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Pollution-related biodiversity loss in Brazil: More actions required

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Abstract

Proposed oil extraction in the Amazon River estuary raises significant concerns among environmentalists and scientists due to the environmental risks associated with this activity. Beyond oil pollution-associated risks, multiple classes of pollutants are threatening Brazilian ecosystems. In this Letter, we draw attention to this environmental issue and highlight actions to control the deleterious effects of pollution on Brazil's biodiversity.

Keywords: Amazon; Brazil; biodiversity; conservation; pollution.

A recent proposal for oil extraction in the Amazon River estuary raises concerns about the potential socioenvironmental consequences of this activity in such an environmentally sensitive region (Marques et al., 2023; Moutinho, 2023; Rodrigues, 2023). Like Brazil's pre-salt offshore oil fields, water depths at the site are up to twice that where the Deepwater Horizon spill gushed unchecked for five months in the Gulf of Mexico and showed that no one in the world has the technology to stop a spill at that depth (Fearnside, 2019). Failures to address oil spills in the Amazon region, associated not only with oil extraction but also with oil transport, would affect vast and pristine aquatic areas and ecosystems, leading to unpredictable consequences for the Amazon's biodiversity (Araújo et al., 2023; Fontes et al., 2023). The proposal for oil extraction in the Amazon River estuary is concerning for the Brazilian scientific and conservation communities because it adds to other pollution-related problems already observed in the Brazilian Amazon. These include CO_2 pollution associated with deforestation and fires (Lapola et al., 2023) and mercury pollution linked to illegal gold mining (Ellwanger and Chies, 2023a). It was estimated that approximately 2.5 tons of mercury are released annually in the Amazon's Tapajós River basin due to artisanal gold mining (Fritz et al., 2024). These pollution-related issues worsen the biodiversity loss due to the ongoing land-use change in Brazil. Brazil ranks among the world's countries with the highest losses of natural vegetation (Metzger et al., 2019), and activities with high pollution potential certainly exacerbate the decay of biodiversity that threaten Brazilian ecosystems.

The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES, 2019) found that climate change, invasive alien species, direct exploitation of organisms, land-/sea-use change, and pollution are the main drivers of biodiversity decline, and these factors are strongly interconnected (Sylvester et al., 2023). For example, loss and degradation of vegetation cover contribute to climate change (Lapola et al., 2023), and invasive species degrade ecosystems (Pyšek et al., 2010). Oil spills have significant negative impacts on terrestrial, freshwater and marine ecosystems (IPBES, 2019). Every year, an estimated 300–400 million tons of heavy metals, solvents, toxic sludge, and various industrial wastes are discharged into the Earth's water bodies. Excessive or improper use of fertilizers poses an additional environmental challenge, significantly impacting biodiversity. Global marine plastic pollution has increased tenfold since 1980, directly affecting sea animals (IPBES, 2019).

In Brazil, pollution-related biodiversity loss is not a problem limited to the Amazon region. A body of evidence underscores the adverse effects of pollution on all of Brazil's six terrestrial regions (Amazon, Atlantic Forest, Caatinga, Cerrado, Pampa, and Pantanal) and in offshore areas (Cobelo et al., 2023; Martinez et al., 2022) This leads to the erosion of biodiversity in multiple way; for instance, Brazil releases 44% of its domestic sewage into the environment without proper treatment (Brazil, MC, 2022), harming aquatic and terrestrial ecosystems (Wear et al., 2021). Discharge of sewage into the das Velhas River in Brazil's Minas Gerais state impacted water quality, leading to declines in the richness and diversity of fish and benthic organisms (Pompeu et al., 2005). A study examining aquatic macroinvertebrates in urban streams in the city of Manaus in the Brazilian Amazon revealed that water pollution impacted the macroinvertebrate fauna similarly to deforestation, leading to a reduction in taxonomic richness and simplification of community structure (Couceiro et al., 2007).

Pollution and other urbanization issues in coastal areas of southern Brazil were associated with alterations in the community structure of macroalgal assemblages, and the decline in macroalgae diversity and richness was specifically associated with nutrient enrichment (Martins et al., 2012). In a study conducted in northeastern Brazil, pollution from plastic bags led to the migration of microalgae towards the sediment surface, primarily driven by limitations in light availability. This effect may cause changes in food webs and benthic community structures (Clemente et al., 2018).

