21 Conservation State of the Bats of the Caribbean Netherlands

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Status

Bats play key roles in terrestrial ecosystems, with different species likely helping to control insects (Petit 1996; Kunz et al., 2011; Riccucci & Lanza, 2014; Tuneu-Corral et al., 2023), other species serving as key pollinators and dispersers of plants like agave and columnar cacti (Petit, 1995; 1996; Kunz et al., 2011) and yet other fruit-eating species playing an important role in seed dispersal for certain other plants (Barlow et al., 2000; Ortega & Castro-Arellano, 2001; Kunz et al., 2011; Pedersen et al., 2018a). On islands, bats are often the main or only surviving native mammalian species and often fulfil keystone functions in terms of pollination and seed dispersal (Cox, 1992; Petit, 1995; Mickleburgh et al., 2002). Such is also the case for all three of the Caribbean Netherlands islands, which have no other surviving native mammals than bats. Compared to other mammals and birds, very little is known about the population status of most bat species, and makes it difficult to decide on priorities for conservation and research (Frick et al., 2019). Worldwide the status of more than half of all species of this keystone group of poorly-understood mammals is unknown or declining.

The current and recent fossil bat fauna of the West Indies amounts to 57 species, of which 27 species are either locally or fully extinct (Morgan, 2001). Looking specifically at the Lesser Antillean fossil bats, these amount to one (fully) extinct species and three locally extinct species, which can fortunately still be found surviving in the Greater Antilles (Morgan, 2001). The assessment by Morgan (2001) further shows that specialized or obligate cave-dwelling species are the most vulnerable to extinction and that the role of past climate change appears quite important. This suggests that the impending climate change caused by humans (IPCC, 2022) is also a big risk factor for the present surviving cave-dwelling species. Notwithstanding many documented extinctions, new bat species (Larsen et al., 2012, Moratelli et al., 2017) and subspecies (Larsen et al., 2017) continue to be described from the Caribbean.

The most recent addition to the known bat fauna of the Caribbean Netherlands is the Visored Bat, *Sphaeronycteris toxophyllum*, known from a single individual collected in Bonaire in 2023 (Simal & Nassar 2025). The species is very rare throughout its large range in South America (Solari, 2018a) and could either be vagrant or recently introduced via shipments of merchandise from Venezuela. Other likely vagrants for Bonaire might be *Ametrida centurio* and *Pteronotus davyi*, for which, respectively, a former or current local population seems very doubtful. As calm waters with small fish suitable for hunting by *Noctilio leporinus* are expansive on the island, the apparent absence of this species, notwithstanding, ample effort by experts might not be so surprising (F. Simal, pers. obs.). On Curaçao the species is only known to roost in seaside caves and overhangs, a habitat which does not seem present on Bonaire and could explain the absence of the species.

Table 1. *Known Conservation State of bat species for Bonaire, St. Eustatius and Saba, Netherlands Caribbean. Our relative ranking of abundance categories is based on the metric 'bat captures per net-night' (BNN), as documented by Genoways et al. (2007) for Saba, Pedersen et al. (2018a) for St. Eustatius and Simal et al. (2021) and Simal and Nassar (2025) for Bonaire. R: range-restricted species; R*: range-restricted subspecies; W: widespread; A: abundant; C: common; U: uncommon; V = very uncommon. Many bats can eat a variety of foods but in our table only the principal diet preference is indicated, unless other food types are also commonly taken. Internation Union for the Conservation of Nature (IUCN) status: LC = Least Concern, V* = Vulnerable by IUCN standards and protected by law in Bonaire.*

