshop consisted of listing possible intervention for increasing the number of chicks successfully fledging from wild nests at the El Perú nesting site. Interventions discussed in more detail within Chapter 9 include: supplemental feeding of chicks; pulling, feeding, and replacing chicks, rearing chicks for replacement at fledging; releasing juveniles at fledging at a wild nest ("precision releases"); double-clutching; fostering chicks; and fostering eggs.

Chapter 10: Reintroduction, Release, and Population Management
Presentations were given and discussions held on natural scarlet macaw behaviors and how this knowledge should be used in captive breeding of the species and ensuring proper preparation of young birds for release into the wild. Most psittacines and certainly scarlet macaws are highly social creatures, living in flocks or enlarged family groups outside the breeding season. Sexually immature juveniles live entirely in a flock until they reach reproductive age and select a mate. During the breeding season, sexually mature pairs separate from the flock to reproduce and are territorial and aggressive towards other members of their species until their chicks fledge. After fledging, chicks spend some months with their parents and later join the parental flock or choose a new flock.

This natural cycle should optimally be simulated in captive breeding of adults and socialization of juveniles for either captive breeding or release into the wild. The findings suggest parent rearing of chicks when possible. After fledging or upon being separated from the parents, juveniles should be allowed to socialize and mature in mixed-age flight cages containing well-adjusted older birds and, if available, wild-caught adults. Fledglings are not suitable for release into the wild. The optimum age for releasing scarlet macaws is likely to be 1 to 3 or 4 years of age. Before being released, the release cohort should spend time together in a flocking cage where they learn to feel as part of the flock, since research has shown better survival when released macaws are attached to a flock of conspecifics. Breeding birds are optimally separated into individual breeding flight cages during the breeding season and placed together in adult or mixed-age flight cages during the non-breeding season.

All releases of macaws and probably of most psittacines should be "soft releases" where the individuals are maintained and acclimated to the release area in pre-release cages for a period of time (periods of weeks to months) and are provided supplemental food and water for some period after release. Protocols were outlined for soft releases of flocks of scarlet macaws and for "precision releases" of small numbers of birds in the vicinity of just-fledged juveniles and their parents. Attempts should be made to retrieve any individuals that do not seem to be able to adapt to the wild environment.

Some environments are so human-modified and human-occupied that no truly wild release is possible. In these cases a modified version of the standard soft release protocol is recommended, a so-called "semi-wild" or "managed release." The members of the target species are released via a soft release into a safe site and are encouraged or trained to use the safe region as a home base while being free to range elsewhere in the landscape. The birds are then continuously managed through provision of safe roosting sites, possibly provision of nest boxes with control of human poaching, natural predation, and bee and parasite infestations as needed, and possibly long term provision of food and planting of food plants. Because the existence of truly wild areas without serious deleterious human impact are so rare, many populations of mammals and birds, including macaws and other psittacines, may only continue to persist if they are managed to this objective.

Chapter 11: Potential Future Scarlet Macaw Program Activities in Guatemala and El Salvador

Participants prepared detailed lists of potential useful future activities for scarlet macaw conservation in each of the two countries without rejecting activities because of issues of feasibility. The activities were grouped for Guatemala under headings of: Conservation, Monitoring and Applied Research, Natural History Research, Ex-situ Management, and Population Augmentation Projects. For El Salvador the groupings were: Monitoring and Applied Research, Conservation/Education, Ex-situ Management, Reintroduction Strategy, Law Enforcement, Conservation-Based Economic Activities, and Permitting

Chapter 12: Workshop Accomplishments and Future Directions in Guatemala

The wide-ranging backgrounds of the participants were summarized, the significant accomplishments of the workshop were described and a multi-year work plan for Guatemala was presented. Because the El Salvador program is so recent, a similar work plan for that project is still being designed.

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1.0 WORKSHOP INTRODUCTION

Macaws are New World members of the parrot family, distinguished by their large, dark (usually black) beaks, relatively featherless and light colored facial patches, and long tails that are often one-third to one-half the total length of the bird. Several macaw species are the largest (hyacinth macaw: *Anodorhynchus hyacinthinus*) and heaviest (great green or Buffon's macaw: *Ara ambiguus*) of the flighted parrots (The flightless kakapo is heaviest of the parrot species). Of 18 known species of macaws, two are already extinct (glaucous macaw: *Anodorhynchus glaucus*; and the Cuban macaw: *Ara tricolor*), and one clings to survival only in captivity (Spix's macaw: *Cyanopsitta spixii*). Most of the other 15 species are endangered in the wild.

The greatest problems threatening wild macaw populations are the rapid rate of deforestation and illegal trapping for the bird trade. In some remote areas, macaws are still killed for food. Nine of the 16 species of macaws are listed on CITES Appendix I, or Threatened with Extinction, the highest ranking on the three lists of the Convention on International Trade in Endangered Species of Wild Flora and Fauna, or CITES. The species of concern in this Workshop, the northern subspecies of the scarlet macaw, *Ara macao cyanoptera*, is one of those listed on Appendix I.

The scarlet macaw has the greatest range of all macaws, ranging originally from southern Mexico in Oaxaca southward through Central America and throughout northern South America east of the Andes and south as far as Bolivia and southern Brazil. In pre-Columbian times, scarlet macaws were bred in northern Mexico for trade. Scarlet macaw bones and rock art have been found in Anasazi ruins in southern New Mexico and Arizona, and their Native American Pueblo descendants still prize red feathers for ceremonial headdresses and other ceremonial art.

Wiedenfeld (1994) identified two subspecies of scarlet macaw, *Ara macao cyanoptera* in the northern part of the range and *Ara macao macao* in the southern. Costa Rica and Panama represent a transitional zone. Morphologically, *A. m. cyanoptera* is distinguished from *A. m. macao* by being larger and having a broad band of yellow on the wing with some yellow feathers tipped in blue. The yellow band abruptly changes to blue on the rest of the wing. *A. m. macao* is somewhat smaller, and has a narrower yellow band that grades into green before turning into blue on the rest of the wing. Kari Schimdt, a PhD student at Columbia University in the United States is investigating the genetic taxonomy of scarlet macaws, and at the conclusion of her research will be able to identify groups of genetic assemblages (haplotypes) and relate them to the morphologically determined subspecies. Among other things, she will be able to tell if there are two or possibly more subspecies (Abramson, 1996, suggests three) and how close or distant they are genetically. One aspect of her work is described in the Appendix.

As early as its designation as *Ara macao cyanoptera* (Wiedenfeld 1994), the subspecies was already in peril. Wiedenfeld wrote:

> *Even as I describe a new form of Scarlet Macaw, I must report that it is in danger of extinction. Although once widespread in southern Mexico and northern Central America, Ara macao cyanoptera has been reduced to only a small number of birds in isolated*

populations. It has been almost completely extirpated from the Pacific slope in Mexico, Guatemala, El Salvador (from which country it was completely extinguished "some decades ago"; Thurber et al. 1987), Honduras, and Nicaragua (Ridgely 1982). There is a small remnant population on the Peninsula of Cosigüina, Nicaragua (pers. observ.). On the Caribbean slope, the macaw now occurs in Mexico only in the Selva Lacandona (Forshaw 1989), in the forest of southwest Belize (Manzanero 1991), in the southwestern Petén region of Guatemala (J. Vannini, pers. comm.), northeastern Honduras (pers. observ.), and eastern Nicaragua (Martínez 1991)….

Extrapolating from the numbers estimated for the Honduran Mosquitia, the total Middle American population of both subspecies of the Scarlet Macaw is probably about 5000 birds, including 4000 Ara macao cyanoptera. These birds are in several isolated populations. Although each population (for example, Selva Lacandona/Petén, or the Mosquitia) now may be large enough to avoid genetic inbreeding problems, because the populations are small and isolated, their long-term survival seems unlikely….

Because the macaw's numbers are so low, strong efforts should be begun immediately to preserve the species. These should include an enforced prohibition of trade, both within Middle America and for export as pets to the developed countries. Habitat preservation should also be a high priority. Continued efforts to preserve the forests in the Selva Lacandona and Petén areas will provide habitat in the remaining northern part of the subspecies's range.

One region mentioned by Wiedenfeld is the "Selva Lacandona and Petén" areas. These areas are part of the tri-national Selva Maya, or Maya Forest, in the nations of Belize, Guatemala, and Mexico. The Maya Forest contributes to the extremely high biodiversity of the Mesoamerican isthmus. Mesoamerica contains 7-10% of all known forms of life on earth, and 17% of terrestrial biodiversity in less than 0.005% of the planet's land area (CEPF, 2004), and the levels of endemism among its mammals (15%), plants (17.3%), birds (18.7%), reptiles (34.7%), and amphibians (64.5%) rank it among one of the top twenty-five biodiversity hotspots in the world: http://www.biodiversityhotspots.org/xp/Hotspots/mesoamerica/Pages/biodiversity.aspx.The three nations that share the Selva Maya are linked together by the rich cultural traditions of the Maya people that have inhabited the region for over five thousand years. The trinational Selva Maya also shares similar ecosystems including montane and lowland tropical moist forest, seasonally flooded scrub forests known as bajos, oxbow lakes and the largest areas of freshwater wetlands in Central America. Every year, during the winter, the region becomes home to up to one billion migratory birds from Canada and the United States.

The Government of Guatemala and UNESCO moved in 1990 to protect the vast majority of Guatemala's remaining intact part of the Selva Maya by creating the multi-use Maya Biosphere Reserve (MBR). The MBR spans roughly the northern half of the Department of the Petén, covering some 2.1 million hectares, consisting of 19% of the surface area of the country of Guatemala, or an area twice the size of Yellowstone National Park. After years of investments and mixed successes, approximately 70% of the reserve[5] remains intact, no small feat given the accelerating loss of habitat across Mesoamerica. Today, some 18 years after its ambitious creation the reserve faces numerous threats, including wildlife poaching, illegal natural resource extraction, expansion of oil exploration, illegal colonization and ranching, habitat destruction, and purposely-set forest fires, in addition to a recent increase the intensity of threats due to the influx of money from the illegal drug trade. Not a good environment in which to be a scarlet macaw.

The Wildlife Conservation Society's Guatemala Program has been promoting the conservation of the Maya Biosphere Reserve since the early 1990's when it began operating out of a modest office in the northern Guatemalan town of Flores. Over the years WCS has developed integrated conservation and community development programs, with a focus on conserving the eastern MBR due to its keystone role in ensuring connectivity between intact adjacent sections in the Mexican Yucatan Peninsula and northern Belize. This large block of trinational lowland forest currently ranks as the largest intact block of forest remaining in Mesoamerica (Ramos, V.H. 2005).

In 2002, WCS began monitoring macaws in the reserve for the first time, recording extremely low fledging rates, and detecting high numbers of poached nests. In 2004, as part of their Living Landscapes Program, WCS-Guatemala began addressing conservation issues of five wide-ranging and charismatic "landscape species" of the Petén: jaguar (*Panthera onca*), white-lipped peccary (*Tayassu pecari*), Baird's tapir (*Tapirus bairdii*), Mesoamerican river turtles (*Dermatemys mawii*), and scarlet macaws (*A. m. cyanoptera*). They began identifying active macaw nests and monitoring nesting success in seven locations, including the important archaeological site of El Perú-Waka'. At that site, in particular, the number of scarlet macaw breeding pairs seemed to be declining and over time the fate of the population did not look promising. Yet it was also clear that if macaws were to survive, improved protection from habitat loss, poaching, and fire would be essential. Support was obtained from the Guatemalan government, the Critical Ecosystem Partnership Fund, and the United States Agency for International Development to address these threats. The results to date include the stabilization of much of the remaining intact habitat, and a drastic decrease in the severity of poaching.

In 2006, preliminary population modeling using the VORTEX model hinted that releasing 5 additional individuals per year into the population would keep the population from going extinct. Those "back of the envelop calculations" piqued the interest of WCS-Guatemala in a possible population augmentation program. In addition, two aviaries containing scarlet macaws were in periodic communication with each other and with WCS. Mrs. Nini de Berger had established a large aviary in the southern part of the country during the early 1980s, Aviarios Mariana, with a collection of scarlet macaws and other species in the hope that perhaps some day she could release the offspring back into the wild. The ARCAS Wildlife Rescue Center, located near Flores, Petén, where WCS-Guatemala was based, had been taking in confiscated and

[5] Including areas in all three reserve zones: the Buffer, Zone, the Multiple Use Zone, and Core Zones (i.e. National Parks and Biotopes).

relinquished macaws for a decade or more and had begun evaluating a possible scarlet macaw reintroduction program.

In spring of 2007, Dr. Janice Boyd of the parrot conservation and research organization, Amigos de las Aves-USA, visited the WCS program in Guatemala. Dr. Boyd brought a strong interest in scarlet macaw reintroduction and captive breeding, having worked in those fields in Costa Rica, and in addition had many contacts in the parrot research, avian medicine, and aviculture fields. After a number of months of discussing macaw reintroductions, Dr. Boyd, M.S.. Gabriela Ponce of WCS Guatemala, and Dr. Robin Bjork of SalvaNATURA visited the Puerto Rican Parrot Recovery Program in Puerto Rico where discussions were held with Dr. Thomas White, director of the field project. Following this inspirational visit, the three institutions decided to convene a "Scarlet Macaw Species Recovery Workshop" in March of 2008 in Flores, consisting of visits to Aviarios Mariana, ARCAS, and the El Peru-Waka´ macaw nesting site. Former WCS research fellow, Dr. Robin Bjork, was by this time working on a possible reintroduction project for scarlet macaws in El Salvador, so the geographical area of interest for the Workshop was expanded to cover El Salvador, as well.

These proceedings summarize the extensive findings of that Workshop. Unfortunately, in most parts of Central America, the status of *Ara macao cyanoptera* has not improved from what Wiedenfeld observed 14 years ago. We hope other supporters of scarlet macaw species survival will find various parts of this document of help in their struggle to preserve for future generations this intelligent, beautiful, and charismatic subspecies that has shared the land of Central America with human beings for thousands of years.

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Ramos, V. H. (2005). Human Footprint of Mesoamerica. WCS Guatemala working paper.

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2.0 PROGRAM OF THE SCARLET MACAW SPECIES SURVIVAL WORKSHOP

Sunday 9 March 2008
Participants arrived in Guatemala City at various times, late dinner

Monday 10 March 2008
Morning: Visit to aviary, Aviarios Mariana
Lunch: Courtesy of Aviarios Mariana
Afternoon: Tour of Auto Safari Chapin
Evening: Meeting in Guatemala City at APANAC (courtesy Nini de Berger).
Presentations:

- Rony Garcia, WCS-Guatemala Scarlet macaw conservation program
- Gabriela Ponce-Introduction to population restocking approaches
- Kari Schmidt (George Amato, advisor)- Preliminary results of genetic analyses of wild and captive macaws
- Darrel Styles – Physical, social, psychological preparation of scarlet macaws for reintroduction
- Donald Brightsmith – Review of three scarlet macaw reintroduction programs
- Robin Bjork – SalvaNATURA Project, El Salvador: initial evaluation of feasibility of reintroduction of Scarlet Macaws in El Salvador

Tuesday 11 March 2008
Morning: Arrival in Flores from Guatemala City
Tour of ARCAS rescue center, scarlet macaw flights and breeding facilities
Lunch: Lunch catered by ARCAS
Afternoon: Meeting in ARCAS pavilion. Macaw restocking and review of potential sites
Evening: Dinner and presentation of GIS model of habitat by Victor Hugo Ramos (WCS)

Wednesday 12 March 2008
Meetings in ARCAS pavilion
Morning: Discussions on population viability analysis (PVA) and group discussion on assigning values for VORTEX model runs
Lunch Lunch catered by ARCAS
Afternoon: Disease issues in reintroduction and testing requirements

Thursday 13 March 2008
Afternoon: Travel from Flores to Maya Biosphere Reserve to village of Paso Caballos. Then by boat down river to Las Guacamayas field station, then to WCS facilities at El Perú
Camp Setup
Evening: Dinner prepared by camp staff
Presentation on environmental education and field efforts (WCS field staff)
Group discussion on in situ management and options

Friday 14 March 2008

Morning: Breakfast and packing for return
Visit to wild macaw nest, to archaeological site, and climb to top of observation tower

Afternoon: Return to Flores

Saturday 15 March 2008

Meetings held in Flores, 2nd floor of WCS office

Morning: Program Director Roan McNab briefing on the WCS-Guatemala Program, scarlet macaw conservation and Workshop objectives

Afternoon: Captive breeding and release discussions; suggestions for future activities

Sunday 16 March 2008

Morning: Departure of outside participants from Flores

3.0 INTRODUCTION TO THE WCS - GUATEMALA SCARLET MACAW CONSERVATION PROGRAM AND WORKSHOP OBJECTIVES

Author: Roan Balas McNab, Wildlife Conservation Society Guatemala Program Director
Spanish Translator: Rony Garcia

3.1 Introduction and Background

Since 2002, the Wildlife Conservation Society has been working to conserve the last remaining population of scarlet macaws (*Ara macao cyanoptera*) in the country of Guatemala. After six years of engagement, WCS is now working to build a broad alliance with local, national, and international institutions to increase the number of wild flying macaws in Guatemala's last safe haven for the species, the Maya Biosphere Reserve (MBR). As part of this ambitious goal, with the help of national and international partners we have convened this workshop to evaluate the viability of a pilot program to reinforce[1] scarlet macaw populations in the Maya Biosphere Reserve. We also hope to compare this intervention with other interventions that may contribute to the recovery of the species, and build alliances that permit greater collaborations on all aspects of scarlet macaw conservation in Guatemala.

During the last six years, WCS and our national partners have engaged in habitat protection, monitoring of nesting success, studies of habitat use and distribution of nesting sites, construction of artificial nests, environmental education in local communities, and involvement of local community members in conservation efforts. As of 2007, we expanded interventions and research to include pilot initiatives including testing permethrin treatments of nests to ward off Africanized bee infestation, and satellite PTT collar telemetry. During 2008 we tested the utility of remote camera technology to monitor chick predation and macaw activity within nesting cavities.

3.2 Rationale

The underlying rationale for evaluating macaw reinforcement and other interventions designed to increase the population size in the Maya Biosphere Reserve is based on the following factors:

1) The current population estimate for the entire country is ~150-250 individuals, although this is an imprecise estimate since a census of macaws remaining *in situ* has not been possible.
2) Significant headway has been made in retarding the spread of habitat colonization and fire into the last remaining nesting strongholds of the species, within the eastern Laguna del Tigre ecosystem. Poaching of chicks was also one of the greatest threats to the species; but this

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[1] According to the "Guidelines for Re-introductions" of the IUCN/Species Survival Commission's Re-introduction Specialist Group (1998), four strategies for *in-situ* population augmentation exist: "***1) Re-introduction:*** *an attempt to establish a species in an area that was once part of its historical range, but from which it has been extirpated or become extinct (Re-establishment is a synonym, but implies that the re-introduction has been successful);* ***2) Translocation****: deliberate and mediated movement of wild individuals or populations from one part of their range to another;* ***3) Reinforcement/Supplementation:*** *addition of individuals to an existing populations of conspecifics; and* ***4) Conservation/Benign Introductions:*** *an attempt to establish a species, for the purpose of conservation, outside its recorded distribution but within an appropriate habitat and eco-geographical area. This is a feasible conservation tool only when there is no remaining area left within a species' historical range"*.

threat has been greatly reduced by protection campaigns at 4 of the 5 major nesting sites remaining. *Note: however, threats to the habitat continue, and sustaining and improving habitat protection efforts with national partners will be an essential part of any effective scarlet macaw conservation plan for the foreseeable future.*

3) Macaws are a very social, long-lived avian species that benefit greatly from social transmission of knowledge about their habitat. The behavior and vocalizations (and presumably the communications) of wild birds vary from those of individuals bred and raised in captive settings. For these reasons, a reinforcement program would be best undertaken when (and where) wild macaws might be able to mix with juveniles released using soft releases from *in situ* flight cages.
4) Preliminary Population Viability Analysis modeling of the species suggested that the additional recruitment of 5 fledges per year would reduce the probability of extinction, assuming the persistence of adequate habitat. (*Note: an expert-led Population Viability Analysis was developed as a result of the workshop, and is included as a chapter in the Compendium from this workshop*).
5) Developing a high profile project designed to increase macaw populations in conjunction with a broad alliance of actors, will focus a strong national (and possibly international) spotlight on the plight of the macaw in Guatemala, and the urgent need for continuing to improve habitat protection and management.

Secondary factors include:

1) The existence of an excellent candidate site (El Perú) for the development of a reinforcement program based on the establishment of an *in situ* flight cage where juvenile macaws could be exposed to wild populations (auditory stimuli, and eventual contact). El Perú is located 3 hours from Flores, and contains a permanent presence of army and guards that protect a camp facility located at the site. El Perú may also be a good candidate for a supplemental feeding intervention due to the low fledging rate of chicks at this site.
2) Two significant captive populations exist in the country (ARCAS, Aviarios Mariana or AM), and both have had success breeding scarlet macaws. Both of these institutions have expressed interest in participating in the program.
3) WCS Field Veterinary Program personnel led a comparative evaluation of the health of wild chicks and adults at the ARCAS rescue center (with no conclusive determination reached as to the viability and/or lack of viability of using those macaws as breeding stock). Serology tests of some ARCAS macaws yielded some positives for polyoma, WNV, Psittacine Herpes Virus (Pacheco's), and paramyxovirus 1, and several also tested low positive for *Aspergillus* and *Salmonella pullorum*. Wild chicks were comparatively clean, with only a few with mites. Ten additional macaw serum samples from Aviarios Mariana (8) and from ARCAS (2) were recently tested (February 2008) at the Texas Veterinary Medical Diagnostics Lab. Samples were reported negative for *S. pullorum*, avian paramyxovirus 1,2, and 3, Pacheco's, polyoma, avian influenza, and West Nile virus except for one positive from Aviario Mariana for WNV. In 2004, PCR tests of ARCAS macaws yielded negatives for avian chlamydia, Pacheco's, polyoma, and *Salmonella* (sp. not specified). While this testing is not conclusive, serious disease issues are not indicated at either aviary (as of early 2008).
4) A genetics study underway by Dr. George Amato of the American Museum of Natural History, and Columbia University Ph.D. student Kari Schmidt, will provide the ability to screen possible breeding pairs prior to engaging them in the production of chicks for wild

release. Kari Schmidt has already visited MBR field sites to obtain genetic samples of wild macaws, as well as conducted initial limited sampling at Aviarios Mariana, ARCAS, and obtained samples from Belize.

5) Technical guidance in macaw husbandry, and partial financial support for jump starting the project is forthcoming from Dr. Janice Boyd, Director of Amigos de los Aves, USA. Dr. Boyd has also enlisted the support of Dr. Darryl Styles of the US Department of Agriculture who has extensive experience in the field of psittacine health, and Dr. Donald Brightsmith of Texas A&M University – a field researcher focused on Peruvian psittacines. WCS Veterinarian Dr. Bonnie Raphael, and Avian Curator Dr. Nancy Clum have also been enlisted to advise our efforts.
6) WCS Guatemala has also joined forces with SalvaNATURA, the largest conservation NGO in El Salvador. Psittacine expert and former WCS Research Fellow Dr. Robin Bjork has been hired by SalvaNatura to lead their campaign to reintroduce scarlet macaws to the country of El Salvador.
7) Due to their important role as flagship species for the conservation of the Maya Biosphere Reserve, WCS Guatemala enjoys the full support of the Guatemalan National Park Service (CONAP) to develop projects that improve the outlook for scarlet macaws.

3.3 Specific Workshop Objectives

1) Gather experts to evaluate and develop a protocol for reinforcing scarlet macaws in the Maya Biosphere Reserve, including each of the possible interventions that may help increase the number of wild flying macaws (i.e. supplemental feeding, natural competitor & predator control, increase nesting cavity availability, captive bred releases, etc.)
2) Search for consensus on minimal health criteria for captive-bred wild releases of juvenile macaws
3) Visit Aviarios Mariana – conduct a quick evaluation of birds in captivity – and develop a plan for formal health testing of aviary birds
4) Visit ARCAS – conduct a quick evaluation of birds in captivity – and develop a plan for formal health testing of aviary birds
5) Visit field site proposed for introductions and in situ management
6) Engage researchers and collaborators to help institutions working in Guatemala and El Salvador develop pilot projects that evaluate the efficacy of proposed interventions, and strengthen macaw (and psittacine) populations

3.4 Desired Workshop Outcomes

1) Initial assessment of the viability of reinforcing scarlet macaws via captive-bred releases, and the viability of other interventions designed to increase wild populations
2) Development of a psittacine reinforcement/reintroduction working group
3) Identification of priority interventions for the next breeding season, taking into account existing resources available
4) Development of ideas for joint fundraising efforts
5) Documentation of the information produced and lessons learned, and dissemination of such to participants, partners, governmental agencies, and interested individuals and institutions.

Chapter 3 Introduction to WCS-G
Scarlet Macaw Program and Workshop
Objectives

4.0 REINTRODUCTION OF THE SCARLET MACAW (*ARA MACAO*) TO EL SALVADOR: PHASE I, FEASIBILITY

Author: Robin Bjork, Ph. D., Senior Scientist, Department of Conservation Science, SalvaNATURA, San Salvador, El Salvador.
Spanish Translation: Celina Montis, SalvaNATURA.

4.1 Introduction

In 2007, SalvaNATURA received a 3-year grant from private U.S. donors, Joe and Cornelia Bruderer-Schwab, for the reintroduction of Scarlet Macaws to El Salvador. SalvaNATURA is a Salvadoran, non-profit, non-governmental environmental organization with a trinational (El Salvador, Honduras, Nicaragua) program in research and inventory of flora and fauna and co-manages two Salvadoran national parks with the Ministry of the Environment. The Bruderer-Schwabs have recently opened an ecolodge in western coastal El Salvador, and in 2007 they approached SalvaNATURA with interest in supporting a project focused on conservation of nature in El Salvador. The idea of reintroducing Scarlet Macaws to El Salvador, initially conceived in 2003 with a pre-proposal report jointly developed by the Wildlife Conservation Society and SalvaNATURA, was revived. With funding from the project, SalvaNATURA co-sponsored the Guatemala workshop to strengthen regional efforts and collaboration with the Wildlife Conservation Society for restocking of Scarlet Macaws into the wild.

The primary goal of the project is to establish a wild, self-sustaining population of the Scarlet Macaw (*Ara macao*) in El Salvador. Reestablishing a species to a landscape where it historically occurred, or reintroduction, is moving beyond trial and error of releasing individuals into a site with the hope that they survive. Reintroduction should be conducted using a strategy with scientifically-based preliminary evaluation of the physical and social landscapes and pre- and post-release monitoring. Given best available phylogenetic data, an explicit decision (or agreement among an advisory group) should be made regarding the genetic makeup of stock for the reintroduction and consideration of availability and quality of stock. Site-specific protocols should be developed and subject to revision based on careful observation and results as the project proceeds (adaptive management). Given the increasing occurrence of reintroduction projects across the globe and the concomitant potential of reintroduction to cause adverse effects of great impact to existing biodiversity, the International Union for the Conservation of Nature/Species Specialist Commission (IUCN/SSC) established the Reintroduction Specialist Group (RSG). The RSG developed guidelines for reintroduction which help insure that reintroduction achieves its intended conservation objectives, that it is “both justifiable and likely to succeed, and that the conservation world can learn from each initiative, whether successful or not” (Appendix 4-A, IUCN/SSC 1995). Guidelines specific to parrot reintroduction are found in Snyder et al. (2000) and Wiley et al. (1992).

4.2 Objectives, Methods & Activities

Our initial considerations for the project are that the reintroduction site is within the historic distribution of the species, there is sufficient habitat in the reintroduction area, the causes of extirpation have been identified and addressed, and potential impacts (+ and -) of the reintroduction on local biodiversity is assessed. The initial phase of the project (2-3 years) is a feasibility study. The feasibility study and reintroduction require approval and permits from the Ministry of the Environment, El Salvador. Objectives of the feasibility study are to:

1) Review historic occurrence and current status of extant Scarlet Macaw populations in the northern Central American Pacific coast,

2) Evaluate foraging habitat for Scarlet Macaws in the ~300 km^2 area proposed for the reintroduction,

3) Develop and specify reintroduction protocols and strategies,

4) Assess potential impact of the reintroduction on the endangered Yellow-naped Parrot (*Amazona auropalliata*) population in the project area,

5) Identify specific sites within the study area which we consider to be most appropriate for the reintroduction, and

6) Disseminate information on and discuss the possible reintroduction of Scarlet Macaws with communities in the project area, and initiate an environmental awareness component focused on psittacine conservation.

The project area is the El Imposible-Barra de Santiago Corridor in the Department of Ahuachapán, southwestern El Salvador (Fig. 4-1). This area was chosen because it has three protected areas within the Central American dry forest ecoregion of the species, it falls within the focal area of a USAID/SalvaNATURA biodiversity conservation and environmental education project which seeks to increase the protection of biodiversity (2007-2009), and it is an area with potential for ecotourism development which would provide incentive to local communities to support the project. The 3 protected areas and their dominant vegetation are: El Imposible National Park: dry tropical forest; Santa Rita Protected Area: seasonally-inundated tropical evergreen forest; and Barra de Santiago Protected Area: mangrove forest. A description of activities and findings follows.

4.2.1 Synthesis of northern Central America Pacific Distribution of Scarlet Macaw

Historic Occurrence

Although generally thought to have historically occurred along much of the Pacific coast of northern Central America (Howell and Webb 1995, Fig.4-2A) from southern Mexico through Nicaragua, there is little documentation of the historic occurrence of the Scarlet Macaw in El Salvador. Figure 4-2B shows the locations of historic accounts and current occurrence of the species along the Pacific coast in El Salvador, Guatemala, and Honduras. Based on reports in El Salvador by Dickey and van Rossem (1938), Scarlet Macaws were “Probably formerly all along the coastal plain, but now completely extirpated except in the almost uninhabited southeast part of the republic.” Further, they state that “As a result of constant persecution, dating from the first days of trading ships, these macaws are now reduced to a comparatively few pairs which are said to nest in the wild section of the coast south of the Colinas de Jucuarán." They collected 3 specimens in that region, at Lake Olomega, in September 1925. Thurber (1987) attributes their

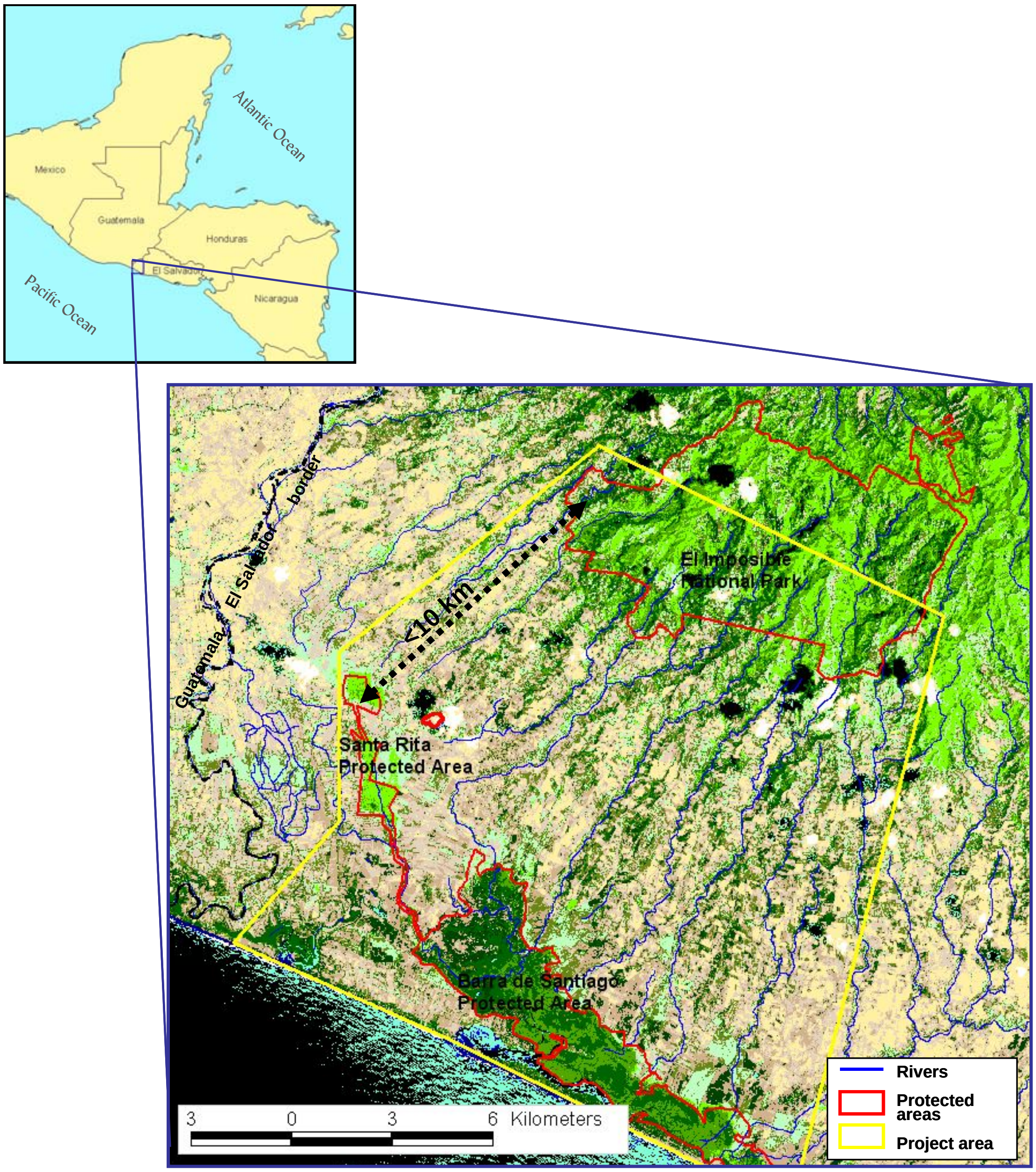


Figure 4-1. Area proposed for Scarlet Macaw reintroduction in western El Salvador referred to as the El Imposible-Barra de Santiago Corridor. The green colors represent forest cover, including primary, second- growth and shade-coffee forests, and agroforestry; the beige colors represent non-forest cover including agriculture, pasture, and other converted lands. Protected areas are in red outline and the project area is in yellow outline. Map of forest cover was produced using unsupervised classification analysis (ERDAS 2003) on 2006 high-resolution satellite imagery (ASTER image). White and black splotches on the image are clouds and their shadows, respectively.

extirpation in El Salvador to “deforestation, hunting for food and feathers, and nest robbing for the pet trade”. Salvadoran biologist, Nestor Herrera (Ministry of the Environment, pers. comm.) recounted a description from a book about the history of El Salvador which described Scarlet Macaws as pests in cacao plantations in the Department of Sonsonate, southwestern El Salvador (Fig. 4-2B) in the 1600s (*from* Escalante Arce 1992). Land (1970) stated that Scarlet Macaws were uncommon residents in the lowlands of Guatemala; his distribution map shows their occurrence extending across the western two-thirds of the Pacific Guatemalan lowlands where they are now extirpated. Monroe (1968) wrote about the status of the species in Honduras: “This macaw is uncommon in most of Honduras though fairly common locally in portions of the arid Pacific lowlands. It is found not only in the vicinity of forests but also in the scrubby growth of the Pacific coast.” It is perplexing why there are not accounts of macaws in the project area since the 1600s, yet they were reported ~100 km to the west in Guatemala in 1970 and ~200 km to the east in El Salvador in 1925 (Figure 4-2B).

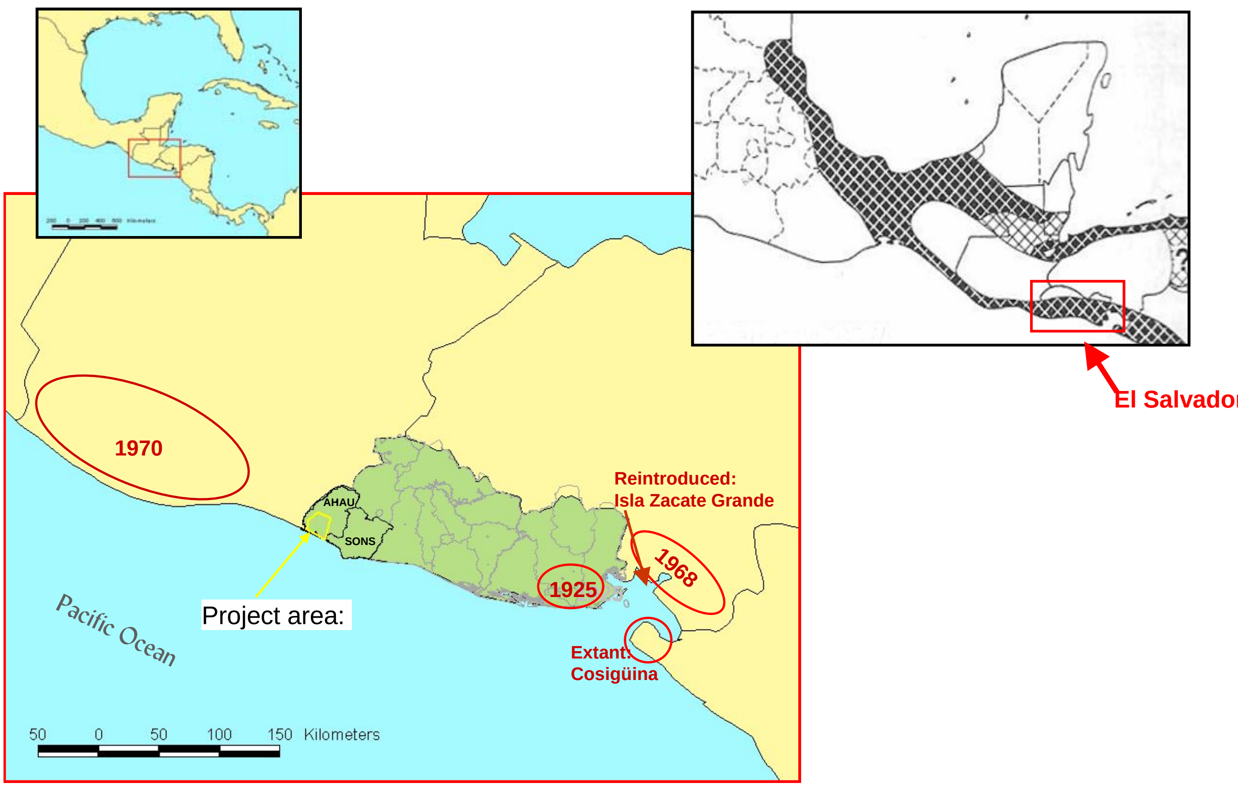


Figure 4-2. RIGHT: Historic (black hatch) and current (white hatch) distribution of the Scarlet Macaw in northern Central America and Mexico (*from* Howell and Webb 1995). LEFT: Locations of historic accounts of the species along the Pacific coast in Guatemala, El Salvador, and Honduras, the highly threatened, small extant population in the Cosigüina Peninsula, Nicaragua, and the reintroduced flock at Isla Zacate Grande, Honduras. The project area is in the Department of Ahuachapán (AHAU) and a historic report of macaws in the 1600s was in the adjacent Department of Sonsonate (SONS). Distribution accounts come from Dickey & Van Rossem 1938, Thurber 1987, Escalante Arce 1992 (El Salvador), Land 1970 (Guatemala), and Monroe 1968 (Honduras). Historic location in Honduras is approximated on the figure based solely on Monroe’s (1968) written description.

Status of extant coastal Pacific Scarlet Macaws in Nicaragua and Honduras

Cosigüina Peninsula, Nicaragua and Isla Zacate Grande, Honduras (Fig 4-2B) were two sites reported to have a population or flock of free-living Scarlet Macaws. Little published information was available on the status of these macaws, which are the closest in proximity (~250 km) and habitat to conditions for macaws that once occurred in El Salvador. Our objective was to visit the sites and document what is currently known about each population/flock and investigate the potential to collaborate with Nicaraguans and/or Hondurans in further research of their birds.

<u>Nicaragua:</u>

Dr. Oliver Komar (Director of Conservation Science, SalvaNATURA) and I made an expedition to the region from 3-8 April, 2008 (Fig. 4-3). Based on field observations, we know that Scarlet Macaws still exist in the wild in the Cosigüina Volcán Nature Reserve, Cosigüina Peninsula. In one day, we observed at least 2 pairs of wild macaws and possibly up to 7 different individuals. Based on unpublished reports (Camacho and Martínez 2006, Frontier Nicaragua 2004), interviews with a community-based park guard, volunteer park guard, and 2 long-time residents (a fisherman and rancher), and on the limited area we covered, we estimated the population to be very small, maybe 20 to 50 birds. The population's continued existence is extremely threatened. Fig. 4-4 provides a few photos of our expedition.

Funding severely limits the ability of LIDER (Luchadores Integrado Desarrollo de la Región), the NGO responsible for co-management of Cosigüina with MARENA (Ministry of Environment and Natural Resources), to protect and manage for their macaw population. There are reports of ongoing chick poaching and 'winging'(i.e. shooting to injure the wing of a flying bird to facilitate its capture) of adult Scarlet Macaws in Cosigüina, which are usually then transported across the Bay of Fonseca to sell in El Salvador. Continued involvement in conservation of and research on this population is not only of highest priority for the population, but valuable to our project as these birds provide a model of wild macaw behavior and habitat use in a similar biogeographic region.

