



Not just sand: The folly of dismantling the environmental protection of dunes in Brazil

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ABSTRACT

The Brazilian federal government has followed an open agenda and land use policy against existing legislation in the past three years using the false argument that it hinders national development. A recent loss has been the repeal of national resolution CONAMA 303/2002. With the action of the Brazilian government to revoke this resolution, the mobile and eolian dunes are currently without legal national protection, and are available for real estate, industry (e.g., wind farms), and urban development, among other activities. In this context, the occupation of the mobile dunes promoted by the revocation of CONAMA 303 increases the risk of erosion of the beaches, damage to estuaries with mangroves, and destabilization of the coastline as a whole owing to the interruption of wind corridors of sand transport. The dunes are also one of the main freshwater reservoirs in Brazil. Therefore, the occupation of the dunes and encouragement of their impermeabilization by the attempted permanent repeal of CONAMA 303 resolution clearly puts the water security of Northeast Brazil (a semiarid region) at risk. This incentive to occupy mobile dunes by changing legislation will have a synergistic impact and amplify the predicted effects of climate change with negative repercussions on the sedimentary balance, tourist activities, and blue carbon sequestration. In addition, the vast quantity and value of goods and services provided to society and discussed in this article are sufficient to justify their conservation and a permanent decision from Supreme Court to keep the CONAMA 303 active.

The Brazilian federal government has followed an open agenda and policy against existing environmental legislation in the past three years using the false argument that it hinders national development (Abessa et al., 2019; Barbosa et al., 2021). In this context, there has been a cut in resources for enforcement and environmental actions (e.g., deforestation and wildfires) (Escobar, 2019, 2020) and scientific research (Nobre, 2019), government inaction against environmental disasters (Brum et al., 2020; Soares et al., 2020), reduction in civil society participation in environmental councils and funds (Ferrante and Fearnside, 2019; Thomaz et al., 2020; Pelicice and Castello, 2021), and a recent modification of environmental laws that pose great risks for the conservation of relevant ecosystems (Bernardino et al., 2021). A recent loss has been the repeal of National Environmental Council (CONAMA) resolution 303/2002 (Anon, 2020).

This national resolution is of pivotal importance for the conservation of several coastal ecosystems such as mangroves and shrub areas in coastal sand barriers (*restingas* in Portuguese), which are now threatened

by real estate speculation, shrimp farms, and industry (Ferreira and Lacerda, 2016; Bernardino et al., 2021). However, the problem of mismanagement of eolian dunes (Kindermann et al., 2013) and intense urban and industrial pressure especially on the coast (Gorayeb et al., 2018), aggravated by this recent federal legislative change is not fully discussed in the scientific literature. The aim of this viewpoint article is to discuss the effects of this normative change to environmental protection of eolian dunes in Brazil.

Brazil has the largest number and area of eolian dunes in the South American continent, mainly in its tropical region (Northeast Brazil) (Santos et al., 2019). These dunes are found in three important neotropical domains: Amazon, Caatinga, and Brazilian Savanna. These sedimentary structures are formed in the interior of the continent (e.g., Jalapão State Park) (Santos et al., 2021) and on the extensive Brazilian coast. Coastal dunes are eolian landforms that develop in situations where an ample supply of loose, sand-sized sediment is available to be moved by the wind. In this regard, a large geodiversity of dune forms is

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found inland of and above the storm-water level of sandy beaches (Martínez et al., 2008). Dunes are characterized as deposits formed by the action of wind on sand, with or without vegetation according to the Brazilian legislation (CONAMA resolution). In this context, the dunes can be classified as fixed (when they have vegetation with an arboreal size that stabilizes the wind dynamics), semi-fixed, or mobile dunes (without vegetation) (Tsoar et al., 2009; Santana-Cordero et al., 2016).

