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ENVIRONMENT, ANTHROPOCENE, AND DISEASES: (RE)OPENING, PANDORA'S BOX

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Abstract

Human activities have caused environmental changes on a planetary scale, not yet fully known by science. This fact has led to new proposals for temporal periodization, establishment, and maintenance of biotic elements suggested as a possibility to better represent these dynamics, replacing concepts still traditionally used. This study aimed to make a theoretical reflection on the environment from these conceptual proposals, applying them to the emergence of the COVID-19 pandemic. For this, national and international articles were consulted and critically analyzed. The results indicate the domination of a world increasingly transformed by society, where crises that threaten humanity have been established, demanding new integrated forms of relationship, management, and use of resources of what we traditionally call nature, both in environmentally protected areas and productive rural areas and cities. The world population is increasingly concentrated, especially in underdeveloped countries in tropical zones, where high social inequalities and the expansion of economic activities to areas that concentrate a large part of the planet's biodiversity, still largely unknown, favor the emergence of new diseases.

Keywords: Time scale; Anthromes; Virus.

AMBIENTE, ANTROPOCENO E ENFERMIDADES: (RE) ABRINDO A CAIXA DE PANDORA

Resumo

As atividades humanas têm provocado modificações ambientais em escala planetária, ainda não totalmente conhecidas pela Ciência, fazendo com que novas propostas de periodização temporal, estabelecimento e manutenção dos elementos bióticos sejam sugeridas como possibilidade de melhor representarem essas dinâmicas, em substituição aos conceitos ainda tradicionalmente utilizados. Esse artigo tem o objetivo de fazer uma reflexão teórica sobre o Meio Ambiente, a partir dessas propostas conceituais, aplicando-as a emergência da pandemia da COVID-19. Para tanto, foram consultados artigos nacionais e internacionais, sobre os quais realizamos uma análise crítica. Os resultados indicam o domínio de um mundo cada vez mais transformado pela Sociedade, onde se estabeleceram crises que em muito ameaçam a humanidade, exigindo novas formas integradas de relacionamento, gestão e uso dos recursos do que tradicionalmente denominamos de Natureza, tanto nas áreas protegidas ambientalmente, como nas áreas produtivas da zona rural e nas cidades. Cada vez mais a população mundial está concentrada, especialmente nos países subdesenvolvidos das zonas tropicais, onde elevadas desigualdades sociais e a expansão das atividades econômicas para as áreas que concentram grande parte da biodiversidade do planeta, ainda em muito desconhecida, estabelecem uma situação que favorece o surgimento de novas enfermidades.

Palavras-chave: Escala temporal; Antromas; Vírus.

MEDIO AMBIENTE, ANTROPOCENO Y ENFERMEDADES: (RE)ABRIENDO LA CAJA DE PANDORA

Resumen

Las actividades humanas han provocado cambios ambientales a escala planetaria, aún no completamente conocidos por la Ciencia, lo que ha sugerido nuevas propuestas para la periodización temporal, el establecimiento y el mantenimiento de elementos bióticos como una posibilidad para representar mejor estas dinámicas, reemplazando los conceptos que todavía se usan tradicionalmente. Este artículo tiene como objetivo hacer una reflexión teórica sobre el Medio Ambiente, a partir de estas propuestas conceptuales, aplicándolas al surgimiento de la pandemia de COVID-19. Para ello, se consultaron artículos nacionales e internacionales, sobre los cuales realizamos un análisis crítico. Los resultados indican la dominación de un mundo cada vez más transformado por la Sociedad, donde se han establecido crisis que amenazan mucho a la humanidad, exigiendo nuevas formas integradas de relación, gestión y uso de recursos de lo que tradicionalmente llamamos Naturaleza, tanto en áreas protegidas ambientalmente, como en las áreas productivas de la zona rural y en las ciudades. La población mundial está cada vez más concentrada, especialmente en los países subdesarrollados de las zonas tropicales, donde las altas desigualdades sociales y la expansión de las actividades económicas a las áreas que concentran la mayor parte de la biodiversidad del planeta, aún desconocida en gran medida, establece una situación que favorece la aparición de nuevas enfermedades.