<u>Honduras:</u>

At an initial planning meeting for our project in 2007, a Scarlet Macaw reintroduction effort carried out in the 1990s on Isla Zacate Grande (Gulf of Fonseca), Honduras, was described by a SalvaNATURA board member. There was no information about the current status of the project or specific details of how it developed, and we decided that a site visit was in order. The Zacate Grande Biological Station, a 2100 ha private reserve on the island, is owned by Miguel Facussé of Corporación DINANT, a large food industry based in Tegucigalpa, Honduras. Señor Facussé established this reserve, and 2 others in Honduras, for protection of biodiversity. Activities at the station include community agroforestry, seminars on wildfire management and laws for park guards and police, and reforestation projects.

On 8 April, Olvin Andino, Director of Environmental Planning for DINANT, gave us a tour of the facility (Figs. 4-5). Prior to joining DINANT, Andino worked with the Centro de Rescate de Fauna in Tegucigalpa and was interested in reintroduction of wildlife. Although the details of the project are a bit sketchy and not formally documented, what we understand from Andino is that their work with Scarlet Macaws began in about 1996-97 when they were given 4 chicks confiscated from poachers; the birds are thought to have originated from the Mosquito (Caribbean) region of Honduras. A few years later they received another 5 macaws (adults and chicks), also confiscations of unknown origin. They set up a macaw feeding platform and erected artificial nests on trees in the well-developed center of the facility where they liberated the birds a few years after receiving them. The birds are provided daily supplemental food and they also feed on wild fruits, including cashew, mango, and tamarindo. None of the birds have been banded and the status of individuals is not known. They have not formally monitored breeding activities or reproductive success; however some of the birds nest and produce young. In 2007, Andino observed the first nesting in a natural cavity—a guanacaste (*Enterolobium cyclocarpum*) tree. Previous nesting had been attempted in artificial nests. They observed 3 nesting attempts in 2008, one in which the eggs were predated, success of the other two nests.

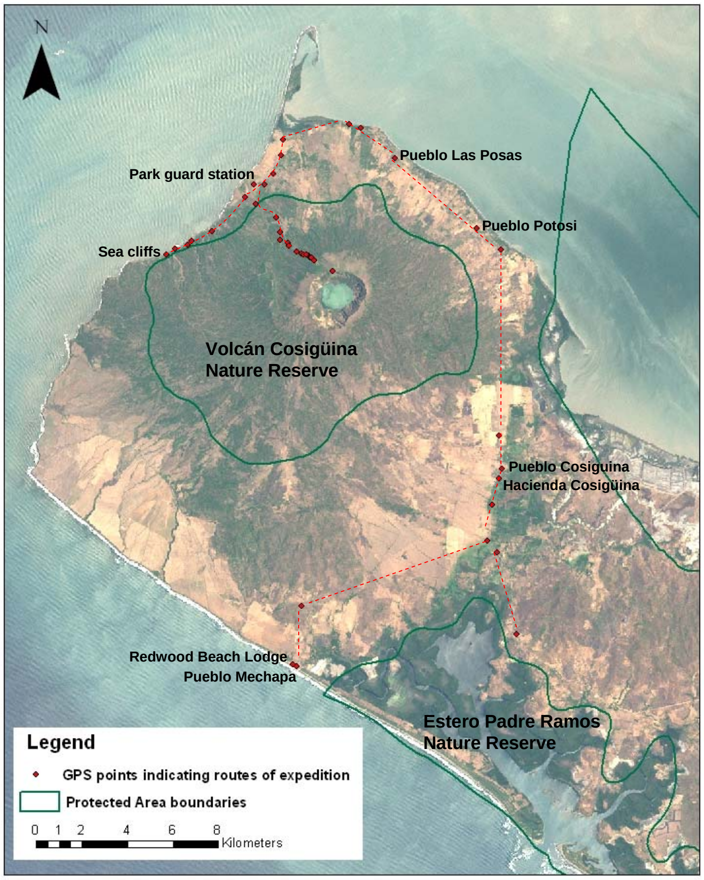


Figure 4-3. Satellite image (ETM+) showing the Cosigüina Peninsula and delineation of protected areas. The red dashed line traces our route during the expedition. We traveled around the east side of the peninsula to reach our lodgings for the next 2 nights—the Cosigüina Park Guard Station in the north. From the park station, we explored the region, including the crater of the volcano and the sea cliffs. At the end of the expedition, we visited the Redwood Beach Lodge on the southwest side of the peninsula; the American owner who provides ecotours to the crater did not know that Scarlet Macaws occurred in the region. Figure 4-2 shows the regional geographic referente of Cosigüina.

Figure 4-4. TOP LEFT: The park guard station at Cosigüina Volcano Nature Reserve with a view of the volcano as the backdrop. TOP RIGHT: Oliver Komar, Martín Lezama, and Zoraida Martínez stand at the edge of the Cosigüina crater. BOTTOM LEFT: Pet Scarlet Macaw in Pueblo Potosi located on the eastern shore of the Cosiguiña Peninsula (Fig. 4-3). The 3-year old bird was brought to the residence as a chick that was poached from a wild nest in the area. A poster stating: YO PROTEJO LA LAPA ROJA" or "I PROTECT THE SCARLET MACAW", was hanging on the front door of the home. BOTTOM RIGHT: Another pet macaw, said to be 22 years old, perches on its owner's arm in Pueblo Potosi.

At least some of the birds range outside the reserve; Andino has received reports of free-flying macaws being trapped in nearby communities and on the adjacent island of Amapala and he believes that there are now ~20 free-flying macaws. Isla Zacate Grande is only ~35 km (over-water) from the Cosigüina Peninsula, an overland flight distance within documented range for Scarlet Macaws. Contact between the Zacate Grande and Cosigüina birds is within the realm of possibility. During our short visit, we observed at least 6 macaws perched in trees and 1 pair nesting in a guanacaste tree located near buildings of the central facility (Fig. 4-5). The birds showed no fear of humans and allowed our close approach. It is encouraging to learn that even without pre-release conditioning these birds are feeding in the wild and breeding. As a model, there are serious concerns about this sort of 'reintroduction'. Disease testing was not performed nor was there documentation of the project. The birds have no fear of humans, continue to depend on regular supplemental food, and appear to have been conditioned to nest in inappropriate situations (e.g. low to the ground) which makes them highly vulnerable to human and non-human predators alike (Fig. 4-5). High security and long-term daily maintenance is required. However, there may be cases where this strategy (semi-wild and managed flocks) is acceptable because it is the only way the species will survive outside of zoos or 'rescue' critically small populations (Chapter 10, *Semi-wild Releases and Managed Populations*), e.g. the possible situation between Cosigüina and Isla Zacate Grande. However, given the potential transmission of disease from released birds to wild populations, appropriate health evaluation should be considered a critical component of any strategy.

Figure 4-5. The Zacate Grande Biological Station, Honduras, where a small Scarlet Macaw reintroduction project with birds released in 1996-97 and in the early 2000s. TOP LEFT: The macaws' feeding station; fresh fruits and corn are placed in trays and the free-living macaws come in to feed daily. RIGHT: Olvin Andino (left) describes the view from the patio of the dining area. Reportedly, macaws fly to nearby islands; El Salvador is barely visible across the Gulf of Fonseca. Free-living Scarlet Macaws at Zacate Grande Biological Station are highly acclimated to the presence of humans. BOTTOM: During our visit to the station, we observed several macaws perched in trees and observed a pair nesting in a guanacaste (*Enterolobium cyclocarpum*) tree around the central facility buildings. The birds showed no fear of humans and allowed our close approach.

4.2.2 Habitat Evaluation

Scarlet Macaws inhabit tropical humid and tropical deciduous dry forests (Weidenfeld 1994). They are considered a lowland species, generally reported to occur from sea level to approximately 400-600 m (IUCN 2001: 600 m, Vaughn 1983: 500 m, Weidenfeld 1994: 400 m); however, other published reports suggest that the upper elevation limit of the species is higher: 900m (Land 1970), 1000m (Renton 2000), 1100m (Monroe 1968). Our project area covers an elevation range of approximately 0-600m above sealevel (Fig. 4-6A), although the park extends well beyond the project area up to 1425m and down the northern slope to approximately 1000m. Headwaters of eight rivers originate in El Imposible. The project area encompasses appropriate dry forest and humid forest types used by Scarlet Macaws (Fig. 4-6B).

Scarlet Macaws are primarily granivores (seed-eaters); they forage on a wide variety of plant species consisting primarily of immature seeds, but also fruit pulp, flowers, and other plant parts (leaves and stems). The species is considered relatively adaptable in diet (Renton 2000) and can exist in somewhat degraded natural habitats (Vaughn et al. 2006) if anthropogenic impacts to survival, such as hunting and poaching, are minimized. They are known to range widely, traveling 15 km or more daily, from roosting to foraging areas (Myers and Vaughn 2004) and more than 100 km in seasonal migrations (Morales et al. 2001) probably tracking variation in food resources. Note that the distance between montane El Imposible National Park and coastal Barra de Santiago and Santa Rita protected areas is 10-15 km (Fig. 4-1).

To evaluate the capacity of the existing foraging habitat in the project area to sustain a population of reintroduced Scarlet Macaws throughout their annual cycle, we are conducting an analysis to determine what natural food resources occur in the area, where and when they are available, and in what quantity. Note that evaluation of nesting resources is a low priority in this phase of the project; once we advance to the phase of preparing for release of birds, we can evaluate nesting resources in the release area and, if insufficient, we can supplement the area with artificial nests which have been successfully utilized by Scarlet Macaws in the wild (Brightsmith 2000; Vaughn et al. 2003; WCS-Guatemala, unpubl. data). Because Scarlet Macaws are known to range widely in search of food and because fruiting within and among species can vary by elevation, fruit monitoring is being conducted across an elevation gradient of 0-600 m. Strategy and progress in this component of the project is detailed below.

We have:

- Produced a map of current forest landcover in the corridor using an unsupervised classification analysis (ERDAS 2003) of 2006 high resolution imagery (ASTER satellite imagery; Fig. 4-1). The map aided in locating sampling sites. In an ongoing mapping effort by USAID, a finer-scale landcover map will be produced and should allow us to quantify the extent (i.e. area) of different forest types. GIS mapping and analyses are carried out with ArcGIS software (ESRI 2005).

- Compiled information on known natural food resources of Scarlet Macaws from published literature and reports (Appendix 4-B; Matuzak et al. 2008; Peréz 1998; Renton 2006; Vaughn et al. 2006). This list was then used as the basis for generating a list of species to be

A.

B.

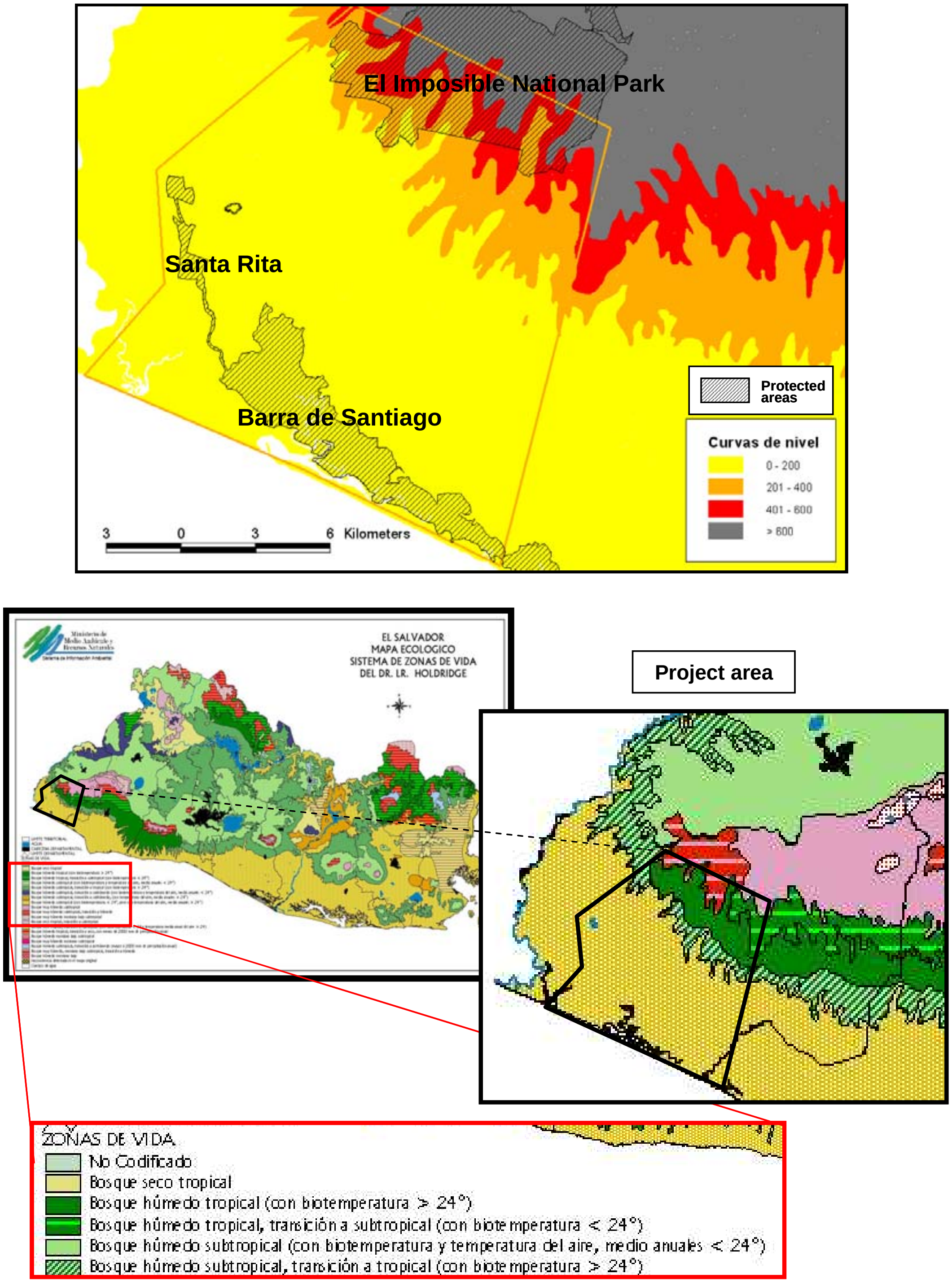


Figure 4-6. **A.** Elevation range in project area (orange polygon). Scarlet Macaws are generally reported to occur from sea level to approximately 400-600 m. **B.** Map of natural vegetation of El Salvador (*from* Centeno et al. 2000) and enlarged section showing the project area.

monitored for reproductive phenology and fruit abundance in the project area. A total of 95 tree and palm species in 29 families was summarized from the Central American literature; dominant families were Anacardiaceae, Apocynaceae, Bombacaceae, Fabaceae, Moraceae, Palmae, and Sapotaceae. Some species are non-native or exotic, including species common to the project area, such as beach almond (*Terminalia catalpa*).

- Contracted Salvadoran botanist, M.Sc. José Linares, in February for initial surveys of different forest types throughout the project area, identification of tree species occurring in the project area that may provide food resources for macaws, and training the field team in identification of these species. 'Potential food resources' include tree and palm species occurring in the project area that match or are similar to documented species, i.e. same genus or family of species on the list of known food species. We identified 76 species in the project area as potential food resources for macaws (Appendix 4-C). Fig. 4-7 provides a few photos to illustrate forest and other land cover types in the project area.

- Divided the project area into 3 elevation zones (0-200 m, 200-400 m, and 400-600 m) and established 4-6 sampling sites in forested lands in each zone (Fig. 4-8A). Obtaining permission to establish sampling sites on private land (outside the protected areas) has been problematic. SalvaNATURA is often equated with the Ministry of the Environment (MARN) and is sometimes viewed with suspicion, especially with respect to land rights and enforcement of illegal activities.

- Marked approximately 5 individuals at each site of any target species that occur at the site, not to exceed approximately 120 marked individuals in order to be able to complete sampling of 1-2 sites in one day. For sampling species that occur on private lands and/or close to community centers (e.g. beach almond, *Terminalia catalpa*), we have instituted an alternative to sampling in discrete sites. We sample trees along public access routes using only a GPS to locate individuals, thereby eliminating the obvious identification number painted on the tree and the need for landowner permission.

Monitoring began in April 2008 of over 2000 individually-marked trees in 21 sites which we observe monthly to document timing of fruiting and abundance of fruit. The variables collected for each marked tree are (1) state of leaves, (2) presence of flowers, (3) number of fruits (classified into numerical-range categories), and (4) percent categories of the fruit crop present relative to maximum expected fruit crop for the given species (Appendix 4-D). We will use these data, interpreted with reference to tree species composition, density, and size distribution, as well as extent of forest, to estimate potential food resources for Scarlet Macaws throughout the region and throughout the annual cycle (Fig. 4-8B).

These data will then need to be assessed in terms of carrying capacity for a target population size considered to be viable over the long-term in order to reach a conclusion about habitat sufficiency for the reintroduction. It is suggested that a "Population and Habitat Viability Analysis will aid in identifying significant environmental and population variables and assessing their potential interactions, which would guide long-term population management" (IUCN/SSC 1995). A PVA for Scarlet Macaws was done as part of the workshop (Chapter 7, *PVA & Vortex Modeling*). A relative sense of carrying capacity for Scarlet Macaws can be made by a comparison of environmental and habitat characteristics between the project area and sites with Scarlet Macaw populations in Costa Rica and Nicaragua. The analysis indicates that the project area is within the general range of habitat conditions and size of the other sites (Appendix 4-E; Brightsmith et al. 2005, Myers and Vaughn 2004).

4.2.3 Reintroduction Protocols and Strategy

Development of our strategy and protocols includes review of relevant reintroduction literature and learning from other parrot/macaw reintroduction attempts and experts. In December 2007, Janice Boyd, Gabriela Ponce, and Robin Bjork were provided an up-close look at the Puerto Rican Parrot (*Amazona vittata*) Recovery Program (White et al. 2005). It is collaboration among the U.S. Fish and Wildlife Service, U.S. Forest Service, the Puerto Rico Department of Natural and Environmental Resources, and the U.S. Geological Survey. Dr. Thomas White (FWS Program Director) and the staff at both the Río Abajo and the El Yunque facilities detailed their protocols and experiences from 40 years of building a program which has attained huge success and has a wealth of knowledge to impart (Fig. 4-9). In April 2008, the workshop in Guatemala (this Proceedings) was held to unite a multi-disciplinary team of experts in the fields of psittacine' health, genetics, ecology, and population modeling, and develop protocols and obtain consensus on optimal strategies for restocking of Scarlet Macaws into the wild. To build capacity for our project in El Salvador, we sponsored two Salvadoran veterinarians to attend the workshop: Dr. Paola Tinetti, an avian veterinarian for the National Zoo and Dr. Ameríco Reyna, a private veterinarian and ecotourism businessman. Both of these professionals have expressed interest in participating in the reintroduction project.

Ms. Kari Schmidt presented preliminary results of her range-wide phylogenetic analysis of Scarlet Macaws (see appendix in this proceedings on Scarlet Macaw genetics study). Her results align well with Weidenfeld (1994) who described 2 subspecies of Scarlet Macaws based on morphometric data: the northern Central American subspecies, *Ara macao cyanoptera* and the southern Central American/South American subspecies, *A. m. macao*. Samples from central and southern Pacific Nicaraguan birds cluster more closely with the southern subspecies than the northern subspecies. Museum samples from macaws collected in El Salvador and coastal Honduras and Guatemala are pending analysis. Additional samples could be obtained from captive macaws on the Cosigüina Peninsula, Nicaragua. Based on regional topography, macaws once existing in El Salvador may be more closely related to *A. m. macao* than to *A.m. cyanoptera* (Schmidt, pers. comm.). Upon completion of Schmidt's analysis, we will be better informed about genetic stock to target with the goal of releasing macaws that most genetically resemble the population that once existed in El Salvador.

4.2.4 Yellow-Naped Parrot Population Evaluation

The Yellow-naped Parrot, *Amazona auropalliata*, is the largest (~400 g) of six extant psittacines in the project area; the others are Pacific Parakeet, *Aratinga nana*; Orange-fronted Parakeet, *Aratinga canicularis*; Red-throated Parakeet, *Aratinga rubritorquis*; Orange-chinned Parakeet, *Brotegaris jugularis*; White-fronted Parrot, *Amazona albifrons*. The Yellow-naped Parrot

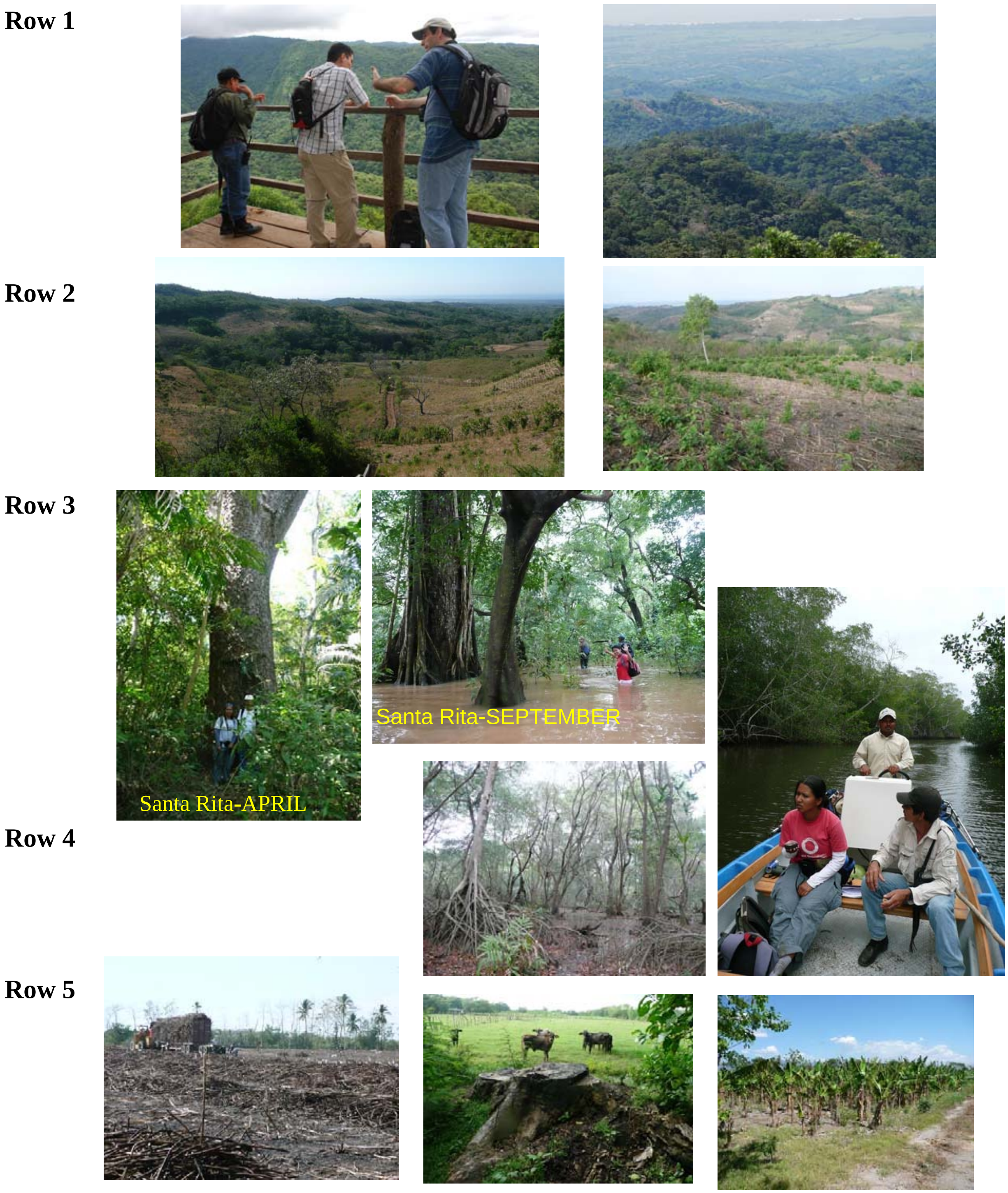
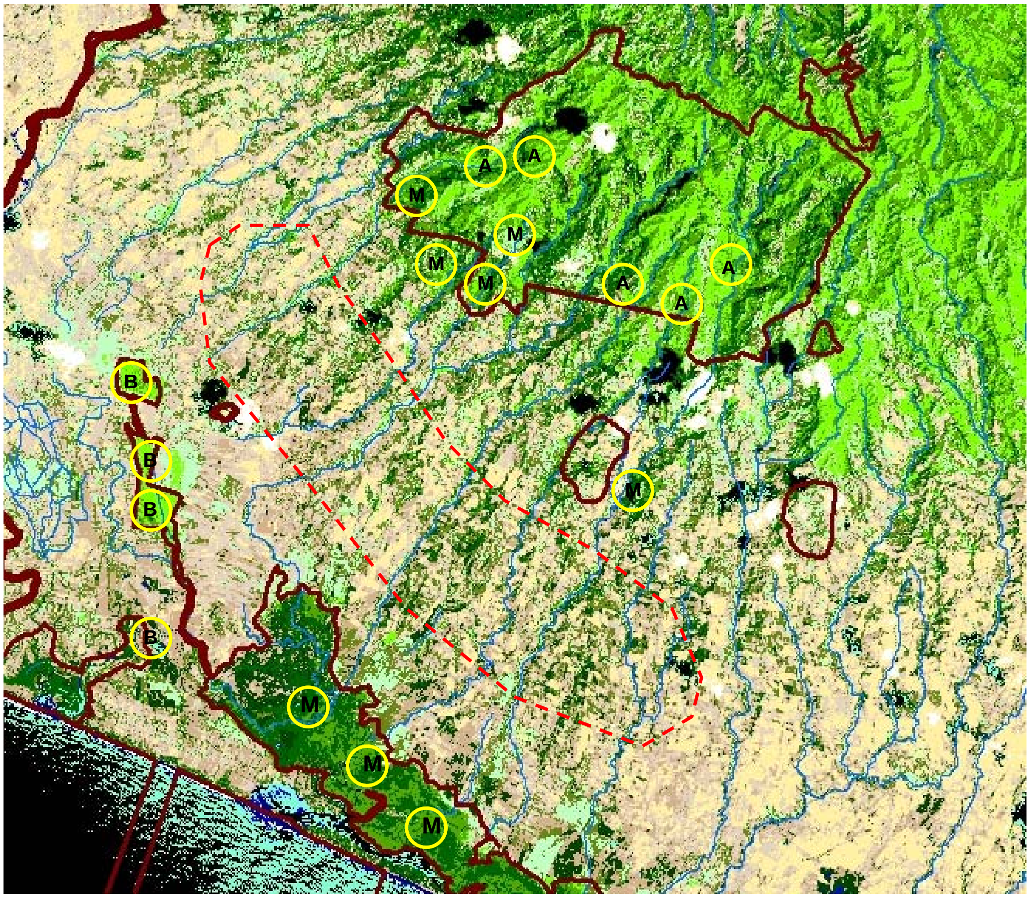


Figure 4-7. Habitat in project area. **Row 1**: View of intact primary forest from overlook in El Imposible National Park & of the corridor from El Imposible to the coast; **Row 2**: Degraded forest patches, corn fields, and pasture in mid-corridor, **Row 3**: Remnant seasonally-inundated primary forest of Santa Rita Protected Area; **Row 4**: Mangroves of Barra de Santiago Protected Area; **Row 5**: Sugar cane, cattle pasture, and other agriculture surrounds the lower elevation protected areas.

A.



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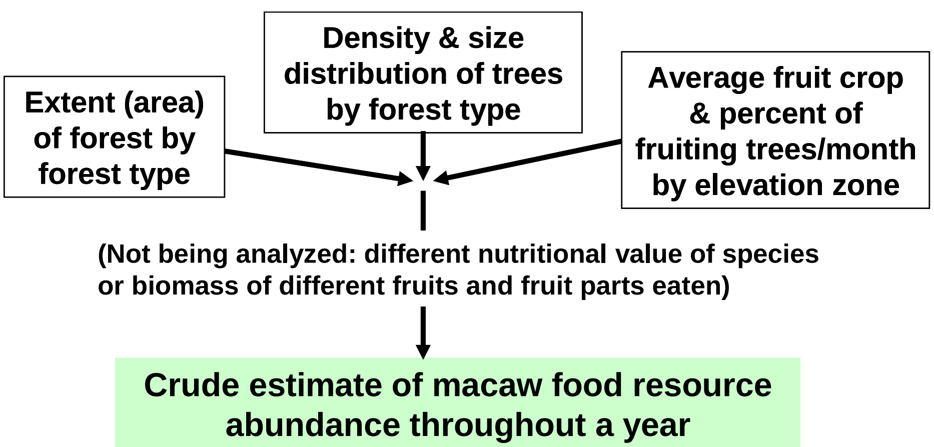

Figure 4-8. **A.** Distribution of sampling sites in different elevation zones of the project area, A= "alto" or high (400-600 m), M= "medio" or mid (200-400 m), and B= "bajo" or low (0-200 m). We have had difficulty locating sites outside protected areas in the mid to low elevation zone (red dashed line) because much of the forest exists in degraded forest patches and under private landowners who are unwilling to grant permission to work on their land. **B.** Schematic of data needed to estimate macaw food resource abundance.

Figure 4-9. Visit to the Puerto Rican Recovery Program. From LEFT to RIGHT, TOP: Tom White and Robin Bjork stand at new flight cage at El Yunque; Jafet Velez-Valentin (Aviary Operations Coordinator) describes health issues in their well-equipped lab at El Yunque. CENTER: Ivan Roman Ricardo (Coordinator of Releases, Río Abajo) and Gabriela Ponce stand at the pre-release cage holding 22 Puerto Rican Parrots; Ricardo Valentin discusses diet and food storage to Janice Boyd at Río Abajo. BOTTOM: Ricardo, Janice, and Gabriela inspect breeding cages at Río Abajo; breeding cages at El Yunque are situated in forest with visual separation between them.

(YNPA) is listed in CITES, Appendix I (CITES 2002 a, b) and is being considered for inclusion on the IUCN Red List as "Vulnerable" (Snyder et al. 2000). It exists in very low numbers on the Pacific slope in Central America, critical in Mexico, low numbers in southern Guatemala in disturbed cane and cattle pastures, and reduced numbers in Salvador and Honduras (Snyder et al. 2000). Negative impacts of reintroduction could contribute to extirpation of this rare species, a concern voiced by the Ministry of the Environment at the initiation of the project. Conversely, given our plan to include education and conservation themes on Yellow-naped Parrot in our outreach/education component, we expect that the reintroduction would have a significant positive benefit for the population's long-term persistence.

We chose the Yellow-naped Parrot as an element of biodiversity in the project area to be among the most likely to exhibit effects—both positively and negatively—from the reintroduction of Scarlet Macaws. The YNPA inhabits mangroves and lowland forest patches in the project area, and we believe it has the high likelihood for resource overlap—and potentially competition—with Scarlet Macaws, especially for food resources. There is broad overlap of food species between YNPA and Scarlet Macaws; over 50% of the tree species on our list of potential food resources for Scarlet Macaws are documented food items of YNPA in the project area (Herrera and Herrera 2008). The birds nest in cavities of large old mangrove trees which have been heavily logged out, and the population is thought to be reproductively limited by insufficient nes–limited (Herrera and Herrera 2008). Beginning in December 2008, we will initiate research on the population (population size, diet, habitat use), erect artificial nests and monitor reproductive activities in natural and artificial nests, and include the species in our education outreach. If birds are captured for a telemetry study (pending), we plan to conduct health evaluations. From what we know about the needs of Scarlet Macaws and what we learn about those of YNPA, we can assess potential impacts of the reintroduction and monitor for predicted impacts if the reintroduction proceeds.

4.2.5 Site Determination

We will identify potential locations for reintroduction facilities considering availability of macaw food resources and forest connectivity throughout the corridor, security issues, land tenure and availability, human density, and educational opportunities. From this evaluation, a site-specific strategy will be defined. More than one site-strategy may be possible (Chapter 10, *Release, reintroduction, population management*), e.g. a remote *in-situ* pre-release facility with young, well-socialized birds and minimal human presence and a park/education facility with semi-tame park birds (older, captive-kept adults) encouraged to remain in the vicinity, even nest, and which require long-term maintenance.

4.2.6 Environmental Education

Critical to the success of this project is the securing of local community support and participation in the project. Public outreach and grade school education is the primary means by which we will approach this task. An effective program must address underlying problems that led to the extirpation of the species, namely poaching and habitat degradation. Poaching is likely the current overriding threat to the continued existence of the Yellow-naped Parrot population. Clearly, poaching is also a threat to reintroduced macaws; even if released within the boundaries of a protected area, birds will easily range outside these boundaries and come into contact with humans. We see a need for a holistic education outreach program that works to influence attitudes toward conservation of psittacines. Included will be education on national laws with respect to poaching and habitat alteration, however effective law enforcement is a necessary element of success on this front. Given the inadequate state of Salvadoran law enforcement on crimes involving wildlife, we plan to encourage and support stronger enforcement and consider including a component for education of law enforcement staff.

There are various ongoing environmental education (EE) initiatives in the project area (Fig. 4-10), and we believe that collaborating with and supporting existing efforts, both facilitates our agenda and benefits the communities. We organized a workshop to unite key actors in EE from the local community, protected areas, and government to (1) present the objectives and status of our reintroduction project, (2) facilitate communication among practioners, (3) gain a better understanding of the state and needs of EE in the urban and rural zones in the region, and (4) develop a proposal for an integrated EE program. The workshop, "*Taller de consulta previo a la elaboración del programa de educación ambiental en el Corredor Biológico El Imposible-Barra de Santiago, El Salvador*" was held in San Salvador on 10 April 2008 (Fig. 4-11). The highly-

Figure 4-10. Environmental education programs in project area. TOP: Santa Rita educators are also park guards who give presentations in the schools surrounding the protected area and bring kids to the park. They also have a reforestation program in the corridor which separates their 2 small protected forests. BOTTOM: The NGO, AMBAS, co-manages Barra de Santiago with the Ministry of the Environment (MARN) and recently constructed a new community education center; SalvaNATURA has an active education program in El Imposible National Park.

participatory format of the workshop was defined and facilitated by Lic. Marta Lilian Quezada, Specialist in Environmental Education and Communication, who is currently directing the USAID/SalvaNATURA EE program in the region. A report summarizing the results of the workshop was produced. Public dissemination of information in the project area, specifically on the reintroduction project, is planned for Winter 2008.

Figure 4-11. We organized a workshop in April 2008 to unite key actors involved in environmental education in the project area, including members of local community organizations, protected areas, and other professionals. LEFT: Round-table discussions in subgroups addressed topics such as local perceptions about biodiversity and knowledge of laws; a representative from each subgroup then presented a summary of their discussions to the full group. Dr. Oliver Komar, Director of SalvaNATURA's Conservation Science Department, is in the red shirt. MIDDLE: Another activity involved a prioritization of threats to biodiversity by first compiling a list of threats, followed by marking of the 3 highest priority threats (with green and red dots) by each participant. RIGHT: A report summarizing the results of the workshop was produced and distributed to all participants by email or hand-delivery of hard copies to those without internet access; the extra effort made (hand-delivery) to insure that all participants received a copy of the results was greatly appreciated and is an important aspect of communication and education to consider.

4.3 Next Phase

The next phase of the project will involve defining a reintroduction strategy or strategies for El Salvador based on our habitat evaluation and the availability of birds. Acceptability of likely sources of birds for reintroduction relative to health, genetics, and personal histories will be evaluated, and optimal strategies and costs will be outlined, including 1) age/gender of birds and procedure of reintroduction, 2) infrastructure requirements, 3) staffing requirements, 4) source of birds and means of their procurement from source to our facility, 5) maintenance of captive and released birds (food, security procedures), and 6) monitoring of birds from pre- through post-release (e.g. behavior, bird counts at feeding stations, radio tracking). We will then present our final analysis to the Ministry of the Environment for their approval, followed by identification of source birds and procurement of necessary national and international permits.

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Appendix 4-A. Summary of the reintroduction guidelines defined by the International Union for the Conservation of Nature/Species Specialist Commission/Reintroduction Specialist Group (IUCN/SSC 1995).

AIMS AND OBJECTIVES

Aims: The principal aim of reintroduction should be to establish a viable, free-ranging population in the wild, of a species, subspecies or race, which has become globally or locally extinct, or extirpated, in the wild. It should be reintroduced within the species' former natural habitat and range and should require minimal long-term management.

MULTIDISCIPLINARY APPROACH

A reintroduction requires a multidisciplinary approach involving a team of persons drawn from a variety of backgrounds. As well as governmental personnel, they may include persons from governmental natural resource management agencies; non-governmental organizations; funding bodies; universities; veterinarian institutions; zoos, with a full range of suitable expertise. Team leaders should be responsible for coordination between the various bodies and provision should be made for publicity and public education about the project

PRE-PROJECT ACTIVITIES

A. Feasibility study and background research:

- An assessment of the taxonomic status of individuals to be reintroduced. They should preferable be of the same subspecies as those which were extirpated. An investigation of historical information about the loss and fate of individuals from the reintroduction area, as well as molecular genetic studies, should be undertaken in case of doubts as to individuals' taxonomic status.
- Detailed studies should be made of the status and biology of wild populations to determine the species' critical needs. This includes descriptions of habitat preferences, intraspecific variation and adaptations to local ecological conditions, social behavior, group composition, home range size, shelter and food requirements, foraging and feeding behavior, predators and disease. Overall, a firm knowledge of the natural history of the species in question is crucial to the entire reintroduction scheme.

B. Previous Reintroductions

- Thorough research into previous reintroductions of the same or similar species and wide-ranging contacts with persons having relevant expertise should be conducted prior to and while developing reintroduction protocol.

C. Choice of release site and type

- Site should be within the historic range and natural habitat of the species. The reintroduction area should have assured, long-term protection.

D. Evaluation of the reintroduction site

- Availability of suitable habitat: reintroductions should only take place where the habitat and landscape requirements of the species are satisfied, and likely to be sustained for the forseeable future. The area should have sufficient carrying capacity to sustain growth of the reintroduced population and support a viable (self-sustaining) population in the long run.
- Identification and elimination, or reduction to a sufficient level, of previous causes of decline. Where the release site has undergone substantial degradation caused by human activity, a habitat restoration program should be initiated before the reintroduction is carried out.

E. Availability of suitable release stock

- If captive or artificially propagated stock is to be used, it must be from a population which as been soundly managed both demographically and genetically, according to the principles of contemporary conservation biology.
- Prospective release stock must be subjected to a thorough veterinary screening process before shipment from original source.

F. Release of captive stock

- Most species of mammal and birds rely heavily on individual experience and learning as juveniles for their survival; they should be given the opportunity to acquire the necessary information to enable survival in the wild, through training in their captive environment; a captive bred individual's probability of survival should approximate that of a wild counterpart.

Appendix 4-A, continued.

SOCIO-ECONOMIC AND LEGAL REQUIREMENTS

- Reintroductions are generally long-term projects that require the commitment of long-term financial and political support.
- Socio-economic studies should be made to assess impacts, costs and benefits of the re-introduction program to local human populations.
- A thorough assessment of attitudes of local people to the proposed project is necessary to ensure long term protection of the re-introduced population, especially if the cause of species' decline was due to human factors (e.g. over-hunting, over-collection, loss or alteration of habitat). The programme should be fully understood, accepted and supported by local communities.
- Where the security of the reintroduced population is at risk from human activities, measures should be taken to minimize these in the reintroduction area. If these measures are inadequate, the reintroduction should be abandoned or alternative release areas sought.
- The policy of the country to reintroductions and to the species concerned should be assessed. This might include checking existing provincial, national and international legislation and regulations, and provision of new measures and required permits as necessary.
- Reintroduction must take place with the full permission and involvement of all relevant government agencies of the recipient or host country.

PLANNING, PREPARATION AND RELEASE STAGES

- Approval of relevant government agencies and land owners, and coordination with national and international conservation organizations.
- Construction of a multidisciplinary team with access to expert technical advice for all phases of the program.
- Identification of short- and long-term success indicators and prediction of programme duration, in context of agreed aims and objectives.
- Securing adequate funding for all program phases.
- Design of pre- and post- release monitoring program so that each reintroduction is a carefully designed experiment, with the capability to test methodology with scientifically collected data.
- Appropriate health and genetic screening of release stock, including stock that is a gift between governments. Health screening of closely related species in the reintroduction area.

Appendix 4-B. Information on known natural food resources of Scarlet Macaws in Guatemala, Belize, and Costa Rica complied from **1**: Peréz 1998, **2**: Renton 2006, **3**: Vaughn et al. 2006, and **4**: Matuzak, unpubl. data. Letters in column 1 refer to additional sources of data and references in Perez 1998, a: Rodas 1997-Guatemala, b: Ramirez 1997-Guatemala, and c: Marineros and Vaughn 1995-Costa Rica).

1	2	3	4	FAMILY	SCIENTIFIC NAME
		X		ACANTHACEAE	*Bravaisia integerrima*
		X	X	ANACARDIACEAE	*Anacardium excelsum*
		X			*Anacardium occidentalis*
			X		*Mangifera indica*
1					*Metopium brownei*
1	X	X	X		*Spondias mombin*
		X	X		*Spondias purpurea*
1					*Spondias spp.*
				ANNONACEAE	*Xylopia frutescens*
1,a				APOCYNACEAE	*Aspidosperma megalocarpon*
a					*Aspidosperma sp.*
		X			*Aspidosperma spuceanum*
1					*Aspidosperma stegomeris*
1,a		X			*Stemmadenia donnell-smithii*
			X	AVICENNIACEAE	*Avicennia germinans*
c		X	X	BIGNONIACEAE	*Tabebuia rosea*
		X		BOMBACACEAE	*Bernoullia flammea*
			X		*Bombacopsis quinata*
			X		*Ceiba aesculifolia*
c		X	X		*Ceiba pentandra*
			X		*Ochroma lagopus*
		X			*Ochroma pyramidale*
		X			*Quararibaea asterolpsis*
		X		BORAGINACEAE	*Cordia collococca*
1,a	X	X	X	BURSERACEAE	*Bursera simarouba*
1,a					*Protium copal*
a				CHRYSOBALANACEAE	*Hirtella americana*
c		X			*Licania platypus*
		X	X	COMBRETACEAE	*Terminalia catappa*
		X			*Terminalia oblonga*
	X			EUPHORBIACEAE	*Cnidoscolus spp.*
c		X			*Hura crepitans*
c		X			*Sapium jamaicense*
a,b	X				*Sebastiana longicuspis*
a,b				FABACEAE	*Acacia angustissima*
b			X		*Cassia grandis*
			X		*Delonix regia*
1		X	X		*Enterolobium cyclocarpum*
		X			*Erythrina spp.*
		X			*Hymenaea courbaril*
			X		*Inga spp.*
		X	X		*Inga vera*
		X			*Lonchocarpus acuminatus*
			X		*Lysiloma divaricatum*
		X			*Pithecellobium saman*
			X		*Pseudosamanea guachapele*
			X		*Samanea saman*

Appendix 4-B, continued.

