# PARROTS, GOATS AND SUN: POPULATION DYNAMICS OF THE YELLOW-SHOULDERED AMAZON PARROT (*AMAZONA BARBADENSIS*) IN BONAIRE ISLAND, DUTCH ANTILLES

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# Foreword

With the new status of special municipality Bonaire's development aims have focused toward more efficient sustainable policies. With centuries of human intervention, ecosystem degradation, pressure of invasive species and tourism industry, services associated to biodiversity are threatened by developmental needs. The Amazona barbadensis parrot is of special conservation concern due to the taxa vulnerability to habitat degradation and poaching and its small range restricted to Bonaire and Northern Venezuela. We ask whether the spatial development plan of Bonaire (ROB) for the coming years have an either a positive or negative effect on the parrot population in the island. We used METAPHOR, an individual-based stochastic model in order to estimate the population for the next 200 years. We use two cases, poaching and no poaching, and four scenarios, Current, 2 scenarios contemplated in the ROB and one scenario of goat control or vegetation recovery that change nest availability. For all the scenarios the model showed great stability around the year 100. Reducing poaching and controlling goats increased each one around a 50% of the population being additive. The ROB scenarios did not increase the population size or made it lower. The estimated population size under current condition was ~1800, increasing poaching to 50% diminished this valued until The poaching didn't affect the age structure, while increasing poaching until 50% diminished the population size 1000 individuals while increasing nests to 130 increased the population size to 3000. The estimated survival of 87% for fledges and adults showed to be the most optimistic case in the sensitivity analysis warning about the real status of the population and the high uncertainty of the model. The control of the invasive goats have been a conservation success in other islands and showed to have the best outcome for the modelled population. Whether it is control of goats or vegetation restoration, increasing vegetation cover would embrace conservationist and economic aims providing habitat for plant and animal communities and a providing more valuable services for terrestrial ecotourism.

Keywords: Amazona barbadensis, Bonaire, population dynamics, land planning, invasive species, poaching, vulnerable.

# Summary

With the new status of special municipality Bonaire's development aims have focused toward more efficient sustainable policies. With centuries of human intervention, ecosystem degradation, pressure of invasive species and tourism industry, services associated with biodiversity are threatened by developmental needs. The *Amazona barbadensis* parrot is of special conservation concern due to the vulnerability to habitat degradation and poaching and its small range restricted to Bonaire and Northern Venezuela. We ask whether the spatial development plan of Bonaire (ROB) for the coming years has an either positive or negative effect on the parrot population in the island. We used METAPHOR, an individual-based stochastic population model in order to estimate the population trend for the next 200 years. We use two cases, poaching and no poaching, and four scenarios, Current, two scenarios contemplated in the ROB and one scenario of goat control and vegetation recovery that changes nest availability.For all the scenarios the model showed great stability around the year 100.Reducing poaching and controlling goats increased the population in each scenario with c. 50%. The ROB scenarios did not increase the population size or made it significantly lower, as only the (minor) impact on carrying capacity was taken into account. The estimated population size under current conditions was ~1800. Increasing poaching to 50% diminished this valued until 1000 while the poaching didn't affect the age structure. Increasing availability of nests to 130 raised the population to 3000. The used survival of 87% for fledges and adults showed to be the most optimistic case in the sensitivity analysis warning about the real status of the population and the high uncertainty of the model. The control of the invasive goats has been a conservation success in other islands and showed to have the best outcome for the modelled population. Whether it is control of goats or vegetation restoration, increasing vegetation cover would favour conservationist and economic aims providing habitat for plant and animal communities and providing more valuable services for terrestrial ecotourism.

# Introduction

The BES islands, Bonaire, Saba and Saint Eustatius are special municipalities of the Caribbean part of the Kingdom of the Netherlands. The islands form part of the Caribbean global biodiversity hotspot area (Myers et al., 2000, Wunderle 2008) on the basis of their species richness and high level of endemism. Over 210 species of birds have been recorded from the former Dutch Antilles,167 of these from the BES islands, the vast majority being migrants, winterers, and occasional vagrants (Prins et. al, 2009). The BES islands are classified as Important Bird Areas (IBAs) for conservation according to BirdLife International (BirdLife, 2011). The breeding status of 17 species have been used to classified it as IBA, including the Yellow-shouldered Amazon *Amazona barbadensis*, American Flamingo *Phoenicopterus ruber*,the Pearly-eyed Thrasher *Margarops fuscatus* and several hummingbirds and tern species(See appendix 1).

Islands are home to ecological communities with relatively little diversification, simplified trophic webs and high rates of endemism, making them highly susceptible to disturbances and extinctions due to their isolation and difficulties in colonization (Courchamp& Chapuis, 2003). Whereas natural extinction in islands is not rare, the introduction of alien species in islands has added a component to these biodiversity losses and ecosystem perturbations (Sax &Gains 2008, Blackburn et al. 2004). Feral goats are particularly destructive to island ecosystems. Introduced goats are responsible for the impacts on island floras altering the structure and composition of plant communities, accelerating soil erosion and causing secondary extinction of native fauna impoverishing the local ecosystem services (Hata et al 2010, Donlan et al. 2007, Hamman 2003, Debrot &Freitas, 1993, Courchamp and Chapuis, 2003, Campbell & Donlan 2005).

The yellow-shouldered Amazon parrot (*Amazona barbadensis*)in Bonaire is of special conservation concern. Just for the Amazona species, 16 (52%) are threatened with extinction (Snyder et al., 2000; BirdLife, 2011). For *A. barbadensis*the current estimate of total population size is between 2500 and 10,000 individuals and the species is considered globally vulnerable (BirdLife, 2011). The parrot is restricted to the northern mainland of the Venezuelan coast, the Venezuelan islands of Margarita and La Blanquilla, and the island of Bonaire. In Aruba, it is now considered extinct (Forshaw 2010, Collar 1992). There are around 650 individuals left in Bonaire(BirdLife, 2011). Habitat loss and capture for the pet trade ("poaching") are the main causes of decline in many parrot populations (Wright et al 2001, Collar 2000) but also introduced mammals are an underestimated cause(Snyder et al., 2000; Engeman 2006, Blackburn et al 2004).

Several attempts have been made in the last 10 years in order to study and conserve the parrot populations resulting in different reintroduction, nursery programs and population viability analysis as well (Williams 2008, Sanz& Rodriguez-Ferrao 2006, Sanz 1998, Rodriguez 2004). Studies in the Venezuela population show that poaching of chicks is one of the main factors for the population decline. As an important economic activity in the 80's and 90`s,poaching reached up to 60% of extraction per year, placing the species as locally endangered (Sanz& Rodriguez-Ferrao 2006).Recent studies in the Bonaire population show similarities to the Venezuelan population except for scarce poaching information (Williams 2008). Even though collection of wild parrots has been illegal on Bonaire since 1952,over 600 captive parrots were found as pets in the island(Montanus, 2003).

