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Research, management, and conservation of the yellow-shouldered Amazon (*Amazona barbadensis*) across its range in the southern Caribbean and mainland Venezuela: 1980s to the present

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The yellow-shouldered Amazon (*Amazona barbadensis*) has been the object of a decentralized research and conservation program throughout its range, spanning mainland Venezuela, the Venezuelan islands of La Blanquilla and Margarita, and Aruba, Curaçao and Bonaire in the southern Caribbean. Multiple interventions have been implemented since the 1980s, primarily on the islands of Bonaire and Margarita, including nest protection, the provision of artificial nests, predator control, health monitoring, ecosystem restoration, community education and awareness. As a result, fledgling recruitment in these two locations has increased and populations have grown substantially. In this article, we summarize the interventions and their impact on population abundance and poaching of nestlings. The status of populations in the Venezuelan mainland continues to be uncertain – yellow-shouldered Amazons were observed recently in their historical distribution, but poaching is still widespread. A 2024 reintroduction in Aruba was the first step toward reestablishment of parrots in the island after being extirpated around 1950. Building on four decades of experience and work, a multi-stakeholder

range-wide action plan produced with the vision that by 2031 *Amazona barbadensis* has functional, viable wild populations throughout its historical range. Steps taken to date suggest that this is within reach if past successes can be sustained and replicated elsewhere, particularly in mainland Venezuela.

KEYWORDS

Aruba, Bonaire, community education, conservation interventions, Curaçao, distribution, poaching, sustainability

1 Introduction

Since the 1980s, various organizations, mostly in Bonaire and Margarita Island (Venezuela), have implemented a wide portfolio of research initiatives and conservation interventions focused on the yellow-shouldered Amazon (*Amazona barbadensis*). The species was first categorized on the IUCN Red List of Threatened Species in 1988 as Threatened, assessed as Vulnerable between 1994 and 2017, and reassessed as Near Threatened in 2021 due to changes in the method for estimating the Extent of Occurrence (BirdLife International, 2021). It is one of the smaller Amazon species with a weight range of 250–500 g. The beak is horn colored, the head is yellow with a hint of white around the nostrils and pastel-blue under the beak; this blue color is also visible in the fanned tail. The shoulders have a yellow patch. Juveniles have grey eyes that change to orange-yellow as they mature beyond 12 months of age (Figure 1). It is a monotypic species, with no sub-species recognized. The yellow-shouldered Amazon is endemic to our study region (Rodríguez-Ferraro, 2024).

Despite population increases in Bonaire and Margarita, poaching pressures continue throughout Venezuela. No major

research or conservation efforts have taken place in mainland Venezuela, where two populations are known to exist (Rojas-Suárez and Rodríguez, 2015), or on La Blanquilla Island, where a small population (estimated at ~100 birds) is found (Rodríguez-Ferraro and Sanz, 2007). At the national level in Venezuela, *Amazona barbadensis* are listed as endangered (Rojas-Suárez and Rodríguez, 2015). For decades, they were considered regionally extinct in Aruba, after being recorded for the last time in 1955 (Voous, 1957). In 2024, they were reintroduced to the island. Although historical records suggest their presence in Curaçao (e.g., Hartert, 1893; Voous, 1983), no firm reports are available of an established, breeding wild population.

Throughout their geographical distribution (Figure 2), yellow-shouldered Amazons enjoy legal protection. In Bonaire, collection of wild parrots has been prohibited since 1952, though the law was not enforced until a pet parrot registration campaign took place in 2002 (Montanus, 2003). The campaign resulted in the registration of over 600 pet parrots. At the time this was more than the estimated entire wild population on Bonaire. Since 2002, no additional pet parrots have been registered and the number of



FIGURE 1

Pair of yellow-shouldered Amazons on verawood (*Bulnesia arborea*) in Macanao, Margarita Island, Venezuela. Photo: Vivek Menon.