Mobile dunes are an extremely unstable and dynamic coastal environment owing to the joint action of waves, tides, and wind on their structure and dynamics (Fig. 1). In Northeast Brazil, high speed winds are one of the main drivers of long- and short-term dune mobility and wind transport (Sparavigna, 2016). This dynamic of the mobile and semi-fixed dunes demonstrates their clear ecological and geological connectivity with estuaries and sandy beaches, where dunes are important providers of sediment to maintain the sand balance in these other interconnected ecosystems and prevent the acceleration of the erosive process, which is especially damaging to mangroves, hypersaline tidal flats, seagrass beds, tropical reefs, and beaches (Duran et al., 2008; Copertino et al., 2016; Elliff and Silva, 2017).

The proximity of the dunes to coastal and urban areas (Fig. 2) makes them targets under the strong human pressure of private and public interest, such as the expansion of urban centers, industries, tourism, and wind farms (Brannstrom et al., 2017; Gorayeb et al., 2018). In addition, the presence of debris, fires, sand mining, and unregulated traffic from off-road vehicles and motorcycles put these unique ecosystems at risk (Kindermann and Gormally, 2013; Santana-Cordero et al., 2016; Hernández-Cordero et al., 2017; Neumann et al., 2017; Santos et al., 2021). In the legal context, they can be protected in several ways. One, which has been quite rare on the Brazilian coast, is the creation of no-take protected areas (indirect use) such as national parks (Schiavetti et al., 2013; Santos and Schiavetti, 2014). One example is the *Lençóis Maranhenses* National Park covering an area of approximately 1550 km², which has the largest dune field in South America with dunes of up to 40 m in height (Gonçalves et al., 2008). Moreover, Brazilian states (and even municipalities) can enact environmental laws and

create state parks to protect dunes, such as the state park 'Dunas de Natal', in Rio Grande do Norte state created in 1977 (Freire, 1990). However, the protection of most of the dunes in the country has been only by the forest code (Law no. 12,651, 2012) and the CONAMA 303 national resolution that was entirely revoked in 9/28/2020.

The forest code (Law No 12,651/2012) guarantees the protection of dunes only when vegetated, as with forests. The CONAMA 303/2002 resolution provided additional protection of the dunes, including the semi-fixed and mobile dunes. However, with the recent action (September 2020) of the Brazilian federal government to revoke CONAMA 303/2002, the mobile dunes are currently without legal national protection, and are available for real estate, industry, and urban development, among other activities. Brazilian states and municipalities can provide protection to these environments through state legislation and ecological-economic zoning (Nicolodi et al., 2021); however, the absence of a unified national legislation can lead to conflict between north-eastern states, which depending on their environmental legislation, may attract private enterprises such as hotels and wind power plants.

Although these neglected ecosystems are seen by society as just a large reservoir of sand, they have enormous ecological, social, and economic importance for coastal conservation and are an especially vulnerable and threatened environment (Fig. 3). The mobile dunes are important as protection for the coastline from rising sea levels (Lisboa et al., 2019) and as a sediment reservoir that regulates and exports sand to the estuaries with mangroves and sandy beaches, which have enormous tourist and recreational importance not only in Brazil but also worldwide (Spalding and Parrett, 2019). They are also an important protection against the erosive action of tides (e.g., macro- and meso-tides), storms, and other climatic phenomena such as the occurrence of swell waves that tend to increase with global warming in Northeast Brazil (Muehe, 2010; Albuquerque et al., 2018).

In this context, the occupation of the mobile dunes promoted by the revocation of CONAMA 303 increases the risk of erosion of the beaches, damage to estuaries with mangroves, and destabilization of the coastline



Fig. 1. Mobile eolian dune in Northeast Brazil (Paracuru, Ceará coast) interconnected with a sandy beach affected by a strong tidal regime and seasonal swell waves. Sand dunes are part of the sand-sharing geosystem composed of the highly mobile beach and the more stable dune landforms. Source: Photo from the authors.



Fig. 2. Dunes and interconnected estuarine lagoons are under growing pressure from urban and human activities in the coastal zone (Jericoacoara National Park, Ceará coast, Northeast Brazil).
Source: Photo from the authors.



