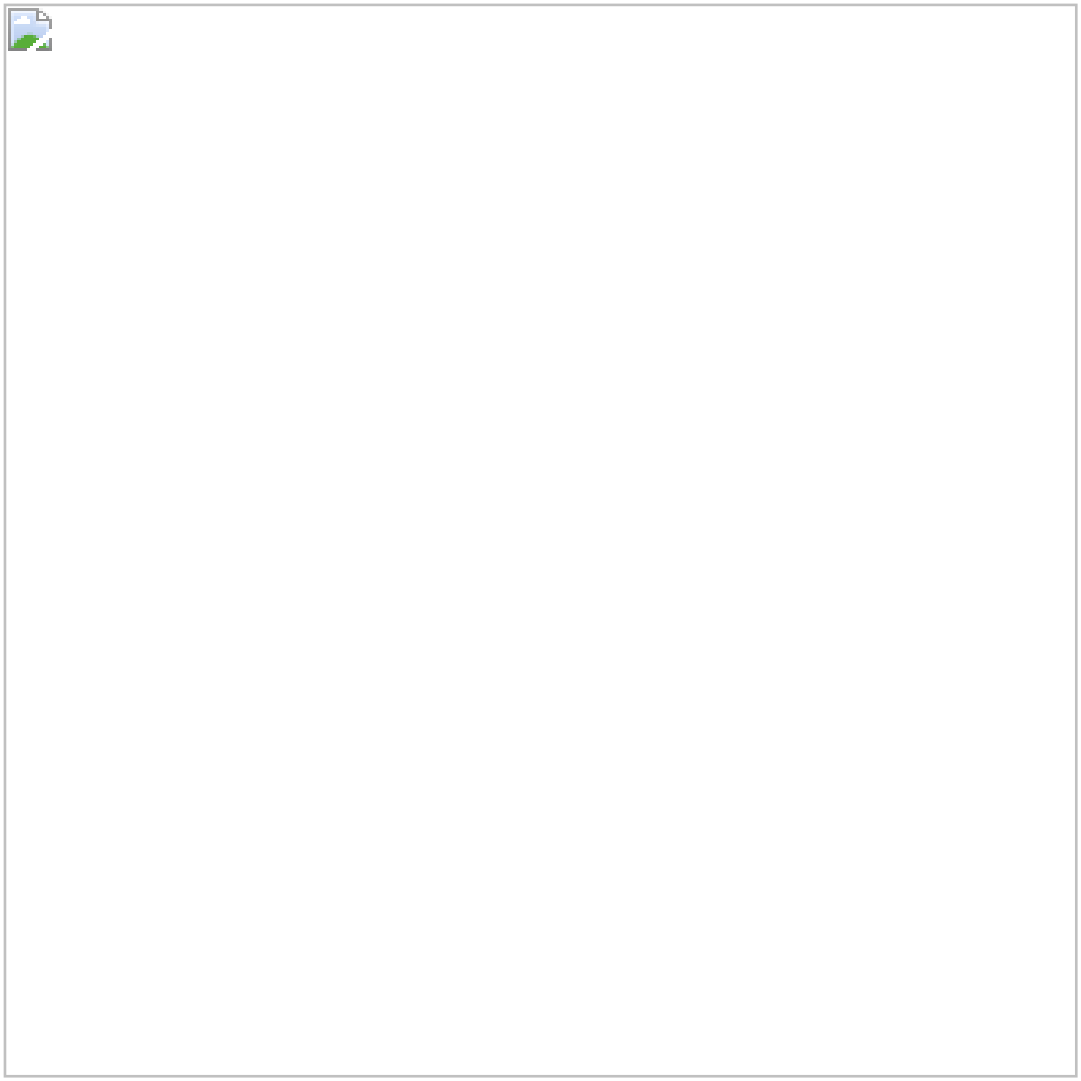

Reintroduction of the scarlet macaw (Ara macao cyanoptera) in the tropical rainforests of Palenque, Mexico: project design and first year progress

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Conservation Letter

Reintroduction of the scarlet macaw (*Ara macao cyanoptera*) in the tropical rainforests of Palenque, Mexico: project design and first year progress

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Abstract

There are 17 extant species of macaws in the Neotropics, most of them found in South America. Two subspecies of scarlet macaw (*Ara macao*) are distinguished in Mesoamerica: *Ara macao cyanoptera*, from Mexico to central Nicaragua, and *Ara macao macao*, from southern Nicaragua to South America. Habitat loss, hunting, and in particular illegal traffic have resulted in the local and regional extinction of this macaw within its historical range. In Mexico, the scarlet macaw has disappeared from about 98% of its indigenous range; it is extinct in El Salvador and occurs in very low numbers in Guatemala, Belize, Honduras, and Nicaragua. The IUCN recommends two tactics for population restoration: Reintroduction and Reinforcement. In this paper we report the design and first-year progress of a project to reintroduce the scarlet macaw (*A. macao cyanoptera*) in the tropical rainforests of Palenque, Mexico, where this macaw has been extinct for more than 70 years. The project is spearheaded by Aluxes Ecopark Palenque, bringing together Xcaret Ecopark (as donor of captive-bred scarlet macaws) and the Institute of Biology of Universidad Nacional Autonoma de Mexico (UNAM; provider of the scientific platform for the project). The design of the project adheres to the IUCN/SSC guidelines for reintroductions. A soft-release protocol was developed as a major axis of the reintroduction of the scarlet macaw. This includes a preparation phase to enhance survival in the wild and a long-term post-release monitoring program. Broad social support was considered essential for the success of the project, and a program was implemented to include the local inhabitants as partners in this initiative. Between April 2013 and June 2014, we conducted six successful releases of a total of 92 macaws. Survival to August 2014 was 92%. The reintroduction of the scarlet macaw in the tropical rainforests of Palenque will restore a seed- and fruit-eating avian species with important consequences for ecosystem functions and processes, in a project that reconnects people with their natural heritage.

Keywords: extinction, refaunation, macaws, Neotropics, rewilding

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Introduction

Conservation background

There are 17 extant species of macaws in the Neotropics, most of them found in South America [1]. The International Union for Conservation of Nature (IUCN) RedList categorizes the scarlet macaw (*Ara macao*) as Least Concerned due to its broad geographic distribution in the Neotropics (Mexico to east of the Andes in Colombia, Ecuador, Peru, Bolivia, Brazil, French Guiana, Guyana, Suriname, Trinidad and Tobago and Venezuela), but indicate populations as decreasing [1]. Two subspecies are distinguished in Mesoamerica: *Ara macao cyanoptera*, found from Mexico to central Nicaragua and *Ara macao macao*, from southern Nicaragua to South America [2] The conservation status of *A. macao cyanoptera* is dire in its indigenous range. For example, this macaw is regionally extinct in El Salvador and occurs in very low numbers in the other Central American countries (Guatemala, Belize, Honduras, and Nicaragua) [3]. Habitat loss, hunting, and in particular illegal traffic have resulted in the local and regional extinction of this macaw within its historical range [3]. The subspecies is listed on Appendix I of CITES because it is threatened with extinction due to illegal traffic [4].