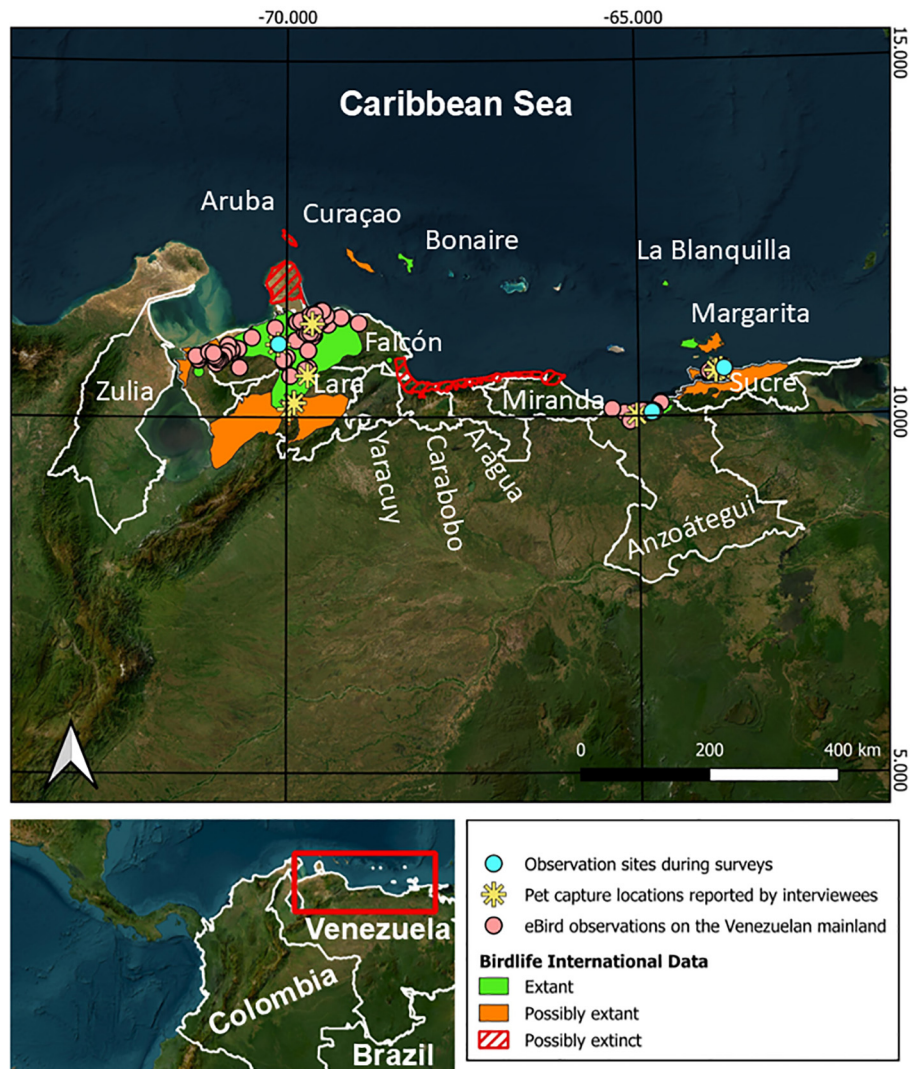


FIGURE 2
 Geographical distribution of the Yellow-shouldered Amazon, according to BirdLife International and Handbook of the Birds of the World (2022), showing the location of field survey observation sites on mainland Venezuela, pet capture locations during interviews, and the location of eBird (2024) reports.

parrots kept as pets on Bonaire is thought to now be much lower (J. Haines, pers. obs.), although no census has taken place. In 2010 the yellow-shouldered Amazons were locally protected by island decree. In Venezuela, it has been illegal to capture and trade *Amazona barbadensis* since 1970, which was reinforced by an official decree in 1996 (Venezuela, 1970, 1996). In 2021, the Macanao Wildlife Reserve was established, protecting 12,000 ha of prime parrot habitat in Margarita (Minec, 2023). However, illegal trade and poaching are still common, as is the practice of keeping parrots as pets (Sánchez-Mercado et al., 2020a; b).

The primary threats to *Amazona barbadensis* are poaching, habitat loss, persecution arising from conflicts with farmers, and invasive species. The magnitude and importance of these threats varies across their geographic range. Interaction between threats amplifies their impacts, as was illustrated by the extinction of the yellow-shouldered Amazon in Aruba. Historically thriving, parrots

faced a significant population reduction due to habitat degradation from urbanization, agricultural expansion, and deforestation. Simultaneously, they were subject to persistent persecution driven by cultural practice of shooting and poisoning as a crop pest. The last wild birds were reported by 1947 (Voous, 1983).

In Bonaire, illegal taking of chicks from nests occurs in several areas of the island. While historically this poaching is thought to have largely supplied local demand (i.e., pet owners on Bonaire), links with trade with Curaçao and international markets further afield have been recorded. In 2009, a chick ringed in the nest by researchers on Bonaire was found being kept as a pet in Curaçao. As Bonaire has few large trees, widespread deforestation led to the loss of dry forest habitat and the landscape became dominated in many areas by cactus scrub and introduced acacias. Donkeys and goats limited the regeneration of large trees. During the dry season parrots have been observed in roost sites within urban areas,

presumably to take advantage of greater availability of food (Williams, 2009). In some areas of Bonaire, parrots are killed in large numbers as they are considered to be a pest on crops including sorghum and mangoes. Multiple incidents of shooting of parrots have been recorded, most recently in 2023 a parrot was rescued with a single puncture wound through the wing and body, indicative of being shot with an air-rifle or .22. Invasive animals have also played a relevant role as drivers of decline: predation of nests and adults by feral cats has been recorded, while nest cavities have been taken over by Africanized honey bees, a hybrid of the western honey bee (*Apis mellifera*), and the East African lowland honey bee (*A. m. scutellata*) (Williams, 2009).

Throughout Venezuela, the primary threat to yellow-shouldered Amazons is poaching, followed by habitat degradation, and to a much lesser degree human-wildlife conflict (Rojas-Suárez and Rodríguez, 2015). Keeping parrots as pets is widespread in the country (Sánchez-Mercado et al., 2020a; b; c), while anecdotal data suggest that in Margarita Island there are more parrots in people's homes than in the wild (J. M. Briceño-Linares, pers. obs.). The largest driver of habitat degradation in Margarita is open-sky sand mining for the construction industry (Briceño-Linares et al., 2011). As large trees grow in seasonal river beds, their removal to mine sand results in the elimination of parrots' nests, which are found in tree holes. Historical degradation of the vegetation of Margarita, which may have had lasting impact to the present, was caused by cattle grazing since colonial times (1500s onward) and goat grazing since the early 1900s (González, 2007). Killing of parrots that raid crops has been reported, but they are not frequent nor widespread (Rojas-Suárez and Rodríguez, 2015).

In 2021, stakeholders in the conservation of yellow-shouldered Amazons from throughout their range in the southern Caribbean and mainland Venezuela came together in a virtual workshop, facilitated by the IUCN Species Survival Commission (SSC) Conservation Planning Specialist Group (CPSG, 2020), to establish an agreed vision for the conservation of the species and outline a strategic plan for how this will be achieved. Here, we summarize the conservation interventions that have taken place over the last four decades focused on *Amazona barbadensis* and compile data on reproductive success and population estimates. Given that methods and interventions varied over time and between locations, we divided most methods and results by study site and then integrated our findings in the discussion. We consider how conservation interventions have impacted populations and ways forward for delivering the 2031 vision set out in the range wide action plan.