Palabras-clave: Escala de tiempo; Anthromes; Virus.

1. INTRODUCTION

According to Greek mythology, in its most popular version, Pandora was the first woman to exist on Earth, who married the Titan Epimetheus. Moved by curiosity, she opened a box given as a wedding gift by Zeus, which was a trap to punish men for having learned to control fire, previously known only to the gods, containing all ills of the world, including diseases, which have since then afflicted humanity (BRANDÃO, 1991).

The new coronavirus (COVID-19) has been the target of attention in the world, due to impacts on public health and economy, in addition to the resulting psychological effects, which were still measured superficially until the time this study was conducted. Thus, remembering such Greek myth seems pertinent as a metaphor to open a discussion on several human activities, which directly or indirectly have modified the environment, causing a series of consequences, such as the emergence of new diseases, incurable so far.

These issues are justified since most of the discussions on the relationship between society and nature, particularly those involving Environmental Sciences, have little related the environmental theme to the diseases that have affected humanity throughout history. Even when such discussions occur, they are generalized and almost nonexistent when considering emerging themes related to a new proposal for the periodization of the Earth's history and biological units, whose establishment is mainly the responsibility of the human species. In this sense, this study aimed to conduct a literature review, reflecting on human activities in the environment and their consequences, emphasizing the emergence and spread of disease-causing germs such as COVID-19, based on the concepts of Anthropocene and anthromes.

2. ENVIRONMENT AND ANTHROPOCENE

According to Schama (1996), the landscape is culture before being nature, which extrapolates materiality, adding a psychological dimension to this category of analysis. Therefore, in addition to what is before our eyes, the landscape can also be conceived as a mental construction.

In the same line of thought as Shama (1996), Turner (1990) emphasizes that, at the time of indigenous dominance in the United States, various native people appropriated the landscape in a symbolic sense. In this case, regarding the tribes that inhabited the Great Plains region in that country, the author points out that:

> Thus, the whole landscape had a spiritual life, a mental fact that indigenous children learned early on. Standing Bear recalls that still small, children began to see that wisdom was everywhere and that they had a lot to learn. Nothing in this world was empty. Even in the sky, there were no empty places. Life existed everywhere, visible and invisible, and each object had something important, which we should also have – even stones (TURNER, 1990, p. 262 – 263).

In this way, both authors lead us to understand a different type of relationship with the Earth, linked to religious beliefs, myth, and imagery, i.e., the culture. This mental construction of landscape possession by humanity would not leave visible marks in terrestrial space, but this is part of it, which greatly influences or even determines our actions, both from people considered "primitive" and those considered "civilized".

These initial words are necessary to understand that the development of our methodological frameworks in science is based not only on technical conceptions about the object to be studied, but it is also subjected to our worldviews. This fact, from a philosophical point of view, is fundamental for us to continue the discussions that directly involve, among other issues, the emergence of new concepts.

Society's relationship with what we call nature is one of the most important theoretical and technical issues in science. In this context, man, biotic and abiotic elements have established connections for thousands of years such as the selection and domestication of plants and animals, which result from a long period of interactions between different species and human groups. From the 1980s, more evident, with the appearance of genetically modified organisms, this initial phase was overcome and the artificial production of new species began (FIGUEIRÓ, 2015). Thus, what is traditionally conceived as nature was expanded, accompanied by new challenges in the analysis of relationships between this category and society, discussed as an environmental issue, or simply Environment, on a world scale.

From temporal demarcation, the term "Anthropocene" was created to designate a time when the effects of humanity would be affecting the whole system of our planet. This discussion, in

principle, was popularized by Crutzen (2002), who won the Nobel Prize in Chemistry in 1995, from a series of publications. Initially, this term was related to climate change and gradually started to incorporate other components of the system (PONTE; SZLAFSZTEIN, 2019), highlighting man as the main determinant of the dynamics on Earth, which were traditionally considered as resulting from natural processes.