1	5	6	7	FAMILY	SCIENTIFIC NAME
c	X	X	X	FABACEAE	*Schizolobium parahybum*
			X		*Tamarindus indica*
a				LAURACEAE	*Ocotea spp.*
			X	LYTHRACEAE	*Lagerstroemia speciosa*
	X			MARCGRAVIACEAE	*Schwartzia spp.*
1		X	X	MELIACEAE	*Cedrella odorata*
		X			*Guarea glabra*
1,a		X		MORACEAE	*Brosium alicastrum*
		X			*Brosium utile*
1,a					*Castilla elastica*
	X				*Cecropia obtusifolia*
		X			*Clarisia biflora*
a					*Coussapoa oligocephala*
		X			*Ficus insipida*
1,a,b		X	X		*Ficus spp.*
	X				*Pourouma bicolour*
		X			*Pseudolmedia oyyphyllaria*
1,a					*Pseudolmedia spuria*
		X		MYRISTICACEAE	*Virola sebifera*
1,a				MYRTACEAE	*Pimenta dioica*
			X		*Psidium guajava*
			X	PALMAE	*Cocos nucifera*
			X		*Elaeis guineesis*
1	X				*Orbignya cohune*
b					*Scheelea lundelli*
		X	X		*Scheelea rostrata*
1,a				POLYGONACEAE	*Coccoloba spp.*
a				RUBIACEAE	*Guettarda combsii*
1					*Sickingia salvadorensis*
1				SAPINDACEAE	*Blomia prisca*
1					*Talisia olivaeformis*
1,a				SAPOTACEAE	*Manilkara sapota*
1,a					*Pouteria amygdalina*
1,a					*Pouteria campechiana*
1,a					*Pouteria durlandii*
1					*Pouteria mammosa*
1					*Pouteria reticulata*
		X			*Pouteria spp.*
	X				*Sloanea tuerckheimii*
a				SIMAROUBACEAE	*Simarouba glaca*
	X			STERCULIACEAE	*Butnerria cf. catalpifolia*
	X		X		*Guazuma ulmifolia*
		X	X		*Sterculia apetala*
			X	TILIACEAE	*Luehea seemannii*
		X		VERBANACEAE	*Gmelina arborea*
		X	X		*Tectona grandis*
		X			*Vitex cooperi*
a,b					*Vitex gaumeri*

Appendix 4-C. List of tree species sampled for phenology and fruit abundance in the project area. The list was developed based on lists of known natural fruit resources of Scarlet Macaws (Appendix 4-A); tree species that occur in the project area which share characteristics with known food species (same family and similar fruit characteristics) were included in the list. There are a total of 78 species considered as potential food resources for macaws in the project area. The list also includes known food resources of spider monkeys, *Ateles geoffroyi* (Ponce-Santizo 2004).

(yellow)	species in project area that is the same species documented as food resource in published reports
(blue)	species in project area that is within genus of species documented as food resource in published reports
(green)	common species in the project area that is within a family used by macaws/parrots as food resource

FAMILY	SCIENTIFIC NAME	COMMON NAME
ANACARDIACEAE	*Anacardium occidentalis* L.	Marañon
	Mangifera indica	Mango
	Spondias mombin L.	Jocote de pava
	Spondias radlkoferi Donn. Sm.	Jocote jobo
APOCYNACEAE	*Aspidosperma megalocarpon* Müll. Arg.	Mojella de pato
	Plumeria rubra var. acutifolia (Poir.) L.H. Bailey	Flor blanca, mayo
	Stemmadenia donnell-smithii (Rose) Woodson	Cojón de puerco, cojón
BIGNONIACEAE	*Tabebuia chrysantha* (Jacq.) G. Nicholson	Cortez negro
	Tabebuia rosea (Bertol.) A. DC.	Maquilishuat
BOMBACACEAE	*Bernoullia flammea*	
	Ceiba aesculifolia (Kunth) Britten & Baker f.	Ceibillo
	Ceiba pentandra (L.) Gaertn.	Ceiba
	Pseudobombax ellipticum (Kunth) Dugand	Shilo
BORAGINAGEAE	*Cordia alliodora*	Laurel
	Cordia collococca	Manuno
	Cordia dentata	Tiguilote
BURSERACEAE	*Bursera (roja)*	
	Bursera simarouba (L.) Sarg.	Jiote
CHRYSOBALANACEAE	*Hirtella racemosa var. hexandra* (Willd. ex Roem. & Schult.) Prance	Aceitunillo
	Licania arborea	Roble de costa
	Licania platypus	Zunza
	Licania retifolia	Mulo
CLUSIACEAE	*Calophyllum brasiliense var. rekoi* Standl.	Mario, Marillo
COMBRETACEAE	*Laguncularia racemosa*	
	Terminalia catalpa	Almendra
	Terminalia oblonga (Ruiz & Pav.) Steud.	Volador
ELEAEOCARPACEA	*Sloanea terniflora* (Sessé & Moc. ex DC.) Standl.	Terciopelo
EUPHORBIACEAE	*Hura crepitans*	
	Omphalea oleifera Hemsl.	Shirán, tambor blanco
	Sapium macrocarpum	Chilamate
FABACEAE	*Acacia hindsii* Benth.	Ixcanal
	Acacia polyphylla DC.	Zarzo
	Albizia adinocephala	Polvo de queso
	Andira inermis (W. Wright) DC.	Almendro de río

Appendix 4-C, continued.

FAMILY	SCIENTIFIC NAME	COMMON NAME
FABACEAE	*Cassia grandis*	Carao
	Delonix regia (Bojer ex Hook.) Raf.	Arbol de fuego
	Enterolobium cyclocarpum (Jacq.) Griseb.	Conacaste
	Gliricidia sepium (Jacq.) Kunth ex Walp.	Madrecacao
	Hymenaea courbaril	Copinol
	Inga calderonii Standl.	Zapato de mico
	Inga oerstedeana	Pepeto
	Inga punctata Willd.	Caspirol
	Inga sapindiodes	Pepeto
	Inga vera Willd.	Cuje de río
	Lonchocarpus minimiflorus Donn. Sm.	Chaperno negro
	Lonchocarpus phaseolifolius Benth.	Patamula
	Lonchocarpus salvadorensis Pittier	Sangre de chucho
	Lonchocarpus schiedeanus (Schltdl.) Harms	Culebro negro
	Lysiloma divaricatum (Jacq.) J.F. Macbr.	Quebracho
	Pithecellobium dulce (Roxb.) Benth.	Mangollano, guachimol
	Samanea saman (Jacq.) Merr.	Cenicero, carreto, gavilan
	Tamarindus indica	Tamarindo
MELIACEAE	*Cedrela odorata*	Cedro
	Guarea glabra Vahl	
	Swietenia macrophylla King.	Caoba
MORACEAE	*Brosimum alicastrum* Sw.	Ojushte de invierno y verano
	Castilla elastica Sessé ex Cerv.	Palo de hule
	Cecropia obtusifolia Bertol.	Guarumo
	Cecropia peltata L.	Guarumo
	Ficus goldmanii Standl.	Amate
	Ficus insipida Willd.	Amate
	Ficus maxima Mill.	Amate peludo
	Ficus ovalis (Liebm.) Miq.	Amate
	Ficus sp. (Fruto rojo pequeño, hojas como obtusifolia)	Amate
	Ficus sp. (Hojas muy anchas)	Matapalo
PALMAE	*Cocos nucifera*	Coco, Coconut
POLYGONACEAE	*Coccoloba montana* Standl.	Papaturro
SAPOTACEAE	*Pouteria compechiana* (Kunth) Baehni	Guaycume
	Manilkara chicle (Pittier) Gilly	Nispero
	Sideroxylon capiri subsp. tempisque (Pittier) T.D. Penn.	Tempisque
SIMAROUBACEAE	*Simarouba glauca DC.*	Aceituno
STERCULIACEAE	*Guazuma ulmifolia* Lam.	Caulote, tapaculo
	Sterculia apetala (Jacq.) H. Karst.	Castaño
TILIACEAE	*Luehea candida*	Tepecaulote, molinillo
TILIACEAE	*Luehea speciosa*	Tepecaulote
VERBENACEAE	*Avicennia bicolor*	Mangle
	Avicennia germinans	Mangle blanco
	Tectona grandis	Teca, Teak

Appendix 4-D. Data sheet used for reproductive phenology and fruit abundance data.

PROYECTO GUARAS: Estudio de fenologia de arboles en el Corredor El Imposible-Barra de Santiago

Sitio:____

Fecha de censos:__________________________________

Hojas
S = sin hojas
T = hojas tiernas
N = hojas normales
V = hojas viejas

Flores
sí
no

Cantidad de la fruta
1-10
11-25
26-50
51-100
101-500
501-1000
1001-5000
5001-10000
>10000

% de la copa
0 = 0
1 = 1-33%
2 = 34-66%
3 = 67-100%

					Porcentaje de la fruta presente por 0.25%						
					% del arbol	**% del arbol**	**% del arbol**				
Codigo	**Especie de arbol**	**DAP**	**Hojas**	**Flor**	**tierna**	**sason**	**madura**	**Cantidad**	**% de la copa**	**En suelo?**	**Notas**

Appendix 4-E. Comparison of environmental and habitat variables between project area in El Salvador and sites in Costa Rica and Nicaragua with reintroduced or extant Scarlet Macaws (data on Costa Rica sites from [1]Brightsmith et al. 2005, [2]Myers and Vaughn 2004 and Nicaraguan site from Frontier Nicaragua 2004). The viability of flocks/populations in Costa Rica and Nicaragua is unknown. Myers and Vaughn (2004) reported that the mangrove reserve "was used by some macaws for nesting and by the majority of the population as a nocturnal roosting site."

ES project area	Area (ha)	Elevation (m)	Rainfall (mm)	Primary Forest Type	Site description
El Imposible	[3]3800	250-1425	3000	tropical dry deciduous	~25% intact forest and 75% matrix of agriculture, cattle pastures, agroforestry, primary and secondary forest, & human habitation
Santa Rita	225	lowland	1700	tropical evergreen	
Barra de Santiago	3100	coastal		mangrove	
Costa Rican sites					
[1]Curu (reintroduced)	1492	sealevel	2000	tropical dry and moist	70% natural forest, 30% human created
[1]Golfito (reintroduced)	[4] ND	sealevel	6000	tropical wet	valley of second growth forest ringed by low mountains of primary forest
[2]Carara (extant)	5500	lowland	2500-3300	tropical dry to humid transition, premontane, & tropical wet	primary and secondary forests, cattle pastures, agriculture, human habitation
Guacalillo Reserve	1100	coastal		mangrove	
Punta Leona Reserve	300	[2] ND		[4] ND	
Nicaraguan site					
Cosigüina (extant)	~13,000	0-870	700-1500	tropical dry & mangrove	primary and second growth forests, cattle pastures, agriculture, human habitation

[1]Brightsmith et al. 2005
[2]Myers and Vaughn 2004
[3]the project area covers ~half of the 3800 ha national park
[4]ND = no information found

5.0 SCARLET MACAW BREEDING AVIARIES AND GENETIC CONSIDERATIONS

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Editors: Janice Boyd, Rony Garcia
Spanish Translators: Paola Tinetti Pinto, Rony Garcia

One of the possible interventions being considered for the future in Guatemala and especially in El Salvador (where the scarlet macaw has been extirpated) is captive breeding and release of scarlet macaws in one or more areas where the conservation situation has stabilized sufficiently to allow this to be considered. Visits were conducted to two Guatemalan facilities that might be used to breed scarlet macaws to produce juveniles for release. On Monday 10 March we visited Aviarios Mariana (AM), owned by Nini de Berger and located in the southwest part of Guatemala in Taxisco, Santa Rosa, not far from the border with El Salvador. On Tuesday March 11 we visited the ARCAS Rescue Center (ARCAS) in Flores, Petén, in the northern part of the country. Both facilities are either currently breeding macaws or have in the past and both have expressed an interest in breeding macaws for possible releases into the wild in the future.

Kari Schmidt of Columbia University is doing her PhD on scarlet macaw genetics under Dr. George Amato of the American Museum of Natural History. A description of her project is included as a workshop Appendix.

5.1 Aviarios Mariana

Aviarios Mariana (AM) is a large private collection of birds, including Amazon parrot species, toucans, and macaws (mostly scarlet macaws, but also military and blue-and-gold macaws) owned by Nini de Berger. The collection originated in 1983, with birds kept at Nini de Berger's residence. Aviarios Mariana was formally founded at the site of Auto Safari Chapin in 1988, under the management of Scott McKnight, formerly of the Houston Zoo. He conducted a tour of the facilities. He has 10 fulltime staff, with any needed veterinary care obtained from a veterinarian who works with the zoo in Guatemala City. Auto Safari Chapin is an animal park and reserve that is one of the popular attractions in the region. The park features a drive-through area with many species of African animals, a pedestrian area and a recreation area with restaurants and a swimming pool.

The founding birds were for the most part purchased as chicks by Doña de Berger or her associates in Petén, although a few individuals were brought over from the small collection at Auto Safari Chapin. The last wild caught scarlet macaws were accepted into the collection in 1991.

Shortly after opening the facility at Auto Safari Chapin, the population experienced a period of rapid growth. At that time there was no management plan to prioritize breeding, so those birds that readily reproduced were allowed to do so. In addition, because there were 12 breeding cages available, only 16 individual scarlet macaws (8 pairs) were used for breeding and the other breeding cages used for other macaw species. Nearly two thirds of the scarlet macaw population at the aviary is descended from three pairs. The surviving founders are nearing 20 years of age, and thus may be approaching the end of their reproductive lifespans.

In the early years of breeding, eggs were frequently pulled to encourage double clutching, with the first clutch of chicks being hand-reared. The first F1 chicks hatched in 1990. The first F2 chicks hatched in 1996. Many of the F1s were found to be poor parents, particularly hand-reared individuals, which may have been due to improper socialization as juveniles, since the importance of such socialization was not recognized at that time. Since 1995, most chicks have either been parent-reared or fostered by proven breeders. There is no distinct breeding season at Aviarios Mariana, as there is in the wild, but rather breeding occurs year round. Nest boxes were closed in 2002, due to lack of space to hold additional birds.

There are 219 scarlet macaws housed at AM, with confirmed records existing for 209 of them. Based on these data there are currently:
Founders: 54 (including all 16 founders used in breeding)
F1: 118 (all adults, no chicks)
F2: 37 (all adults, no chicks)

The macaws are housed in three different types of cages. The breeding cages are 3 m x 1.78 m x 1.9 m tall and suspended 1 m above ground (Figs. 5-1 and 5-2). Nonbreeding birds are housed as singles and duos in holding cages 2.5 m x 1.22 m x 1.22 m high suspended 1 m above ground (Fig 5-3). The aviary also has 5 flight cages for juvenile holding ranging from 5 m (3), 6.25 m (1) to 10 m (1) long by 2 m wide and 2.1 m high (Fig 5-4). Floors are concrete. The procedure was to move year old chicks to a flight cage with seven or eight other juveniles for three or four years. Bonded pairs were then removed and placed in general holding cages. Current thinking would suggest that the juveniles be allowed to mature in the presence of some well-adjusted adult birds, not only with other juveniles.

Figure 5-1. Breeding cages at Aviarios Mariana. Nest boxes are placed in the back in a covered barn.

Figure 5-2. Breeding cages and nest boxes at Aviarios Mariana. Nest boxes are made of conacaste wood and are 93 cm x 63 cm x 53 cm high. When opened for breeding, pine shavings changed as needed were used as nesting substrate.

Figure 5-3. Caging for nonbreeding macaws, kept one or two per cage. Concrete posts are used because wooden posts were found to rot too quickly.

Figure 5-4. One of five flights at Aviarios Mariana. The flights are large enough for housing groups of several breeders during the nonbreeding season and could be used for early socialization of fledglings destined for a release program, but are not large enough to be used as training flights for older fledglings prior to their being moved to a release site.

Current avicultural recommendations would be to flock the genetically compatible breeding and potential breeding birds during the nonbreeding season, with possible mate switching possibly occurring. Birds to be allowed to breed would be returned to breeding cages prior to the desired breeding period. Juveniles would be flocked in mixed age flights for several years and allowed to pick their own mates. Flocking in flights containing well adjusted adults is important for proper socialization of juveniles.

The diet is 90% corn/bean/dog kibble mix plus 10% mixed raw vegetables and seasonal fruits. Macaws receive 1/4 cup of sunflower seeds daily. Diet amounts tripled when parents were feeding chicks. The facility has a kitchen plus brooders and other facilities for hand rearing chicks if needed.

Kari Schmidt has conducted preliminary genetic analysis of mitochondrial haplotypes for 29 of the 54 surviving founders and 15 of 16 recruited founders. These data show that the majority of founders exhibited native haplotypes. However, two individuals were found to have non-local haplotypes that originated in Southern Central America or South America. Owner Nini de Berger recalls these two birds were imported from Panama.

One of these individuals was not a successful breeder, but the other was very prolific. Twenty four percent of the scarlet macaws at AM descended from this single macaw. Because this individual belongs to different genetic stock (“subspecies”) than Guatemalan and El Salvador scarlet macaws, offspring from this bird are not considered suitable for release purposes in these countries. A breeding program for release into Guatemala or El Salvador would require that a systematic survey of the population be conducted to bar all of this bird's descendants from that breeding program.

Plans have begun to move the aviary to another site near the town of Escuintla, situated at a somewhat higher and cooler altitude. The new site is expected to be up and running by 2010. Only scarlet macaws with local haplotypes will be moved to the new aviary and serve as the stock to produce juveniles for release. While in the long term this may be good for the birds, the disturbance of the move may reduce any breeding, should the nest boxes be opened.

Recommendations: If a decision is made to have the aviary supply significant numbers of juveniles for release into the wild, it will probably be necessary to improve the recruitment rate, since only a small percentage of the founders have bred. More genetic diversity is desirable. Recommendations would include:

- Ideally, obtain consulting services of an avian veterinarian familiar with avicultural issues to give advice and assist in the following recommendations. Experience in breeding scarlet macaws or related species particularly valuable. Macaws are intelligent, social animals and successful breeding of desired birds has been found to often depend upon proper socialization and management techniques.
- Review husbandry procedures, records of individual macaws, and breeding records with the consulting veterinarian and define management goals for nonbreeding and breeding stock.
- Conduct full physical examinations, including recommended disease testing, as discussed in Chapter 8.0. Other testing would be decided upon as the result of clinical findings and management goals. (PCR and serological tests done on a relatively small subset of birds in previous years indicated no disease issues, and the aviary reported no history of disease problems)
- Endoscopic exams to look at state of reproductive organs to identify birds still able to breed or some of the offspring would be advisable if feasible.
- Select a genetically diverse subset of the potential breeding population for breeding to supply juveniles. As much of the Northern Central America genetic variability as possible should be reflected in birds selected for release.
- Breeding success is likely to be improved if breeding birds are flocked together in the nonbreeding season in one or more large flights and allowed to switch mates if desired.
- Juveniles would need to be flocked in one or more large flights with some older birds for a period after weaning in order to properly socialize them, either for future breeding or for conditioning for release purposes.
- Existing flights at the facility are not large enough to use as conditioning flights before sending to a release site. Another option would be to send medically screened young birds (not adults) for possible release to the ARCAS-Flores facility for socialization and conditioning in their large flights, along with suitable ARCAS birds, as well.
- For breeding for release, recommendations from a consulting avian veterinarian with Neotropical psittacine breeding flock experience should ideally be obtained to help design any new psittacine facilities that are built. While the facilities at the Autosafari Chapin site are very good, additional large flights are needed if birds are to be conditioned for release

into the wild. These additional facilities would include at least larger flights for flocking breeder birds with some nonbreeders in the nonbreeding season and larger flights for socializing young birds for release with mixed age groups of conspecifics and for physical conditioning.

5.2 ARCAS Rescue Center

The second aviary visited was the ARCAS Wild Animal Rescue and Rehabilitation Center. ARCAS is the abbreviation for Asociacion de Rescate y Conservacion deVida Sivestre, a Guatemalan NGO founded in 1989. The Rescue Center is located in the Petén in the northern part of Guatemala, on the edge of the Maya Biosphere Reserve. The site is a 45 hectare wooded area of land on Lake Petén Itza next to the Peténcito Zoo, a 10 minute boat ride from the town of Flores, the capital of the Petén. Flores is also where the office of the Wildlife Conservation Society Guatemala is located. In addition to the rescue center, ARCAS has its main office and co-administers a cloud forest reserve in Guatemala City, and a sea turtle and mangrove conservation program on the Pacific coast. We toured their Rescue Center on Tuesday 11 March, and they hosted a day and a half of workshop meetings at their educational center on the same site on Tuesday and Wednesday. Their scarlet macaw breeding program is also on the grounds of the Rescue Center.

ARCAS works in close collaboration with the Guatemalan equivalent of the National Park Service, the National Council of Protected Areas (CONAP) by accepting locally confiscated animals for rehabilitation, observation and, ideally, release into the wild. They also conduct education of the general public on wildlife issues. Confiscated animals are quarantined and if possible rehabilitated and released. Not all individuals are deemed appropriate candidates for release and are thus kept for educational purposes. ARCAS cares for over 35 species across broad taxonomic groups, including (but not limited to) psittacines, felids, primates, crocodilians, turtles, and mustelids. During peak traffic periods, they may receive 20-80 animals per week; 80% of which are juvenile parrots. They have a fulltime veterinarian on staff and the rescue center director is also a veterinarian. They rely very heavily upon volunteer labor. Several times per year, ARCAS and CONAP coordinate animal releases in different parts of the Mayan Biosphere Reserve. These releases are usually of parrots (being the most commonly trafficked animal in Guatemala), but releases of other birds, reptiles and mammals are also carried out.

The ARCAS scarlet macaw population has been fairly stable over the past 8 years. Additional confiscated or donated scarlet macaws are continually added to the population, but these are sporadic and unpredictable events of one or a few birds per year. Many of the macaws are not suitable for breeding purposes having disabilities or having been long time pets and may require human intervention such as incubator hatching or hand-feeding. Records are available for acquisition dates, but it is sometimes not known how old adult birds are when they enter the Center. Four pairs have been breeding since 2004 and are beginning to show regular fledge success. This project has been supported by the Columbus and Cincinnati Zoos, and the US Fish and Wildlife Service.

ARCAS currently (mid 2008) has about 49 scarlet macaws, many of them confiscated from sources in the Petén. The composition is:

Founders: 37 (all adults)
F1: 12 (7 adults and 5 chicks)
F2: 0

The facilities at ARCAS consist of variations on two types of enclosures: general holding of non-breeding individuals of mixed ages in medium to large flights (Figs. 5-5 and 5-6), and smaller but still spacious breeding flights with nest boxes for breeding pairs (Figs.5-7 and 5-8). The enclosures are set in the natural dry forest that predominates at the Center, and when possible, live trees are left in the enclosures. Constant vigilance for human and non-human predators is necessary. The diet consists of mixed fruits, corn and black beans , supplemented with locally collected wild foods.

To date, no genetic analyses have been conducted on the ARCAS population. However, Kari Schmidt has collected samples from all adults and one chick. This genetic analysis should be reviewed before any release program is begun or other pairs are set up for breeding in order to achieve the greatest genetic diversity of birds to be released into the wild population. In addition, this review should eliminate from the breeding or release pool any birds not of Northern Guatemala haplotypes.

ARCAS plans on continuing to breed macaws and would like to increase the number of pairs set up for breeding in anticipation of the establishment of a macaw population reinforcement program to release individuals or flocks into the wild. Again, increasing recruitment among a genetically variable subset of the population would be needed for the center to provide significant numbers of juveniles for such a program. Most of the recommendations for Aviarios Mariana apply to the ARCAS center as well. As with AM, results of past PCR and serological tests reported no disease problems among the macaws, suggesting no particular disease issues, although some serological positives – almost certainly false positives- indicate additional testing would be needed before using their juveniles for release.

Recommendations:

- Ideally, obtain consulting services of an avian veterinarian familiar with avicultural issues to give advice and assist in the following recommendations. Experience in breeding scarlet macaws or related species would be particularly valuable.
- Review husbandry procedures, records of individual macaws, and breeding records with the consulting veterinarian and define management goals for nonbreeding and breeding stock.
- Genetic analyses on birds to be considered for breeding for release is highly recommended, with the goal of maximizing genetic diversity among the available Northern Guatemala haplotypes available.
- Conduct full physical examinations, including recommended disease testing. See section 8.0 for some recommendations. Other testing would be decided upon as the result of clinical findings.
- Consider endoscopic exams to look at state of reproductive organs to identify birds in good reproductive condition
- Consider flocking breeders and other genetically suitable breeding stock in the nonbreeding season in one or more large flights. Allow mate switching if desired.

- Composition of diet should be reviewed to see if modifications might help with health and breeding success (e.g., more fat and/or protein).
- Juveniles would need to be flocked in one or more large flights with some older birds for a period after weaning in order to properly socialize them. Existing large flights are large enough. Review socialization procedures with consulting veterinarian.

Figure 5-5. Views of one of several large flights housing mixed-age groups of scarlet macaws at ARCAS.

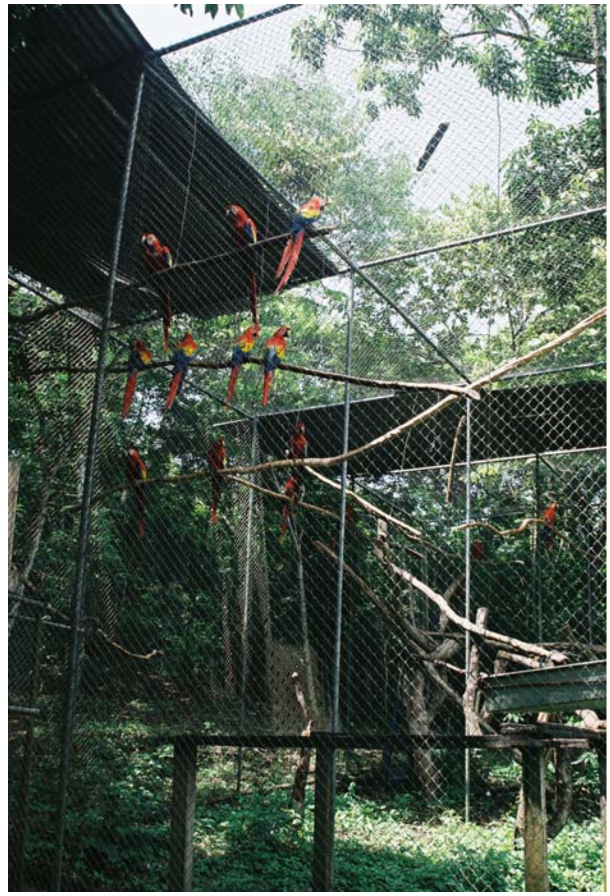

Figure 5-6 . ARCAS macaws on swinging perches that increase their activity levels.

Figure 5-7. Two of the four scarlet macaw breeding enclosures at ARCAS. On the left is Fernando Martínez, Rescue Center Director, and on the right is Alejandro Morales, Rescue Center Veterinarian.

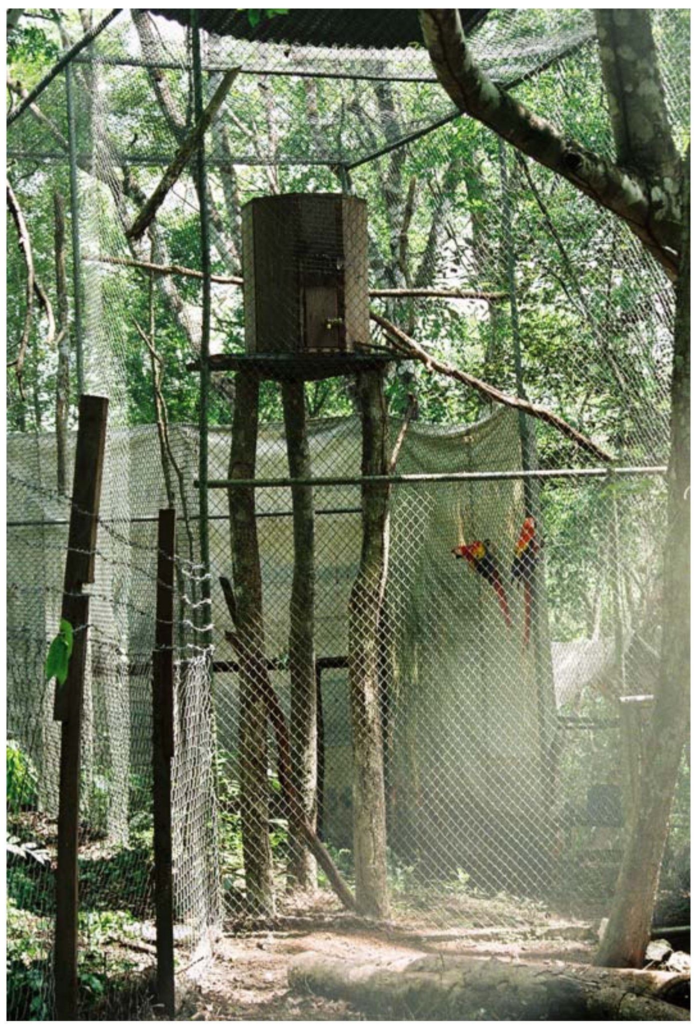

Figure 5-8 . Another view of one of the ARCAS breeding enclosures.

6.0 WCS SCARLET MACAW CONSERVATION PROGRAM AND MONITORING SITES

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6.1 The Maya Biosphere Reserve

The Wildlife Conservation Society's Guatemala Program is focused on the conservation of the eastern Maya Biosphere Reserve (MBR), in the northern half of the Guatemalan Department of Petén. The MBR was established by the Guatemalan government in 1990 and is part of the largest tract of intact tropical forests remaining in Central America (Fig. 6-1), the tri-national *Selva Maya* of Belize, Mexico, and Guatemala. The reserve contains both core protected areas and multiple use areas dedicated to sustainable extraction of forest resources and is managed by CONAP, Guatemala's National Council of Protected Areas. Key protected areas include Laguna del Tigre National Park, Mirador-Rio Azul National Park, Sierra del Lacandón National Park, Tikal National Park, El Zotz Biotope, Dos Lagunas Biotope, and Yaxha-Nakum-Naranjo National Park (Fig. 6-2). Unfortunately, the reserve faces many threats; in particular, illegal human invasion and colonization, illegal conversion of land to ranching and agricultural activities (often fueled by money from the illegal drug trade), uncontrolled fire-setting, unsustainable natural resource extraction, looting of archaeological sites, and weak governance.

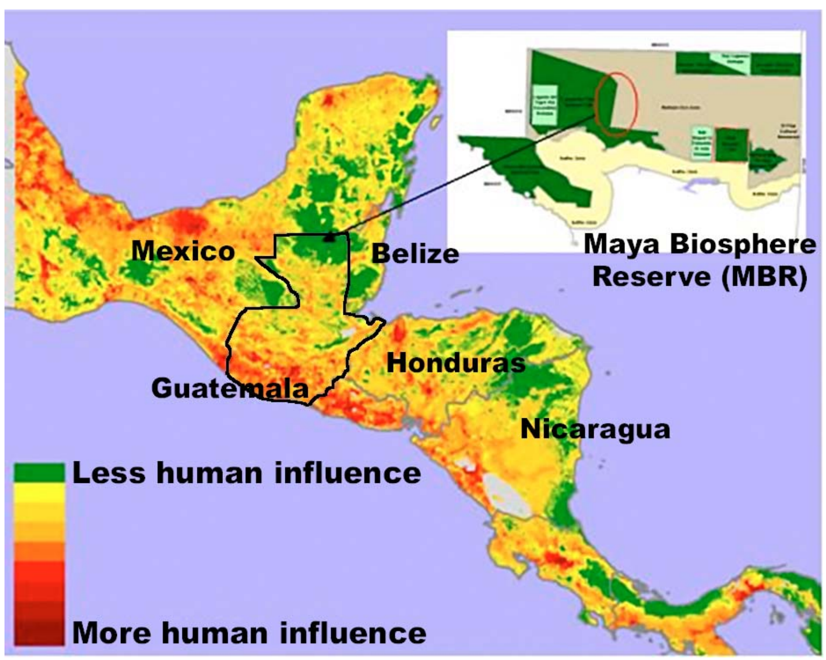

Figure 6-1. Much of Central America is heavily impacted by human influences (red to yellow). The Maya Biosphere Reserve is the largest tract of intact tropical forests remaining in Central America. (From Ramos and McNab, in prep., "The Maya Biosphere Reserve in Relation to the Human Footprint in Mesoamerica")

MAYA BIOSPHERE RESERVE, GUATEMALA

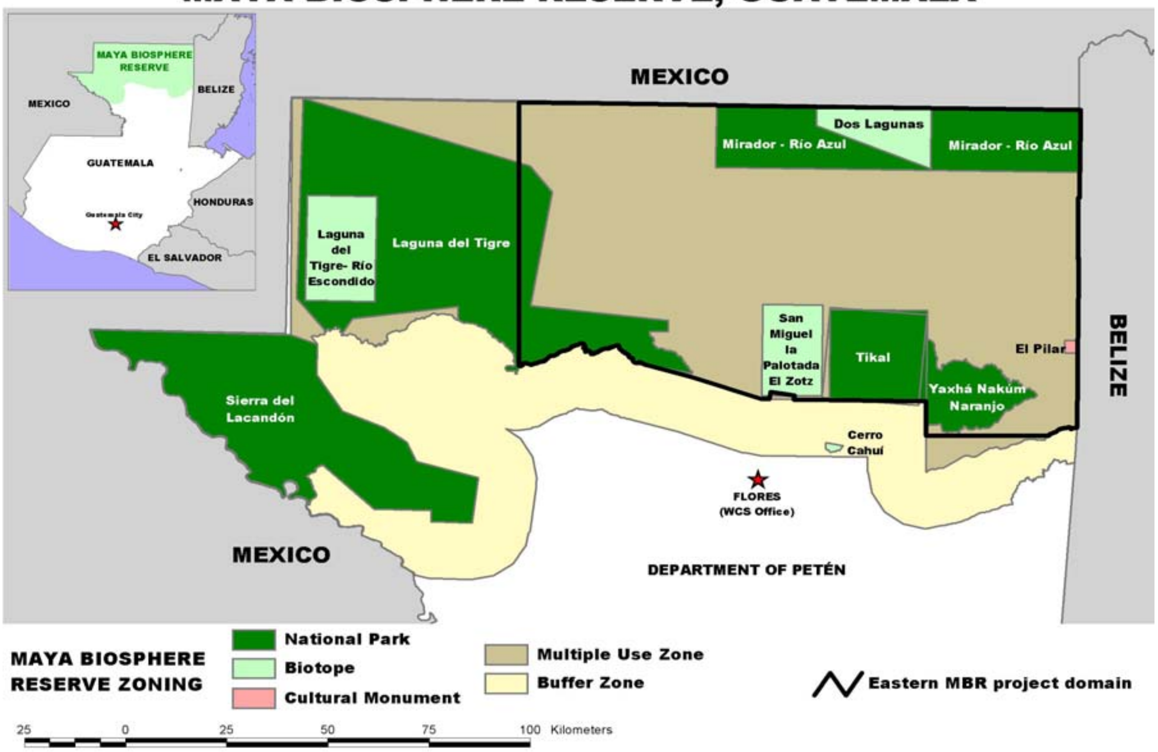

Figure 6-2. Maya Biosphere Reserve and the core protected areas and multiuse and buffer zones. (CEMEC/WCS-Guatemala)

6.2 WCS Scarlet Macaw Conservation Program

In his presentation on the WCS program on scarlet macaw conservation on Monday evening (10 March), Lic. Rony Garcia of WCS Guatemala described the four main threats to scarlet macaws in the MBR: habitat destruction, poaching, natural predation, and competition for nest cavities. Of the four, habitat destruction and natural predation are currently of the most significant concern. Prior to WCS work in the region, poaching was also of serious concern.

6.2.1 Main Threats to the Scarlet Macaw

Habitat destruction: Habitat destruction is largely the result of illegal invasions into the MBR, and subsequent deforestation and purposely set fires. The problem is particularly severe in the western sections of the reserve, particularly in Laguna del Tigre and Sierra del Lacandón, both areas formerly being strongholds of scarlet macaws. In many sections of these national parks, areas are so dangerous that WCS cannot operate on the ground. WCS conducts over-flights (via the volunteer LightHawk program) to detect illegal colonization, deforestation and fires, and cooperates with the government of Guatemala to strengthen protected areas. WCS also works with national partners to strengthen fire prevention and suppression initiatives in and around key macaw nesting sites. Almost all fires are purposely set by people for hunting, forest destruction for agricultural and ranching purposes, and on rare occasions to induce removal of the land from conservation protection. Where WCS is able to work, the area burned by fires has dropped by an order of magnitude, as mentioned in Chapter 3, and the deforestation rate has been drastically reduced compared to other parts of the MBR. The severity of fires and habitat conversion is apparent from Fig. 6-3, where large sections of Laguna del Tigre and parts of Sierra del Lacandón have been seriously degraded.

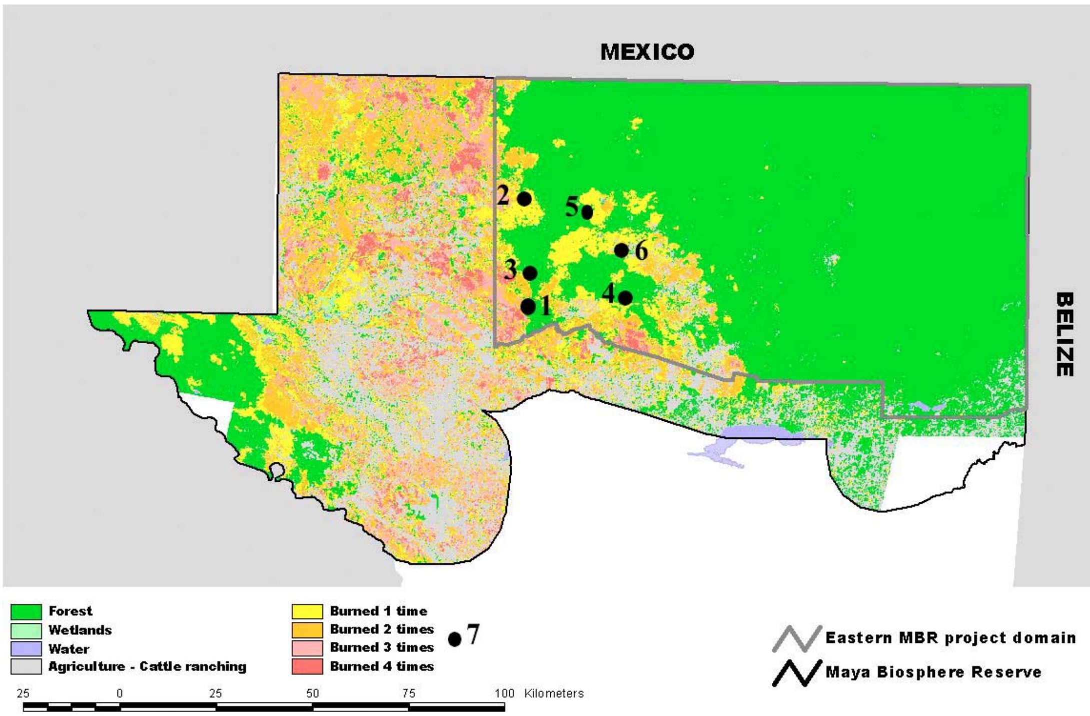

Figure 6-3. Vegetation types and burn status of the Maya Biosphere Reserve as of 2007. Natural fires are rare; virtually all fires are human set illegally to clear land or for hunting. Numbered sites are the locations of scarlet macaw nesting sites monitored by WCS: 1 – El Perú; 2 – La Corona; 3 – El Burral; 4 - Peñon de Buena Vista; 5 – AFISAP; 6 - La Colorada; 7 – Pipiles (outside the MBR)

Poaching: Poaching occurs where there is human presence coupled with lack of law enforcement and/or protection. Poaching in areas where WCS has been working has dropped greatly since 2003. (See Figs. 6-3 and 6-4 for these areas.). In areas where such protection is lacking, however, it is likely that the vast majority of macaw nests are poached, with few if any young are being recruited into the population from these unprotected areas. The exceptions to this rule are likely to come from macaws nesting in standing dead trees considered to risky to climb, or nests in trees with Africanized bees in an adjacent cavity.