2 Methods

2.1 Study sites

Aruba is a 180 km² oceanic island located approximately 30 kilometers off the northern coast of Venezuela (Figure 2). Within the Kingdom the Netherlands, Aruba holds a distinctive status as a constituent country, transitioning from its previous affiliation with the Netherlands Antilles post their dissolution in 2010.

Bonaire, is an oceanic island (288 km²) in the southern Caribbean, about 80 km from the coast of Venezuela (Figure 2). Bonaire was part of the Netherlands Antilles until the country's dissolution in 2010, when the island became a special municipality (officially, a "Caribbean public entity") within the country of the Netherlands.

Curaçao, is an oceanic island (444 km²) of the Netherlands Antilles in the Southern Caribbean, about 70 km from the coast of Venezuela (Figure 2). Curaçao was part of the Netherlands Antilles until the country's dissolution in 2010, when the island became an independent country within the Kingdom of the Netherlands.

These islands have an average annual temperature of 28°C and receive low, irregular and localized rainfall. Average precipitation differs strongly between them (likely explained by difference in elevation). Curaçao has 600 mm/year currently (long term published average is 550 mm). Bonaire 463mm (1971-2000), Aruba 451 mm (1991-2020), over half of which falls between October and December. Near constant trade winds arrive from the east north-east with an average speed of 12.8 knots. Unlike the windward Caribbean islands, Aruba, Bonaire and Curaçao seldom experience hurricane force winds. These conditions favor a mixture of open cactus, thorn scrub and dry forest communities (De Freitas et al., 2005). Nests of yellow-shouldered Amazons in Bonaire are found across the island, north of the town of Kralendijk, in tree and rock cavities. A large proportion of known nest sites are in cavities found either in large boulders or on cliff faces (up to 20 m high), in either heterogeneous volcanic or limestone formations (De Freitas et al., 2005). On Bonaire, yellow-shouldered Amazons typically initiate breeding from late April/early May with chicks fledging approximately 90 days later (Martin, 2009; Williams, 2009). No nests have been reported in Aruba or Curaçao.

In Venezuela, yellow-shouldered Amazons live on the islands of La Blanquilla and Margarita, off the northeastern coast, and in two disjunct mainland regions to the northwest and north east of the country (Figure 2, Rojas-Suárez and Rodríguez, 2015). La Blanquilla (64.5 km²) is an emerged island in the southern Caribbean Sea, 90 km northeast of Margarita Island, and 170 km northeast of Venezuela's mainland, with a maximum elevation of 30 m. Most of the island is covered by xerophytic vegetation, including dense cacti formations (Rodríguez-Ferraro and Sanz, 2007). In Margarita, yellow-shouldered Amazons occupy the western portion of the island, known as the Macanao peninsula. Spanning 330 km², Macanao's pronounced topography ranges from sea level to 745 m at the center of the peninsula. Mean annual temperature is 27°C, and mean total annual rainfall is 500 mm, with a marked dry season from January to May. Plant communities are dominated by open cactus/chaparral scrub with columnar cacti and legume trees. Seasonal riverbeds support permanent deciduous forests (Hoyos, 1985; González, 2007), where parrots nest. Mainland populations are found in dry forest similar to those of Macanao, in northeastern and northwestern Venezuela, but they have not been systematically studied, though some indirect analyses have been performed (Ferrer-Paris et al., 2014). The breeding season of *Amazona barbadensis* in Venezuela begins roughly when the dry season ends, with egg-laying typically beginning in late March. Eggs are laid in tree holes, incubated for approximately 26 days, and

nestlings are fledged in 50–60 days (Rojas-Suárez, 1994a). The last nestling typically fledges in August (Sanz and Rodríguez-Ferraro, 2006).

2.2 Research and conservation activities

2.2.1 Aruba

2.2.1.1 Reintroduction

Yellow-shouldered Amazons were reintroduced to Aruba in 2024. This reintroduction followed the confiscation by Aruban authorities of 32 parrot chicks just under fledging age, allegedly smuggled from Venezuela in a fishing boat. Birds were hand raised, weaned and socialized as a cohesive group in captivity. Pre-release training involved training to recognize local flora known to form the diet of parrots on Bonaire, through exposure to the food type using a process of incrementally reducing the processing to serve as found in the wild on the branch.

From January 2024, 25 parrots were released in three cohorts (of 8, 8 and 9 respectively), staggered a week apart. Daily monitoring and the provision of supplemental feeding were carried out at feeding stations immediately adjacent to the release aviaries twice daily, once at dawn and again at dusk. At the 8-month mark, the most recent time for which data are available, 17 of 25 regularly returned to feeding stations, forming a cohesive flock showing strong site fidelity.

Challenges included predator encounters, particularly from peregrines (*Falco peregrinus*) and crested caracaras (*Caracara plancus*) which were seen to chase parrots. The parrot flock showed typical predator avoidance behavior and no predation events have been recorded. Notably, no evidence of predation from boas (*Boa constrictor*) has emerged yet, despite initial public concerns.

A long-term project in collaboration with European zoos is currently in the planning stage, aiming for regular translocations to reinforce the population. Strong government support has facilitated project development, with community engagement around the release informing the public. An extensive education program is planned for the future.

2.2.2 Bonaire

Conservation efforts for the Yellow-shouldered Amazon on Bonaire have experienced periods of varying intensity, initially spearheaded by governmental initiatives and later supported by non-governmental organizations (NGO). In 2006 field research into the ecology, behavior and threats was initiated, which formed the foundation for a range of conservation initiatives and the development of a locally-based NGO, Echo, focused on the conservation of yellow-shouldered Amazons. Partnerships between government, local and international NGOs and other civil society groups have sustained a combination of research, public awareness campaigns, law enforcement, and habitat restoration initiatives.