Cavity-nesting species, as the yellow-shouldered Amazon parrot , are limited by cavity supplying forests for their reproduction (Newton 1994). While the quantity of cavities is determined by coverage of primary forest that brings enough trees with adequate height and diameter, quality is more complex (e.g. shape, size, depth, surrounding habitat,etc.) but has a straight influence on population size (lommus & Remm, 2004 Remm et al. 2008). Felling of trees in Bonaire (in particular *Haematoxylonbrasiletto, Zanthoxy lumflavum and Guaiacum officinale*) was an important activity since colonial times until the second half of the twentieth-century when land clearings for infrastructure and tourism were developed (De Freitas et al. 2005). The former jointly with the presence of invasive grazers such as goats and donkeys for centuries have stopped the potential regeneration of the vegetation cover, maintaining large parts of the island in a degraded secondary scrub state(Debrot &Freitas 1993), unsuitable for parrot nesting.

The aim of this study is to compare the effects on the population of *Amazona barbadensis*of Bonaire's spatial planning with alternative management scenarios, using a population model. We ask:

Which scenario increases the population size compared to the current state?

Whether the age structure is affected by poaching or not

What is the relationship between percentage of poaching and population size?

How does the number of nests (cavities)affect the population size?

How doeschange in survival values of adults and fledges affect the modelled population?

# Methods

The BES islands, Bonaire, Saba and Saint Eustatius are part of the recently declared especial municipality of the Caribbean part of the Kingdom of the Netherlands. Bonaire is located in the Southern Caribbean Sea (between 68º11′ and 68º25�much W and 12º2‛ and 12º19‛ N) about 87 kilometres north of the coast of Venezuela and 40 kilometres east of Curaçao (Fig. 1). The region has a semi-arid climate with rainfall below 500mm/yr with an average of 463mm/yr. Rainfall on the island is seasonal, with the last three months of the year accounting for 51% of the long-term annual average. With an area of 288 km$^2$, Bonaire is similar to other arid areas of the Caribbean and American continent corresponding to ‘tropical deciduous forest’ and ‘dry evergreen woodland’. On the other hand, St.Eustatius and Saba are smaller than Bonaire with 21 and 13km$^2$respectively, around 700 km apart from Bonaire being part of the arc of the Lesser Antilles. Both are located at the Köppen classification between a savannah- and monsoon-climate with an average rainfall of1072.7 mm peryear (De Freitas et al 2000).


Figure 1. Location of the BES islands in the Caribbean sea (picture from STENAPA 2009)

**Selecting species**

We made alist of avifauna of the BES islands (Appendix 1) and classified according to different criteria: UICN red lists, Birdlife Society, CITES, Convention of Migratory species and Dutch Red-lists. We chose *Amazonabarbadensis* because of(1) its restricted area compared to the other species, (2) itbeinga resident species of the BES islands, (3) the vulnerability status, (4) it's targetofextraction (“poaching”), (5) presence of long-term reproductive data and other vital rates.

**The model, demographic Data and Parameter Values**

We use METAPHOR in order to simulate the population trend of the *Amazonabarbadensis* for the next 200 years. METAPHOR is an individual-based population model that describes the spatial and temporal dynamics of a metapopulation in discrete time and in the landscape. The model is stochastic andthe population is monitored once a year. In between years, the individuals have a chance to reproduce, age and die. For the Bonaire population, we chose to regard the entire island population as one, unfragmented population, because of the home range size of the birds compared to the size of the island.The model is described in detail elsewhere (Verboom et al. 2001; Vos et al. 2001; Schippers et al 2009; Verboom et al. 2010).

The demographic values were taken from previous work on Bonaire, Margarita and Blanquilla Islands in Venezuela. These parameters don't differ significantly between them (Williams S, 2008) but we use Venezuelan parameters because these include poaching information. Population size estimates and breeding pairs were initiated according to data of Sam Williams in Bonaire (Williams S, 2008). The carrying capacity is limited by the number of available nests (cavities used for breeding)i.e. the size of the breeding population. No other density dependence effects were introduced in the simulations for the survival and recruitment parameters . We considered three age classes: chick, fledge, adult. Fledges have the same survivorship as adults but they don´t breed (Table 1). Survival parameters were recalculated from Sanz& Rodriguez-Ferraro (2006) with poaching "mortality" of 27.5% and other mortality of 20.6%. The captured individuals are removed from the population and they don't contribute with siblings for the next years. We made 50 simulations in each scenario

We distinguish two cases: with poaching and without poaching, that differ in chick survival (Table 2). In each case we compare four different scenarios that mainly involve change in the number of suitable nest holes(Table 2).The Current scenario has the current estimated number of nests. ROB 1 and ROB 2, the current policy scenarios, are based on the spatial development program for Bonaire to 2025, this management plan is based on the Dutch "Beleidsprogramma Biodiversiteit 2008-2011" and Nature Policy, both recognize an urgent need for management to ensure sustainability exploitation and protection of biodiversity and are developedto reduce the impact of this development on nature (ROB 2010).

ROB Scenario 1 assumes possible developments such as new homes, new residence and recreation buildings, expansion of industrial estates in different locations; upgrading of some roads and redevelopment of two sandy beaches. Scenario 2 is a complement, it assumes new residential areas and preconditions for a golf course. (See appendix 2 for maps of the scenarios)."No goats", is the restoration or conservation scenario which increases nest quantity or quality in the area classified as "Open Landscape" in the ROB. In this scenario we assumed a progress in vegetation recovering as we have seen in Galápagos islands (Hamman 1993) with an annual increase of 1.18% since the year 10 to year 39 to simulate gradual recuperation of the area and the population. Each scenario changes the number of nests suitable for the parrot in function of the modified area. For the calculation of the number of nests in each scenario we use nest density estimated with survey areas and nest numbers in Margarita Island in La Chica Creek (~18km$^2$). Areas of the ROB map were estimated with the software Image J.

**Table 1 Parameters of the Yellow shouldered parrot model**

| | | |
|---|---|---|
| **Initial Population size** | 650 | Williams S, 2008 |
| **Initial Breeding population** | 146 | Williams S, 2008 |
| **Chick Survival** | 51% (s.d. ±0.11) | Average Poaching mortality (27.5) and other mortality (20.6) from Sanz& Rodriguez-Ferraro (2006) |
| **Fledge survival** | 87% | Average of min and max of the interval in Rodriguez et al 2004 |
| **Adult survival** | 87% | Average of min and max of the interval in Rodriguez et al 2004 |
| **# Chicks hatched per breeding female** | 3.09 (s.d. ±0.92) | Sanz& Rodriguez-Ferraro (2006) |
| **Nest density** | 1.8 /km2 | estimated from Sanz& Rodriguez-Ferraro (2006) |
| **Femate/male ratio** | 1:1 | Rodriguez et al. 2004 |

The age structure was compared for the poaching and no poaching case in the year 100 when the population size stabilizes in the model. Sensitivity analyses were done in order to know how the population size was affected by modification of the poaching intensity, survival of the age classes and the number of nests. The Poaching “Current” scenario was chosen as default for the sensitivity analyses, changing poaching from 10 to 50%, survival of adults and fledges from 40 to 87% separately and additionally changing both, adults and fledges, at the same time with the same value from 40% to 87%. Differences between the median of the groups were tested with the non parametric test of Kruskall-wallis

**Table 2 Cases and Scenarios**

| | | |
|---|---|---|
| **Poaching** | Chick survival as in Table 1 | |
| **No poaching** | Chick survival 79% (0.06) | Recalculated from Sanz& Rodriguez-Ferraro (2006) |
| **Current** | # of suitable nest holes as Table 1 | |
| **ROB 1** | Reduces habitat ~1km$^2$. | See appendix 2 ROB (2010) |
| **ROB 2** | Destroys potential habitat ~9.5 km$^2$ | See appendix 2 ROB (2010) |
| **No goats** | Increase of potential habitat in ~33km$^2$ | |

and a multiple comparison test (z´) was done in order to find out the different groups with α=0.05.

