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Mangroves of the North Brazil Shelf

LC

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Abstract

Mangroves of the North Brazil Shelf (NBS) are a regional ecosystem subgroup (level 4 unit of the IUCN Global Ecosystem Typology). It includes the marine ecoregions of Amazonia, Guianan, Northeastern Brazil, and the Southern Caribbean. The NBS mangrove province had a mapped extent in 2020 of 13204.0 km^2, representing 9.0% of the global mangrove area. The biota is characterized by *Rhizophora mangle*, *R. racemosa*, *R. harrisonii*, *Avicennia germinans*, *A. schaueriana*, and *Laguncularia* racemosa species of mangrove trees, including several species of vertebrates and invertebrate comprising the benthic fauna. They serve as a natural barrier against tropical storms, provide a safe habitat for endangered species from marine and terrestrial environments, enhance food security, and supply resources for the local economy. Beyond their socio-ecological relevance, mangroves are interconnected with different environments, such as *várzeas*, *igapós*, brackish water marshes, *and terra firme,* and may be present in lentic freshwater environments. Despite the increasing negative impact of human activities, the NBS mangroves are well preserved, mainly due to their vast extent and low human occupation, with a loss of 0.8% along the Brazilian Amazon coast since 1996. If this trend continues, an overall change of 2.1% is projected over the next 50 years. Furthermore, under a high sea level rise scenario (IPCC RCP 8.5) ≈-8.9% of the NBS mangroves would be submerged by 2060. Moreover, 3.8% of the province's mangrove ecosystem is undergoing degradation, with the potential to increase to 11.2% within a 50-year period, based on a vegetation index decay analysis. Overall, the NBS mangrove ecosystem is assessed as **Least Concern (LC)**.

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Keywords:
Mangroves; Red List of ecosystems; ecosystem collapse; threats.

Ecosystem classification:
MFT1.2 Intertidal forests and shrublands

Assessment's distribution:
North Brazil Shelf Province

Summary of the assessment

Criterion	A	B	C	D	E	Overall
Subcriterion 1	**DD**	**LC**	**DD**	**DD**		
Subcriterion 2	**LC**	**LC**	**LC**	**LC**	**NE**	**LC**
Subcriterion 3	**DD**	**LC**	**DD**	**DD**		

LC: Least Concern, DD: Data Deficient, NE: Not Evaluated

Mangroves of The North Brazil Shelf LC

1. Ecosystem Classification

IUCN Global Ecosystem Typology (version 2.1, Keith *et al.* 2022):

Transitional Marine-Freshwater-Terrestrial realm

MFT1 Brackish tidal biome

MFT1.2 Intertidal forests and shrublands*

MFT1.2_4_MP_13 Mangroves of the North Brazil Shelf*

*Uniquely, mangroves on the Amazon Delta (00°52′ N to 01°41′ N) have been recorded - since the early 2000s - to exist in freshwater tidal environments with surface water salinity reaching 0 (zero) practical salinity units (PSU) (Costa Neto *et al*., 2006).

IUCN Habitats Classification Scheme (version 3.1, IUCN 2012):

1 Forest

1.7 Forest – Subtropical/tropical mangrove vegetation above high tide level *below water level*[1]

12 Marine Intertidal

12.7 Mangrove Submerged Roots

The world's largest continuous mangrove belt is located on the Brazilian Amazon coast, North Brazil Shelf (Photo credit: Sam Marcelo – Mangues da Amazônia/Petrobras).

[1] Note on the original classification scheme. This habitat should include mangrove vegetation below water level. Mangroves have spread into warm temperate regions to a limited extent and may occasionally occur in supratidal areas. However, the vast majority of the world's mangroves are found in tropical/subtropical intertidal areas.

2. Ecosystem Description

Spatial distribution

The Mangroves of the North Brazil Shelf (NBS) province include intertidal forest and shrublands of the marine ecoregions of Amazonia, Northern Brazil, French Guiana, Suriname, Guyana, Venezuela, and the island of Trinidad in the southern Caribbean (Figure 1). The estimated extent of mangroves in this province was 13,204.0 km^2 in 2020, representing about 9.0% of the global mangrove area. A 0.8% net area change has occurred since 1996 (Bunting *et al.*, 2022).

Mangroves are generally continuous throughout the entire NBS, with the world's largest continuous mangrove belt (7.210 km^2; Hayashi *et al*., 2019) extending across the entire Brazilian state of Pará until São José Bay in the state of Maranhão (Souza-Filho, 2005; Nascimento et al., 2013; Hayashi *et al*., 2023). These mangrove forests may extend several kilometers inland along seasonally flooded riverbanks (Menezes *et al.*, 2008). Mangrove forests in this province are highly productive, dense, and have some of the tallest mangrove trees worldwide (Nascimento *et al*., 2013; Hayashi *et al*., 2023). They are also transitional ecosystems between other forested environments, such as *várzea* (Gomes *et al*., 2024), *igapós*, *restinga*, and *terra firme*. Mangroves form transition zones with other systems such as dune, saltmarsh, and brackish water marsh and comprise a hypersaline tidal flat (*apicum*) and multiple typologies (Mendes, 2005). Nonetheless, gaps exist where the coastline is less favourable for mangrove colonisation, such as rocky shores or adverse hydrology. For example, mangrove development at the mouth of the Amazon River is inhibited by the sheer quantity of sediment discharge, with mangrove fragments occurring only in the Bailique and Marajó archipelagos (Menezes *et al.,* 2008; Abreu *et al.*, 2016).

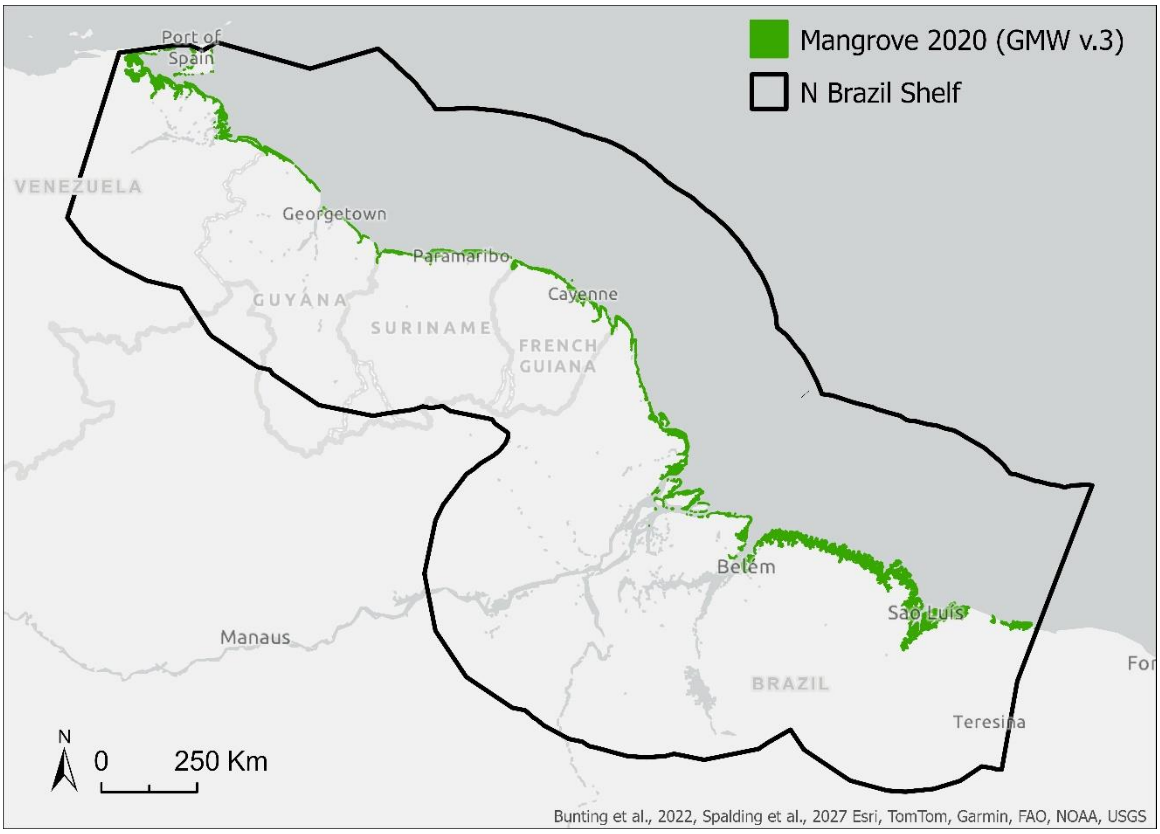


Figure 1. The mangroves of North Brazil Shelf.

East of the mouth of the Amazon River, the region is characterised by many minor estuaries and inlets (Isaac & Ferrari, 2017), which, in addition to the Amazon River (Crooks *et al.*, 2019), provide sediment and freshwater throughout the coastal plains (Anthony *et al.*, 2010). Large mangrove tracts prograde over this area's subtidal sands and some active cliffs. Near São Luís, mangroves develop in the estuarine environments formed by naturally occurring sand barriers parallel to the coastline (Teixeira & Souza-Filho, 2009). The area west of the mouth of the Amazon River is flat, covered with a thick mud wedge built up from ancient sediment deposits (Souza Filho *et al.*, 2008), which is subject to alternating phases of sedimentation and erosion, controlling the landscape morphology and extent of mangroves in this region (Anthony *et al.*, 2010). The magnitude of this extent is significant, with annual rates of mangrove progradation and retreat reaching 500 m in French Guiana (Proisy *et al.*, 2021).

High sedimentation from the Amazon River creates a thick mud layer on the edge of Amazonian mangroves (Photo credit: Sam Marcelo – Mangues da Amazônia/Petrobras).

Biotic components of the ecosystem (characteristic native biota)

There are six recorded mangrove species in the NBS province. Two black mangroves: *Avicennia germinans* (L.) L. and *A. schaueriana* Stapf & Leechm. Ex Moldenke, three red mangroves: *Rhizophora mangle* L., *R. racemosa* G.F.W. Meyer, and *R. harrisonii* Leechman), and one white mangrove: *Laguncularia racemosa* (L.) C.F. Gaertn (Appendix 1. List of Key Mangrove Species). The black mangrove, *A. germinans,* which demonstrates an extremely high salinity tolerance (>60 PSU; Marchand *et al.*, 2004), grows rapidly and is among the tallest of the mangrove species, predominates along the entire extent of the NBS province and will also occupy hypersaline areas forming scrub mangrove forests of three recognised height classes (**class-1** up to 8 m in height – mean salinity of 49 PSU; **class-2** up to 2.5 m – 54 PSU; and **class-3** up to 1 m – >100 PSU) (Virgulino-Júnior *et al*., 2019). By comparison, the related *A. schaueriana* has a much more limited distribution associated with more sandy areas in reports from Suriname and Brazil. Red mangroves are more common inland, bordering rivers and swamps where salinity levels are usually lower (Costa Neto *et al*., 2006).

Rhizophora mangle is most abundant among the red mangroves, with *R. racemosa* and *R. harrisonii* (considered a hybrid species) being less frequently observed. White mangroves are the smallest mangrove species (≤6 m) in the province and are typically observed in areas inundated by spring tides on the landward edge of mangrove stands. Overall, *R. mangle* is the most dominant mangrove tree species along the NBS, followed by *A. germinans* and *L. racemosa* (Abreu, 2007), and is associated with several plant species (Appendix 2. List of Associated Species).

NBS is dominated mainly by red mangrove forests, Rhizophora mangle (Photo credit: Diego N. Carneiro – Instituto Sarambuí).

The NBS is the only ecoregion in the world where mangroves occur in essentially freshwater environments. In the State of Amapá, in the Piratuba Lake Biological Reserve, with the advancement and interiorisation of mangroves, there is a lesser dependence of mangroves on tidal regimes, having been found in environments under the direct influence of freshwater (ICMBio, 2021). In these areas, mangroves establish contact with freshwater marsh areas and lakes, which are influenced by seasonal flooding regimes, conditioning the development of mangroves according to the variation of local gradients (Costa Neto *et al*., 2007). As the relationship with rainwater increases, the mangrove trees become smaller, the density decreases, and the population becomes more dispersed, forming a typology that may follow the coastal plain evolution. In the lakes of the "Eastern Lake Belt" of the reserve (lakes: Piratuba, Trindade, Escara-Jussara, Maresia or Floriano, dos Ventos - locally called dos Gansos - and other smaller ones), whose geographical location is close to the coastline, the freshwater lentic system is dominated by trees of the genus *Rhizophora* L. with the occurrence of plant species such as *Lemna* L., *Wolffiella* Hegelm., *Apalanthe* Planch., *Amaranthus* L., *Utricularia gibba* L., *U. foliosa* L., *Liminobium* Rich., *Hydrocotile* L., além de *Typha domingensis* (Pers.), *Leersia hexandra* Sw., *Eleocharis interstincta* (Vahl) Roem. & Schult., *E. mutata* (L.) Roem. & Schult., *Sebastiana* Spreng., *Nymphaea gardneriana* Planch., *Salvinia auriculata* Aubl., *Pistia stratiotes* L., e *Annona glabra* L. (Silveira & Santos, 2006).