Sequence of conservation interventions carried out since 1980:

- 1980. Initiation of annual roost counts during the non-breeding season.

- 1998. STINAPA, the NGO mandated to manage Bonaire's national parks, launched an environmental education initiative together with the organization *Rare* using the Yellow-shouldered Amazon as its flagship species as part of a "pride campaign" (Scholtens and Butler, 1999).
- 2002. Launch of a pet amnesty program, resulting in the ringing and registration of 615 illegally kept pet parrots (Montanus, 2003).
- 2003. Annual public awareness campaigns initiated by local organization Salba Nos Lora timed to coincide with breeding season when risk of poaching at highest level (Salazar et al., 2019).
- 2006. Field research and nest monitoring initiated by University of Sheffield and World Parrot Trust (nest monitoring and poaching vigilance, description of methods below). Documentation of nesting areas with intensive monitoring of breeding productivity and causes of failure for approximately 25-30 nests annually from 2006 to 2010.
- 2007. Repair of 10 nests damaged by poachers and installation of a further 10 new nest boxes (Roberts et al., 2014).
- 2009. Echo launched to focus on conservation of yellow-shouldered parrots on Bonaire and Netherland Antilles. Echo maintained annual public awareness campaigns initiated by Salba nos Lora.
- 2009. Increase in law enforcement with house inspections by DROB (Dienst Ruimte en Ontwikkeling Bonaire, or Bonaire Spatial Planning and Development) leading to the confiscation of illegally held parrots.
- 2010. Implementation of the Nature Management Island Decree under the Nature Ordinance, protecting local species including the Yellow-shouldered Amazon.
- 2010. Introduction of a parrot club in schools and initiation of eco-tourism with parrot tours.
- 2010. Establishment of the Dos Pos Conservation Centre for the rehabilitation and care of seized illegally held parrots. Releases included 26 parrots between 2006-2013, 8 in 2016, 3 in 2017, and 6 in 2021.
- 2011. Confiscation of 14 yellow-shouldered Amazons destined for export to international markets.
- 2013. Native plant nursery created to grow trees for habitat restoration.
- 2015. Eleven herbivore exclusion zones, covering 33ha, created and replanted with trees. Campaign to encourage land owners to plant native food trees for parrots initiated.
- 2013-2023. Implementation of nest protection using hidden cameras. Surveillance was widely advertised in the media as a deterrent. Between 2015 and 2018, highly vulnerable nests actively monitored.
- 2018 Introduction of Wildlife Guardian group for secondary schools.
- 2019-2023. Intensive monitoring of 30-40 nests to measure nest productivity and poaching rates.

2.2.2.1 Roost counts

Counts at overnight communal roost sites have been conducted since 1980, but did not occur every year and varied in seasonal timing. Since 2005, these counts have been conducted annually on the last Saturday of January, during the non-breeding season. Counts are conducted by a team of citizen scientist volunteers who visit the different locations simultaneously to count numbers leaving roosts. In years when there were insufficient volunteers to visit all sites, priority was given to counting at those roosts that typically had the highest numbers of parrots in previous years. A methodological refinement was introduced in 2014, involving checks on roosts in the days prior to the annual roost count to determine the current activity levels at roost sites. Based on this information, priority was then given to counting at roosts that were most active. This approach was adopted to reduce the impact of the variability in survey effort (number of volunteers available) and patterns of roost use by parrots, on overall coverage. The selection of roost sites for counting each year was determined by the availability of volunteers and the priority assigned based on historic roost size and the results of the pre-count checks. Consequently, the specific sites counted varied each year with increasing effort over the years such that between 1999 and 2012, a mean of $20.27 \pm \text{SE } 1.41$ (11 - 27) and between 2013 and 2023 mean was $25.91 \pm \text{SE } 1.38$ (17-32). Prior to 2001 the total number of roost sites counted was rarely reported.

Counts of parrots leaving roost sites took place simultaneously across all locations selected. Counts were carried out by local volunteers with a range of experience from completely inexperienced with no training, through to the involvement of professional field biologists. Vantage points for counting parrots leaving each roost were pre-determined and all volunteers arrived at the designated point prior to dawn. The end of the counting period was determined either by 20 minutes passing since the last parrot sighting or two hours since the start of the count, whichever occurred sooner.

2.2.2.2 Nest monitoring

Nest inspections were carried out between mid-May and mid-September between 2006-2010 and 2021 and 2023, using a standardized approach. The locations of active nests were determined based on the behavior of breeding pairs (repeated entering of the cavity, copulation, allofeeding) observed during targeted observations in areas known to be used by nesting parrots. Yellow-shouldered Amazons on Bonaire consistently use the same nest areas and often the same cavities each year (Martin, 2009). Once determined as likely active, nest cavities were inspected at least once per week until nests were no longer active (chicks fledged successfully or nest failed). Where necessary abseiling and single rope technique were used to access nests in cliffside cavities. Inspections of nest contents were conducted as quickly as possible and nests were only approached while the parents were not in the nest to minimize disturbance. Nest contents were observed directly or with inspection mirrors, cameras and endoscopes for deeper cavities. A small number of nests were inaccessible and also monitored through observation of adult behavior. Such nests,

where status could not be directly confirmed, are not included in our analysis. Causes of chick mortality and nest failure were identified where possible; for example, the presence of wire hooks used to pull chicks out of nests, or makeshift ladders suggested chicks had been poached from nests, injuries on dead chicks suggested attempted predation of infanticide. The timing of nestling mortality or nest failure was recorded, and nesting failure was considered to be "late" if it happened after 6 weeks. After this period natural causes of nest failure are rare and chicks are particularly vulnerable to poaching (Martin, 2009; Williams, 2009). Nest failure during this period is therefore considered to be suggestive of poaching, although the cause of failure could not always be determined.