# Results

In general terms, reducing poaching and controlling goats increases c. 50% the population size each one Fig2). There are no significant differences between the ROB sc1 scenarios and the Current scenario due to the small amount of nests reduced by this scenario of development (Fig 2). The worst scenario was poaching and ROB Sc2 where the effect of poaching and the reduced amount of potential habitat for the parrot results in a  population of around 1300 individuals. A considerable positive effect is seen when the goats are controlled, in this case the  increase in number of nests has a strong impact on the population size due to its direct effect on the number of breeding pairs in the model. Contrary to what was expected the age structure was not affected by the poaching intensity when the population size stabilized at year 100 (Fig 3). This can be explained by the fact that the data show the surviving, not poached chicks and in relative terms there is a fixed ratio between the age classes (see Fig. 2).

Variation of poaching intensity decreases significantly the population size (K-W: H=87.53; p<<0.001) with a minimum of 1000 when annual extraction of chicks is 50% of the produced by the population(Fig 4). There are significant differences between the nest categories (K-W: H=131; p<<0.001). As expected, the number of suitable nest holes affect directly the population size, showing a lineal trend due to the fact that no extra density dependence was introduced in the model, i.e. survival and number of chicks hatched per nest were density independent (Fig 4). There are significantly differences between the groups evaluated in the sensitivity analysis of survival of fledges (K-W: H=111.56; p<<0.001), adults(K-W: H=107.43; p<<0.001) (Fig5). A significant effect was found when both parameters were changed at the same time (K-W: H=51.56; p<<0.001), 70% of survival is enough to maintain  a viable population but below that the population would decline to extinction (Fig 5).

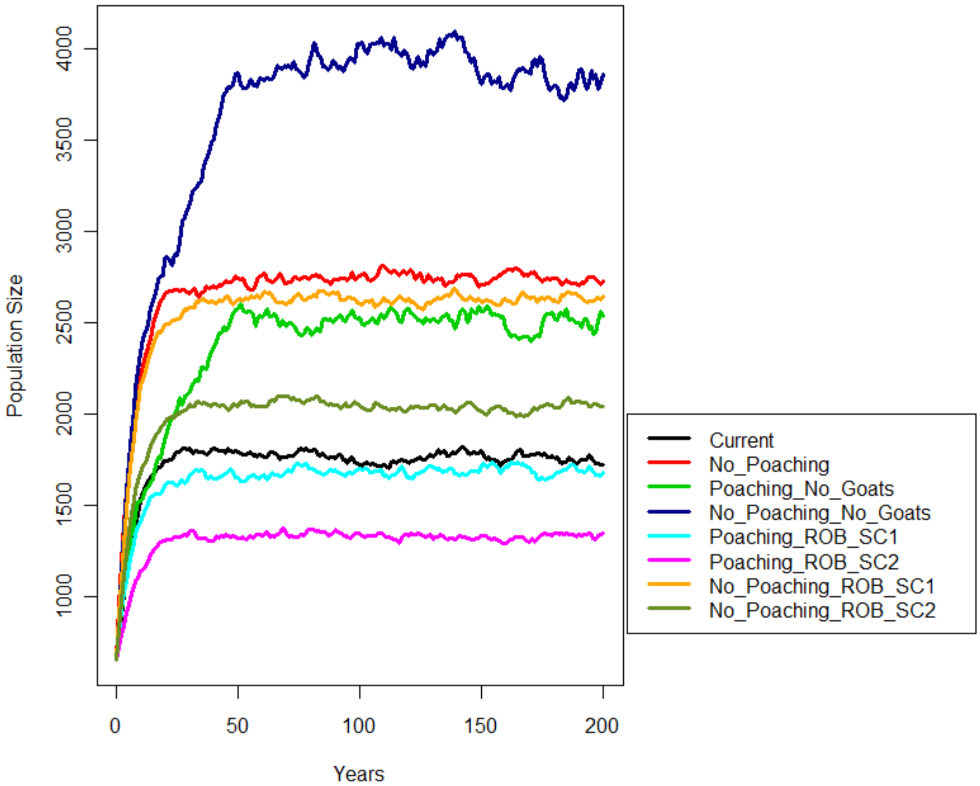

Figure 2. Average population trend under the different scenarios with 50 simulations.

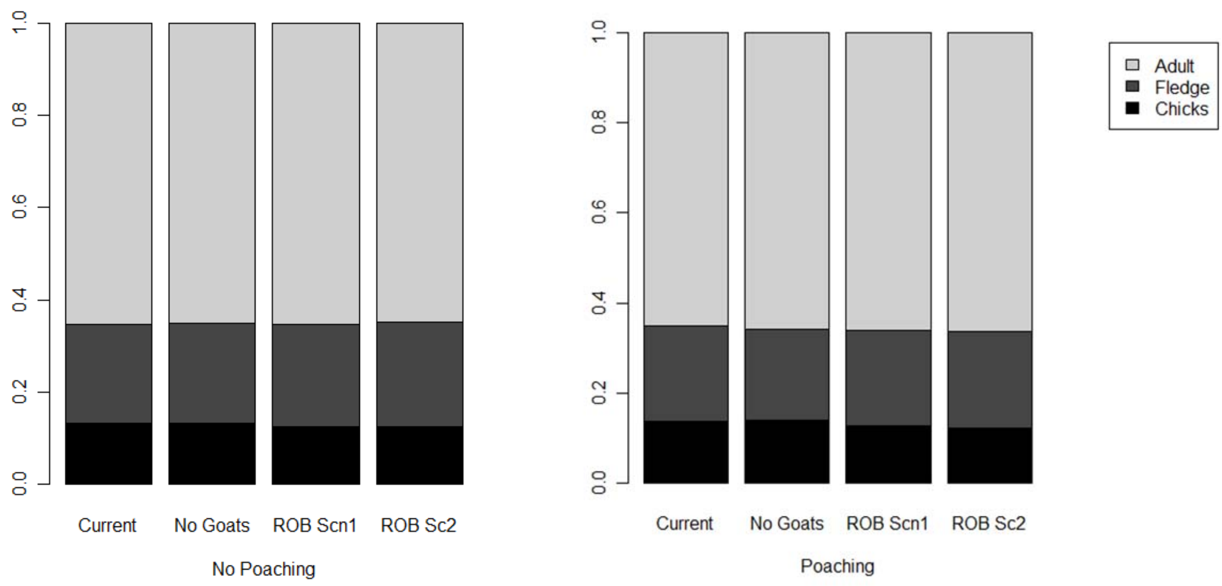


Figure 3. Average structure of ages at year 100 in the different scenarios with poaching(right) and without poaching (left). Chicks refers to the surviving, non-poached chicks.