Natural Predation: Adult macaws are only rarely taken by non-human predators for most of their life span, since macaw predators such as harpy eagles are in very low numbers in the MBR, and predation by other large eagles such as hawk eagles is uncommon. Most natural predation occurs on chicks. Nest monitoring by WCS field personnel during the 2008 breeding season in El Perú using in-nest cameras have indicated predation commonly takes place in the nest on chicks by collared forest falcons (*Micrastur semitorquatus)*; three predation events by *Micrastur* were recorded in 2008 (García et al. 2008). However, in most monitored nests that lost chicks, nestlings have simply disappeared and no specific predator could be identified. WCS personnel feel it is unlikely that these were human poaching events, since no tree scars indicating use of climbing spikes were observed. This remote monitoring based on placing infra-red cameras in nest cavities was initiated in 2008 as an attempt to better understand natural sources of nest failure, and will be continued during the 2009 nesting season in El Perú to identify these unknown sources of chick mortality.

Falcons are sight predators, so double-chambered artificial nests that obscure view of the chicks from the outside have been constructed out of sections of large fallen trees in an attempt to reduce predation. By the end of last season (2007), ten double-chambered nests had been installed. So far only two artificial nests have been used, but macaws did successfully fledge offspring from one in 2006. The type of substrate inside artificial nests might be one of the factors why the nests have not been used by macaws, since very little/no natural material had been placed in the nests previously. Thus, the nest substrate did not fully replicate natural cavity conditions, nor permit macaws to bury their eggs (a behavior recorded with the in-nest cameras). This season we will line nests with natural wood detritus, place fist-sized wooden chunks in the cavity to allow nesting macaws to chew on the material, and evaluate if the frequency of use is improved.

Competition for cavities: the most serious competitor for cavities seems to be Africanized bees that prevent cavity use by their presence or drive away adults, and kill chicks or cause them to starve by taking over occupied cavities. Preliminary experiments in 2007 consisting of spraying the inside of nest cavities with permethrin (5%) suggest that persistent application of insecticides with low avian toxicity is highly effective. Of 15 nest treated, 14 were not invaded by Africanized bees during this breeding season. Additional research on this topic continues.

6.2.2 Habitat Modeling

Victor Hugo Ramos presented his work on scarlet macaw habitat modeling in the Maya Biosphere Reserve, part of the WCS Maya Forest Living Landscape Program financially supported by USAID/Global Conservation Program, on Tuesday evening (11 March).

Biological Landscape: The scarlet macaw landscape conservation model uses historical records of nesting sites over the last 25 years to preliminarily define the general distribution of the species, and helps us to exclude areas without recent distribution records. The density of active nests in three general areas with known active nesting populations (and precise nest locations) was used to estimate the potential number of macaws across the landscape, although we do have reservations regarding the current state of nesting numbers in Belize and Mexico (see Literature consulted, 2008, in References). Similarly, the biological model to estimate habitat suitability was based on habitat type and surface water availability, although these two values combined accounted for only 15% of the weight of the biological model. The biological model estimates a potential for approximately 120 active nests across the Guatemalan, Belizean, and Mexican areas modeled, and assigns an average number of 3 birds to each active nest, that is to say, one breeding pair and one juvenile. The model also assumes the presence of another 117 available nesting cavities capable of being used by a nesting pair, although they are not occupied by macaws. In total then, we estimate the carrying capacity (K) for the landscape based on 234 nesting cavities distributed across the landscape, with an average of 3 individuals per each cavity (i.e. a total of 702 individuals). These calculations are only partially based on recent field observations (just from a large percentage of the current Guatemalan distribution), and for this reason they should be considered as a first, rough guess, and be subject to revision as more precise data are obtained. Table 6-1 details the carrying capacity (K) without considering the threats resulting from human activities, and/or human activities designed to mitigate threats, such as effective park management and protection.

Human Landscape: The "human landscape" detailing threats and protection efficacy is largely defined by two key parameters, ease of access and history of fire. The greatest weight was assigned to ease of access, since it functions as a proxy for the poaching of macaw chicks in the nest – that is, the anthropogenic threat most likely to reduce the population over time. The recurrence of fire was registered as a threat due to the ability of fire to destroy viable nesting cavities, although its ability to reduce the carrying capacity (K) was considered lower than that of human access (i.e., poaching). Finally, as previously mentioned, within the human landscape model we also assigned values to specific areas that partially reduced the severity of the threats. These values were based on protected area status, and known/estimated efficacy of the protection on the ground (especially in Guatemala).

Conservation Landscape: We spatially identified the priority conservation areas by superimposing the human (i.e. threats) landscape on top of the biological (i.e. carrying capacity) landscape, and identifying areas where threats are causing the greatest reduction in population numbers, or may do so in the future. The resulting map coincides with much of the ongoing work of WCS in the Guatemalan section of the landscape. However, it also identifies the western part of Laguna del Tigre National Park as an area with capacity to support significant numbers of scarlet macaws – and as an area that is currently lacking conservation interventions. Table 6-1 depicts estimates for the carrying capacity (K), the reduction of estimated abundance per each threat, and the estimated current abundance. Figures 6-6, 6-7, 6-8, and 6-9 depict, respectively, the biological landscape, the human landscape, the current carrying capacity (K), and the conservation landscape for scarlet macaws in the tri-national area.

Table 6-1. Scarlet macaw carrying capacity, reduction of populations based on threats, and current abundance per country and protected area status

AREA	**Carrying Capacity (K) (individuals)**	**Reduction in Population (individuals)**	**Current Abundance (individuals)**
BELIZE (Unprotected)	21	11	11
BELIZE (Protected)	131	39	92
GUATEMALA (Unprotected)	16	10	6
GUATEMALA (Protected)	281	128	153
MEXICO (Unprotected)	131	71	60
MEXICO (Protected)	121	44	77
TOTALS	**702**	**303**	**399**

The model predicts that two main blocks of good habitat remain, including a modest tract of intact habitat in the Chiquibul and Maya Mountains areas of Belize, and a large area of potentially high and very high quality habitat in the western part of the MBR and extending into Mexico. Unfortunately, comparing Figs 6-6 and 6-7 reveals that the regions of highest human encroachment (Laguna del Tigre and Sierra del Lacandón), are where the best macaw habitat is predicted to be. Rony García said that based on data from one nesting site (El Perú), the impression is that the population of adult birds nesting there is decreasing—perhaps as much as 40% since 2003, but this impression may not be accurate since nesting adults may be moving to nest at other sites.

6.2.3 Nest Monitoring

WCS-Guatemala field staff led by Rony García search for and monitor scarlet macaw nests at five main sites/areas in the MBR to:

a) increase field presence, and thereby discourage poaching
b) evaluate levels of poaching, natural predation, and levels of competition for nest sites
c) estimate scarlet macaw nesting success
d) estimate population trends

Additional information is also collected annually for two other nesting sites that are monitored less intensely, La Colorada and Pipiles.

These focal field sites/areas are (see Figs. 6-3, 6-4, and 6-5):

1. El Perú
2. La Corona
3. El Burral
4. Peñon de Buena Vista
5. AFISAP
6. La Colorada
7. Pipiles

In 2007, 31 active scarlet macaw nests were monitored within these seven sites. The highest concentration of nests was at El Perú, but that is also where the level of monitoring effort has been greatest. In 2007, 51 chicks hatched across this sites, but only 15 (29.4%) fledged successfully. For reasons not fully understood, the percentage of chicks that fledged successfully was particularly low in the sites of El Perú, El Burral, and Peñon de Buena Vista (Fig. 6-4 and Table 6-2). Nevertheless, research during 2008 has helped us begin to unravel the mystery. As previously noted we were able to register three predation events at El Perú by one of the chicks' predators, the collared forest falcon (*Micrastur semitorquatus*) reinforcing the hypothesis that natural predation is one of the main forces determining chick survival and fledging.

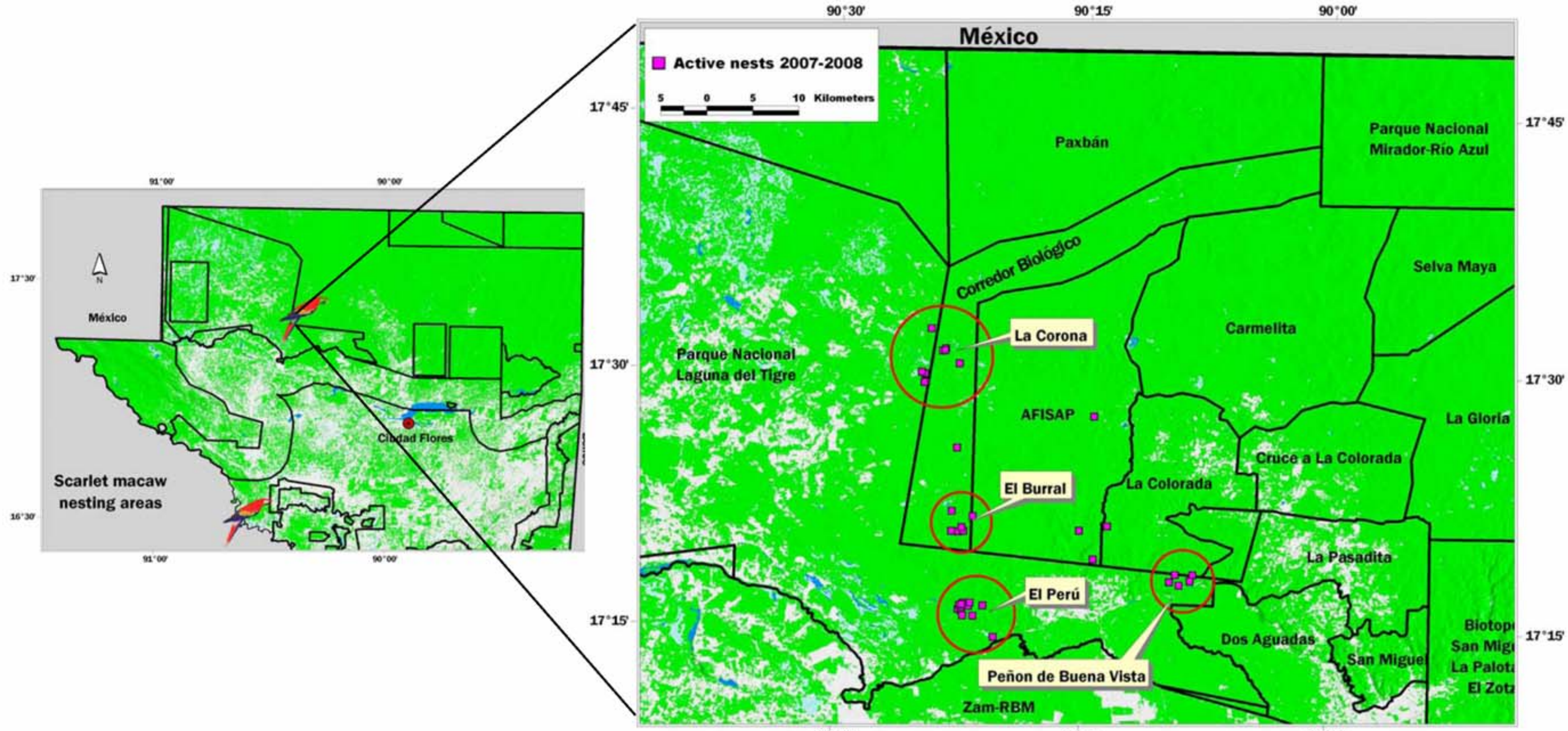

Figure 6-4. Active scarlet macaw nest distribution in the eastern Maya Biosphere Reserve, 2007-2008. (Note: green areas represent intact forest, grey-white areas represent deforested habitat. The smaller map to the left depicts the entire Maya Biosphere Reserve, with national parks and Biotopes located on the peripheral edges of the reserve (i.e. "Core Zones" in theory dedicated to protection), and a large Multiple-Use Zone at the center of the reserve. The larger map to the right zooms in on the concentrations of nests in eastern Laguna del Tigre National Park, the Laguna del Tigre-Mirador Biological Corridor, and Multiple Use Zone community forest concessions such as AFISAP, and La Colorada).

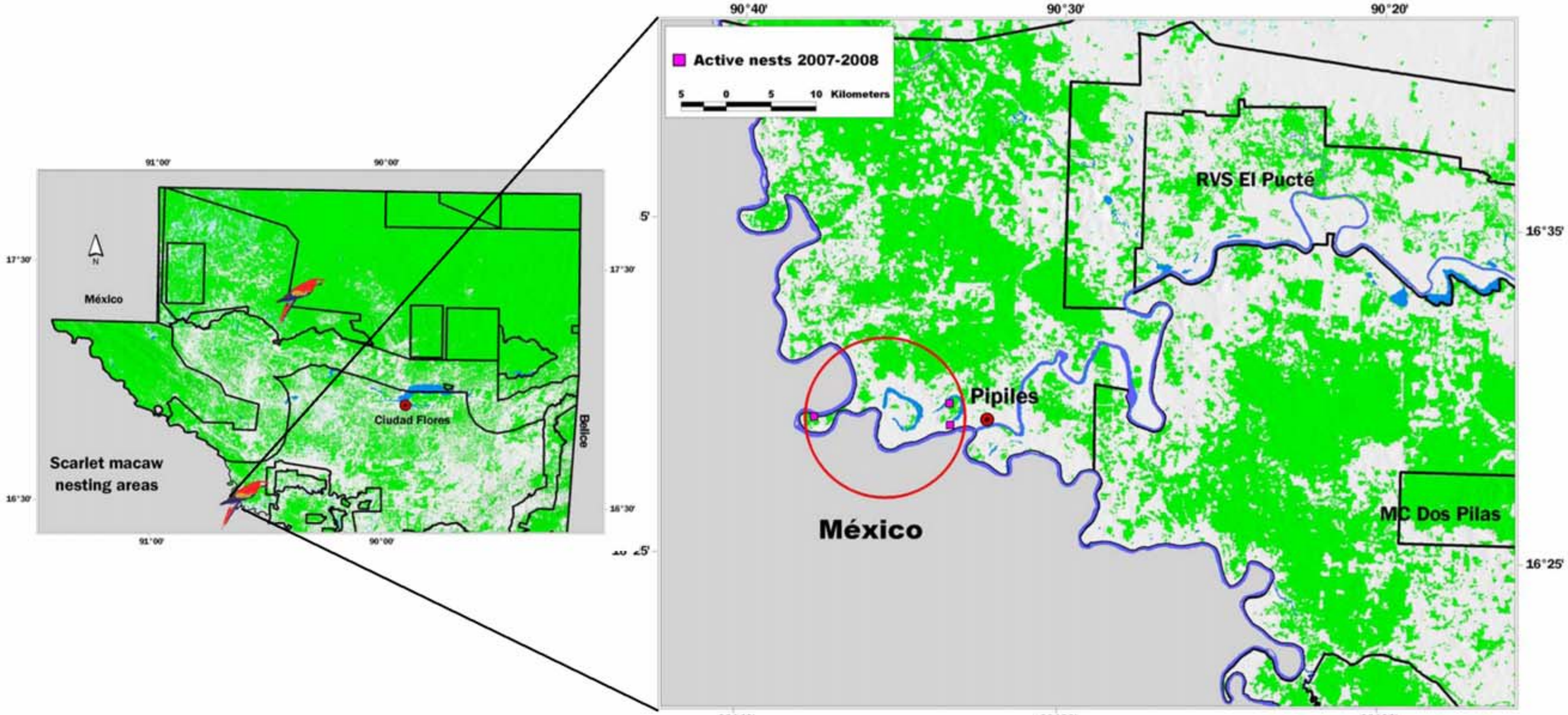

Figure 6-5. Active scarlet macaw nest distribution in Pipiles in the South of Petén, 2007-2008. (Note: green areas represent intact forest, grey-white areas represent deforested habitat. The smaller map to the left depicts the entire Maya Biosphere Reserve, with national parks and Biotopes located on the peripheral edges of the reserve. The Pipiles nesting sites lie just beyond the southern edge of the Maya Biosphere Reserve Buffer Zone, and slightly to the west of the Dos Pilas Archaeological Reserve. The larger map to the right zooms in on the concentrations of nests in Pipiles. Note the abundance of riparian habitat, as the border with Mexico is also divided by a waterway, the Usumacinta River, Mesoamerica's largest river.)

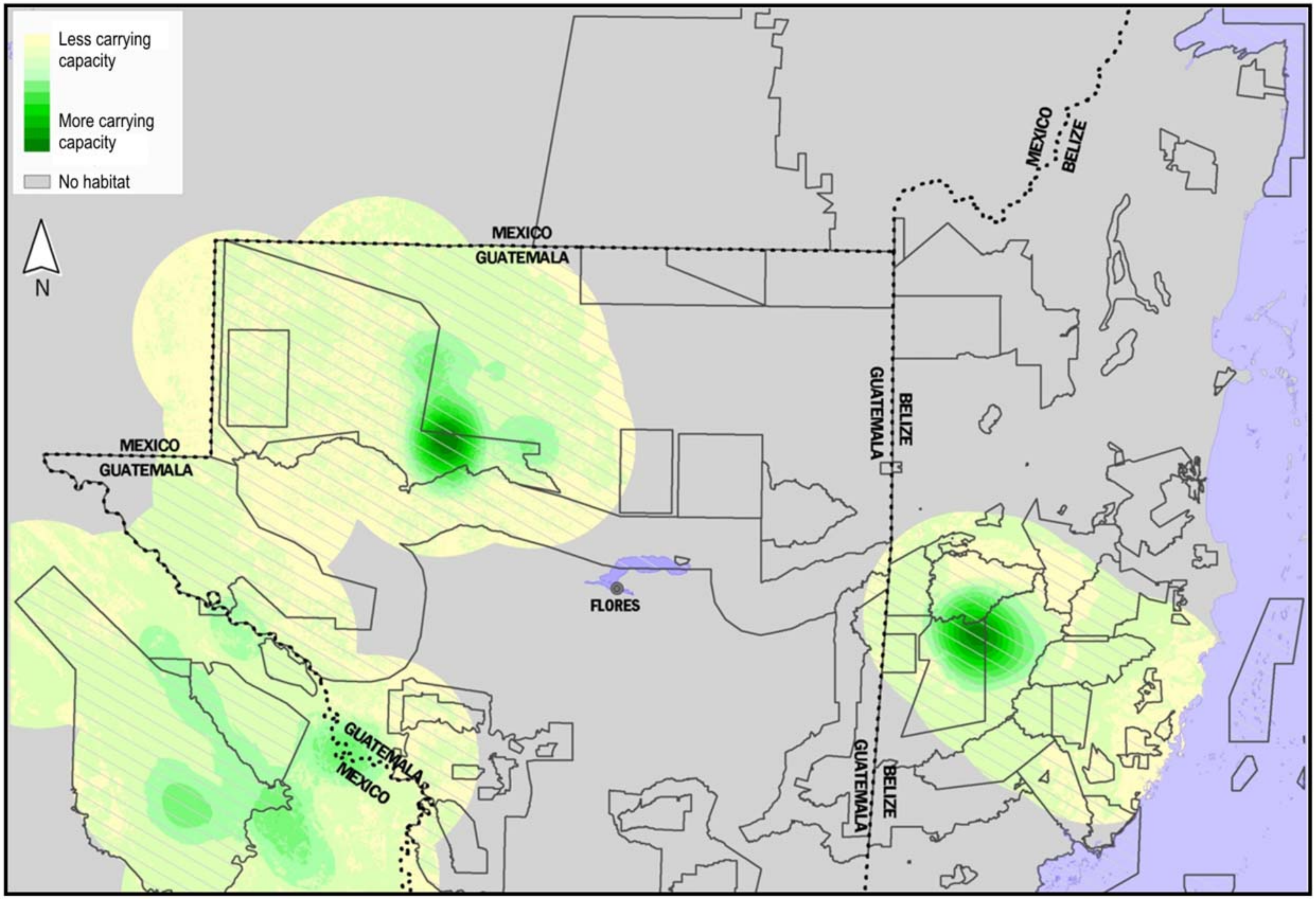

Figure 6-6. Carrying Capacity of the Scarlet Macaw (Biological Landscape).

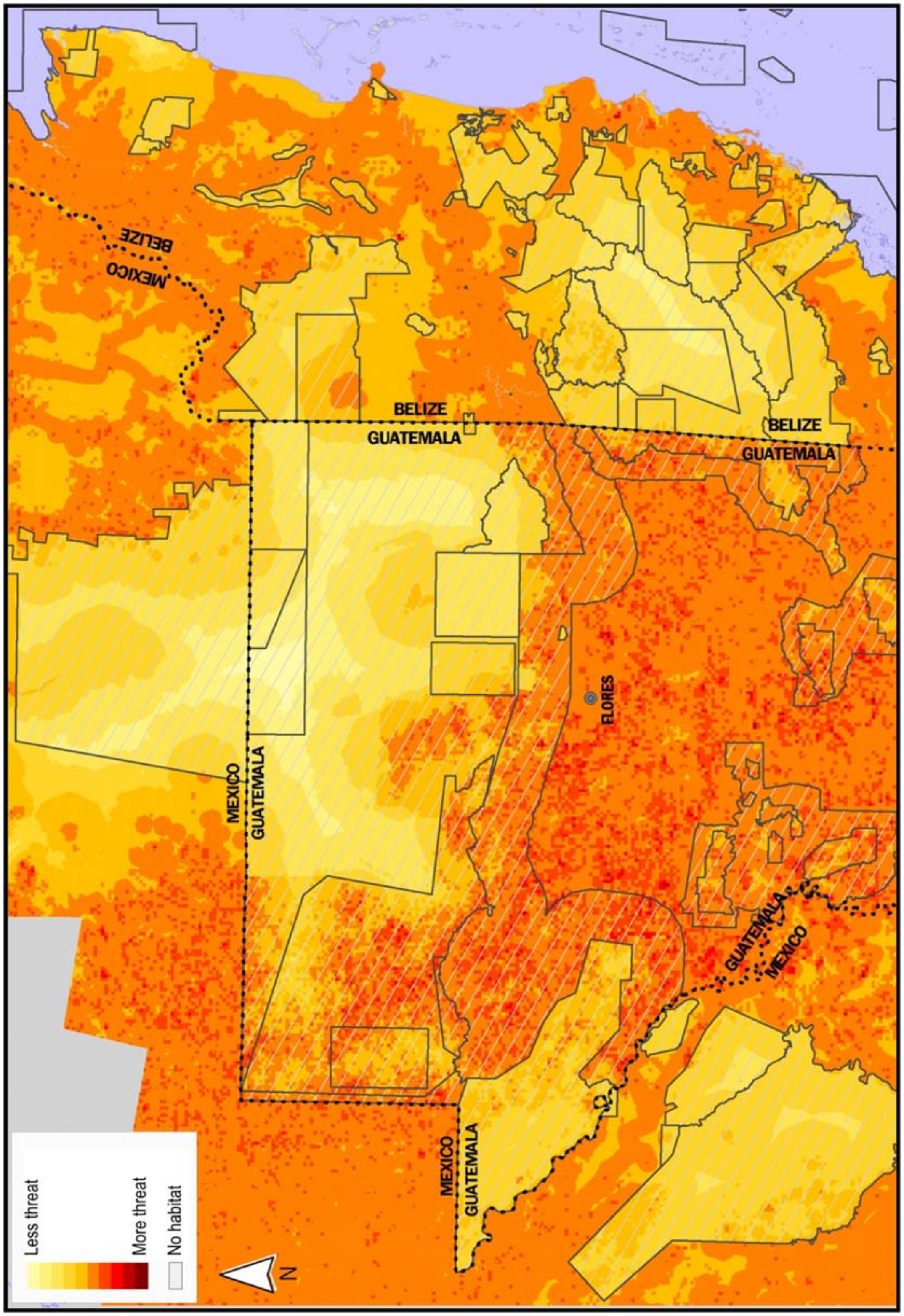

Figure 6-7. Synthesis of Threats to Scarlet Macaws (Human Landscape).

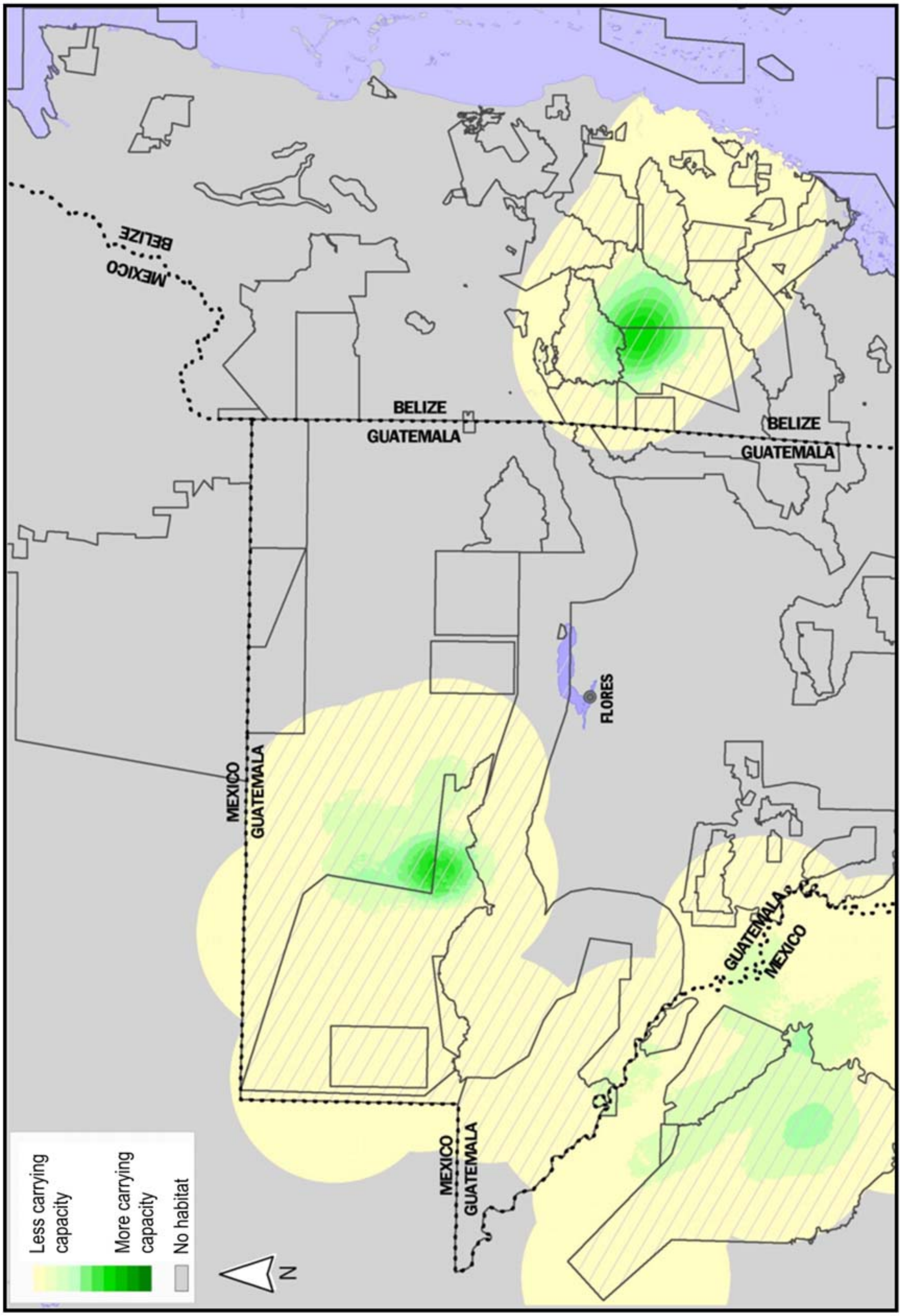

Figure 6-8. Carrying Capacity of Scarlet Macaws as Impacted by Threats (Biological Landscape – Human Landscape).

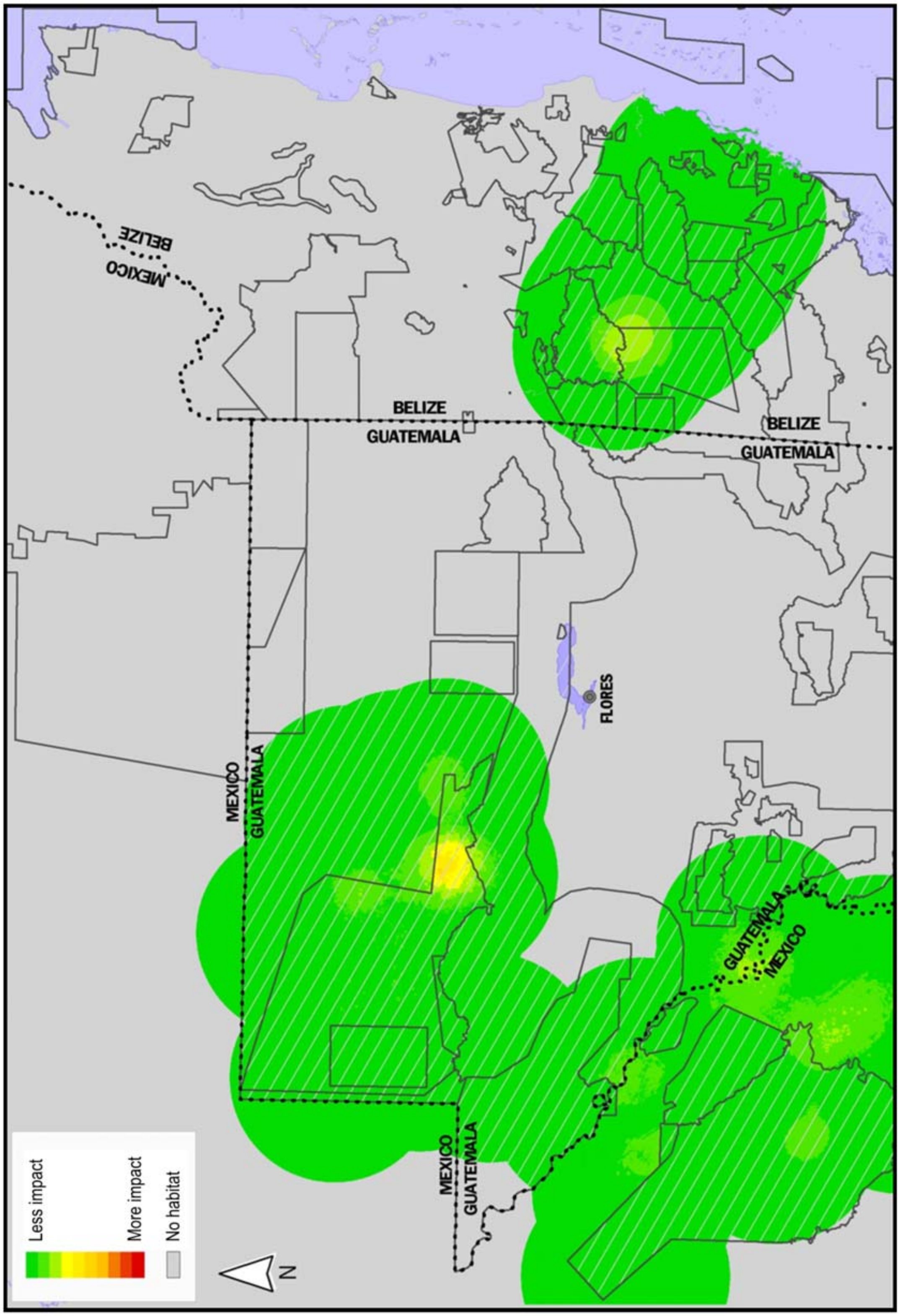

Figure 6-9. Potential Impact of Scarlet Macaw Conservation Interventions (Conservation Landscape)

Table 6-2. Nesting success (% of chicks successfully fledged) during 2007, 2008 breeding season in MBR nesting sites. (García et al. 2007, García et al. 2008)

Sites	Area	Active Nests		Eggs		Chicks		Successful		% Success	
		2007	2008	2007	2008	2007	2008	2007	2008	2007	2008
El Perú	Laguna del Tigre NP	9	10	31	26	13	17	1	5	8%	29%
Peñón de BV	Laguna del Tigre NP	4	4	15	6	11	5	2	0	18%	0%
El Burral	Central BC	5	2	20	8	6	4	1	1	17%	25%
La Corona	Central BC	7	7	19	22	12	13	4	12	33%	92%
AFISAP	MUZ	3	3	6	7	5	5	3	5	60%	100%
La Colorada	MUZ	1	1	3	2	1	2	1	0	100%	0%
Pipiles	Outside MBR	2	2	5	4	3	4	3	2	100%	50%
	TOTAL	**31**	**29**	**99**	**75**	**51**	**50**	**15**	**25**	**29%**	**50%**

Nesting sites are in Laguna del Tigre National Park; the Central Biological Corridor (formerly known as the Laguna del Tigre-Mirador Biological Corridor); the Multiple Use Zone (MUZ); or in forest patches around the rural town of Pipiles located in the Municipality of Sayaxché near the confluence of the Río Pasión and the Río Usumacinta.

The WCS scarlet macaw conservation strategy is based on maintaining the quantity and quality of the current habitat strongholds used by scarlet macaws in the Maya Biosphere Reserve, and undertaking interventions to enhance the quality from a macaw standpoint (e.g., artificial nests or nest treatment to deter bees). However, given the low number of confirmed breeding pairs in secure parts of the Maya Biosphere Reserve and an apparent downward trend (i.e. from 31 to 29 active nests over the last two breeding seasons), a second crucial aspect is now the investigation of causes leading to both the apparent reduction in the number of nesting adults, as well as the high rate of chick loss mentioned previously. Finally, we also hope to be able to identify and test management interventions that increase both of these key variables, active nests and nesting success.

One possibility for the observed reduction in the number of nesting adults within some key nesting foci is that nests are failing so frequently that the macaws are abandoning these sites (i.e., at El Perú). Another possibility is that the number of macaws in the MBR is actually decreasing and the reduction in nests is a reflection of a true population decline. The ongoing work to identify reasons behind disappearance of chicks from nests is crucial, as is further work into the efficacy of treating cavities with an insecticide with low toxicity to vertebrates (permethrin) to stave off African bee infestations. Increasing nesting success may help to stabilize the number of nesting adults in an area. However, that answer will not be at hand for a number of years. If the total population of the MBR is decreasing, perhaps due to the aging of breeding adults and low historical recruitment (resulting in a low number of younger breeding age birds due to poaching and/or nest failure), one possible management intervention could involve “reinforcing” the population through captive breeding and release of young birds into the wild population. Considering the “hows” of this technique was one of the motivations for this workshop. As our program advances, it is likely that we will apply and evaluate several management interventions that address potentially diverse causes of reduced numbers of active nests until we are able to pinpoint what the most significant causes actually are.

As described in Chapter 3, a *preliminary* population viability analysis (PVA) conducted by WCS Guatemala personnel using the VORTEX model suggested that adding an additional 5 birds per year to the MBR population could be effective at reducing the probability of extinction of the overall population (assuming no further habitat loss). Because this effort was preliminary, and clearly incomplete, a detailed PVA analysis conducted by Nancy Clum of WCS was developed with the input of experts participating in the workshop to model different scenarios for the population of scarlet macaws in the Maya Biosphere Reserve. A full report on this PVA analysis is provided as Chapter 7. One highlight of the PVA was that one of the most important variables significantly and consistently impacting population growth was the percentage of successfully breeding females (each year). This variable corresponds to the ongoing management interventions aimed at nest protection from colonization, fire, and poaching, colonization by Africanized bees, and predation by forest falcons. Results suggested that these *in situ* management actions should have the greatest conservation impact and further, that at least some level of *in situ* management is necessary for the population to recover (see Chapter 7).

Irrespective of the conclusions of the PVA, one clear benefit associated with a scarlet macaw reinforcement program was detailed, consisting of engaging high profile national partners in the effort, consequently helping to focus strong national and perhaps international attention on the scarlet macaws struggle for survival, and encouraging a stronger governmental response to the clear threats. It was for this reason that this Workshop was convened with a number of experts to review, evaluate, and develop a protocol for restoring scarlet macaw populations in the wild.

6.3 Characteristics of Monitored Sites

WCS-Guatemala personnel suggested that the most suitable place for undertaking such an effort would be at the nesting hotspot of El Perú, where a field camp exists. The area also benefits from a long-term archaeological investigation at the site, ensuring that the Guatemalan army maintains a presence. Workshop participants felt it would be valuable to step back and review all macaw sites as well as other possible locations to see if the same conclusions would be drawn by the whole group. Donald Brightsmith facilitated the discussion about the relative suitability of the seven sites (Fig. 6-10). Sites were ranked according to the degree of each of five threats (fire, invasions, poaching, natural predation, hunting) and the logistics of working there. A summary of the conclusions was drawn up by Nancy Clum and is presented in Table 6-3.

Table 6-3. Summary of analysis of the potential sites for conducting macaw population reinforcement (N/A = information not available)

Site	Type	# Nests	Fire	Invasions	Poaching	Predation	Hunting	Logistics
El Perú	Park	7 to 15	Moderate	Moderate	Low	N/A	N/A	Good
Peñon BV	Park	6	Moderate	High	N/A	N/A	N/A	Good
AFISAP	Concession	3+	Low	Moderate	High	N/A	N/A	Okay
El Burral	Corridor	5 to 8	High	High	High	N/A	High	Okay
Pipiles	Cooperative	3+	High	N/A	High	N/A	High	Okay
La Colorada	Concession	1+	High	High	High	N/A	High	Okay
La Corona	Corridor	5 to 8	High	High	High	N/A	N/A	Poor

Figure 6-6. Don Brightsmith, with the assistance of Gabriela Ponce, facilitated a discussion on the characteristics of the seven macaw nesting regions monitored by WCS personnel and an evaluation of which would be best for first implementation of management interventions such as population augmentation through release of captive raised juveniles. El Perú was deemed the best choice.

Three sites, El Perú, Peñon de Buena Vista, and AFISAP were considered the best candidates for a release. It was pointed out that El Perú is easiest to control but that encroachment pressure is greatest to the west, possibly threatening El Perú. Releases in this area could be advantageous, drawing attention and encouraging investment that would help prevent the invasion boundary from sweeping further westward. But the site is also more at risk and could become isolated if the line of invasion eventually does sweep around it. El Perú contains the greatest concentration of known nests and is also already important for other reasons (e.g., an archeological site and a potential tourism facility at the former Las Guacamayas field station), meaning more people are concerned by its fate, and the army already has a presence. AFISAP is further east and has started to face invasion pressure, although local people are more invested in its success and hence it is less at risk. The consensus was that El Perú was the best site for a macaw restocking effort.

All of the sites considered already have an existing population of wild macaws. Some experts advise against releasing animals into an existing population because of potential disruption of that population through disease introduction or other unanticipated factors. While the group agreed there were potential hazards, the group also seemed to feel these hazards could be adequately mitigated. A question was also raised as to whether it is preferable to do a release in an area where threats are less intense, or in an area where the presence of a release may help to decrease threats. Again, assuming the potential hazards could be mitigated, the group felt the advantage of potentially decreasing threats was important enough to take the chance of doing releases in a more threatened area.

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7.0 POPULATION VIABILITY ANALYSIS (PVA) AND VORTEX MODELING

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Editors: Janice Boyd, Donald Brightsmith
Spanish Translator: Rony Garcia

7.1 Introduction

These scenarios model the population(s) of scarlet macaws (*Ara macao cyanoptera*) in the Maya Biosphere Reserve (MBR). Studies support the contention that this subspecies is morphologically and genetically distinct from *A. m. macao* that is present in South America and southern Central America (Wiedenfeld 1994, K. Schmidt and G. Amato, unpublished data). Although the nominate subspecies is listed as Least Concern by IUCN, *A. m. cyanoptera* has been proposed for Endangered status and will likely qualify. *A. m. cyanoptera* is currently known to occur in Mexico, Guatemala, and Belize. The largest and best known breeding population occurs in the Petén of Guatemala, where the Wildlife Conservation Society (WCS) has been working to conserve scarlet macaws since 2001. Most of the data used to set values for model parameters are based on information collected by WCS Guatemala and national partners.

7.2 Baseline Scenario Settings:

In addition to the narrative below, a summary table with values for deterministic r, stochastic r, final population size, and probability of extinction for each scenario is included at the end of this document (Appendices 7-1 and 7-2). A spreadsheet documenting parameters for all the runs is included in the report CD as a file name "Ara PVA ver2.xls" and a printout of that Excel file is attached as the second Appendix.

Number of Populations: One population was simulated for 100 years, 500 iterations. For the baseline model, we assume that there is only one population, i.e. that birds in the three range countries can/do traverse the MBR for complete gene flow among disjunct areas. Genetic data to date indicate that birds from Guatemala are not genetically distinct from birds in Mexico and Belize (K. Schmidt and G. Amato, unpublished data). Extinction was defined as no animals of one or both sexes. There was assumed to be no inbreeding depression as genetic studies to date have found a high level of heterozygosity among mitochondrial haplotypes of wild birds (H_d = 0.911; K. Schmidt and G. Amato, unpublished data).

Reproduction: Scarlet macaws are assumed to have a long-term monogamous pair bond with 100% of adult males participating in breeding. Based on input from aviculturists, the sex ratio at birth is assumed to be 50:50 and the age of first reproduction for females and males is six years. Based on published values for captive macaws (Brouwer et al. 2000) and input from field biologists, the maximum breeding age (senescence) was set at 25 years. Based on field data from Guatemala, the average percentage of adult females breeding successfully was 52% with a standard deviation of 16% (based on 79 nests at two sites over four years). These data, however, are based solely on protected nests and are likely an overestimate as many nests in the population are unprotected and subject to poaching. A revised estimate of 30% success was calculated based on the following assumptions: 1) Approximately 77% of nests in Guatemala (34/44) are protected (with a breeding success of 52%), 2) of the remaining nests in Guatemala, Mexico, and Belize, roughly half are unprotected (subject to poaching), and 3) poaching results in 0% breeding success. Based on field data from Guatemala, of those females producing progeny, 76% produce one chick, 23% produce two chicks, and 1% produce three chicks in an average year (back-calculated from productivity of 104 nests from seven sites over five years). Both field and captive data previously supported the maximum number of successfully fledged progeny as two, but new observations from the field have documented that broods of three, while rare, do occur (WCS Guatemala, unpublished data); as many as four chicks may hatch.