2.2.2.3 Poaching vigilance

In response to escalating poaching concerns, particularly during the period 2021-2023, we implemented additional surveillance measures. Movement-sensitive camera traps were strategically deployed to provide surveillance at nests considered to be most vulnerable, including those with a history of poaching or those perceived to be easily accessible. Evidence of poaching incidents includes circumstantial indicators such as the presence of poaching tools (e.g., ladders, forked sticks, and wire for extracting chicks) and signs of nest cavity destruction (e.g., chainsaw damage to tree cavities). More direct circumstantial evidence includes sightings of people in the vicinity coinciding with the disappearance of chicks.

2.2.3 Curaçao

In 1999, the government of the Dutch Antilles issued an amnesty period where people could register their CITES-listed pets, including *Amazona barbadensis*. As they are included in the Specially Protected Areas and Wildlife (SPAW) annex 2, they also receive protection following the SPAW protocol being included in local legislation.

In 2001, the first Yellow-shouldered Amazon was registered, eventually reaching over 1,000 registered birds after a public campaign that involved local bird club volunteers and veterinarians. During the two years after the campaign, smuggled birds declined as recorded in patient logs at veterinary clinics. Despite campaign and legislation, however, parrot smuggling increased again. Occasionally, *Amazona barbadensis* are observed flying, which are likely escaped cage birds. Most birds are illegally brought in through fishing boats from Venezuela (May-July) and during the Bonaire regatta period in October. Due to a lack of proper quarantine facilities, confiscated birds are euthanized.

Fundashon dier en Onderwijs Cariben and Vetdoest have carried out an education project in Curaçao since 2002. Elementary and secondary school children are taught parrot conservation, why they should not keep a wild-caught parrot, and proper care should they own a pet parrot.

2.2.4 Venezuela

Research, management, and conservation activities began in the late 1980s, spearheaded by Silvius (1997) in Macanao and Rojas-Suárez (1994a; 1994b) in Macanao and La Blanquilla. Between 1990

and 1999, efforts focused primarily on understanding the reproductive biology of the yellow-shouldered Amazon, and increasing fledgling recruitment, with a focus on the largest known breeding area in Macanao. During this span, the number of yellow-shouldered Amazons fledged each year ranged between 23 and 81, with an annual mean of 53 (Provita, unpublished annual reports). Nestling losses averaged 49% annually, primarily due to poaching (Sanz and Rodríguez-Ferraro, 2006). Between 2000 and 2003, due to funding limitations and project restructuring, field activities were paused and re-designed, leading to a new phase of the project that continues to the present, with some variations over time that we describe below. Conservation interventions were summarized Briceño-Linares et al. (2011). Here, we update that list to the present in chronological order (Briceño-Linares and Rodríguez, 2022), we present the methods of previously unpublished annual censuses, and describe recent surveys designed to inform a current distribution map of *Amazona barbadensis* in mainland Venezuela.

Sequence of conservation interventions carried out since 2004 (all in Macanao):

- 2004. Environmental education at schools, creation of a team of EcoGuardians (originally called biomonitors), who are young men and women dedicated to carry out field work, nest repairs and 24-h surveillance.
- 2005. In addition to 2004's interventions, implemented foster nests and performed the pilot of an assisted breeding program.
- 2006. In addition to existing interventions, increased assisted breeding to all monitored nests.
- 2007. In addition to existing interventions, used artificial nests.
- 2008. In addition to existing interventions, brought in a veterinary doctor to monitor the health of nestlings and adults in nests, and had support from the municipal police to reinforce security in the field.
- 2009-2010. In addition to existing interventions, engaged with the National Guard, who accompanied the field team especially during the night.
- 2011 onwards. We settled on a stable protocol of three interventions: 24-hour surveillance by EcoGuardians, foster nests, and improved artificial nests. Environmental education at schools continued, but with a wider focus on all of the biodiversity of the island.

2.2.4.1 24-hour surveillance by EcoGuardians

EcoGuardians are young women and men from Margarita Island, some of them identify as being previous poachers. Currently, there are 18, and they are paid a salary during the parrot breeding season, approximately between May and August. A camp is established at quebrada La Chica, the largest parrot roost in Macanao (Briceño-Linares et al., 2011), and they rotate to maintain 24-h surveillance of an area that included 98 nests (69 active in the 2024 breeding season): 47 in natural tree holes (38 active in 2024),

30 artificial PVC nests (14 active in 2024), and 21 improved artificial nests (17 active) (see nest descriptions below). Their role is to patrol the area, especially at night, but not to engage directly with any potential poacher that they encounter. Typically, the presence of EcoGuardians is sufficient to deter poachers.

2.2.4.2 Foster nests

Beyond the area patrolled by EcoGuardians there are additional nests that are too far away to monitor. Most of those nests, except a few located on very tall trees, are regularly poached. Fledglings from these high-risk nests are thus extracted and placed into foster nests at quebrada La Chica, where clutches are uniformly increased to 5 eggs. This technique was tested, standardized and implemented early in the project's history (Sanz and Rojas-Suárez, 1997), and continues to be used since.

2.2.4.3 Improved artificial nests

Three types of artificial nests have been tested: wood-boxes, painted PVC tubes covered at both ends and with mesh on the inside, and natural nests that were originally damaged by poachers, we cut off from the tree (always verawood, *Bulnesia arborea*), repaired, and hung from a branch of a tree with no natural nest (Briceño-Linares, 2010; Sanz et al., 2003). Wood-boxes were unsuccessful and no longer implemented, but the other two designs continue to be used.