In Mexico, the scarlet macaw historically occurred from southern Tamaulipas through the lowlands of the states of Veracruz, Tabasco, Campeche, Oaxaca and Chiapas [5]. Currently its range in Mexico has been reduced by 98% as a result of illegal traffic, hunting, and habitat loss [6]. Only about 150-200 scarlet macaws exist in the southern Lacandon forest in the state of Chiapas [7, 8] and about 50 individuals apparently occur in the Chimalapas mountain region shared by the states of Oaxaca and Chiapas [9] (Fig. 1). This macaw is classified as “endangered” by the official environmental norm of the government of Mexico (NORM-059-SEMARNAT 2010).

Recent studies have shown that the scarlet macaw population in the Usumacinta River Basin shared by Mexico, Guatemala and Belize is a metapopulation of only about 400 breeding individuals [10-13].

Fig. 1. Historical (green) and current (red and yellow dots) distribution of *Ara macao cyanoptera* in Mexico. Red dot indicates approximate location of relict population of 150-200 scarlet macaws at the southeastern boundary of the Montes Azules biosphere reserve in Mexico, close to the border with Guatemala. Yellow dot indicates a presumed population of *ca* 50 individuals in the Chimalapas mountain region shared by the states of Oaxaca and Chiapas in Mexico. Map adapted from [6].

Reintroduction of species as a conservation tactic

The IUCN considers the local and regional extinction of species a critical problem for the conservation of biodiversity and has recommended a strategy for population restoration that contemplates two tactics: Reintroduction and Reinforcement [14]. Reintroduction is the intentional transport and release of an organism into its indigenous range from which it has disappeared (Fig.

2). The goal is to establish a viable population of the focal species within its indigenous range. Reinforcement is the intentional transport and release of an organism into an existing population of conspecifics [14] (Fig. 2). Such actions may result in the recovery of the species of interest, in the conservation of local and regional biodiversity, in recovery of ecosystem functions and services, and in economic and cultural benefits [15]. The IUCN provides a set of key guidelines for assessing the feasibility of a reintroduction project. These guidelines emphasize careful selection of suitable habitat, the use of founders from captive or wild sources, attention to disease and parasite transmission and animal welfare, among others [14].

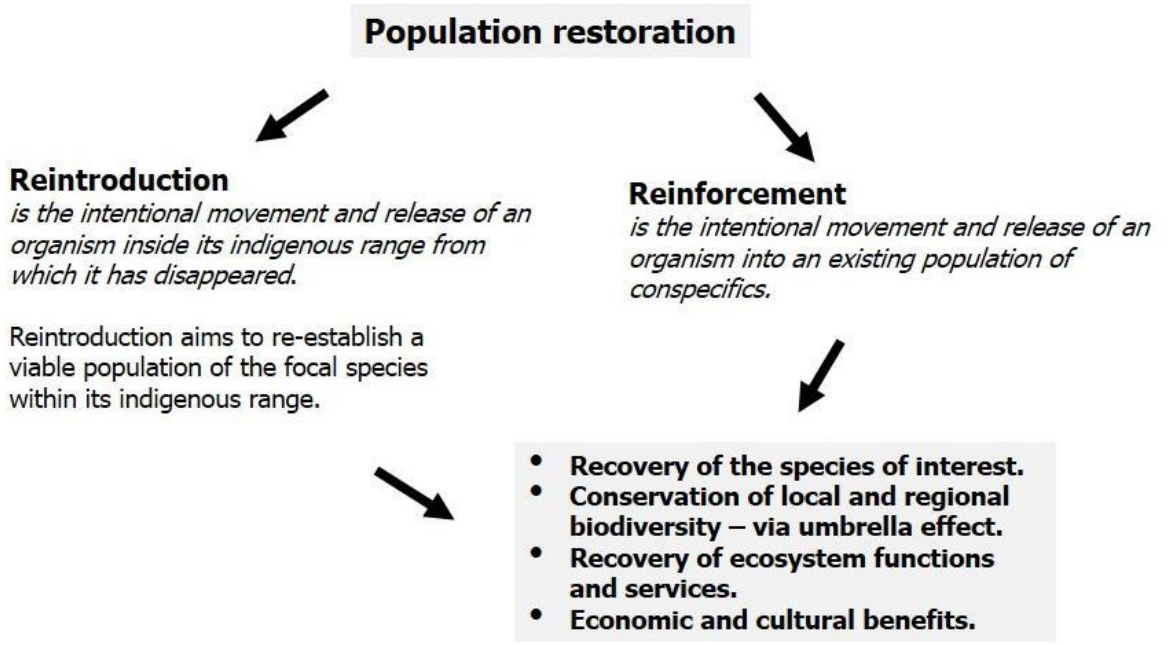

Fig. 2. Schematic representation of the concept of reintroduction as a conservation tactic recommended by the IUCN [14] to restore species in their indigenous range.

The ultimate objective of a reintroduction is the establishment of a self-sustaining population [15] and the IUCN guidelines urge that projects include clear definitions of success in three phases of any reintroduction: establishment, growth, and regulation, with future population persistence assessed through population viability analysis [14]. A study that reviewed reintroduction success or failure in more than 180 species of birds and mammals found that the most important indicators of success were habitat quality at the release site and total number released [16]. Risks of inbreeding and loss of genetic variation are important variables; these risks are minimized by creating large effective population sizes in a reintroduction program [17]. Both the IUCN [14] and specific studies show that causes of success or failure can be detected only through adequate post-release monitoring [18], which in many cases will involve a long time scale [17].

In the case of psittacines, guidelines for reintroductions as a conservation tool are provided by White Jr. et al. [19]. Such guidelines are based on an analysis of common denominators of success in

reintroductions of parrots, including three species of macaws. Salient points in this White Jr., et al. are the following: (1) the use of SWOT (Strengths, Weaknesses, Opportunity and Threats) analysis for a comprehensive evaluation of potential release sites, where potential threats and weaknesses of the release site can be profiled and appropriate pre-release compensating measures developed [19, 20]; (2) the parrots to be released should be free of diseases and in good physical condition; (3) the need for systematic and detailed documentation of all methods used and an effective plan for post-release monitoring, necessary for short and long term evaluations of success; (4) the use of post-release food provisioning to promote site fidelity of released birds, increased social interactions, and accelerated integration of subsequently released flocks. In their analyses, White Jr. et al. [19] established as an objective definition of success a first-year survival of >50% and released birds breeding with conspecifics.

Aims

In this paper we describe the design and first-year progress of a project for reintroducing the scarlet macaw (*A. macao cyanoptera*) in the tropical rainforests of Palenque in the state of Chiapas, Mexico. The project was designed to adhere as closely as possible to the IUCN guidelines for reintroductions [14] and to the recommendations by White Jr., et al. [19]. It is our hope that the information presented here will be useful to conservation practitioners and scientists developing reintroduction projects for the scarlet macaw and for other parrot species in other localities in Mexico and Central and South America. Additionally, we briefly present the progress made in the project in its first year of implementation.