Fig. 3. Mobile and vegetated dunes are important water and sediment reservoirs in Brazil (Jericoacoara National Park, Ceará coast).
Source: Photo from the authors.

as a whole owing to the interruption of wind corridors of sand transport. These tropical environments are already under intense pressure from the effects of climate change (droughts and rising sea levels) that already put approximately 42.4% of the beaches in Northeast Brazil at the risk of erosion (Muehe, 2018; Oppenheimer et al., 2019). This unusual incentive to occupy mobile and semi-fixed dunes by changing national legislation will have a synergistic impact and amplify the predicted effects of climate change with negative repercussions on the sedimentary balance (Soares et al., 2021), tourist activities, and blue carbon sequestration (captured by the Brazilian mangroves, salt marshes, and seagrass beds) (Copertino et al., 2016; Kauffman et al., 2018).

The dunes are also one of the main freshwater reservoirs in Brazil. Owing to the percolation of rainwater, these coastal environments are important for the water security of the human population and the export of groundwater to adjacent ecosystems (such as estuaries) (Pinheiro, 2009; Soares et al., 2021). Northeast Brazil is largely situated in a semi-arid climate region subject to severe and prolonged droughts and annual rainfall generally below 1000 mm/year (Souza and Oyama, 2011; Marengo et al., 2017). In addition, it has a high population density, and more than 50 million people live in its territory, mostly located in the coastal zone. Of the nine capitals of the north-eastern states, eight are on the coast (Pinheiro et al., 2008). Most of the water security in this tropical region is guaranteed by an integrated system of canals, dams, and reservoirs that provide fresh water for industries, agriculture, and cities (Araújo et al., 2019; Tomaz et al., 2019).

In recent decades, drilling of groundwater wells in dunes has advanced as an alternative to water scarcity in dams and reservoirs in the Brazilian semi-arid region. However, with the advance of climate change and the expected reduction in rainfall from 10% to 20% by 2040 and 25% to 35% by 2070 (Marengo et al., 2017, 2020), conservation of the dunes is critical. Therefore, the occupation of the dunes and encouragement of their impermeabilization by the attempted permanent repeal of CONAMA 303/2002 clearly puts the water security of Northeast Brazil at risk. Finally, the dunes, whether fixed, semi-fixed, or mobile, are important areas of archeological and cultural heritage (Mansur and Carvalho, 2011), for traditional communities (*quilombolas* – African slave descendants, indigenous people, and artisanal fishers), and as residence, nursery, or migratory habitat of terrestrial fauna and flora, including endemic species (Freire, 1990; Wartchow et al., 2015; Rodrigues and Juncá, 2002) along with other terrestrial and aquatic environments such as the Amazon Forest, Cerrado, Caatinga, the coastal zone vegetation complex, and the estuaries with mangroves.

The revocation of CONAMA 303/2002 represents an important setback in environmental legislation that must be reversed. Currently, the Brazilian Supreme Court has delivered an injunction (*periculum in mora*) with a subsequent suspensive temporary effect (10/29/2020). Moreover, a preliminary (and provisional) decision (11/27/2020) delivered by one of the judges the Court has demanded the federal government to keep in force Resolution 303 of CONAMA in all its purposes, i.e., including the protection of dunes, until the final judgment of the merits by the full court. In this context, numerous administrative and judicial processes have sought to temporarily reverse the revocation of this CONAMA fundamental to the protection of mobile and active eolian dunes. The dunes are an important environment for mitigation of and adaptation to climate change (e.g., fires, extreme events, storms, droughts, and sea-level rise) (Marengo et al., 2020; Santos et al., 2021). In addition, the vast quantity and value of ecosystem goods and services (Nehren et al., 2017) provided to society and discussed in this article are sufficient to justify their conservation and a permanent decision from Supreme Court to keep the CONAMA 303 active. Therefore, their conservation should be a priority in the current Anthropocene both in Brazil and worldwide (Kindermann and Gormally, 2013; Santana-Cordero et al., 2016; Hernández-Cordero et al., 2017).

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