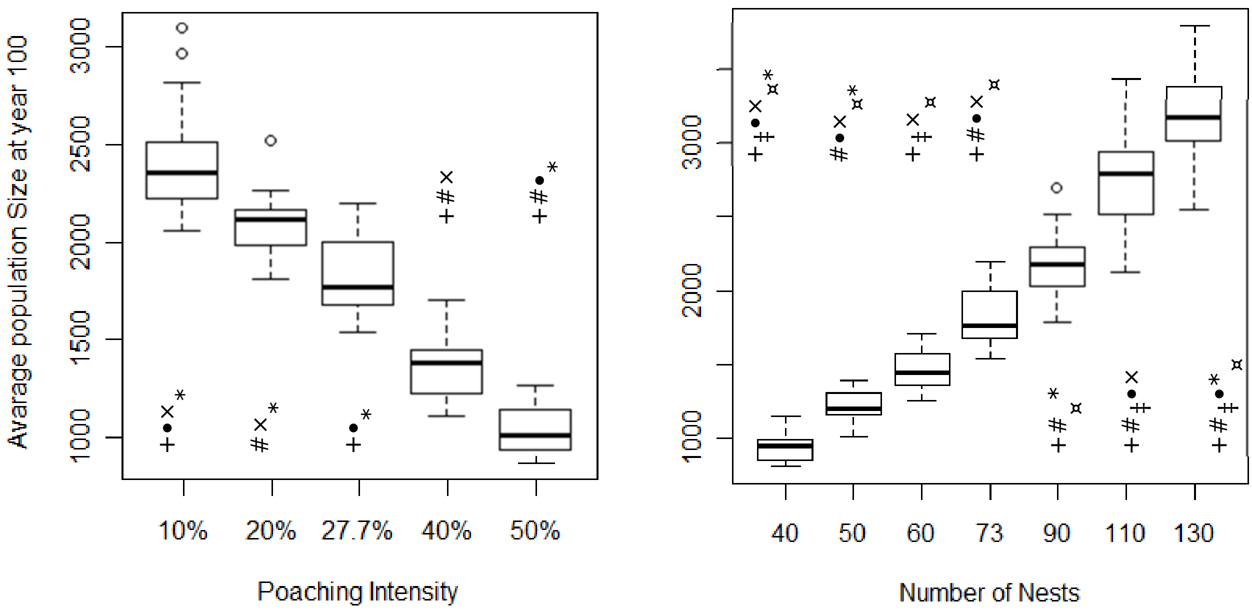


Figure 4. Sensitivity of population size of the population of *Amazona barbadensis*in Bonaire according to METAPHOR when poaching (Left) and number of suitable nests (right) is modified. Groups significantly different at 0.05 show the same symbol. Poaching at 27.5% and 73 nests are the estimated current values for the species, and are used in the simulations as default values.

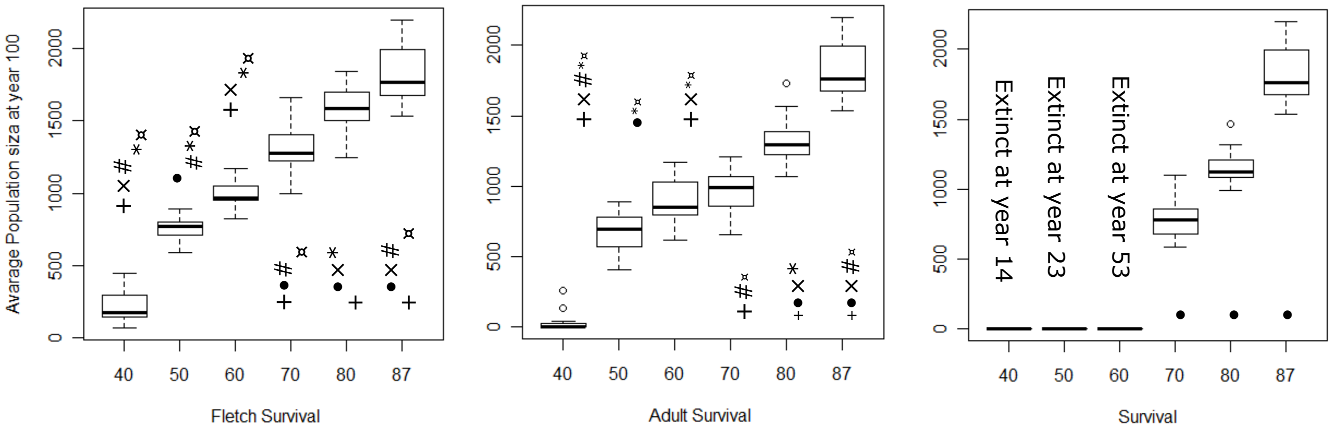


Figure 5. Sensitivity of population size of *Amazona barbadensis* in Bonaire according to METAPHOR when survival of, fledges (left), adults (centre) and both (right) are modified. The 40% simulations in the central graph got extinct before the year 100. Significant differences at 0.05 are shown with the same symbol.

# Discussion

The combination of reduction of poaching and increasing the number of suitable nest holes doubled the current population in the model compared from the current scenario. The ROB scenarios didn´t contribute to the population increase unless is coupled with reduction of poaching or increasing number of nests. While the population size was affected in the model, the age structure was unaffected. The average population size was affected by adult and fledge survival

Our model is partially a simplification of what would be the population behaviour under current conditions. Simplification is a necessity to understand crucial factors that affect the population. Here, population sizes are uncomparable to the natural populations because does not include the enormous variability and complexity of the natural populations. A more close to reality model would include interactions with other species such the competition with *Margarops fuscatu*s and predation by natural and invasive species. More precise scenarios would include better area estimation and parrot density and effects of climate change and extreme environmental events that have shown to be important for the Amazona genera (White Jr, et al 2005, Rodriguez & Rojas-Suarez 1994, Williams S. 2008). Despite the simplification our model shows important effects of different scenarios and the assumed survival and additional similarities with other works.

The population of *Amazona barbadensis* showed a considerable viability under the model assumptions despite the small population size and poaching. Previous PVA's have showed similar trends showing that poaching above 60% puts in risk the persistence of the species for the following 100 years (Rodriguez & Rojas-Suarez, 1994, Rodriguez et al., 2004). This apparent stability has to be taken with caution because the growth rate of the population is slow and survival of adults and fledges are estimated from scarce data, then there is a considerable uncertainty, underestimating random or catastrophic events in the population(Rodriguez & Rojas-Suarez, 1994, Thompson 2004, Beissinger 2008).The uncertainty is also introduced by both adult and fledge assumed survival because there is no empirical information available of natural mortality. Adult survival only is available for Parrotlet *Forpus passerines* that is around 50% (Sandercock et al., 2000). As has been shown by the sensitivity analyses the current sensitivity assumption of fledge and adult survival of 87% show that more empirical research is needed to estimate vital parameters of adults and fledge.