2.2.4.4 Annual censuses

Censuses were carried out at six permanent roosts located throughout Macanao: Quebrada La Chica, San Francisco, Guainamal, Chacaracual, La Vieja and Caño de Maíz (Rojas-Suárez, 1994a, 2015). All roosts were censused simultaneously for three consecutive days from 4:30 pm to 7:00 pm. A week before the census, a pre-census was carried out throughout the peninsula to locate the best roost observation points, as they may shift. Over the years, counts have been carried out at different times of the year (before, during and after the breeding season), but here we only include post reproductive counts, which typically are carried out between August and December. Each day, the team of observers, which include at least one experienced team member, but also include volunteers and team members in training, count the birds as they come in to roost for the night. Here, we report the largest number recorded each day to minimize underestimating population size (Rodríguez-Ferraro and Sanz, 1996). Censuses were not performed all years, or by a consistent team of observers. We therefore reported only years where a formal census was carried out, and also provide notes on the reliability and confidence of each year's estimate according to our knowledge and experience. For example, years where surveys were led by a team member with several years of experience, and all participants had been involved at least one year prior, ranked highest.

2.2.4.5 Mainland surveys

In 2023, we carried out two exploratory surveys in the Venezuelan mainland, to document the presence of *Amazona barbadensis* within the two mainland regions identified in the past (BirdLife International, 2021; Rojas-Suárez and Rodríguez,

TABLE 1 Abundance estimates for the yellow-shouldered Amazon in Bonaire.

Period	Methodological approach	Mean roost count \pm s.e.
Pre-2005	Timing of counts inconsistent	531 \pm 135.1
2005-2009	Timing standardized from 2005 onwards	513.6 \pm 80.2
2010-2014		754.2 \pm 65.1
2015-2019	Pre-roost count checks introduced	934.2 \pm 95.7
2020-2023		1151.6 \pm 172.8

2015). Surveys were conducted in the states of Sucre and Anzoátegui in northeastern Venezuela between 3 to 14 September 2023, the states of Lara, Falcón and the eastern coast of Zulia in the northwest between 6 to 14 November 2023.

Opportunistic sampling was employed whereby we traveled by car through the region, stopping at towns along the way to identify and interview people who owned captive parrots, particularly *Amazona barbadensis*. The interview protocol comprised a series of semi-structured questions aimed at gathering information on the wild and captive populations of *Amazona barbadensis* in the locations visited, including the timing of breeding, the locations of nesting trees and overnight roost, feeding habits in the wild and captivity, poaching methods, and the market price of chicks in the illegal trade. Interviewees were informed that the interviews were part of a study on the yellow-shouldered Amazon, aimed at understanding its conservation status across different parts of its distribution. In each location, a local guide accompanied the team to facilitate trust and rapport with the interviewees.

3 Results

3.1 Bonaire

3.1.1 Abundance

Counts in the 1980s and 90s, which involved highly variable survey efforts, typically totaled around 300 parrots. Since 2005 when the

timing of counts was standardized, reported numbers of parrots have gradually increased. The mean annual count for the most recent period (2018-2023) was $1\,130.17 \pm 130.31$ s.d. (755-1 779); approximately double the number counted between 2005-2010 of 513.6 ± 80.2 s.d. (277-669)(Table 1). Variation in survey efforts over this period may account for some of the apparent increase and unpublished analyses controlling for survey effort suggest a more modest, but nevertheless statistically significant increase in numbers.

Abundance estimates made using distance method point counts between 2009-2017 estimated the population on Bonaire to be $2\,924 \pm 340$ parrots across a survey region covering 17 000 ha (Rivera-Milán et al., 2018). However, uncertainty over the suitability of these survey methods for this species and situation mean that abundance estimates based on roost counts are typically used by civil society and government organizations on Bonaire.

3.1.2 Nest productivity and poaching

Between 2006 and 2010, a mean of 24.6 (15-38) active yellow-shouldered Amazon nest attempts (i.e. displaying eggs or chicks) were monitored annually (Table 2). Of these, a mean of 52% (12.8) successfully fledged at least one chick. Recorded nest success was higher between 2021 and 2023, during which 76.2% (a mean of 15.0 of 19.7 breeding attempts) were successful. Productivity per successful nest did not differ considerably between the two periods, with a mean of 1.92 (1-4) chicks fledged per nest between 2006 and 2010 and 2.08 ± 0.13 (1-4) chicks between 2021 and 2023.

TABLE 2 Nest productivity for the yellow-shouldered Amazon in Bonaire.

Year	Active nests monitored	Nests successfully fledged (% of nests monitored)	Number of chicks fledged per successful nest (mean \pm se)	Nests poached (% of nests that would have otherwise fledged)
2006	13	10 (76.9%)	2.17 \pm 0.32 (1-4)	0 (0.0%)
2007	29	9 (31.0%)	1.91 \pm 0.28 (1-3)	3 (25.0%)
2008	28	9 (32.1%)	1.50 \pm 0.20 (1-3)	4 (30.7%)
2009	28	12 (42.9%)	2.33	4 (25.0%)
2010	25	15 (60.0%)	1.67 (1-3)	2 (11.7%)
Mean	24.6	12.8 (52.0%)	1.92 (1-4)	2.6 (20.3%)
2021	22	19 (86.4%)	2.26 \pm 0.25 (1-4)	2 (10.5%)
2022	20	12 (60.0%)	1.88 \pm 0.12 (1-2)	0 (0.0%)
2023	17	14 (82.4%)	1.92 \pm 0.14 (1-3)	0 (0.0%)
Mean	19.7	15.0 (76.2%)	2.08 \pm 0.13(1-4)	0.67 (4.5%)

Between 2006 and 2010, 13 poaching incidents were detected, accounting for 20.3% of active breeding attempts that would have otherwise fledged chicks (Table 2). Poaching was monitored using camera traps between 2021 and 2023, where no definitive poaching events were recorded. However, two incidents were suspected based on the absence of chicks in the nest during the late nesting stage and observable changes to the nest environment, such as opened cavities and signs of disturbance. These accounted for only 4.5% of active breeding attempts that would have otherwise fledged chicks during this period.