Latin name	common name	distribution	daytime roost	main food habits	spec or gen.	Bonaire	Statia	Saba	worldwide trend	IUCN
Ardops nichollsi montserratensis	Antillean Tree Bat	R	trees, higher island elevations	frugivore	spec.	-	V	V	unknown	LC
Artibeus j. jamaicensis	Jamaican Fruit-eating Bat	W	hollow trees, caves	frugivore	gen.	-	A	U	stable	LC
Ametrida centurio	Little White-shouldered Bat	W	dense foliage	fruits, insects, nectar	gen.	V	-	-	unknown	LC
Brachyphylla c. cavernarum	Antillean Fruit-eating Bat	R	principally caves	omnivore	gen.	-	C	C	unknown	LC
Glossophaga longirostris elongata	Miller's Long-tongued Bat	W	light and dark caves, also buildings	nectarivore	spec.	C	-	-	unknown	LC
Leptonycteris curasoae	Curaçaoan Long-nosed Bat	W	principally caves but also man-made structures	nectarivore	spec.	A	-	-	decreasing	V*
Molossus m. molossus	Pallas's Mastiff Bat	W	man-made structures	insectivore	gen.	-	C	C	unknown	LC
Molossus molossus pygmaeus	Pallas's Mastiff Bat	W	man-made structures	insectivore	gen.	V	-	-	unknown	LC
Monophyllus plethodon luciae	Insular Single-leaf Bat	R	caves, man-made structures, higher elevations	nectar, fruits, insects	?	-	V	V	unknown	LC
Mormoops megalophylla intermedia	Ghost-faced Bat	R*	warm caves	insectivore	spec.	C	-	-	decreasing	LC
Myotis nesopolus nesopolus	Curaçao Myotis	R	warm caves	insectivore	spec.	U	-	-	unknown	LC
Natalus tumidirostris	Trinidadian Funnel-eared Bat	W	warm caves	insectivore	spec.	U	-	-	unknown	LC
Natalus s. stramineus	Mexican Funnel-eared Bat	R	warm caves	insectivore	spec.	-	-	U	unknown	LC

Latin name	common name	distribution	daytime roost	main food habits	spec or gen.	Bonaire	Statia	Saba	worldwide trend	IUCN
Pteronotus davyi	Davy's Naked-backed Bat	W	warm caves	insectivore	spec.	V	-	-	stable	LC
Sphaeronycteris toxophyllum	Visored Bat	W	caves/trees	frugivore	spec.	V	-	-	unknown	LC
Tadarida brasiliensis antillularum	Mexican Free-tailed Bat	W	caves and man-made structures	insectivore	gen.	-	V	C	stable	LC
Confirmed species per island						9	6	7		
Common or abundant (C, A)						3	3	3		
Uncommon or very uncommon (U & V)						6	3	4		

A total of 22 island occurrences of 16 bat taxa have so far been documented for the Caribbean Netherlands (nine from Bonaire, six from St. Eustatius and seven from Saba; Table 1). Of these, only nine occurrences can be characterised as "common" or "abundant" with 59% of the occurrences concerning uncommon, very uncommon or likely vagrant species. The critical state of conservation of bats in the Caribbean Netherlands should be clear. Island endemic bats, like particularly the four range-restricted species listed for Saba and St. Eustatius, are significantly more threatened than those not restricted to islands and have also typically been much less-well studied (Conenna et al., 2017). This is also the case for the bats of the Caribbean Netherlands, most of which remain poorly studied.

The principal components of an IUCN (International Union for the Conservation of Nature) extinction risk assessment are decline, geographic range and population size (abundance) (Le Breton et al., 2019). The available data for none of the range-restricted species is anywhere suitable for detecting decline, nor is anything really known about population size. Nevertheless, comparing bat counts to rank species according to relative abundance is a critical criterium for conservation assessment, but it is extremely difficult, and the challenges and caveats have been well-highlighted by Pedersen et al. (2009). The most simple and pragmatic metric is 'bat captures per net night' (BNN) (Pedersen et al., 2009). Based on BNN, we present a preliminary relative species ranking of abundance for the Caribbean Netherlands (Table 1) based on data from Genoways et al. (2007) for Saba, Pedersen et al. (2018) for St. Eustatius and Simal et al. (2021) for Bonaire.

Relative BNN values we use for a ranking (as in Table 1), and as reported by Genoways et al. (2007) for Saba were as follows: *Tadarida brasiliensis* n = 24 (33%); *Brachyphylla cavernarum,* n = 17 (23%); *Molossus molossus*, n = 11 (15%); *Artibeus jamaicensis*, n = 9 (12%); *Natalus stramineus,* n = 9 (12%); *Monophyllus plethodon,* n = 2 (2%); *Ardops nichollsi*, n = 1 (1%). Relative BNN captures we use for a ranking, and as reported by Pedersen et al. (2018) for St. Eustatius were as follows: *A. jamaicensis*, n = 124 (72%); *B. cavernarum*, n = 22 (13%); *M. molossus*, n = 22 (13%); *A. nichollsi*, n = 3 (2%); *M. plethodon*, n = 1 (1%); *T. brasiliensis*, n = 0 (0%). Relative BNN captures we use for a ranking for Bonaire, and as provided by Simal et al. (2021) for Bonaire were as follows: *Leptonycteris curasoae*, n = 2379 (51%), *Glossophaga longirostris*, n = 995 (21%); *Mormoops megalophylla*, n = 754 (16%); *Myotis nesopolus*, n = 269 (6%), *Natalus tumidirostris*, n = 234 (5%); *Pteronotus davyi*, n = 1 (<<1%). Based on bat detector data, *M. molossus* seems more common in Saba than suggested by BNN, probably because it is a fast, open-spaces hunting bat that has less chance of getting into a mist net than species that forage lower in the vegetation (Noort, pers. obs.). Methodological limitations must be kept in mind and improvements or changes in our assessments will certainly occur in time as long newer, better, and more sophisticated research becomes available.