In our model the "No Goats" scenario represents conservation initiatives that improve quantity of nests assuming that all nests were occupied, however, this numbers would be optimistic and should be taken cautiously because of the habitat differences between Margarita and Bonaire islands and the low rates of cavity occupancy. It is known that just a small percentage of cavities in an area are occupied by cavity nester birds around the world (Brightsmith, 2005;Cockle et al 2008, 2010;Aiken&Martin 2004)and *A. barbadensis* in Bonaire is not the exception, occupying only 30% of the available cavities in the studied area (Williams 2008).Then, where cavities appear to be abundant there may be a shortage of high quality cavities (Lohmus& Rehms2004) or some other factor seems to be limiting the population.

Despite foster nests have been the most successful method for the species compared with captive breeding and nest boxes (Briceño-Linares et al, 2011, Sanz et al 2003, Sanz&Grajal 1998), it does not ensure the persistence of the population without intervention and is highly dependent of funding and organizational restructuring, putting in risk the continuation of the conservation program as already happened in 2000 in Venezuela (Briceño-Linares et al, 2011). Then long-term planning with scarce intervention and alternatives for poaching are needed to ensure the persistence of the population.

Since Bonaire is a touristic island, its economy is highly dependent of external parties (Abel T, 2003). Bonaire's ecotourism depends on environmental attributes like water quality, fish and bird diversity among others that determine the tourist's willingness to visit the island (Uyarra et al 2005, Urraya et al 2009). Then it is clear that increasing biodiversity threats such as the invasive mammals (Reaser et al 2007), new invasive species such as the dacetine and ghost ants(Wetterer 2011 , 2009), urban development, increasing human population (ROB 2010) and climate change (Debrot &Bugter, 2010) will affect these attributes in different manners and put in risk Bonaire's economy. In this work we evaluated how much of the spatial planning for the coming 15 years would help in the recovering of one of the most endangered bird species of the former Dutch Antilles, the *Amazona barbadensis*, a charismatic parrot species. Using population simulations we discuss alternative scenarios of land planning that could achieve sustainability aims in Bonaire.

Even when tourists prefer Bonaire because of marine attractiveness rather than because of its terrestrial landscapes(Uyarra et al 2005), there is an important opportunity for terrestrial ecotourism and biodiversity conservation if land planning focuses on restoration of vegetation cover. Twofold benefits would offer the restoration of vegetation by controlling goats. On one hand, investment in landscape could raise the willingness to pay of tourist and would bring enough revenues to maintain protected areas as has been demonstrated for marine protected areas in Bonaire (Thru 2010). On the other hand, the increase in vegetation density would assist in long-term conservation of local species and ecosystems, not just the yellow-shouldered parrot, and at the same time would enhance natural succession and habitat quality for the local fauna (Donlain, 2007, White et al 2005).

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## Apendix1

| Common Name | Scientific name | Saint-Eustatius | Saba | Bonaire | UICN Class | CITES | RedList-Dutch Antilles | BES endemics | CMS | Birdlife |
|---|---|---|---|---|---|---|---|---|---|---|
| American Cliff Swallow | Petrochelidonpyrrhonota | no | yes | yes | LC | no | no | no | no | no |
| SpottedSandpiper | Actitis macularius | yes | yes | yes | LC | no | no | no | no | no |
| Wood Duck | Aixsponsa | no | yes | no | LC | no | no | no | no | no |
| Yellow-shoulderedAmazon | Amazonabarbadensis | no | no | yes | VU | I | yes | Netherlands Antilles | no | yes |
| Grasshopper Sparrow | Ammodramussavannarum | no | no | yes | LC | no | no | Subspecies | no | no |
| NorthernPintail | Anasacuta | no | no | yes | LC | no | no | no | no | no |
| American Wigeon | Anas americana | no | no | yes | LC | no | no | no | no | no |
| White-cheekedPintail | Anasbahamensis | no | no | yes | LC | no | no | no | no | no |
| NorthernShoveler | Anasclypeata | no | no | yes | LC | no | no | no | no | no |
| Blue-wingedTeal | Anasdiscors | no | no | yes | LC | no | no | no | no | no |
| Mallard | Anasplatyrhynchos | no | no | yes | LC | no | no | no | no | no |
| Black Noddy | Anous minutus | no | no | yes | LC | no | no | no | no | no |
| Brown Noddy | Anousstolidus | no | no | yes | LC | no | no | no | no | no |
| Greylag Goose | Anser anser | no | no | yes | LC | no | no | no | no | no |
| Chuck-will's-widow | Antrostomuscarolinensis | no | yes | yes | LC | no | no | no | no | no |
| Brown-throatedParakeet | Aratingapertinax | no | yes | yes | LC | II | yes | Subspecies | no | no |
| Great Blue Heron | Ardeaherodias | no | no | yes | LC | no | no | no | no | no |
| RuddyTurnstone | Arenariainterpres | yes | no | yes | LC | no | no | no | no | no |
| BurrowingOwl | Athene cunicularia | no | no | yes | LC | II | no | no | no | no |
| LesserScaup | Aythyaaffinis | no | no | yes | LC | no | no | no | no | no |
| Ring-necked Duck | Aythyacollaris | no | no | yes | LC | no | no | no | no | no |
| UplandSandpiper | Bartramialongicauda | no | no | yes | LC | no | no | no | no | no |
| CattleEgret | Bubulcus ibis | yes | yes | yes | LC | no | no | no | no | no |

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|---|---|---|---|---|---|---|---|---|---|---|
| White-tailed Hawk | Buteoalbicaudatus | no | no | yes | LC | II | yes | no | no | no |
| Red-tailed Hawk | Buteojamaicensis | yes | yes | no | LC | II | yes | no | no | no |
| StriatedHeron | Butorides striata | no | yes | yes | LC | no | no | no | no | no |
| Green Heron | Butoridesvirescens | yes | yes | yes | LC | no | no | no | no | no |
| Sanderling | Calidris alba | yes | no | yes | LC | no | no | no | no | no |
| Dunlin | Calidris alpina | no | no | yes | LC | no | no | no | no | no |
| Baird'sSandpiper | Calidrisbairdii | no | no | yes | LC | no | no | no | no | no |
| Red Knot | Calidriscanutus | no | no | yes | LC | no | no | no | yes | no |
| White-rumpedSandpiper | Calidrisfuscicollis | no | no | yes | LC | no | no | no | no | no |
| Stilt Sandpiper | Calidrishimantopus | no | no | yes | LC | no | no | no | no | no |
| Western Sandpiper | Calidrismauri | no | no | yes | LC | no | no | no | no | no |
| PectoralSandpiper | Calidrismelanotos | no | no | yes | LC | no | no | no | no | no |
| LeastSandpiper | Calidrisminutilla | no | yes | yes | LC | no | no | no | no | no |
| SemipalmatedSandpiper | Calidrispusilla | yes | no | yes | LC | no | no | no | no | no |
| White-tailedNightjar | Caprimulguscayennensis | no | no | yes | LC | no | no | Subspecies | no | no |
| NorthernCrestedCaracara | Caracaracheriway | no | no | yes | LC | II | yes | no | no | no |
| Great Egret | Casmerodius albus | no | yes | yes | LC | no | no | no | yes | no |
| Veery | Catharusfuscescens | no | no | yes | LC | no | no | no | no | no |
| Grey-cheekedThrush | Catharusminimus | no | no | yes | LC | no | no | no | no | no |
| Swainson'sThrush | Catharusustulatus | no | no | yes | LC | no | no | no | no | no |
| Chimney Swift | Chaeturapelagica | no | no | yes | NT | no | no | no | no | no |
| CollaredPlover | Charadriuscollaris | no | no | yes | LC | no | no | no | no | no |
| PipingPlover | Charadriusmelodus | no | no | yes | NT | no | no | no | no | no |
| SnowyPlover | Charadriusnivosus | no | no | yes | LC | no | no | no | no | no |
| SemipalmatedPlover | Charadriussemipalmatus | no | no | yes | LC | no | no | no | no | no |
| Killdeer | Charadriusvociferus | yes | no | yes | LC | no | no | no | no | no |
| Wilson's Plover | Charadriuswilsonia | no | no | yes | LC | no | no | no | no | no |