Brief background on the origin of the project in Palenque: inter-institutional alliances

Reintroduction of a species within its indigenous range is recommended not only by the IUCN but also adopted by the Ministry of the Environment and Natural Resources of Mexico (SEMARNAT) to recover locally or regionally extinct species. In 2012 an initiative spearheaded by Aluxes Ecopark Palenque (www.ecoparquepalenque.com) brought together Xcaret Ecopark (as donor of captive bred scarlet macaws [21]) and the Institute of Biology of Universidad Nacional Autonoma de Mexico (UNAM; www.ibiology.unam.mx) in a project to reintroduce the scarlet macaw to the tropical rainforests of Palenque, Chiapas, Mexico, where this macaw has been extinct for over 70 years [22].

Release site

The planning of the program was initiated in 2007 and finalized by 2012, when preparations were completed. The reintroduction project was implemented in April of 2013 with a first release of macaws on the grounds of Aluxes Ecopark (Aluxes hereafter), the logistics and operating base for the project. Aluxes is a rescue and rehabilitation center for wildlife. The center has built infrastructure to house birds, mammals and reptiles. It also has a fully equipped animal hospital. There are two full-time vets and support staff consisting of animal caretakers, maintenance workers, administrators and others. Additional infrastructure was built for the macaw reintroduction project, including two large outdoor aviaries, quarantine cages, and two observation towers. From the inception of the project it was considered that infrastructure and support staff were an indispensable part of the project to ensure the macaws´ well-being before and after the release. The land of Aluxes encompasses *ca* 40 ha with extensive forest cover, and is only about 0.5 km from the forest that extends toward Palenque National Park (*ca* 1,800 ha; Fig.3) [23].

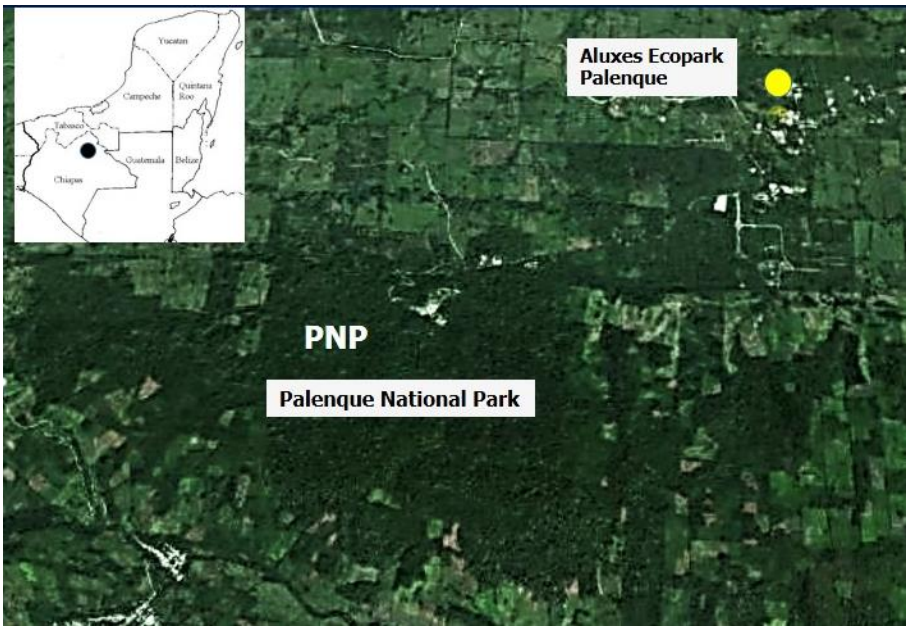

Fig. 3. Location of Aluxes Ecopark Palenque (yellow dot) and of Palenque National Park. The forested land extending north-east from PNP is only 0.5 km away from the release site. Black dot in inset shows location of Palenque. Google map adapted from Google Earth, July 2014.

Human component in the release area

The municipality of Palenque has about 110,918 inhabitants. Thirty-eight percent of these live in the town of Palenque, located about 8km northeast of the release site. The rural landscape surrounding the town of Palenque and Palenque National Park is inhabited also by Mayan indigenous people of two ethnic/linguistic groups, Maya-Chol and Maya-Tzeltal. These communities are located within the area of influence of Aluxes and of Palenque National Park [24].

The human population in the town of Palenque and in the rural areas has been very much aware of the need to preserve natural resources, thanks to the presence of Palenque National Park, created 33 years ago [25]. Because Palenque National Park harbors one of the most important archaeological sites of the ancient Maya civilization, a great deal of public awareness exists of the importance of preserving the biodiversity-rich tropical rainforest of PNP and the ancient Mayan ruins found within; this interest has been extended as well to the remaining forest fragments in the region [26]. Such awareness and interest have been sustained through annual programs of environmental education by CONANP (Commission de Areas Naturales Protegidas), the local division of the environmental agency of the government of Mexico.

Preparing the release

Genetic study

An initial step in the reintroduction project was to ensure that the scarlet macaws to be donated by Xcaret Park to the project were all *A. macao cyanoptera,* the subspecies originally distributed in Mexico. Aluxes hired the services of the Conservation Genetics Laboratory of the Institute of Biology of UNAM to run molecular analysis. The results indicated that the population of scarlet macaws selected for release were *A. macao cyanoptera*. The analysis also showed that the captive population at Xcaret has a genetic variability that closely approaches the variability found in wild populations in Mexico, Guatemala and Belize [10].

Screening for diseases

The macaws selected for release in Palenque were screened for infectious diseases by Xcaret at HealthGene, Molecular Diagnostics and Research Center, Toronto, ON, Canada, and at certified Mexican government laboratories (SAGARPA). Diseases screened were: Polyoma Pacheco's disease (herpes) virus, avian bornavirus (proventricular dilatation disease), Psittacine beak and feather disease, Chlamydia Newcastle's disease, Avian flu and Salmonella. Results were negative in all cases [21]

Population viability analysis

VORTEX [27] simulations were used to model the viability of the population under different demographic scenarios. Each model was run 500 times with a carrying capacity of 250 macaws ± 25 individuals. We checked for differences between releasing 30 males and 30 females one year of age at the same time (same year) and releasing the same number of macaws, but during 2-3 years. Probability of extinction was null in both cases, but the annual stochastic population growth rate varied from 3.8% in a single release to 5.1% and 5.8% in two and three years. We also evaluated if mortality of released individuals would affect the population. In the original model mortality was estimated at 10% for the wild population, but for the reintroduced population the rate was increased to 25% (Fig. 4). The model showed that the growth rate was virtually unchanged from one scenario to the next (3.8-3.7%).

