



Brazilian mangroves at risk

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Abstract: Recent statements from the Brazilian federal government indicate that impacting economic activities, particularly commercial shrimp farming, are being encouraged in mangrove areas in the near future. Alterations of the National Action Plan and legal instruments that partially protected mangrove ecosystems have created an even weaker legal framework than previously existed. Such changes are leading Brazil far from the global call to conserve mangroves and from the Aichi targets and United Nations Sustainable Development Goals. Unfortunately, the loss of mangrove ecosystems and their ecosystem services will negatively impact living standards for Brazilians in coastal areas.

Keywords: Biodiversity, Carbon capture, Conservation, Nursery, PAN Manguezal.

Manguezais brasileiros sob risco

Resumo: As recentes determinações do governo Brasileiro indicam que atividades econômicas impactantes para os manguezais, particularmente a carcinocultura, serão incentivadas num futuro próximo. Alterações no Plano de Ação Nacional e em outros instrumentos legais, que parcialmente protegem os manguezais, fragilizaram ainda mais os meios legais para proteção dessas áreas. Essas mudanças fazem o Brasil seguir na contra-mão da demanda global pela conservação dos manguezais e dos objetivos de desenvolvimento sustentável traçados pela Organização das Nações Unidas, bem como das metas de Aichi para a biodiversidade. Consequentemente, a iminente perda dos ecossistemas de manguezais impactará negativamente o padrão de vida dos Brasileiros que vivem em áreas costeiras.

Palavras-chave: Berçário, Biodiversidade, Captura de Carbono, Conservação, PAN Manguezal.

Introduction

Mangroves (Figure 1) represent highly productive ecosystems, once relatively common along tropical and subtropical oceanic coastlines, especially around estuaries, and currently present over an area about 181,000 km² globally (Donato et al. 2011, Giri et al. 2011). Only about 2% of mangrove stands occur along temperate coastlines (Morrissey et al. 2010). Historically, several impacts have affected mangrove extents, such as: pollution, logging, and conversion to non-sustainable aquaculture and agriculture (Friess et al. 2019). Consequently, the global mangrove area, which is already smaller than previously estimated, continues to decline (Giri et al. 2011), making mangrove ecosystems top priorities for implementing conservation actions (Friess et al. 2019).

Mangrove ecosystems are characterized by transitional gradients of physiological and ecological characteristics, strongly influenced by salinity, nutrient concentrations, soil type, tidal amplitudes, and freshwater inputs, all of which create hostile conditions for most plant species (Walsh 1974, Cintrón & Schaeffer-Novelli 1983, Araujo & Pereira 2009, Silva et al. 2016). The vegetation is characterized by a homogeneous phytophysiology with low species diversity, but remarkable specializations in morphology and physiology (Figure 1) (Walsh 1974, Cintrón & Schaeffer-Novelli 1983, Araujo & Pereira 2009, Silva et al. 2016).

Brazilian mangrove plant associations are dominated by specialized species. These include some species of the genera *Acrostichum* L. (Pteridaceae), *Avicennia* L. (Acanthaceae), *Cinnamodendron* Endl. (Canellaceae), *Conocarpus* L. (Combretaceae), *Crenea* Aubl. (Lythraceae), *Hibiscus* L. (Malvaceae), *Laguncularia* C.F. Gaertn. (Combretaceae), *Rhizophora* L. (Rhizophoraceae), *Spartina* Schreb. (Poaceae), *Spergularia* (Pers.) J. Presl & C. Presl (Caryophyllaceae), and *Talipariti* Fryxell (Malvaceae). Those species include herbaceous, shrubby, and woody plants (Schaeffer-Novelli & Cintrón 1986, Bernini & Rezende 2004, Martins et al. 2011, Santos et al. 2012, Flora do Brazil 2020) (Figure 1). Mangrove forest losses extirpate this unique and specialized flora.