The Lesser Antilles are a disaster-prone region with various risks of volcanic eruption (even for Saba, Roobol and Smith, 2004) and hurricanes (Pedersen et al., 2009; Rodriguez Duran, 2020), which have been shown to have heavy consequences for bat populations. The regional analysis by Pedersen et al. (2009) found that Saba and St. Eustatius have relatively low numbers and abundance of bat species considering their size (along with St. Maarten) and as compared to most other islands in the northern Lesser Antilles.

For all except one species, the current IUCN listing is as "Least Concern" (LC; Table 1). However, this is only based on information regarding their occurrence on multiple islands and the assumption that they are "probably" abundant on the islands on which they occur. On the other hand, our assessments indicate that for both Saba and St. Eustatius at least, the scant abundance of *A. nichollsi* and *M. plethodon* can provide very little assurance against extinction risk. In fact, *A. nichollsi*, *M. plethodon* and *N. stramineus* all appear rare or (in some cases) even totally absent on St. Maarten and St. Barthelemy (Larsen et al., 2006; Genoways et al., 2006) and Nevis (Pedersen et al., 2003), while *A. nichollsi* is slightly more abundant on St. Kitts, but *N. stramineus* is altogether absent (Pedersen et al., 2005). Their scant populations on the various surrounding islands provide little reassurance against local extinction risk for bats on Saba or St. Eustatius. Recent work shows that *A. nichollsi* and *M. plethodon* fortunately appear common on Martinique (Catzeflis et al., 2019) and St. Lucia (Pedersen et al., 2018b) so that as a species their global status may

still be less of a concern. *Leptonycteris curasoae* is the only species for the Caribbean Netherlands with a listing other than LC (see Table 1). It is listed as "Vulnerable" (VU) by IUCN-criteria based on decreasing populations, breeding that is limited to a few major caves in northern South America (3 to 4 per ABC island, 5 in Venezuela, 1 in Colombia; Otálora-Ardila et al., 2024) and the decline of the dry cactus-dominated ecosystem it depends on in South America which, for the most part, lies outside protected areas (Nassar, 2015, Cole & Wilson, 2006). Due to its IUCN status as "Vulnerable", *Leptonycteris curasoae* also happens to be the only species of bat fortuitously included as a legally protected species for the island of Bonaire.

Characteristics

Description

Overall, few studies have been done on the bats of these islands but several patterns can still be discerned. First, the bat fauna of Bonaire, leeward Dutch island, on the one hand, and Saba and St. Eustatius, windward Dutch islands on the other, show practically no overlap in species. Only one species (the generalist insectivore, *Molossus molossus*) overlaps at species level but with different subspecies in the two island groups. In total, the islands together possess six range-restricted bat taxa. Bonaire has two range-restricted bat taxa, of which one subspecies and one species of insectivorous bat all depend on warm caves (Table 1). In contrast, Saba and St. Eustatius have four range-restricted bat taxa, all of which at the (higher) species level and of which three are principally frugivorous and one insectivorous. The principal daytime roosts are in caves for three species and in trees for one species.

On Saba and St. Eustatius, current bat faunas are impoverished compared to surrounding islands and compared to former pristine conditions (Pedersen et al., 2009), and this has in part been ascribed to deforestation. On St. Eustatius, deforestation was for agricultural purposes during the colonial epoch but on Saba due to die-off of a key forest tree species (Freitas et al., 2019). On Bonaire, longstanding deforestation resulted from unsustainable wood harvest during colonial times (Freitas et al., 2005) and continuing chronic overgrazing that limits forest recovery and threatens keystone cacti landscapes just as in Curaçao (Petit, 2009). On Bonaire, the only documented species that has never again been collected and which may have been a rare vagrant is *Ametrida centurio*, a tree-roosting and principally fruit-eating species that may be especially sensitive to deforestation. The individual recorded of this species probably arrived from the mainland, while foraging and losing orientation, or alternatively was accidentally transported in a merchandise ship coming from Venezuela. The same may be true for the most recently documented Visored Bat, *S. toxophyllum*, also a fruit-eating species.