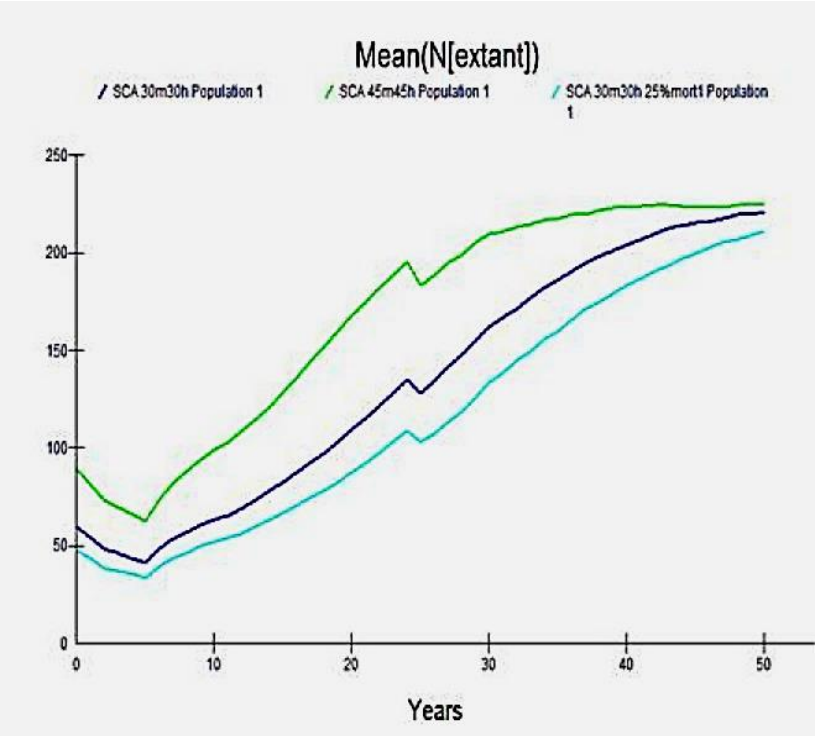

Fig. 4. Example of results of simulations of macaw population viablity using Vortex. The black line in the graph shows the results of a simulation with 30 males and 30 females. The green line, the simulation with 45 males and 45 females. Both simulations with 10% mortality. The blue line shows the model with 30 males and 30 females at 25% mortality. Analysis and graph by Dr. Juan Cornejo (Loro Parque, Tenerife, Spain).

Habitat quality

In Mexico, the scarlet macaw is mainly found inhabiting lowland evergreen and semi-evergreen rainforest [9,11]. The lowland region of Palenque harbors plant species-rich rainforests. Inventories at Palenque National Park indicate the existence of about 410 species of plants of 252 genera in 86

families. About 60% of the species are trees, 15% herbs, 12% shrubs, and 7% climbing plants, 3% ferns and 3% palms [28]. A summary of the plant species used by scarlet macaws as a source of food in Guatemala, Belize, Honduras and Nicaragua lists 72 species of 25 families [13]. We determined that 70% of these plant species are present in the forest of Aluxes and Palenque National Park. The families Fabaceae and Moraceae that contribute to the highest number of species in the reported diet of macaws, are also dominant in the tree community in the forests of Palenque (Appendix 1).

Potential food availability: fruit and leaf phenology in the tropical rainforest of Palenque

Long term studies of fruit and leaf phenology for tree species (N = 60) in the tropical rainforest of Palenque showed that although there are pulses of production, both young and mature fruit are available throughout the year, and the same is the case for presence of young leaves (Fig. 3; Estrada, unpublished data). This suggests that released macaws can find food resources throughout the year to satisfy metabolic and nutritional demands.

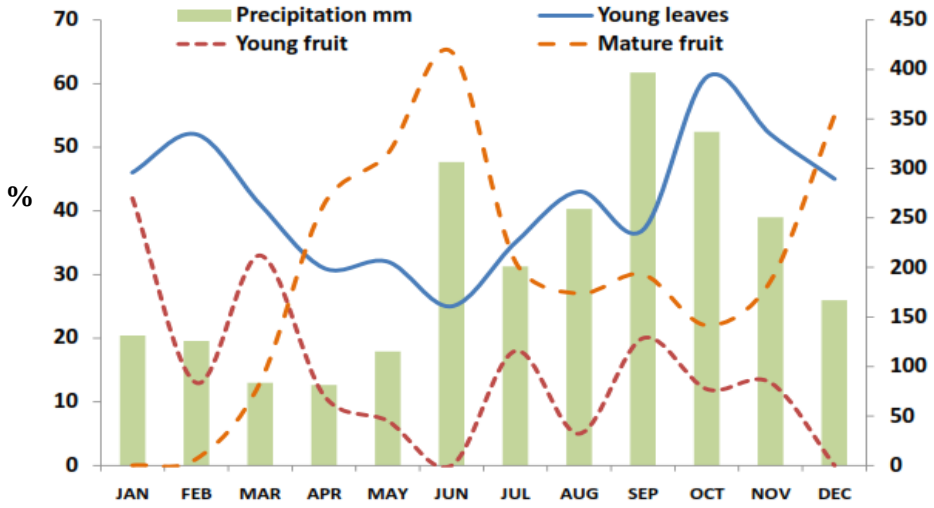

Fig. 3. Fruit and leaf phenology of tree species (N = 60) in the forests of Palenque National Park. Source: Estrada, A., unpublished data.

Habitat availability

In the region of Palenque there are large tracts of forest and also landscapes that still retain constellations of forest fragments and numerous riparian corridors, as well as corridors created by humans who plant live fences to delimit their land lots or to rotate cattle between pastures. The landscape in which Aluxes and Palenque National Park are found has an estimated accumulated area of tropical rainforest vegetation of *ca* 6,000ha [26]. There are many forest fragments of various sizes, the majority of which are protected by government land-use regulations [25].

Potential predation pressure in the release area

Surveys of avian and mammalian potential predators showed that raptors thus far identified at the release area are small (250g - 800g; e.g. *Falco femoralis (Aplomado falcon), Micrastur semitorquatus (Collared forest falcon)*, *Pseudastur albicollis* (White hawk) and occur in low numbers [29, 22]. These

may not represent a significant pressure upon scarlet macaws with an average adult weight of 1,000g. Large size raptors such as *Harpia harpyja* (Harpy Eagle), *Spizaetus melanoleucus* (Black-and-white Hawk-Eagle) and *Spizaetus ornatus* (Ornate Hawk-Eagle) have been reported as absent from the area for several decades [22]. Present in low numbers in the forests of the release area are tree climbing felines such as the ocelot (*Leopardus pardalis)* and the margay (*Leopardus wiedii*), procyonids such as the coati (*Nasua narica*), and mustelids such as the Tayra (*Eira barbara*) [30; Estrada unpublished data]. Among reptiles, the boa (*Boa constrictor*) is found in the forests in the area (Estrada, pers. obs.).

Potential predation pressures from the human population in the vicinity

Potential predation pressure by humans was considered minimal due to several years of actions by PROFEPA, the division of the Mexican government in charge of monitoring and stopping illegal traffic of wildlife in the region. The activity of this agency coupled with the environmental education programs in place for several years by CONANP (see Release Site above) have raised a significant level of awareness in the local population about protection of wildlife and the need to protect the liberated macaws.

Selection of macaws for release

The following key features were considered relevant to the process of selection of the macaws from Xcaret for the reintroduction project in Palenque.

Genetic Diversity

Xcaret was asked to select for the Palenque release program individuals from four natural genetic groups in their collection [21], under the assumption that this may provide enough genetic variation to reduce future genetic bottlenecks in the established population.

Young individuals

It was also requested that donated birds be relatively young (3-5 years of age), under the assumption that having a young population would result in more breeding events through the years.

Balanced sex ratio

Xcaret was also asked to try to balance the sex ratio in each shipment of macaws, in order to release similar numbers of males and females.

Macaws raised by their parents

While the majority of the captive-bred macaws from Xcaret have been raised by humans [21], we asked Xcaret to also select a cohort to be raised by their parents and be sent to Palenque once they reached the required age, because macaws raised by their parents may display behaviors that could be learned by others and thus further facilitate adaptation to the wild, via social bonding and cohesion and faster learning.