Climate change is still the target of skepticism in part of the world, including by some country leaders and even some scientists, which generally calling into question the real capacity of climate models to make predictions of such process. However, Hausfather *et al*. (2020) recently show the reliability of climate models, published between 1970 and 2007, in the projection of future changes in the global surface mean temperature, not yet counting on the technological and forecast level, currently available. Most of the models analyzed by these authors showed warming consistent with observations made in the field.

From the geomorphological point of view, Wilkinson (2005) argues that in some period in the last part of the first millennium A.D., human beings became the main erosion agents in the world, causing more significant changes than the sum of all-natural processes on Earth. This was observed in the United States, for example, where, according to Pimentel *et al.* (1995), Pimentel *et al.* (1999), and the United States Department of Agriculture (USDA 1994), soil loss rates in cultivated lands exceed soil formation by more than an order of magnitude.

In this context, regarding river dynamics, Nienhuis *et al*. (2020) recorded that 11,000 deltas analyzed worldwide had an increase of 12,000 km² of sediments, in the last 30 years, and 25% of this material was attributed to the increased river sediment supply induced by deforestation, even with the increase in sea level.

According to Turner (1990) and Crutzen (2002), almost all systems on Earth have been significantly altered by humans, particularly in the last 300 years, thus indicating the emergence of the Anthropocene. Therefore, it is understood there is practically no more wild nature to be found, only environments at different levels of human interaction (CRONON, 1996). This implies that the current and future state of the biosphere depends on and will be determined by human systems (ELLIS, 2011).

From the above, it is clear that there is still no consensus on the beginning of the Anthropocene. Nevertheless, Ellis (2011) proposes three main stages, as follow:

I- Paleolithic (between 2.5 Ma and 10,500 years B.C.), when human species began to occupy a large part of the planet and, through hunting, extractivism, and fire began to modify ecosystems, contributing to the extinction of species, particularly the megafauna;

II- Neolithic (between 10,000 B.C. and 1,800 A.D.), when plants and animals were domesticated and the human population expanded, replacing native ecosystems with anthropized ecosystems;

III- Industrial (18th century), from the use of fossil energy, the nitrogen industrial synthesis, and genetics.

It is noteworthy that, although the Anthropocene has not yet been formalized on a geological scale and despite the possibility of its non-formalization, the widespread popularity of this concept implies an unquestionable paradigm shift (ELLIS, 2017), resulting from the attempt to interpret a world in constant changes and, through these new understandings, bring solutions to several problems from more realistic scientific bases.

Considering there will be no officialization of the term, even so, currently, and increasingly in the future, ecosystems will have their processes and forms dominated by anthropogenic activities, although, for some authors, this has been occurring for thousands of years, intentionally or not (DEARING *et al.*, 2006; ELLIS *et al.*, 2009). Thus, climate and other geophysical and biotic factors, even though they continue to influence ecosystems, their actions will be increasingly secondary, surpassed in importance by the type, intensity, and duration of human interactions in environments (HOBBS *et al.*, 2006; ELLIS; RAMANKUTTY, 2008).

This is the basis for the creation of another new concept, called by Ellis and Ramankutty (2008) as anthropogenic biomes or "anthromes". These authors defend that human species is a force of nature that rivals the geological forces in the development of the terrestrial biosphere and its processes. Similar to the Anthropocene, the concept of anthrome has not yet been formalized in science; however, it has also been known more and more inside and outside scientific circles.

In short, these concepts give the idea that one lives in a world where human activities modified and have been modifying the whole originally dominant natural system, establishing a time frame on a geological scale, called Anthropocene, in which primitive nature is rare or perhaps nonexistent, increasingly replacing what was originally conceived as biome, where society is absent in the process of establishing and maintaining biotic elements, by the concept of anthrome.

Both proposals, by combining natural and social forces, end up constituting themselves as interpretations of a hybrid world, since they designate the dominance of processes that are neither entirely natural nor entirely human (DEARING *et al.*, 2015; MINOR *et al.*, 2019), establishing systems and dynamics that express this reality.

By synthesizing these new interpretations of the world, through a combination of agents, actions, and times considered originally separated, Morin (2012, p. 37) explains that "…Today, a common time synchronizes the different times. Multiple bio-anthropo-cultural entanglements constitute the first emergencies of a humanity whose "diasporized" fragments "come together"...".

