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LETTER TO THE EDITOR

Challenges in preserving restinga and beach ecosystems in Brazil

CARLA C. SIQUEIRA & CARLOS FREDERICO D. ROCHA

The Brazilian coastline encompasses some ecosystems, including mangroves, restingas (coastal sand-dune habitats), and beaches. Despite only a quarter of the remaining restinga being under protection (Manes et al. 2023), it harbors at least 40 species of vertebrates threatened with extinction (MMA 2018), a number that may be revised up with the incorporation of refined geospatial data (Ocampo-Peñuela et al. 2016). Also, Brazilian beaches shelter at least 35 endangered species, including five sea turtles, which use them as their exclusive reproductive sites (MMA 2018).

Restingas and beaches, designated as permanent preservation areas by the Brazilian Forest Code (Federal Law 12.651/2012), face anthropogenic pressures driven by real estate speculation, infrastructure, industry, vehicle traffic, and invasive species. Between 1985-2022, a 10% reduction in arboreal restingas was observed, whereas beach, dune, and sandy areas experienced a 15% decline (MapBiomas 2023). However, these data mask a more alarming reality when examined on a finer scale. Comparing the coastal Brazilian states between 1985 and 2022, the state of Santa Catarina had the largest loss of arboreal restingas, with 70.4% of this habitat remaining. The states with greater reduction of beach, dune, and sandy areas occurred in Rio de Janeiro and Espírito Santo states, both reduced to 55.1% (MapBiomas 2023).

Analyzing the distribution of the critically endangered beach lizard *Liolaemus lutzae* in the state of Rio de Janeiro between 1985 and 2022 (MapBiomas 2023), the largest loss of arboreal restingas occurred in Araruama municipality, where only 51% of this habitat remains, followed by Niterói municipality, with 60% (Fig. 1a). Meanwhile, still within this geographic distribution range, the beach area covered by halophilous-psammophilous vegetation – the habitat where this species is restricted to – has diminished substantially, reaching the lowest values of coverage at 60% in Niterói municipality, and 62% in Maricá municipality (Fig. 1b). These numbers might be underestimated because habitat losses on a finer spatial scale, such as those from vehicle traffic (Fig. 1c-d) and some municipal paving works, may not be detected. Anthropogenic threats also include the construction of the 'Terminal Ponta Negra' in Jaconé beach, Maricá municipality, for oil logistics. The area is home not only to *L. lutzae* (Rocha et al. 2009), but also to the endangered 'cloud fish' *Notholebias vermiculatus* (MMA 2018), and the *beachrocks* discovered by Darwin (Castro et al. 2014). In the municipality of Maricá, the Supreme Court of Brazil ordered the suspension of the construction of a luxury resort on the restinga within the environmental protection area (APA de Maricá), inhabited by artisanal fishermen (Zacarias), indigenous people (Guarani ethnicity), and at least 12 endangered species of the fauna;