Macaws of breeding age and reproductive pairs

While the goal of the reintroduction is to release relatively young macaws, we also asked Xcaret to send to us small groups of older individuals that were already in breeding age, $\geq$ 5 years old and successful breeders, because younger macaws would learn species-specific social and other behaviors from older individuals, which would expedite adaptation to a free-ranging life.

Soft-release protocol

For psittacines, a soft-release protocol is recommended in reintroductions because these birds greatly depend on learning and membership in flocks to survive [19]. Such a protocol includes a period of acclimatization in enclosures in the release site. After release, individuals are food-provisioned to anchor them to the release site and to complement their foraging on wild foods. The pre-release phase of the soft-release protocol implemented in Palenque may last 2-3 months prior to the release date of each flock, and involves the key aspects shown in Fig.4 and briefly described below.

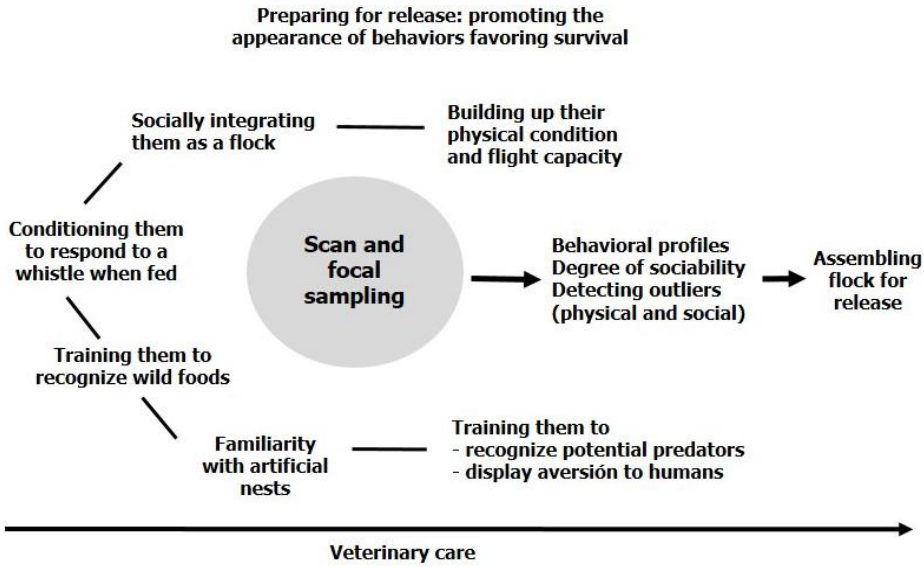

Fig. 4. Diagram summarizing key components of the protocol designed to prepare the macaws for release

1) *Promoting social integration of individuals as a flock.* Feeding stations and perches in the pre-release cage are set up to promote aggregation of individuals, gradually resulting in tolerance to close inter-individual proximity and in the development of social bonds. The feeding platforms are designed to stimulate co-feeding in close proximity (Fig. 5a).

2) *Building up their physical condition.* This is an important component as macaws to be released need to be in adequate physical shape to fly longer distances than in the cage. This was done by setting up feeding stations in the middle of the cage and at variable distances from each other (see Design of the pre-release and release cage below; Fig.6). This motivated individuals to fly, rather than climb on the mesh, gradually building up their physical condition.

3) *Training the macaws to recognize wild foods.* This consists in offering three times a week branches of fruiting plants known to be consumed by scarlet macaws. The offering of branches with fruits was done to motivate the macaws to learn not only to recognize the fruits, but also to learn how to harvest them, as different plants offer fruits in different ways (http://www.theplantlist.org/; consulted July 2014).

Fig. 5a. Left: feeding platforms in the pre-release cage. Macaws are stimulated to fly to them to feed and for water. Right: feeding platforms in the release cage. Released macaws are provisioned daily with a ration of sun flower seeds. Photos by A. Estrada.

4) *Conditioning the macaws to respond to the sound of a whistle.* While in the pre-release cage, the macaws were conditioned to the sound of a whistle each time they were fed (twice a day). Such conditioning is a critical component of our soft-release protocol because after release the macaws are called twice a day with the whistle to gather by the feeding stations in the release cage. This allows us to count the macaws returning to the release cage to feed, and to check their wellbeing. Sustained conditioning coupled to food provisioning after the release has been a very useful tool to anchor the macaws to the release site and to complement their foraging on wild foods. Such an approach has been implemented with success in the six releases we have conducted between April 2013 and June 2014.

5) *Exposure to nest boxes.* The pre-release cage has 4-6 artificial nest boxes placed on the upper segments of the walls of the cage. At the start, the nest boxes were made out of wood, but later replaced by plastic barrels (Fig. 5b). Field tests of nest boxes made out of wood showed that that wood quickly rotted due to high humidity and ambient temperatures. In addition, some of the wooden nests were colonized by bees. Field tests with plastic barrels showed that these did not present these problems. Macaws constantly explore the nest boxes in the pre-release cage, and after release they recognize these nest boxes as familiar objects in the wild.

Fig. 5b. Left: artificial nest in the pre-release cage. Right: artificial nest in the forest. Released macaws may recognize these as familiar objects in the release area. Photos by A. Estrada.

Activities 1-5 listed above are accompanied by systematic behavioral observations of the macaws, both as a group and individually, using scan and focal sampling observation techniques (Fig. 4). Behavioral profiles are built with such data to assess: (a) the degree of social integration of the flock to be released, (b) flight capacity and physical condition, and (c) degree of sociability of individual macaws. Such observations allow us to detect outliers in the flock. Outliers are macaws that may have behavioral issues (e.g., being consistently over-aggressive or not social) and/or physical problems (e.g. poor flight capacity, poor general physical condition). This part of the pre-release

protocol leads to the selection of the individuals to be liberated as the release date approaches. Those macaws retained will continue to be observed to prepare them for a later release.

6) *Aversion experiments towards potential predators and to humans*. These experiments are conducted a week before the release and only once or twice to avoid habituation. The first consists in introducing a potential predator, one at a time (e.g., a coati, an ocelot, and a raptor) into the cage, under control by the handler. In all cases the macaws responded by moving rapidly to the upper part of the cage close to the roof and remaining vigilant. The exposure to the stimuli only lasted 5 min. The second consists of disguising two humans as poachers (long raincoats, rubber boots and large straw hats) and bringing them into the pre-release cage with a bamboo pole that has a large black plastic garbage bag at its end. Upon a silent signal the two men raise the pseudo-nets and simulate attempts to capture the macaws. The response invariably has been of alarm with the macaws rapidly moving to the top of the cage. The experiment lasts about 5 min.

Detailed documentation and behavioral records for each of the six above aspects are stored in relational data bases.

Veterinary care and diet

Veterinary evaluation is made of each macaw at Xcaret before being transported to Palenque. Any individual with concerns is retained. Upon arrival at Aluxes each macaw is given a veterinary examination by the resident vets for general body and plumage condition, ectoparasites and other problems. Once in the pre-release cage, the macaws are regularly supervised by the veterinarians until the day before the release.

