Post-Graduate Diploma in International Wildlife Conservation Practice – 2016

Independent Research Project

Population viability assessment for reintroduced giant anteater (Myrmecophaga tridactyla) population in Iberá Reserve, Corrientes, Argentina

Abstract

The use of post-release monitoring data in conservation translocation programmes is essential for predicting population trends over time, and for guiding management actions. This study aimed to update a pre-release Population Viability Assessment (PVA) from a giant anteater population reintroduced in Iberá reserve (Corrientes, Argentina), and to determine the availability of suitable habitat for its expansion. Using a 10 year post-release monitoring dataset, vital rates from the reintroduced population were estimated. Telemetry location of reintroduced individuals was used to analyse landscape variables affecting anteater's habitat selection. A map of habitat suitability was developed for the reserve and a potential expansion area, estimating the carrying capacity of suitable habitat. A final PVA was developed using the estimated carrying capacity, in order to compare predicted parameters over 100 years (stochastic growth rate, extinction probability and genetic diversity) with previous scenarios. PVA results from post-release data showed an optimistic overlook of the population in the future, with no need urgent management actions. The population has suitable habitat available for dispersing in the future, even outside the reserve where it is currently distributed. Nonetheless, additional aspects affecting anteater's habitat selection outside the reserve and potential human-wildlife conflict should be assessed in future studies of the population expansion. Recommendations from this study include the development of a well-designed monitoring programme for being applied in short-term PVAs projections, the continuity of a fire management programme inside the reserve, and the constant communication with neighbours to avoid human-wildlife conflict, considering the potential population expansion in the area.

Keywords: Conservation translocation, reintroduction, anteater, post- release monitoring, habitat suitability, population viability assessment

Introduction

Over the last few decades, species conservation translocation – defined as the intentional movement of living organisms from one area to another with primary conservation purposes (IUCN 2013) – has been increasingly used as a conservation approach to reverse species extinction (Ewen et al. 2012). When such translocations occur in areas within a species' indigenous range where the species has been extirpated they are referred to as reintroductions (IUCN 2013).

During conservation translocations, the pre and post-release monitoring of the translocated population are identified as essential steps (IUCN 2013) as they are necessary for adaptive management (McCarthy et al. 2012). Additionally, modelling and predicting the potential outcomes of a conservation translocation before it actually takes place help guide the management strategy chosen. Likewise, post-release monitoring data and its use on demographic models can help improve the predictability of pre-release models and help determine how management decisions may affect demography (Converse & Armstrong in press). Post-release monitoring is essential for reintroduction projects, as it helps making management decisions, assessing the progress towards established objectives, learning and developing models from its information (Nichols & Armstrong 2012). Despite its importance, many reintroduction projects do not carry out an effective post-release monitoring, essential for an adaptive management approach (Nichols & Armstrong 2012).

In order to predict the future status of a translocated population, population parameters (e.g., mortality, reproduction, sex ratio) of the reintroduced animals are required (IUCN 2013), as they will help determine the eventual success of a reintroduction (Converse & Armstrong in press). Usually, model-based risk assessments are used to analyse population viability (Ewen et al. 2012), by estimating the possibility of a population decline over a certain time frame (Burgman 2005). A modelling tool often used to accomplish such predictions is a Population Viability Analysis (PVA), which helps evaluate the best management strategy to achieve proposed objectives and guides management decision-making (Soulé 1987; Lacy 2000).

While demographic parameters and management actions may be key to success within a first post-release phase a reintroduced population (establishment), environmental conditions can be more influential in the later phases (persistence)(Armstrong & Seddon 2008; Tavecchia et al. 2009). The dispersal ability of individuals should be considered for the short and long term viability of translocated populations, as it helps reduce their extinction risk by facilitating access to suitable habitat (Osborne & Seddon 2012) and reduces density-dependent competition near release sites (Le Gouar et al. 2012). Assessing the spatial arrangement of suitable habitats, and the temporal and spatial use, would help us understand and project the species' spatial dispersion (Osborne & Seddon 2012). Also, the estimation of the carrying capacity of the reintroduced population considering suitable habitat available, can help define population viability objectives, identifying limiting factors that could affect the reintroduced population's growth or persistence (Robert et al. 2015).

The Giant anteater and its reintroduction in Corrientes

The giant anteater (*Myrmecophaga tridactyla*), hence referred as anteater, is an endemic mammal of Central and South America, listed as Vulnerable by the IUCN Red List (Miranda et al. 2014). In Argentina the species is also considered as Vulnerable (Diaz & Ojeda 2000) as it has disappeared from much of its original range due to habitat loss and conflict with humans (farm workers kill adults as they are considered dangerous for dogs and take cubs as pets or to sell them illegally (Di Blanco 2014). Anteaters are currently present in Chaco, Formosa, Jujuy, Misiones, Salta, Santa Fé, Santiago del Estero and Tucumán (Miranda et al. 2013) and have disappeared elsewhere; in Corrientes the last sighting records date back to 1986 (Chebez 1994; Pérez Jimeno & Llarín Amaya 2009).

Since 2007, the NGO Conservation Land Trust (CLT) has been working on the restoration of grassland and wetland habitats in the Iberá Natural Reserve (INR) in the core of Corrientes (Jiménez Pérez 2007), as well as on the reintroduction of native species, including the anteater (Jiménez Pérez 2013). The overall aim of the anteater reintroduction programme is to bring this iconic mammal back to the INR and surrounding areas, by establishing viable populations that could later expand to all suitable habitat within the reserve (Jiménez Pérez 2006). The reintroduction programme is based on rescued animals (usually orphan cubs) from elsewhere in Argentina where the species is still present, after a quarantine phase. To date, the CLT has established two new anteater populations: the first one in Socorro and a second one in San Alonso (which is still being supplemented with new individuals), both private reserves within INR. Both populations are showing positive growing rates post release (Jiménez Pérez 2013; Zamboni et al. 2014).

Before the first reintroduction, a recovery plan was developed which included a Population Viability Assessment (Jiménez Pérez 2006). The PVA used hypothetical data (bibliographic sourced and expert meetings) to project population trends under different reintroduction and ensuing management scenarios. The results of the PVA were used in choosing the best management options during the release process, as well as identifying the main factors that could affect the future population persistence. The models suggested that the best management strategy consisted in establishing three subpopulations with some genetic exchange, and to focus on reducing the frequency of bush fires and adult mortality.

Since the model did not use actual population data but expert knowledge and parameters from other wild populations, there may be some uncertainty in its predictions. For instance, mortality and reproductive rates may vary between populations and different environmental conditions (Jimenez Perez 2006). In this regard, a post-release demographic model may be helpful for evaluating the progress of the reintroduction process towards attaining its objectives, identifying any risks that should be taken into account for management, as well as recommending ways to improve previous models.

Along with the PVA, periodical monitoring of the released animals was carried out to identify habitat selection by the reintroduced animals within the Socorro population (Di Blanco 2014; Di Blanco et al. 2015a). The population has no exchange with other populations that we are aware of, since the released animals constitute the first anteater population to be restored in Corrientes. Both populations are being monitored periodically (weekly through all the year), and the Socorro population already counts with a 10 year database of births, deaths, and GPS locations of individuals. This information is useful to explore the potential of post-release monitoring data to improve pre-release models into more realistic and precise estimates.

Objectives and Research Questions

The goal of this study is to help improve the management of reintroduced anteater populations in INR by: a) improving the PVA models using post-release data, b) identifying life history characteristics (e.g., mortality rates) of that should receive special conservation attention, c) predicting potential population growth within INR, and, d) developing a set of recommendations for the reintroduced populations as well as for future reintroduction attempts.

Specifically, the project tries to achieve the following specific objectives:

- Model the probability of extinction of a translocated anteater population, in the short, medium and long-term, using post-release monitoring data to estimate the population current survival and reproductive rates.
- Determine which population parameter is the most influential upon the extinction probability, by evaluating models sensitivity with the increase or reduction of each parameter.
- Predict the potential of the habitat for population expansion, by identifying suitable habitat available and their carrying capacity.
- To make recommendations for the management of the two translocated anteater populations, and other anteater reintroduction attempts, from key management aspects identified during the modelling process.

Methods

Study Area

The Iberá Natural Reserve (INR) in Corrientes was created in 1983 and occupies 13,000km2. Since 1997 the Conservation Land Trust (CLT) has acquired large areas of land from private owners adjacent to the INR's publically owned protected areas. The study area of this project includes the Socorro Reserve (313 km2) (S 28° 32´, W 57° 10´) where anteaters have been reintroduced, as well as potential area for anteater expansion, neighbouring Socorro on its western limit, property of different owners (Fig. 1).