In the middle of the flooded area of the lentic lakes in the Piratuba Lake Biological Reserve, Amapá, Brazil, mangrove islands dominated by Rhizophora racemosa and R. harrisonii are found associated with species of aquatic macrophytes and freshwater fish (Photo credit: Paulo C. C. Virgulino Júnior – LAMA/IECOS/UFPA).

Mangroves associated with low salinity and freshwater are also found in other locations in the state of Amapá as on the Bailique Archipelago (locations: Bailique – between 0 and 2 PSU and Sucuriju – between 0 and 11 PSU; Bernardino *et al*., 2022). In the state of Pará, the same conditions can also be found on the eastern side of Marajó Island, the largest fluvio-marine island worldwide (locations: Furo do Saco - mean 3.3 between 0 and 9 PSU and Praia do Goiabal - mean 5.8 between 0 and 16 PSU; Gomes, 2012) and on the Bragança Peninsula (Furo do Taici - between 0 and 16 PSU; Virgulino Júnior *et al*., 2019). Although these mangrove areas occur on riverbanks and coasts subject to tidal influence, the massive inflow of fresh water from the Amazon River and other large rivers from the Amazon basin ensures that the salinity of the soil is remarkably low (oligohaline) or even absent. These conditions result in unique mangrove structures and compositions throughout the coastal region, with mangrove tree species associating with typical tree species from freshwater floodplains - *várzeas* (Abreu *et al*., 2016; Gomes *et al*., 2023), promoting the introduction of understory vegetation into mangrove forests (Costa Neto & Viana, 2002; Costa Neto *et al*., 2003; Costa Neto *et al.*, 2007). In these situations, the salinity of the water present in the sediment pores can be influenced by different processes, from evaporation concentrating salts in the soil to past saline intrusion events. In other words, it is a response to multiple factors (geomorphological, geological, geochemical, and oceanographic) locally determined that allow the punctual existence of mangroves in environments dominated by freshwater.

Many animal species are associated with mangrove forests (Appendix 2. List of Associated Species). There are at least 294 threatened animal and plant species in the IUCN Red List of Threatened Species (IUCN, 2023) that have natural history collection records or observations within mangroves of this province. Among these species, 12 are Near Threatened; 11 Vulnerable, including *Trichechus manatus* (West Indian Manatee), a flagship species of conservation efforts in this province (Costa *et al.*, 2023); three are Endangered: the stingray, *Styracura schmardae* (Atlantic Chupare), and two mammals: *Alouatta ululata* (Maranhão Red-Handed Howler Monkey), *Pteronura brasiliensis* (Giant Otter); and three Critically Endangered: *Pristis pectinata* (Smalltooth Sawfish), *P. pristus* (Largetooth Sawfish), and *Eretmochelys imbricata* (Hawksbill Turtle).

However, this province's total species will likely exceed this number. Within just the Brazilian Amazon mangroves, there are reports of at least 97 plants, 302 fish (Camargo and Isaac, 2003), 91 birds (Rosário and Fernandes, 2016), 10 reptiles, and 14 amphibians (Silva and Fernandes, 2016), 41 mammals (Fernandes, 2000; Andrade and Fernandes, 2005), 53 marine macroinvertebrates (Beasley *et al*., 2005; Lima, 2016), and an untold number of terrestrial invertebrates including at least 45 species of ant (Ferreira, 2013) and 7 termites (Silva, 2014). A number of these species are also listed in the Red Book of Brazilian Fauna Threatened with Extinction, Volume 1 (ICMBio/MMA, 2018; Appendix 3. Nacional Red List of Species) and are facing major population declines due to hunting for consumption and the sale of meat and skin and deteriorating conditions of mangrove habitat.

Abiotic Components of the Ecosystem

The coast of the NBS is mostly low-lying (0 – 80 m) with extensive muddy coastal plains up to 70 km wide (Souza-Filho, 2005; Anthony *et al*., 2013). Much of the sediment that makes up the coastal plains comes from the Amazon River, which has the highest particulate discharge rate found anywhere in the world (as much as 1,200 Mt per year; Milliman & Farnsworth, 2011) and discharges this mix of clays and fine sands into the Atlantic Ocean (Meade *et al*., 1985; Dunne *et al*., 1998; Filizola & Guyot, 2009; Nittrouer *et al*., 2021). These are then transported toward the Orinoco River in Venezuela (Crooks *et al.*, 2019) by the Northern Brazil Current. This current flow deflects northwest along the Amazon coast and forms the Guiana Current from

January until June and the North Equatorial Counter Current from July to December (Johns *et al.*, 1998; Bourles *et al.*, 1999). The Northern Brazil Current also forms the largest anticyclonic rings in any Western Boundary Current (Fratantoni & Richardson, 2006), which transports vast amounts of nutrients and freshwater from the Amazon River into the ocean, creating low salinity channels in the process (Buehner *et al.*, 2003).

The NBS province has a macro to meso-tidal regime with spring tides ranging from 2 to 6.6 m (Dominguez, 2009), with an average wave height of 0.5 m (Ellenberg, 2010). In the Brazilian coastal portion of this province, tides reach 8 m in Maranhão and, exceptionally, up to 12 m in Amapá (Fernandes, 1997). The average sea temperature is >27°C, and salinity is usually in the range of 10 to 35, with lower values closer to the mouth of the Amazon River.

The Inter-Tropical Convergence Zone drives the two wet and dry seasons (Nobre and Molion, 1986), which give rise to a tropical climate encompassing Tropical Monsoon (Am; North and South of, and throughout French Guiana), Tropical Rainforest (Af; Eastern Venezuela, Guyana, Suriname, and South of the Amazon Delta), and Tropical Savannah (Aw; Brazil, around the Amazon River mouth and further south in the region of São Luís—Maranhão) (Peel *et al.*, 2007). Historical climate data from the WorldClim v1 database were used to assess precipitation patterns in Brazilian mangrove ecosystems. The highest precipitation levels were recorded in the northern region of the country, with Nazaré, located in Amapá, documenting the highest annual precipitation (BIO12) at 3,791 mm. Additionally, the precipitation during the wettest quarter (BIO16) in Nazaré reached 1,655 mm. In Algodoal, Pará, the precipitation for the wettest month (BIO13) was 613 mm, while in Marajó, Pará, the precipitation for the coldest quarter (BIO19) totaled 1,634 mm (Ximenes et al., 2016).

Souza-Filho *et al*. (2023) proposed a classification based on geological, morphological, oceanographic, and climatic characteristics dividing the Brazilian Amazon coast of the NBS province into three distinct subsectors: Subsector North 1(N1 = from Orange Cape – Amapá to North Cape -Amapá state), Subsector North 2 (N2 - from North Cape—Amapá state to Marajó Bay—Pará state), and Subsector North 3 (N3 - from Marajó Bay—Pará state to Santo Amaro City—Maranhão state). This region is characterized by a macrotidal coast with average annual precipitation consistently exceeding 1800 mm (Souza-Filho et al., 2023), air temperature ranging from 21 to 33°C, evaporation between 1000 and 1600 mm per year, and air relativity humidity between 80 and 90%. In addition, combined with extensive Cenozoic deposits (Souza-Filho *et al*., 2023), the hydrological and geomorphological conditions throughout the NBS are favourable for establishing and growing extensive mangrove forests.

Key processes and interactions

The evolutionary process of mangroves depends on a series of physical and ecological interactions closely linked to the pattern of vegetation structure and tidal dynamics (Gomes *et al*., 2025). According to Mendes (2005), there are different typologies for Amazonian mangroves, particularly for mangrove forests with a succession of monospecific vegetation zones. Based on the geomorphological, sedimentological, and hydrodynamic processes involved in the development of the landscape, particularly in the coastal region of the state of Pará, Brazil, mangroves were identified according to the following typologies: **Ladder** – is associated with zones of muddy progradation and mangrove islands that evolved from sandy banks, such as Ilha Nova in the Mojuim River estuary and Ilha dos Bombeiros in the Marapanim River estuary. The succession is generally formed by a herbaceous stratum of *Spartina* Schreb. in the outer portion, followed by young trees of *Laguncularia* and *Rhizophora* in the mesozone and then mature trees of *Avicennia*, which would represent the climax species. **Toothpick** – is observed in erosion zones associated with the concave portions of meanders and/or island tips, with adult and well-developed trees of *Avicennia* and *Rhizophora*. **Mushroom** – presents a concentric distribution of tree species. This typology consists of young trees of *Avicennia* (average height of 5 m), surrounded by smaller individuals and, later, by a fringe of *Spartina*.

The schematic model of the Amazonian coast (Figure 2) presents key processes and interactions where the main source of sediments and nutrients comes from river discharge (Nittrouer *et al*., 2021), originating from continental drainage, which reaches the coastal zone through estuaries. The most significant abiotic and ecological interaction occurs between mangroves and the ocean, where not only the transport of nutrients and sediments takes place, but primarily, the transport of fish and invertebrate larvae such as the mangrove crab (*Ucides cordatus*) that, throughout their life cycle, interact between these two ecosystems (Diele, 2000).

Mangroves act as structural engineers, possessing traits such as pneumatophores, salt excretion glands, vivipary, and propagule buoyancy that promote survival and recruitment in poorly aerated, saline, mobile, and tidally inundated substrates (Tomlinson, 2016). They exhibit high efficiency in nitrogen use and nutrient resorption (Hogarth, 2015). Mangroves produce large amounts of detritus, which is either buried in waterlogged sediments, consumed by crabs and gastropods, or more commonly decomposed by fungi and bacteria, thus mobilising carbon and nutrients to higher trophic levels (Saenger & Snedaker, 1993). This ecosystem is a major blue carbon sink incorporating organic matter into sediments and living biomass (Alongi, 2009).