The diet of the macaws during their residency in the pre-release cage is similar to that received while in Xcaret, but lower in carbohydrates. It includes fresh fruits and sunflower seeds. The latter replace corn provided in the diet at Xcaret. Dietary consumption is monitored weekly to determine if adjustments are needed due to changing levels of activity by the macaws. After the release, sunflower seeds continue to be provided, along with fresh water, at the feeding platforms in the release cage. The outside gates remain open for macaws to have access 24 hours a day. Sunflower seeds are rich in protein and are not cultivated in the tropics, thus avoiding the possibility of macaws becoming pests to local crops. The macaws accept the seeds readily.

Design of the pre-release and release cage

The prerelease cage was designed with the following criteria in mind: the cage should be large enough to facilitate flight behavior and aggregation of subgroups of macaws in perching locations and to avoid stress from crowding. The cage is 30 m long, 6 m wide and 7 m tall. In addition, the cage has an oblique design to entice the macaws to display maneuvers in flight (Fig. 6). Feeding and water stations are located along the sagittal axis of the cage to promote flight. Attached to the pre-release cage is the release cage where macaws selected for release are placed 24 hours before being liberated. Both cages are connected via two large open gates which open towards the inside of the pre-release cage, if necessary. The release cage has two large open gates at its upper part that remain open after the release to continue food provisioning on feeding platforms located at the top of the cage (Fig. 6).

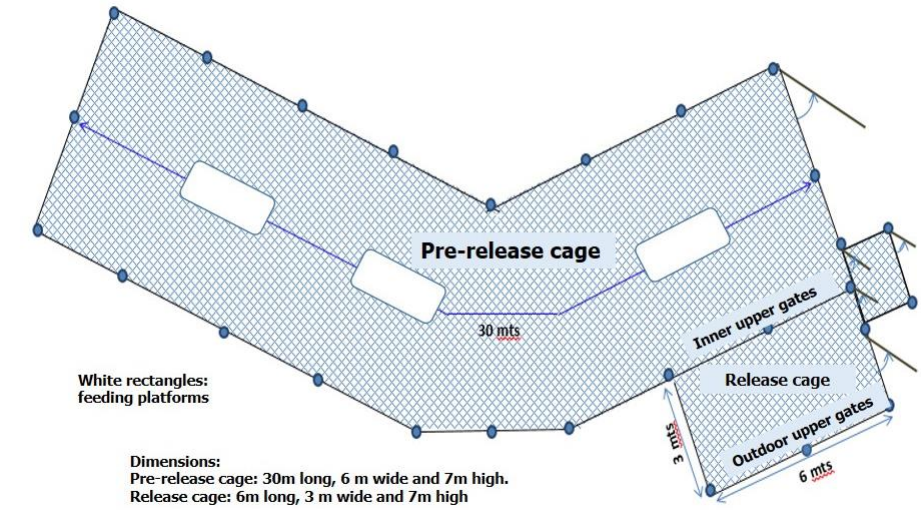

Fig. 6. Top: ground plan of pre-release and release cages. The oblique shape of the pre-release cage allows the macaws to improve flight capacity and maneuvering. White rectangles are feeding platforms.

Bottom: pre-release and release cage in the forest of Aluxes Ecopark Palenque. Note the open gates to the outside of the release gate. Macaws have free access to the interior to feed on provisioned food and water.

Cage dsign by Dr. Juan Cornejo, Dr. Salomon Gonzalez and Dr. A. Estrada.

Cage ground plan modified after original by Maria de Lourdes Silva. Photo by A. Estrada.

Preparing the community-at-large for the release(s)

Broad social support was considered essential for the success of the project. A program to inform and alert local human populations about the reintroduction project was initiated in June 2012. The goal of the program is to incorporate the local inhabitants as partners in this initiative. The on-going program involves a long-term public awareness campaign to rally broad social support for the project and to build social pride in the conservation of the scarlet macaw. Indirect routes used to achieve this are news bulletins, posters/signs, and radio and television programs and interviews. These take place at municipal, state, and federal levels, and also included numerous web reports. Direct routes were talks in local schools and to the public at large, and organized visits by school groups to Aluxes. Additionally, the public is invited to attend the releases, and special attention is paid to specific demographic groups in the population. For example, the sixth release was dedicated to elementary school children of Palenque, from both urban and rural areas, including the Mayan indigenous communities (Fig. 7). Each of the releases have also been attended by high level government officials at the municipal, state, and federal levels, and each is widely announced through mass media channels.

A local composer was asked to write a song about the scarlet macaw. The song is broadly disseminated with each release via local radio/tv stations and in schools. Part of these initiatives was also the creation of the annual scarlet macaw festival. The first was celebrated in April of 2013, two days before the first release of macaws. The second took place in March 2014, coinciding with the fifth release. Other collateral events have been organized by the local division of the Mexican environmental agency (CONANP). For example, the theme of the annual national conservation week (November) was "Conserving the Scarlet Macaw". This involved week-long activities in both urban and rural areas of Palenque.

Fig. 7. Examples of public attendance at three of the releases of scarlet macaws conducted between April 2013 and June 2014. Photos by Maria de Lourdes Silva.

Mechanics of releases

Keeping in mind the well-being of the macaws, releases are only conducted under optimal weather conditions. Once a date is selected for a release, satellite weather maps are regularly reviewed along with weather forecasts to ascertain that conditions will be favorable for the release. If weather conditions are not adequate, the release is postponed one week. Because releases are open to the public to recruit massive social support by sharing the experience, releases are scheduled for Sundays when attendance is maximized. Additionally, all releases are conducted at 10 a.m., when ambient temperatures are not extreme. Twenty-four hours before the event, those macaws selected for release are transferred in the early morning to the release cage. This is done by opening the inner gates of the release gate. Then food is offered to the macaws in the feeding platforms at the top of the release cage. The macaws will invariably move into the release cage to feed. Once all are inside feeding, the inner gates are closed and the flock is contained. The macaws will spend the rest of the afternoon and night there, until 10 a.m. the next morning.

Using veteran macaws to guide the new flock outside

The above procedure was followed for the first release, but in subsequent releases the procedure had the following modification. Forty-eight hours before the release, about 10 free-ranging macaws are captured when going into the release gate to eat the provisioned food. They are captured by closing the outer gates of the release cage. (The rest of the free-ranging macaws are fed outside for the next 48 hours on platforms placed on the roof of the cage.) The 10 captured "veteran" macaws are then released into the pre-release cage to mix with the macaws to be released. Twenty-four hours before release, the entire group of macaws is moved into the release cage. The 10 veteran macaws are the first to leave the release cage when the gates are opened at 10 a.m. on the day of the release. By doing so, they entice the others to follow them and leave the enclosure.

Once the macaws are liberated, the caretakers call the macaws with the sound of a whistle and place the morning rations of provisioned food on the feeding platforms in the release cage, which now has its gates open to the outside. The macaws respond by flying into the release cage to feed. The newcomers follow the veteran macaws back to the release cage where they will co-feed with the others. This allows the newcomers to quickly learn how to return to the release cage where food and water can be found (Fig. 5a).

Immediately after the release, research assistants, veterinarians and animal caretakers at Aluxes Ecopark scan the surroundings for strayed macaws. If any require attention, the macaw is rescued, examined and brought to the pre-release cage where it may spend 24-48 hours in special holding cages under veterinary supervision. Once cleared by the vets, the macaw is released by placing it inside the release cage where it will meet the rest of the flock.