Mortality: Males and females are assumed to have identical mortality schedules with average first year mortality at 35% and environmental variation (EV) of 5%. Birds between 1-2 and 2-3 years are assumed to have a mortality rate of 10% and EV of 3%. Thereafter birds are assumed to have a mortality rate of 5% with an EV of 2%. These data are largely guesstimates, though probably realistic ones. The only available data come from captive scarlet macaws released in Costa Rica and Peru (Brightsmith et al. 2005), where first year survivorship averaged 75% (mortality = 25%, range 8-40%) and post-first year survivorship was 96% (mortality = 4%). Even the author of these published values, who was present at the meeting, thought that they might be a little optimistic for wild birds. Environmental variation in mortality was assumed to be concordant among age-sex classes but independent from EV in reproduction.

Population size, structure, and carrying capacity: Initial population size was set at 354 based on habitat modeling that predicted the remaining extent of nesting habitat based on characteristics of sites currently in use by breeding birds (WCS Guatemala and CEMEC[1], unpublished data). This number only represents the potential number of breeding birds, but the history of poaching in the area and documentation of suitable, unoccupied nesting cavities suggests that a significant non-breeding population is unlikely. This number could also be interpreted to represent the carrying capacity for the breeding population rather than the existing population, but to avoid artificially constraining population growth in the model, carrying capacity was set at 1200 with an EV of 120 (10%). In the baseline model, it is further assumed that carrying capacity does not change in the future, i.e., the Guatemalan National Park Service (CONAP) and partners such as WCS Guatemala are able to hold the line on habitat destruction in the MBR. The population is assumed to not have a stable age structure, given the long history of poaching that has likely suppressed recruitment. The baseline model presents a scenario where individuals are present in all age classes but the distribution is skewed towards older individuals.

Catastrophes: Six diseases were identified as being of sufficient risk to screen birds in the event of any attempt at population augmentation: *Polyomavirus*, psitticine beak and feather disease (PBFD), psitticine *Herpes* 3, PMV 1 (Newcastle's), *Chlamydia*, and *Salmonella*. Because of the prevalence of both poultry and captive psitticines in the region, these diseases have the potential for introduction into wild populations whether or not augmentation is attempted and so can be considered potential catastrophes. However, with the exception of PMV 1 (severity of effects on survival 0.25, i.e. only 25% of birds survive), all diseases have low rates of infection, morbidity, and mortality of adults; two have no effect on survival (*Polyomavirus* and *Herpes* 3, severity = 1.0) and the other three have a minimal effect on survival (severity = 0.9). Effects on reproduction are also most severe for PMV 1 (severity = 0.1). Chicks are disproportionately

[1] CEMEC is the Center of Monitoring and Evaluation of the Guatemalan National Park Service, CONAP

affected in PBFD (severity of effects on reproduction = 0.75) but reproductive effects in other diseases are minimal (severity = 0.9). For this reason, the baseline model was simplified to only include PMV 1 with a frequency of 1% (one disease event every 100 years).

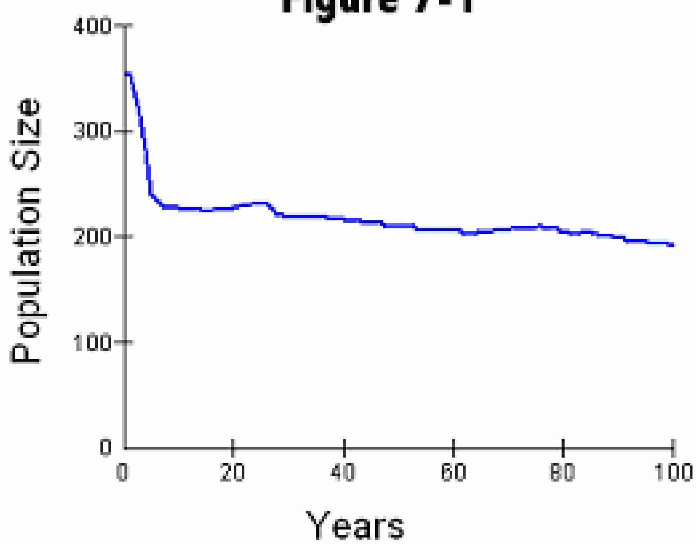
Harvesting, supplementation, genetic management: The baseline model assumes no harvesting as the effects of poaching are taken in to consideration as reduced nesting success. The baseline also assumes no supplementation. Genetic management is not necessary due to high heterozygosity.

7.3 Results of the Baseline Scenario

Deterministic calculations: Deterministic projections show rates of population growth in the absence of any stochastic fluctuations (changes in population associated with random events). As a result, they are a good indication of whether or not rates of reproduction and survival are sufficient to allow populations to persist under the best of conditions, since stochastic events (such as catastrophes) tend to depress population growth. The deterministic rate of exponential growth for the baseline scenario is slightly negative (r = -0.002), indicating that the population is unsustainable and will decline gradually over time.

Stochastic calculations: In the real world, rates of reproduction and survival are not uniform from year to year, and particularly in small populations, a bad year or years can put a population in a tailspin. As expected, rates of population growth are lower under a stochastic model (r = -0.017 $\pm$ 0.162). Because the baseline model assumes an age structure biased towards older birds, there is a rapid drop in population size during the first seven years which then tapers off to a very gradual decline (Figure 7-1). Because the population growth rate is negative, the population will eventually go extinct, but it will take a very long time (hundreds of years). Within the 100 year time frame, the probability of extinction is 12.4% ($\pm$1.5%SE). Various assumptions associated with the model are evaluated below.

Figure 7-1

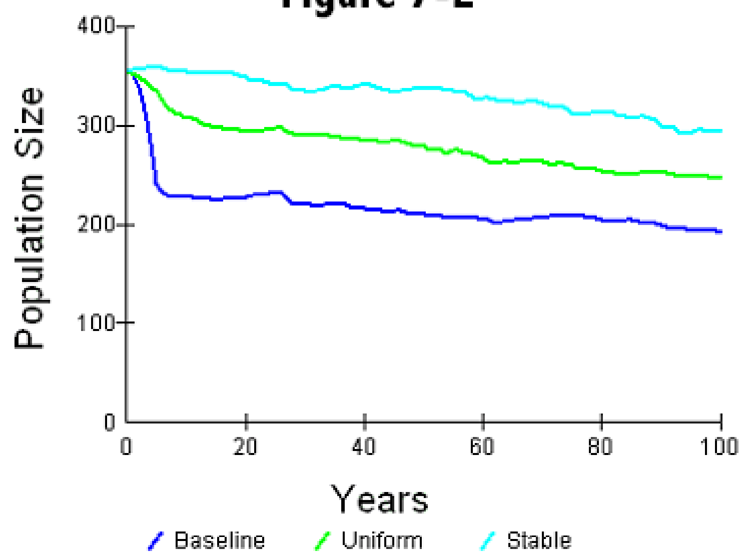


7.4 Effect of Population Age Distributions

One of the major uncertainties of the baseline model is the age distribution of the population. While we can be virtually certain that poaching has significantly reduced recruitment into the population and that the population lacks a stable age distribution, there are no data to indicate the true structure of the distribution. The baseline model (weighted towards older age classes) was compared to a stable age distribution (weighted towards younger age classes, representing normal recruitment into the population) and a uniform distribution which assumes equal numbers of individuals in each age class.

The effect of assuming a stable age distribution (normal recruitment) is that the extinction rate is halved (6.0%±1.1%SE) and the population declines less rapidly (r = - 0.010±0.152). The most significant difference between a stable and unstable age distribution is that the initial rapid drop in population size is lost and as a result the population is maintained at a higher level (Figure 7-2). This means that even if protection efforts effectively "hold the line" on poaching and other non-natural sources of mortality, a significant population decrease could occur in the next decade; whether a decline occurs and the size of the drop will depend on the true age structure of the population. It is likely that the production of offspring from protected nests since 2001 has already begun to restore a stable age distribution.

Figure 7-2



7.5 Effect of Population Size

The habitat modeling performed by WCS predicts a nesting population of 354 birds in the tri-national area including the Maya Biosphere Reserve in Guatemala, Montes Azules of Mexico, and the Chiquibul area of Belize. Extrapolating from 29 known nests in Guatemala, we assume a population of roughly 150 birds in this area. Based on field observations reported by Mark

McReynolds, we have assumed a minimum estimate of 100 birds in Belize. The remaining 100 birds are assumed to be in Mexico. It should be noted, however, that modeling only predicts the number of birds that *could* be present based on habitat; there is no guarantee that the model is equally representative of all three countries included or that the habitat is actually full, and thus the population size could be smaller or larger than predicted.

The baseline model was compared to scenarios with initial populations of 554 and 254. A similar age structure, unstable and weighted towards older individuals, was maintained.

Because the characteristics of the population are the same in each scenario, population growth rates and the pattern of decline are similar; the curves are simply offset as a result of different starting points (Figure 7-3). Although population size is a determining factor in population growth rates, the differences between scenarios are small and therefore the effect is minimal. The most significant aspect of changing population size is that since the variability around growth rates does not change, smaller populations are more likely to go extinct when population size fluctuates (Figure 7-4).

Figure 7-3

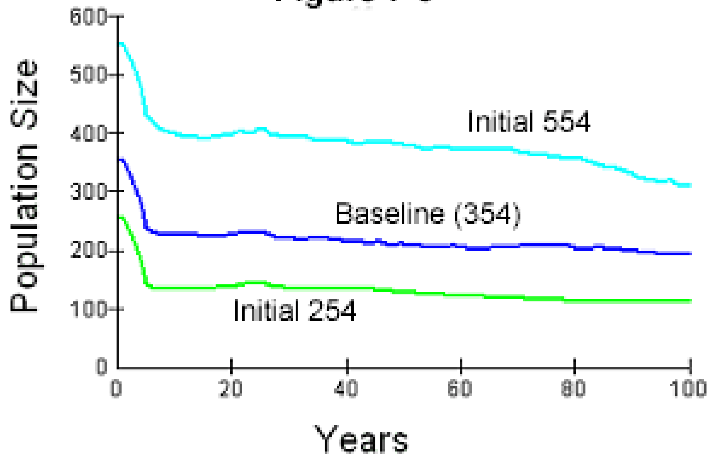
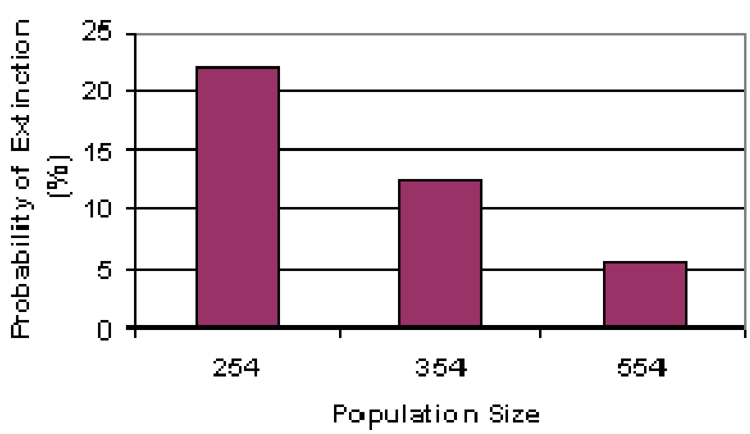


Figure 7-4



7.6 Effect of Population Structure

Recent genetic studies indicate that birds from Guatemala are not genetically distinct from birds in Mexico and Belize and therefore, at least historically, there was movement between populations. It is possible, however, that population declines have recently isolated these populations from one another, and that while still genetically similar, there is no longer communication among them, resulting in two or three smaller populations instead of one large one. It is also possible that regardless of genetic similarities, birds nesting in different areas may have different reproductive rates.

A series of Two Population and Three Population scenarios were created in which birds from Mexico, Guatemala, and Belize have different levels of annual exchange. Genetic analyses to date suggest that there is full gene flow among all three countries. However, it is important to note that there is a time lag between changes in connectivity and detecting changes in genetic structure. We have therefore modeled various levels of exchange ranging from no exchange (0%) to full exchange (4%). The Two Population scenarios all assume full genetic exchange (4%) between Guatemala and Mexico; the models differ in the level of symmetrical exchange that they assume between Mexico/Guatemala and Belize (0%, 0.04%, 0.4%, and 4%). Using the same assumptions described under the baseline model, the percentage of successfully breeding females in Belize would be 26% (half of nests with 52% and half unprotected with 0% success) and the percent breeding success of the combined Mexico/Guatemala population would be 31% (67 nests protected and 44 unprotected). Because these values imply that there is no source population for scarlet macaws in the MBR, another scenario was run with Belize as a source population with a 39% success rate. Recent data show that four out of ten monitored nests in Belize were poached (which would give a success rate of 31% if representative of the entire population) but only the most accessible nests were monitored, so success for the overall population could be higher. The Belize birds were assigned a uniform age distribution, largely as a matter of convenience due to the small population size. The Three Population scenarios assume each population is isolated from the others to differing degrees. In one set of scenarios, all populations are assumed to have symmetrical exchange at different levels (0%, 0.04%, 0.4% and 4%). In three additional scenarios there is moderate (0.4%) symmetrical exchange between Mexico and Guatemala with varying levels of symmetrical exchange with Belize (0%, 0.04%, 0.4%). In the last scenario there is full exchange between Mexico and Guatemala (4%) and symmetrical exchange between Belize and other populations at a rate of 0.04%. This last scenario is genetically equivalent to a Two Population scenario but assumes populations are reproductively distinct. In all Three Population scenarios, Belize and Mexico each have a 26% breeding success rate and Guatemala has a 40% success rate. See Appendix 7-2 for a list of population structure scenarios.

In the Two Population scenarios the rate of exchange between Mexico/Guatemala and Belize populations had little effect on the populations until rates of full exchange were approached (Fig. 7-5). At full exchange between populations, the Belize population benefited from exchange while the Mexico/Guatemala population was negatively impacted; both maintained a negative growth trajectory. When Belize was considered a source population with even a minimal level of growth ($r = 0.005 \pm 0.016$) and a minimal level of exchange with Mexico/Guatemala (0.04%), populations not only increased in Belize but stabilized in Mexico/Guatemala (Fig. 7-6).

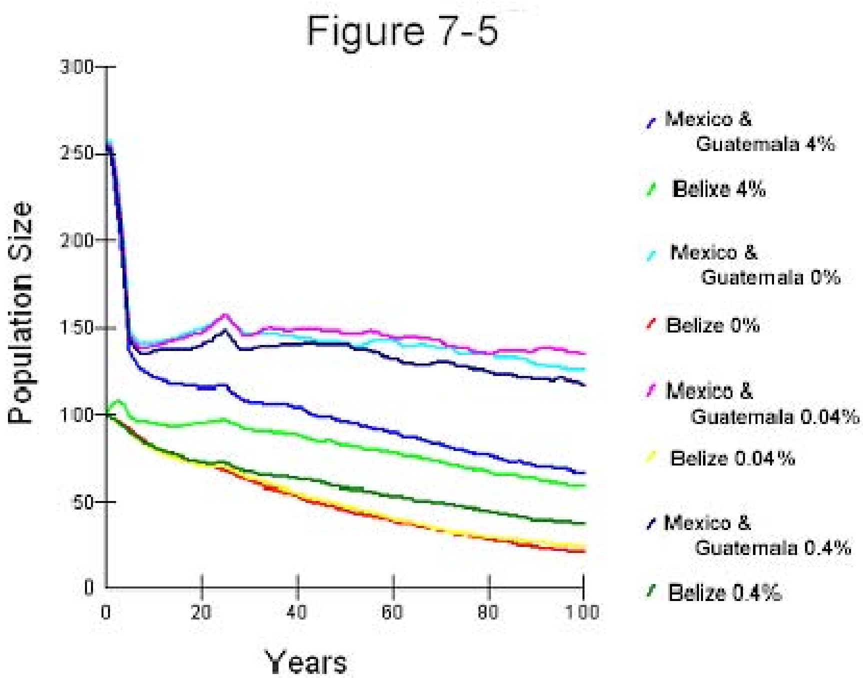


Figure 7-5
Population Size
Years
0
20
40
60
80
100
50
150
200
250
300
Mexico & Guatemala 4%
Belixe 4%
Mexico & Guatemala 0%
Belize 0%
Mexico & Guatemala 0.04%
Belize 0.04%
Mexico & Guatemala 0.4%
Belize 0.4%

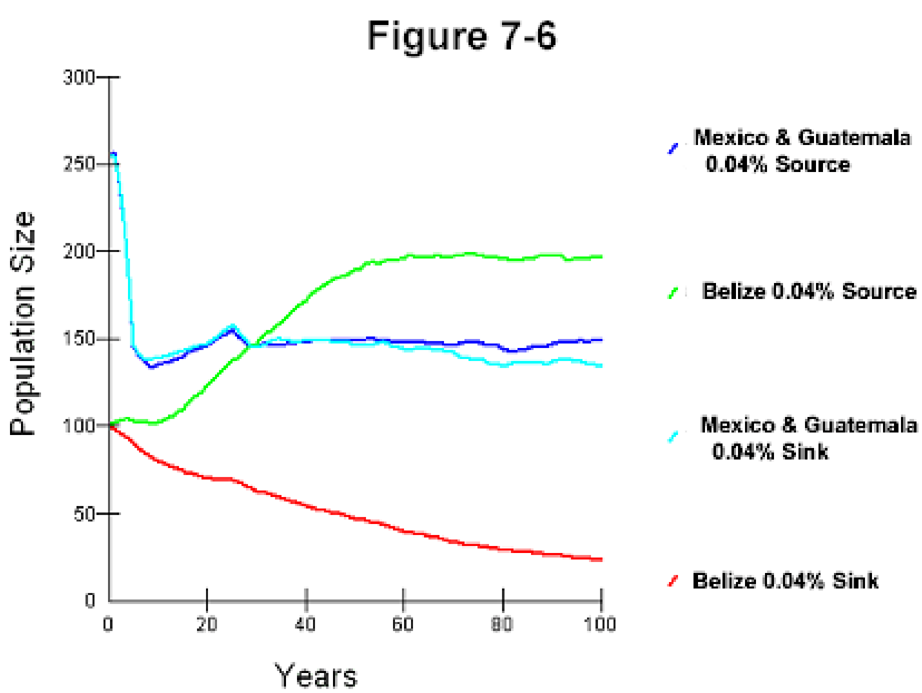


Figure 7-6
Population Size
Years
0
20
40
60
80
100
50
150
200
250
300
Mexico & Guatemala 0.04% Source
Belize 0.04% Source
Mexico & Guatemala 0.04% Sink
Belize 0.04% Sink

In the Three Population scenarios, the population trajectories for the metapopulation were generally positive because of the presence of a source population (Guatemala). As with the Two Population scenarios, exchange rates had little effect on the overall population except at the level of full exchange (Fig. 7-7). With full exchange, birds were siphoned from the source population into the two sink populations with the effect that Belize and Mexico populations were stabilized at the cost of a declining population in Guatemala (Fig. 7-8). The most significant aspect to a structured population, therefore, was not the division of birds into smaller populations, but the potential impact of source/sink dynamics between areas of differing reproductive potential. Although there is reason to believe that the genetic structure of the MBR follows a one-population model, because of regional differences in reproductive success, one, two, and three population scenarios (all assuming full exchange between Mexico and Guatemala) produced slightly different results even at the level of the metapopulation (Fig. 7-9).

Figure 7-7

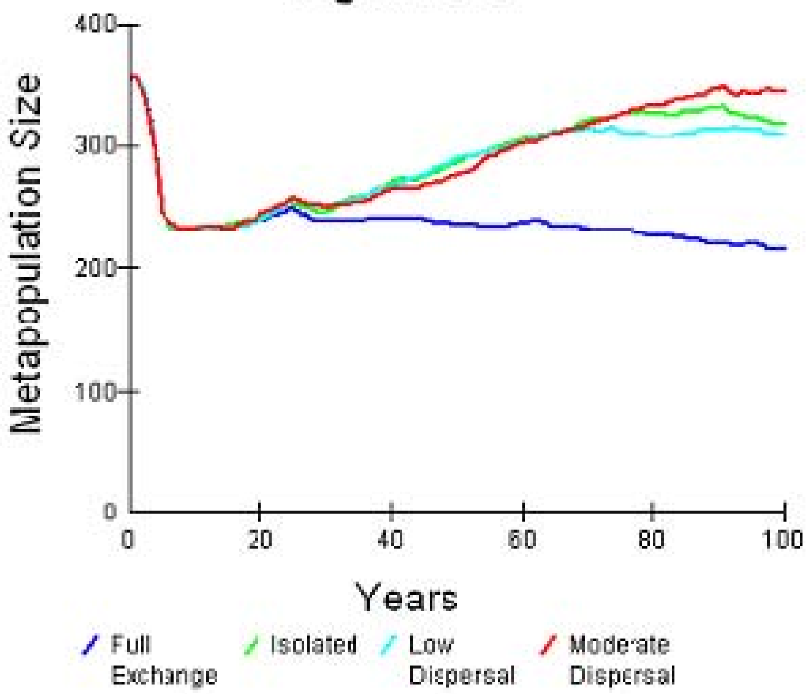


Figure 7-8

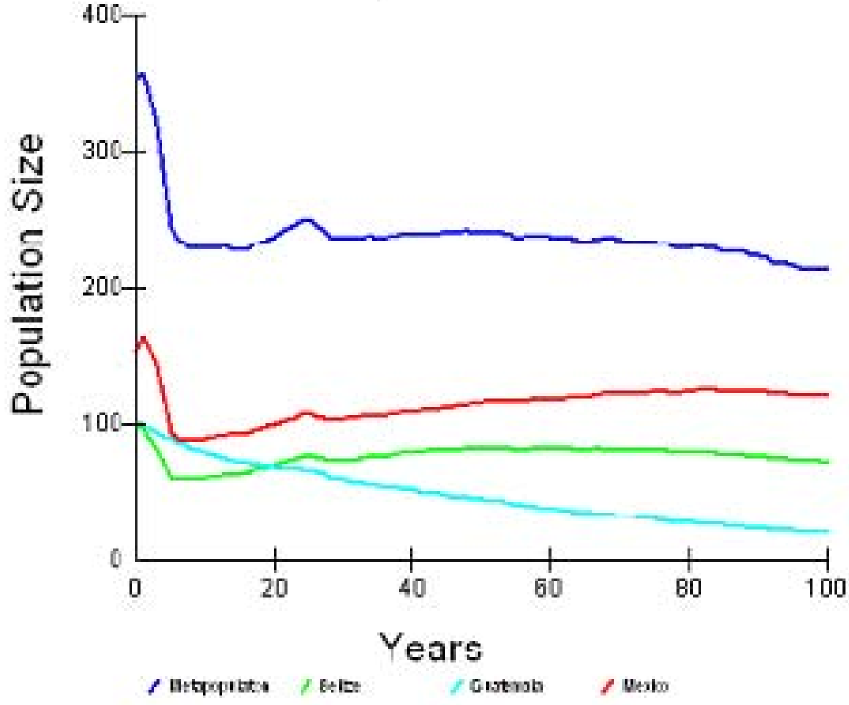
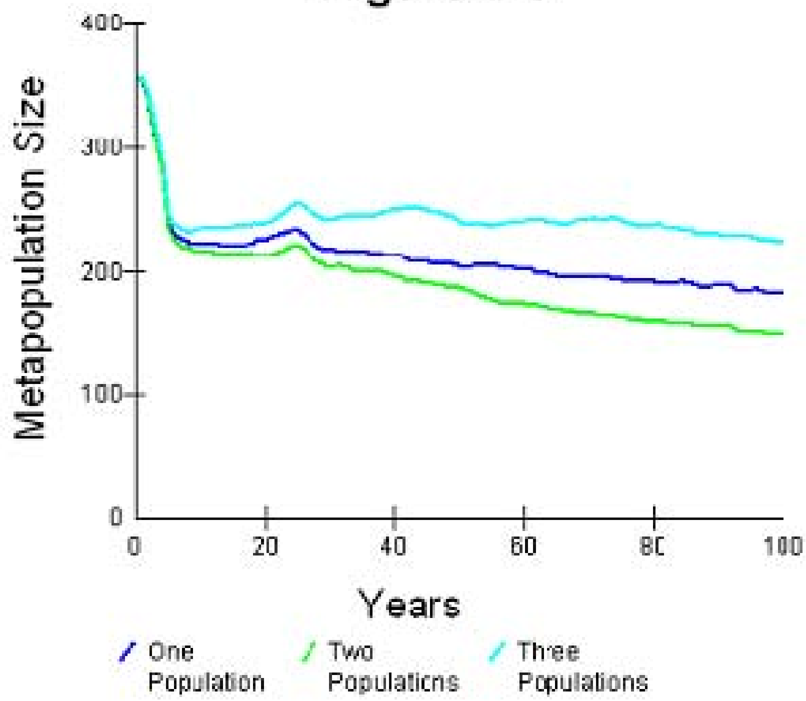


Figure 7-9

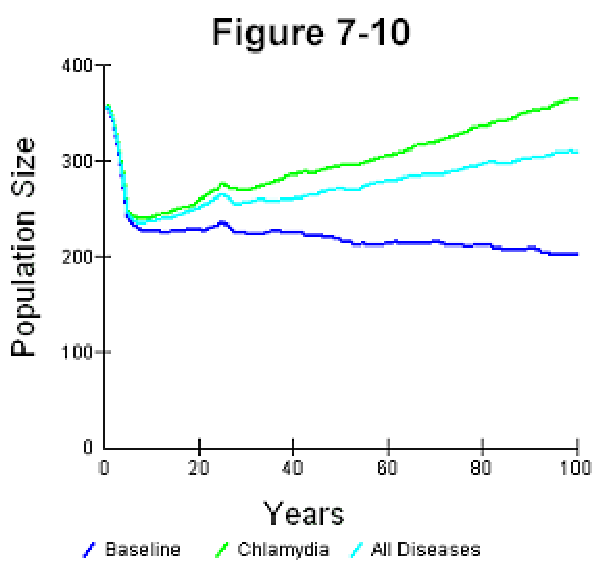


7.7 Effect of Catastrophes (Disease)

Disease is the primary candidate for a catastrophic decline in this species and region. Annual variation in food as a result of El Niño/La Niña events is expected to be captured in natural environmental variation, poaching is captured under changes in the percentage of adult females nesting successfully, and fires (also related to El Niño/La Niña events) infrequently impact significant numbers of nest trees and generally burn low with minimal impact on food plants (McNab pers. comm.).

Modeling disease effects involves significant uncertainties in both potential frequency of occurrence and in the severity of effects on survival and reproduction. The baseline model assumes an overall frequency of one catastrophic event every 100 years that results in a 90% decline in reproduction and a 75% reduction in survival for one year resulting from an outbreak of Newcastle's Disease (PMV 1), which has high rates of infection, morbidity, and mortality. This is compared to a scenario where *Chlamydia*, which has a similar origin and therefore a similar likelihood of occurrence; but low rates of infection, morbidity, and mortality, causes the outbreak. An "all disease" scenario was also run with all six diseases having the same cumulative frequency of occurrence (1%) and severity but with each disease having a lower individual likelihood of occurrence (e.g. PMV 1 and *Chlamydia* each at 0.25%).

Because the baseline model has only a slightly negative growth trajectory, reducing either the severity of disease or the frequency of disease was sufficient to cause the population to increase, with a reduction in severity having a more pronounced impact (Fig. 7-10). In addition to increasing the population growth rate, the variability around population growth rates was dramatically lower ($r_{chalmydia}$ = -0.001$\pm$0.062, $r_{all\ diseases}$ = -0.005+0.100). Lower variability is significant because it reduces the probability of extinction, especially at low population sizes; in this case extinction probabilities were reduced to zero or near zero ($P[E]_{chlamydia}$ = 0%, $P[E]_{all\ diseases}$ = 1.4%).



One important aspect of disease not captured here is the potential for long term effects. Four of the six diseases (PBFD, psittacine herpes 3, *Chlamydia*, *Salmonella*) considered important to monitor can permanently affect reproduction and may continue to be transferred to other members of the population. Thus, while these diseases may have little short term impact on the population if introduced, the long term affects on population sustainability are uncertain. The issue of disease will be revisited again in the supplementation scenarios.

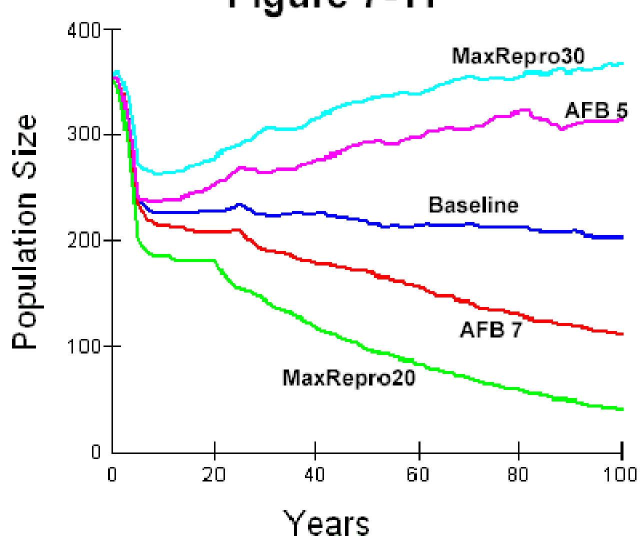
7.8 Effects of Life History Traits: Age at First Breeding and Maximum Age of Reproduction

Uncertainties in life history traits can be important because they influence deterministic growth rates and the inherent ability of a population to increase. Two traits for which we do not have definitive information are the age at which females first breed (AFB) and their maximum age of reproduction, which together determine the reproductive lifespan and the lifetime contribution to population growth.

The baseline model was compared to scenarios in which the AFB was increased or decreased by one year and to scenarios in which the maximum age of reproduction was increased or decreased by five years.

As would be expected, shortening the reproductive lifespan, either by increasing AFB or decreasing the maximum age at reproduction, reduced the deterministic growth rate of the population (r_{AFB7} = -0.008, $r_{MaxRepro20}$ = -0.016 vs. r = -0.002 for Baseline), while increasing the reproductive lifespan was sufficient to create a slightly positive growth trajectory (r_{AFB5} = 0.004, $r_{MaxRepro30}$ = 0.005). A similar pattern was seen with stochastic growth rates, though these rates were naturally lower (Fig. 7-11).

Figure 7-11



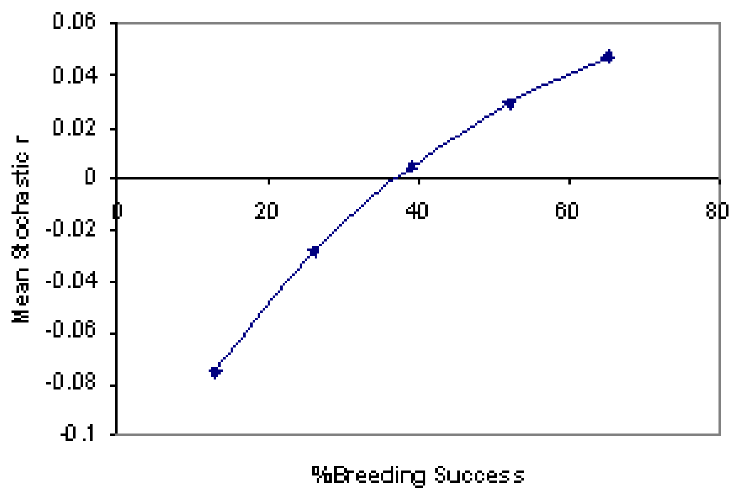
7.9 Effects of Reproductive Success (Poaching and Natural Mortality)

The average nesting success in a four year period at WCS sites was 52% and ranged between 30% and 75%. Since WCS has been highly effective at eliminating poaching in these areas, we assume that remaining losses reflect rates of natural mortality in the population. Current management activities attempt to reduce natural sources of mortality and thus elevate the average success rate. Any human incursions into the area that might result in poaching would likewise depress the success rate.

We compared the rate of nesting success of protected nests (52%) to a potential 25% increase (as a result of current and proposed management activities) and a 25%, 50%, and 75% decrease (to see the potential impact of various levels of poaching).

Success rates characteristic of protected nests and higher values produced robust levels of population growth ($r_{52} = 0.029 \pm 0.157$, $r_{65} = 0.047 \pm 0.160$) but values only slightly below 40% (including the 30% used in the Baseline scenario) caused the population to decline (i.e., produced values of $r < 0$; Fig.7-12). Relatively low levels of poaching, therefore, would be expected to result in a population decrease.

Figure 7-12



7.10 Effects of Supplementation (Population Augmentation)

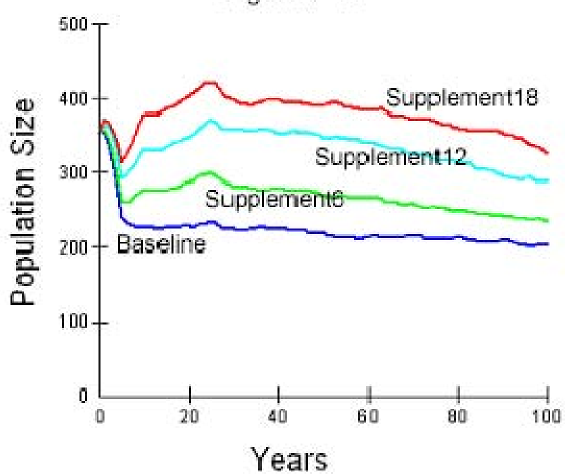
There are two ways of augmenting the macaw population. One way is to increase the number of chicks fledged from a nest, since pairs are routinely producing clutches larger than they successfully fledge. The second is to add individuals to the population by releases from captive stock.

The baseline scenario (no supplementation) was compared to scenarios that supplemented six, 12, and 18 individuals a year for a 10-year period beginning in the first year of the simulation.

Individuals added were two years of age as discussion of reintroduction procedures suggested individuals would be held from one to three years prior to release. The numbers of individuals supplemented could represent increased numbers of fledglings as a result of *in situ* management (e.g., chick food supplementation), release of captive-produced individuals, or a combination of both strategies. Chick food supplementation is modeled as an addition of birds to the population rather than an increase in the average number of chicks fledged because food supplementation would be feasible for only a few nests, and not the population as a whole.

The addition of young birds to the population had a minimal effect on the overall stochastic growth rate of the population ($r_{baseline}$ = -0.017±0.162, r_6 = -0.013±0.158, r_{12} = -0.010±0.154, r_{18} = -0.009±0.156). Supplementation did, however, reduce the initial decline associated with loss of older birds and gave a brief boost to population growth post-supplementation (Fig. 7-13). The net result was that although populations in all supplementation scenarios declined in the long term, supplemented populations achieved a higher population size in the short term. Supplementation decreased the probability of extinction by as much as two-thirds ($P[E]_{baseline}$ = 12.4%, $P[E]_6$ = 8.6%, $P[E]_{12}$ = 6.0%, $P[E]_{18}$ = 4.6%) Supplementation had a much smaller effect on rates of population growth compared to changes in the percent breeding success (Fig.7-14; diamonds represent the baseline scenario).

Figure 7-13



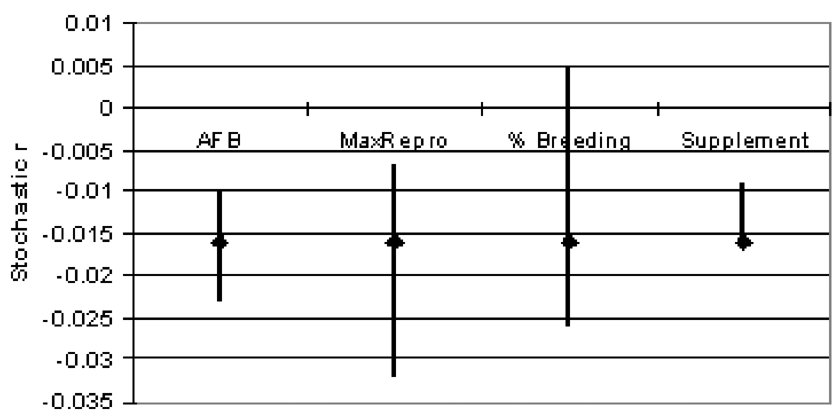
An additional supplementation scenario was run to evaluate the possibility of increasing the risk of disease introduction as a result of releasing captive individuals. In this scenario (Supplementation 18 Disease), the risk of disease introduction was doubled. The result was that the extinction rate was almost doubled above baseline (22.8±1.9%) and the stochastic rate of population growth was reduced to below the non-supplementation level (r = -0.024±0.212).

7.11 Effects of Changing Carrying Capacity (Habitat Quality)

Data compiled by WCS shows that deforestation rates in the Petén of Guatemala have fluctuated between 0.05% and 2% between 1967 and 2001. Since 2001, deforestation rates have increased by an order of magnitude, averaging about 0.5% with a peak of almost 0.9% in 2006. During the same time period, deforestation rates did *not* increase in communities where WCS was working[2] McNab, unpublished data).

We modeled a scenario called "Loss of K" that assumes a cessation of effective protection efforts by CONAP, WCS Guatemala, and our partners, and a corresponding decrease in carrying capacity at an annual rate of 0.5%. This corresponds to a decrease in carrying capacity of about 100 birds for every 20 years of deforestation, assuming rates do not rise above 0.5%. Although population growth rates and populations trends are initially unaffected (because other population parameters are unchanged and because the population is not increasing), the ultimate effect would be a decrease in total size of any recovered population. If the carrying capacity for breeding birds is as low as the habitat modeling suggests (354, compared to the 1200 we have set in the baseline model), current habitat could theoretically be eliminated within the 100 year time frame.

Figure 7-14



7.12 Summary

1) Overall, the deterministic rates of population growth for *A. m. cyanoptera* were slightly negative, indicating an inherent tendency for the population to decrease even in the absence of stochastic (random) events. The reason for this is that rates of poaching are included within the estimates of breeding success and breeding success is the primary force driving population growth rates. In the baseline model and other scenarios based on this model, breeding success rate is modeled at 30%, which is just under the 32% needed for a stable population. These scenarios suggest that a) even moderate levels of poaching could result in

[2] In 2008, following the scarlet macaw workshop held in Petén, an 120 acre patch of forest was indeed cleared near the Peñon de Buena Vista nesting site. Although this event did not affect the sites of known active nests, the deforestation was close (i.e. some 2 km away), and it did portend to threaten the nesting site in the future. Fortunately, CONAP and their partners including WCS Guatemala successfully addressed the situation by negotiating the exit of the illegal squatters. Subsequently, America Rodriguez of WCS played a key role in organizing a declaration by the community of Paso Caballos stating their opposition to any continued threats to the area, as well as their support for CONAP's protection efforts. In conclusion, despite the brief setback, known areas containing nests have continued intact in WCS focal areas.

a population decrease, b) prior to 2001 the population in Guatemala/Mexico was probably experiencing a significant rate of decline, and c) the work initiated by CONAP with the support of WCS Guatemala and local partners with regard to nest protection has probably been essential in halting that decline.

2) The stochastic rates of population growth were naturally lower than deterministic rates (by 87% for the baseline scenario) and the extinction probability was 12.4% for baseline. As with deterministic rates, stochastic rates were dependent on the percentage of successfully breeding females. In a stochastic model, however, the percentage of successfully breeding females needs to be about 37% in order for the population to grow. It should be noted that these target values are averages and the scenarios assume that there will be significant variation around them from year to year.
3) Because the age structure of this population is likely skewed towards older birds as a result of poor recruitment in the past, it is expected that the population may remain at its current level and could even decrease over the next ten years. This is a demographic artifact resulting from previous poaching and would occur regardless of current nest protection efforts. Any decrease in nest protection efforts would exacerbate this trend. The extent of any decrease will depend on the true age structure of the population, but chicks fledged from protected nests over the last seven years should help to mitigate this effect.
4) Although there are uncertainties with regard to the size, distribution, and connectivity of subpopulations, a metapopulation structure in and of itself does not appear to significantly impact population growth. When subpopulations differ in the percentage of successfully breeding females, however, the resulting source/sink dynamic could significantly negatively impact the Guatemala birds and (to a much lesser extent) affect the overall population. This means that if birds in Mexico are under significant pressure, it could delay or even prevent a recovery in the Guatemala and possibly eventually deplete the Guatemala population. It also suggests that the WCS strategy of “holding the line” at the western side edge of the intact forest block in the eastern Maya Biosphere of Petén may be important for maintaining the population as a whole.
5) Although genetic data support using a one-population model, because populations likely have some level of connectivity yet differ in source/sink status, a three-population model will be more accurate and transparent for predicting population trends in different countries.
6) Because of the likelihood of source/sink dynamics and the primacy of breeding success rates as a driving force in population growth rates, improved knowledge of macaw status in all three countries is of the highest importance for accurately predicting population trends. Expansion of nest protection efforts within and beyond Guatemala would have a positive impact on all populations.
7) Generally speaking, disease risks are small because the probable frequency of occurrence is low. If population augmentation raises the risk of disease introduction, however, it would negate any benefits associated with population augmentation and could even depress population growth below baseline levels. Disease severity appears to have a greater impact on populations than frequency of occurrence; it should be noted that severity is a function of which disease is introduced and therefore, unlike the frequency of occurrence, cannot be managed. Of greater concern may be the introduction of a disease that permanently impacts reproduction and remains in the population. Different software (Outbreak) would be required to model these effects.