The climate in INR is subtropical with mean temperatures ranging between 15 to 26 °C during winter (July-September) and summer (December-March) respectively (Neiff & Neiff 2006). In Socorro the main terrestrial habitats are seasonally flooded grassland (known locally as Malezales), savannahs with sparse palms and legume trees, open forests with small forest patches and bushes within an herbaceous matrix, and patches of hygrophilous forests with continuous closed canopy - surrounded by either type of savannah (Di Blanco et al. 2015, Fig. 2).

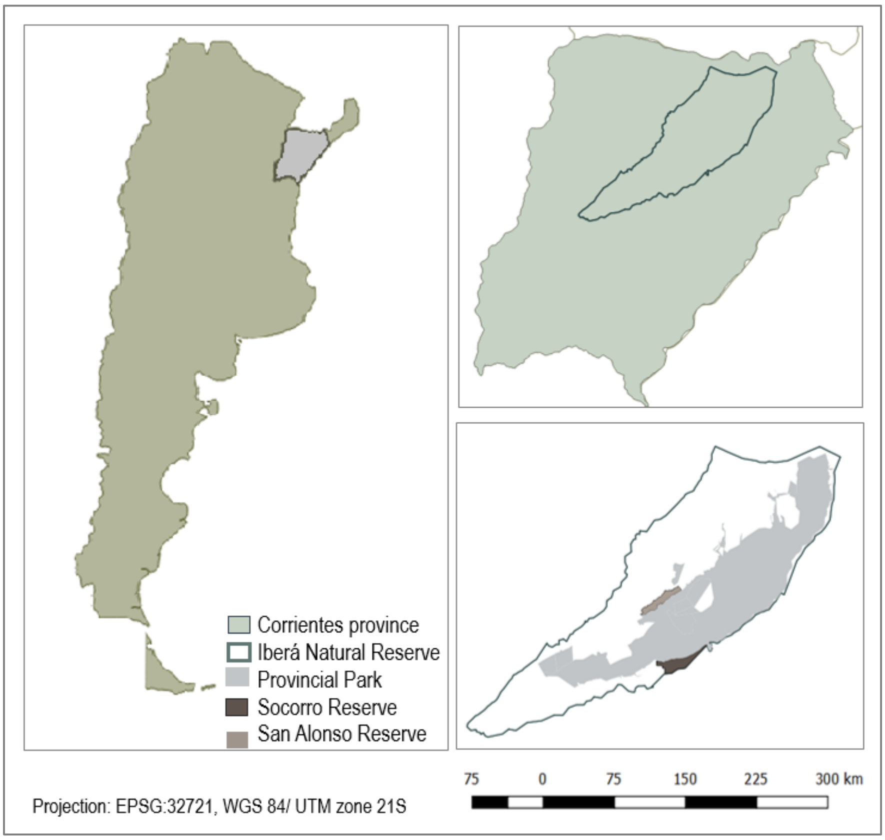

Figure 1. Location of CLT Socorro and San Alonso Reserves, where anteaters have been reintroduced. Both reserves are located near the Provincial Park within Iberá Natural Reserve in the province of Corrientes, Argentina.

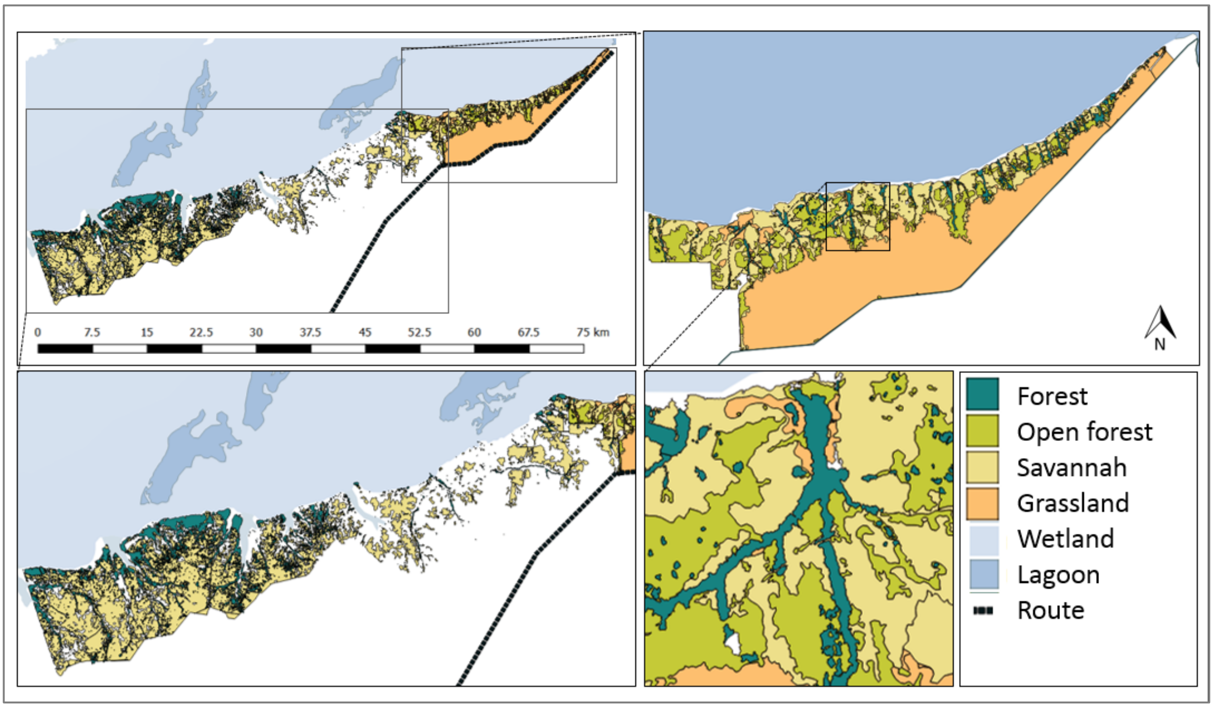

Figure 2 Vegetation classification in four vegetation classes for Socorro Reserve (top right) and the selected area for a potential expansion of anteater population (bottom left) from which habitat suitability was estimated. Detail of Socorro vegetation configuration can be seen in the right bottom image. Classification made by Di Blanco (2014).

Data collection

The reintroduced anteaters were mostly young orphan animals rescued from private households or donated from private or public entities (Bertonatti et al. 2013). The rescued young went through a phase of intensive care and quarantine, and after being checked and deemed to be old enough, a soft release was undertaken in Socorro Reserve (Bertonatti et al. 2013).

Very High Frequency tags including activity and death sensors (Telonics, Mesa, Arizona , USA, www.telonics.com/products/vhfStandard/anteater.php) were fitted to all individuals released using a harness originally designed by Rodrigues et al. (2003) for anteaters in Brazil, but with further modifications made by CLT technicians (Di Blanco et al. 2012). Post-release monitoring consisted of periodical location of the animals with the help of a hand-held antenna. All direct sightings were recorded with a GPS unit (Di Blanco 2014). Mortality sensors helped to detect and locate dead animals quickly, enabling the estimation of death dates with high precision. After at least two years of monitoring, radio tags were removed, partly to prevent wounds resulting from the harnesses and due to the increasing population hindering effective monitoring (Di Blanco et al. 2012).

Wild born individuals, once independent from their mothers, could not be readily monitored since they had no radio-tags. Therefore, as a complement to the telemetry monitoring, trap cameras were installed within the reserve to detect those individuals and assess their status. Cameras (Moultrie® and Reconyx, Inc., Wisconsin, USA) were placed at sites frequently used by anteaters (e.g., forest edges, trails) and were baited with a dietary supplement (fruits, milk, protein sources, etc.) fed to anteaters prior to their release (Di Blanco et al. 2012). As camera locations were opportunistically placed, the data was not suitable for robust data analysis (e.g., occupancy modelling, capture-recapture analysis) but provided information on some individuals' status, especially regarding their survival and/or breeding status (Di Blanco et al. 2012). Overall, the combined use of telemetry and camera trap data allowed to have a 10 year dataset including sex, date of release, number of cubs (for females), dates of deaths, dates of births (for all detected cubs) and sex of some cubs, as well as a wealth of information on which areas were being used by the anteaters.