Concerning the biotic elements in this hybrid world, regarding the fauna in the Anthropocene, Barnosky *et al.* (2011), Dirzo *et al.* (2014), and Ceballos *et al.* (2017) argue that human beings have caused a wave of elimination and declines in local populations similar to the five previous mass extinctions in Earth's history. This process, named biological annihilation by the above-mentioned authors, has caused direct impacts on the functions of ecosystems and their services, in particular insect pollination (necessary for 75% of all food crops in the world), agricultural pest control, water quality, human health (due to changes in the abundance, behavior, and effectiveness of pathogens), and evolutionary patterns of species (DIRZO *et al.* 2014). Moreover, there are also stratigraphic records corroborating these changes throughout the world (ELLIS, 2018).

According to Ellis *et al.* (2012), anthropogenic plant communities are increasingly globalized, characterized by reduced native richness. However, they are enriched in species, on a regional landscape scale, by exotic plants globally extracted

from a relatively small group of species that tolerate or benefit from new habitats created by human residences and land use (MCKINNEY; LOCKWOOD, 1999; HOBBS *et al.*, 2009). This means an establishment and mastery of new realities still little known as for their consequences, which constitutes a new challenge for science.

Mcneely (1994), ratifying these two new concepts and applying them to vegetation, considers that forest biodiversity results from complex interactions between abiotic, biotic, and social forces, observed over time, which are influenced by various types of cycles, where human activities play a fundamental role. This author cites fire, agricultural technology, and trade as powerful influences on forests, with highly significant effects, resulting in the formation of landscapes characterized by a mosaic of habitat patches in continuous mutation, varying in size, shape, and arrangement, in addition to the number and variety of species, managed or not by society.

For Grime (1979), due to land use by humans, plant biodiversity is higher in unproductive and poor soils than in fertile and productive soils; a pattern found worldwide. In this case, these regions will not be able to support the growth of commercial agriculture without the intensive use of chemical inputs. This has become more and more frequent, to the point that agricultural activities become almost independent of soil fertility, also leading to the introduction of exotic species in these remnants (KUEFFER, 2017), creating new dynamics.

Furthermore, these lands, initially marginal for more intense productive processes, have not only been used for the development of agriculture and extractivism by human populations, but also for recreational and residential activities, which further contributes to eliminating the remaining natural biodiversity in these areas (HUSTON, 1993; HUSTON, 2005), although their occupation for these latter activities is, in many cases, based on the idea of a remnant of primitive nature, which can be used by people who have the capital to do so.

Returning to the initial discussion on immateriality and possession of the landscape, it is observed an example of social construction or imagined reality based on a belief shared by many people (HARARI, 2018), according to which, in the context of our discussions, there would be, if not an untouched nature, something very close to this, where happiness would be found, capable of being purchased.

In a kind of counterpoint to the idea of a still virgin nature, Ellis (2018) argues that, even in regions where human influence is apparently null or absent today, paleoecological pieces of evidence have shown that their landscapes, in their ecological patterns and processes, were established by human societies that had previously colonized such regions, leaving their marks (not necessarily visible at first glance) in the current landscapes.

This is the case of the Amazon, which is still considered by the scientific community and mainly in the popular imagination as a remnant of a primitive nature, where it has recently been discovered that human activities have historically played a decisive role in the development and maintenance of hybrid areas. This fact was proved by Levis *et al*. (2017), in research involving botany and archeology, showing that at least 85 species of trees found in that forest resulted from the domestication by pre-Columbian peoples, who managed to live in that environment for thousands of years, modifying soils and, in contrast to unmanaged lands, providing some areas with high artificial fertility, which are currently still used by many peoples who inhabit such regions (JUNQUEIRA *et al*., 2010).

Also in the Amazon, Lombardo *et al*. (2020) recently found, in savanna areas, traces of several cultivated agricultural products and that, around 10,350 years (BP), indigenous peoples built thousands of artificial forest islands in seasonally flooded areas, which are an important part of the landscape, including because they play a fundamental role in the conservation of several native species.