8) While changing the life history characters (such as age at first breeding or the maximum age of reproduction) can affect population trajectories and therefore model predictions, these are largely determined by evolutionary processes and are not particularly instructive from a management standpoint. However, refining our estimates of these parameters will allow more effective modeling in the future.
9) Of all the variables manipulated in the scenarios (age at first breeding, maximum age of reproduction, age structure, population size, population structure, disease risk and severity, percentage of successfully breeding females, population augmentation, and trends in carrying capacity) the variable that most significantly and consistently impacted population growth was the percentage of successfully breeding females. This variable corresponds to ongoing management activities of nest protection against poaching, colonization by Africanized bees, and predation by forest falcons (*Micrastur ruficollis*). Results suggest that these *in situ* management actions should have the greatest conservation impact and further, that at least some level of *in situ* management is necessary for the population to recover. Additional data on natural causes of nest failures will help evaluate the relative importance of mitigating natural versus anthropogenic causes of nest failure.
10) Population augmentation has the potential to minimize a short term population decrease associated with an unstable age distribution and to raise the baseline population size. Several important caveats bear mentioning: 1) the benefits of population augmentation could be negated and/or population status could worsen if proper biosecurity is not observed during reintroduction; 2) the benefits of population augmentation are contingent upon current assumptions of an unstable age structure and a population growth rate near zero; if the population is performing significantly better or significantly worse, population augmentation at the level that is suggested as feasible would have little impact; 3) population augmentation is strictly a short term solution and does not address the cause of decline nor ultimately prevent population decline.
11) It is important to note that the value of population viability analysis does not lie in the absolute values that come out the scenarios; models are only as good as the data and assumptions they are based on and uncertainties can significantly change model results. This is particularly true in this analysis, where the variable with the greatest weight (breeding success) has been set at a level just below what is needed for a stable population. As a result, small changes in a number of different parameters can dramatically change population trajectories in a way that would not happen if the population was growing or declining more rapidly. Population viability analysis is most valuable for understanding which parameters give the greatest leverage (in this case breeding success) and which management activities have the greatest impact on those parameters (in this case, poaching). This allows managers to focus their efforts on those activities with the greatest conservation impact.

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Appendix 7-1: Scenario Growth Rates, Extinction Rates and Final Population Sizes

Scenario	Det r	Stoch r	SD (stoch r)	Final N	SD (Final N)	P (extinction)
Baseline	-0.002	-0.016	0.16	204	242	0.122
Uniform	-0.002	-0.13	0.162	248	283	0.108
Stable	-0.002	-0.01	0.152	293	304	0.06
Initial Population 554	-0.002	-0.14	0.16	310	321	0.056
Initial Population 254	-0.002	-0.02	0.167	113	145	0.22
Two Pops 0%: M&G	0	-0.016	0.162	20	32	0.16
Two Pops 0%: Belize	-0.013	-0.027	0.161	297	125	0.464
Two Pops 0%: Meta		-0.019	0.157	167	201	0.148
Two Pops 0.04%: M&G	0	-0.018	0.168	129	166	0.174
Two Pops 0.04%: Belize	-0.013	-0.026	0.169	20	32	0.424
Two Pops 0.04%: Meta		-0.02	0.162	150	188	0.152
Two Pops 0.4%: M&G	0	-0.02	0.162	105	135	0.186
Two Pops 0.4%: Belize	-0.013	-0.019	0.164	36	49	0.306
Two Pops 0.4%: Meta		-0.021	0.161	141	178	0.168
Two Pops 4%: M&G	0	-0.023	0.167	72	87	0.21
Two Pops 4%: Belize	-0.013	-0.014	0.169	62	75	0.232
Two Pops 4%: Meta		-0.021	0.156	133	161	0.182
Two Pops Source: M&G	0	-0.016	0.164	138	164	0.144
Two Pops Source: Belize	0.017	0.006	0.157	198	145	0.086
Two Pops Source: Meta		-0.005	0.157	336	287	0.072
Three Pops 0%: Mexico	-0.013	-0.033	0.168	11	20	0.552
Three Pops 0%: Belize	-0.013	-0.027	0.161	19	32	0.434
Three Pops 0%: Guat	0.19	0.004	0.163	297	223	0.086
Three Pops 0%: Meta		-0.005	0.158	327	252	0.086
Three Pops 0.04%: Mexico	-0.013	-0.027	0.166	17	26	0.394
Three Pops 0.04%: Belize	-0.013	-0.024	0.165	24	36	0.37
Three Pops 0.04%: Guat	0.019	0.003	0.164	287	221	0.092
Three Pops 0.04%: Meta		-0.006	0.157	328	261	0.09
Three Pops 0.4%: Mexico	-0.013	-0.015	0.168	52	55	0.22
Three Pops 0.4%: Belize	-0.013	-0.015	0.163	54	61	0.198
Three Pops 0.4%: Guat	0.019	-0.002	0.163	240	212	0.116
Three Pops 0.4%: Meta		-0.008	0.154	346	317	0.108
Three Pops 4%: Mexico	-0.013	-0.014	0.182	56	61	0.202
Three Pops 4%: Belize	-0.013	-0.014	0.181	58	67	0.218
Three Pops 4%: Guat	0.019	-0.017	0.179	74	87	0.21
Three Pops 4%: Meta		-0.017	0.159	189	213	0.168
Three Pops 0%: Mexico Asym	-0.013	-0.014	0.171	51	53	0.208
Three Pops 0%: Belize Asym	-0.013	-0.027	0.165	21	37	0.44
Three Pops 0%: Guat Asym	0.019	0.001	0.162	258	214	0.09
Three Pops 0%: Meta Asym		-0.007	0.155	330	285	0.086
Three Pops 0.04%: Mexico Asym	-0.013	-0.014	0.166	52	54	0.19
Three Pops 0.04%: Belize Asym	-0.013	-0.023	0.159	25	34	0.354
Three Pops 0.04%: Guat Asym	0.019	0.001	0.16	262	216	0.072
Three Pops 0.04%: Meta Asym		-0.006	0.152	339	289	0.068
Three Pops 0.4%: Mexico Asym	-0.013	-0.016	0.176	45	51	0.234

Three Pops 0.4%: Belize Asym	-0.013	-0.016	0.168	49	59	0.248
Three Pops 0.4%: Guat Asym	0.019	-0.004	0.169	223	211	0.118
Three Pops 0.4%: Meta Asym		-0.01	0.161	318	311	0.108
Three Pops 4%: Mexico Asym	-0.013	-0.008	0.176	75	74	0.176
Three Pops 4%: Belize Asym	-0.013	-0.025	0.166	21	34	0.426
Three Pops 4%: Guat Asym	0.019	-0.012	0.175	128	142	0.16
Three Pops 4%: Meta Asym		-0.014	0.161	224	237	0.136
Chlamydia	0.005	-0.001	0.062	366	210	0
All Diseases	0.003	-0.005	0.1	309	225	0.014
AFB 5	0.005	-0.1	0.16	315	334	0.09
AFB 7	-0.008	-0.022	0.159	111	140	0.18
Max Repro 20	-0.016	-0.32	0.162	39	54	0.288
Max Repro 30	0.005	-0.007	0.155	382	370	0.046
Breeding Success 65%	0.058	0.047	0.159	991	306	0
Breeding Success 39%	0.017	0.005	0.157	627	417	0.022
Breeding Success 26%	-0.013	-0.026	0.159	65	83	0.19
Breeding Success 13%	-0.06	-0.074	0.17	0.3	1.4	0.95
Supplement 6	-0.002	-0.013	0.16	237	269	0.08
Supplement 12	-0.002	-0.011	0.157	279	294	0.058
Supplement 18	-0.002	-0.008	0.156	329	324	0.064
Supplement 18 Disease	-0.01	-0.24	0.212	146	249	0.228

Appendix 7-2: Summary of Scenarios with Different Population Structures

Single Population (Mexico/Guatemala/Belize)

Full Exchange (4%), 30% average success all regions

Two Populations (Mexico/Guatemala and Belize)

Exchange (M/G and B)	Success (M/G)	Success (B)
0%	31%	26%
0.04%	31%	26%
0.04%	31%	39%
0.4%	31%	26%
4%	31%	26%

Three Populations (Mexico and Guatemala and Belize)

Exch (M/G)	Exch (G/B)	Exch (B/M)	Success (M)	Success (G)	Success (B)
0%	0%	0%	26%	40%	26%
0.04%	0.04%	0.04%	26%	40%	26%
0.4%	0.4%	0.4%	26%	40%	26%
4%	4%	4%	26%	40%	26%
0.4%	0%	0%	26%	40%	26%
0.4%	0.04%	0.04%	26%	40%	26%
0.4%	0.4%	0.4%	26%	40%	26%
4%	0.04%	0.04%	26%	40%	26%

8.0 DISEASE ISSUES AND TESTING RECOMMENDATIONS

Major Contributors: Darrel Styles, Bonnie Raphael
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Spanish Translators: Judy Uhart, Hebe Ferreyra and Marcela Uhart

8.1 Disease Risk Assessment

Introducing animals from outside into a population always carries with it some possibility of also introducing disease. If no animals of the same species are present, the level of risk is lower, being limited to the failure of the introduction effort, possible introduction of disease into related species, if present, and contamination of the environment. For a Guatemala or El Salvador effort, the plans as they are evolving generally assume new individuals will be introduced into an existing scarlet macaw population (Guatemala) or into an environment containing other wild psittacines (El Salvador). Disease risk assessment and then risk mitigation are thus of considerable importance. Risk assessment begins with compilation of as comprehensive a list of potential diseases as possible, followed by assessing the risks from each of these diseases and winnowing the comprehensive list down to a short list of diseases of real concern. The last element of risk assessment involves a risk reduction plan, including diagnostic testing. Darrel Styles, an avian veterinary virologist and aviculturist, and Bonnie Raphael, a zoo veterinarian, led this workshop discussion on Wednesday afternoon (March 12) (Figs. 8-1 and 8-2).

Figure 8-1. Veterinarians Darrel Styles (left) and Bonnie Raphael leading the discussion on avian diseases and testing needed for a macaw release program in Guatemala or El Salvador.

8.2 Problems in Using Diagnostic Tests for Screening

By way of introduction to the discussion, Darrel Styles discussed some of the problems inherent in using diagnostic tests for health screening. Two primary methods of testing include serology tests looking for a response of the animal to the organism via antibodies in blood serum and PCR (polymerase chain reaction) which identifies the actual organism [or causative agent] in blood, other tissues or secretions. In the case of RNA viruses, a more complicated reverse transcriptase PCR (RT-PCR) test must be used where the organism RNA is first converted to a DNA form.

Most diagnostic tests have performance problems when used for screening clinically healthy animals because they are designed for optimal performance in situations where the presence of disease is "enriched" Rideout, et al (2008) point out that many tests are species specific and few have been validated for wildlife species. It is often assumed that a test validated for one species – say domestic chickens – can be considered validated for the broader taxonomic group, but this is not necessarily the case. Serologic tests are especially difficult to interpret, being prone to both false positives and false negatives, particularly when not validated for the particular species being tested. Serologic tests will sometimes not be able to identify the agent, particularly if present at low levels (false negatives). Some tests cross react with related agents that may not be pathogenic, thus resulting in false positives. Serologic tests may be positive, reflecting past exposure (or cross reactivity with related agents), but the agent, disease causing or otherwise, may no longer be present in the animal.

Another problem lies in the statistics of using tests designed for disease diagnosis for the purpose of screening groups of clinically healthy animals. Whether a test performs satisfactorily differs for these two scenarios (clinically healthy versus clinically ill), and diagnostic tests perform better when the agent of interest is "enriched" in the population being studied (that is, when most members of the population are clinically ill).. When screening animals, the animals are pre-selected for absence of clinical signs, the agent is at a low level in the population, and test performance for evaluating disease status of the herd or flock declines because of the very high probability of at least one false positive.

Rideout, et al. (2008), noted that in their experience, not appreciating how common false positives can be when using diagnostic tests in wildlife species has had many seriously negative impacts on programs. These have included disrupted conservation programs, animals being removed from breeding programs, unnecessary euthanasia, and healthy animals remaining improperly suspected of a disease problem for years. They have the following four recommendations when screening clinically healthy animals for disease:

1. Choose non-species-specific tests
2. Choose tests that identify the agent
3. Expect false positives
4. Always follow-up to confirm positives
5. Use a laboratory with wildlife experience

8.3 Comprehensive List of Avian Diseases

Over the past seven years, both serology testing and some PCR testing of some birds at both Aviarios Mariana and ARCAS had been performed. The group elected to draw up its comprehensive list of avian diseases from the diseases covered by these tests, plus several others added by veterinarians in the group. The list of diseases was:

1. Polyoma
2. Psittacine Beak and Feather Disease (PBFD)
3. Psittacine Herpes or Pacheco's disease
4. Proventricular Dilitation Disease (PDD)
5. Chlamydia (*Chlamydophila psittaci*)
6. West Nile Virus
7. Avian Influenza
8. Infectious Bursal Disease (IBD)
9. Infectious Laryngotracheitis
10. Paramyxovirus 1 (PMV 1)
11. Paramyxovirus 2 (PMV 2)
12. Paramyxovirus 3 (PMV 3)
13. Infectious Bronchitis
14. Marek's Disease
15. Tuberculosis
16. Aspergillosis
17. Parasites
18. Malaria
19. Salmonella

Figure 8-2. Bonnie Raphael summarizing conclusions on the significance of various diseases in the comprehensive list.

Darrel Styles provided the group with relevant information on each of these diseases from the standpoint of a macaw captive release program, summarized in section 8.6.

8.4 Recommended Disease Screening

After considerable discussion, the group winnowed down the comprehensive list of diseases to the short list of diseases for which screening should be performed before any scarlet macaws are released into the wild in Guatemala or El Salvador (Table 8-1). For each disease, the method or methods for testing were also recommended. Dr. Styles' input here was invaluable, because as a trained veterinarian and avian virologist with extensive experience as an aviculturist he was able to supply a wealth of specialized information that probably could not be obtained anywhere else. Generally PCR (polymerase chain reaction) testing was recommended over serology, since PCR identifies the actual organism while serology looks for a response of the animal to the organism. In the case of RNA viruses, reverse transcriptase PCR (RT-PCR) must be used.

Table 8-1. Recommended disease testing for scarlet macaws for Guatemala release programs

Disease	Priority	Method	Comments
Polyoma	High	PCR	
Pacheco's disease	High	PCR	
Chlamydia	Recommended Consider	PCR DCF serology	Serology testing (DCF) may be less reliable unless the infection is recent. Participating veterinarians agreed on the value of PCR testing. Use of DCF testing may be considered
Avian influenza	Consider	RT-PCR	Consider defensive testing in case questions are raised
PMV-1 (Exotic Newcastle's disease or END)	Consider	RT-PCR or consistent serology negatives	Consider defensive testing because Newcastle's is such an important poultry disease, not because clinically healthy psittacines are likely to have it
Salmonella pullorum	Consider	Serology	In domestic poultry. Could infect chicks or humans or humans could transmit to other nests or birds.
Salmonella typhimurium	Consider	Most reliable is via culture	See above. Not as likely to be a problem as *S. pullorum*
Psittacine Beak and Feather disease (PBFD)	Recommended	PCR	Although rarely crosses over into New World populations, easily done along with other PCR tests and recommended to avoid controversy.

The PCR testing can be done with choanal and cloacal swabs. Pooled testing of up to 5 birds can be done in order to reduce costs, but individual testing would be required if any positives were detected. Costs are estimated (2008) to range from $US 20 - $US 50 per PCR test, depending on where the test is conducted. Additional costs would be associated with obtaining import and export permits and shipping of samples; this is discussed below. Serology tests are likely to cost $US 10 - $US 20 per test, or somewhat less if done at TVMDL (see below).

Successfully conducting a disease screening program with either of the two aviaries visited during the workshop (Aviarios Mariana and ARCAS) will require careful planning, and the effort should not be underestimated. The maximum time between sample collection and testing for PCR depends upon sample and preservation method and may be days, weeks, or even months. However, samples for RT-PCR must be maintained at 4˚ C and be processed within 24 hours. These short time frames, especially for RT-PCR, are a challenge when samples are collected in a remote location and must be sent to a distant analysis laboratory, perhaps on a different continent. Obtaining permits for both exportation of samples from Guatemala or El Salvador and importation into the country of the testing laboratory must take place well in advance of sample collection. Unfortunately, time was not available for fully discussing ways of handling these crucial details.

Among the issues that would need to be resolved include what testing laboratories to use. Some of the tests such as END could possibly be run in Guatemala or El Salvador, but no specific laboratories were identified. A list of commercial companies and organizations that could conduct tests on appropriate samples was compiled. See the company web sites for further information on what tests they can run and what types of samples are required.

- HealthGene in Toronto Canada (PCR testing of appropriate samples)
- Avian Biotech UK in Truro, United Kingdom (PCR testing of appropriate samples)
- Veterinary Molecular Diagnostics, Inc in Milford, OH (PCR testing of appropriate samples). This laboratory is one of the best exotic and avian testing laboratories in the United States and has one of the most extensive array of tests.
- Texas Veterinary Medical Diagnostics Laboratory (TVMDL) in College Station, TX The laboratory is one of the largest full-service veterinary diagnostic laboratories in the world. It is also one of the least expensive.
- Research Associates Laboratory in Dallas, TX (PCR testing of appropriate samples).
- UNAM (Universidad Nacional Autónoma de México) in Mexico – various departments have the capabilities, but a faculty member or student would need to become interested in a project

A CITES export permit from the country of origin (e.g., Guatemala or El Salvador), and the appropriate import permits from the country in which the laboratory is located will always be required when samples are shipped or otherwise transported. As of mid-2008, for a laboratory in the United States, importation permits would be needed from the US Fish and Wildlife Service (USFWS) Office of Management Authority and from the US Department of Agriculture (USDA) Animal and Plant Health Inspection Service(APHIS). In addition, a USFWS Wildlife Declaration Form 3-177 must be submitted at the entry port at the time of importation. (Note: the following information was accurate as of mid-2008, but URLs and telephone numbers change, so in the future, interested parties may have to do internet searches to get this information.)

- Apply for the USFWS permit by submitting completed Form 3-200-29 “Permit for Import/Export/Re-export of Wildlife Samples and/or Biomedical Samples.’ The application fee is either $100 or $200 depending upon whether the application is for a one-time sample or for multiple samples.(http://www.fws.gov/forms/3-200-29.pdf)
- Apply for the USDA permit by submitting Form VS Form 16-3. “Veterinary Permit for Importation and Transportation of Controlled Materials and Organisms and Vectors.” The application fee is $94 and the permit is good for one year. Because of the presence of Exotic Newcastle’s Disease (END) in Guatemala and El Salvador, the samples must be sent to either a BSL-2 (Biosecurity Level-2) laboratory or else the receiving laboratory must treat the samples in such a way as to destroy END. The applicant will have to contact the intended

laboratory and describe this information in sections 9 and 10 of the form. (http://www.aphis.usda.gov/animal_health/permits/)

- Samples must enter the US through a designated port, which includes most of the major entry ports into the United States, including Atlanta, Dallas/Fort Worth, Houston, Los Angeles, Miami, New York, New Orleans and San Francisco. A list is given at http://www.fws.gov/le/ImpExp/Contact_Info_Ports.htm
- The Wildlife Declaration Form 3-177 may be obtained at the port itself or from the webpage http://www.fws.gov/le/ImpExp/Info_Importers_Exporters.htm

The Wildlife Conservation Society webpage http://www.wcs.org/sw-high_tech_tools/wildlifehealthscience/fvp/168570/170367 also discusses permit guidelines for the United States, although many of its links were outdated as of mid-2008.

It should be apparent that considerable long term planning is needed to send samples into the United States. One recommendation is that representatives from USFWS and USDA involved in the permitting process be contacted about how long it will take to get such permits when the time approaches to apply. Generally the time will be at least several months. Telephone numbers to try are (703) 358-2104 for USFWS Office of Management Authority and (301) 734-3277 for USDA-APHIS.

Obtaining permits for importing samples into Canada or the United Kingdom/European Union is reportedly considerably easier than importing samples into the United States.

8.5 Flock Health Testing and Health Maintenance

While the group was able to come up with recommendations regarding the most important diseases for which to test if scarlet macaws are to be bred and released, time was not available to address the testing protocol including what birds should be tested (all birds in the aviary, breeding adults, or only juveniles to be released), how many times, and at what stage of life or in the breeding and release process. In many cases, screening can be done by pool testing groups of macaws or in interacting flocks (e.g., in large flights), by pooling and testing results from representative members of the flock.

Flock health maintenance issues also need consideration. Among these issues are:

1. Biosecurity and quarantine procedures
2. Routine flock health surveillance and testing
3. Routine parasite control
4. Health assurance procedures for birds for actual release

8.6 Summary of Disease Characteristics

A summary of the characteristics of the diseases on the comprehensive list considered by the group is given below. The workshop participants were extremely lucky to have Dr. Styles present because he was able to present this summary to us from his extensive studies and experience. This information is not available from any one source or even from several sources.

8.6.1 Polyoma

Polyoma viruses are small, potentially oncogenic DNA based viruses. In birds, disease is transmitted via feather dander. In the *Ara* genus, it is typically a disease of juvenile birds before fledging. Adults can be infected but rarely die. When *Ara* genus birds are exposed prior to 12 weeks, ~100% sicken and die. Exposed after 12 weeks, they generally survive, show no clinical symptoms, and clear the virus in 60-90 days. In aviculture, the disease is typically not seen in nest boxes but rather in nurseries. Infection rate in nurseries approaches 100%. The disease is not medically treatable but is controllable in aviaries through proper management. In the wild it would be expected to cause loss of production in individual nests, but not to be spread from one nest site to another. The risk in Guatemala would be due to exposure to birds in the pet trade, but for birds being introduced from the two captive collections examined, the risk is considered low. Poultry viruses cross react in the serology test, so false positives are possible. Testing should be done via PCR

8.6.2 Psittacine Beak and Feather Disease (PBFD)

The disease is caused by a circovirus. The origin is not known, and the host species are unknown. It may be of African origin. Lovebirds (*Agapornis*) and budgerigars (*Melopsittacus*) can be carriers. Guatemala receives shipments of lovebirds from Cuba for the pet trade, so the disease could potentially enter the country via such shipments. Wild parrots have been infected, with the most serious (present) impact seen in cockatoos and lories in Australia. The disease acts through immunosuppression. It generally affects young birds, but can also infect adults. The disease is highly unlikely to pass into New World psittacines, as they typically clear the virus quickly. The infection rate is low, morbidity is low and fatality rate is low. An experimental vaccine exists for prevention. For birds being introduced from the two captive collections examined, the risk is considered low. In a source population exposed to other than New World psittacines, the risk should be considered moderate. Testing should be done via PCR.

8.6.3 Psittacine Herpes or Pacheco's disease

The disease was first described in the 1930's in Brazil by a Dr. Pacheco; hence the name. New World psittacines seem to be more susceptible than Old World parrots from Australasia and Africa. There is one documented case of a Keel-billed Toucan succumbing to the disease. Some species of conures are thought to carry the virus asymptomatically in captivity and the length of time they shed the virus is unknown. There may be other hosts. The disease has never been detected in the wild by PCR, although some serological positives from Costa Rican and Peruvian psittacines have been reported.

The disease infects both *Ara* and *Amazona* genera, and the outcome depends on which of 4 possible strains are involved:

- Strain 4 will kill *Ara* species but not *Amazona* species.

- Strain 3 usually does not kill *Ara* species but causes persistent infection. Strain 3 kills *Amazona* species.
- Strains 1 and 2 are rare in the New World

Birds with papillomas are Pacheco's positive and carrier of one or more of the strains. The infection rate in outdoor aviaries can be moderate, but the disease can be controlled by biosecurity. The infection rate can approach 100% in indoor aviaries. The virus not thought to pass into the egg, so persistently infected macaws may be used for breeding if eggs are pulled and fostered or artificially incubated. This disease causes acute mortality so it is not likely to be introduced from captive collections, and there is a low risk of obtaining it in the wild unless papilloma positive macaws carrying the virus are released.

There is no practical treatment. There has been some success in captive parrots treating with the antiviral drug acyclovir followed by supportive therapy, and acyclovir can prevent infection. Testing should be done via PCR.

8.6.4 Proventricular Dilatation Disease (PDD)

At the time of this workshop, PDD is a histopathological diagnosis, not a disease diagnosis because the causative agent or agents is/are unknown. A bornavirus has been implicated; or the disease may result from multiple interacting factors. It is an area of active research as of mid-2008 and considerably more is likely to be understood about the disease in the next few years.

The disease is known to occur in New World psittacines, especially macaws, but it also afflicts multiple species including toucans, free-ranging Canada geese, spoonbills and weaver finches as well as Old World psittacines from Asia, Australia, and Africa. It is an autoimmune disease, with two manifestations: gastrointestinal and neurological. Mortality approaches 100%. Transmission routes are unproven. No tests are currently available and there is no treatment except supportive therapy. Since it cannot be tested for and already exists in New World birds, the only way to deal with it is not to release any birds with symptoms or birds that have been around symptomatic birds. This recommendation is likely to change in the future as tests and possibly immunization are likely to emerge.

8.6.5 Chlamydia / Chlamydophila (*Chlamydophila psittaci*)

Chlamydophila psittaci is a bacterial organism, but it can't be grown in agar, it must be grown in cells. The organism can infect people, where it causes severe flu-like symptoms and fevers because the organism affects the temperature regulatory system. Infection can cause long term health problems. There is a minimal infection risk from wild psittacines because the disease is not maintained in wild bird populations as those that are sick die or are predated. However, a significant percentage of urban pigeons in Guatemala are likely to be infected. Cockatiels and other carriers may shed asymptomatically for at least a year. Infection occurs via the oral-nasal route. The disease can cause reproductive problems in breeding birds. The infection rate in open aviaries is low and the infection rate is density dependent. The disease can be treated medically with doxycyline and related drugs. Transmission in the wild is likely to be low, and the likelihood of transmission from captive collections is moderate. PCR should be used if testing is performed. Serologic testing (DCF) may be useful for detection of previous infection and could be considered as an ancillary chlamydophila diagnostic test.

8.6.6 West Nile Virus

WNV is a member of the family of RNA arboviruses and originated in Africa. Some bird species can be carriers. Corvids, raptors, and flamingos are very susceptible, with high viremia leading to liver disease and rapid mortality. WNV can infect many species of birds but only some become sick. The disease affects all life stages. It has already been documented in Central and South America (as of 2008). The disease is usually transmitted by mosquitoes, except in some flocking birds via lateral transmission. Death rates seem lower where mosquitoes are found year-round—native arboviruses may provide some cross-protection. Psittacines can show clinical signs but can't transmit the disease because the viremic phase does not reach the threshold of infection for mosquitoes. A macaw experimentally infected showed some symptoms in 10-14 days. Because it is an RNA virus, it would require testing via RT-PCR, something difficult to do in most developing countries. Testing for WNV is not considered necessary for aviaries or pre-release health screening in Guatemala or El Salvador.

8.6.7 Avian Influenza

Avian influenza is of worldwide occurrence. The low pathogenic version is a natural infection of juvenile waterfowl and shorebirds. If the virus passes through chickens it can mutate to the high pathogenic form. Psittacines can be experimentally infected with the high pathogenic form. Adult psittacines in the wild probably don't get AI, but in an aviary situation, close to chickens, ducks and guinea fowl, psittacines could become infected. Testing could be done to head off any questions by authorities, but since it is an RNA virus, testing would need to be done by RT-PCR or an antigen strip test.

8.6.8. Infectious Bursal Disease (IBD)

Not a disease of psittacines so of no concern and no testing needed.

8.6.9 Infectious Laryngotracheitis

Very limited occurrence in psittacines; not important, no testing needed.

8.6.10 Paramyxovirus 1 (PMV 1)

PMV I is Newcastle's disease, an economically important poultry disease. Psittacines can get Newcastle's, where the infection rate is high and it causes high morbidity and high mortality within 5-7 days. There is a very low likelihood of this disease entering a wild population from birds in the aviaries visited. Infection from domestic chickens or people carrying it on clothing, footwear, etc., is a more likely route of infection of wild psittacines. Because this disease resides in poultry, exposure is more difficult to control and this disease may have a likelihood of being introduced into the wild, even in the absence of releases of captive birds. Unfortunately, once in a population it could be devastating because it causes acute and high mortality rates. It is an

RNA virus; so requires RT-PCR test for definitive diagnosis. Serology positives or negatives are probably indicative and because it is an important poultry disease, defensive serology testing of clinically healthy macaws in a release program could be advisable. Any serological positives should be retested.

8.6.11 Paramyxovirus 2 (PMV 2)

A poultry disease only. Of no concern for psittacines and no testing needed.

8.6.12. Paramyxovirus 3 (PMV 3)

A disease of turkeys. It has been implicated / associated with proventricular dilatation disease (PDD), but the relationship is not proven. The virus can infect psittacines and causes CNS symptoms until recovery. Low mortality. An RNA virus; so requires RT-PCR testing. Serology positives or negatives are probably indicative of present or past infection.

8.6.13 Infectious Bronchitis

Not a disease of psittacines and no testing needed.

8.6.14 Marek's Disease

Not a disease of psittacines and no testing needed

8.6.15 Tuberculosis

In psittacines, infection is by *Mycobacterium avium* and *M. genavense*. The disease is not likely to be a problem in Guatemala or El Salvador, but *Brotogeris* species in captivity have sometimes been found to be infected. Very rarely people have given TB to birds. The disease has low morbidity, low mortality, and infection is for life. There are no good tests. Serology doesn't work; and PCR is not likely to be useful because birds do not shed sufficient organisms in their secretions and feces. Only PCR from selected tissues on necropsy can detect infection.

8.6.16 Aspergillosis

Aspergillus is a genus of about 200 fungal species. It is ubiquitous in the environment, commonly occurring on starchy foods such as corn (especially if grown under drought stress) as well as on peanuts. Infection can cause respiratory disease, but the disease is rarely a problem in adult birds unless they under stress or have compromised immune system. *Aspergillus* also produces mycotoxins, with an unknown effect on birds. No testing is required.

8.6.17 Parasites

- Ectoparasites: the worst are parasitic flies. Also mites, lice, and ticks. Control with permethrum (permethrin) or carbaryl (Sevin)

- All captive psittacines with outside access should be periodically wormed. Control with pyrantel pamoate, fenbendazole, or ivermectin
- Coccidia probably not important in psittacines, although unconfirmed reports exist
- Tapeworms not common in Central or South America in psittacines. Control with praziquantel (Droncit) or epsiprantel (Cestex).

8.6.18 Malaria

Actual malaria is very rare in psittacines. The blood parasite hemoproteus is very common in macaws and can't easily be differentiated from malaria. Both types of protozoa are already in the environment and are natural commensal infections of many birds. Testing is not needed for clinically healthy birds.

8.6.19 Salmonella

Rodents and other vermin can carry the organism. Most important is probably *Salmonella pullorum* typhoid. The disease can cause mortality in chicks, and reproductive failure is possible. There is a moderate risk to wild populations from captive collections, from humans, or from domestic poultry. Transmission from nest to nest by humans handling chicks or nests is possible. Testing for detection of the disease or carriers is by serology and cloacal culture. Any poultry lab should be able to do testing.

LITERATURE CITED

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9.0 SCARLET MACAW *IN SITU* MANAGEMENT

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9.1 Overview

Thursday and Friday, 12-13 March 2008, workshop participants visited the scarlet macaw nesting area location known as El Perú, where WCS-Guatemala has a permanent field station (See figure in Chapter 6 for location). During the January – August breeding season, field personnel locate nests and monitor scarlet macaw breeding success in the area. Nearby is an ongoing archaeological excavation of an important ancient Maya site known as El Perú-Waka', with a resulting frequent nearby presence of Guatemalan Army guards. As discussed in Chapter 6, El Perú was agreed upon as a good test site for first implementation of macaw conservation interventions in the MBR.

Participants drove from Flores to the village of Paso Caballos located inside Laguna del Tigre National Park and boarded a small boat to motor about 5 km down the San Pedro river (Fig 9-1). After a brief visit to Las Guacamayas Biological Field Station and a bit of birding (Fig. 9-2), the group continued several more kilometers to a landing from which a dirt road led to the WCS field camp.

Figure 9-1. The workshop participants traveled from the village of Paso Caballos several kilometers down the San Pedro river, visiting Las Guacamayas Biological Station and putting in at a landing about a 1 km walk from the WCS permanent field camp.

Figure 9-2. Scenes from the short visit to the Las Guacamayas Biological Field Station – a great base for research or for birding and visiting the archaeological site.

Thursday evening we heard presentations by WCS field personnel on their environmental education program (Fig. 9-3) followed by a presentation on nest monitoring, the anti-poaching program, and other field activities (Fig. 9-4). An education program run by WCS in several local communities involves school children in the nest monitoring work and this program has been successful in encouraging community protection of nest sites that "belong" to the children. Later in the evening Don Brightsmith facilitated a discussion in English and Spanish on possible *in situ* interventions that could be implemented to increase the number of chicks fledging from the monitored nests in the area.

Figure 9-3. WCS field staff and Merlinda, one of the volunteers (green shirt).

Figure 9-4. Presentation on the WCS environmental education program.

Friday morning we visited several scarlet macaw nests, including one containing three chicks (Fig. 9-5). After a visit to the archaeological dig at El Peru-Waka', we climbed an unexcavated Maya pyramid and a tower on top of that to get a view of the whole surrounding area (Fig 9-6). Several participants suggested the tower could be used for regular macaw or other bird counts. Counts from towers have been used elsewhere with psittacines to obtain estimates of temporal population variations, and this might be a way to get a better understanding of the migration of the scarlet macaws into and out of the El Perú area. Population structure has also been assessed using group size counts since many parrot species -- including *A. macao* – travel in discernable family groups. Upon return to the field facility, the group departed for the several hour drive back to Flores.

Figure 9-5. Nest visited at el Perú, containing three chicks. The parent exited and flew away as we approached. Note the eggshells to the left and up from the two chicks. Usually only one or two chicks successfully fledge from a nest even if more hatch. .

Figure 9-6. Observation tower near El Perú from which point counts might be made to assess population age structure (singles, pairs without fledglings, pairs with fledglings) and changes in numbers and population structure over time. On right, view from the tower.

9.2 Observations from Tambopata Macaw Project

Following the environmental education presentation Thursday evening, Don Brightsmith opened the discussion of *in situ* management options that might increase scarlet macaw breeding success by describing some of his work during 9 years as lead on the Tambopata Macaw Project at the Tambopata Research Center (TRC) in Peru. Among the themes of his research has been developing and evaluating techniques for increasing reproductive output of wild macaws and expanding knowledge of macaw nesting behavior. Since 1999, he and his assistants have studied 15-30 large macaw (*A. macao*, *A. chloroptera*, and *A. ararauna*) nests each year, climbing each nest generally every day or two from incubation through fledging. After hatching, chicks are periodically weighed, measured, and photographed and survival recorded. While such nest inspections are considered benign by macaw researchers, one of his findings was that when scarlet macaw nests were inspected during incubation, 33% of the eggs hatched. But when they refrained from climbing during incubation, 53% of the eggs hatched.

Both in the wild and in captivity, scarlet macaws typically lay three to four eggs during a nesting attempt. Unless a clutch is lost, they nest only once in a breeding season. Of 96 scarlet macaw chicks studied at TRC, 4% were predated, 6% died when the nest was taken over by other macaws, 27% starved, 52% fledged, and other things happened to 10%. Most of the birds that sucessfully fledged were first chicks. In total 25% of second chicks died of apparent starvation and 100% of third and fourth chicks died.. Chicks at TRC fledge around 86-93 days. In El Perú chicks fledge around 90-100 days, while at ARCAS the range seems to be about 75-80 days. Weighing and measuring chicks from El Perú nests so as to allow a comparison of growth curves between TRC and Guatemala might be worth considering if personnel are available. Don Brightsmith offered to supply written protocols, training, or ideally personnel trained on his project in Tambopata.

Don also described his research on supplemental feeding of chicks in wild nests at TRC. When chicks less than 15 days of age were noted to be falling behind the standard growth curve, his personnel were able to successfully save starving second chicks by climbing a nest once or twice daily for several days to feed them (using a commercial US macaw hand feeding diet (Harrison's). They fed the chick until the crop was full or the chick stopped eating. They did not need to feed more than 1 week and sometimes only 1 or 2 times before the parents would resume feeding the second chick adequately. However, the same technique did not work on starving third chicks. Two feedings per day allowed third chicks to maintain weight for about 5 days but not to gain weight, and the parents did not begin feeding the chicks. The third chicks typically died after a week or so. Preliminary analysis of nest videos from Tambopata suggests that parents were rejecting the third chick, by separating it from the group and ignoring it. There is some circumstantial evidence that one of the chicks may have even been attacked and killed by the adult. (However, see Fig. 9-7 for an example of a Guatemalan wild nest at the La Corona site north of El Perú that actually fledged 3 chicks).

9.3 Observations from Aviculture

Darrel Styles commented on some relevant avicultural observations with scarlet macaw chicks:

- Chick growth rates are logarithmic, so the longer the time between eggs laid or the longer a chick does not grow properly, the greater the disadvantage for that chick. Two days difference in age or developmental stage is about as great as is usually consistent with survival. This is also consistent with information from Tambopata. Illustrating this are the three chicks in Fig. 9-7 that are quite close in development.
- When chicks are hand reared, rearing has been found to be more successful when chicks of the same age, rather than different ages, are grouped together.
- In captivity where food should be adequate, scarlet macaws, nevertheless, usually successfully feed only two chicks.
- Chick weight peaks around 60 days in the wild. However, data from captive situations show that weight may peak as early as 55 days (from Abramson et al. 1995 book, The Large Macaws).
- Chicks can be fed in the nest with little problem until their eyes open. The experience in captivity is that if they are removed from the nest after their eyes are open (around 18 - 21 days), they are hard to feed. They apparently do not recognize the hand feeder as a food source. Applying this information to feeding chicks over 18 days of age in the nest suggests they may not readily take to supplemental feeding, or that if chicks are pulled and returned to the nest after their eyes are open, they may not recognize the parents as a food source (a comment also made by Dr. Thomas White of the Puerto Rican Parrot Recovery Project)..

Figure 9-7. While parent scarlet macaws generally appear to be willing to feed only one or two chicks to fledging, there are exceptions, presumably in situations where food is abundant. These three chicks successfully fledged from a nest at La Corona (north of El Perú) in 2008. Note the chicks are close to one another in development. A chick significantly younger than its siblings rarely survives.

9.4 Possible *In Situ* Management Techniques

With this background, discussions followed on possible interventions to increase the number of chicks successfully fledged from nests in El Perú and then in other sites in the MBR.

Supplemental feeding of chicks in the nest: Based upon experience at TRC, frequent monitoring of nests and then once to twice daily feeding of second or possibly third chicks with commercial macaw hand feeding formula for a few days to a week might increase the numbers of chicks that survive to fledging. However, this is a very labor intensive intervention, and as such is a major disadvantage with present WCS field staffing levels. Climbing and checking nests is time consuming and requires special equipment and training. Before attempting this intervention an analysis is needed to weigh the additional work needed to identify and save second or third chicks versus the additional number of chicks that would be likely to be saved. That is not to say it might not be a viable intervention, particularly if more personnel are available. This method may also be valuable elsewhere, with scarlet macaws or another species of macaws
.

Pulling, feeding, and replacing chicks: If chicks do not respond to supplemental feeding or if in-nest feeding is considered too labor intensive, a possible intervention is to remove the chicks from the nest, feed them for a period of time, and then replace them in the nest. Reportedly Igor Berkunsky of World Parrot Trust has used this technique with a nest of blue-throated macaws (*Ara glaucogularis*) in Bolivia and has found that by feeding a third chick for up to a week he was able to replace it to be successfully fledged by the parents. More details are needed on this work. Avicultural experience, however, suggests at least some parents might not accept the chick back once it was removed if it were old enough to have developed individual characteristics. In addition, as Darrel Styles related, avicultural experience indicates that chicks that have their eyes open do not transition easily from being parent-fed to being hand-fed by a human or vice versa. Very young Puerto Rican Parrot (*Amazona vittata*) chicks have been removed from a wild nest, hand fed (and treated for medical problems) and replaced successfully. If this intervention were considered, an experimental phase should precede any attempt to do this on a larger scale. In addition, providing proper housing conditions (e.g., sufficient warmth) and feeding frequencies, particularly for young chicks, would have to be arranged. Furthermore, an ARCAS participant remarked that a captive-hatched chick removed from the nest and fed smooth, easily digested handfeeding formula later died from crop impaction after being replaced in the nest and fed coarser chunks of adult diet by its parents. This suggests care may need to be taken when transitioning from a diet of one consistency to another, particularly from a smooth, easily digested diet to a coarser and less pre-processed one.

Rearing chicks for replacement at fledging: If the adults will not accept a chick back into the nest, one potential intervention would be to hand feed it and replace it just before fledging. Potentially, captive raised chicks ready to fledge could also be used. WCS field workers reported they did this with one orphaned chick and the wild pair did accept it and mentor it. Again, proper conditions for rearing removed chicks would have to be provided and techniques for getting a previously parent-fed chick to accept human feeding would need to be developed. Since a newly fledged youngster is completely dependent upon its parents for feeding for a period of time after fledging and then dependent upon them for instruction for an even longer time, an experimental phase to evaluate this intervention concept would need to be performed before it could be deemed feasible, with field personnel around to rescue the fledgling if it were ignored by the adults. Since success might depend upon the proclivities of an individual pair, human intervention to rescue an ignored chick may be necessary each time this was attempted with a new pair of adults. If feasible, this intervention could be implemented with a chick unrelated to the adult pair.

Releasing juveniles at fledging at a wild nest: As opposed to releasing a fledgling at a nest fledging young, this technique, termed “precision release” by Dr Thomas White of the Puerto Rican Parrot Recovery Project, involves release of one or two juveniles aged one to several years at the site of a fledging nest. The released birds would be properly conditioned and the limited flight ability of the fledglings would allow the new birds an opportunity to become a part of a small family group. Either captive hatched or rescued wild chicks could be used. This technique is covered in Section 10 under population augmentation techniques.