1. Range of Brazilian Mangroves

In Brazil, mangrove areas occur along an extensive coastline, from the Oiapoque River mouth in the north, to Laguna, in Santa Catarina state, in the south (Saenger et al. 1983, Novelli et al. 2000, Maia et al. 2006). Their Brazilian range represents 7% of the total global mangrove land cover (Giri et al. 2011). Considering only the Brazilian north coast, the country has the largest continuous formation of this ecosystem type in the world (Souza-Filho 2005).

2. Ecosystem Services

Many animal phyla and species use mangrove forests, such as molluscs, arthropods, fishes, reptiles, birds, and mammals (Giesen et al. 2006). For example, sixty-seven primate taxa, most of them exhibiting rare behaviors shelter or feed in tropical and subtropical mangroves (Supriatna & Wahono 2000, Santos et al. 2019, Presotto et al. 2020). The high productivity rates of mangrove ecosystems are crucial for the benthic and pelagic components of neritic food webs (Robertson et al. 1992), providing direct and indirect resources (Tomlinson 1986, Luther & Greenberg 2009) for transient fishes and crustaceans as nursery and foraging habitats (El-Regal & Ibrahim 2014, Hutchison et al. 2014, Sheaves 2017, Litvin et al. 2018). In particular, mangrove ecosystems are critical for sustaining economically valuable crustaceans (e.g., pink shrimps and swimming crabs), finfishes (e.g., snooks, mullets, sardines,

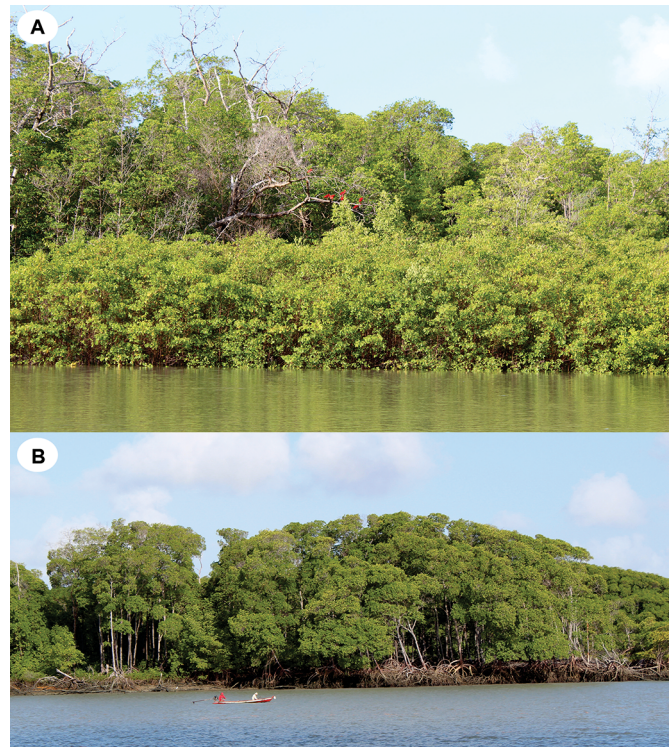


Figure 1. A (high tide) and B (low tide): mangroves in Cururupu locality, at Ilha dos Lençóis, archipelago of Maiaú, north Brazil. Photographed by Ricardo Rodrigues dos Santos.

some catfish species, snappers, several sciaenids, and some groupers), and their fisheries (Robertson & Duke 1990, Sheridan 1992, Rogers & Mumby 2019, Sheaves et al. 2020). In addition, mangrove forests provide several other ecosystem services, delivered to human society across local, regional and global extents (Barbier et al. 2011). These include such critically important services as erosion control, water purification, coastal protection from storms, raw materials and food, maintenance of fisheries, carbon sequestration and cultural services associated with tourism, recreation, education, and research (Figure 2).