The initial population released in Socorro in 2007 was supplemented with animals released during seven consecutive years (2007-2013), with no further addition of individuals, and with no exchange of individuals with other populations that we are aware of, since they constitute the first anteater population to be restored in Corrientes.

Data analysis

Population viability analysis (PVA) software Vortex 10 (Lacy & Pollak 2014) was used to simulate the reintroduced population dynamics over 100 years under different scenarios of demographic parameter values. Telemetry and trap camera monitoring data of the reintroduced population were used to estimate the remaining parameters. A post-release population viability model was constructed using estimated parameters from the ten year monitoring of the reintroduced population (Appendix I). For those model parameters for which post-release data were not available, the same values used in the pre-release PVA were applied (Jiménez Pérez 2006).

Sensitivity tests were carried out to determine the influence of each parameter on the population deterministic growth rate and extinction probability, which was later used to make management recommendations on priority factors. The sensitivity tests of the PVA Vortex models to eight parameters (reproduction rate, mortality from age zero to one, mortality from age one to two, mortality after two years, influence of catastrophes on reproduction, influence of catastrophes on survival, frequency of catastrophes and number of supplemented animals) were conducted by changing one of those parameters at a time by ±10% from its original value. Parameter variations were ranked according to their effect on the variation of stochastic growth rates and extinction probabilities.

The demographic parameters of the PVA models were estimated using the following approaches. The % of females breeding was calculated as (Lacy 2000):

Mean number of females that gave birth for each year/
Number of reproductive females for each year

Females were considered to be reproductive from their second year of life (Miranda et al. 2014). To avoid a post-release effect due to translocation stress on vital rates including reproduction (Converse & Armstrong in press), reproduction rate estimates excluded females during their first year of being reintroduced, even if they were of reproductive age. In some cases, females gave birth twice within the same calendar year (e.g., January and December) and did not give birth the following year. In those cases, if the second birth occurred nearly a year apart, we considered them as having occurred in consecutive years. Since reproductive rate values were estimated from reintroduced individuals, and considering that this parameter may be low due to post-release effects, a second scenario increasing this parameter was tested to represent the population in the future with free born individuals.

The mortality of new-born animals (year 0 to 1) was estimated as:

Mean number of dead or missing animals less than 6 months old
in each year /Number of animals born that year

According to bibliography, cubs start their weaning around six months old, and get totally independent from their mothers when they are about nine months to one year old (Valle

Jerez & Halloy 2003). During telemetry monitoring, cubs could be seen on their mother's back or walking alongside until 6-10 months old and then not seen again (only few individuals were seen again on camera traps) as they were not fitted with radio-tags. After their 10th week of life, cubs start to move farther from their mothers for several minutes (Valle Jerez & Halloy 2003), explaining why cubs tend not to be seen on their mother's back during monitoring, even if they have not reached their estimated independence age. For this reason, cubs older than six months when last seen were considered to have survived their first year.

Since none of the cubs born in Socorro were seen after their first year (only one animal was seen as a 20 month old), only reintroduced individuals were considered for this age class estimation. For each year, the number of reintroduced animals>1 and <1.5 years old were considered for the mortality estimate as:

Mean number of dead or missing animals < 2 year old in each year/Number of animals with >1 and <1.5 year old that year

The mortality of adult animals (≥2 year old) was estimated as:

Mean number of dead or missing animals in each year/
Number of animals >2 year old that year

Within Socorro Reserve, a grassland burning regime with different patches burned each year is carried out year round to prevent large uncontrolled wildfires (Di Blanco 2014). Up to the date, no anteater has been reported dead due to these managed fires, and reproduction rate does not seem to be affected by the fires either. Considering large uncontrolled fires are not likely to occur frequently under this management regime, a catastrophe occurrence frequency of 10% and an effect over reproduction of 5% and on survival of 10% were considered for the model. The established frequencies were lower than the pre-release model values (Jimenez Perez 2006) for which a frequency of occurrence of 20% and an impact of 10% and 25% over reproduction and survival respectively, were set.

Initial population size was set at zero. Since the number of supplemented individuals varied at different years of the reintroduction project, an average number of 8 animals (2 juveniles and 2 adults from both sexes) was set as the annual supplementation parameter in the model, extending over seven years as per the reintroduction plan. The carrying capacity was set at 200 individuals as in the pre-release PVA. A further model was set using carrying capacity estimated for the total area (Socorro and expansion area) from the resource selection model explained bellow.

Resource selection and parameter development

A resource selection function was used in order to estimate the availability of suitable habitats for the anteater potential population expansion beyond Socorro reserve limits. The previous habitat selection analysis performed by Di Blanco (2014) was used as a starting point for testing influential covariates on anteater habitat selection, with the addition of new covariates to be tested. Variables considered by Di Blanco to be influential on habitat selection were considered: habitat type and distance to forest. Distance to the points where animals were released used in the previous model, was not included, as this variable was considered to affect only reintroduced individuals, and the resource selection function was intended to represent an established population. Habitat selection was estimated using different landscape parameters from Socorro, and analysing the influence of each variable on the selection of monitored individuals by comparing used versus available habitats.

Telemetry locations (2008-2014) from all monitored reintroduced individuals were used to generate a dataset of anteater habitat use. In order to reduce port-release effect on habitat use, animal locations during their first year of release were excluded. To avoid spatial correlation, only one randomly selected location per day from each animal was considered. Four times as many “available” locations (1163) were randomly selected within an area defined by merging the 1km buffers of all “used” points (4652), excluding areas within 100m from those “used” points. For each used and available point I extracted the parameters for all resource selection function candidate parameters (see below).

I used a vegetation classification map of Socorro developed by Di Blanco (2014), with four vegetation categories: forests, grasslands, savannahs and open forests.

Spatial analysis of Socorro was carried out using Fragstats 4.2.1. (McGarigal 2013), estimating three metrics; forest cover: the sum of the areas (m2) of all patches of forests, divided by total landscape area (m2), multiplied by 100, Contiguity Index: average contiguity value for the cells in a forest patch, and Contrast Weighted Edge Density: the sum of the lengths (m) of each edge segment in the landscape multiplied by the corresponding contrast weight, divided by the total landscape area (m2) and expressed in hectares (McGarigal et al. 2012).

For the variable distance to forest, I used a raster map with the estimate for each pixel. The raster represents the distance of each pixel to the nearest forest boundary.

Resource selection modelling

I analysed the influence of each variable for anteaters habitat selection using binomial Generalized Linear Models (GLMs) (McCullagh & Nelder 1989). Presence data was tested against each variable or combination of variables (continuous variables were standarized) that were tested as explanatory variables, selecting the model with the lowest AIC value (Bozdogan 1987). I used the MuMiN package (Bartoń 2013) to test all possible combination of covariates, and selecting the best model by its lowest AIV value. Average beta coefficients from models with a dAIC<2 were used.

Suitable habitat availability

The area for the reintroduced anteater population potential expansion included a 60km long stretch of land neighbouring Socorro to the West. This includes private lands where predominant activity is cattle ranching, and with no physical boundaries for anteaters movement from Socorro. For this area, available vegetation classification included forests and open forests. Using the best RSF model, I created a raster layer of habitat suitability values for Socorro and the expansion area. Suitable habitat was considered to be all areas with a probability of anteater presence over 0.5. I estimated the total area of suitable habitat for Socorro and expanded region. By extrapolating the carrying capacity of Socorro Reserve/Socorro available habitat, I estimated the carrying capacity of the expansion area. Socorro's carrying capacity was considered to be the mean number of individuals on Vortex simulations after 100 years for the simulated populations that did not become extinct. A second (and more conservative) carrying capacity value was set as the estimated number of animals for year 10 (2016) on Vortex model simulation. The sum of Socorro and expansion area carrying capacity was used to run a new scenario in Vortex, in order to determine the influence of the population expansion on stochastic growth, extinction probability and genetic diversity.

Results

Post-release monitoring data (telemetry and trap cameras) from 31 reintroduced individuals (17 males and 14 females) and from 34 individuals born in Socorro (9 males, 7 females and 18 of unknown sex) were used for population vital rates estimation. A mean of 7.5±3.92 months of monitoring data per individual from animals born in Socorro, and a mean of 3.54±2.76 years of monitoring data per individual from reintroduced individuals were used for vital rates estimation. A total of 1163 points from telemetry data from 27 reintroduced individuals were considered as "used" and a total of 4652 random points were considered as "available" for resource selection function analysis.