Oil spills as drivers of biodiversity loss is not just a speculation. The "oil-spill disaster" in 2019–2020 on the northeast coast of Brazil from an unidentified source resulted in a rapid reduction in species richness and abundance of benthic communities associated with *Jania capillacea* and *Penicillus capitatus* algae upon the arrival of the oil (Craveiro et al., 2021). This oil spill also had detrimental effects on sea turtles, birds, and mammals (Disner and Torres, 2020).

Industrial and urban pollution of a tropical river in an urbanized region of northeastern Brazil has led to a decrease in microbial diversity, concurrently associated with the presence of pathogenic bacterial species (Köchling et al., 2017). Pathogen pollution is a significant issue in Brazil, frequently linked to poor sanitation, with adverse effects on multiple organisms, thereby contributing to biodiversity loss (Ellwanger and Chies, 2023b).

An example of damage to plant species due to environmental pollution is provided by a study performed with *Joannesia princeps* Vell. (Euphorbiaceae), a species native to Brazil's Atlantic Forest, showing that the plant tissues suffered multiple types of air pollution-related damage (Silva et al., 2023). Mercury from anthropogenic atmospheric pollution often accumulate to elevated concentrations in the soil and litter of the Atlantic Forest, potentially impacting the abundance and richness of soil fauna (Buch et al., 2015). Brazil's pesticide pollution is associated with the mortality and biochemical alterations of multiple animal species (Disner et al., 2021). Species can also be harmed by illegal mining activities and disposal of industrial waste in the environment (Gurgel et al., 2016; Ellwanger and Chies, 2023a), and by emerging pollutants such as polycyclic aromatic hydrocarbons, pharmaceuticals, and microplastics (Souza et al., 2022).

Pollution affects biodiversity by impacting species at the individual, population, and assemblage levels (Martinez et al., 2022; Michelangeli et al., 2022). A systematic review focused on studies performed in Brazil at the individual level found that pollution can adversely impact species by altering oxidative stress levels, carbohydrate reserves, osmotic regulation, genome stability, and various other cellular and tissue functions (Martinez et al., 2022). At the population level, pollution may influence factors such as survival, abundance, development, fertility, diet, and reproduction. At the assemblage level, pollution can affect abundance, taxonomic composition, richness, and overall biodiversity of species. Species biodiversity and richness consistently exhibit a declining trend with increasing pollution levels (Martinez et al., 2022).

Actions on Brazil's environmental crises should embrace pollution-related biodiversity loss in all Brazilian ecosystems. We argue that Brazil must (I) ban oil exploitation in environmentally sensitive regions such as the Amazon basin (Fearnside, 2023), (II) accelerate the "energy transition", transitioning its energy matrix to renewable sources, decarbonizing its economy and reducing Brazil's participation in the oil market (Marques et al., 2023), (III) curb deforestation in the Amazon rainforest, thereby substantially decreasing Brazil's CO_2 emissions and meeting the Brazilian goal of zeroing Amazon deforestation by 2030 (Moutinho, 2023), (IV) strengthen environmental protection agencies such as the Brazilian Institute of Environment and Renewable Natural Resources (*Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis* - IBAMA), which operate in the Amazon forest and throughout Brazil (Silva and Fearnside, 2022), (V) strengthen the National Indian Foundation (*Fundação Nacional dos Povos Indígenas* - FUNAI) and protect the Amazon's Indigenous Lands, preventing the actions of land grabbers and "wildcat" gold miners (*garimpeiros*) (Ferrante and Fearnside, 2022; Ellwanger et al., 2023), (VI) reduce

Brazil's dependence on mining activities by advancing the bioeconomy (Ellwanger et al., 2023) and delineating 'no-go' mining zones crucial for conserving biodiversity (Siqueira-Gay et al., 2022), (VII) expand the collection and treatment of domestic sewage, industrial waste, and pesticide residues (Pescke et al., 2022; Ziliotto et al., 2023), (VIII) better apply the National Solid Waste Plan (Brazil, MMA 2022), (IX) more carefully evaluate the ecotoxicological potential of emerging contaminants and invest in technologies for the removal of these compounds from natural environments (Marson et al., 2022), and (X) advance education on pollution control in Brazilian schools and communities (Carneiro et al., 2021). These actions are critical to controlling the deleterious effects of pollution on Brazil's biodiversity.

Statements & Declarations

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Competing Interests

The authors declare no conflicts of interest regarding this article.

Author Contributions (CRediT author statement)

Joel Henrique Ellwanger: Conceptualization, Writing – original draft. Philip Martin Fearnside: Writing – review & editing. Marina Ziliotto: Writing – review & editing. José Artur Bogo Chies: Writing – review & editing, Supervision.

Data Availability

No dataset was generated in this study.

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