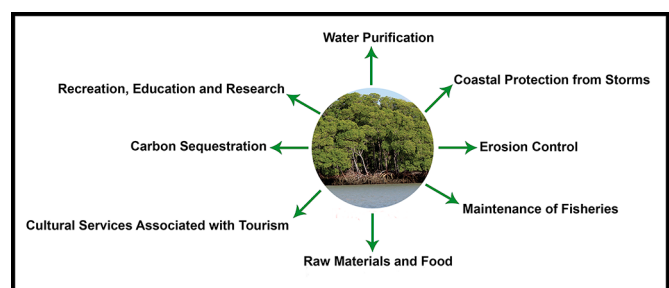


Figure 2. Representation of mangrove ecosystem services (green arrows). Water purification: Rybicki (1997), Lee & Dunton (1999), Gacia et al. (1999), Cornelisen & Thomas (2006), Romero et al. (2006), and Koch et al. (2006). Coastal protection: Fonseca & Cahalan (1992), Koch (1996), Prager & Halley (1999), Hemminga & Duarte (2000), Spalding et al. (2003), and Koch et al. (2009). Erosion: Hemminga & Nieuwenhuize (1990). Maintenance of fisheries: Cesar & van Beukering (2004), and Zeller et al. (2007). Raw materials and food: Hemminga & Duarte (2000), de la Torre-Castro & Rönnbäck (2004), and Lauer & Aswani (2010). Cultural Services associated with tourism: Naylor & Drew (1998). Carbon sequestration: Freeman (2003), Pagiola et al. (2004), NRC (2005), Barbier (2007), U.S. EPA (2009), Mendelsohn & Olmstead (2009), and Hanley & Barbier (2009). Recreation: Mathieu et al. (2003).

For example, Brazil has some conservation units in which mangrove forests play a major role in creating jobs and income, generating millions of reais per year through tourism, handcrafts, crab extraction, and traditional/commercial fishing. The Parque Nacional dos Lençóis Maranhenses (PNLM) and Delta do Rio Parnaíba (DRP) are both examples of areas that are benefited economically by ecosystem services provided from mangrove ecosystems. The PNLM received 151,786 tourists from all over the world in 2019 (ICMBIO 2020) to visit mainly sand dunes with freshwater lagoons, but also mangrove areas. In the DRP, crab extraction and commercial fishing are the main local economic activities, being the major location of crab harvest in Brazil (Legat et al. 2006, Fogaça et al. 2018).

3. Legal Statute Concerns

As with the global trend, Brazilian mangrove forests have been threatened for years, particularly by deforestation to build ponds for crustacean farming (Ferreira & Lacerda 2016a). However, an astonishing set of recent events has further threatened these ecosystems, derived from an orchestrated sequence of Brazilian political decisions. Since the 2012 alterations in the Brazilian Forest Code (Código Florestal law 12.651/2012), mangrove ecosystems have not been fully protected (Ferreira & Lacerda 2016b). Then, amidst the 2019 oil contamination crisis in coastal ecosystems (Escobar 2019) and government inability to protect the affected areas (Brum et al. 2020), the National Action Plan for Mangroves (Plano de Ação Nacional para a Conservação das Espécies Ameaçadas e de Importância Socioeconômica do Ecossistema Manguezal; PAN Manguezal) was altered. The PAN Manguezal, which identifies priority actions for ecosystem protection, was modified in 2019 to exclude the eradication of shrimp farming and the recovery of mangrove as goals. Later, in September 2020, the number of NGOs, universities and indigenous peoples represented in the National Environment Council (Conselho Nacional do Meio Ambiente; CONAMA) was reduced. The Bolsonaro government subsequently revoked

CONAMA resolution 303/2002, which established regulations to protect Brazilian mangrove ecosystems. These two recent changes have created a pathway for increasingly unregulated economic activities and impacts on mangrove ecosystems, leaving them without any protective regulations.