While the range-restricted taxa listed by Bos et al. (2018) are identical to those we list here for Saba and St. Eustatius, those listed for Bonaire here differ from those presented previously by Debrot (2006). We have delisted both *Leptonycteris curasoae* and *Natalus tumidirostris* as "range-restricted" species/subspecies for the Leeward Dutch islands, based on the wide range of documented distribution for both species, genetic assessments (Newton et al., 2003), and the documented connectivity between the islands and the mainland of Venezuela for *L. curasoae* (Simal et al., 2015). However, we have added one new bat subspecies and one new species to the list of range-restricted taxa for Bonaire, based on their limited range of distribution. The first concerns *Mormoops m. intermedia,* an otherwise wide-ranging species of which the subspecies *intermedia* is limited to a very small area in the Southern Caribbean (Rezsutek and Cameron, 1993). The second concerns *Myotis nesopolus*, currently limited to the Leeward Dutch islands and a small portion of Venezuela (Solari, 2016). According to earlier as well as more recent work using a multivariate analysis, *M. n. nesopolus* from Bonaire and Curaçao differ from *M. n. larensis* from coastal Venezuela more than expected of subspecies in mammals (Genoways and Williams, 1979, Larsen et al., 2012).

Even though new analyses, based on a multivariate assessment of measurements for four subpopulations (Tejedor, 2011) showed no overlap between subpopulations, *N. tumidirostris* is still counted as monotypic. The species is the most geographically variable of the four continental *Natalus* species and is found in

Colombia, Venezuela, the Leeward Dutch islands, Trinidad, and all the way down to French Guyana (Tejedor, 2011). The Curaçao and Bonaire *N. tumidirostris* population, referred to traditionally as *Natalus t. tumidirostris*, has often been considered a subspecies endemic to Curaçao and Bonaire (Genoways and Williams, 1979). Three subspecies were recognized in the past, *N. t. tumidirostris* (Netherlands Antilles; G. S. Miller, 1900), *N. t. continentis* (mainland Venezuela; Thomas, 1910), and *N. t. haymanii* (Trinidad; Goodwin, 1959), but they seem to represent little more than color and body-size ecological variants: smaller and paler in drier habitats and larger and darker in wetter habitats.

In conclusion:

- On all three islands, very few species can be considered common or abundant. Most species are uncommon or very uncommon, and their future status on these islands can be considered quite uncertain.
- The islands of Saba and St. Eustatius have a lower-than-expected number of bat species than on average to be expected in the Antilles based on island size.
- The principal cause for low bat diversity is believed to be deforestation.
- There are large differences in bat faunas between leeward Bonaire and the two windward islands of Saba and St. Eustatius.
- Saba and St. Eustatius have more-highly range-restricted ("endemic") bat taxa (4) than Bonaire (2), because of greater isolation from mainland sources of bat diversity.

Relative Importance Within the Caribbean

Bats form an ecologically important component of the biodiversity of the Lesser Antilles which amounts to 27 species (Pedersen et al., 2013). This is low compared to the number of bat species on the larger islands like Cuba and Hispaniola or on the mainland parts of the Americas. Even so, the Lesser Antillean islands have 11 endemic species typically found on just few adjacent islands and contribute meaningfully to the unique biodiversity of the region. The Caribbean Netherlands form part of the Caribbean biodiversity hotspot (Myers et al., 2000; Mittermeier et al., 1999) and have a total of 16 bat taxa, six of which are range-restricted species or subspecies and ten other ones are more widely distributed bat taxa.

The keystone roles fulfilled by bats as pollinators, seed dispersers and insectivores have high ecosystem importance to the maintenance of terrestrial biodiversity on these islands, including many other endemic taxa. An example from Bonaire is the role that nectar- and fruit-feeding bats play as key pollinators and seed dispersers of candelabra cacti (Petit, 1995), which in turn are a principal dry-season food source for the endangered parrot, *Amazona barbadensis*, and the following six endemic subspecies of birds: parakeet, *Aratinga pertinax xanthogenius*; Tropical Mockingbird, *Mimus gilvus rostratus*; Pearly-eyed Thrasher, *Margarops fuscatus bonairensis*; Bananaquit, *Coereba flaveola bonairensis*; Black-faced Grassquit, *Tiaris bicolor sharpei*; and Yellow Oriole, *Icterus nigrogularis curacoensis*.

Ecological Aspects

Habitat:
With the likely small population sizes of bats found particularly on Saba and St. Eustatius, bat species survival in these and surrounding islands depends on the ability of bats to move between islands. Yet practically nothing is known about this (Pedersen et al., 2009). Their essential habitat for long-term survival thus extends beyond any given island.