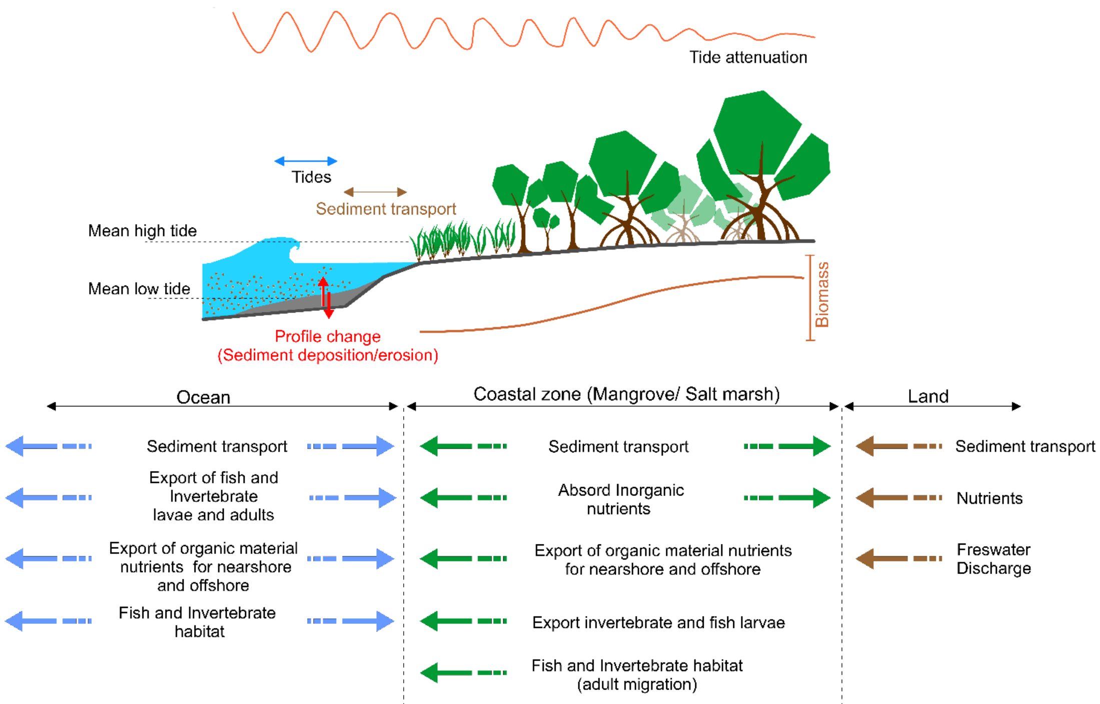
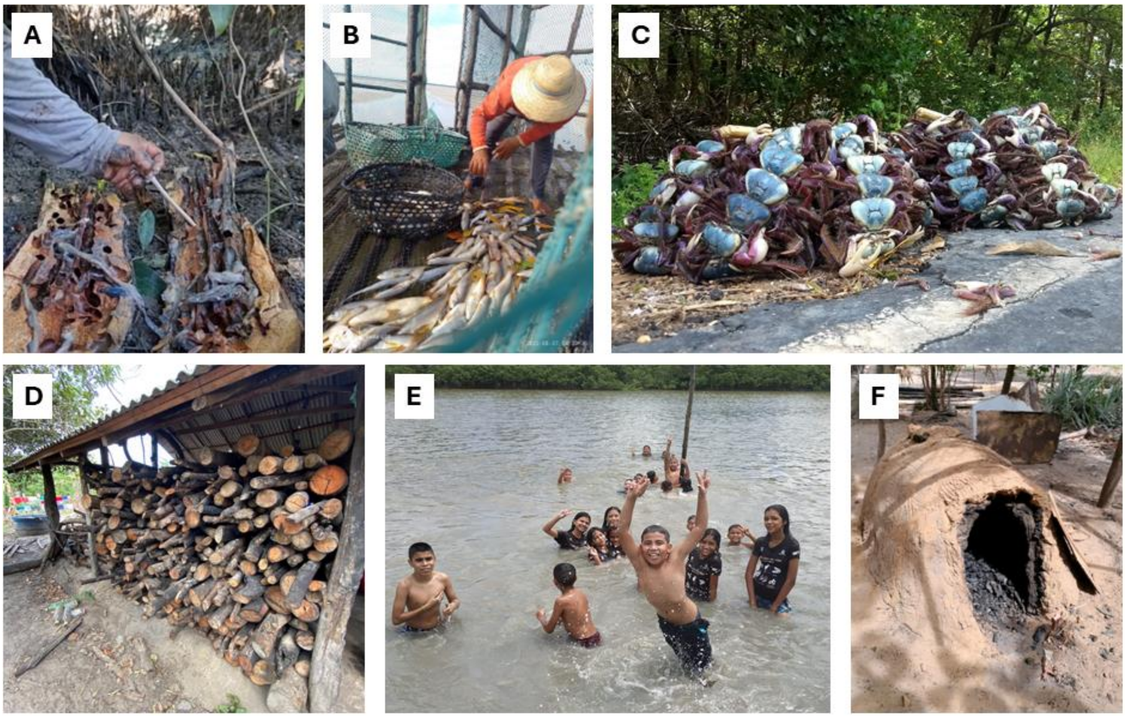


Figure 2. Schematic model showing key processes and interactions on the Amazon coast.

Mangroves are essential for maintaining the coastline (van Hespen *et al*., 2022) and providing various ecosystem services (Silvestri & Kershaw, 2010), supporting an extensive production chain along the Amazon coast. They regulate the ecological balance by preventing soil erosion and controlling greenhouse gases; provide a source of food, water, medicines, wood, and biofuels; and serve as a place for cultural, spiritual, artistic, and economic purposes (Glaser, 2003; Walters *et al.*, 2008; Isaac & Ferrari, 2017; Fernandes *et al*., 2018). Many commercially harvested species, including mangrove crabs, oysters, mussels, and catfish (*Brachyplatystoma vaillantii* & *B. rousseauxii*), depend on mangroves in this province as critical recruitment habitat.

Mangroves produce large amounts of detritus (e.g., leaves, twigs, and bark), which is either buried in waterlogged sediments, consumed by crabs and gastropods, and then decomposed further by meiofauna, fungi, and bacteria, thus mobilising carbon and nutrients to other trophic levels in the mangrove and coastal waters food web. Mangrove ecosystems are important blue carbon sinks, sequestering organic matter in sediments and living biomass. The average value recorded here for the carbon stock of the mangroves from the NBS province is 314.4 Mg C ha^{-1}, with the lowest value recorded for Guyana (140.0 Mg C ha^{-1}) and the highest for the Amazon coastal region of Brazil (672.3 Mg C ha^{-1}) (Table 1). Scrub mangroves dominated by *Avicennia* on the Brazilian coast of the NBS (Ajuruteua Peninsula, Bragança-Pará) correspond to less than 5% of the mangrove vegetation. The carbon estimate of this typology represents circa of 10% (72.93 Mg C ha^{-1}) of the highest value on the Brazilian Amazon coast (Virgulino Júnior *et al*., 2020). Figures for above and below-ground carbon are highest in Surinam and French Guiana mangroves, respectively, while soil carbon values are most expressive in Brazil. The values in Table 1 represent a synthesis of the most up-to-date and accessible estimates for the different carbon compartments in the mangroves analysed. However, figures represent a wide range of variation in these estimates and still do not express the magnitude of the carbon stocks of these exuberant forests. It is still necessary to unify protocols and improve spatial distribution of efforts to access carbon stock values that contemplate the structural diversity of mangrove forests expressed in their multiple typologies that adequately characterize the NBS province, one of the planet's most exuberant and largest mangrove areas.



Uses and products from the mangroves on the Ajuruteua Peninsula, Bragança, Pará state, Brazilian Amazon coast. Shipworms locally known as "turu" (A) fresh fish (B), live mangrove crab (C) firewood (D), recreation and leisure (E), charcoal production (F) (Photo credit: A and C = John Gomes – Mangues da Amazônia/ Petrobras, B = João Farias LAMA/IECOS/UFPA, D and F = Madson Galvão – Instituto Sarambuí, E = Ádria Freitas – Mangues da Amazônia/Petrobras).

Table 1. Carbon stock estimates in Mg C ha^{-1} from mangroves of the NBS. *Mean values representing the Brazilian Amazon coast (states of Amapá + Pará + Maranhão). AGC=above-ground carbon, BGC=below-ground carbon, SC=soil carbon.

	AGC	BGC	SC	TOTAL	References
Guyana	37.0	-	103.0	140.0	Dookie *et al*. (2024)
Suriname	119.8	28.8	27.6	176.2	Government of Suriname (2024)
French Guiana	118.0	40.0	111.0	269.0	Walcker *et al*. (2018)
Brazil*	113.1	29.6	529.6	672.3	Virgulino Júnior (2025)
NBS	**97.0**	**32.8**	**192.8**	**314.4**	
Scrub Mangrove	**36.95**	**35.98**	**-**	**172.93**	Virgulino Júnior *et al*. (2020)

3. Ecosystem Threats and vulnerabilities

Main threatening process and pathways to degradation

Worldwide, mangroves are at high risk from multiple human activities responsible for negative impacts on mangroves. In the Amazon region, mangroves are threatened by aquaculture, urbanisation, over-harvesting, and pollution from domestic, industrial, and agricultural land use (Hayashi *et al*., 2023; Mendes *et al*., 2024a, b).

Aquaculture has been the main driver of the loss of mangroves in other regions of South America, playing only a secondary role in habitat conversion on the Amazon coast. In general, Amazonian mangroves are still very well preserved. According to Hayashi *et al*. (2023), on the Amazon coast, mangroves have less than 1% of their total forest area converted to other uses, mainly urban areas and roads, unlike aquaculture (mostly shrimp farming), which has been the leading cause of mangrove loss in different regions of South America.

The paved road network is one of the main drivers of land use in the mangrove, whereas other factors, such as population density, urban centers, and the number of settlements, are much less critical. The study by Hayashi *et al*. (2019) shows that the region of Pará and Maranhão has 2,024 km of paved highways, unpaved roads (17,496 km) facilitate access to the mangrove, with approximately 90% of anthropogenic impact being recorded within a 3 km radius of these roads. However, the land use area in the forested mangrove areas on the Pará e Maranhão coastline, considering different types of use, settlements (urban areas) represent 88.2% while deforestation only 2.2% (Hayashi *et al*., 2023). In this context, urban expansion into these mangrove regions is clearly due to human pressure through establishing settlements in border areas between the mangrove forests and the adjacent terra firme forests.

The paved road PA-458 in Bragança - Pará, Brazil, is one of the main anthropogenic land-use changes in the Amazonian mangroves *(Photo credit: Amisterdan Botelho – LAMA/IECOS/UFPA)*.

Overfishing and converting mangroves for agriculture and aquaculture near the coast are widespread (Isaac & Ferrari, 2017). This threatens not only the mangroves of this province but also the local communities that depend on them for economic income and food security (Freitas *et al.,* 2013; Hollowed *et al.,* 2013). In Guyana, the conversion of near-coastal land for agriculture and aquaculture has prompted the controversial installation of coastal dikes as a protective measure. However, this artificial solution is less effective and significantly more expensive than the role performed by mangroves (Anthony and Gratiot, 2012). In Suriname, there are reports of "dead waters", where illegal trawling, discarded by-catch, and disturbance of ground sediment cause oxygen depletion and death of local biodiversity (Phillips, 2011; Isaac & Ferrari, 2017). Industrial activities such as clay and salt mining (Senna *et al.,* 2002) result in deforestation and waste, and proximity to growing urban centres generates pollution (Rebelo-Mochel *et al*., 2001). Moreover, oil extraction and exploration are common throughout the province, and oil spills severely threaten mangrove systems (Souza-Filho *et al*., 2009; Silva Junior and Magrini, 2014).

Plastic and heavy metal pollution significantly threatens aquatic systems on the Amazon coastline. The increase in plastic (macro, meso, micro, and nano) in the water is directly related to urban development and population growth. The study by Mendes *et al*. (2024a), located in the Caeté River estuary, Bragança - Pará state, on the Brazilian Amazon coast, showed that an abundance of microplastics (MPs) occurs in the internal portion = 1.03 items/m^3 and external = 0.82 items/m^3, corresponding to the most populated areas and with the highest fishing activity, respectively. Most of the MPs identified are made up of fibers (89.8%), blue (55.2%), and measuring between 1000–2000 µm (31.7%). However, a risk analysis showed a low level of danger, revealing a low impact on the region. Pollution by microplastics (MPs) in mangrove areas is a concern due to its potential impact on the environment and human health. The risk assessment of MPs in coastal sediments of the Amazon region is still insufficient. Mendes *et al.* (2024b) showed that in the Ajuruteua Peninsula, Pará, Brazil, MP concentrations in surface sediment vary on average from 433±261.6 items kg^{-1}. Six types of polymers are associated, including alkyd varnish (AV), resin dispersion (RD), chlorinated polyethylene (CPE), polyethylene-polypropylene (PE-PP), low-density polyethylene (LDPE) and hostaperm blue (HB). The risk assessment showed that all sampling sites were at risk level I: a low level of contamination in the mangrove sediments. Hydrodynamic processes within estuaries and tidal channels play a crucial role in explaining the concentrations found, as circulation determines the pattern of sediment deposition and the particles that adhere to the sediment. Similarly, studies on the concentration of heavy metals in the mangrove environment have ecological relevance for people's food and financial security who live in the mangroves in this region. The mangrove crab (*Ucides cordatus*) is a leading product used for food and trade. The study by Silva et al. (2024) showed that in the different stages of development of the gonads of this crustacean, the concentration of Chromium (Cr) and Lead (Pb) for both sexes presented concentrations above the limits permitted by the Brazilian regulatory agency ANVISA and only Pb by international agencies, revealing a greater degree of contamination of these metals in the gonads of mangrove crabs. Noting that there are still no official standards for these metals in Amazonian environments and only considering the limit concentrations of national and international regulatory agencies, it is worth highlighting that the increase in consumption of this species of crab also increases the risk of contamination among the human population, which may cause public health problems. In addition, Costa (2012) showed that heavy metals such as Cadmium (Cd), Chromium (Cr), Copper (Cu), Lead (Pb), Zinc (Zn), and Mercury (Hg) have contaminated fish and water in the Cassiporé River, Amapá, Brazil, especially with Hg due to gold mining activities. The Strategic Actions Program highlights that mining activities in the Guiana Shield can lead to aquatic pollution, sedimentation, and silting of rivers, modifying hydrological processes extending to estuaries (OTCA, 2018). These studies highlight the connection between mining in the Guiana Shield and river pollution, with negative impacts affecting water quality and biodiversity of coastal ecosystems, such as mangroves.

The location of mangrove forests within intertidal areas renders them vulnerable to predicted sea-level rise due to climate change. IUCN (2024) states climate change threatens one-third (33%) of the mangrove ecosystems assessed. Tropical storms can damage mangrove forests through direct defoliation and destruction of trees and the mass mortality of associated biotic communities. Climate change, particularly sea-level rise, is a critical threat to this province's mangroves. River runoff, mean annual precipitation, and temperature, both inland and sea-surface, have increased since the 1980-90s in Amazonia (Gloor *et al.*, 2015) and threaten to submerge mangrove forests if these trends continue. Furthermore, extreme hydrological conditions such as severe flooding (e.g., 2008/2009, 2011/2012, and 2013/2014) and droughts (e.g., 2005, 2007, 2010) are increasing in frequency compared to previous decades (Gloor *et al.*, 2013).