Double-clutching: A clutch of eggs could be pulled to encourage females to re-lay, and the pulled clutch could be incubated and reared for release. Even quite young chicks could be removed. According to well-known, experienced aviculturist Rick Jordan, “when the hen is mature, usually a second clutch will be laid to replace a lost clutch of eggs or "young" chicks. But if the parents were tending to the young for, let’s say more than 21 days, the hen's hormones will have changed and she will no longer be in breeding condition and will not lay another clutch. So, it is a matter of age, and even a little bit of genetics. We find that hens that lay multiple clutches produce daughters that do the same.” Double clutching is a standard technique in captivity and has been used successfully *in situ* with other bird species, but it was felt to be possibly problematic because of the narrow time frames of opportunity and the frequency with which WCS field personnel are able to check nests, and because macaws also are more likely to abandon nest sites after failure. Eggs would have to be translocated within a day or so of laying and before significant incubation had occurred in order to preserve the viability of the embryo. In the case of removing chicks, all chicks would have to be removed at a time when the hen’s hormone status would still cause her to relay.

Fostering chicks: Captive produced chicks could be fostered into wild nests that had failed or possessed only one chick, or third chicks from wild nests could be placed into single chick nests. The technique is used successfully by the Puerto Rican Parrot Recovery Project to increase the number of wild-fledged chicks, and it has been used with other bird species. There was some discussion about at what age adults would accept chicks into the nest, and at what ages captive produced chicks would accept feeding by parents. Avicultural experience suggests the transition from hand-feeding to parent-feeding is easier with young chicks whose eyes are not open, but using parent fed chicks would be advisable. Chicks with eyes open should have been parent-fed while in captivity; however, with Puerto Rican parrot chicks, once the chicks had developed individually distinguishable characteristics, there was a greater chance of rejection by the adults. Hence younger chicks would be preferable to older. Introduced chicks should be comparable in age/development to the existing chick to avoid issues in competition for feeding.

While fostering would be predicted to work a significant percentage of the time, particularly with younger chicks, a number of complicating factors would need to be weighed before implementing this intervention. First, timing would have to right: the introduced chick would need to be comparable in age to any resident chick and would preferably be quite young. If a chick were to be introduced into a failed nest, it probably would need to be done immediately or infertile eggs removed around expected hatch date and replaced with a young chick or ready to hatch egg. Second, most macaw pairs would be unlikely to raise more than two chicks, so the number of additional chicks that could be introduced into the population would be limited. In addition, it was pointed out that the bacterial flora varies even from nest to nest and that chicks placed in a new environment might not have the proper immunity to thrive. It could also potentially promote spread of disease, although if the parent birds had been tested and certified disease free, this issue would not arise. This approach has been successful with an Amazon species, so it is an intervention that has some history of success with psittacines. Implementing this might be most valuable as a research effort to prove the concept in *Ara* species.

Fostering eggs: Captive-laid eggs could be placed in wild nests or translocated from one nest to another. However, moving eggs would need to be done within 48 hours of laying and before incubation or just as the chick is ready to hatch, since moving at any other time is likely to disrupt developing blood vessels and kill the embryo. Transported eggs need to be protected from shocks and kept warm. Aviculturists in the United States have transported eggs within hollowed out loaves of bread. Timing would be critical, as chicks need to be comparable in age (within 2 days) in order to compete successfully for feeding. Again, the value of the number of individuals added to the population would need to be weighed against the level of effort before considering this intervention unless it were conducted as an experiment to prove the concept in a wild *Ara* species.

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10.0 SCARLET MACAW REINTRODUCTION, RELEASE AND POPULATION MANAGEMENT

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10.1 Introduction

Due to the busy workshop schedule and the enthusiastic discussions during each session, the important topics of scarlet macaw reintroduction, release, population augmentation, and the general topic of macaw population management could only be addressed for a few hours during the afternoon of the last day, Saturday March 14th. This chapter summarizes the information discussed that afternoon as well as information presented on Monday evening March 10th by Darrel Styles on the "Physical, Social, and Psychological Preparation of Scarlet Macaws for Reintroduction" and by Donald Brightsmith in his "Review of Three Scarlet Macaw Reintroduction Programs." Both of these presentations are based upon published works that are referenced at the end in the Literature Cited section.

A note on terminology: We use the term "reintroduction" for releasing macaws or other species into an environment were they are not found. We use the term "release" to mean releasing them into an environment where members of that species exist. We also use "release" as a generic term for freeing captive birds into the environment. Population augmentation refers to releasing members of a species into the wild specifically to increase, or augment, the existing population.

10.2 Natural Psittacine Behaviors and Implications for Captive Breeding and Release Projects

Breeding Strategies and Behavioral Implications: In his Monday evening presentation, Darrel Styles discussed the two general breeding strategies of animals and how these strategies impact their natural behavior. This discussion was important for explaining some of the inherent characteristics of psittacines that strongly impact successful captive breeding and release techniques. Much of this section is taken from his presentation and published proceedings article.

The two extremes of these breeding strategies are the K-strategists and the R-strategists. K-strategists are those animals that have low reproductive rates, long parental contact periods, and many of the survival behaviors are learned from the parents or group. Macaws are an example of K-strategists. The K-strategists rely on intelligence and learning to ensure survival of their offspring (genes). K-strategists usually demonstrate strong pair-bonding; there is little promiscuous behavior and long-term bonds are common. This means in captivity that K-strategists should be allowed to self-select mates and cannot easily be force-paired. R-strategists have high reproductive rates, short or no parental contact periods, and survival skills are predominately instinctive or innate. The R-strategists are highly promiscuous and rely on sheer numbers of offspring produced to ensure survival of their genes. Selection of mating partners is more capricious and opportunistic. Budgerigars tend towards being R-strategists. An entire spectrum exists between the K and R strategies and many species fall somewhere in-between, but macaws are definitely K-strategists.

Darrel Styles also described the resulting types of intraspecific dynamics that provide the socialization of members of most psittacine species. The majority of parrot species are highly social creatures that live in flocks or enlarged family groups outside of the breeding season. Sexually immature juveniles live entirely in a flock until they reach reproductive age and select a mate. During the breeding season, sexually mature pairs separate from the flock to reproduce and are aggressive towards other members of their species. After fledging, chicks either join the parental flock or choose a new flock, which helps to promote genetic diversity of the species. In the wild, K-strategist species require an extended learning period to learn both social and survival skills, and it is within the flock that the juveniles learn these skills. R-strategists innately possess much of the necessary knowledge required for successful reproduction and survival. While K-strategist species may have some innate social and survival skills, it seems that most of the knowledge needed for survival, proper social interaction, and reproduction is gained during the formative learning period after weaning and up to the onset of sexual maturity.

Not understanding the differences between these breeding strategies and the behavioral consequences has led to many misapprehensions regarding captive breeding macaws and other psittacines, socializing them, and successfully releasing them into the wild environment. As mentioned previously, K-strategists form strong pair bonds and breeding is typically more successful if the birds are allowed to select their own mates. It is also more natural for pairs to be alone during the breeding season but then in larger multi-age flocks during the non-breeding season. While macaw pair bonds are usually strong, “divorces” do happen and natural re-pairing usually leads to better breeding success. These tendencies suggest that in captivity, breeding pairs should be isolated in breeding cages during the breeding season during which time they would be aggressive towards other members of their species anyway. In the non-breeding season, they should live in mixed-age groups.

Chick Rearing Strategies in Captivity: Since rearing macaw chicks in captivity – either from captive breeding or from rearing confiscated wild-hatched chicks – is one of the strategies proposed in Guatemala and elsewhere for producing birds for release into the wild, Dr. Styles discussed the four types of chick rearing approaches in captivity. They include 1) complete parent rearing; 2) partial parent rearing with hand feeding to weaning; 3) co-parenting and 4) artificial or foster incubation with complete hand-feeding to weaning.

Complete parent-rearing appears to be one of the better approaches for producing reliable breeders provided that the birds reach sexual maturity in the context of an avian flock. One overlooked aspect of parent rearing is the potential importance of vocalization and recognition of vocal patterns specific for that particular species. This may be critical for flock cohesion and recognition of groups because a local “dialect” is used for identification and communication among family groups. In addition, parent-rearing may provide training in other subtle, non-vocal, species-specific behaviors (“body language”) that may have significant adaptive value for birds released where they interact with wild conspecifics. Parent-rearing may be more important for some species compared to others, but further work needs to be done to establish how important this parent-contact and communication may be in various parrot species. Optimally, chicks should be allowed to fledge in the breeding aviary and remain with the parents for some period of time at least until they are well on their own, are physically coordinated, and can fly well. If left too long, however, the adults are likely to become aggressive towards the juveniles as the next breeding season approaches.

Partial parent-rearing with hand-feeding to weaning is a common approach in aviculture. The chicks are removed from the nest at 10-18 days of age depending on the species, just prior to the eye-slits opening and the chicks are hand reared to weaning. The chicks produced in this manner are usually healthier and more robust than parent-reared chicks due to a variety of factors. This approach may also allow the pair to produce another clutch, but again, care must be taken to avoid overproduction. Problems associated with this approach mainly deal with preventing diseases from entering the nursery.

If birds are to be hand-fed, the aviculturist needs to ensure the proper social as well as nutritional care of the chick. Chicks should be kept in groups preferably by related clutch or species of similar size and age. Housing chicks of disparate sizes or ages together does not work well.. Chicks held in clutches display more vigorous feeding responses, benefit from the thermostasis provided by other chicks' bodies, and seem socially better adjusted as they approach weaning. This "clutch mentality" seems to be one of the first social interactions learned by the neonate. Chicks reared in isolation may not perform as well or readily adapt to new social situations and environments compared to chicks reared in clutches. Good nutrition can be provided by using one of the many commercial hand rearing formulas. Since macaws need relatively high levels of dietary fat, commercial macaw hand rearing formula should be used for them. If only parrot hand rearing formula is available, some peanut butter should be added to the diet to provide fat. There is no need to conceal the fact that a human is doing the feeding, such as by using puppets or masks.

Incubator-hatching followed by hand-rearing to weaning permits the aviculturist to control the entire process and may be particularly useful for birds who have papillomas (thus infected with herpes virus) or who consistently break eggs or kill or mutilate chicks. Incubation can be accomplished by natural means, such as fostering the eggs under reliable brooding hens, or artificial means like commercial incubators. Natural incubation has a higher hatch-rate than artificial incubation. While an extremely labor-intensive process, hand-feeding from day one helps to prevent the entry of infectious disease into the nursery and permits multiple clutching from the same pair, but there is also significantly higher mortality. Partially parent-reared and incubated and hand-reared chicks should not be placed together until after weaning. Incubator hatched and hand reared chicks are immunologically naïve compared with parent reared chicks. The two populations should be housed and handled separately and never mixed until the chicks have weaned.

Co-parenting is a relatively new approach intended to develop birds that may be used successfully both for pets and for breeding. The chicks are fed in the nest by the breeding pair and the chicks are removed from the nest box and handled daily to accustom them to humans. The chicks may also be given some supplemental feeding. Rearing pet birds was not the focus of the workshop, so this approach will not be further discussed here.

Socialization of Captive Macaws: Once chicks have fledged and are well coordinated and eating well on their own, or at the end of the breeding season, the approach most likely to promote proper socialization and psychological well-being of all the birds is to put the fledglings into mixed age "neutral" flight cages to simulate the flocking that takes place in the non-breeding season. Chicks destined for release into the wild should probably be kept at all times only with members of the same species to prevent any potential species-confusion that could interfere with mate selection and breeding or that could lead to hybridization. The mixed age composition could include non-paired adults, parents and other bonded pairs, juveniles from earlier years, and recently fledged chicks, depending upon the size of the flight cage. At least a few adult breeding age birds should be included. It is important, however, that the birds be introduced together into a neutral flight cage and not one where there are already resident birds who may object to the "invasion" of strangers. In addition, birds that may exhibit unusual (to another bird) behavior such as former pets or fledglings should be observed to ensure they are not picked on or prevented from feeding by other birds. If this is a persistent problem, the subordinate birds may have to be removed and put in a flight cage with less aggressive birds.

Spending time in socialization flight cages may in time re-educate former pets to where they could become successful breeders or potentially be released, particularly as part of a "semi-wild release" described in section 10.5 below. However, former pets may display abnormal behaviors that could adversely impact the socialization of fledglings destined for release, so socialization of former pets should probably not take place in flight cages containing fledglings (Thomas White, pers. com.). They should be socialized in flight cages containing well-adjusted older pre-adults and adults, particularly some wild caught birds..

All this information needs to be taken into account in developing a captive breeding and release program for scarlet macaws. The program should have breeding flight cages and also socialization flight cages and flocking cages for release cohorts. Fledglings are not suitable for release into the wild. Fledglings and other juveniles should be socialized in flocks containing a variety of ages, particularly well-adjusted older birds and wild-caught adults. They should be allowed to select their own mates if they are to be used as breeders. Sexually mature birds may be released in the non-breeding season, but may be less flexible than younger birds. The optimum age for releasing scarlet macaws is likely to be about 1 to 3 or 4 years of age, since they will begin evidencing serious breeding behavior shortly thereafter. Bonded pairs should be released together. Older wild caught birds and active, inquisitive older birds who are in good physical condition, are familiar with wild foods, and who are well integrated into a release flock are also likely to be suitable release candidates.

Soft Release/Reintroduction Strategies: Three release/reintroduction options are discussed in the following parts of this chapter. The first is the classic reintroduction/release approach where captive-raised young birds (including birds taken from wild nests as chicks and raised in captivity) are released as pre-adults from a pre-release cage at the desired location. Only a "soft release" approach should be used, where the released birds are acclimated to the site in a pre-release cage and are provided supplemental food after release. The second is an approach termed "precision release" where a pre-adult is released at the site of a nest where juveniles are fledging (recently introduced by Thomas White, Puerto Rican Parrot Recovery Program). The third, "semi-wild release," is where free flying, somewhat human-habituated and perhaps somewhat human-dependant birds are released to fly free in protected human-modified and human-occupied landscapes, allowing pairs to breed and possibly raise young that develop without significant human interaction and are not so human dependant.

The last topic discussed is that of managing populations of macaws or other psittacine species in human modified environments where free flying populations would not be likely to persist if human management actions were not undertaken.

10.3 Soft-Release of Groups

Both “hard” and “soft” release protocols have been used for releasing animals into the wild. The choice of protocol may well influence whether the released animals survive, so this is a serious issue. In a hard release, the animals are transported to the release location and released directly into the wild. A soft release is a more conservative approach in which the animals are kept in an on-site acclimation cage for a period of time and provided food and water. Wild conspecifics may visit the acclimation cage and provide the beginnings of social groupings. Typically the animals are provided some period of supplemental feeding after release. For animals as dependent upon learning and flock membership for survival as psittacines, only soft release protocols should be used, even for translocations of wild caught birds.

The purpose of a soft release of a group of scarlet macaws or of other parrot species could be to establish a new population in an area or to increase the number of individuals in an already existing population. In some cases, the purpose of a release could be to liberate previously confiscated individuals into a suitable location. A release could also be done to increase the level of genetic variability in an existing population. Lack of genetic diversity does not appear to be a problem in the Petén. In the case of El Salvador, scarlet macaws have been extirpated and a release would be a true reintroduction. However, due to the widespread human population impact, it is not clear that a reintroduction into the “wild” would be successful there and other approaches may need to be considered (e.g., see section 10.5). The discussion regarding the WCS-Guatemala monitoring sites (Chapter 6) resulted in participants concluding that, if a release of macaws were to be conducted in the Petén, the El Perú site is the first choice, at least initially, because of the presence of the WCS monitors and security personnel to help protect the birds from hostile human interference. However, it was noted by Brightsmith that the disease risks of releasing birds in areas with relatively large populations are greater than when conducting releases in areas partially or wholly depopulated.

Scarlet macaw biology is very seasonal in the El Perú area (and the other monitored areas). The macaws are not year-round residents. Their presence in the monitored areas is presumably due to the food resources that become available in those locations during the macaw breeding season and because of the availability of nest sites. The birds return to the areas for nest site selection and defense in December. Eggs are laid February through April and fledging occurs May through July, with most clutches being laid in February and most fledging taking place in May. Later clutches represent replacement clutches for eggs or chicks that die or are predated. The fledglings and parents leave the area in September, presumably because food resources in the area decline. A release of scarlet macaws in one of the monitored areas will have to take into account that food resources decline as the rainy season arrives and progresses, and from about

September through November there may be insufficient food for scarlet macaws. Either the released birds need to have been assimilated into the wild population sufficiently that they migrate out of the area with the wild birds or else supplemental food may need to be supplied not only when they are first released but also for the months until food resources are again available and the wild birds return. Alternatively, the released birds that do not migrate could be recaptured and considered for release again in a later year.

The seasonality of the scarlet macaw biology in the Petén suggests a timetable for the process of captive breeding and then juvenile bird preparation, acclimatization, and release that is described below.

Preparation and Selection of Release Candidates: Chicks that fledge from captive parents should remain with their parents for one to several months. Then they should be moved to a large mentoring and socialization flight cage that includes fledglings, release candidates, older birds, and possibly even the parents and non-breeding pairs. Fledglings should be observed to make sure they are not picked on by other birds. If they are, they should be moved to a "halfway house" flight cage to mature with a few selected non-aggressive older birds for a few months. (Any birds that are persistently picked on should be permanently removed from consideration for release). Parents and other breeding birds may instead be flocked separately in the non-breeding season, possibly along with a few other breeding age birds.

In about December, captive breeding pairs in the Petén area should be returned to their breeding cages, and any release candidates for the coming year should be selected and placed together in a flocking cage. The size of the flock will depend upon the size of the *in situ* pre-release cage at the release location, but Don Brightsmith's study indicated larger flocks are better, particularly for a reintroduction into an area without resident members of the same species. Realistic and acceptable flock size ranges are likely to be about 6 to 16 macaws. A larger number of birds would require a very expensive pre-release cage, taking up funds that might be better used elsewhere. Releases of smaller numbers of birds should only take place if wild macaws frequently visit the cage during acclimization so that immediate assimilation into the wild flock is assured. Equal numbers of males and females are probably advisable but may not be required for release into an already existing population. It may be advisable to have a few extra "alternates" in the cage in case one or two individuals need to be removed.

Once release candidates are selected and put into the flocking cage, they should not have contact with other birds (especially poultry). As long as adequate disease testing is performed, the juveniles for release could come from multiple suitable scarlet macaw sources; for example, from both Aviarios Mariana and from ARCAS. No contact with any other birds is essential once the first round of disease testing is performed (see below). Diet should be an adequate and well-balanced diet that can be replicated initially at the release site, plus as many wild foods as possible. The birds should be observed in the flight cage to insure the flock members show ability to manipulate wild foods, physical agility, and a sense of flock membership. Any birds not adapting well or that appear ill should be removed and evaluated. The flock should remain together for at least several months, say until April for release into a site in the Petén in mid-May or June.

Prevention of Disease Introduction: See Chapter 8 on disease issues for testing recommendations. Because domestic poultry can carry disease, untested poultry should be kept away from birds to be released. Two rounds of disease testing separated by at least one month are recommended, plus a general hands-on examination by a veterinarian, preferably an avian veterinarian. Negative PCR test results for polyoma, Pacheco's (psittacine herpes), and Chlamydophila psittaci should be required. If the source facility has any non-Neotropical birds (e.g., cockatoos), then tests for psittacine beak and feather disease (PBFD) should also be done. Other tests may be required by local authorities or felt advisable by members or advisors of a project.

Move to Release Site: The birds need to be visually healthy, eating well, flying well, socializing well with other group members, with no behavioral or physical abnormalities. A checkup by an avian vet is recommended. Transport the birds in carrying cages to the pre-release flight about 6 weeks to two months before date of intended release. In the Petén that would mean transport in April for a release in mid-May or June.

Pre-release Flight Cage: The cage should be constructed at the location of the release on flat ground in an open area that preferably has no overhanging vegetation nearby that predators could use to get on top of cage. The flight size and design will depend upon finances available. A size approximately 12 m long, 5 m wide, 3 m high is a suggestion for about 10 – 12 birds. A release door should be constructed either on the roof or in the upper part of one of the sides. Meter-high metal sheeting with an overhang could be installed along the bottom of the cage to dissuade ground predators. Some sort of roofing material should cover part of the cage to afford protection from sun and rain. A natural dirt floor is adequate.

Outside Feeding Station: A feeding station should be constructed outside the cage within sight of the macaws in the cage. One design is to have the feeding station built into a side of the pre-release cage so that the same feeding station could be used before and after release and possibly even be used as a trap if a bird needs to be recaptured. Alternatively, the feeding station could be located not far from the door from which the macaws will be released Beginning a few days before the release is to take place, food should begin to be placed on the feeding station in sight of the macaws. However it is constructed, the outside feeding station should resemble the feeding station used inside the cage for the weeks before release.

Security: Security will need to be provided for the 6 – 8 weeks during which the birds are in the pre-release cage. One option is to have the cage located near the camp where macaw monitors sleep and to have one or two guard dogs around the cage at night. Another option is to build a small sleeping area for a night monitor. Use of one or two guard dogs still should be considered to alert the monitor to possible predators.

Care and Feeding: The birds should first be given the basic well-balanced diet they were used to in the flocking cage, but they should also immediately be presented with wild foods in as natural a state as possible (e.g., on branches hanging from some sort of stand). Careful consideration should be given to the design of the feeding station inside the cage. It should be similar to the feeding station outside of the cage. One option is to have the feeding station built into a side of the pre-release cage so that the same station can be used before and after release and possibly even be used as a trap if a bird needs to be recaptured. Over about a month the birds should be shifted to a diet consisting of significant quantities of natural foods but with sufficient amounts of the basic balanced diet to ensure good nutritional status. A macaw monitor should observe the macaws to make sure all are adapting to the wild foods and to the new environment. Any bird that doesn't adapt well or that behaves oddly or is injured should be evaluated to decide if it is suitable for release or not.

Anti-predator Training: There are three species of hawk eagles in the Petén that may be macaw predators, but there are no known reports of actual predation. In the case of smaller birds such as *Amazona* species, the possibility of anti-predator training should be considered. As an example, the Puerto Rican Parrot Recovery Program has developed fairly successful predator avoidance training for their *Amazona* species, *A. vittata*, against red-tailed hawks, *Buteo jamaicensis*. This program should be consulted if there is a desire to institute anti-predator training.

Evaluation and Preparation for Release: After 6 – 8 weeks the birds should be evaluated and prepared for release. Criteria for suitability for release include: (1) all birds socializing well with each other; (2) all birds manipulating and feeding well on wild foods; (3) a sustained flight capability, especially along the length of the cage; (4) no obvious health problems, and optimally (5) visits by resident wild macaws (if not a reintroduction) and vocalizations back and forth between wild and caged macaws. While not mandatory, if wild macaws are in the area this should occur because of the social nature of the birds. If interaction does not occur, the situation is odd, and the release situation should be re-evaluated. Is it still too early in the breeding season for chicks to have fledged? Have the wild macaws already migrated out of the area? Is a release still advisable? A final deworming is recommended. For temporary marking, plastic leg bands may be put on the birds or marks made on tail feathers with magic markers, etc. If any radio or satellite transmitters are to be used, they should be put on the birds several weeks to a month before release and the collared birds observed for adequate adaptation. It may be preferable to use dummy units rather than live transmitters to preserve battery power, and the mockups could be slightly heavier than the actual units. Replacement with actual telemetry units could take place during the final health check and deworming. A few days before release, a regular schedule of placing food on the outside feeding station(s) in sight of the caged macaws should bgin. The regular schedule of placing fresh food out should continue until the released birds have left the area with the wild birds or until they no longer return to the feeding station. This may require providing food for the released macaws for a time period of several months up to a year.

Release: Before or at dawn[*] and as unobtrusively as possible, the door to the outside should be opened and then left open, allowing the birds to go in and out as they wish for 3-4 weeks. By that time the macaws should have joined the wild flock and no longer use the pre-release cage or feeding station for any significant period of time. Any bird that spends a large amount of time in or on the cage or at the feeding station should be re-evaluated for suitability for release. Fresh food should be provided on a regular schedule in the outside feeding station(s) until the birds no longer depend upon the supplemental food for significant nutrition. Attempts should be made to recapture any bird that does not migrate with the wild birds in September or that does not seem

[*] Opening of release door at dawn suggested by Thomas White of Puerto Rican Parrot Recovery Project based upon their successful experience. As the birds become active as daylight increases, they begin to exit the cage as they notice the door is open.

to be adapting well. If it is hanging around the feeding station, attempts can be made to lure it back into the pre-release cage with food, or trap it at the feeding station if it has been so designed.

Modifications and customization of these guidelines will be needed for specific projects and as experience is gained. Consideration should also be given to using a similar protocol for the release of other psittacine species, particularly ones that have been confiscated as chicks and raised by humans.

Thomas White, Jr., of the Puerto Rican Parrot Recovery Program made a valuable comment that should be kept in mind: “The process of converting captive-reared birds to truly wild birds can be a multigenerational process. Don’t expect the first ‘pioneers’ of a reintroduced population to simply “go wild” just because they’re free. If you have to keep giving them supplemental food and cozy nest boxes for the first few years, then so be it. It may actually be the second, even third, generation of fledglings that really become the truly wild birds. Above all…BE PATIENT!”

10.4 Precision Release of Small Numbers

This technique involves releasing one or more young birds (1 to 3 years old) adjacent to a nest that has fledged at least one youngster within a day or two beforehand. The newly fledged juveniles cannot fly very well, so they remain in a localized area for several days and are attended by their parents. This means there are "mentor birds" of the same species for the newly released birds to associate with and learn behaviors from. Because their chicks have fledged, the adult parents are no longer defensive of the nest cavity nor aggressive towards new birds. This technique has recently (2008) been used successfully for Puerto Rican parrots (Thomas White pers. com.).

The released bird or birds need to be fully prepared for release, meaning they need to have been in a large flight with other birds so that they are socially competent and have good flying skills. They need to have been presented with the same type of wild food as they will find at the release site. They need to have been fully checked out for disease issues. And they need to be juveniles no older than one or two or perhaps three years of age so they do not cause the wild parents to have aggression issues towards strange adult macaws. The hard release version may be done by just bringing the new birds in carriers from where they had been living and opening the carrier doors and allowing them to fly out when the adults and fledglings are in the immediate vicinity. A softer version of this would involve having the birds to be released reside for a few days in a small portable flight so that the wild and captive macaws can become familiar with each others’ presence through vocalizations and sight. Again, the door to the small flight would be opened unobtrusively when wild macaws are in the immediate vicinity.

There are advantages to considering use of this technique when adding new individuals into an already existing breeding population, but there are also caveats. A major advantage is that it is cheaper than the soft release approach described in section 10.3. There is no need for a large pre-release flight and several months of care. It can be done with smaller number of birds because the new birds are being introduced into a pre-existing group of wild birds (the parents and chicks), so there is no longer the need to release a flock of a dozen or more. On the other hand, only one or several birds could be released at any one time and it may be difficult to know if the wild fledglings are actually nearby. Myers and Vaughn (2004) found in their study of newly fledged scarlet macaws in Costa Rica that for the first 1 – 12 days the fledglings remained within about 1 km of their nest sites, although the exact distances were quite variable. Several fledglings spent seven days within 250 m of their nest tree, while another fledgling flew 3 km away on day four with its parents but then returned the next day with its parents to its sibling that had remained closer to the nest.. This technique has never been tried with scarlet macaws so there is no guarantee it would work as well as it seems to for Puerto Rican parrots, a completely different genus.

An experimental protocol for attempting a precision release with scarlet macaws is outlined below. At least the first few times such a release is attempted, consideration should be given to tagging wild chicks before fledging and the juvenile release birds with radio telemetry collars such as the Holohil AI-2C and tracking them to see if the release birds integrate with the wild family. Argos satellite collars probably would not give frequent enough positions nor would the positions be of sufficient accuracy.

Identify and Prepare Release Candidates: Use similar techniques and criteria as for the soft release protocol described in section 10.3.

Locate Wild Nests and Prepare for Release: Identify and observe one or more successful wild nests in the release area. As soon as the last wild chick seems likely to fledge in a few days, transport one or several of the release birds to the release site. Place in a small portable flight cage unless the chick has fledged. If it has, either release the new macaw from the carrying cage or, alternatively, place in the portable flight cage for one or several days, observing if the wild and captive birds vocalize to one another.

Release: As soon as the last wild chick fledges and assuming parents and chick(s) are in the vicinity, unobtrusively open the cage door and allow the release bird(s) to leave on their own.

Monitoring: Observe the wild and released birds for a few days or more to see how well the released birds adapt to the area, how well they forage, and how well they interact with the wild birds. In case of poor adaptation, attempt to recapture the captive-raised birds, perhaps by using a favorite food such as peanuts as bait.

10.5 Semi-Wild Release

The concept of "semi-wild release" may be the only way some species can persist or be re-introduced into human modified and occupied landscapes. It can be considered a version of a standard soft release protocol adapted to the specific conditions of a highly human-modified landscape that necessitates on-going management of the released population. In a semi-wild release, the members of the target species – scarlet macaws, in our case - are released into a safe site and encouraged or trained to use a safe location as a home base while being free to range elsewhere in the landscape as they desire. This is effectively done in New Zealand where native birds and other animals have been released into locations surrounded by anti-predator fencing or onto islands from which introduced predators have been removed. The kakapo is an example of a species that would have gone extinct if it were not for the, at the time controversial, initiative to capture and relocate all known members of the species from the mainland onto the four islands of Maud, Hauturu/Little Barrier, Codfish and Mana. It also has been effectively done by an unknown number of small organizations such as Asociación Amigos de las Aves in Costa Rica and Corporación DINANT on Isla Zacate Grande (Gulf of Fonseca) in Honduras (discussed in chapter 4).

In a semi-wild release, birds are released into a site, whether small or large, and then continuously managed through provision of safe roosting sites, perhaps provision of nest boxes, and possibly long term provision of supplemental food or planting of food plants. Recall training may be used, at least initially, to keep the birds around the safe location. Alternatively, the birds can be trained to return to a feeding station by teaching them to associate some sound such as a whistle with the provision of food, as was done in the echo parakeet project on Mauritius. (Woolaver et al. 2000). This type of release can be considered for an environment where human occupation is widespread and the associated poaching, hunting, or continued habitat modification pressures are so great that completely unmanaged populations of birds cannot persist. For example, a private landholder could introduce scarlet macaws into his lands but take measures to keep them coming back to his secure property for breeding and perhaps feeding and roosting. A landholder did this in Costa Rica with about eighteen captive raised scarlet macaws. His property is located across the Tempisque River from Palo Verde National Park, but the park suffers from considerable poaching pressure. He provides nesting boxes on his land as well as mature and young food trees. The released birds interact with the small population of macaws in Palo Verde but do much of their nesting in nest boxes on his property.

Another example is a large Costa Rican resort hotel that wishes to offer “eco-adventure” experiences. They have purchased large areas of surrounding land and are reforesting some of it, including with native shrubs and trees that provide food for scarlet macaws (as well as other birds and mammals). They are attempting to get permission from the government to release captive-bred macaws on the property. They already have a collection of macaws and have set some up for breeding.

Sound protocols for successfully implementing this approach in the various conditions that will be encountered in the real world have not been defined for macaws and other psittacines, nor most likely for most other avian species or other taxa. The birds to be released should certainly be examined and tested to insure health and minimal risk of introduction of disease to related species. They should be properly conditioned. Some practitioners have declared that the birds should not be conditioned in large flight cages so that when they are released they are not able initially to range too widely and become lost. Others might disagree. Alternatively, forms of recall training can be used to keep the birds from wandering off and getting lost until they are familiar with the surroundings. As with releases into the wild, the released birds should be provided with supplemental food at one or more feeding stations. Conditions might be such that they will need to be provided with supplemental food permanently, for reasons that might range from wanting to encourage them to remain in the safe area to insufficient wild foods for breeding or even adult maintenance. See Woolever et al. (2000) for a description of the many management interventions used for the echo parakeet. Supplemental foods are provided to female kakapos to increase breeding success and small amounts of a favorite supplemental food (sunflower seeds) have been provided at sites in Costa Rica to encourage released scarlet macaws to remain in the release area. Another intervention that may be required in human modified habitats may be providing artificial nesting sites, since large trees with natural cavities may be scarce (all three projects described in Brightsmith, et al. 2005 provided artificial nest boxes).

This may – or may not – be the optimal approach for reintroducing scarlet macaws under the conditions in El Salvador (see Chapter 4). SalvaNATURA biologists will have to determine that. Considerable reflection, debate and experimentation will be needed before the appropriate situations and appropriate protocols for semi-wild releases can be set down. However, as truly wild places distant from human threats and human-associated predators such as feral cats and rats become more and more rare, the semi-wild release approach and the continued management of otherwise wild populations (see next section) may be the only way for some species to persist in such modified habitats.

10.6 Managed Populations

Because of human population pressure and attendant problems such as feral cats, habitat destruction, unbalanced ecological conditions, lack of nesting sites, and so on, some populations of birds, including macaws and other psittacines, may only continue to persist if they are managed. This is certainly the case with many other species in worldwide human-modified landscapes, e.g., provision of hay to bison and elk during winters in the United States. Some management measures may need to be continued indefinitely if the program is to be ultimately successful, so this should be taken into account before deciding to invest resources in a program. A number of management measures are described below. However, along with species management, environmental education to create more environmentally friendly attitudes and better enforcement of laws are very important. Without them, the technical management measures may only be holding actions.

- Anti-poaching measures. Just the presence of WCS-Guatemala personnel has drastically reduced poaching pressure on scarlet macaws in the Petén.
- Provision of sanctuaries surrounded Provision of sanctuaries surrounded by anti-predator fencing as is done, for example, in New Zealand and may be needed for survival of the Bahama parrot.
- Periodic treatment of nesting cavities to prevent Africanized bee infestations or high levels of parasites that reduce chick survival. For example, periodic treatment to prevent Africanized bee infestations may be required in some of the WCS monitored sites in the Petén and in locations in Bolivia where Bolivian NGO Armonía is working with blue throated macaws (*Ara glaucogularis*).
- Predator control measures may be required when predator levels are so high as to threaten the survival of the targeted population. This may be the case in the El Perú site where high population levels of forest falcons (*Micrastur spp.)* may be drastically reducing fledging rates of scarlet macaw chicks. Such control measures may be non-lethal such as modifying nest cavities or nest boxes so the falcons cannot see the chicks, or may occasionally involve lethal measures. Lethal measures and distant relocation of predators has been used in the Puerto Rican Parrot Recovery program.

- Increasing or maintaining the number of breeding sites through provision of nest boxes (e.g., for scarlet macaws in the Petén and for blue throated macaws in Bolivia), increasing the number of cliffside nesting holes (e.g., red fronted macaws in Bolivia), or targeted protection of nesting trees. The latter was attempted in Costa Rica for protecting large dipteryx trees (*Dipteryx panamensis)* used by great green macaws (*Ara ambiguus*) but the program was unable to continue the practice of paying landholders not to cut down the trees.
- Local habitat modification such as planting of additional food trees (an example is the Curú wildlife refuge in Costa Rica) or the creation of additional "forest islands" in periodically flooded landscapes in Bolivia as Armonía is considering..
- In some instances, provision of supplemental food during times of low food availability. In Brazil, Lear's macaws (*Anodorhynchus leari)* have taken to raiding farmers' cornfields to supplement their diet of Licuri palm nuts. A program has been instituted to give farmers sacks of corn to replace the corn destroyed by the macaws. This program will only be successful as long as the corn payments are continued. Some other program of providing supplemental food to the birds while increasing the availability of natural foods might have more long term impact.

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11.0 POTENTIAL FUTURE SCARLET MACAW PROGRAM ACTIVITIES IN GUATEMALA AND EL SALVADOR

This list is a set of potential activities that the scarlet macaw conservation programs in Guatemala and El Salvador may consider. The activities were generated from and inspired by the workshop discussions. In compiling the list we did not include consideration of the realities of available funding and manpower. These realities will limit and otherwise influence selection of which activities will eventually be undertaken. The activities are listed first for Guatemala and then for El Salvador.

GUATEMALA

G11.1 Conservation

- Continue efforts at habitat preservation including:
  - Fire suppression
  - Prevention of illegal colonization
  - Prevention of illegal logging
  - Prevention of illegal clearing for agriculture
- Prevention of poaching
  - Monitoring of nests to detect poaching and use of anti-poaching patrols
- Promote social support for macaw conservation
  - Environmental education with local schools
  - Employment as macaw guards at key nesting foci
  - Publicize the plight of macaws via popular articles, scientific papers, presentations
  - Ensure governmental decision makers are kept abreast of the state of macaws

G11.2 Monitoring and Applied Research

- Continue Vortex analyses
  - Look at sensitivity analysis to determine which life history parameters have the greatest potential influence over the recovery / decline of the population
    - Key life history parameters may include adult survival, chick survival post fledging, number of chicks fledged per nest, percent of the population breeding, nest predation, etc.
    - Obtain local information about these key life history parameters
    - Investigate ways to improve key life history parameters for the population
  - Review previous analyses periodically to evaluate precision and adjust based on lessons learned
- Conduct or continue annual population censuses
  - Develop standardized protocols for estimating annual indices of abundance or population census
    - Conduct annual active nest counts at key nesting foci based on verified reproductive activity (i.e. number of verified breeding pairs)
    - Monitor the number of successful fledges produced annually
    - Monitor the number of management units with active nests
    - Emergent point count population monitoring techniques (i.e. tower counts)

        - Develop standardized data collection: how often, for how long, what time of day, what observations to record to
        - Objectives:
            - Determine population structure (based on group size) and numbers of individuals
            - Determine changes in population structure and numbers over time
        - Enlist volunteers in data collection

- Summarize and analyze data from previous years of the project
    - Data to be summarized include:
        - Annual number of active nests per region
        - Nest monitoring (date and nest contents of each check)
            - Number of eggs or chicks, estimated egg/chick age, numbers of evidence of predation events, evidence of nest competition
        - Nest characteristics (depth, width, height, tree species, number of openings, bottom substrate, evidence of habitation, presence/absence of bees or other competitors)
    - Evaluate results
        - Possible additional related data to collect in future
        - Possible publication/dissemination

- Improve artificial nestbox designs
    - Document characteristics of acceptable natural nest cavities for use in box design
    - Make new anti-predator designs (e.g., double-chambered)
    - Investigate and refine:
        - Materials
        - Mounting techniques
        - Maintenance regimes
        - Nesting substrates (i.e. natural wood detritus on nest floor)
- Continue anti-predator studies
    - Continue development and use of in-nest IR cameras to identify other possible predators and reasons for poor nesting success at El Perú
    - Consult with Ursula Valdez (Peru) on *Micrastur* behavior
    - Investigate procedures / interventions to reduce forest-falcon predation
        - Obstruction to prohibit falcon nest access (internal versus external)
        - Culling of falcons at sites with proven predation
- Study effectiveness of anti-bee treatments of cavities
    - Two possible agents: permethrin and carbaryl (Sevin)
    - Initial evaluation during non-breeding season suggested
- Joint ARCAS/WCS nest guarding program with volunteers at El Peru
- Attempt to understand reasons for decline of number of active nests at El Perú
    - Examine population indices (is it due to a declining overall population?)
    - Examine *Micrastur* abundance at comparative sites, including El Perú
    - Compare chick growth rates and nutrition to sites with higher fledging success rates in the MBR (i.e. La Corona)

- Evaluate parental feeding time bouts at El Peru, and compare to sites with higher fledging success rates (i.e. La Corona)
    - Evaluate time to cavity re-colonization by Africanized bees after treatment and compare to other sites in the MBR
    - Evaluate comparative nest parasite loads at El Peru and La Corona

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G11.3 Natural History Research

- Increase understanding of macaw habitat use
    - Document observations of foraging macaws (feeding bouts) recording food species if known, food type (fruit, flower, etc.), or collect a sample of species if unknown
    - Documentation of food resource availability through an annual phenological inventory of known food plants (particularly at El Perú to better understand the timing of suspected macaw "migrations")
    - When appropriate technology exists, continue satellite collar development to determine landscape movements and habitat use throughout the year
- Institute monitoring of chick growth and development where feasible
    - Weigh, measure (wing, and beak) and photograph wild chicks regularly
        - Allows estimation of how chick is developing and shows if birds suffer from food limitation / starvation
        - Allows comparison with captive rearing in other aviaries
        - Allows us to indirectly evaluate the diets fed to the breeding birds
        - Allows better understanding of how many chicks the adults can raise
        - Digital photos taken from the nest entrance may be useable for aging chicks and assessing development
        - Allows comparative studies of chick development as compared with work in Tambopata and in captive situations
- Diet evaluation and chick nutrition via crop sampling
    - Technique development at ARCAS with sampling at El Perú.
    - Comparison to results from Tambopata, Peru
- Collect any dead chicks and/ or adults for necropsy to determine cause of death
    - Develop protocol for field sampling
    - Identify veterinarian willing to conduct necropsies
    - Develop a protocol for necropsy
- Consider possibility and utility of banding and/or micro-chipping chicks
    - Because window of opportunity for applying closed bands is so short, open bands probably advisable
    - Microchips require special reader and must be injected under the skin
    - Bands can be cut off; microchips can't be removed
- Continue with genetic analyses of wild scarlet macaws.
    - Determine the degree of subpopulation isolation between Belize, Mexico, and Guatemala
    - Use information to adjust Vortex models, and better estimate susceptibility of the Guatemalan population

- Identify if concentrations of nests at significant nesting foci (i.e. El Perú, La Corona, El Burral) are related to family groups or share genetic affinities of some kind

G11.4 Ex-situ Management

- Conduct regular health assessments of Aviarios Mariana and ARCAS macaws
- Biosecurity analysis for ARCAS, Aviarios Marianas, and El Perú to evaluate the susceptibility to disease penetration
- Conduct genetic analyses of ARCAS birds
- Apply genetics results at both aviaries to identify most appropriate breeders

G**11.5 Population Augmentation Projects**

- Determine from Vortex modeling the potential impacts of different types of population augmentations
- Evaluate the feasibility of the different types of population augmentations (See Chapter 10 for a review of the options). Feasibility should include:
    - Cost
    - Logistics
    - Timing
    - Manpower needed vs manpower available
    - Participants
- Evaluate the risks to the natural wild populations of each population augmentation
    - Determine acceptable level of risk
    - Ensure governmental entities legally responsible for macaws are aware of risks and tradeoffs of each option
- Compare the potential impact on the population to the feasibility and risk and choose which if any population augmentation procedures to conduct
- Identify field locations for population augmentation activities. Smaller scale tests should first be conducted and evaluated under optimized conditions before larger scale and more expensive tests are conducted:
    - El Perú
        - Wild releases
        - Precision releases
    - Las Guacamayas Biological Station
        - Managed (semi-wild) releases
- Evaluate use of in-situ management options cited in Chapter 10

EL SALVADOR

ES11.1. Monitoring and Applied Research

- Evaluate potential foraging habitat for Scarlet Macaws in the project area.
    - Continue monthly tree surveys (~2000 trees) for reproductive phenology and fruit abundance.
    - Calculate extent (area) of forest by forest type (pending classification mapping by USAID-El Salvador).