3.2 Venezuela

3.2.1 Abundance

The first censuses were carried out in 1989, and continued with interruptions and variations in reliability until the present (Table 3).

TABLE 3 Annual census counts for the yellow-shouldered Amazon in the Macanao Peninsula of Margarita Island.

Year	Number of birds	Confidence
1989	700	M
1990	750	H
1991	800	H
1992	914	H
1993	1,514	H
1994	1,580	H
1995	1,768	H
1996	1,842	H
2001	1,689	L
2002	1,800	L
2003	1,271	M
2009	816	M
2010	935	M
2011	1,480	H
2012	776	M
2013	1,055	M
2015	1,600	M
2016	1,492	M
2017	1,500	M
2018	1,282	H
2019	1,544	H
2020	2,109	H
2021	1,951	H
2022	1,962	H
2023	2,155	H

Confidence is a subjective assessment of the reliability of the estimate, based on the experience of the field team (H, high; M, medium; L, low).

Estimates with higher confidence are concentrated during the first and last few years of the time series. In the 1990s, we recorded a fairly rapid growth in population size from about 700 in 1989 to around 1,800 in 1996. Between 2001 and 2017, numbers oscillated between 800 and 1,600 birds, probably more due to methodological inconsistencies than to true changing population sizes, though there is some evidence that this was a time of rapid degradation due to increased mining intensity of at least two of the roost sites, which could have affected parrot populations (Rojas-Suárez, 2015). During the last few years, 2020–2023, our confidence on the estimates is high and the population seems to have settled around 2,000 birds.

3.2.2 Nest productivity and poaching

Between 2004 and 2023, we recorded 1,756 birds fledging from monitored nests, and 144 lost to poachers, which represent 8% of the total (Table 4). Two main trends are revealed by the data: increase of the number of birds fledged over time and decrease of proportion poached. During the first five years (2004–2008) the mean number of birds fledged was 45.8, rising to 178.4 during 2019–2023. The first time that more than 100 parrots fledged was 2018, while this number has been larger than 200 between 2021 and 2023. Likewise, the mean proportion of birds poached during 2004–2008

TABLE 4 Nest productivity and poaching for the yellow-shouldered Amazon in the Macanao peninsula of Margarita Island.

Year	Birds fledged	Birds poached (%)
2004	25	32 (56)
2005	56	12 (18)
2006	72	0 (0)
2007	23	34 (60)
2008	53	10 (16)
2009	66	1 (1)
2010	40	8 (17)
2011	50	16 (24)
2012	27	0 (0)
2013	77	4 (5)
2014	61	0 (0)
2015	97	10 (9)
2016	47	5 (10)
2017	44	2 (4)
2018	126	4 (3)
2019	140	0 (0)
2020	140	3 (2)
2021	202	3 (1)
2022	202	0 (0)
2023	208	0 (0)
Total	1,756	144 (8)

was 30%, dropping to a mean of 1% during 2019–2023. Poaching rates have remained consistently low during more than a decade.

3.2.3 Mainland surveys

Keeping parrots as pets was found to be widespread among residents in the towns visited. Of 39 people interviewed during both routes combined, 38 kept parrots, and of these 32 were *Amazona barbadensis*. Most obtained their parrots as presents from friends or family, and reported to have had the parrot from four months ago to up to 27 years ago. The mean age was 6.7 years. All were reported to have been taken from a nest or obtained by placing a net on a tree and trapping them.

Wild populations of parrots were observed during the survey. Direct counts were performed at communal overnight roosts in three locations (Figure 1). During 4–7 September 2024, 74 parrots were observed in Guayacán, Sucre state, during 9–12 September 2024, 184 parrots were counted at Laguna El Juncal, next to the José Antonio Anzoátegui Petrochemical Complex, Anzoátegui State, while on 13 November, >1,120 parrots were recorded roosting at El Pedregal in Falcón state. The field guides of our surveys in Falcón, Julio Loyo, Luis Loyo and Endri Chirinos, visited the border between Falcón and Zulia state on 11–12 February 2024, and observed yellow-shouldered Amazons around the towns Quisiro, Papayo and La Cuadra (eBird, 2024), confirming their presence where they were considered possibly extant (Figure 1).

4 Discussion

Monitoring of wild populations of yellow-shouldered Amazons on two southern Caribbean islands, where multi-faceted and varied conservation interventions have been implemented since the late 20th century, indicates that populations have increased over the last two decades. While it is not possible to attribute these increases to any specific conservation intervention with certainty, improvements in breeding success associated with reductions in nest poaching suggest that interventions aimed at reducing poaching likely played a significant role in population recovery in both situations, as has been demonstrated for other Neotropical parrots (Wright et al., 2001). In contrast, recent surveys in mainland Venezuela suggest high rates of poaching persist and reinforce concerns over the long-term viability of these populations in the absence of focused conservation efforts.