In the NBS, several areas are legally established to protect mangroves and their associated biodiversity. In Guyana, the Shell Beach Protected Area is essential for protecting beaches and mangroves and is an important nesting site for sea turtles. In Suriname, the Galibi Nature Reserve, established in 1969, was the first coastal protected area in the region and is home to endangered turtles. In French Guiana, the Kaw-Roura Nature Reserve preserves vast mangroves and wetlands of great ecological importance. In addition, the Coppenamemonding Nature Reserve in 1985 (Site No. 304) – in Suriname; the Basse-Mana in 1993 (Site No. 643), Marais De Kaw in 1993 (Site No. 644) and Estuaire du fleuve Sinnamary in 2008 (Site No. 1828) – in French Guiana, and Cape Orange National Park in 2013 (Site No. 2190) and Amazon Estuary and its Mangroves in 2018 (Site No. 2337) – both in Brazil, have been designated as Ramsar Sites.

In Brazil, protected areas, called Conservation Units, are of Full Protection, which allows only the indirect use of their natural resources and of Sustainable Use, which makes nature conservation compatible with the sustainable use of their natural resources. On the Brazilian Amazon coast, the first Marine Protected Areas (MPAs) were created in the 1980s, with the implementation of the Cabo Orange National Park, the Lago Piratuba Biological Reserve, and the Maracá-Jipióca Ecological Station, covering almost the entire coast of the state of Amapá. However, most MPAs were created after 2002, such as the Marine Extractive Reserves, which currently total 18 throughout Pará (14 reserves) and Maranhão (4 reserves), which focus on the sustainable use of mangrove resources, benefiting traditional communities. On the other hand, the areas of complete protection, such as those in Amapá, aim at total preservation. Hayashi (2018) showed that approximately 85% of the mangroves on the Amazon coast are within an MPA. In addition, this coastal region currently has 23 protected areas, totalling 66,132.8 km^2. Most of these protected areas are classified as "Sustainable Use", in three categories: Extractive Reserves (ER), Areas of Environmental Protection (EPA), and Sustainable Development Reserves (SDR), including National Parks (NP). Among these protected areas, EPAs have been the least effective in conservation, as they allow private land use, such as shrimp farming, contributing to the loss of mangroves. Although coastal areas in Brazil are considered Permanent Protection Areas, some mangrove areas in the State of Amapá are private properties received as "*sesmaria*", a donation by the king. The granting of *sesmarias* was a practice legally instituted in Portugal in 1375, during the reign of Dom Fernando (1367-1383). In these areas, there is a practice of setting fire to the mangroves. Similarly, there is a practice of setting fire to brackish water marshes in the state of Pará to facilitate access to the mangroves, which ends up burning the edges of the mangroves. The consequence is that all the vegetation (mainly composed of Poaceae species) and the species of benthic fauna, including young individuals of the mangrove crab, *U. cordatus*, are burned, becoming yet another threat to this resource typical of the NBS mangroves and essential for the food security and trade of local traditional communities. Although MPAs on the Brazilian Amazon coast have helped preserve mangroves, a prevention strategy with the active participation of local communities, academic support, and collaborative public policies are essential to ensure the sustainability of mangroves, which, for now, remain relatively well preserved.

Mangroves on fire, a recurring event caused by human action in the state of Amapá, Brazil. The photos show a recent event in the Reserva Biológica do Lago Piratuba in 2024 (Photo credit: Reserva Biológica do Lago Piratuba/ICMBio).

Definition of the collapsed state of the ecosystem

Mangroves act as structural engineers, possessing specialised traits that facilitate high nitrogen use efficiency and nutrient resorption. They influence critical processes and functions within their ecosystem. Ecosystem collapse is recognized when the tree cover of diagnostic true mangrove species dwindles to zero, indicating complete loss (100%).

This ecosystem exhibits remarkable dynamism, with species distributions adapting to local shifts in sediment distribution, tidal patterns, and variations in local inundation and salinity gradients. Disruptive processes can trigger shifts in this dynamism, potentially leading to ecosystem collapse. Ecosystem collapse may manifest through the following mechanisms: a) restricted recruitment and survival of diagnostic true mangroves due to adverse climatic conditions (e.g., low temperatures); b) alterations in rainfall, river inputs, waves, and tidal currents that destabilize and erode substrates, hindering recruitment and growth; c) shifts in rainfall patterns and tidal flushing alter salinity stress and nutrient loadings, impacting overall survival.

In the NBS province, ecosystem collapse can be exacerbated by regionally specific factors. For example, large-scale deforestation and land-use changes in upland areas increase sedimentation rates and alter hydrological regimes, potentially suffocating mangrove roots and reducing oxygen availability. Gold mining activities in the Guiana Shield release toxic heavy metals such as mercury into rivers, which bioaccumulate and disrupt mangrove physiology and associated food webs. Coastal urbanization and infrastructure development often replace mangrove areas mangroves, resulting in habitat fragmentation and increased vulnerability to sea level rise and storm surges.

In addition, global climate change poses significant threats. Sea level rise could exceed the sediment accumulation capacity of mangroves, leading to submersion. The increased frequency and intensity of extreme weather events, such as tropical storms, can cause direct physical damage to mangroves, uprooting trees and altering sediment dynamics. Changes in the inflow of freshwater from the Amazon River due to the construction of dams and upstream water extraction can further disrupt salinity gradients crucial to mangrove survival. These interacting factors highlight the urgent need for preventive conservation and restoration strategies and robust policies to mitigate human impacts and adapt to climate change to prevent mangrove collapse in this province.

Threat Classification

IUCN Threat Classification (version 3.3, IUCN-CMP, 2022) relevant to mangroves of the NBS province:

1. Residential & commercial development
- 1.1 Housing & urban areas
- 1.2 Commercial & industrial areas
- 1.3 Tourism & recreation areas

2. Agriculture & aquaculture
- 2. Wood & pulp plantations
  - 2.2.1 Small-holder farming
  - 2.2.2 Small-holder plantations
- 2.3 Livestock farming & ranching
  - 2.3.1 Nomadic grazing
  - 2.3.2 Small-holder grazing, ranching or farming
- 2.4 Marine & freshwater aquaculture
  - 2.4.1 Subsistence/artisanal aquaculture

3. Energy production & mining
- 3.1 Oil & gas drilling
- 3.2 Mining & quarrying
- 3.3 Renewable energy

4. Transportation & service corridors
- 4.1 Roads & railroads
- 4.2 Utility & service lines
- 4.3 Shipping lanes

5. Biological resource use
- 5.1 Hunting & collecting terrestrial animals
  - 5.1.1 Intentional use (species being assessed is the target)
  - 5.1.2 Unintentional effects (species being assessed is not the target)
- 5.2 Gathering terrestrial plants
  - 5.2.1 Intentional use (species being assessed is the target)
  - 5.2.2 Unintentional effects (species being assessed is not the target)
- 5.3 Logging & wood harvesting
  - 5.3.1 Intentional use: subsistence/small scale (species being assessed is the target [harvest]
  - 5.3.2 Intentional use: large scale (species being assessed is the target)[harvest]
  - 5.3.3 Unintentional effects: subsistence/small scale (species being assessed is not the target)[harvest]
- 5.4 Fishing & harvesting aquatic resources
  - 5.4.1 Intentional use: subsistence/small scale (species being assessed is the target)[harvest]
  - 5.4.2 Intentional use: large scale (species being assessed is the target)[harvest]
  - 5.4.3 Unintentional effects: subsistence/small scale (species being assessed is not the target)[harvest]
  - 5.4.4 Unintentional effects: large scale (species being assessed is not the target)[harvest]

  - 5.4.5 Persecution/control
  - 5.4.6 Motivation Unknown/Unrecorded

6. Human intrusions & disturbance

- 6.1 Recreational activities
- 6.2 Work & other activities

7. Natural system modifications

- 7.1 Fire & fire suppression
  - 7.1.1 Increase in fire frequency/intensity
  - 7.1.2 Suppression in fire frequency/intensity
  - 7.1.3 Trend Unknown/Unrecorded
- 7.2 Dams & water management/use
  - 7.2.1 Abstraction of surface water (domestic use)
  - 7.2.2 Abstraction of surface water (commercial use)
  - 7.2.3 Abstraction of surface water (agricultural use)
  - 7.2.4 Abstraction of surface water (unknown use)
  - 7.2.5 Abstraction of ground water (domestic use)
  - 7.2.6 Abstraction of ground water (commercial use)
  - 7.2.7 Abstraction of ground water (agricultural use)
  - 7.2.8 Abstraction of ground water (unknown use)
  - 7.2.9 Small dams
  - 7.2.11 Dams (size unknown)
  - 7.3 Other ecosystem modifications

8. Invasive & other problematic species, genes & diseases

- 8.1 Invasive non-native/alien species/diseases
  - 8.1.1 Unspecified species
  - 8.1.2 Named species
- 8.2 Problematic native species/diseases
  - 8.2.1 Unspecified species
  - 8.2.2 Named species
- 8.3 Introduced genetic material
- 8.4 Problematic species/diseases of unknown origin
  - 8.4.1 Unspecified species
  - 8.4.2 Named species

9. Pollution

- 9.1 Domestic & urban wastewater
  - 9.1.1 Sewage
  - 9.1.2 Run-off
  - 9.1.3 Type Unknown/Unrecorded
- 9.2 Industrial & military effluents
  - 9.2.1 Oil spills
  - 9.2.2 Seepage from mining
  - 9.2.3 Type Unknown/Unrecorded
- 9.3 Agricultural & forestry effluents
  - 9.3.1 Nutrient loads
  - 9.3.2 Soil erosion, sedimentation
  - 9.3.3 Herbicides & pesticides
  - 9.3.4 Type Unknown/Unrecorded
- 9.4 Garbage & solid waste
- 9.5 Air-borne pollutants
- 9.6 Excess energy
  - 9.6.1 Light pollution

- 9.6.3 Noise pollution
- 9.6.4 Type Unknown/Unrecorded

11. Climate change & severe weather

- 11.1 Habitat shifting & alteration
- 11.2 Droughts
- 11.3 Temperature extremes
- 11.4 Storms & flooding
- 11.5 Other impacts (sea-level rise)

4. Ecosystem Assessment

Criterion A: Reduction in Geographic Distribution

Subcriterion A1 measures the trend in ecosystem extent during the last 50-year time window. Data is available for the Brazilian coast mangrove forest area from 1985 to 2020 (Diniz *et al*., 2019; Souza-Filho *et al*., 2023). The total percentage of mangrove cover in this area has remained constant. Unfortunately, there is currently no common regional dataset that provides information for the entire target area in 1970, nor are there other country-level estimates of mangrove extent that can be used to extrapolate the total regional trend between 1970 and 2020. Therefore, the NBS mangrove ecosystem is classified as **Data Deficient (DD)** for this subcriterion.

Subcriterion A2 measures the change in ecosystem extent in any 50 years, including from the present to the future: The NBS province mangroves show a net area change of 0.8% (1996-2020; Figure 3) based on the Global Mangrove Watch time series (Bunting *et al.*, 2022). This value reflects the offset between areas gained (+ 0.3%/year) and lost (- 0.2%/year). This dynamic indicates that the ecosystem's extent since 1996 has been stable, and there has been neither a positive nor a negative trend over this period. Therefore, the NBS mangrove ecosystem is classified as **Least Concern (LC)** for this subcriterion.

Subcriterion A3 measures changes in the mangrove area since 1750. Unfortunately, there is no reliable data on the extent of mangroves in the entire province during this period. Therefore, the NBS mangrove ecosystem is classified as **Data Deficient (DD)** for this subcriterion.

Overall, the ecosystem is assessed as **Least Concern (LC)** under criterion A.