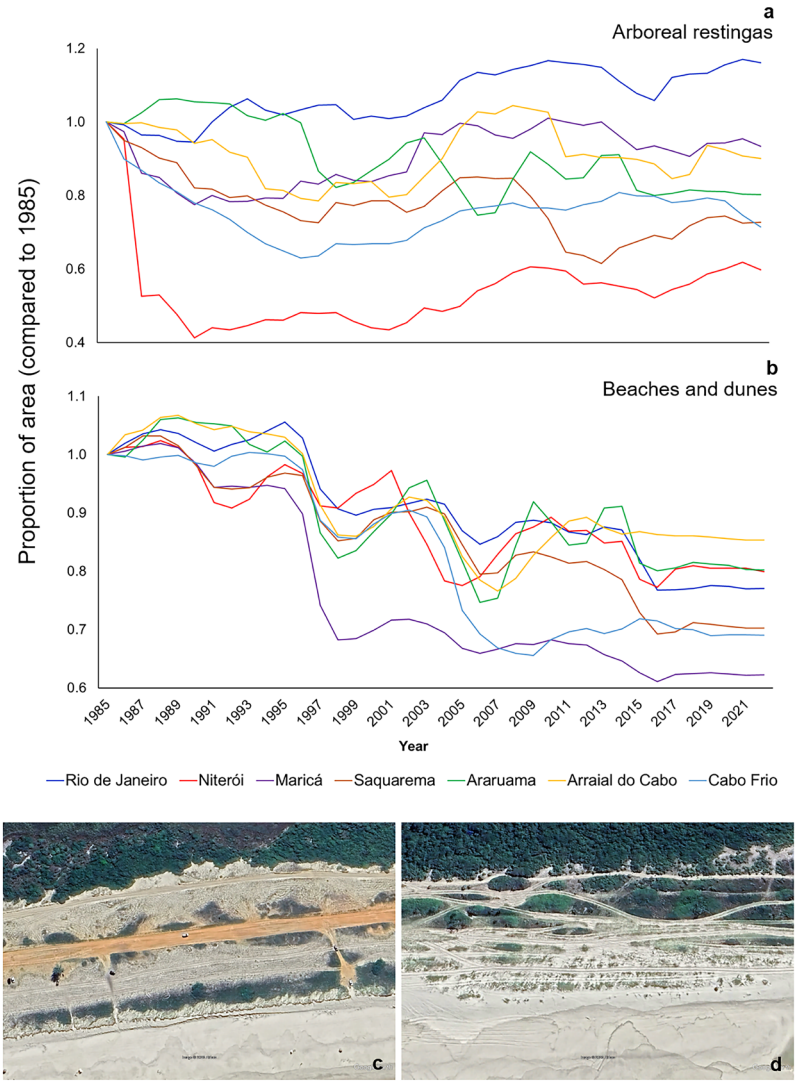

Figure 1. Graphs depict the proportion of area, relative to 1985, for arboreal restingas (a) and the 'beaches and dunes' category (b) in seven municipalities in the state of Rio de Janeiro, Brazil. Intensive fragmentation due to vehicle traffic is see in the halophilous-psamophilous habitat based on Google Earth® images from a section of two beach areas: c) APA de Maricá; d) Itaúna, Saquarema. The calculations utilized data sourced from MapBiomas (2023).

nevertheless, IDB Brazil has expressed intentions to challenge this judicial decision and proceed with the project.

The coastline habitats, being more vulnerable and exposed, face serious risks due to climate changes, with Brazil being one of the countries most subject to the impacts of coastal flooding and erosion (Manes et al. 2023). It is worth noting that anthropogenic interferences, especially due to urbanization and infrastructure along the coastline, have been linked to erosion and sediment accumulation (progradation). This phenomenon impacts approximately 60% of the Brazilian coastal zone, particularly in the North and Northeastern regions. The revocation of Brazilian law providing permanent protection for dunes and restingas (CONAMA-303/2002) in 2020 facilitated the expansion of real estate and urban infrastructure in these areas. Additionally, the proposed PL 2159/2021, currently under consideration in Congress, threatens to bring significant negative changes to the environmental licensing process. Moreover, the port and oil sectors are set to expand with proposed investments of US$ 11 billion and US$ 72 billion, respectively, from the federal government's investment program ("Novo PAC"), directly impacting restingas and beaches.

Conserving coastal ecosystems in Brazil in the face of climatic changes and local anthropogenic disturbances is a complex task. While the establishment of new protected areas and restoration efforts are crucial (Agapito et al. 2023), it is evident that decision-makers have yet to fully understand the urgency of these actions to safeguarding biodiversity (Sinervo et al. 2010) and ecosystem services (Manes et al. 2023). Furthermore, despite Brazil being currently engaged in a so-called "clean" energy transition, concerns about the impacts of increasing coastal oil extraction for exportation on coastal ecosystems have intensified (Antunes 2023). The model often referred to as "progress" is characterized by intense exploitation of nature, hyper-consumerism, unplanned urban development, and extreme social inequality. Among the 20 largest municipalities in Brazil in terms of oil royalty values received, the financial application remains inefficient and marked by immediate priorities for most of them (Agenda Pública 2023). The critical evaluation of the current practices of financial resource allocation should aim to mitigate existing inequalities by prioritizing long-term initiatives, including sustainable urban projects that protect permanent protection areas, alongside efforts targeting economic diversification and social well-being. Achieving meaningful progress in coastal habitat conservation demands innovative solutions that address the causes of degradation while promoting resilience and adaptive capacity in the face of future challenges.

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CARLA C. SIQUEIRA
https://orcid.org/0000-0002-5518-7090

CARLOS FREDERICO D. ROCHA
https://orcid.org/0000-0003-3000-1242

Universidade do Estado do Rio de Janeiro, Instituto de Biologia, Departamento de Ecologia, Rua São Francisco Xavier, 524, Maracanã, 20550-011 Rio de Janeiro, RJ, Brazil

Correspondence to: **Carla Costa Siqueira**
E-mail: carlacsiqueira@yahoo.com.br