Parameter values estimated from monitoring data

Reproduction rate

The age of females when giving birth for the first time ranged from 3 to 9 year old (mean=4.87, SD= 2.1, n=8) (Table 1). Time from the date they were released and their first birth varied between 10-58 month (mean=27, SD=15.2, n=8).

Table 1. Reproductive rate of females reintroduced to Socorro Reserve in Iberá. Percentage of females that gave birth each year in relation to the number of reproductive females each year. In order to avoid post-release effects, females during their first year following reintroduction were excluded.

Year	N reproductive females	N females gave birth	Reproduction rate (%)
2009	2	1	50
2010	3	1	33
2011	5	4	80
2012	5	3	60
2013	8	5	62

2014	8	6		75
2015	8	8		100
2016	8	6		75
			Mean	67
			SD	20

Survival rates

Survival rates for cubs born in Iberá varied in different years from 60% to 100%. The lowest survival value registered (year 2016, Table 2) corresponded to two animals considered dead for the estimates, but for which death was not confirmed (were not seen again before reaching their 6th month of age). A similar range (50% to 100%) was estimated for individuals 1 to 2 year old (Table 3), and a higher survival rate (79% to 100%) for adult animals (Table 4).

Table 2. Survival rate of animals born in Iberá for their first year of life. Percentage of survival rate at each year for cubs born in Iberá. Mean survival rate and Standard Deviation (SD) also shown. Since cubs do not have radio-tags, and most of them are not seen again before reaching their first year (they become independent from their mothers at 6-9 month), individuals older than 6 month when seen for the last time were considered to have survived their first year of life. For each year, the number of individuals that were confirmed to have born were counted (N cubs born). From them, the number of individuals that survived at least their first six months of life and the ones that were confirmed to have died or were not recorded again before they reached six month during that year (N Died). Survival rate was estimated as (N animals that survived/total animals).

Year	N cubs born	N cubs > 6 months old	Died	Survival rate (%)
2009	1	1	0	100
2010	1	1	0	100
2011	4	3	1	75
2012	3	2	1	67
2013	5	4	1	80
2014	6	6	0	100
2015	8	8	0	100
2016	5	3	2	60
Total	33		Mean	88
			SD	14

Table 3. Survival rate of reintroduced animals from age 1 to 2. Percentage of survival rate at each year of individuals from their first year of life to their second year of life within the reintroduced population. Mean survival rate and Standard Deviation (SD) are also shown. For this estimation, only reintroduced animals between 1 to 1.5 years old were considered. For each year the number of individuals from age 1 to 1.5 years were counted, (Total) and from them, the number of individuals that survived to the next year (N Survived) and the ones that died or were not registered anymore (one animal) during that year (N Died). Survival rate was estimated as (N animals that survived/total animals).

Year	Survived	Died	Total	Survival Rate (%)
2008	2	0	2	100
2009	1	0	1	100
2010	2	0	2	100
2011	2	0	2	100
2012	2	1	3	67
2013	1	1	2	50
Total	10	2		Mean 86
				SD 22

Table 4. Survival rate of reintroduced animals after age 2. *Percentage of survival rate for each year for individuals older than two years. Mean and Standard Deviation (SD) of survival rates are also shown. For this estimation, only reintroduced animals were considered, discarding reintroduced animals younger than two years, and including them once they reached two years old. For each year, the number of individuals older than two years within the population were counted, and from them, the number of individuals that survived to the next year (Alive) and the ones that died (Dead) or were not registered anymore (Missing) during that year. Survival rate was estimated as (N animals that survived/total animals).*

Year	Alive	Dead	Missing	Total	Survival rate (%)
2007	2	0	0	2	100
2008	4	0	0	4	100
2009	7	1	0	8	88
2010	10	1	0	11	91
2011	11	3	0	14	79
2012	14	2	1	17	82
2013	15	2	2	19	79
2014	16	0	1	17	94
2015	15	0	1	16	94

Mean	89
SD	8

Supplementation

Since the onset, the Socorro population has been supplemented with 31 animals in seven successive years. The released population was composed of a slightly higher number of males compared to females and individuals <1year old compared to animals >1 year old (Table 5).

Table 5. Number of anteaters translocated to the Socorro population each year since the beginning of the reintroduction project in 2007, to the last supplementation in 2013. Animals that were less than 1 year old and animals that were older than one year when translocated are also shown.

Year	Females	Males	Total
2007	1	1	2
2008	1	3	4
2009	2	1	3
2010	4	3	7
2011	1	4	5
2012	4	3	7
2013	1	2	3
Total	14	17	31
<1 year old	7	11	18
>1 year old	7	6	13

Population viability analysis

The post-release models using the field-based parameter estimates show higher stochastic growth rates compared to the results from pre-release models. Even if non pre-release model was similar to the real population parameters, the scenario considering the release of four males and four females in three releasing sites and reducing the impact of catastrophes to 5% and 15% in reproduction and survival, had the most similar results to the post-release models (Scenario12, Table 6).

Table 6. Pre-release models (3 first scenarios) selected from the ones reported by Jimenez Perez (2006) and post-release scenarios results from 1000 iterations over 100 years. Stochastic growth rate (Stoch-r + SD), Probability of Extinction (PE), mean number of individuals after 100 years (N), Genetic diversity (H) and number of individuals at year 10 (2016, SD). Scenario 1 will be considered as the baseline pre-release model from now on.

#	Scenario	Stoch-r	SD (r)	PE	N	H	N at year 10 (SE)
1	Releasing 12 males and 12 females in one year (baseline)	0.015	0.154	0.18	118	74	35.61 (0.51)
2	Like 1, reducing catastrophes impact to 5% and 15% in reproduction and survival	0.044	0.095	0.01	187	85	43.9 (0.46)
3	Like 1, releasing 4 males and 4 females in three releasing sites and reducing catastrophes impact as model 2	0.081	0.110	0	346	87	17.26 (0.23)
4	Post-release monitoring data	0.095	0.227	0.011	169	83	50.15 (0.76)
5	Post-release monitoring data (rep. rate increased to 72%)	0.116	0.223	0.007	177	85	55.63 (0.86)

Sensitivity tests

Pre-release sensitivity test

For the pre-release PVA model performed by Jimenez Perez (2006), a variation of the effect of fire on anteater's survival was the parameter that affected the most either negatively or positively the stochastic growth rate (Table 7). The mean number of individuals after 100 years from the scenario with reduced fire effect is around 72% higher than the scenario with an increased fire effect and around 25% higher than the baseline model (Fig. 3).

Table 7. Sensitivity test (Vortex) for pre-release PVA model from anteater reintroduction project in Socorro reserve. Stochastic growth rate (SD), extinction probability, number of individuals remaining after 100 year (N-extant+SD) with the variation of different parameters from the baseline model made by Jimenez Perez 2006. Only the three worst and four best scenarios are shown (considering stochastic r).

Scenario	stoch-r	SD(r)	PE	N-extant	SD(Next)
Base post release model	0.0151	0.154	0.18	118	61.70
Effect of fire on survival increased to 33%	0.0005	0.19	0.378	78.64	60.86
Cubs mortality increased to 55%	0.0053	0.15	0.23	87.41	60.86
Reproduction rate deduced to 76.5%	0.0059	0.14	0.229	89.31	61.94
Mortality from 1 to 0 reduced to 6.3%	0.0327	0.13	0.038	158.13	45.87
Reproduction rate increased to 93.5%	0.0384	0.13	0.023	167.9	40.23

Cubs mortality decreased to 45%	0.0389	0.13	0.018	169.04	37.06
Effect of fire on survival decreased to 18%	0.0412	0.10	0.003	183.39	25.71