Preparing for post-release monitoring

External temporary marks

All released macaws have a subcutaneous microchip and a leg band with an alphanumeric code. To ensure that post-release monitoring can be performed with a good level of accuracy it has been necessary to have a conspicuous external temporary mark that can be visually distinguished at a distance. This is especially important during the first four weeks after the release, a period critical for survival of recently released macaws.

We experimented with five types of markings: beak marking consisting of thin lines and dots engraved with a dremel and painted with nail polish; stainless steel ball chain collars with a numbered tag; beak marking consisting of a number painted with nail polish on both sides of the beak; and painting coded symbols with nail polish on one of the tail feathers (Fig. 8). Tests were made with these markings in the aviary for two months prior to the release, to ensure that the markings do not affect the behavior of macaws and do not interfere with flight. Beak marking lasted only about 2-3 weeks. Ball chain collars with numbered tags are long-lasting, but it was decided to remove these from the few macaws marked this way to avoid potential hazards. The best and longest lasting markings were those on one of the tail feathers (ventral and dorsal sides). These last about 60 days after the release and are visible at a distance when the macaw is perched and in some occasions in flight. In addition, the mark is quickly and easily placed with less stress for the macaw.

Fig. 8 Temporary markings used in macaws over a period of a year for visually tracking individuals after release. Ball chain collars were removed from macaws after two months of use because of potential hazards. Longest lasting markings were those on a tail feather (both ventral and dorsal sides). Photos by A. Estrada.

Radiocollars

Before the release, some macaws are selected for radiocollar tagging. The functioning of the transmitters is tested before placing them on the macaws. Radiocollars never exceed 3% of the macaws´ body mass.

Post-release monitoring

Post release monitoring is an intensive phase of the reintroduction project in Palenque, using several types of surveys to track different aspects of the behavior of released macaws. These surveys are conducted daily following structured schedules by teams of two research assistants each. Such monitoring is programmed to encompass different time periods of the day and different areas of the release site and beyond (Fig 9). For each survey, sampling protocols have been field tested, detailed, and documented. Information for each type of survey is stored in relational databases.

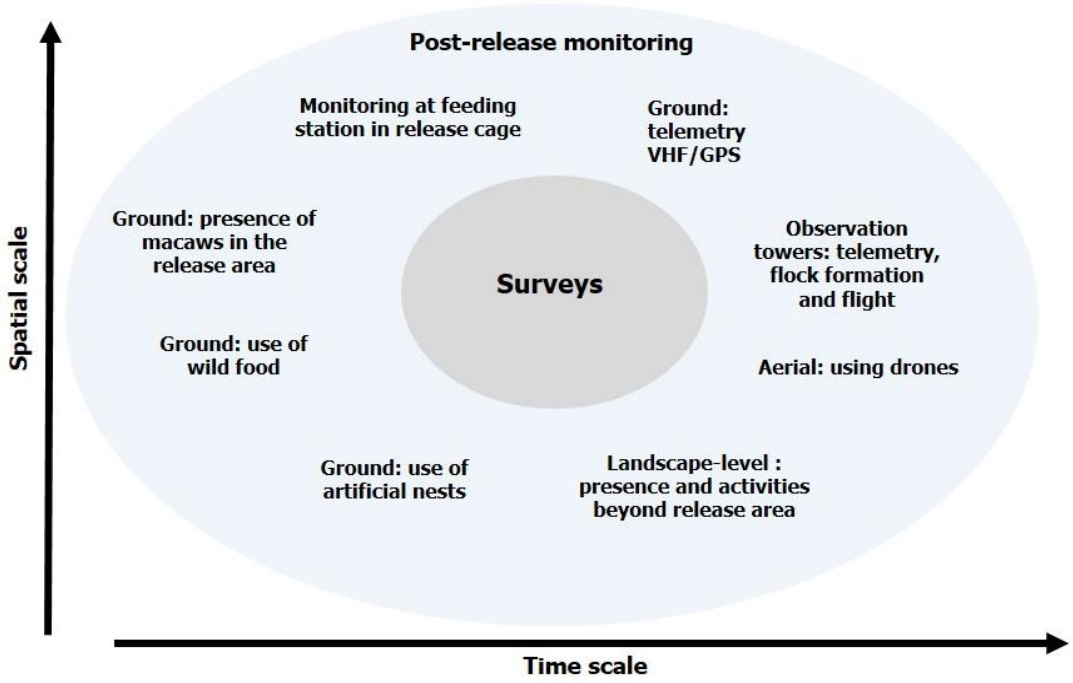

Fig. 9. Diagram showing the key areas involved in post release monitoring of liberated macaws.

Below, we briefly sketch the different techniques used for monitoring the free-ranging macaws

Monitoring at feeding station

The macaws are provided food twice a day, early morning and mid-afternoon. The macaws are called by the sound of a whistle and then a ration of sunflower seeds is spread out on the feeding platforms and water is replenished. The macaw caretaker and a research assistant will count all macaws that come to feed and those that remain outside perching on trees, taking note of macaws with provisional markings on the beak or feathers. On average, about 80% of the released macaws will come to feed then. Others arrive later as evidenced by our sighting records.

Ground surveys to detect presence of macaws in the release site

Daily ground surveys are conducted along 8 km of trails within the grounds of the release site. Every time a macaw or a group of macaws is intercepted during these surveys, a GPS waypoint is recorded along with contextual data such as general activity (feeding, perching, social interactions, flight). If macaws are observed flying, the direction of flight is also recorded.

Ground surveys to monitor use of wild foods by the macaws

Daily surveys along a trail system traversing the grounds of Aluxes are systematically conducted using a pre-designed and pre-tested sampling protocol. Any time macaws are detected feeding on wild food, we record how many macaws are feeding, the plant part(s) being consumed, and the height at which the macaws are found. The observers remain with the macaws until the feeding bout ends. While documenting the feeding bout, the plant source of the food for the macaws is noted. If a tree, the following metrics are obtained: DBH and estimated total height. The tree is marked and GPS positioned. Fresh samples of the plant parts being consumed by the macaws are collected and photographed with an HD camera using standardized botanical protocols. Taxonomic identification is made by using published lists of the flora for the region of Palenque. If identification is not possible, the photographs are sent for identification to a botanist specialized in tropical rainforest flora from the Institute of Biology of UNAM.

Surveys from the observation tower

Monitoring of macaws from a 50 m tall observation tower is conducted daily both in the early morning (sunrise to 10 a.m.) and afternoon (5 p.m. to dusk) in order to track flocks in flight. When these are detected the number of individuals in each flock are counted and the compass direction of the flight is recorded, along with other parameters such as flock shape and spread. During these surveys additional records are made of location of macaw presence and activity detected by sight and sound in the surrounding landscape.

Radiotelemetry tracking

Standard VHF transmitters manufactured by Telenax (www.telenax.com) are placed on selected macaws. Daily monitoring of radiocollared macaws using Yagi antennas is conducted from the observation tower, from dawn to 9 a.m. and from 5 p.m. to dusk. On average we may track four macaws simultaneously with the assistance of two observers. During the session the landscape is scanned with the antennas (one per observer) tuned to preselected frequencies (two transmitters per observer). Scanning for transmitter frequencies is alternated in five minute intervals from one transmitter to the other. When the strongest signal of the transmitter is detected, the compass direction of the signal is noted. If the macaw is on the move, the signal is followed for as long as possible, noting its starting point and compass direction and the point where signal was lost.