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|---|---|---|---|---|---|---|---|---|---|---|
| Black Tern | Chlidoniasniger | no | no | yes | LC | no | no | no | no | no |
| Blue-tailed Emerald | Chlorostilbonmellisugus | no | no | yes | LC | II | yes | no | no | no |
| LesserNighthawk | Chordeilesacutipennis | no | no | yes | LC | no | no | no | no | no |
| Common Nighthawk | Chordeiles minor | no | no | yes | LC | no | no | no | no | no |
| Bonaparte'sGull | Chroicocephalusphiladelphia | no | no | yes | LC | no | no | no | no | no |
| Black-headedGull | Chroicocephalusridibundus | no | no | yes | LC | no | no | no | no | no |
| Ruby-topazHummingbird | Chrysolampismosquitus | no | no | yes | LC | II | yes | no | no | no |
| Yellow-hoodedBlackbird | Chrysomusicterocephalus | no | no | yes | LC | no | no | no | no | no |
| Brown Trembler | Cinclocerthiaruficauda | yes | yes | no | LC | no | no | LesserAntilles | no | no |
| Yellow-billedCuckoo | Coccyzus americanus | yes | no | yes | LC | no | no | no | no | no |
| Grey-cappedCuckoo | Coccyzuslansbergi | no | no | yes | LC | no | no | no | no | no |
| Mangrove Cuckoo | Coccyzus minor | no | yes | yes | LC | no | no | no | no | no |
| Boat-billedHeron | Cochleariuscochlearius | no | no | yes | LC | no | no | no | no | no |
| Bananaquit | Coerebaflaveola | yes | yes | yes | LC | no | no | Subspecies | no | no |
| Common Pigeon | Columbalivia | no | no | Introduced | LC | no | no | no | no | no |
| Scaly-napedPigeon | Columbasquamosa | yes | yes | yes | LC | no | no | no | no | no |
| Common Ground Dove | Columbinapasserina | yes | yes | yes | LC | no | no | no | no | no |
| RuddyGround Dove | Columbinatalpacoti | no | no | yes | LC | no | no | no | no | no |
| Olive-sidedFlycatcher | Contopuscooperi | no | no | yes | NT | no | no | no | no | no |
| Eastern Wood Pewee | Contopusvirens | no | no | yes | LC | no | no | no | no | no |
| Smooth-billed Ani | Crotophaga ani | yes | yes | no | LC | no | no | no | no | no |
| Groove-billed Ani | Crotophagasulcirostris | no | no | yes | LC | no | no | no | no | no |
| Red-leggedHoneycreeper | Cyanerpescyaneus | no | no | yes | LC | no | no | no | no | no |
| Black-belliedWhistling Duck | Dendrocygna autumnalis | no | no | yes | LC | III | no | no | no | no |

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|---|---|---|---|---|---|---|---|---|---|---|
| FulvousWhistling Duck | Dendrocygnabicolor | no | no | yes | LC | III | no | no | no | no |
| American YellowWarbler | Dendroica aestiva | no | no | yes | LC | no | no | no | no | no |
| Black-throated Blue Warbler | Dendroicacaerulescens | no | no | yes | LC | no | no | no | no | no |
| Bay-breastedWarbler | Dendroicacastanea | no | no | yes | LC | no | no | no | no | no |
| CeruleanWarbler | Dendroicacerulea | no | no | yes | LC | no | no | no | no | no |
| MyrtleWarbler | Dendroicacoronata | no | no | yes | LC | no | no | no | no | no |
| Yellow-rumpedWarbler | Dendroicacoronata | yes | no | no | LC | no | no | no | no | no |
| Prairie Warbler | Dendroicadiscolor | yes | yes | no | LC | no | no | no | no | no |
| BlackburnianWarble r | Dendroicafusca | no | no | yes | LC | no | no | no | no | no |
| Magnolia Warbler | Dendroica magnolia | no | no | yes | LC | no | no | no | no | no |
| Palm Warbler | Dendroicapalmarum | no | yes | yes | LC | no | no | no | no | no |
| Chestnut-sidedWarbler | Dendroicapensylvanica | no | no | yes | LC | no | no | no | no | no |
| YellowWarbler | Dendroicapetechia | yes | no | yes | LC | no | no | Subspecies | no | no |
| Blackpoll Warbler | Dendroica striata | no | yes | yes | LC | no | no | no | no | no |
| Cape May Warbler | Dendroicatigrina | yes | yes | yes | LC | no | no | no | no | no |
| Black-throated Green Warbler | Dendroicavirens | no | no | yes | LC | no | no | no | no | no |
| Bobolink | Dolichonyx oryzivorus | no | yes | yes | LC | no | no | no | no | no |
| Little Blue Heron | Egrettacaerulea | yes | yes | yes | LC | no | no | no | no | no |
| ReddishEgret | Egrettarufescens | no | no | yes | NT | no | no | no | no | no |
| SnowyEgret | Egrettathula | yes | yes | yes | LC | no | no | no | no | no |
| TricoloredHeron | Egretta tricolor | no | no | yes | LC | no | no | no | no | no |
| LesserElaenia | Elaeniachiriquensis | no | no | yes | LC | no | no | no | no | no |
| Caribbean Elaenia | Elaeniamartinica | yes | yes | yes | LC | no | no | yes | no | yes |
| Swallow-tailedKite | Elanoidesforficatus | no | no | yes | LC | II | no | no | no | no |
| Green-throatedCarib | Eulampisholosericeus | yes | yes | no | LC | II | yes | LesserAntilles | no | yes |
| Purple-throatedCarib | Eulampis jugularis | yes | yes | no | LC | II | yes | LesserAntilles | no | no |