The key importance of caves for the range-restricted species of the bats of the Caribbean Netherlands is clear and caves have been indicated as a key conservation priority for bats in the islands (Genoways et al., 2007; Pedersen et al., 2013, 2018a; Simal et al., 2021). While for Bonaire the presence of bats in caves is well-established (Simal et al., 2021), for Saba and St. Eustatius, the key bat caves appear to be much more elusive (Genoways et al., 2007; Pedersen et al. 2018a). Finding the key bat caves or other

roosting locations on Saba and St. Eustatius is of crucial importance, but in 2022 and 2023 Boeken and Noort made a larger effort to find, map and survey key caves, crevices and overhangs of Saba (in addition to the Sulphur mine, of which only two of the 19 were 10 meters or deeper) and St. Eustatius (two, including the location listed by Pedersen 2018a for Venus Bay). However, signs of a few bats were only found at a single "cave" shelter (the Sulphur Mine) and one man-made shelter location (ceiling) on Saba while scientists from the Royal Netherlands Meteorological Institute incidentally encountered a few bats roosting in a shallow coastal cave near Ladder Bay. Figure 1 illustrates the results of the efforts to document important bat roosting sites for Saba. The question of where the bats of Saba and St. Eustatius are roosting and why they do not appear to use natural rock shelters on these islands is key to their protection and requires further investigation. The possible low availability of suitable caves or their low use due to preference for more ephemeral manmade structures may explain the (at least temporary) extirpation of certain bats species from these islands due to hurricane impact (Rodriguez Duran et al., 2020).