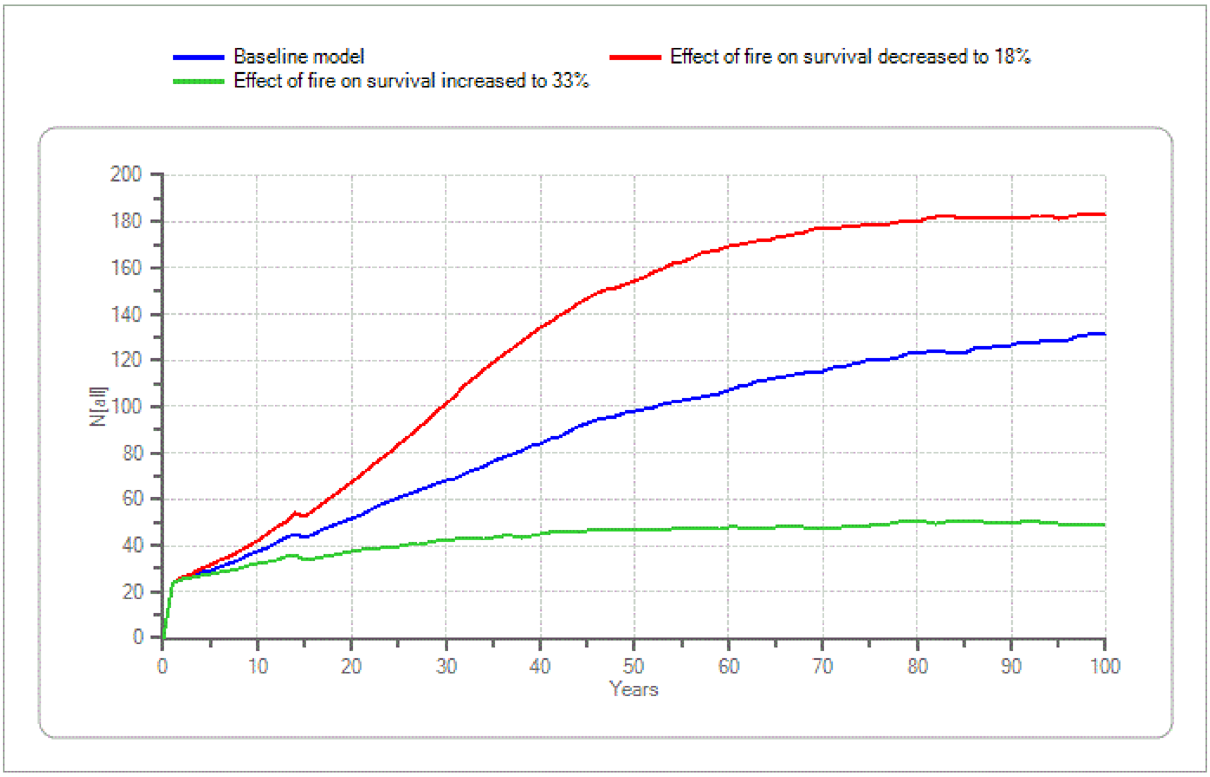

Figure 3. Mean number of individuals over 100 years (mean of 1,000 iterations) thereunder three PVA scenarios: a reduction of fire effect on survival of anteaters, a baseline model (Jimenez Perez 2006) and an increase of fire effect on anteaters survival.

Post release sensitivity test

For the post-release PVA model performed, the reproduction rate was the variable to which the stochastic growth rate was most sensitive to (Table 8). However, under all three scenarios the mean number of animals after 100 years did not vary considerably unlike the stochastic rate (Fig. 4).

Table 8. Sensitivity test (Vortex) for post-release PVA model from anteater reintroduction project in Socorro reserve. Stochastic growth rate (SD), extinction probability, number of individuals remaining after 100 year (N-extant+SD) with the variation of different parameters from the baseline model. Only the four worst and best scenarios are shown (considering stochastic r).

Scenario	stoch-r	SD(r)	PE	N-extant	SD(Next)
Base post release model	0.0899	0.222	0.029	168.61	40.18
Reproduction rate reduced to 60.3%	0.0743	0.2228	0.026	162.27	60.3
Effect of fire on survival increased to 19%	0.0815	0.2290	0.027	161.82	67
Adult mortality increased to 12.1%	0.0852	0.2222	0.01	166.07	67
Cubs mortality increased to 16.5%	0.0896	0.2219	0.006	168.99	40.87
Cubs mortality reduced to 13.5%	0.944	0.2172	0.008	170.61	40.85
Adult mortality reduced to 9.9%	0.1003	0.2167	0.006	176.42	67
Effect of fire reduced to 0	0.1021	0.2211	0.005	173.9	67
Reproductive rate increased to 73,7%	0.1086	0.22	0.003	175.09	73.7

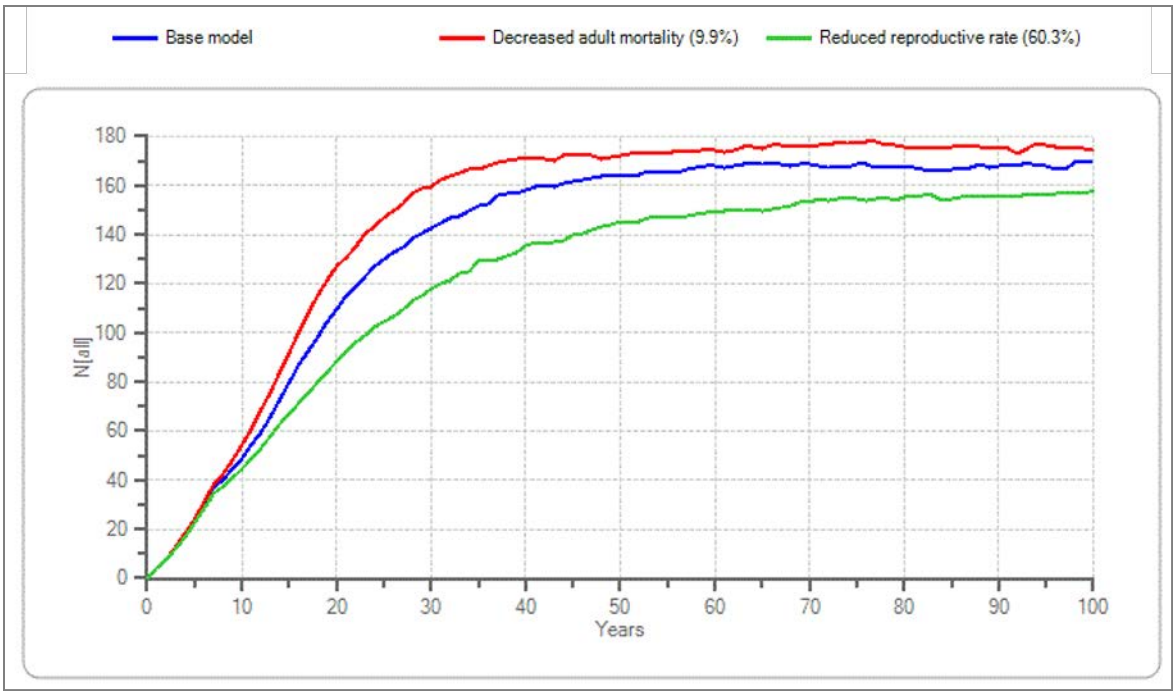

Figure 4. Mean number of individuals over 100 years (mean of 1000 iterations) thereunder three PVA scenarios an increase of reproductive rate of female anteaters, a baseline model and a reduction of reproductive rate of female anteaters.

Habitat selection model

The estimated landscape metrics (% Forest, Distance to Forest, Forest Contiguity and Contrast Weighed Edge Density) were all positively correlated to each other (r>0.6). Therefore only the parameter with the best supported univariate model (lowest AIC) was considered in the multivariate RSF models (distance to forest).

The best model selected suggests a higher preference of anteaters for forests (estimated coefficient=1.41) and, in a lower extent to open forest (estimated model coefficient=0.84), as well as a higher preference to habitats with smaller distances to forests (estimated coefficient=-2.47, Table 9).

Table 9. Generalized linear models tested to explain reintroduced anteater locations on Socorro Reserve. Models are ranked according to their AIC values. DFOREST: Distance to forest border, F: Forest, OF: Open forest, SA: Savana, MA: Grassland, CWED: Contrast Weighted Edge Density, PLAND: Percentage of forest, CONTIG: Forest contiguity.

Model	AIC
DFORESTS + BH + ES	4,385
DFORESTS + BH	4,419
DFORESTS	4,593
DFORESTS + ES	4,594
CWED	4,821

BH	5,145
PLAND	5,342
CONTIG	5,166
MA	5,409
ES	5,735
SA	5,788

Suitable habitat availability

A habitat suitability map was created considering vegetation types in Socorro reserve and the selected potential expansion area, combined with the selected resource selection model. A higher suitability for anteaters can be seen within or around forests, with a lower suitability in open habitats far from forests (Fig. 5). In order to compare high suitable areas in Socorro with the proportion of high suitable areas within the expansion region, areas with anteater preference higher than 0.5 were examined. A total area of 5.5km2 in Socorro (4.8% of total area) and 54km2 in the potential expansion area (18% of considered area) are available (Fig. 6).