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|---|---|---|---|---|---|---|---|---|---|---|
| AntilleanEuphonia | Euphoniamusica | yes | yes | no | LC | no | no | LesserAntilles | no | no |
| Merlin | Falcocolumbarius | yes | yes | yes | LC | II | yes | no | no | no |
| PeregrineFalcon | Falcoperegrinus | no | no | yes | LC | I | yes | no | no | no |
| American Kestrel | Falcosparverius | yes | yes | yes | LC | II | yes | no | no | no |
| MagnificentFrigatebird | Fregatamagnificens | yes | yes | yes | LC | no | no | no | no | no |
| American Coot | Fulica americana | no | no | yes | LC | no | no | no | no | no |
| Caribbean Coot | Fulicacaribaea | no | no | yes | NT | no | yes | no | no | yes |
| Wilson's Snipe | Gallinagodelicata | no | no | yes | LC | no | no | no | no | no |
| Common Gallinule | Gallinulagaleata | no | yes | yes | LC | no | no | no | no | no |
| Gull-billedTern | Gelochelidonnilotica | no | no | yes | LC | no | no | no | no | no |
| Common Yellowthroat | Geothlypistrichas | no | no | yes | LC | no | no | no | no | no |
| BridledQuail-Dove | Geotrygonmystacea | yes | yes | no | LC | no | no | LesserAntilles | no | yes |
| American Oystercatcher | Haematopuspalliatus | no | no | yes | LC | no | no | no | no | no |
| Worm-eatingWarbler | Helmitherosvermivorum | no | no | yes | LC | no | no | no | no | no |
| Black-necked Stilt | Himantopus mexicanus | no | no | yes | LC | no | no | no | no | no |
| Barn Swallow | Hirundo rustica | yes | yes | yes | LC | no | no | no | no | no |
| CaspianTern | Hydroprognecaspia | no | no | yes | LC | no | no | no | no | no |
| Baltimore Oriole | Icterus galbula | no | no | yes | LC | no | no | no | no | no |
| VenezuelanTroupial | Icterus icterus | no | no | Introduced | LC | no | no | no | no | no |
| YellowOriole | Icterus nigrogularis | no | no | yes | LC | no | no | Subspecies | no | no |
| WattledJacana | Jacanajacana | no | no | yes | LC | no | no | no | no | no |
| LaughingGull | Larusatricilla | yes | yes | yes | LC | no | no | no | no | no |
| Ring-billedGull | Larusdelawarensis | no | no | yes | LC | no | no | no | no | no |
| American HerringGull | Larussmithsonianus | no | yes | yes | LC | no | no | no | no | no |
| White-tipped Dove | Leptotilaverreauxi | no | no | yes | LC | no | no | no | no | no |
| Short-billedDowitcher | Limnodromusgriseus | no | yes | yes | LC | no | no | no | no | no |
| Long-billedDowitcher | Limnodromus scolopaceus | no | no | no | LC | no | no | no | no | no |

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|---|---|---|---|---|---|---|---|---|---|---|
| HudsonianGodwit | Limosa haemastica | no | no | yes | LC | no | no | no | no | no |
| LesserAntilleanBullfinch | Loxigillanoctis | yes | yes | no | LC | no | no | LesserAntilles | no | yes |
| Pearly-eyedThrasher | Margaropsfuscatus | yes | yes | yes | LC | no | no | Netherlands Antilles/LesserAntilles | no | yes |
| Scaly-breastedThrasher | Margaropsfuscus | yes | yes | no | LC | no | no | LesserAntilles | no | no |
| Belted Kingfisher | Megacerylealcyon | yes | yes | yes | LC | no | no | no | no | no |
| Yellow-headedCaracara | Milvagochimachima | no | no | yes | LC | II | no | no | no | no |
| TropicalMockingbird | Mimusgilvus | no | no | yes | LC | no | no | no | no | no |
| Black-and-whiteWarbler | Mniotilta varia | yes | yes | yes | LC | no | no | no | no | no |
| ShinyCowbird | Molothrusbonariensis | no | no | yes | LC | no | no | no | no | no |
| Brown-crestedFlycatcher | Myiarchustyrannulus | no | no | yes | LC | no | no | no | no | no |
| StreakedFlycatcher | Myiodynastes maculatus | no | no | yes | LC | no | no | no | no | no |
| Masked Duck | Nomonyxdominicus | no | no | no | LC | no | no | no | no | no |
| Whimbrel | Numeniusphaeopus | no | no | yes | LC | no | no | no | no | no |
| Yellow-crownedNightHeron | Nyctanassa violacea | yes | yes | yes | LC | no | no | no | no | no |
| Black-crownedNightHeron | Nycticorax nycticorax | no | no | yes | LC | no | no | no | no | no |
| Wilson's Storm Petrel | Oceanitesoceanicus | no | yes | yes | LC | no | no | no | no | no |
| Leach's Storm Petrel | Oceanodroma leucorhoa | no | yes | yes | LC | no | no | no | no | no |
| NorthernWheatear | Oenantheoenanthe | no | no | yes | LC | no | no | no | no | no |
| Connecticut Warbler | Oporornisagilis | no | no | yes | LC | no | no | no | no | no |
| Kentucky Warbler | Oporornisformosus | no | no | yes | LC | no | no | no | no | no |
| Tennessee Warbler | Oreothlypisperegrina | no | no | yes | LC | no | no | no | no | no |
| AntilleanCrestedHummingbird | Orthorhyncuscristatus | yes | yes | no | LC | II | yes | LesserAntilles | no | yes |
| Osprey | Pandionhaliaetus | yes | yes | yes | LC | II | yes | no | yes | no |

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|---|---|---|---|---|---|---|---|---|---|---|
| Louisiana Waterthrush | Parkesiamotacilla | no | no | no | LC | no | no | no | no | no |
| NorthernParula | Parula americana | yes | yes | yes | LC | no | no | no | no | no |
| House Sparrow | Passer domesticus | no | no | Introduced | LC | no | no | no | no | no |
| Blue Grosbeak | Passerinacaerulea | no | no | yes | LC | no | no | no | no | no |
| Indigo Bunting | Passerinacyanea | no | yes | yes | LC | no | no | no | no | no |
| Bare-eyedPigeon | Patagioenascorensis | no | no | yes | LC | no | no | no | no | yes |
| White-crownedPigeon | Patagioenas leucocephala | yes | yes | no | NT | no | no | no | no | no |
| Brown Pelican | Pelecanus occidentalis | yes | yes | yes | LC | no | no | no | no | no |
| Red-billedTropicbird | Phaethon aethereus | yes | yes | yes | LC | no | no | no | no | yes |
| White-tailedTropicbird | Phaethonlepturus | yes | yes | yes | LC | no | no | no | no | no |
| Double-crestedCormorant | Phalacrocorax auritus | no | no | yes | LC | no | no | no | no | no |
| NeotropicCormorant | Phalacrocoraxbrasilianus | no | no | yes | LC | no | no | no | no | no |
| Red Phalarope | Phalaropusfulicarius | no | no | yes | LC | no | no | no | no | no |
| Red-neckedPhalarope | Phalaropus lobatus | no | no | yes | LC | no | no | no | no | no |
| Wilson's Phalarope | Phalaropus tricolor | no | no | yes | LC | no | no | no | no | no |
| Rose-breastedGrosbeak | Pheucticusludovicianus | no | no | no | LC | no | no | no | no | no |
| American Flamingo | Phoenicopterusruber | no | no | yes | LC | II | Yes | no | no | yes |
| White-crowned Parrot | Pionussenilis | no | no | yes | LC | II | no | no | no | no |
| Western Tanager | Pirangaludoviciana | no | no | yes | LC | no | no | no | no | no |
| ScarletTanager | Piranga olivacea | yes | yes | yes | LC | no | no | no | no | no |
| Summer Tanager | Pirangarubra | no | yes | no | LC | no | no | no | no | no |
| Summer Tanager | Pirangarubra | no | no | yes | LC | no | no | no | no | no |
| RoseateSpoonbill | Plataleaajaja | no | no | yes | LC | no | no | no | no | no |
| Glossy Ibis | Plegadisfalcinellus | no | no | yes | LC | no | no | no | no | no |
| American Golden Plover | Pluvialisdominica | yes | no | yes | LC | no | no | no | no | no |
| GreyPlover | Pluvialissquatarola | no | yes | yes | LC | no | no | no | no | no |

