



## ECOLOGICAL SCIENCE AND THE MYTH OF CASSANDRA IN BRAZIL

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**Abstract:** In the last decade, Brazilian ecologists have developed many researches on ecological science, with strong potential for application to environmental management. This progress had three approaches: publishing papers in international journals, developing a consolidated system of postgraduate courses training new generations of ecologists, and organizing the Brazilian Association for Ecological Science and Conservation (ABECO). However, this scientific potential has been hindered by science denialism here quoting by the Myth of Cassandra, but Brazilian ecologists will not remain cursed forever and still working to shaping a better future based on ecological science.

**Keywords:** biodiversity loss; conservation plans; Ecology; science-based decisions.

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As scientific term, Ecology was apparently first used in XIX century by the zoologist Ernest Haeckel. Some years after, however, Ecology achieved a broader meaning. For example, according to the British Ecological Society, Ecology is defined as “the study of interactions among living things and their environment” (British Ecological Society 2022). Nowadays, Ecology has a prominent role among scientific disciplines due to its strategic value for society, since it may reveal major anthropogenic drivers of biodiversity loss and ecosystem impoverishment,

which is paramount to propose evidence-based environmental management and biodiversity conservation plans (Egerton 2001, Sutherland *et al.* 2013). Indeed, most theories and concepts of biological conservation come from Ecology (Wilcox & Soule 1980, Caughley & Gunn 1996).

Promoting ecological science, particularly in megadiverse countries, is essential to well-conducted management of natural resources, which is crucial for human well-fare across the globe (IPBES 2019). For example, is already argued by scientists in Brazil that without the knowledge

of biodiversity and its importance in supplying ecosystem services, it is impossible to implement more effective and long-term conservation actions (Magnusson *et al.* 2018). Indeed, a recent analysis of dataset with articles published in top-ranked Ecology journals in the last 40 years detected an increase of studies on anthropogenic effects on nature (McCallen *et al.* 2019). Therefore, it is expected that megadiverse countries, such as Brazil, needs effective environmental policies, including more protected areas and species conservation planning. Obviously, to achieve those targets, any country needs commitment, which includes investment in solid science funding.

Moreover, as science-based decisions are crucial, integration between scientists and policy makers is necessary. However, this integration is sometimes difficult due to the science denialism plague that we are currently facing. Science flourishes as a human enterprise since 17th century, contributing to human well-being. Undoubtedly, Science is the fastest way to increase our knowledge of Nature, and to find solutions for the problems of humankind. However, it has been falling into discredit by several groups in our society, which opted for ignoring the predictive power of science, such as science denialism due political interest (*e.g.* Diele-Viegas *et al.* 2021). This phenomenon is called myth of Cassandra, quoting the mythological figure that received the power of predict the future, while nobody believed in her predictions. The myth of Cassandra is a very appropriate symbol to express the agony of scientists over the first decades of the 21st century in Brazil and also in the world.

Brazil is today perhaps the closest example we may figure out of the myth of Cassandra applied to evidence-based environmental knowledge in the world. Brazilian ecologists produce solid basic and applied ecological science, with strong potential for application to environmental management. This statement is grounded on three points we develop over the next paragraphs: (1) Brazilian ecologists have important contributions to international scientific production, both in terms of theoretical, empirical and applied knowledge; (2) Brazil has a well consolidated system of postgraduate courses training new generations of ecologists; (3) Over the last decade, Brazilian ecologists organized the

Brazilian Association for Ecological Science and Conservation (ABECO in Portuguese acronym), and dedicated efforts to build two journals called *Oecologia Australis* and *Perspectives in Ecology and Conservation*. Despite all those efforts to improve scientific knowledge on ecology and conservation, we show here some evidence of governmental actions that deliberately have been ignoring the knowledge accumulated over the years by Brazilian ecologists, and have acted against environmental health based on science denialism, in close resemblance to the myth of Cassandra.

Over the last fourteen years, the scientific production in Ecology and Conservation flourished in Brazil (Fernandes *et al.* 2017), which recently achieved the 13th position of the global ranking of scientific production according to the report of Clarivate Analytics (2018). This is the last report of Clarivate with cross-countries comparisons. The period evaluated in this report (between 2011 and 2016) reflects the increased science funding in the country, with a peak in 2013 (Fernandes *et al.* 2017). Furthermore, the citation impact of Brazilian scientific production in some fields of knowledge, such as environment/ecology, approaches to the world average, which indicates the potential of Brazil to emerge as leader in the production of ecological knowledge (Clarivate Analytics 2018). An additional effect of the scientific maturity of Brazilian ecologists was the establishment of two networks: i) Long-term Ecological Research to answer ecological question that deserve large temporal dataset, and ii) a Biodiversity Research Network Program, with focus on biological monitoring (Brito *et al.* 2020, Bergallo *et al.* 2021, Rosa *et al.* 2021,)

Nowadays the Brazilian graduate system harbors 44 graduate courses in Ecology, Ecology and Conservation, and Ecology and Evolution, which are distributed across all Brazilian States, with strong expansion over the last 20 years. For example, between 1996 and 2014 the system of graduate courses had a three-fold increase in the number of PhD courses, and six-fold in the number of PhD titles (Fernandes *et al.* 2017). The investment of Brazilian government in the recent past allowed the expansion of graduate courses, preparing future professionals to act in universities, governmental agencies, and

non-governmental organizations. Since most scientific production comes from universities, the investment in graduate programs explains the increase in scientific production in the country.