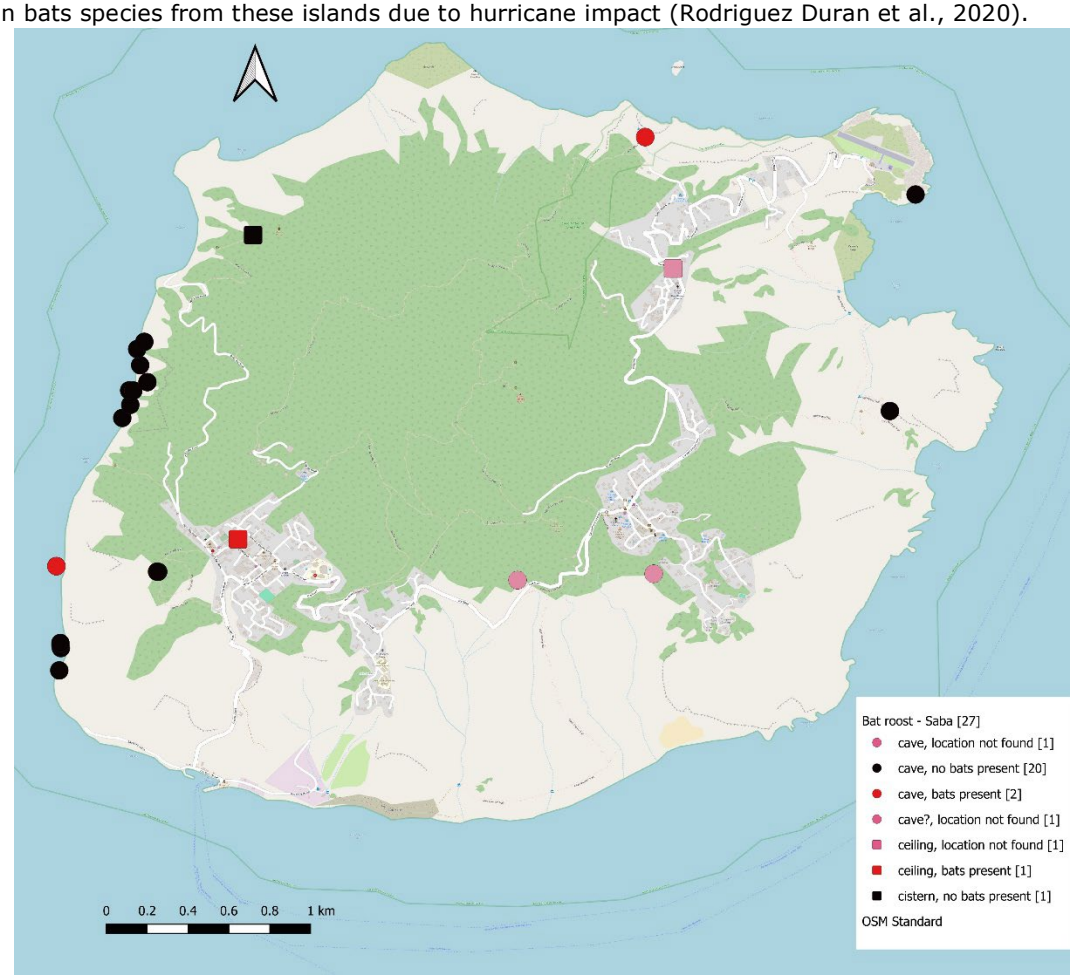

Figure 1. *Bat* roosting *site survey results for Saba in 2023, based on 27 site visits to high-potential bat roosting sites. Round = natural cave, Square = artificial/man-made structure. Black: searched potential sites with no bats detected, red: sites with a few or dozens of bats found roosting, pink: sites reported to have likely bat roosts but which were unable to find.*

Minimum viable population size: not reached for any species

A minimum viable population (MVP) means a 5% extinction risk within 100 years. MVPs for bats are unknown; however, based on the surveys that have been conducted, it is safe to say that, with exception of *L. curasoae*, which moves among the ABC islands and mainland and probably migrates seasonally to southern Venezuela and eastern Colombia (Simal et al., 2015), none of the islands of the Caribbean Netherlands have populations that even approach the 5,000 population size criterium that is typically considered a minimum for long-term survival. Therefore, survival of these species on the islands will depend critically on animals immigrating from beyond the islands. Unfortunately, for very few species is

anything known about movements between neighbouring islands (e.g.; Simal et al., 2015; Pedersen et al., 2009) nor about the population sizes inhabiting nearby islands. In fact, for three of the four Antillean endemic bat species of Saba and St. Eustatius *(A. nichollsi*, *M. plethodon* and *N. stramineus)*, their status on neighbouring islands appears equally tenuous (Genoways et al., 2006; Larsen et al., 2006; Pedersen et al., 2003, 2005).

Present Distribution and Reference Values

Little can really be said with great certainty about the habitat distribution or habitat preferences of bats on the islands of the Caribbean Netherlands. Nevertheless, a few key points can be made based on the available mist-netting results and additional observations by experts.

Saba (based on Genoways et al., 2007): *T. brasiliensis* has so far only been documented from a single location in English Quarter. All *B. cavernarum* were documented from Island Gut. *Artibeus jamaicensis* was found in low numbers in the Sulphur Mine. *N. stramineus* was documented from one location at Mary's Point, but a cave could not be located. A roost of *M. molossus* was found in one building on Saba, but more are expected. Genoways et al. (2007) searched three caves on Saba without finding any bats. These were Deep Cave on Great Hill, a small overhang cave south of The Bottom and the seaside cave at Well's Bay which was reported at one time to have harboured bats. The historic collection site of Bat Hole, a small cave at Ladderberg near Land Point is worth examining again as a potential daytime roost for *B. cavernarum*, if it still exists.

St. Eustatius (based on Pedersen et al., 2018a): *B. cavernarum* were seen in large numbers in a cave at Venus Bay. *A. nicholsi* and *M. plethodon* were only documented from the higher regions of the Quill. *A. nicholsi* apparently prefers the higher parts of islands (Catzeflis et al., 2019). Even though *M. plethodon* is also found in low numbers on more xeric islands, it may be dependent on the Quill in Statia because of the major impact of man on the vegetation (Pedersen et al., 2018a). According to Catzeflis et al. (2019) *M. plethodon* is also clearly a species of higher elevations.

Bonaire (based on Simal et al., 2021): While in contrast to Saba and St. Eustatius, on Bonaire the five principal bat caves studied until now are fairly well-known, and several of these caves are now part of the BONAIRE CAVES & KARST NATURE RESERVE, none of them have true legal protection or structural management. However, this island is rich in caves and karst, deserving further exploration for possible additional caves used by bats as day, mating and maternity roosts. The real distribution of bats across the island while foraging is less well-known, because all mist-netting has focussed on the larger bat caves. For this reason, recent results may also not give proper representation of species that roost in other structures (such as buildings, cisterns, scattered crevices and trees).

Assessment of National Conservation State

Trends in the Caribbean Netherlands

Aside from a few recent baseline studies that provide at least some points of reference, nothing is known about population trends for bats in the Caribbean Netherlands. However, on Bonaire, after erecting physical barriers to keep humans out of bat maternity chambers at the five most important bat maternity roosts in 2020, ongoing research has preliminarily shown an increase in the size of the colonies after four years (2021-2024) of data collection (F. Simal and J. Nassar, unpublished data). This ongoing research is a 6-year quantitative study, which collects data simultaneously at these five caves using infrared light to take images of the bat colonies during the day at two of these caves and filming their evening exits at the other three. The aim of the study is to assess the long-term effect of the protective barriers on the colonies.