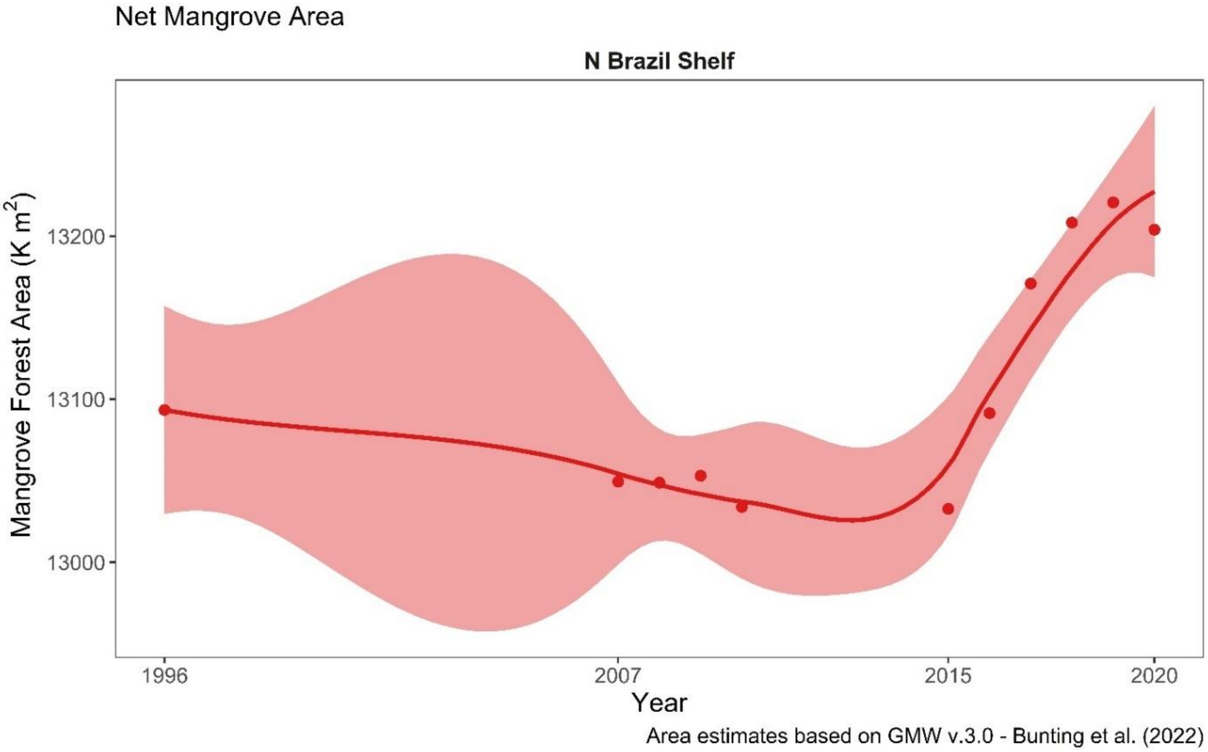


Figure 3. NBS mangrove area (circles) from 1996 to 2020, based on the GMW v3.0 dataset and equations in Bunting *et al.* (2022). The solid line represents a LOESS regression, with the shaded area showing the 95% confidence intervals.

Criterion B: Restricted Geographic Distribution

Criterion B measures the risk of ecosystem collapse associated with restricted geographical distribution based on standard metrics (Extent of Occurrence EOO, Area of Occupancy AOO, and Threat-defined locations). These parameters were calculated based on the 2020 NBS province mangrove extent (GMW v.3).

Province	Extent of Occurrence EOO (Km^2)	Area of Occupancy (AOO)	Criterion B
The North Brazil Shelf	794166.0	777	**LC**

For 2020, AOO and EOO were measured as 1039 grid cells 10 x 10 km and 794166.0 km^2, respectively (Figure 3). Excluding from the AOO those grid cells that contain patches of mangrove forest that account for less than 1% of the grid cell area (< 1 Km^2), the AOO is measured as **777, 10 x 10 km grid cells** (Figure 4, red grids).

Considering the very high number of threat-defined locations, there is no evidence of plausible catastrophic threats leading to the potential disappearance of mangroves across their extent. As a result, the NBS mangrove ecosystem is assessed as **Least Concern (LC)** under criterion B.

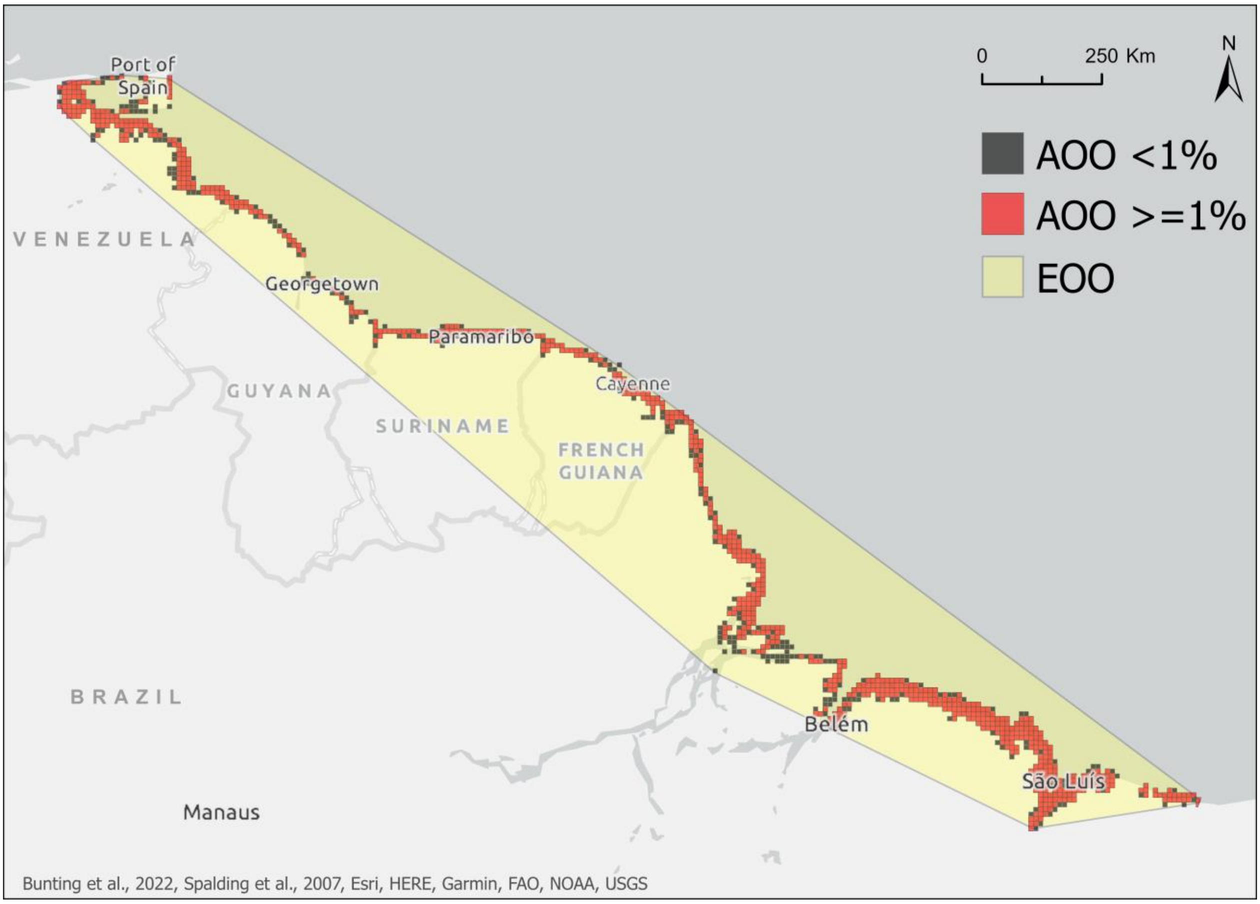


Figure 4. The NBS Mangrove Extent of Occurrence (EOO) and Area of Occupancy (AOO) in 2020. Estimates based on the 2020 GMW v3.0 spatial layer (Bunting *et al.*, 2022). The red 10 x 10 km grids (n=777.) are more than 1% covered by the ecosystem, and the black grids <1% (n= 262).

Criterion C: Environmental Degradation

Criterion C measures the environmental degradation of abiotic variables necessary to support the ecosystem.

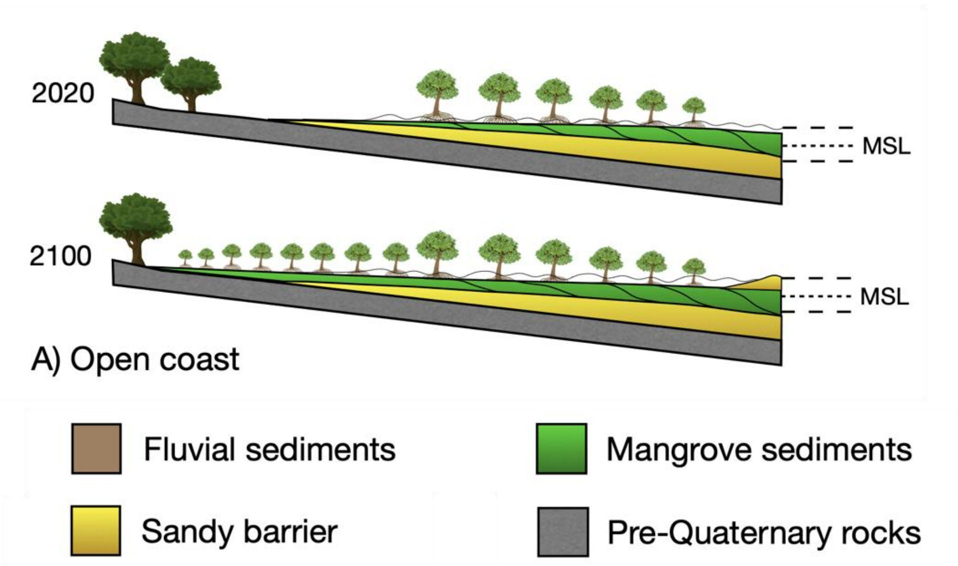
Subcriterion C1 measures environmental degradation over the past 50 years: There are no reliable data to evaluate this subcriterion for the entire province, and therefore, the NBS mangrove ecosystem is classified as **Data Deficient (DD)** for subcriterion C1.

Subcriterion C2 measures environmental degradation in the future or over any 50 years, including from the present. Several papers have discussed the impact of future sea-level changes (Ellison, 2015; Duncan *et al*., 2018) on the sedimentation, morphology, and development of mangrove ecosystems (Cohen *et al*., 2015; Woodroffe *et al*., 2016; Woodroffe, 2019). One way to observe the impact of sea-level changes on mangrove forests in this province is to assess how tidal flats colonised by mangroves have responded to the rise in sea level since the Last Glacial Maximum (LGM). Different responses of mangrove shorelines to sea-level change have been discussed, including drowning, backstepping, catch-up, keep-up, progradation, and emergence (Woodroffe, 2018; Souza-Filho *et al*., 2023). The past trajectories of the mangrove shorelines depend on the Holocene sea-level history. Along the NBS and the Caribbean Sea, it is possible to observe evidence of a continuous sea-level rise during the Holocene (Khan *et al*., 2015).

Future trends of sea-level rise on open coasts along Venezuela, Suriname, Guyanas, and Amapá and sheltered coast on the east side of the Amazon River mouth will cause an increase in upstream penetration of the salt wedge and landward migration of mangroves along riverine and supratidal flats that are progressively converted to intertidal flats (Souza-Filho *et al*., 2023). Mangrove deposits will continue to migrate landward by seedling recruitment and vegetative reproduction as new brackish habitat becomes available landward through inundation (Figure 5) and concomitant changes in salinity (Souza-Filho *et al*., 2006). Erosive processes at the seaward front can result in mangrove loss along the shoreline (Allison *et al*., 2000; Anthony *et al*., 2010; Santos *et al*., 2016).

Here, we measured the impact of future sea level rise (SLR) on mangrove ecosystems by adopting the methodology presented by Schuerch *et al.* (2018). The published model was designed to calculate both absolute and relative change in the extent of wetland ecosystems under various regional SLR scenarios (i.e., medium: RCP 4.5 and high: RCP 8.5), considering sediment accretion. Therefore, the Schuerch *et al*. (2018) model was applied to the NBS mangrove ecosystem boundary, using the spatial extent in 2010 (Giri *et al*., 2018) and assuming mangrove landward migration was not possible.

According to the results, under an extreme sea-level rise scenario of a 1.1-meter rise by 2100, the projected submerged area is ~ -8.9% by 2060, which remains below the 30% risk threshold. Therefore, considering that no mangrove recruitment can occur in a submerged system (100% relative severity), but that -8.9% of the ecosystem extent will be affected by SLR, the NBS mangrove ecosystem is assessed as **Least Concern (LC)** for subcriterion C2.