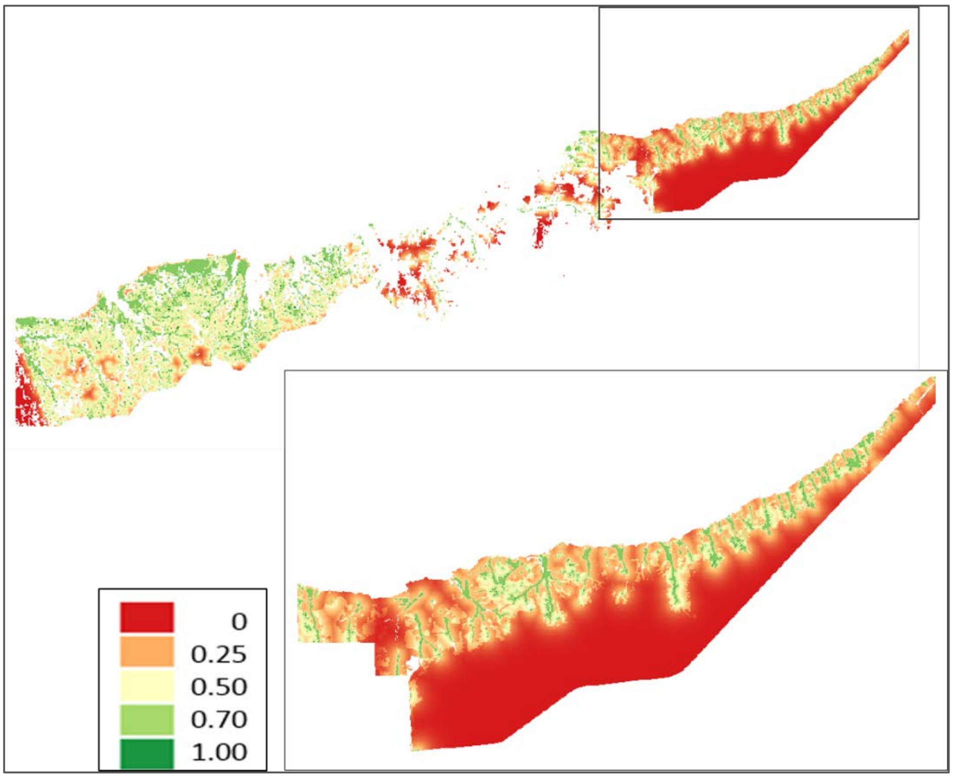

Figure 5. Habitat suitability considering an anteater resource selection model with forest, open forest and distance to forest as covariates for Socorro Reserve (square) and the selected area for a potential expansion of anteater population (left). Areas occupied by forest or surrounding them have higher suitability values, while areas of open habitats far from forests result non suitable.

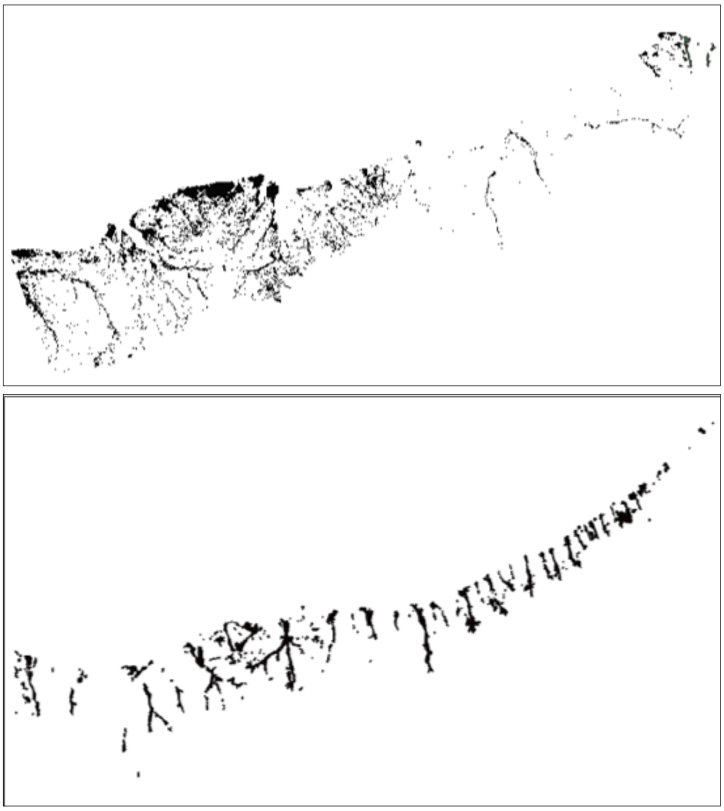

Figure 6. Suitable habitat with anteater habitat suitability index higher than 0.5 for Socorro Reserve (bellow) and the selected area for a potential expansion of anteater population (above).

Carrying capacity for expansion area

Considering Socorro suitable habitat available (5.5km2) and the mean population size (from extant populations after 100 years) in the pot-release PVA baseline model tested (169 individuals), suitable area for potential expansion of the population (54km2) could support an additional 1,644 animals. A more conservative approach, considering as Socorro's carrying capacity the estimated number of individuals at year 10 in the post-release PVA baseline models (50.1 ind), the expansion area could have an additional of 487 individuals.

Running a new PVA models considering new estimated carrying capacities for both areas together (1802 and 510), similar values compared to the post-release baseline model are shown in terms of stochastic growth rate, extinction probability, genetic diversity and population size at year 10 (Table 10). Mean abundance of extant populations after 100 years are higher than the baseline model, but no model reaches the carrying capacity value, suggesting that habitat availability is not the limiting factor for the giant anteater's population growth in the landscape. The post-release model with an increase of reproductive rate has the highest parameters among models (except for the final population size, Table 10).

Table 10. Post release scenarios results from 1000 iterations over 100 years. Stochastic growth rate (Stoch-r + SD), Probability of Extinction (PE), mean number of individuals after 100 years (N), Genetic diversity (H) and number of individuals at year 10 (2016, SD). Baseline model, model considering an increase in reproduction rate, a scenario increasing carrying capacity to 1802 and to 510 are shown.

Scenario	Stoch-r	SD (r)	PE	N	H	N at year 10 (SD)
Post-release monitoring data	0.095	0.227	0.011	169	83	50.15 (0.76)
Post-release monitoring data (rep. rate increased to 72%)	0.122	0.221	0.007	179	86	59.31 (0.87)
Post-release monitoring data carrying capacity 1802	0.097	0.220	0.013	1535	89	51.65 (0.76)
Post-release monitoring data carrying capacity 510	0.097	0.220	0.018	437	88	51.29 (0.77)

Discussion

The findings of this study emphasize the importance of collecting and making use of post-release population data of reintroduced populations, so as to detect factors that are likely to affect the population growth to prioritize them on management actions. Population viability analysis using post-release data showed a more optimistic projection of the population in terms of growth rate, extinction probability and genetic diversity parameters than the pre-release models. Moreover, our findings on habitat preference of reintroduced anteaters and suitable habitat availability, shows the potential of the studied population to expand beyond Socorro reserve with a carrying capacity of over 500 individuals.

Population parameters

Demographic parameters estimated from post-release monitoring data, varied from those used to generate the pre-release model done by Jiménez Pérez (2006). The relatively lower female reproduction rate estimated from post-release data could be related to a post-release effect on individuals. In this sense, an effect of stress on translocated individuals could affect some vital parameters (e.g., survival, reproduction) for a certain period of time after the animal is released, or even throughout its life (Nichols & Armstrong 2012). For this reason, comparing models with and without considering post release effects is recommended to determine whether initial vital rates are actually influenced by post-release effect (Nichols & Armstrong 2012). Even if a higher reproduction rate would be expected in the future from those individuals born in Socorro, monitoring wild individuals in order to effectively measure those parameters would require a high investment of human resources. Such a constraint would also apply to estimating reproductive parameters for any wild anteater population, for which no long-term population studies are available, and vital parameters are not known with precision - in many cases those are estimated from captive individuals (Miranda et al. 2013).

A negative effect on vital rates due to low density (i.e., Allee effect, Courchamp et al. 2008) in reintroduced populations may also explain the lower reproductive rates observed in the study area post-release, especially in the early stages of a reintroduction process (Nichols & Armstrong 2012). In this regard, during the first two years of the project, and due to a small number of reproductive females (two in the first year and three in the second), reproductive rates were considerably low. A low probability of encounter with reproductive males can also explain two more years with low reproduction rates (2012 and 2013). The study performed by Di Blanco (2014) on the reintroduced population evidenced that, even if the home ranges of reintroduced individuals were highly overlapping, a low overlapping between potential mates (reproductive males and females) occurred during those particular years, which could be explained by a low density population.