Reference values for population size and distribution: limited
Very few quantitative assessments have been done for the Caribbean Netherlands and assessments are by nature plagued by limited site-selection and technical difficulties as accurately counting bats is extremely difficult.

Recent developments: none
No major developments aside from the several recent studies cited herein need to be mentioned.
However, during 2019 and 2020, a Bonaire Caves and Karst Nature Reserve was inaugurated to protect all the known Middle Terrace bat maternity roosts from disturbance by gating the cave entrances. Unfortunately, since then the project has stagnated due to lack of local support and a legal status remains wanting.

Assessment of distribution: unfavourable-bad
While on Bonaire the five main roosting and pupping caves are well known, on Saba and St. Eustatius most daytime roosting locations remain unknown while those that are known appear small. One notable exception is a coastal cave at Venus Bay St. Eustatius, that has been found to (at least once) have harbored about 250 *B. cavernarum* (Pedersen et al., 2018). Due to the critical nature of roosting/pupping caves, and notwithstanding the island-wide foraging distribution of bats in general, we apply a more restrictive concept of "distribution" than would, for instance, be applied to birds (which also fly all around an island but which are much less restricted to a highly specialized habitat feature like caves).

Assessment of population: unfavourable-bad
With exception of *L. curasoae*, and probably *G. longirostris*, there can be little doubt that none of the other bat species on any of the three islands meet the 5,000 minimum viable population (MVP) size for long-term survival. Long-term survival of these species will critically depend on the status of these species on surrounding islands (in the case of Bonaire, also in Venezuela) and the movement of bats between the various islands. Fifteen of the 22 documented species occurrences regard species to be characterized as either uncommon, very uncommon or already extirpated (Table 1). Most species are very vulnerable to local extirpation and clearly highly dependent on populations of adjacent islands.

Assessment of habitat: favourable
In general, forest habitat quality for bats is certainly to have been degraded compared to early colonial conditions but, on the other hand, probably improved in recent decades due to reduced agricultural activity (de Freitas et al., 2005; 2014; 2016). The only major persistent negative pressure is uncontrolled and excessive grazing by roaming livestock (e.g., Debrot et al., 2015; Lagerveld et al., 2015; Madden, 2020), which does not allow the much-needed forest recovery to take place. Bat caves of Bonaire presently seem to be of adequate quality while the bat roosting habitats of bats of St. Eustatius and Saba are largely unknown, destroyed (Bat Hole, Saba) or recently degraded (Sulphur Mine, Saba). Disturbance, even based on well-meaning interest, can cause serious disturbance to roosting or nursing bat colonies and is a danger that needs to be controlled by limiting human access.

Assessment of future prospects: unfavourable-bad in the long-term
Given the apparent intractability of the roaming livestock problem, the inexorable long-term climate change impacts, the already seemingly small and vulnerable island population sizes of most bats on Saba and St. Eustatius and the growing risk of disturbance of key daytime roosting habitat, long-term prospects for bats on the islands of the Caribbean Netherlands seem quite uncertain.

Table 2. *Summary overview of the status of the bats of the Caribbean Netherlands in terms of different conservations aspects.*

Aspect (for the many rare and range-restricted species)	**2024**

Distribution	Unfavourable-bad
Population	Unfavourable-bad
Habitat	Favourable
Future prospects	Unfavourable-bad
Overall Assessment of Conservation State	**Unfavourable-bad**

Comparison to the 2018 State of Nature Report

This is the first CS assessment made for the bats of the Caribbean Netherlands and hence no comparison can be made to any earlier report.

Recommendations for National Conservation Objectives

Setting priorities in conservation is essential as the number of species requiring action is large and because the costs for the necessary interventions on a species-basis typically exceed the available resources (Possingham et al., 2002). Careful choices need to be made on what to do and where to spend resources. Ideally then, an ecosystem-based, holistic approach to conservation with the participation of local communities is needed, whereby the focus should be on conserving and restoring systems of benefit to the conservation of various species at the same time. Due to the poor level of knowledge available for bats and the high costs of detailed research, management interventions to guarantee the future presence of this keystone group of important and yet vulnerable animals should also focus on holistic ecosystem measures that simultaneously benefit multiple species, systems and the human communities that share the habitat with the bat fauna. As pointed out by Pedersen et al. (2013) and Simal et al. (2021), the conservation actions most needed for protection of bats are:

a. Find the key daytime shelter habitats for the bats of Saba and St. Eustatius, whether natural or manmade (as these remain largely unknown).
b. Protect caves and other shelter locations, such as abandoned cisterns or rock overhangs that are known to serve as bat shelters (e.g., implementation of the Bonaire Caves and Karst Nature Reserve). Protect roosts in houses and/or create special artificial shelters.
c. Add all bats to the island lists of protected species. Only *Leptonycteris curasoae* is protected on Bonaire by means of the Island Ordinance for Nature Management (A.B. 2008, no. 23).
d. Improve forestation and forest diversity for a more ample, and stable supply of fruit and insect food.
e. Restore and protect hydrological systems, such as springs, ponds, and natural freshwater sources that bats will eagerly make use of.
f. Increase local awareness and create direct and indirect connections between local communities, bats and their roosts, through bat-related cultural and ecotourism activities as a source of profit. Improve knowledge on healthcare in combination with mosquitos and diseases brought by mosquitos and the role of insectivore bats as potential regulators of mosquito populations.
g. For Saba, a longstanding bat habitat is the so-called sulphur mine. In recent years, several entrances to the mine have become obstructed, probably leading to unfavourable conditions inside the old mine shafts, in turn resulting in reduced bat usage of the mine. Restoring the openings could help restore the apparently degraded habitat quality in the mines.

Key Threats and Management Implications

The major threats to bats are principally fourfold:

a. The first and most immediate is further degradation and or lack of recovery of forest habitat. Grazing pressure by goats causes aridification, floral impoverishment and lack of forest recovery. This plays on all three islands.

b. The second is the pressure of increasing human disturbance or destruction of caves and other daytime roosting habitat. For Saba and St. Eustatius, with only two exceptions, roosting caves/mines are all but unknown. On the other hand, for Bonaire the main roosting caves are largely known. Although they are not inside managed or protected parklands, a conservation intervention led by WILDCONSCIENCE and IVIC (Venezuela) since 2019 to exclude humans from the main cave chambers used by bats, is gradually showing positive effects on the protection of cave-dwelling bats on this island (F. Simal and J.M. Nassar, unpublished data).
c. The assessment by Morgan (2001) shows that specialized or obligate cave-dwelling species are the most vulnerable to extinction and the role of past climate change appears to have been quite important. The threat of climate change whereby the expected warming and drying trend in the Caribbean will reduce and ultimately eliminate the rainforest and remnant elfin woodlands on the highest zones of these islands, can be expected to endanger the food supply and daytime roost habitat for those species roosting in trees. Climate change will also affect temperatures within cave systems used by bats and other vulnerable fauna (Mammola et al., 2019; Medina et al., 2023), possibly causing bats to lose certain roosting habitat. An important negative link between bat diversity and temperature in the Caribbean has been further suggested by Hoffman et al. (2019).
d. For the bats of Saba and St. Eustatius, hurricanes can cause heavy mortality rates, especially for those species or populations that shelter in trees or buildings as opposed to caves (Gannon and Willig, 2009).

Data Quality and Completeness

In spite of (and possibly because of) the fact that many bat species are endangered and have small population size and/or limited distribution, very little is known about the species-specific ecology of most Antillean species. This is a key knowledge gap that may seriously hamper their conservation, not only in the Caribbean Netherlands but in the Caribbean as a whole. As pointed out by Pedersen et al. (2009), quantitative insights into bat populations (population size) are extremely difficult, not only because many roosts remain unknown, but because bats will switch between roosts depending on their specific needs and because counting all bats in complex roost sites is almost impossible. Documenting population trends is therefore also very problematic. Both are key criteria for determining IUCN population Conservation State of a species (Le Breton et al., 2019). In addition, practically nothing is known about the ecology of three of the island endemic species of Saba and St. Eustatius (*A. nichollsi*, *M. plethodon*, *N. stramineus*) (Davalos & Rodriguez Duran, 2019; Davalos & Tejedor, 2016; Rodriguez Duran & Davalos, 2018). More is fortunately known about the fourth more-widely-spread island endemic *B. cavernarum* (Rodriguez Duran & Davalos, 2019). Further understanding of the ecology of all, but especially the range-restricted bats species (which represent the unique local contribution to biodiversity), would be of great value.

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Photo cover: An extreme example from St. Eustatius of how uncontrolled livestock husbandry can overgraze vulnerable slopes to the point at which even infrastructure at the top of the cliff comes in danger from erosion.

Photo: J. Hazenbosch

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