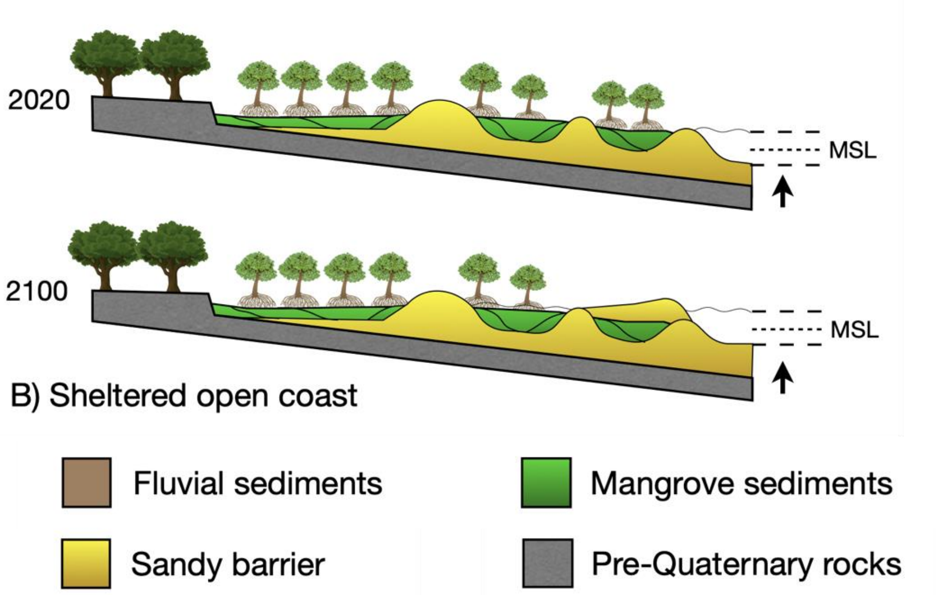


Figure 5. A) On open coasts, a rise in sea-level will cause an increase in upstream penetration of the salt wedge and landward migration of mangroves along riverine and supratidal flats that are progressively converted to intertidal flats. Hence, mangrove zones migrate landward by seedling recruitment and vegetative reproduction as a new brackish habitat becomes available landward through inundation and concomitant changes in salinity. Erosive processes at the seaward front can result in mangrove loss along the shoreline. B) If sea-level is rising over a sheltered open coast densely colonized by mangroves and bounded landward by inactive cliffs, the muddy tidal flat will experience an elevation in the water level and a sedimentary aggradation process. Under this hydromorphic condition, the inner tidal flat may also expand laterally, prograding toward the estuarine channels and tidal creeks. The landward retreat of the shoreline due to the rising sea-level will result in barrier sand deposition over muddy flats and mangroves. This will cause coastal erosion, tree falling, increased salinity, in frequency and depth of inundation in mangrove forests. Figure adapted from Souza-Filho *et al.* (2023) with permission.

Subcriterion C3 measures the change in abiotic variables since 1750. Because there is a lack of reliable historical data on environmental degradation covering the entire province, the NBS province is classified as **Data Deficient (DD)** for this subcriterion. Overall, the ecosystem is assessed as **Least Concern (LC)** under criterion C.

Criterion D: Disruption of biotic processes or interactions

The global mangrove degradation map developed by Worthington and Spalding (2018) was used to assess the level of biotic degradation in the NBS province. This map is based on degradation metrics calculated from vegetation indices (NDVI, EVI, SAVI, NDMI) using Landsat time series (≈2000 and 2017). These indices represent vegetation greenness and moisture conditions.

Mangrove degradation was calculated at a pixel scale (30 m resolution) on areas intersecting with the 2017 mangrove extent map (GMW v2). Mangrove pixels were classified as degraded if two conditions were met: 1) at least 10 out of 12 degradation indices showed a decrease of more than 40% compared to the previous period, and 2) all twelve indices did not recover to within 20% of their pre-2000 value (detailed methods and data are available at: maps.oceanwealth.org/mangrove-restoration/). The decay in vegetation indices has been used to identify mangrove degradation and abrupt changes, including mangrove die-back events, clear-cutting, logging, and fire damage, as well as to track mangrove regeneration (Lovelock *et al.*, 2017; Santana *et al.*, 2018; Murray *et al.*, 2020; Aljahdali *et al.*, 2021; Lee *et al.*, 2021).

However, it is important to consider that changes observed in the vegetation indices can also be influenced by data artifacts (Akbar *et al.*, 2020). Therefore, a relative severity level of more than 50% but less than 80% was assumed.

This analysis shows that over 17 years (~2000 to 2017), 2.9% of the NBS mangrove area is classified as degraded, resulting in an average annual degradation rate of ≈0.2%. Assuming this trend remains constant, +8.6% of the NBS mangrove area will be classified as degraded over a 50-year period. Since less than 30% of the ecosystem will meet the category thresholds for criterion D, the NBS mangrove province is assessed as **Least Concern** (**LC)** under subcriterion D2b.

No data were found to assess the disruption of biotic processes and degradation over the past 50 years (subcriterion D1) or since 1750 (subcriterion D3). Thus, both subcriteria are classified as **Data Deficient (DD).** Overall, the NBS ecosystem remains **Least Concern (LC)** under criterion D.

Criterion E: Quantitative Risk

No model was used to quantitatively assess the risk of ecosystem collapse for this ecosystem; hence, criterion E was **Not Evaluated (NE)**.

5. Summary of the Assessment

CRITERION			
A. Reduction in Geographic Distribution	**A1** Past 50 years DD	**A2** Future or any 50y period LC	**A3** Historical (1750) DD
B. Restricted Geo. Distribution	**B1** Extent of Occurrence LC	**B2** Area of Occupancy LC	**B3** # Threat-defined Locations < 5? LC
C. Environmental Degradation	**C1** Past 50 years (1970) DD	**C2** Future or any 50y period LC	**C3** Historical (1750) DD
D. Disruption of biotic processes	**D1** Past 50 years (1970) DD	**D2** Future or Any 50y period LC	**D3** Historical (1750) DD
E. Quantitative Risk analysis		NE	
OVERALL RISK CATEGORY		LC	

DD = Data Deficient; LC = Least Concern; NE = Not Evaluated

Overall, the status of the NBS mangrove ecosystem is assessed as **Least Concern (LC).**

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7. Appendices

1. List of Key Mangrove Species

List of plant species considered true mangroves according to Red List of Threatened Species (RLTS) spatial data (IUCN, 2022). We included species whose range maps intersected with the boundary of the marine provinces/ecoregions described in the distribution section.

Class	Order	Family	Scientific name *	RLTS category
Magnoliopsida	Malpighiales	Rhizophoraceae	*Rhizophora mangle*	LC
Magnoliopsida	Malpighiales	Rhizophoraceae	*Rhizophora racemosa*	LC
Magnoliopsida	Malpighiales	Rhizophoraceae	*Rhizophora harrisonii*	
Magnoliopsida	Lamiales	Acanthaceae	*Avicennia germinans*	LC
Magnoliopsida	Lamiales	Acanthaceae	*Avicennia schaueriana*	LC
Magnoliopsida	Myrtales	Combretaceae	Laguncularia racemosa	LC

* *Rhizophora harrisonii is a key mangrove species along the NBS but has not been classified in any of the RLTS categories.*

2. List of Associated Species

List of taxa that are associated with mangrove habitats in the Red List of Threatened Species (RLTS) database (IUCN, 2022). We included only species with entries for Habitat 1.7: "Forest - Subtropical/Tropical Mangrove Vegetation Above High Tide Level" or Habitat 12.7 for "Marine Intertidal - Mangrove Submerged Roots", and with suitability recorded as "Suitable", with "Major Importance" recorded as "Yes", and any value of seasonality except "Passage". We further filtered species with spatial point records in the GBIF (some species are excluded due to mismatch in taxonomic names, or lack of georeferenced records). The common names are those shown in the RLTS and other sources.

Class	Order	Family	Scientific name	RLTS category	Common name
Actinopterygii	Perciformes	Epinephelidae	*Epinephelus itajara*	CR	Atlantic Goliath Grouper
Actinopterygii	Atheriniformes	Atherinopsidae	*Atherinella brasiliensis*	LC	Brazilian Silverside
Aves	Ciconiiformes	Ardeidae	*Tigrisoma lineatum*	LC	Rufescent Tiger Heron
Aves	Ciconiiformes	Ardeidae	*Agamia agami*	VU	Agami Heron
Aves	Ciconiiformes	Ardeidae	*Cochlearius cochlearius*	LC	Boat-billed Heron
Aves	Ciconiiformes	Ardeidae	*Zebrilus undulatus*	LC	Zigzag Heron
Aves	Ciconiiformes	Ardeidae	*Botaurus pinnatus*	LC	Pinnated Bittern
Aves	Ciconiiformes	Ardeidae	*Ixobrychus exilis*	LC	Least Bittern
Aves	Ciconiiformes	Ardeidae	*Nycticorax nycticorax*	LC	Black-crowned Night Heron
Aves	Ciconiiformes	Ardeidae	*Nyctanassa violacea*	LC	Yellow-crowned Night Heron
Aves	Ciconiiformes	Ardeidae	*Butorides striata*	LC	Striated Heron
Aves	Ciconiiformes	Ardeidae	*Ardeola ralloides*	LC	Squacco Heron
Aves	Ciconiiformes	Ardeidae	*Bubulcus ibis*	LC	Cattle Egret
Aves	Ciconiiformes	Ardeidae	*Ardea cocoi*	LC	Cocoi Heron
Aves	Ciconiiformes	Ardeidae	*Ardea alba*	LC	Great Egret
Aves	Ciconiiformes	Ardeidae	*Pilherodius pileatus*	LC	Capped Heron

Class	Order	Family	Scientific name	RLTS category	Common name
Aves	Ciconiiformes	Ardeidae	*Egretta tricolor*	LC	Tricolored Heron
Aves	Ciconiiformes	Ardeidae	*Egretta thula*	LC	Snowy Egret
Aves	Ciconiiformes	Ardeidae	*Egretta caerulea*	LC	Little Blue Heron
Aves	Ciconiiformes	Threskiornithidae	*Eudocimus ruber*	LC	Scarlet Ibis
Aves	Ciconiiformes	Threskiornithidae	*Mesembrinibis cayennensis*	LC	Green Ibis
Aves	Ciconiiformes	Threskiornithidae	*Phimosus infuscatus*	LC	Bare-faced Ibis
Aves	Ciconiiformes	Threskiornithidae	*Theristicus caudatus*	LC	Buff-necked Ibis
Aves	Ciconiiformes	Threskiornithidae	*Platalea ajaja*	LC	Roseate Spoonbill
Aves	Ciconiiformes	Ciconiidae	*Ciconia maguari*	LC	Maguari Stork
Aves	Ciconiiformes	Ciconiidae	*Jabiru mycteria*	LC	Jabiru Stork
Aves	Ciconiiformes	Ciconiidae	*Mycteria americana*	LC	Wood Stork
Aves	Phoenicopteriformes	Phoenicopteridae	*Phoenicopterus ruber*	LC	American Flamingo
Aves	Cathartiformes	Cathartidae	*Cathartes aura*	LC	Turkey Vulture
Aves	Cathartiformes	Cathartidae	*Cathartes burrovianus*	LC	Lesser Yellow-headed Vulture
Aves	Cathartiformes	Cathartidae	*Coragyps atratus*	LC	Black Vulture
Aves	Falconiformes	Pandionidae	*Pandion haliaetus*	LC	Osprey
Aves	Falconiformes	Accipitridae	*Rostrhamus sociabilis*	LC	Snail Kite
Aves	Falconiformes	Accipitridae	*Buteogallus aequinoctialis*	NT	Rufous Crab Hawk
Aves	Falconiformes	Accipitridae	*Rupornis magnirostris*	LC	Roadside Hawk
Aves	Falconiformes	Falconidae	*Caracara plancus*	LC	Southern Caracara
Aves	Falconiformes	Falconidae	*Milvago chimachima*	LC	Yellow-headed Caracara
Aves	Gruiformes	Rallidae	*Rallus longirostris*	LC	Mangrove Rail
Aves	Gruiformes	Rallidae	*Aramides mangle*	LC	Mangrove Rail
Aves	Gruiformes	Rallidae	*Pardirallus maculatus*	LC	Spotted Rail
Aves	Charadriiformes	Charadriidae	*Vanellus chilensis*	LC	Southern Lapwing
Aves	Charadriiformes	Charadriidae	*Pluvialis dominica*	LC	American Golden Plover
Aves	Charadriiformes	Charadriidae	*Pluvialis squatarola*	LC	Black-bellied Plover
Aves	Charadriiformes	Charadriidae	*Charadrius semipalmatus*	LC	Semipalmated Plover
Aves	Charadriiformes	Charadriidae	*Charadrius wilsonia*	LC	Wilson’s Plover
Aves	Charadriiformes	Charadriidae	*Charadrius collaris*	LC	Collared Plover
Aves	Charadriiformes	Scolopacidae	*Limnodromus griseus*	LC	Short-billed Dowitcher
Aves	Charadriiformes	Scolopacidae	*Limosa fedoa*	NT	Marbled Godwit
Aves	Charadriiformes	Scolopacidae	*Numenius phaeopus*	LC	Whimbrel
Aves	Charadriiformes	Scolopacidae	*Actitis macularius*	LC	Spotted Sandpiper
Aves	Charadriiformes	Scolopacidae	*Tringa solitaria*	LC	Solitary Sandpiper
Aves	Charadriiformes	Scolopacidae	*Tringa melanoleuca*	LC	Greater Yellowlegs
Aves	Charadriiformes	Scolopacidae	*Tringa semipalmata*	LC	Willet
Aves	Charadriiformes	Scolopacidae	*Tringa flavipes*	LC	Lesser Yellowlegs
Aves	Charadriiformes	Scolopacidae	*Arenaria interpres*	LC	Ruddy Turnstone
Aves	Charadriiformes	Scolopacidae	*Calidris canutus*	NT	Red Knot
Aves	Charadriiformes	Scolopacidae	*Calidris alba*	LC	Sanderling
Aves	Charadriiformes	Scolopacidae	*Calidris pusilla*	NT	Semipalmated Sandpiper