Radiocollared macaws are also tracked on the ground survey routes, following a predesigned schedule and a protocol similar to that used for radiotracking from the observation tower.

Use of artificial nests

Artificial nest boxes have been placed in various locations throughout the release area. Selection of trees to place the nest boxes was made following observations and guidelines on artificial nest use by scarlet macaws in Peru by Olah et al. [31], in Guatemala and Belize by Britt [32] and in Costa Rica by Vaughn [33]. Height of 20 trees selected for placing artificial nests was 25.8m ± 4.9m, and DBH was 1.7m ± 0.40m. When choosing the tree, we paid close attention to the degree of connectivity between the focal tree and other trees around it, as this variable may influence vertebrate predation on eggs and chicks [32]. Nest boxes are surveyed every other day both in the morning and in the late afternoon for macaw activity . The number of macaws in or near the nest and behaviors displayed by the macaws are noted (Fig. 5).

Landscape-level surveys beyond the release area

Ground and vehicle surveys are conducted once or twice a week to detect macaws within a perimeter of 10 km from the release site. The area has been divided into four quadrats, following the cardinal points with the release site at its center. Each of the four quadrats is surveyed with the assistance of personnel from Palenque National Park, following a structured schedule. If macaws are sighted flying, the sighting location, direction of flight and number of macaws are noted. If stationary, GPS location, number of macaws and the predominant activity are recorded.

Aerial surveys using drones

DJi Phantom 2 Vision drones (www.dji.com) with a mounted camera are used on selected days to film and photograph aspects of the habitat such as forest cover, overall height of vegetation, and flyways used by macaws (Fig. 10) The drone is also use to obtain visual data on fruiting trees and other aspects of the landscape of the release site and beyond. The drone measures 30cm on each side and 20cm in height. It is only used in areas where at that moment macaws are not present to avoid disturbing their behavior.

Fig. 10. Left photo taken at 100m elevation from the ground by the drone. It shows a segment of the forest of Aluxes Ecopark. White arrow shows the pre-release and release cages. Red arrow indicates the upper structure of the observation tower rising above the forest canopy. Right: DJi 2 Phantom Vision drone with built-in camera. Photo: Araks Onyahan.

Releases conducted between April 2013 and June 2014 and number of macaws released

The program to reintroduce the scarlet macaw in the tropical rainforests of Palenque has been unfolding with success since its implementation (Fig. 11). Between April 2013 and June 2014, we conducted six releases. A total of 92 macaws (51 females and 41 males) were released in that period (Table 1). Average age (August, 2014) of macaws in the released population was 43.2 ± 18.7 months.

Fig. 11. Images of one of the releases and of free-ranging macaws in the tropical rainforests of Palenque. Photos: far left, E. Thomas, middle A. Borgaro, far right A. Dizb.

Seven macaws were lost (2 females and 5 males; three were preyed upon in different occasions by crocodiles in a nearby lagoon when falling to the water during severe rainstorms; one hit a tree branch while flying: cause of death for the other three was undetermined due to the high degree of decay of the body (Table 1).

Considering the number of macaws released and the seven losses, survival at the time of writing of this report was 92%. While such high survival is encouraging, the process of adaptation of the macaws to the wild will take much longer and thus post-release monitoring continues to be essential.

Table. 1. List of releasing events conducted between April 2013 and June 2014.

Date of release event	Number released
21 April, 2013	17
29 June, 2013	11
11 August, 2013	8
14 December, 2013	14
23 March, 2014	25
22 June, 2014	17
Total	**92**
Losses	7
Adjusted total free-ranging	**85**
Surviving	**92%**

Salient achievements

After a year of implementation of the project, progress is substantial. Between April 2013 and June 2014, we released 92 scarlet macaws in the tropical rain forests of Palenque. Only seven losses have occurred up till August 2014, indicating a 92% survival. The project's success to August 2014 is due to careful planning and to the use of a soft release protocol promoting a gradual adaptation of macaws to the wild. The protocol includes a preparation phase for free-ranging life and an intensive post-release monitoring phase using various techniques, technologies, and infrastructure. Food provisioning after release has been an important tool in anchoring the macaws to the release site. The presence of macaws in the pre-release cage waiting for later release has been another stimulus further anchoring the macaws to the release area. Familiarity with the pre-release cage, the macaws´ home for 2-3 months before release, may also act as a strong incentive to stay in the release area. Such enhanced phylopatry promotes a gradual adaptation of the macaws to the wild and allows for daily monitor of the released population at various levels.

A first successful nesting event took place on August 24^{th,} 2014 in the released population of scarlet macaws. A female laid two eggs in an artificial nest box. This suggests that the process of adaptation of the introduced macaws to the wild is proceeding well.

As shown in earlier pages, the reintroduction of the scarlet macaw in Palenque closely follows the IUCN guidelines and recommendations for reintroduction of locally extinct species [13], and more specifically for psittacines [19, 34]. It is our hope that this approach and the outline of the design of the reintroduction project in Palenque will be of use as a general guideline to others interested or involved in reintroductions of macaws in Central and South America.

Three important tangible outcomes of the reintroduction project in Palenque after the first year of implementation are: (1) the scarlet macaw is no longer extinct in Palenque, (2) the number of reintroduced and surviving macaws raises the number of extant macaws in the wild in Mexico by about 34% and (3) the reintroduced population increases the estimated number of macaws existing in Mexico, Guatemala and Belize (*ca* 400; [10-13]) by about 20%.

Importantly, the reintroduction of the scarlet macaw in Palenque will restore a seed and fruit-eating avian species with important consequences for ecosystem functions and processes [35], and will also serve to reconnect people with their natural heritage [15].

Much remains to be done to ensure the persistence of the released population. The participation of the inhabitants of the urban and rural areas of the municipality of Palenque, as well as the support of the municipal, state and federal government, have been and will continue to be crucial to the success of the reintroduction project beyond its first year of implementation. The program of community involvement initiated in June 2012 and running continuously in 2013 and now in 2014 is gradually integrating the population of the municipality of Palenque as key partners in this conservation initiative.

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Appendix 1. Plant families in the diet of *Ara macao cyanoptera* in its indigenous range in Mexico and other Central America.

Plant family	Species used	Number of species used present in the forests of Palenque
Anacardiaceae	4	3
Apocynaceae	3	3
Bignonaceae	2	2
Bombacaceae	4	3
Boraginaceae	3	1
Burseraceae	2	2
Chrysobalanaceae	4	1
Clusiaceae	1	-
Combretaceae	3	2
Eleaeocarpacea	1	-
Euphorbiaceae	3	1
Fabaceae	17	10
Meliaceae	3	3
Moraceae	10	10
Palmae	1	1
Polygonaceae	1	1
Sapotaceae	3	3
Simaroubaceae	1	1
Sterculiaceae	2	2
Tiliaceae	2	2
Verbenaceae	2	-
Total	72	52 (70%)