The PAN Manguezal and CONAMA changes imperil mangrove ecosystem services (see mangrove ecosystem services in Barbier et al. 2011) and, as a consequence, economic activities (e.g. tourism and commercial fisheries), that represent the main income and budget in several municipalities along the Brazilian coast. The Bolsonaro's government legal changes ignore global perspectives that consider mangroves as vitally important ecosystems for conservation (Friess et al. 2019). In addition, the new statutes are in opposition to the Aichi targets, which Brazil agreed to follow as part of the Convention on Biological Diversity, and the United Nations Sustainable Development Goals (SDGs). The SDGs are a set of goals aimed at reaching a sustainable planet that started to emerge during the 2012 United Nations Conference on Sustainable Development (Rio + 20), which occurred in Rio de Janeiro and brought together global leaders (Sachs 2015). In particular, the statutes violate four SDGs: SDG 2 (End hunger, achieve food security, improve nutrition, and promote sustainable agriculture); SDG 13 (Take urgent action to combat climate change and reduce its impacts); SDG 14 (Conserve and ensure the sustainable use and development of the oceans, seas, freshwater bodies and marine resources); and SDG 15 (Protect, restore and promote the sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, halt degradation, and halt biodiversity loss). See Table 1 for a summary of the status of these statutes. The Brazilian government must reinstitute legal protections for mangrove ecosystems to abide by these global objectives. Otherwise, mangrove forests will be increasingly subjected to impacts that will threaten their biodiversity and the living standards of millions of Brazilian citizens living in coastal areas, whose lives depend on activities directly related to mangrove conservation.

Table 1. Summary of international and Brazilian mangrove related policies. Links in "Access" column direct to official government internet pages.

International Agreements	Main Resolves and Guidelines	Regulating Organ/ Event	Implementation Date	Status in January 2021	Access
Aichi Biodiversity Targets	Target 5 - Halving of habitat loss ratings; Target 6 - Sustainable management of fisheries and other seaborn stocks; Target 11 - Conservation of at least 10% of coastal and marine areas; Target 14 - Restoration and safeguarding of ecosystems that provide essential services.	Convention on Biological Diversity (1992 Rio Earth Summit)	January 2011	Active	https://www.cbd.int/sp/targets/
United Nations Sustainable Development Goals (SDGs)	SDG 2 - End hunger, achieve food security and improved nutrition, and promote sustainable agriculture; SDG 13 - Take urgent action to combat climate change and reduce its impacts; SDG 14 - Conserve and ensure the sustainable use and development of the oceans, seas, freshwater bodies and marine resources; SDG 15 - Protect, restore and promote the sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, halt degradation, and halt biodiversity loss.	United Nations Conference on Sustainable Development (Rio + 20)	September 2015	Active	https://www.un.org/sustainabledevelopment/sustainable-development-goals/

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Brazilian Environmental Policies					
Resolution CONAMA No 303/2002	Establishes mangroves as permanent preservation areas.	Conselho Nacional do Meio Ambiente (CONAMA)	May 2002	Judicially Active	http://www2.mma.gov.br/port/conama/legiabre.cfm?codlegi=299
Código Florestal (Law 12.651/2012)	Allows and regulates implementation of shrimp farms and salt pans in mangroves and surrounding environments.	Ministério da Casa Civil; Ministério do Meio Ambiente	May 2012	Active	http://www.planalto.gov.br/ccivil_03/_ato2011-2014/2012/lei/l12651.htm
PAN Manguezal (ordinance ICMBio No 9/2015)	Establishes actions and directions aiming for the conservation and sustainable use of mangroves and associated endangered species; Specifically proposes eradication of shrimp farms and salt pans in mangroves.	Instituto Chico Mendes de Conservação da Biodiversidade (ICMBio)	January 2015	Revoked	https://www.icmbio.gov.br/cepsul/images/stories/legislacao/Portaria/2015/p_icmbio_09_2015_aprova_pan_manguezais.pdf
PAN Manguezal Updated (ordinance ICMBio No 647/2019)	Revokes and replaces the text of previous PAN Manguezal; Unstringing regulations and guidelines for shrimp farms and salt pans.	Instituto Chico Mendes de Conservação da Biodiversidade (ICMBio)	October 2019	Active	https://www.icmbio.gov.br/portal/images/stories/docs-pan/pan-manguezal/1-ciclo/pan-manguezal-portaria-aprovacao-e-gat.pdf
Resolution CONAMA No 500/2020	Revokes resolution CONAMA No 303/2002.	Conselho Nacional do Meio Ambiente (CONAMA)	October 2020	Judicially Suspended	https://www.in.gov.br/en/web/dou/-/resolucao-conama-mma-n-500-de-19-de-outubro-de-2020-284006009

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Conflicts of Interest

The authors declare that they have no conflict of interest.

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