Class	Order	Family	Scientific name	RLTS category	Common name
Aves	Charadriiformes	Scolopacidae	*Calidris minutilla*	LC	Least Sandpiper
Aves	Charadriiformes	Jacanidae	*Jacana jacana*	LC	Wattled Jacana
Aves	Columbiformes	Columbidae	*Columbina passerina*	LC	Common Ground Dove
Aves	Columbiformes	Columbidae	*Columbina talpacoti*	LC	Ruddy Ground Dove
Aves	Cuculiformes	Cuculidae	*Coccyzus minor*	LC	Mangrove Cuckoo
Aves	Cuculiformes	Cuculidae	*Crotophaga major*	LC	Greater Ani
Aves	Cuculiformes	Cuculidae	*Crotophaga ani*	LC	Smooth-billed Ani
Aves	Cuculiformes	Cuculidae	*Guira guira*	LC	Guira Cuckoo
Aves	Apodiformes	Trochilidae	*Amazilia leucogaster*	LC	White-chested Emerald
Aves	Coraciiformes	Alcedinidae	*Megaceryle torquata*	LC	Ringed Kingfisher
Aves	Coraciiformes	Alcedinidae	*Chloroceryle amazona*	LC	Amazon Kingfisher
Aves	Coraciiformes	Alcedinidae	*Chloroceryle aenea*	LC	American Pygmy Kingfisher
Aves	Coraciiformes	Alcedinidae	*Chloroceryle americana*	LC	Green Kingfisher
Aves	Coraciiformes	Alcedinidae	*Chloroceryle inda*	LC	Green-and-rufous Kingfisher
Aves	Galbuliformes	Bucconidae	*Notharchus macrorhynchos*	LC	White-necked Puffbird
Aves	Paciformes	Picidae	*Celeus torquatus*	LC	Ringed Woodpecker
Aves	Paciformes	Picidae	*Campephilus melanoleucos*	LC	Crimson-crested Woodpecker
Aves	Passeriformes	Dendrocolaptidae	*Glyphorynchus spirurus*	LC	Wedge-billed Woodcreeper
Aves	Passeriformes	Dendrocolaptidae	*Xiphorhynchus picus*	LC	Straight-billed Woodcreeper
Aves	Passeriformes	Dendrocolaptidae	*Xiphorhynchus guttatus*	LC	Buff-throated Woodcreeper
Aves	Passeriformes	Furnariidae	*Xenops minutus*	LC	Plain Xenops
Aves	Passeriformes	Tyrannidae	*Todirostrum maculatum*	LC	Spotted Tody-Flycatcher
Aves	Passeriformes	Tyrannidae	*Pitangus sulphuratus*	LC	Great Kiskadee
Aves	Passeriformes	Tyrannidae	*Myiodynastes maculatus*	LC	Streaked Flycatcher
Aves	Passeriformes	Tyrannidae	*Tyrannus melancholicus*	LC	Tropical Kingbird
Aves	Passeriformes	Vireonidae	*Cyclarhis gujanensis*	LC	Rufous-browed Peppershrike
Aves	Passeriformes	Turdidae	*Turdus rufiventris*	LC	Rufous-bellied Thrush
Aves	Passeriformes	Thraupidae	*Tachyphonus rufus*	LC	White-lined Tanager
Aves	Passeriformes	Thraupidae	*Ramphocelus carbo*	LC	Silver-beaked Tanager
Aves	Passeriformes	Thraupidae	*Conirostrum bicolor*	LC	Bicolored Conebill
Aves	Passeriformes	Icteridae	*Psarocolius decumanus*	LC	Crested Oropendola
Aves	Passeriformes	Icteridae	*Cacicus cela*	LC	Yellow-rumped Cacique
aves	Passeriformes	Icteridae	*Chrysomus ruficapillus*	LC	Chestnut-capped Blackbird
Aves	Passeriformes	Icteridae	*Molothrus bonariensis*	LC	Shiny Cowbird
Aves	Passeriformes	Icteridae	*Sturnella militaris*	LC	Red-breasted Blackbird
Bivalvia	Mytiloida	Mytilidae	*Mytella guyanensis*	LC	Guyana mussel
Bivalvia	Mytiloida	Mytilidae	*Mytella charruana*	LC	Charrua mussel

Class	Order	Family	Scientific name	RLTS category	Common name
Bivalvia	Ostreida	Ostreidae	*Crassostrea rhizophorae*	LC	Mangrove oyster
Bivalvia	Cardiida	Donacidae	*Iphigenia brasiliana*	LC	Brazilian clam
Bivalvia	Cardiida	Solecurtidae	*Tagelus plebeius*	LC	Stout razor clam
Bivalvia	Cardiida	Tellinidae	*Macoma constricta*	LC	Constricted macoma
Bivalvia	Myida	Myidae	*Sphenia fragilis*	LC	Fragile bivalve species
Bivalvia	Myida	Corbulidae	*Corbula caribaea*	LC	Caribbean corbula
Bivalvia	Venerida	Veneridae	*Protothaca pectorina*	LC	Chestnut clam
Bivalvia	Venerida	Veneridae	*Anomalocardia brasiliana*	LC	Brazilian venus clam
Crustacea	Decapoda	Ucididae	*Ucides cordatus*	NT	Mangrove crab
Crustacea	Decapoda	Ocypodidae	*Ocypode quadrata*	LC	Atlantic ghost crab
Crustacea	Decapoda	Ocypodidae	*Uca maracoani*	LC	Maracoani fiddler crab
Crustacea	Decapoda	Ocypodidae	*Leptuca thayeri*	LC	Thayer's fiddler crab
Crustacea	Decapoda	Ocypodidae	*Leptuca cumulanta*	LC	Cumulative fiddler crab
Crustacea	Decapoda	Ocypodidae	*Minuca vocator*	LC	Calling fiddler crab
Crustacea	Decapoda	Ocypodidae	*Minuca mordax*	LC	Sharp-clawed fiddler crab
Crustacea	Decapoda	Ocypodidae	*Minuca burgersi*	LC	Burgers's fiddler crab
Crustacea	Decapoda	Ocypodidae	*Minuca rapax*	LC	Red-jointed fiddler crab
Crustacea	Decapoda	Menippidae	*Menippe nodifrons*	LC	Stone crab
Crustacea	Decapoda	Panopeidae	*Panopeus americanus*	LC	American mud crab
Crustacea	Decapoda	Panopeidae	*Panopeus bermudensis*	LC	Bermuda mud crab
Crustacea	Decapoda	Panopeidae	*Panopeu lacustris*	LC	Lake mud crab
Crustacea	Decapoda	Grapsidae	*Goniopsis cruentata*	LC	Red mangrove crab
Crustacea	Decapoda	Grapsidae	*Pachygrapsus transversus*	LC	Transverse shore crab
Crustacea	Decapoda	Grapsidae	*Pachygrapsus gracilis*	LC	Graceful shore crab
Crustacea	Decapoda	Grapsidae	*Planes cyaneus*	LC	Blue oceanic crab
Crustacea	Decapoda	Sesarmidae	*Aratus pisonii*	LC	Mangrove tree crab
Crustacea	Decapoda	Sesarmidae	*Armases benedicti*	LC	Benedict's mangrove crab
Crustacea	Decapoda	Sesarmidae	*Armases rubripes*	LC	Red-legged mangrove crab
Crustacea	Decapoda	Sesarmidae	*Armases angustipes*	LC	Narrow-footed mangrove crab
Crustacea	Decapoda	Sesarmidae	*Sesarma curacaoense*	LC	Curaçao mangrove crab
Crustacea	Decapoda	Sesarmidae	*Sesarma rectum*	LC	Rectangular mangrove crab
Crustacea	Decapoda	Xanthidae	*Eurytium limosun*	LC	Mud flat crab
Crustacea	Decapoda	Xanthidae	*Menippe nodifrons*	LC	Stone crab
Crustacea	Decapoda	Gecarcinidae	*Cardisoma guanhumi*	RC	Blue land crab
Crustacea	Decapoda	Portunidae	*Callinectes bocourti*	LC	Bocourt's swimming crab
Crustacea	Decapoda	Portunidae	*Callinectes danae*	LC	Dana swimming crab
Crustacea	Decapoda	Portunidae	*Callinectes exasperatus*	LC	Rugose swimming crab
Crustacea	Decapoda	Portunidae	*Callinectes sapidus*	DD	Blue crab
Crustacea	Decapoda	Portunidae	*Callinectes larvatus*	LC	Ghost swimming crab

Class	Order	Family	Scientific name	RLTS category	Common name
Crustacea	Decapoda	Portunidae	*Callinectes ornatus*	LC	Ornate swimming crab
Crustacea	Decapoda	Panopeidae	*Panopeus americanus*	LC	American mud crab
Crustacea	Decapoda	Panopeidae	*Panopeus bermudensis*	LC	Bermuda mud crab
Crustacea	Decapoda	Panopeidae	*Panopeus lacustris*	LC	Lake mud crab
Crustacea	Decapoda	Panopeidae	*Panopeus occidentalis*	LC	Western mud crab
Crustacea	Decapoda	Palaemonidae	*macrobrachium amazonicum*	LC	Amazon river prawn
Crustacea	Decapoda	Caridea	*Macrobrachium rosenbergii*	NA	Giant freshwater prawn
Crustacea	Decapoda	Penaeidae	*Penaeus monodon*	NA	Giant tiger prawn
Gatropoda	Littorinimorpha	Littorinidae	*Littoraria flava*	LC	Yellow mangrove periwinkle
Gatropoda	Littorinimorpha	Littorinidae	*Littoraria angulifera*	LC	Angulate periwinkle
Gatropoda	Ellobiida	Ellobiidae	*Melampus coffeus*	LC	Coffee bean snail
Gatropoda	Ellobiida	Ellobiidae	*Ellobius pellucens*	LC	Mangrove ellobiid snail
Liliopsida	Poales	Poaceae	*Spartina alterniflora*	LC	Smooth cordgrass
Liliopsida	Alismatales	Hydrocharitaceae	*Halophila baillonii*	LC	Baillon's seagrass
Liliopsida	Alismatales	Ruppiaceae	*Ruppia maritima*	LC	Widgeon grass
Magnoliopsida	Myrtales	Combretaceae	*Conocarpus erectus*	LC	Buttonwood mangrove
Mammalia	Carnivora	Felidae	*Panthera onca*	NT	Jaguar
Mammalia	Sirenia	Trichechidae	*Trichechus inunguis*	VU	Amazonian manatee
Mammalia	Sirenia	Trichechidae	*Trichechus manatus*	CR	West Indian manatee
Mammalia	Carnivora	Procionidae	*Procyon cancrivorus*	LC	Crab-eating raccoon
Mammalia	Cetacea	Delphinidae	*Sotalia guianensis*	NT	Guiana dolphin
Mammalia	Cetacea	Pontoporidae	*Pontoporia blainvillei*	VU	La Plata dolphin
Mammalia	Primates	Atelidae	*Alouatta ululata*	EN	Maranhão red-handed howler
Mammalia	Primates	Cebidae	*Sapajus xanthosternos*	CR	Yellow-breasted capuchin
Mammalia	Primates	Cebidae	*Sapajus apella*	LC	Tufted capuchin
Mammalia	Carnivora	Canidae	*Cerdocyon thous*	LC	Crab-eating fox
Mammalia	Pilosa	Cyclopedidae	*Cyclopes didactylus*	LC	Pygmy anteater
Mammalia	Didelphimorphia	Didelphidae	*Didelphis marsupialis*	LC	Common opossum
Mammalia	Carnivora	Mustelidae	*Eira barbara*	LC	Tayra
Mammalia	Pilosa	Myrmecophagidae	*Tamandua tetradactyla*	LC	Collared anteater
Mammalia	Cingulata	Chlamyphoridae	*Euphractus sexcinctus*	LC	Six-banded armadillo

3. National Red List of Species

This table includes the species in the Brazilian territory of the NBS listed in the Red Book of Brazilian Fauna Threatened with Extinction (ICMBio, 2018).