In terms of mortality, a lower mortality rate was estimated from post-release field data than based on the pre-release models. In this sense, habitat quality and the absence of known predators (Di Blanco 2014) could be positively affecting cubs' survival. Monitoring limitations should be taken into account while interpreting this finding, since the low probability of encountering cubs after 6 to 10 months hinders the ability to effectively determine their survival over their first year of life. Cub mortality may also be overestimated when missing animals are considered dead, when there is no certainty that that is actually the case.

Conversely, a higher estimation of mortality of adult anteaters compared to pre-release models, could also be related with limitations to detect missing animals. In this sense, for instance, individuals considered as dead for mortality estimations consisted of 10 confirmed to be dead and 10 missing individuals which were never relocated (they did not have radio-tags and were not detected on camera traps). As a result, it is quite possible that the mortality rate estimation may have been overestimated. When estimating vital rates from a reintroduced population, detectability should always be considered, and methods such as capture-recapture analysis may help determine detection probabilities to make more robust inferences (Nichols & Armstrong 2012). Furthermore, the fact that adult mortality rates have been estimated primarily on translocated individuals and not on animals born in the wild, a post-release effect could be also considered as being expressed in our parameter estimates. Finally, since most of the released individuals were young adults, the age composition of the released population may not be reflecting the age structure of a natural one, affecting also mortality rates. It is therefore plausible that vital rates from reintroduced populations and the growing trend of those populations in the early stages of a reintroduction project may not reflect the real population, since the reintroduced population's age and sex composition may not be balanced (Nichols & Armstrong 2012).

Sensitivity tests

The parameters ranked as the ones to which both pre and post-release models were more sensitive to, were the same, but they differed in their effect level. This concordance emphasizes the real effect that these parameters have over the reintroduced population growth rate, which conservation actions should target to manage. Pre-release models showed a greater sensitivity to changes in wildfire frequency of occurrence, while post-release models were more affected by changes in female reproduction rates, but to a smaller extent. Even if those factors did indeed affect the population stochastic growth rate parameter, other parameters considered (Extinction probability, genetic diversity, mean population size) remained almost unaltered, suggesting that no variation of extinction probability could be reached by an increase of those parameters, at least in the ranges tested. Similar studies on wild anteater populations in Brazil found other parameters affecting populations (Diniz & Brito 2015). Sensitivity tests showed that changes in mortality rates and sex ratio (that resulted in increasing male representation) were the parameters that affected population growth, extinction probability and genetic diversity most, while increasing catastrophes only affected the extinction probabilities and genetic diversity of small populations (n=150) (Diniz & Brito 2015). This sensitivity of populations to mortality rates variations could be explained by their relatively small size, since demographic stochasticity effects over population growth are inversely proportional to its size, whereas environmental stochasticity may be independent of population size (Lande 1993).

Population Viability analysis

Overall, the post-release models projected a more optimistic outlook for the reintroduced population compared to pre-release scenarios in terms of growth, extinction probability, population size and genetic diversity. Even if we can expect changes in vital parameters over time, the population seems to have a low chance of becoming extinct, and no urgent management actions would seem to be needed. Nonetheless, and due to changes in demographic and environmental variations over time, short period predictions from PVA are recommended over the long-term (i.e. 100 years), in order to avoid larger estimation errors (Beissinger & Westphal 1998). This approach encourages the need of performing a standardized post-release monitoring on the population, in order to estimate its size and status projection over time (Nichols & Armstrong 2012).

Resource selection models

The landscape covariates affecting habitat selection by anteaters agree with the ones used by the previous resource selection model (Di Blanco 2014). The accordance of both model covariates considered emphasize the effect they have on habitat selection by anteaters in Socorro. In this regard, presence of forest and distance to forest were strong habitat selection predictors in both studies, for which the effect of open forests was less marked. However, Di Blanco (2014) also found some differences in habitat selection between sex, age and season, which this study did not examine. The reported preference for forests may be explained as an anti-predator strategy and as a way of preventing thermal stress (Di Blanco 2014).

Even if the same covariates could influence habitat selection by anteaters outside Socorro, and since no anteaters have yet dispersed beyond the reserve boundaries, the effect of other variables cannot be tested. Socorro is a strictly protected reserve with sound management in place; it is worth bearing in mind that factors not present in Socorro could play a critical role in habitat selection by anteaters outside the reserve. For instance, Di Blanco (2014) found that anteaters tended to avoid cattle ranches, probably as a response to the effect of grazing over the ant community.

Suitable habitat availability

The habitat analysis suggests that there is suitable habitat available for the potential future expansion of the anteaters beyond Socorro. However, more information from monitored individuals would be required to ascertain the ability of individuals to disperse to new areas where conservation measures are not as prevalent as in Socorro. The reintroduced individuals must show dispersal and be able to find suitable habitats to guarantee long-term population persistence; such capacity may vary between sex and age classes, and between released individuals versus those born in the wild (Le Gouar et al. 2012).

The eventual dispersal of anteaters outside protected areas may eventually lead to human-wildlife conflict (Le Gouar et al. 2012). The potential expansion area considered for Socorro's anteater population includes a small village of around 30 dispersed households depending on cattle, sheep and horse ranching, where domestic dogs and hunting are not regulated (Di Blanco 2014). While this study did not consider those anthropogenic factors as models covariate due to time constraints, they should be included in any future studies on dispersal and habitat selection by anteaters.

The PVA model representing an expanding population, and using estimated carrying capacity for the whole area, showed no differences in parameters such as stochastic growth rate, extinction probability, gene diversity or abundance on year 10, compared to models using a baseline carrying capacity of 200 individuals. The only parameter that changed substantially was the mean number of individuals in the population after 100 years, which in none of the scenarios reached the carrying capacity. These results suggest that a range expansion could lead to a larger population, but it would not be critical for long-term population persistence of the species as habitat availability does not appear to be a population limiting factor.

A minimum carrying capacity of 200 individuals can be expected for the reintroduced population, based on the availability of suitable habitat inside and outside Socorro. As means of comparison wild anteater population viability analyses in Brazil determined that the smallest demographically stable population (PE<%5) would be of 150 individuals (Diniz & Brito 2015). Considering such a threshold, an expected population size of 168 individuals within 100 years, based in a carrying capacity of 200 individuals, would meet that threshold. And a greater number of individuals would be expected considering habitat availability beyond Socorro limits.

Integrated studies predicting species expansion and patch suitability are of great help for reintroduction projects, either for management or to learn about model predictability (Osborne & Seddon 2012). Post-release monitoring can provide essential information for estimating vital rates of reintroduced populations, which could not be equally estimated from bibliography or from extrapolation based on other populations (Osborne & Seddon 2012). Nonetheless, estimating vital rates from a few individuals (which is usual in reintroduced populations) may lead to imprecise estimates (Nichols & Armstrong 2012). With regard to habitat selection by reintroduced populations, it is necessary to consider not only habitat suitability, but the capacity of individuals to disperse and colonize such habitats (Le Gouar et al. 2012). Irrespective of its huge potential for guiding management actions and learning from predictive models (Armstrong & Reynolds 2012), species distribution modelling has still not delivered strong evidence in terms of precision due to its relatively new application on reintroductions (Le Gouar et al. 2012), stressing the importance of such studies.

Recommendations

From this study, some suggestions for the reintroduced anteater population in Socorro and future efforts can be made.

- Follow up reintroduced animals with a standardized monitoring programme, to better estimates of vital rates such as reproductive rate, mortality rate for each age structure, and sex ratio – all essential parameters for generating population trend predictive models. Assuming that the anteater population will continue to grow, and complete census is not feasible, a greater focus on approaches that account for detection probability (e.g., mark-recapture sampling, a well-designed camera-trap grid) would be advisable.

- The continuation of fire management within Socorro is required to minimize the occurrence of uncontrolled fires.

- The expansion of the anteater population beyond Socorro should be surveyed. For that purpose the suitability map developed here would facilitate the prioritization of survey efforts over areas with higher probability of anteater use.

- The risk of an increase in human-wildlife conflict should be taken into account. Good, regular communication with neighbouring landowners and local villagers will help reducing the probability of anteater being killed.

- A periodic update of PVA models (every 5-10 years) using monitoring data will help in generating more precise population projections and associated management actions.