- Quantify density and size distribution of tree species (on list of potential food resources) by forest type.
  - Analyze carrying capacity of habitat for Scarlet Macaws in the project area
- Assess potential impact of the reintroduction on the Yellow-naped Parrot (YNPA) population in the project area.
  - Develop methods for population status assessment and long-term population monitoring in the project area (specifically, Barra de Santiago-Santa Rita corridor and protected areas).
  - Conduct baseline population survey using new survey method, and evaluate the method.
  - Construct and erect artifical nest boxes for Yellow-naped Parrots in Barra de Santiago mangroves. The mangroves are the primary habitat for YNPAs in the project area; however, the large red mangrove (*Rhizophora mangle*) trees which provide the YNPAs primary nesting substrate have been logged out and therefore the birds are nest site-limited.
  - Conduct nest searches and monitor reproductive success of nests (natural and artificial nests).
  - Conduct health testing on wild adult YNPAs.
  - Conduct study of movements of Yellow-naped Parrots using radio-telemetry to determine if there are habitats outside the protected areas that are seasonally important for the birds. Adults captured for radio-tagging could be sampled for health evaluations.
- Continue assessment of northern Pacific coast historic and extant Scarlet Macaw populations.
  - Conduct oral histories of elders who grew up in the project area to document any recollections elders have of Scarlet Macaws in the area (required by the Ministry of the Environment) and other interesting recollections, for example, the historic landscape.
  - Conduct a field survey to estimate the size of the Cosigüina Scarlet Macaw population.
  - Support and collaborate in research and monitoring of the Cosigüina Scarlet Macaws, particularly monitoring of population size over time, reproductive success, and illegal activities (i.e. poaching, hunting).

ES11.2. Conservation/Education

- Initiate public outreach about the macaw reintroduction project. Identify key communities and audiences to target; discuss the project at annual assembly meetings or with target audiences. Including cooperatives, community-based development associations (ADESCOs), towns, and other associations such as a fishermen's association.
- Institute and support environmental education in the project area.
  - Hold a workshop with local and national educators who are directly involved in community environmental education in the project area (i.e. AMBAS @ Barra de Santiago, Santa Rita park guards, Asociación de Barra de Santiago, SalvaNATURA @ El Imposible National Park, FUNZEL, and others). The objectives of the workshop are to (1) ask each educator to present their 'program'

to the other educators, including giving a sample presentation of the type they give to schools and/or other audiences, (2) have participants (educators) exchange ideas for strengthening each other's programs, and (3) compile a list of materials or equipment that each educator would like to have to improve their program. For example, a Santa Rita park guard gives only verbal environmental education presentations to the 6 grade schools surrounding the Santa Rita protected area because they have no projector to show photos to show the kids. When I asked what he needed to improve his presentations, he told me that the kids really want to see pictures of the animals; the park has lots of digital photos but no projector or laptop to take to the schools or money to even print the photos.

  - Strengthen existing environmental education programs with or develop a program focused on a psittacine conservation component for grade schools in the project area, particularly in the vicinity of Barra de Santiago and Santa Rita protected areas.
  - Develop and hold workshops with and for the civil wildlife police officers (Policia Nacional Civil-Wildlife Department) about wildlife laws and better enforcement practices.

- Facilitate a workshop to develop a funding proposal for conservation of the Cosigüina, Nicaragua Scarlet Macaw population using the high-priority Pacific dry forest ecoregion as an added incentive for international involvement (e.g. The Nature Conservancy has major focus on conservation of this ecoregion).

- Promote programs for reforestation in project area, particularly native species that serve as food and nesting resources for Yellow-naped Parrots and Scarlet Macaws. Possibly funding from grants supporting carbon sequestration activities could be tapped.

ES11.3. *Ex-situ* Management Relative to Source of Birds for Reintroduction.

- Pursue collaboration with aviaries which breed Scarlet Macaws with the future goal of procuring young macaws from them for reintroduction (e.g. Nini de Berger/Aviarios Mariana in Guatemala).
- Evaluate the value of and (if deemed valuable) provide guidance and support for starting breeding programs at Salvadoran government and private facilities that currently have confiscated or pet Scarlet Macaws, respectively (i.e. the National Zoo, FUNZEL, Patricia Bence). Guidance and support could be in the form of hosting experts (e.g. Darrel Styles) to examine the facilities and macaws and provide recommendations for best management practices to optimize potential of breeding. It is likely that some recommendations would be related to housing of birds, for example separating a flock of birds currently in one cage into pairs of birds in breeding cages; support therefore could be for construction of breeding cages.

ES11.4. Reintroduction Strategy

- Prioritize potential reintroduction sites and site-specific strategies (given there is sufficient habitat and local public support). A site-strategy may be a remote site with an *in-situ* pre-release cage with young, well-socialized birds and minimal human presence or it may be a park/education facility with semi-tame park birds (older, captive-kept adults) encouraged to remain in the vicinity, even nest, and which require long-term maintenance. Outline comprehensive reintroduction strategy to present to the Ministry of the Environment for review and authorization to proceed with the reintroduction.

- Construct facility(ies) depending on priority site-strategy.

ES11.5. Law Enforcement

- Support the intensification of surveillance for and enforcement of illegal Scarlet Macaw traffic in La Unión, El Salvador which was determined[1] to be the major deposit of Scarlet Macaws poached or captured in the Cosigüina Volcán Nature Reserve, Cosigüina Peninsula, Nicaragua.
- Monitoring and protection of YNPA nests in Barra de Santiago and Santa Rita protected areas

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ES11.6. Promote Conservation-based Economic Activities for Communities in the Project Area

- Reforestation with ramon (*Brosimum alicastrum*), the seeds of which can be harvested for a growing international market in ramon flour and other health food products.
- Ecotourism Markets
  - Promote development of high quality artisan products with nature themes
  - Promote nature tours and nature guide training.

ES11.7. Permitting

- Obtain permits for all aspects of the research: Yellow-naped Parrot studies require national (government and CITES) permits; health testing requires export/import permits and CITES permits; reintroduction requires national and CITES permits, and if the macaws for release are from outside El Salvador, export/import permits; and working in environmental education in El Salvador requires Ministry of Education authorization.

[1] Camacho and S. Martínez. 2006. Caracterización y evaluación de seis sectores de avistamiento de lapa roja (*Ara macao*) en la Reserva Natural Volcán Cosigüina. Undergraduate thesis, Universidad Nacional Autónoma de Nicaragua UNAN, León, Nicaragua.

12.0 WORKSHOP ACCOMPLISHMENTS AND FUTURE ACTIVITIES IN GUATEMALA

The Scarlet Macaw Species Recovery Workshop held 10-15 March 2008 in Guatemala City and Flores had a number of significant accomplishments. First, the backgrounds of some of the participants made for a broad based series of discussions that resulted in a number of practical conservation approaches that are documented in this report. They included personnel from the Wildlife Conservation Society (WCS)-Guatemala (Rony Garcia, Gabriela Ponce, WCS field assistants, volunteer Merlina Barnes, and vet student Melvin Mérida; with Jose Moreira, Victor Hugo Ramos, and Roan McNab for shorter periods) who had done enough field work on scarlet macaws in the Petén to be able to give a realistic assessment of conditions on the ground. Another participant (Dr. Don Brightsmith) had 8 years of experience working with scarlet macaws in Peru and is a worldwide recognized authority on macaws. One participant (Dr. Darrel Styles) was a world-recognized avian virologist, avian veterinarian, and aviculturist. Another from WCS-New York (Dr. Bonnie Raphael) was a zoo and wild animal veterinarian with extensive experience in a variety of animal taxa. A participant from WCS-NY (Dr. Nancy Clum) was familiar with population viability analysis and one of the commonly used mathematical models, VORTEX. Two participants (Kari Schmidt and Dr. George Amato) were beginning a study to identify the different genetic subtypes of scarlet macaws so that in the future, any macaws released from any captive breeding programs would be of the same genetic subtype(s) as are found in the Selva Maya.

One theme of the workshop was assessing the possibility of captive breeding macaws and releasing them in either the Petén where a scarlet macaw population persists or reintroducing them in El Salvador where the population was extirpated a number of decades ago. Guatemala is fortunate in having two potential source populations of captive bred macaws. One is in the southwestern part of the country near the border with El Salvador (Aviarios Mariana with Workshop participants owner Nini de Berger and Aviary Manager Scott McKnight). The second is in Flores near the Petén (ARCAS Wildlife Rescue Center with participants ARCAS Director Colum Muccio, Director of the Rescue Center, Fernando Martinez, and Rescue Center veterinarian Alejandro Morales). Those two aviaries could become sources of juvenile scarlet macaws for release without too much expense. Several of the participants had prior experience in aviculture, captive breeding for release, and releasing macaws into the wild (Dr. Darrel Styles, Dr. Janice Boyd, and Dr. Don Brightsmith), and were able to guide us in developing protocols for captive breeding and for releases into the wild.

There was a significant number of participants from the branch of the Guatemalan Government responsible for preserving the country’s protected areas, CONAP or Consejo Nacional de Areas Protegidas (Kurt Duchez, Hiram Ordoñez, Julio Madrid). There were also participants from El Salvador: NGO SalvaNATURA (Dr. Robin Bjork), Parque Zoológico Nacional El Salvdor (Paola Tinetti), and a veterinarian and owner of an ecotour company (Americo Reyna).

The Workshop investigated a number of factors related to survival and recovery of the scarlet macaw population in Guatemala and by extension in Mexico and Belize. To investigate the feasibility of captive breeding of macaws for reintroduction or population augmentation, participants visited the two possible sources for captive bred juveniles and determined that, with some changes, the aviaries could be used to supply young scarlet macaws for a release program. Protocols for socializing the young birds for release and then actually releasing them under several different sets of conditions were outlined in discussions. A list of serious psittacine diseases for which testing needs to be conducted before allowing any captive-raised macaws to be released into the wild was determined. The results of 5 years of monitoring the eastern MBR scarlet macaw population by WCS-Guatemala were summarized and used for some of the parameters for population viability analysis. VORTEX modeling was conducted on the tri-national scarlet macaw population (Mexico, Guatemala, Belize) using a series of different scenarios and parameters from the WCS field programs and from the knowledge-base of the expert participants. The modeling concluded that the populations were in a precarious but not hopeless state, with the most important parameter being the percentage of reproductive age females successfully breeding. A significant level of poaching reduces this percentage to the point where the population will go extinct. So does significant reduction in habitat. Disease issues did not appear to be a significant detrimental factor on the modeled populations. Release of 6 to 18 captive-raised juvenile scarlet macaws each year for 10 years could probably help the population recover from the effects of the presumed older-age biased population distribution, but would be ineffective if poaching and loss of habitat continued. This latter conclusion is the most important finding: The tri-national Maya Biosphere Reserve scarlet macaw population can survive and thrive only if poaching and habitat destruction are reduced to insignificant levels.

A work plan for future activities in Guatemala follows. A work plan is being developed for the much more recent El Salvador initiative.

FUTURE ACTIVITIES GUATEMALA		Done in previous years?	Planned for:			Responsible			
			2009	2010	Beyond	CONAP	ARCAS	WCS	OTHER
G11.1 CONSERVATION									
Continue efforts at habitat preservation including:									
*	Suppress fire	Yes	Yes	Yes		x		x	x 1,2
*	Prevent illegal colonization	Yes	Yes	Yes		x		x	x 1,2
*	Prevent illegal logging	Yes	Yes	Yes		x		x	x 1,2
*	Prevent illegal clearing for agriculture	Yes	Yes	Yes		x		x	x 1,2
Prevention of poaching									
*	Monitor nests to detect poaching and use of anti-poaching patrols	Yes	Yes	Yes		x		x	x
Promote social support for macaw conservation									
*	Environmental education with local schools	Yes	Yes	Yes				x	
*	Environmental education with non-local schools						x		
*	Employment as macaw guards at key nesting foci	Yes	Yes	Yes		x		x	
*	Incentives program with adjacent communities linking scarlet macaw conservation to social investment								
*	Publicize the plight of macaws via popular articles, scientific papers, presentations	Yes	Yes	Yes		x	x	x	
*	Ensure governmental decision makers are kept abreast of the state of macaws	Yes	Yes	Yes		x	x	x	x 3
G11.2 MONITORING AND APPLIED RESEARCH									
Continue Vortex analyses									
*	Track life history parameters that have the greatest potential influence over the recovery / decline of the population	Yes	Yes	Yes		x	x	x	
	(a) Key life history parameters may include adult survival, chick survival post fledging, number of chicks fledged per nest, percent of the population breeding, nest predation, etc.								
	(b) Obtain local information about these key life history parameters								
	(c) Investigate ways to improve key life history parameters for the population							x	
	(d) Review previous analyses periodically to adjust the Vortex model based on lessons learned							x	
Conduct or continue annual population censuses									
*	Develop standardized protocols for estimating annual indices of abundance or population census	No	Yes	Yes				x	
*	Conduct annual active nest counts at key nesting foci based on verified reproductive activity (i.e. number of verified breeding pairs)	Yes	Yes	Yes				x	
*	Monitor the number of successful fledges produced annually	Yes	Yes	Yes				x	
*	Monitor the number of management units with active nests	Yes	Yes	Yes				x	
*	Emergent point count population monitoring techniques (i.e. tower counts)	No	Yes	Yes				x	

FUTURE ACTIVITIES GUATEMALA		Done in previous years?	Planned for:			Responsible			
			2009	2010	Beyond	CONAP	ARCAS	WCS	OTHER
Summarize and analyze data from previous years of the project									
*	Annual number of active nests per region	Yes	Yes	Yes				x	
*	Nest monitoring (date and nest contents of each check)	Yes	Yes	Yes				x	
*	Number of eggs or chicks, estimated egg/chick age, numbers or evidence of predation events, evidence of nest competition	Yes	Yes	Yes				x	
*	Nest characteristics (depth, width, height, tree species, number of openings, bottom substrate, evidence of habitation, presence/absence of bees or other competitors)	Yes	Yes	Yes				x	
Evaluate results									
*	Possible additional related data to collect in future	Yes	Yes	Yes				x	
*	Possible publication/dissemination	No	Yes	Yes		x		x	
Improve artificial nest box designs									
*	Document characteristics of acceptable natural nest cavities for use in box design	Yes	Yes	Yes				x	
*	Make new anti-predator designs (e.g., double-chambered)	Yes	Yes	Yes				x	
*	Investigate and refine: Materials, Mounting Techniques, Maintenance regimes, Nesting subtrates	Yes	Yes	Yes				x	
Continue anti-predator studies									
*	Continue development and use of in-nest IR cameras to identify other possible predators and reasons for poor nesting success at El Perú	Yes	Yes	Yes				x	
*	Consult with Ursula Valdez (Peru) on Micrastur behavior	No	Yes					x	
*	Investigate procedures / interventions to reduce forest-falcon predation	Yes	Yes	Yes				x	
Study effectiveness of anti-bee treatments of cavities									
*	Permetrin	Yes	Yes	Yes				x	
*	Carbaryl	No	No	?				x	
*	Evaluate using tests during non-breeding	Yes	Yes	Yes				x	
Joint ARCAS/WCS nest guarding program with volunteers at El Peru		No	No	Yes			x	x	
Attempt to understand reasons for decline of number of active nests at El Perú									
*	Examine population indices (is it due to a declining overall population?)	No	Yes	Yes				x	
*	Examine Micrastur abundance at comparative sites (El Perú-La Corona)	No	Yes	Yes				x	
*	Compare chick growth rates and nutrition to sites with higher fledging success rates in the MBR (El Perú-La Corona)	No	Yes	Yes			x	x	
*	Evaluate parental feeding time bouts at El Peru, and compare to sites with higher fledging success rates (i.e. La Corona)	No	Yes	Yes				x	
*	Evaluate time to cavity re-colonization by Africanized bees after treatment and compare to other sites in the MBR	No	Yes	Yes				x	
*	Evaluate comparative nest parasite loads at El Peru and La Corona	No	Yes	Yes			x	x	

FUTURE ACTIVITIES GUATEMALA		previous years?	Planned for:			Responsible			
			2009	2010	Beyond	CONAP	ARCAS	WCS	OTHER
G11.3 NATURAL HISTORY RESEARCH									
Increase understanding of macaw habitat use									
*	Document observations of foraging macaws (feeding bouts) recording food species if known, food type (fruit, flower, etc.), or collect a sample of species if unknown	Yes	Yes	Yes				x	
*	Document food resource availability through an annual phenological inventory of known food plants (particularly at El Perú to better understand the timing of suspected macaw "migrations")	No	No	?				x	
*	When appropriate technology exists, continue satellite collar deployment to determine landscape movements and habitat use throughout the year	Yes	?	?		x	x	x	
Monitor chick growth and development where feasible									
*	Weigh, measure (wing, and beak) and photograph wild chicks regularly	No	Yes	Yes			x	x	
Evaluate diet and chick nutrition via crop sampling									
*	Develop technique at ARCAS - sample at El Perú	No	No	?			x	x	
*	Compare results with data from Tambopata, Peru	No	No	?			x	x	
Collect any dead chicks and/ or adults for necropsy to determine cause of death									
*	Develop protocol for field sampling	No	Yes	Yes			x	x	x 4
*	Identify veterinarian willing to conduct necropsies	Yes	Yes	Yes			x	x	x 4
*	Develop a protocol for necropsy	No	Yes	Yes			x	x	x 4
Evaluate possibility and utility of banding and/or micro-chipping chicks		Yes (chicks banding)	Yes	Yes				x	
	(a) Because window of opportunity for applying closed bands is so short, open bands probably advisable								
	(b) Microchips require special reader and must be injected under the skin								
	(c) Bands can be cut off; microchips can't be removed								
Co									
*	Determine the degree of subpopulation isolation between Belize, Mexico, and Guatemala	No	Yes					x	x 5
*	Use information to adjust Vortex models, and better estimate susceptibility of the Guatemalan population	Yes	Yes					x	x 5
*	Identify if concentrations of nests at significant nesting foci (i.e. El Perú, La Corona, El Burral) are related to family groups or share genetic affinities of some kind	Yes	Yes					x	x 5
G11.4 *EX-SITU* MANAGEMENT									
Conduct regular health assessments of Aviarios Mariana and ARCAS macaws		Yes	Yes				x	x	
Biosecurity analysis for ARCAS, Aviarios Marianas, and El Perú & test susceptibility to disease		No	Yes				x	x	
Conduct genetic analyses of ARCAS birds		Yes	Yes				x	x	x 5
Apply genetics results at both aviaries to identify most appropriate breeders		No	Yes	Yes			x	x	

FUTURE ACTIVITIES GUATEMALA		Done in previous years?	Planned for:			Responsible			
			2009	2010	Beyond	CONAP	ARCAS	WCS	OTHER
G11.5 POPULATION AUGMENTATION PROJECTS									
Determine from Vortex modeling the impacts of different types of population augmentations		Yes	Yes	Yes		x	x	x	
Evaluate the feasibility of the different types of population augmentations, based on:		Yes	Yes	Yes		x	x	x	
(a) Cost, (b) Logistics, (c) Timing, (d) Manpower needed vs manpower available, (e) Participants									
Evaluate the risks to the natural wild populations of each population augmentation									
*	Determine acceptable level of risk	No	Yes	Yes		x	x	x	
*	Ensure governmental entities legally responsible for macaws are aware of risks and tradeoffs of each option	No	Yes	Yes		x	x	x	
Compare the potential impact on the population to the feasibility and risk and choose which if any population augmentation procedures to conduct		No	Yes	Yes		x	x	x	
Identify field locations for population augmentation activities		Yes	TBD *	TBD *		x	x	x	
*	El Perú								
	(a) Wild releases								
	(b) Precision releases								
*	Las Guacamayas Biological Station								
	(a) Managed (semi-wild) releases								
Evaluate use of in-situ management options cited in Chapter 10		No	TBD	TBD		x	x	x	
1	Guatemalan Army	TBD = To Be Determined							
2	DIPRONA (]Guatemalan Natural Resourse Police)	* Need a MOU between CONAP, ARCAS, Balam & WCS							
3	Asociación Balam								
4	Universidad de San Carlos de Guatemala								
5	American Museum of Natural History (New York)								
?	= Possible Activity in the Future								

MOLECULAR GENETICS AS A CONSERVATION MANAGEMENT TOOL FOR SCARLET MACAWS (*ARA MACAO*) IN LA SELVA MAYA

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INTRODUCTION:

Genetic considerations are an integral component of any wildlife management program. This is especially true when reintroduction or translocation initiatives are aimed at population reinforcement, where released individuals are intended to breed with wild population. Before intensive metapopulation management programs are initiated the needs and goals of the project must be clearly identified, including the careful assessment of the genetic status of historical and extant wild populations and potential source populations (wild or captive). Strategies can then be designed to introduce genetic variation that will enhance, yet complement, the genetic composition of the wild population.

Our research employs molecular genetic techniques at multiple hierarchical levels to develop a genetic management plan for scarlet macaws in La Selva Maya and will consider issues of taxonomy, extent of gene flow between breeding sites in Belize, Guatemala and Mexico, and overall genetic variation within wild and captive populations. This work will provide critical empirical data for local managers to guide the development and help monitor the genetic impacts of intensive metapopulation management efforts. While our project focuses on La Selva Maya, these results will have important implications for other scarlet macaw conservation programs such as the proposed reintroduction efforts of SalvaNatura in El Salvador.

OBJECTIVES:

Objective # 1: To use molecular genetic data to detect broad patterns of intraspecific genetic variation and identify diagnostic characters for unique evolutionary lineages. These data will be compared with the subspecies taxonomy (*Ara macao cyanoptera* and *Ara macao macao*) to determine if current designations represent operational conservation units.

Objective # 2: To use molecular data from both modern and historical samples to quantify the genetic diversity within and degree of gene flow between extant populations in La Selva Maya, and assess whether these patterns have changed over time.

Objective # 3: To use molecular data to develop a comprehensive metapopulation management program for scarlet macaws within La Selva Maya. This will include the genetic assessment of *ex situ* source populations to address questions of taxonomy and ancestry, design a genetic management plan, and identify potential release candidates.

METHODS:

Sample Collection

Genetic samples will be obtained from two primary sources. Feathers will be collected from within or below nest cavities, or plucked from macaw chicks prior to fledging. Tissue samples will be taken from museum specimens collected 40-120 years ago to provide a historical context for the observed genetic patterns within extant populations.

Molecular Markers

- Mitochondrial Sequences: The mitochondrial genome is a maternally inherited piece of DNA that provides a useful tool for conservation geneticists. Different gene regions mutate at different rates, providing the opportunity to evaluate genetic variation at multiple hierarchical levels.

- Microsatellites: These markers are short repeated nucleotide segments with variants designated by the number of motif repeats (e.g. CT_4 = CTCTCTCT). Microsatellites exhibit high levels of variability, facilitating analysis of population genetics and individual kinship.

- Nuclear Sequences: Nuclear sequences and their associated single nucleotide polymorphisms (SNPs) mutate at a much slower rate and are used to infer older divergence events such as between taxonomic units.

Taxonomic Resolution

To determine the historical population structure of scarlet macaws throughout the species' range, DNA will be extracted from both museum specimens and samples from existing populations. Sequence data will be generated from four mitochondrial gene regions (12S, 16S, cytochrome oxidase I and cytochrome b). Single nucleotide polymorphisms (SNPs) will be used to characterize nuclear genetic variation. Data analysis will follow both a population aggregation analysis (identify diagnostic nucleotide characters) and phylogenetic tree-based approach to quantify intraspecific variation and diagnose conservation units.

In Situ *Population Assessment – La Selva Maya*

Both mitochondrial control region sequences and microsatellite data will be generated using samples collected from extant populations in Guatemala, Mexico and Belize. Haplotype, nucleotide, and allelic diversity will be used to assess levels of genetic diversity. Traditional F_{ST}-based genetic distances and Bayesian inference will be used to detect population structure and migration rates. Data from museum specimens collected in La Selva Maya prior to fragmentation will provide a baseline to infer temporal changes in the abovementioned population genetic parameters.

Ex Situ *Population Assessment – Aviarios Mariana and ARCAS*

Two captive breeding aviaries in Guatemala have been identified as potential source populations for future reintroduction efforts. Aviarios Mariana is a privately owned aviary and Asociación de Rescate y Conservación de Vida Silvestre (ARCAS) is a rescue and rehabilitation center for confiscated animals. A preliminary analysis of founder genotypes at each facility will be used to determine the best suited source population. Further work will utilize microsatellite data to generate multilocus genotypes for each individual. A detailed genetic management program will be developed based upon an analysis of relative relatedness and the identification of genetically important individuals.

PRELIMINARY RESULTS:

- Analysis of mitochondrial data revealed four distinct haplogroups based on fixed nucleotide differences (Fig. 1). The geographic overlap between the red and yellow haplogroups advocates for these populations to be treated as a single taxonomic unit. A similar pattern is seen with the green and blue haplogroups, suggesting both should be considered a single taxonomic unit as well. Interestingly, the boundary between the two haplogroups clusters is concordant with the subspecies boundary. This observation supports the designation of *A. m. cyanoptera* and *A. m. macao* as operational conservation units.

- Shared mitochondrial control region haplotypes provide evidence of gene flow between nest sites in Guatemala and Belize, thus encouraging trans-national collaborative management efforts.

- High levels of mitochondrial diversity are still present in La Selva Maya and should be seen as an encouraging sign for local managers.

- Both native and non-native individuals have been found in captivity; therefore caution is needed when designing breeding programs to produce juveniles for release.

FIGURES:

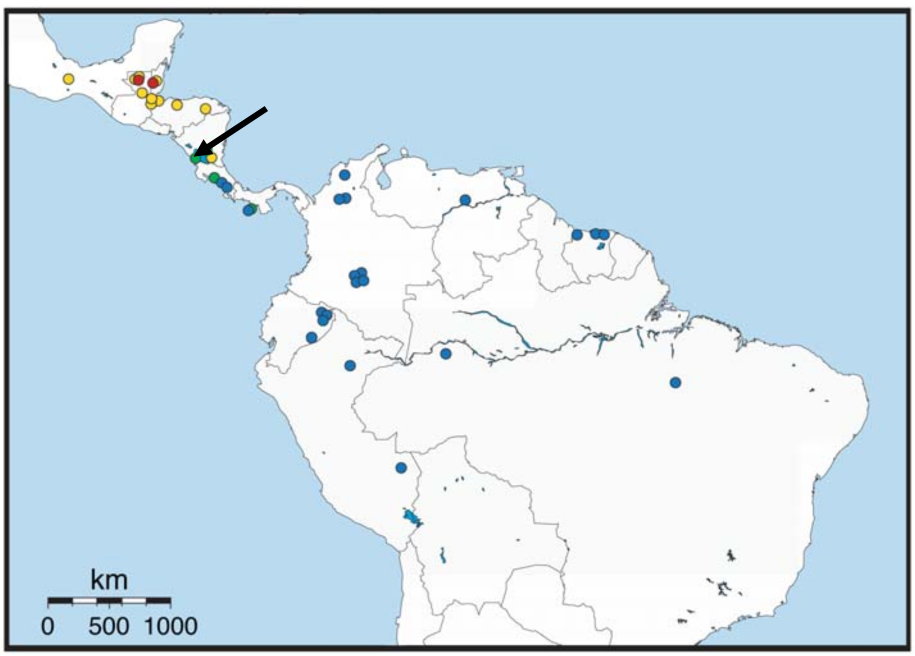

Figure 1. Map illustrating geographic distribution of mitochondrial haplogroups. The arrow points to the subspecies boundary between Nicaragua and Costa Rica.

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APPENDIX SUMMARY OF PARAMETERS FOR VORTEX RUNS

The Excel spreadsheet from which these parameter values were extracted is provided on the report CD with file name "Ara PVA ver2.xls"

SCENARIOS			
Parameter	**Baseline**	**Stable**	**Uniform**
# Iterations	500		
# Years	100		
Definition of Extinction	Only one sex remains		
# Populations	1		
Inbreeding Depression	No		
EV Concordance between Reproduction and Survival	No		
EV Correlation among Populations	N/A		
# Catastrophes	6		
Labels and State Vairables	N/A		
Dispersal	N/A		
Reproductive System	Longterm Monogamy		
Age at 1st Breeding (females)	6		
Age at 1st Breeding (males)	6		
Maximum Age of Reproduction	25		
Maximum # Progeny	3		
Sex Ratio	50		
Density-dependent Reproduction	No		
% Adult females breeding	30		
EV % Adult females breeding	16		
% Broods with 1 chick	76		
% Broods with 2 chicks	23		
% Broods with 3 chicks	1		
Mortality Age 0-1 (m/f)	35		
EV Mortality Age 0-1 (m/f)	5		
Mortality Age 1-2 (m/f)	10		
EV Mortality Age 1-2 (m/f)	3		
Mortality Age 2-3 (m/f)	10		
EV Mortality Age 2-3 (m/f)	3		
Mortality Age 3-4 (m/f)	5		
EV Mortality Age 3-4 (m/f)	2		
Mortality Age 4-5 (m/f)	5		
EV Mortality Age 4-5 (m/f)	2		
Mortality Age 5-6 (m/f)	5		
EV Mortality Age 5-6 (m/f)	2		
Adult Mortality (m/f)	5		
EV Adult Mortality (m/f)	2		
Catastrophe 1 Frequency	0		
Catastrophe 1 Severity (reproduction)	0.9		
Catastrophe 1 Severity (survival)	1		
Catastrophe 2 Frequency	0		
Catastrophe 2 Severity (reproduction)	0.75		
Catastrophe 2 Severity (survival)	0.9		
Catastrophe 3 Frequency	0		
Catastrophe 3 Severity (reproduction)	0.9		
Catastrophe 3 Severity (survival)	1		
Catastrophe 4 Frequency	1		
Catastrophe 4 Severity (reproduction)	0.1		
Catastrophe 4 Severity (survival)	0.25		
Catastrophe 5 Frequency	0		

Catastrophe 5 Severity (reproduction)	0.9		
Catastrophe 5 Severity (survival)	0.9		
Catastrophe 6 Frequency	0		
Catastrophe 6 Severity (reproduction)	0.9		
Catastrophe 6 Severity (survival)	0.9		
All males breeding	Yes		
Initial Population Size	354		
Stable Age Distribution	No	Yes	
Carrying Capacity	1200		
EV of Carrying Capacity	120		
Trend in Carrying Capacity	No		
Harvesting	No		
Supplementation	No		
Genetic Management	No		

(Page 2 over)						
All Diseases	**Chlamydia**	**Supplement 18 Disease**	**Initial Pop 254**	**Initial Pop 554**	**AFB 7**	**AFB 5**
					7	5
					7	5
0.125	0	0				
0.9	0.9	0.9				
1	1	1				
0.125	0	0				
0.75	0.75	0.75				
0.9	0.9	0.9				
0.125	0	0				
0.9	0.9	0.9				
1	1	1				
0.25	0	2				
0.1	0.1	0.1				
0.25	0.25	0.25				
0.125	1	0				

0.9	0.9	0.9				
0.9	0.9	0.9				
0.25	0	0				
0.9	0.9	0.9				
0.9	0.9	0.9				

(Page 3 over)							
Max Repro 30	**Max Repro 20**	**%Breeding 65**	**%Breeding 52**	**%Breeding 39**	**%Breeding 26**	**%Breeding 13**	**Loss of K (%/yr)**
30	20						
		65	52	39	26	13	

							-0.5

(Page 4 over)	
Two Populations	**Three Populations**
2	3
Guatemala/Mexico and Belize	Guatemala, Mexico and Belize
see Dispersal sheet	see Dispersal sheet

254/100	154/100/100
800/400	600/200/400
80/40	60/20/40

	AGE DISTRIBUTIONS								
Age	**Baseline**	**Stable**	**Uniform**	**Initial Pop 254**	**Initial Pop 554**	**Max Repro 20**	**Max Repro 30**	**Two Populations: Guat/Mex**	**Two/Three Populations: Belize**
1	4	20	8	2	8	4	4	2	2
2	4	17	8	2	8	4	4	2	2
3	4	14	7	2	8	4	4	2	2
4	4	12	7	2	8	4	4	2	2
5	4	11	7	2	8	4	4	2	2
6	4	10	7	2	8	4	4	2	2
7	4	10	7	2	8	4	4	2	2
8	4	8	7	2	8	4	4	2	2
9	4	9	7	2	8	4	4	2	2
10	4	7	7	2	8	4	4	2	2
11	4	7	7	2	8	4	4	2	2
12	4	6	7	2	8	4	4	2	2
13	4	5	7	2	8	4	4	2	2
14	4	5	7	2	8	4	4	2	2
15	4	5	7	2	8	4	4	2	2
16	4	4	7	2	8	33	4	2	2
17	4	3	7	2	8	28	4	2	2
18	4	4	7	2	8	23	4	2	2
19	4	3	7	2	8	20	4	2	2
20	4	3	7	2	8	13	4	2	2
21	29	2	7	27	33		4	27	2
22	24	2	7	22	27		4	22	2
23	19	2	7	17	23		4	17	2
24	16	2	7	14	20		4	14	2
25	9	2	7	7	13		4	7	2
26							25		
27							20		
28							15		
29							12		
30							5		

Three Populations: Guatemala	**Three Populations: Mexico**
1	1
1	1
1	1
1	1
1	1
1	1
1	1
1	1
1	1
1	1
1	1
1	1
1	1
1	1
1	1
1	1
1	1
1	1
1	1
1	1
21	6
16	6
11	6
8	6
1	6

SUPPLEMENTATION

	Supplement 6	Supplement 12	Supplement 18
1st year of supplementation	0		
last year of supplementation	10		
interval	1		
number of males	3	6	9
number of females	3	6	9
age of individuals	2		

DISPERSAL					
Scenario	Annual Exchange (M/G and B)	Annual Exchange (M/G)	Annual Exchange (G/B)	Annual Exchange (B/M)	Success (M/G)
Two Populations 0%	0				31
Two Populations 0.04%	0.04				31
Two Populations 0.4%	0.4				31
Two Populations 4%	4				31
Two Populations Source	0.04				31
Three Populations 0%: Mexico		0	0	0	
Three Populations 0.04%: Mexico		0.04	0.04	0.04	
Three Populations 0.4%: Mexico		0.4	0.4	0.4	
Three Populations 4%: Mexico		4	4	4	
Three Populations 0%: Mexico Asym		0.4	0	0	
Three Populations 0.04%: Mexico Asym		0.4	0.04	0.04	
Three Populations 0.4%: Mexico Asym		0.4	0.4	0.4	
Three Populations 4%: Mexico Asym		4	0.04	0.04	

Success (M)	**Success (G)**	**Success (B)**
		26
		26
		26
		26
		39
26	40	26
26	40	26
26	40	26
26	40	26
26	40	26
26	40	26
26	40	26
26	40	26

GROWTH AND EXTINCTION RATES				
Scenario	**Deterministic r**	**Stochastic r**	**SD (stoch r)**	**Final N**
Baseline	-0.002	-0.016	0.16	204
Uniform	-0.002	-0.13	0.162	248
Stable	-0.002	-0.01	0.152	293
Initial Population 554	-0.002	-0.14	0.16	310
Initial Population 254	-0.002	-0.02	0.167	113
Two Populations 0%: M&G	0	-0.016	0.162	20
Two Populations 0%: Belize	-0.013	-0.027	0.161	297
Two Populations 0%: Meta		-0.019	0.157	167
Two Populations 0.04%: M&G	0	-0.018	0.168	129
Two Populations 0.04%: Belize	-0.013	-0.026	0.169	20
Two Populations 0.04%: Meta		-0.02	0.162	150
Two Populations 0.4%: M&G	0	-0.02	0.162	105
Two Populations 0.4%: Belize	-0.013	-0.019	0.164	36
Two Populations 0.4%: Meta		-0.021	0.161	141
Two Populations 4%: M&G	0	-0.023	0.167	72
Two Populations 4%: Belize	-0.013	-0.014	0.169	62
Two Populations 4%: Meta		-0.021	0.156	133
Two Populations Source: M&G	0	-0.016	0.164	138
Two Populations Source: Belize	0.017	0.006	0.157	198
Two Populations Source: Meta		-0.005	0.157	336
Three Populations 0%: Mexico	-0.013	-0.033	0.168	11
Three Populations 0%: Belize	-0.013	-0.027	0.161	19
Three Populations 0%: Guat	0.19	0.004	0.163	297
Three Populations 0%: Meta		-0.005	0.158	327
Three Populations 0.04%: Mexico	-0.013	-0.027	0.166	17
Three Populations 0.04%: Belize	-0.013	-0.024	0.165	24
Three Populations 0.04%: Guat	0.019	0.003	0.164	287
Three Populations 0.04%: Meta		-0.006	0.157	328
Three Populations 0.4%: Mexico	-0.013	-0.015	0.168	52
Three Populations 0.4%: Belize	-0.013	-0.015	0.163	54
Three Populations 0.4%: Guat	0.019	-0.002	0.163	240
Three Populations 0.4%: Meta		-0.008	0.154	346
Three Populations 4%: Mexico	-0.013	-0.014	0.182	56
Three Populations 4%: Belize	-0.013	-0.014	0.181	58
Three Populations 4%: Guat	0.019	-0.017	0.179	74
Three Populations 4%: Meta		-0.017	0.159	189
Three Populations 0%: Mexico Asym	-0.013	-0.014	0.171	51
Three Populations 0%: Belize Asym	-0.013	-0.027	0.165	21
Three Populations 0%: Guat Asym	0.019	0.001	0.162	258
Three Populations 0%: Meta Asym		-0.007	0.155	330
Three Populations 0.04%: Mexico Asym	-0.013	-0.014	0.166	52
Three Populations 0.04%: Belize Asym	-0.013	-0.023	0.159	25
Three Populations 0.04%: Guat Asym	0.019	0.001	0.16	262
Three Populations 0.04%: Meta Asym		-0.006	0.152	339
Three Populations 0.4%: Mexico Asym	-0.013	-0.016	0.176	45
Three Populations 0.4%: Belize Asym	-0.013	-0.016	0.168	49
Three Populations 0.4%: Guat Asym	0.019	-0.004	0.169	223
Three Populations 0.4%: Meta Asym		-0.01	0.161	318
Three Populations 4%: Mexico Asym	-0.013	-0.008	0.176	75

Three Populations 4%: Belize Asym	-0.013	-0.025	0.166	21
Three Populations 4%: Guat Asym	0.019	-0.012	0.175	128
Three Populations 4%: Meta Asym		-0.014	0.161	224
Chlamydia	0.005	-0.001	0.062	366
All Diseases	0.003	-0.005	0.1	309
AFB 5	0.005	-0.1	0.16	315
AFB 7	-0.008	-0.022	0.159	111
Max Repro 20	-0.016	-0.32	0.162	39
Max Repro 30	0.005	-0.007	0.155	382
Breeding Success 65%	0.058	0.047	0.159	991
Breeding Success 39%	0.017	0.005	0.157	627
Breeding Success 26%	-0.013	-0.026	0.159	65
Breeding Success 13%	-0.06	-0.074	0.17	0.3
Supplement 6	-0.002	-0.013	0.16	237
Supplement 12	-0.002	-0.011	0.157	279
Supplement 18	-0.002	-0.008	0.156	329
Supplement 18 Disease	-0.01	-0.24	0.212	146

SD (Final N)	P (extinction)
242	0.122
283	0.108
304	0.06
321	0.056
145	0.22
32	0.16
125	0.464
201	0.148
166	0.174
32	0.424
188	0.152
135	0.186
49	0.306
178	0.168
87	0.21
75	0.232
161	0.182
164	0.144
145	0.086
287	0.072
20	0.552
32	0.434
223	0.086
252	0.086
26	0.394
36	0.37
221	0.092
261	0.09
55	0.22
61	0.198
212	0.116
317	0.108
61	0.202
67	0.218
87	0.21
213	0.168
53	0.208
37	0.44
214	0.09
285	0.086
54	0.19
34	0.354
216	0.072
289	0.068
51	0.234
59	0.248
211	0.118
311	0.108
74	0.176

34	0.426
142	0.16
237	0.136
210	0
225	0.014
334	0.09
140	0.18
54	0.288
370	0.046
306	0
417	0.022
83	0.19
1.4	0.95
269	0.08
294	0.058
324	0.064
249	0.228