In both Margarita Island and Bonaire, conservation efforts have been sustained over extended periods of time, apparently leading to the recovery of populations. The opportunity to explore multiple interventions and the ability to secure long-term funding have probably been key to success (Sodhi et al., 2011; Parks et al., 2022). In both instances, these interventions have varied over the years, adapting to changing circumstances, due to variation in the availability of funding, the involvement of governmental and various non-governmental organizations, changing personnel, political environments and emerging threats. These situations and challenges have varied considerably between the two islands. However, both situations can be characterized by sustained multi-decadal efforts involving and variously led by diverse stakeholders. In Bonaire the pro-active involvement of the island government,

working closely with locally-based non-governmental organizations has likely been an important ingredient of success. The long-term commitment and support of an international organization, the World Parrot Trust, which has supported and worked closely with all stakeholders to provide financial, operational and technical support for conservation efforts on Bonaire for close to two decades, has also been critical. Similarly, in Margarita, the Venezuela-based organization Provita has been working in Macanao for the past two decades, with repeated support from organizations such as the Whitley Fund for Nature, Loro Parque Fundación, World Land Trust and Arenera La Chica – Hato San Francisco, in addition to municipal and state government agencies. The sporadic and variable conservation efforts in the face of diverse circumstances are likely representative of many conservation challenges in the region and around the world. The consistent positive outcomes of the two sites, however, demonstrate the power of partnerships, long-term commitment and persistence, and should be cause for optimism.

While it is ideal for research teams to implement systematic, carefully designed protocols leading to statistically robust analyses, the primary goal of conservation efforts is to mitigate threats and achieve population increases in threatened species. Achieving these outcomes can be complex and non-linear. Despite differing protocols over the years, field teams in Bonaire and Margarita have quantitatively demonstrated improvements in the status of yellow-shouldered Amazons. This further highlights the importance of adaptive management and sustained, multi-year financial support for achieving long-term conservation success (Briceño-Linares et al., 2011; Parks et al., 2022).

Preliminary observations on the Venezuelan mainland, combined with citizen science reports, allowed us to verify the persistence of populations of yellow-shouldered Amazons in the northeast and northwest of the country (Figure 2). Though our surveys were not aimed at formally estimating population size or measuring the intensity of poaching, we found that two topics deserve future analyses. First, poaching for pets continues to be widespread. Caged yellow-shouldered Amazons were found at all of our interview locations. Second, yellow-shouldered Amazons continue to inhabit mainland sites reported in the past, but appears to be absent in the central-northern part of the country (Figure 2). The fact that more than 1,000 parrots were counted one day at a single overnight roost site in El Pedregal, Falcón state, plus a number of recent eBird records between Falcón and Zulia, are encouraging. However, the long-term viability of this population in the face of significant poaching to supply local demand for pets and likely markets further afield is far from certain. Seizures of yellow-shouldered Amazons in Bonaire in 2011 and Aruba in 2022, indicate an international dimension to poaching and trafficking.

The current IUCN Red List assessment for the species assumes an overall declining population that approaches but does not exceed the threshold of 10% over three generations (25.5 years) (criterion C1) and that a population reduction projected, inferred or suspected in the future approaches 30% over the same length period (criterion A3cd) (BirdLife International, 2021). Inferring from apparent levels of exploitation for local and international trade within the species distribution in mainland Venezuela, we consider that it is plausible and likely that these thresholds are met or exceeded (particularly

regarding C1) and that this information should be taken into account in assessments of population trends informing future Red List reassessments.

A range-wide action plan is in the final stages of publication (Briceño-Linares et al., 2024). Stakeholders from Aruba, Bonaire, Curaçao and Venezuela, plus collaborators from other parts of the world were actively involved in workshops and as reviewers. Based on the information and experience accumulated over the last four decades, the group converged on achieving the vision that by 2031 the yellow-shouldered Amazon has functional, viable wild populations throughout its historical range. That by 2031, three wild populations are under evidence-based management programs and at least one population is reintroduced at a location where it went extinct. The plan foresees commitment and engagement of local communities that apply sustainable use principles, a reduction of the drivers of historical population decline, and the establishment of an international network of collaborators that supports these efforts. The first steps have been taken with the reintroduction of yellow-shouldered parrots into Aruba. Evidence-based management is also taking place in Bonaire and Macanao. Expanding evidence-based management to Aruba, assuring that the work in Bonaire and Macanao continues, exploring options in Curaçao, and initiating research or conservation activities in mainland Venezuela are the next steps in assuring that the decline of the yellow-shouldered Amazon is halted and reversed.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material. Further inquiries can be directed to the corresponding author.

Ethics statement

The animal study was approved by Instituto Venezolano de Investigaciones Científicas. The study was conducted in accordance with the local legislation and institutional requirements.

Author contributions

JB-L: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Writing – review & editing. JA-A: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Visualization, Writing – review & editing. JC: Funding acquisition, Investigation, Project administration, Writing – review & editing. AD: Project administration, Supervision, Writing – review & editing. OD: Investigation, Writing – review & editing. JH: Conceptualization, Investigation, Methodology, Writing – review & editing. EH: Investigation, Methodology, Writing – review & editing. RM: Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Writing – original draft, Writing – review & editing, Conceptualization. PM: Conceptualization, Investigation, Methodology, Supervision, Writing – review & editing. GN: Investigation, Methodology, Writing – review & editing. LS: Funding acquisition, Investigation,

Methodology, Writing – review & editing. BS: Writing – review & editing, Conceptualization, Funding acquisition, Methodology, Project administration. FS: Conceptualization, Formal analysis, Methodology, Writing – review & editing. JR: Conceptualization, Data curation, Funding acquisition, Investigation, Supervision, Writing – original draft, Writing – review & editing.

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Conflict of interest

OD is the owner of VetDoest.

The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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