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|---|---|---|---|---|---|---|---|---|---|---|
| Pied-billedGrebe | Podilymbuspodiceps | no | no | yes | LC | no | no | no | no | no |
| PurpleGallinule | Porphyriomartinica | no | no | yes | LC | no | no | no | no | no |
| Sora | Porzanacarolina | no | no | yes | LC | no | no | no | no | no |
| Caribbean Martin | Prognedominicensis | yes | yes | yes | LC | no | no | no | no | no |
| Purple Martin | Prognesubis | no | no | yes | LC | no | no | no | no | no |
| ProthonotaryWarbler | Protonotariacitrea | no | no | yes | LC | no | no | no | no | no |
| Black-cappedPetrel | Pterodromahasitata | no | no | yes | LC | no | no | no | no | no |
| Great Shearwater | Puffinus gravis | no | no | yes | LC | no | no | no | no | no |
| Audubon'sShearwater | Puffinuslherminieri | yes | yes | yes | LC | no | no | no | no | yes |
| CaribGrackle | Quiscaluslugubris | no | no | yes | LC | no | no | no | no | no |
| American Avocet | Recurvirostra americana | no | no | yes | LC | no | no | no | no | no |
| Sand Martin | Ripariariparia | no | no | yes | LC | no | no | no | no | no |
| Black Skimmer | Rynchopsniger | no | no | yes | LC | no | no | no | no | no |
| Comb Duck | Sarkidiornissylvicola | no | no | yes | LC | II | yes | no | no | no |
| Ovenbird | Seiurusaurocapilla | no | yes | yes | LC | no | no | no | no | no |
| NorthernWaterthrush | Seiurusnoveboracensis | yes | yes | yes | LC | no | no | no | no | no |
| American Redstart | Setophagaruticilla | yes | yes | yes | LC | no | no | no | no | no |
| SaffronFinch | Sicalisflaveola | no | no | Introduced | LC | no | no | no | no | no |
| Yellow-belliedSapsucker | Sphyrapicusvarius | no | no | yes | LC | no | no | no | no | no |
| Southern Rough-wingedSwallow | Stelgidopteryxruficollis | no | no | no | LC | no | no | no | no | no |
| NorthernRough-wingedSwallow | Stelgidopteryxserripennis | no | no | yes | LC | no | no | no | no | no |
| Parasitic Jaeger | Stercorariusparasiticus | no | no | no | LC | no | no | no | no | no |
| BridledTern | Sternaanaethetus | yes | yes | yes | LC | no | no | no | no | no |
| LeastTern | Sternaantillarum | yes | no | yes | LC | no | no | no | no | yes |
| RoseateTern | Sternadougallii | no | yes | yes | LC | no | no | no | yes | no |
| SootyTern | Sternafuscata | yes | yes | yes | LC | no | no | no | no | no |
| Common Tern | Sterna hirundo | no | yes | yes | LC | no | no | no | yes | yes |

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|---|---|---|---|---|---|---|---|---|---|---|
| Royal Tern | Sterna maxima | yes | yes | yes | LC | no | no | no | yes | yes |
| Sandwich Tern | Sterna sandvicensis | yes | no | no | LC | no | no | no | yes | yes |
| White-collared Swift | Streptoprocnezonaris | no | yes | no | LC | no | no | no | no | no |
| EasternMeadowlark | Sturnella magna | no | no | yes | LC | no | no | no | no | no |
| Common Starling | Sturnus vulgaris | no | no | yes | LC | no | no | no | no | no |
| NorthernScrubFlycatcher | Sublegatusarenarum | no | no | yes | LC | no | no | Subspecies | no | no |
| MaskedBooby | Sula dactylatra | no | yes | yes | LC | no | no | no | no | no |
| Brown Booby | Sula leucogaster | yes | yes | yes | LC | no | no | no | no | no |
| Red-footedBooby | Sula sula | yes | yes | yes | LC | no | no | no | no | no |
| WhistlingHeron | Syrigma sibilatrix | no | no | yes | LC | no | no | no | no | no |
| LeastGrebe | Tachybaptusdominicus | no | no | yes | LC | no | no | no | no | no |
| SwallowTanager | Tersina viridis | no | no | yes | LC | no | no | no | no | no |
| Cabot'sTern | Thalasseusacuflavidus | no | no | yes | LC | no | no | no | no | no |
| Black-facedGrassquit | Tiarisbicolor | yes | yes | yes | LC | no | no | Subspecies | no | no |
| LesserYellowlegs | Tringaflavipes | no | yes | yes | LC | no | no | no | no | no |
| GreaterYellowlegs | Tringamelanoleuca | no | no | yes | LC | no | no | no | no | no |
| Willet | Tringasemipalmata | no | no | yes | LC | no | no | no | no | no |
| SolitarySandpiper | Tringasolitaria | no | no | yes | LC | no | no | no | no | no |
| Buff-breastedSandpiper | Tryngitessubruficollis | no | no | yes | NT | no | no | no | yes | no |
| Gray Kingbird | Tyrannus dominicensis | yes | yes | yes | LC | no | no | no | no | no |
| TropicalKingbird | Tyrannus melancholicus | no | no | yes | LC | no | no | no | no | no |
| Fork-tailedFlycatcher | Tyrannus savana | no | no | yes | LC | no | no | no | no | no |
| EasternKingbird | Tyrannus tyrannus | no | no | yes | LC | no | no | no | no | no |
| Western Barn Owl | Tyto alba | no | no | yes | LC | II | yes | no | no | no |
| Southern Lapwing | Vanellus chilensis | no | no | yes | LC | no | no | no | no | no |
| Golden-wingedWarbler | Vermivorachrysoptera | no | no | yes | NT | no | no | no | no | no |
| Black-whiskeredVireo | Vireoaltiloquus | yes | yes | yes | LC | no | no | no | no | no |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Red-eyedVireo | Vireoolivaceus | no | no | yes | LC | no | no | no | no | no |
| Blue-black Grassquit | Volatiniajacarina | no | no | yes | LC | no | no | no | no | no |
| Canada Warbler | Wilsoniacanadensis | no | no | yes | LC | no | no | no | no | no |
| HoodedWarbler | Wilsoniacitrina | no | yes | yes | LC | no | no | no | no | no |
| White-winged Dove | Zenaidaasiatica | no | yes | no | LC | no | no | no | no | no |
| Eared Dove | Zenaidaauriculata | no | no | yes | LC | no | no | Subspecies | no | no |
| Zenaida Dove | Zenaidaaurita | yes | yes | no | LC | no | no | no | no | no |

**Appendix 2.** Actual policy scenarios of development in Bonaire corresponding to ROB scn1 (left) and ROB scn2 (Center). Projected planning (right), in pink shows "open landscape", the area proposed in the "No goats" scenario.