The third point explored here is that over the last decade, Brazilian ecologists organized the Brazilian Association for Ecological Science and Conservation (ABECO in Portuguese acronym). In 2005, during the Forum of Coordinators of Graduate Programs in Ecology and the Environment, the need to bring together ecological science professionals working in different graduate courses in Brazil was discussed, both to facilitate communication within the community and to address the need for greater inclusion of ecological issues in society in general and government agencies.. Two journals have been built, called *Oecologia Australis* (formerly named *Oecologia Brasiliensis*) and *Perspectives in Ecology and Conservation* (formerly named *Natureza & Conservação*).

The former was launched in 1995 with a clear objective to publish papers on ecological science, and also environment science (e.g. Environmental education and Environmental management), and it is an official journal of the ABECO since 2020. *Oecologia Australis* publish papers of opinions, original research, revisions and short notes. Also, this journal every year has special issues, on a myriad of themes in ecological science, such as: Ecology of Fishes in Streams; PELD: Long-Term Ecological Research in Brazil; Ecology of Wetlands; Survey, Ecology and Species Management in Protected Areas; Ecology and Evolution of Interactions; Macroecology and Geographical Ecology; Ecology of Parasites and Vectors; Behavioral Ecology; “Campos de Altitude”, and many others. In essence, *Oecologia Australis* is a journal for ecologists to publish since their original results on ecological and correlates themes (e.g. adaptative evolution – Diniz-Filho *et al.* 2018) up to opinion as for example new approaches for long-term studies (Vieira 2020). Besides this, *Oecologia Australis* publish reviews with scientific production on ecological themes and correlates, such as biological conservation (Grelle *et al.* 2009), climate change (Scarano *et al.* 2016), animal-plant interactions (Calixto *et al.* 2018), and macroecology (Weber 2018) among other themes.

*Perspective in Ecology and Conservation* was launched in 2003 and comprises another official journal of the ABECO since 2010. This journal has the “main purpose of communicating new research and advances to different actors of society, including researchers, conservationists, practitioners, and policymakers”. In fact, many papers show clear potential to help in science-policy interface (Fernandes *et al.* 2017, Crouzeilles *et al.* 2019, Dobrovolski *et al.* 2018, Metzger *et al.* 2019).

We have shown above evidence that demonstrates the potential role of Brazilian ecologists in helping to define public strategies for conservation of biodiversity and resource managements. For instance, the synthesis published by Brazilian Platform for Biodiversity and Ecosystem Services (BPBES) with analyses for all Brazilian Biomes (Joly *et al.* 2019). It is important to note that Brazil is the only country with analyses following IPBES protocol (IPBES 2019). Thus, Brazil, as well as the rest of the world, would benefit from building a bridge between ecologists and decision makers, which would bring new opportunities to advance in best practices for resource management and biodiversity conservation.

However, the scientific knowledge accumulated over the years has been recently ignored by Brazilian authorities. After a period of constant increase in governmental budgets of science in Brazil between 2006 and 2014, there was a drastic and progressive cut-off in total amount from 2015 to nowadays (Fernandes *et al.* 2017, Escobar 2019). Cuts in the budget to development of science in environmental/ecology area and the erosion of postgraduate programs funding can prevent studies aiming to understand urgent problems that challenge our society. This hinders the proposition of solutions to minimize problems as the accelerated loss of biodiversity and its consequences (Overbeck *et al.* 2018), as well to international commitments of Brazil with development goals and National Determined Contribution (Fernandes *et al.* 2017, Dobrovolski *et al.* 2018). In addition to this cut-off in budgets, the present Brazilian federal govern is dismantling environment laws and social-environmental policies, censoring scientific publications, and is promoting a politic of instability that jeopardize

the governance of all the environmental sectors in the country (Petorelli *et al.* 2019, Levis *et al.* 2020). In opposition to world's efforts, the Brazilian government is promoting fire, mining and illegal occupation on public lands in the Amazon Forest, with drastic ecological and socioeconomic consequences (Mortara *et al.* 2020, Siqueira-Gay & Sánchez 2021), and in complete denial of the great advantages of a socio-ecological agenda (Strassburg 2019). The option of going against all scientific evidence is dramatic, especially in a megadiverse country.

Unfortunately, the Brazilian version of the myth of Cassandra, in specific case of Ecology, is helping to increase biodiversity loss and weakening our capacity to environment monitoring, with cascade effects for socio-ecological systems and a myriad of consequences. This scenario is worse with the current pandemic and, besides the discredit, Brazilian ecologists are contributing and leading papers on epidemiological models to understand some diseases (Ferreira *et al.* 2021, Prist *et al.* 2017) and the spread of COVID-19 that has been killing thousands of people (Pequeno *et al.* 2020, Ribeiro *et al.* 2020). However, unlike Cassandra, Brazilian ecologists will not remain cursed forever. We keep holding our position to help shaping a better future.

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