Class	Order	Family	Scientific name	RLTS category	Common name
Actinopterygii	Perciformes	Epinephelidae	*Epinephelus itajara*	CR	Atlantic Goliath Grouper
Aves	Ciconiiformes	Ardeidae	*Agamia agami*	LC	Agami Heron
Aves	Falconiformes	Accipitridae	*Buteogallus aequinoctialis*	NT	Rufous Crab Hawk

Aves	Charadriiformes	Scolopacidae	*Limosa fedoa*	NA	Marbled Godwit
Aves	Charadriiformes	Scolopacidae	*Calidris canutus*	CR	Red Knot
Aves	Charadriiformes	Scolopacidae	*Calidris pusilla*	EN	Semipalmated Sandpiper
Crustacea	Decapoda	Ucididae	*Ucides cordatus*	NT	Mangrove crab
Crustacea	Decapoda	Caridea	*Macrobrachium rosenbergii*	NA	Giant freshwater prawn
Crustacea	Decapoda	Penaeidae	*Penaeus monodon*	NA	Giant tiger prawn
Crustacea	Decapoda	Gecarcinidae	*Cardisoma guanhumi*	RC	Blue land crab
Mammalia	Carnivora	Felidae	*Panthera onca*	VU	Jaguar
Mammalia	Sirenia	Trichechidae	*Trichechus inunguis*	VU	Amazonian manatee
Mammalia	Sirenia	Trichechidae	*Trichechus manatus*	CR	West Indian manatee
Mammalia	Cetacea	Delphinidae	*Sotalia guianensis*	VU	Guiana dolphin
Mammalia	Cetacea	Pontoporidae	*Pontoporia blainvillei*	CR	La Plata dolphin
Mammalia	Primates	Atelidae	*Alouatta ululata*	EN	Maranhão red-handed howler
Mammalia	Primates	Cebidae	*Sapajus xanthosternos*	EN	Yellow-breasted capuchin

4. National Estimates for subcriterion A1

To estimate the NBS mangrove ecosystem extent in 1970, we gathered reliable information on the mangrove area for each country within the province around this period (Table b). We then estimated each country's mangrove area in 1970, assuming a linear relationship between mangrove extent and time. Finally, we summarized the country estimates to determine the total mangrove area in the NBS province (Table a). We assumed that the percentage of mangrove extent by country within the province remained constant over time, as the percentages did not change between 1996 and 2020 (GMW v3.0 dataset). However, using mangrove area estimates from different sources can lead to uncertainty (Friess and Webb, 2014)[2], and no regional statistics or global studies are available for this period. Thus, the estimates for 1970 should be considered only indicative.

Table a. Estimated mangrove area by country in 1970 and 2020. Estimates for 2020* mangrove area are based on the Global Mangrove Watch Version 3 (GMW v3.0) dataset. The references used to calculate mangrove area for each country in 1970 are listed below in Table b.**

Year	Country total 2020*	Within province 2020*	Country total 1970**	Within province 1970**
Brazil	1,141,470	706,345	1,380,000	1,065,400
French Guiana	62,970	62,970		
Suriname	80,044	80,044		
Guyana	28,859	28,859		
East Venezuela	284,675	283,820		

[2] Friess, D. A. and Webb, E. L. (2014). Variability in mangrove change estimates and implications for the assessment of ecosystem service provision. *Global Ecology and Biogeography*, 23 (7). 715-725 doi:10.1111/geb.12140

Table b. List of selected studies considered to have reliable information on mangrove area for the period around 1970 only in the Brazilian mangroves of the NBS province.

Country	Year	Mangrove area (ha)	Reference
Brazil	1970 to 1975	1,380,000	Herz, R. (1991). Manguezais do Brasil. São Paulo. Instituto Oceanográfico, Universidade de São Paulo. 227 pp.
NE Pará -NW Maranhão states	1999 and 2000	759,109	Souza-Filho, P.W.M., 2005. Costa de manguezais de macromaré da Amazônia: cenários morfológicos, mapeamento e quantificação de áreas usando dados de senores remotos. Revista Brasileira de Geofísica 23, 427-435, https://doi.org/10.1590/S0102-261X2005000400006.
NE Pará -NW Maranhão states	1996	670,506	Nascimento Jr., W.R., Souza-Filho, P.W.M., Proisy, C., Lucas, R.M., Rosenqvist, A., 2013. Mapping changes in the largest continuous Amazonian mangrove belt using object-based classification of multisensor satellite imagery. Estuarine, Coastal and Shelf Science 117, 83-93, 10.1016/j.ecss.2012.10.005.
NE Pará -NW Maranhão states	2008	742,360	Nascimento Jr., W.R., Souza-Filho, P.W.M., Proisy, C., Lucas, R.M., Rosenqvist, A. (2013). Mapping changes in the largest continuous Amazonian mangrove belt using object-based classification of multisensor satellite imagery. Estuarine, Coastal and Shelf Science 117, 83-93, 10.1016/j.ecss.2012.10.005.
Orange and Cassiporé capes, Amapá state	2003	362,490	Batista, E.M., Souza-Filho, P.W.M., Silveira, O.F.M. (2009). Avaliação de áreas deposicionais e erosivas em cabos lamosos da zona costeira Amazônica através da análise multitemporal de imagens de sensores remotos. Revista Brasileira de Geofísica 27, 83-96, https://doi.org/10.1590/S0102-261X2009000500007
São Marcos Gulf, Maranhão state	1992	193,010	Teixeira, S.G., Souza-Filho, P.W.M. (2009). Mapeamento de ambientes costeiros tropicais (Golfão Maranhense, Brasil) utilizando imagens de sensores remotos orbitais. Revista Brasileira de Geofísica 27, 69-82, 10.1590/S0102-261X2009000500006.
NE Pará and NW Maranhão states	1999	120,990	Rodrigues, S., Souza-Filho, P. (2011). Use of Multi-Sensor Data to Identify and Map Tropical Coastal Wetlands in the Amazon of Northern Brazil. Wetlands 31, 11-23, 10.1007/s13157-010-0135-6.
Bragança, NE Pará state	1998	67,200	Souza-Filho, P.W.M., Paradella, W.R. (2005). Use of RADARSAT-1 fine mode and Landsat-5 TM selective principal component analysis for geomorphological mapping in a macrotidal mangrove coast in the Amazon region. Canadian Journal of Remote Sensing 31, 214-224, 10.5589/m05-009.
Brazil	1985	1,010,263	Diniz, C., Cortinhas, L., Nerino, G., Rodrigues, J., Sadeck, L., Adami, M., & Souza-Filho, W. P. (2019). Brazilian Mangrove Status: Three Decades of Satellite Data Analysis. Remote Sensing 11, http://dx.doi.org/10.3390/rs11070808. MAPBIOMAS Collection v.8.0 (https://brasil.mapbiomas.org/)
Brazil	1996	1,034,414	Diniz, C., Cortinhas, L., Nerino, G., Rodrigues, J., Sadeck, L., Adami, M., & Souza-Filho, W. P. (2019). Brazilian Mangrove Status: Three Decades of Satellite Data Analysis. Remote Sensing 11, http://dx.doi.org/10.3390/rs11070808. MAPBIOMAS Collection v.8.0 (https://brasil.mapbiomas.org/)

Country	Year	Mangrove area (ha)	Reference
Brazil	2000	1,001,000	Diniz, C., Cortinhas, L., Nerino, G., Rodrigues, J., Sadeck, L., Adami, M., & Souza-Filho, W. P. (2019). Brazilian Mangrove Status: Three Decades of Satellite Data Analysis. Remote Sensing 11, http://dx.doi.org/10.3390/rs11070808. MAPBIOMAS Collection v.8.0 (https://brasil.mapbiomas.org/)
Brazil	2020	1,038,359	Diniz, C., Cortinhas, L., Nerino, G., Rodrigues, J., Sadeck, L., Adami, M., & Souza-Filho, W. P. (2019). Brazilian Mangrove Status: Three Decades of Satellite Data Analysis. Remote Sensing 11, http://dx.doi.org/10.3390/rs11070808. MAPBIOMAS Collection v.8.0 (https://brasil.mapbiomas.org/)
Brazil	1996	1,147,456	Bunting, P., Rosenqvist, A., Hilarides, L., & Lucas, R. M. (2022). Global Mangrove Extent Change 1996–2020: Global Mangrove Watch Version 3.0. Remote Sensing, 14(15). 10.3390/rs14153657
Brazil	2020	1,141,470	Bunting, P., Rosenqvist, A., Hilarides, L., & Lucas, R. M. (2022). Global Mangrove Extent Change 1996–2020: Global Mangrove Watch Version 3.0. Remote Sensing, 14(15). 10.3390/rs14153657
Brazil	1999 to 2003	1,300,000	Spalding M, Kainuma M, Collins L (2010). World Atlas of Mangroves (version 3.1). A collaborative project of ITTO, ISME, FAO, UNEP-WCMC, UNESCO-MAB, UNU-INWEH and TNC. London (UK): Earthscan, London. 319 pp. https://doi.org/10.34892/w2ew-m835
Brazil	2013 to 2014	1,398,996	ICMBIO. 2018. Atlas dos Manguezais do Brasil. ICMBIO, Brasília. https://www.gov.br/icmbio/pt-br/centrais-de-conteudo/atlas-dos-manguezais-do-brasil-pdf
Brazilian Amazon coast	1970 to 1975	1,065,400	Herz, R. (1991). Manguezais do Brasil. São Paulo. Instituto Oceanográfico, Universidade de São Paulo. 227 pp
Brazilian Amazon coast	1985	728,279	Souza-Filho, P.W.M., Diniz, C.G., Souza-Neto, P.W.M., Lopes, J.P.N., Nascimento Júnior, W.R., Cortinhas, L., Asp, N.E., Fernandes, M.E.B., Dominguez, J.M.L., 2023. Mangrove Swamps of Brazil: Current Status and Impact of Sea-Level Changes, in: Dominguez, J.M.L., Kikuchi, R.K.P.d., Filho, M.C.d.A., Schwamborn, R., Vital, H. (Eds.), Tropical Marine Environments of Brazil: Spatio-Temporal Heterogeneities and Responses to Climate Changes. Springer International Publishing, Cham, pp. 45-74, 10.1007/978-3-031-21329-8_3. MAPBIOMAS Collection v.9.0 (https://brasil.mapbiomas.org/)
Brazilian Amazon coast	2020	728,300	Souza-Filho, P.W.M., Diniz, C.G., Souza-Neto, P.W.M., Lopes, J.P.N., Nascimento Júnior, W.R., Cortinhas, L., Asp, N.E., Fernandes, M.E.B., Dominguez, J.M.L., 2023. Mangrove Swamps of Brazil: Current Status and Impact of Sea-Level Changes, in: Dominguez, J.M.L., Kikuchi, R.K.P.d., Filho, M.C.d.A., Schwamborn, R., Vital, H. (Eds.), Tropical Marine Environments of Brazil: Spatio-Temporal Heterogeneities and Responses to Climate Changes. Springer International Publishing, Cham, pp. 45-74, 10.1007/978-3-031-21329-8_3. MAPBIOMAS Collection v.9.0 (https://brasil.mapbiomas.org/)
French Guyana	2020	62,970	Bunting, P., Rosenqvist, A., Hilarides, L., & Lucas, R. M. (2022). Global Mangrove Extent Change 1996–2020: Global Mangrove Watch Version 3.0. Remote Sensing, 14(15). 10.3390/rs14153657

Country	Year	Mangrove area (ha)	Reference
Suriname	2020	80,044	Bunting, P., Rosenqvist, A., Hilarides, L., & Lucas, R. M. (2022). Global Mangrove Extent Change 1996–2020: Global Mangrove Watch Version 3.0. Remote Sensing, 14(15). 10.3390/rs14153657
Guyana	2020	28,859	Bunting, P., Rosenqvist, A., Hilarides, L., & Lucas, R. M. (2022). Global Mangrove Extent Change 1996–2020: Global Mangrove Watch Version 3.0. Remote Sensing, 14(15). 10.3390/rs14153657
East Venezuela	2020	283,820	Bunting, P., Rosenqvist, A., Hilarides, L., & Lucas, R. M. (2022). Global Mangrove Extent Change 1996–2020: Global Mangrove Watch Version 3.0. Remote Sensing, 14(15). 10.3390/rs14153657