References

Armstrong DP, Reynolds MH. 2012. Modelling reintroduced populations: the state of the art and future directions. Reintroduction Biology: integrating science and management **12**:165.

Armstrong DP, Seddon PJ. 2008. Directions in reintroduction biology. Trends in Ecology & Evolution **23**:20-25.

Bartoń K. 2013. MuMIn: multi-model inference. R package version **1**.

Beissinger SR, Westphal MI. 1998. On the use of demographic models of population viability in endangered species management. The Journal of wildlife management:821-841.

Bertonatti C, et al. 2013. Oso hormiguero : regreso al monte correntino The Conservation Land Trust Argentina, Ciudad Autónoma de Buenos Aires

Bozdogan H. 1987. Model selection and Akaike's information criterion (AIC): The general theory and its analytical extensions. Psychometrika **52**:345-370.

Burgman M 2005. Risks and decisions for conservation and environmental management. Cambridge University Press.

Chebez JCJCC 1994. Los que se van: especies argentinas en peligro.

Converse SJ, Armstrong DP. in press. Demographic Modeling for Reintroduction Decision-Making in Jachowski, editor. Reintroduction of Fish & Wildlife Populations.

Courchamp F, Berec L, Gascoigne J. 2008. Allee effects in ecology and conservation. Environ. Conserv **36**:80-85.

Di Blanco YE. 2014. Patrones de actividad y de uso de hábitat de osos hormigueros (Myrmecophaga tridactyla) reintroducidos en Iberá, Corrientes, Argentina Universidad de Córdoba.

Di Blanco YE, Jiménez Pérez I, Di Bitetti MS. 2015a. Habitat selection in reintroduced giant anteaters: the critical role of conservation areas. Journal of Mammalogy **96**:1024-1035.

Di Blanco YE, Pérez IJ, Di Bitetti MS. 2015b. Habitat selection in reintroduced giant anteaters: the critical role of conservation areas. Journal of Mammalogy **96**:1024-1035.

Di Blanco YE, Pérez IJ, Díaz P, Spørring YK. 2012. Cinco años de radiomarcaje de osos hormigueros (Myrmecophaga tridactyla): mejoras implementadas y lecciones aprendidas. Edentata **13**:49 - 55.

Diaz GB, Ojeda RA. 2000. Libro rojo de mamíferos amenazados de la Argentina. SAREM (Sociedad Argentina para el Estudio de los Mamíferos), Mendoza:1-106.

Diniz MF, Brito D. 2015. Protected areas effectiveness in maintaining viable giant anteater (Myrmecophaga tridactyla) populations in an agricultural frontier. Natureza & Conservação **13**:145-151.

Ewen JG, Armstrong DP, Parker KA, Seddon PJ 2012. Reintroduction biology: integrating science and management. John Wiley & Sons.

IUCN S. 2013. Guidelines for reintroductions and other conservation translocations. Gland Switz Camb UK IUCNSSC Re-Introd Spec Group.

Jiménez Pérez I. 2006. Plan de recuperacion del Oso hormigero gigante en los Esteros del Ibera, Corrientes.

Jiménez Pérez I. 2007. Participatory planning in large mammal restoration: The esteros de Ibera case in Argentina. Iberian lynx ex-situ conservation. Session 4. Reintroduction of wild carnivores: applicable experiences to the Iberian lynx. , Doñana National Park, Spain.

Jiménez Pérez I 2013. Oso hormiguero: Regreso al monte correntino. , Buenos Aires, Argentina.

Lacy RC. 2000. Structure of the VORTEX Simulation Model for Population Viability Analysis. Ecological Bulletins:191-203.

Lacy RC, Pollak JP. 2014. Vortex: A stochastic simulation of the extinction process. Version 10.0. in Chicago Zoological Society B, Illinois, USA., editor.

Lande R. 1993. Risks of population extinction from demographic and environmental stochasticity and random catastrophes. American Naturalist:911-927.
Le Gouar P, Mihoub J-B, Sarrazin F. 2012. Dispersal and habitat selection: behavioural and spatial constraints for animal translocations. Reintroduction biology: integrating science and management:138-164.
McCarthy MA, Armstrong DP, Runge MC. 2012. Adaptive management of reintroduction. Reintroduction biology: integrating science and management **12**:256.
McCullagh P, Nelder J. 1989. Generalized Linear Models, 2nd edn, Chapman-Hall, London. Standard book on generalized linear models.
McGarigal K. 2013. FRAGSTATS 4.2 Help. University of Massachusetts, Amherst, MA.
McGarigal K, Cushman SA, Ene E. 2012. FRAGSTATS v4: Spatial Pattern Analysis Program for Categorical and Continuous Maps. in Computer software program produced by the authors at the University of Massachusetts A, editor.
Miranda F, Bertassoni A, Abba A. 2013. Myrmecophaga tridactyla. IUCN Red List of Threatened Species.
Miranda F, Bertassoni A, Abba AM. 2014. Myrmecophaga tridactyla. . The IUCN Red List of Threatened Species 2014: e.T14224A47441961.
Neiff J, Neiff A. 2006. Situación ambiental en la ecorregión Iberá. Pages 177-184. La situación ambiental Argentina. Brown, A.,Martinez Ortiz, U., Acerbi, M., Corcuera, J. eds., Buenos Aires, Argentina.
Nichols JD, Armstrong DP. 2012. Monitoring for reintroductions. Reintroduction biology: integrating science and management:223-255.
Osborne PE, Seddon PJ. 2012. Selecting suitable habitats for reintroductions: variation, change and the role of species distribution modelling. Reintroduction biology: integrating science and management **1**.
Pérez Jimeno G, Llarín Amaya L. 2009. Contributión al Conocimiento de la Distributión del Oso Hormiguero Gigante (Myrmecophaga tridactyla) en Argentina. Edentata **8**:8-12.
Robert A, Colas B, Guigon I, Kerbiriou C, Mihoub JB, Saint-Jalme M, Sarrazin F. 2015. Defining reintroduction success using IUCN criteria for threatened species: a demographic assessment. Animal Conservation **18**:397-406.
Rodrigues F, de Miranda GB, Medri Í, dos Santos F, Mourão GdM, Hass A, Amaral PT, Rocha FL. 2003. Fitting radio transmitters to giant anteaters (Myrmecophaga tridactyla). Edentata **5**:37-40.
Soulé ME 1987. Viable populations for conservation. Cambridge university press.
Tavecchia G, Viedma C, Martínez-Abraín A, Bartolomé M-A, Gómez JA, Oro D. 2009. Maximizing re-introduction success: assessing the immediate cost of release in a threatened waterfowl. Biological Conservation **142**:3005-3012.
Valle Jerez Sd, Halloy M. 2003. El oso hormiguero, Myrmecophaga tridactyla: crecimiento e independización de una cría. Mastozoología Neotropical. Sociedad Argentina para el Estudio de los Mamíferos Tucumán, Argentina **10**:323-330.
Zamboni T, Albuín R, Galetto E, Pérez IJ, Antúnez B, Delgado A, Blanco YD, Masat M, Peña J, Solís G. 2014. Proyecto de recuperación del oso hormiguero gigante en la Reserva Natural Iberá: Informe de resultados y actividades.

Appendix I

Parameters used in the pre-release (Jimenez Perez 2006) and post-release PVA model for the reintroduced anteater population in Socorro Reserve, Corrientes. Parameters that were not updated were remained as the pre-release PVA values. Parameters marked with an asterisk were updated.

Parameter	**Previous PVA**	**Post release PVA**
Number of iterations	1000	1000
Years	100	100
Endogamic depression	No	No
EV in reproduction and mortality concordant	Yes	Yes
Mating system	Poligynus	Poligynus
Minimum reproductive age	2 years	2 years
Maximum reproductive age	15 years	15 years
Mean number of progeny per breeding	1	1
Sex ratio of progeny (female: male)	1:1	1:1
Density dependent reproduction*	No	No
Reproductive adult females*	85%	67%
Reproductive adult males	100%	100%
Mortality for age 0 to 1 (EV)*	50% (5%)	12% (14%)
Mortality after age 1 on (EV)*	8% females (1%), 7% males (1%)	14% females and males
Catastrophe (wildfire) frequency*	20%	10%
Catastrophe impact on reproduction*	10%	5%
Catastrophe impact on survival*	25%	10%
Carrying capacity	Subpopulation 1=200	Subpopulation 1=200
Harvesting	No	No
Supplementation (reintroduction)	Yes	Yes