Even with the examples highlighted above, changes caused by human activities are not always positive. According to Prigogine (1996), systems can self-develop in response to changes, which is corroborated by Lovelock (2001), who emphasizes that, if man manages to modify the environment in a sensitive way, the resulting new organization may not necessarily be beneficial to our species, establishing a degradation problem difficult to solve.

Morse *et al*. (2014) report that the main characteristics of these new ecosystems are: (1) human-induced changes, (2) presence of new assemblages of species and abiotic conditions, (3) non-dependence on continuous human intervention for their maintenance, and (4) presence of practically irreversible ecological thresholds.

Ratifying the last above-mentioned characteristic, a current ability to manage these new systems or restore them to a condition closer to the original historical one is still largely unknown (HOBBS *et al*., 2009). In this case, the decision on how much will be invested in the conservation and restoration of these environments will depend mainly on changes in cultural values and priorities for subsistence (HOBBS *et al*., 2009). Therefore, as humans have been increasingly operating as a force that affects and transforms the whole Earth, to the detriment of non-human nature and, in many cases, humanity itself, Ellis (2018) asks: What can we do about it? Who is responsible? Who should act? We will try to answer these questions later.

Regarding vegetation cover in the world, Rodney *et al*. (2015) report that there was little change, between 1990 and 2015, in areas of original occurrence of boreal, temperate, and subtropical forests, and that they even expanded in Europe, North America, Caribbean, Far East, and Central-West Asia, different from what was observed in tropical forests of Central America, South America, South and Southeast Asia, and Africa.

Rodney *et al*. (2015) also highlight that the definitions of remote sensing application methods for the quantification of vegetation cover worldwide are still a challenge. Even so, these authors identified that the overall annual rate of vegetation loss (natural and planted), in the world, decreased from 7.3 in the 1990s to 3.3 million hectares between 2010 and 2015. They also observed that, between 1990 and 2015, the total area of natural vegetation decreased, whereas planted forests increased. On the other hand, from 2010 to 2015, the area of natural tropical forest decreased at a rate of 5.5 million hectares, whereas the area of temperate forest expanded at a rate of 2.2 million hectares.

In both cases, the overall result can be considered negative because, if there was a decrease in the loss of vegetation in temperate regions, this was due to reforestation, in which exotic species are used, either for environmental or commercial purposes. In tropical forests, this is even worse because, in

addition to losing area, they have been replaced with plantations of exotic species for commercial purposes, which is also corroborated by Sloan and Sayer (2015), who point out that the demand for industrial wood and firewood has increased 35% in these regions since 1990, especially in the poorest countries, with a prospect of increased demand in the future, mainly in the Asia-Pacific region.

Ellis *et al*. (2012) believe it is still possible to maintain the majority of native plant species in anthromes enriched with exotic species, which now comprise most of the terrestrial biosphere, as long as the anthropogenic ecological succession is redirected to maintain native plant species as part of multifunctional land management strategies, which is also defended by Kareiva *et al*. (2007) and Goddard *et al*. (2010). For science, the challenge will be to advance the understanding of how native species can be conserved in the new plant communities developed and supported by human systems in most of the terrestrial biosphere of the Anthropocene (Goddard *et al.*, 2010; Ellis, 2011).

Faced with this increasingly visible reality, Turner (1990, p. 239) argues that "We live in a land transfigured by our demands. It seems unbelievable that North America was not long ago a place without scars, of enormous beauty and fertility, where the human hand had dark skin, was aboriginal, and limited by myths".

Harari (2018) also leads us to an important reflection on this scenario:

> …Gods on our own merit, relying only on the laws of physics to keep us company, we answer to no one. Consequently, we are destroying other animals and the ecosystem around us, aiming at not much more than our own comfort and fun, but never finding satisfaction. Is there anything more dangerous than dissatisfied and irresponsible gods who don't know what they want? (HARARI, 2018, p. 556)."

3. GERMS, DISEASES, AND THEIR RELATIONSHIP WITH THE HISTORY OF HUMANITY

According to Diamond (2002), the main diseases that affect human beings (e.g. measles, tuberculosis, and influenza.) developed from the advent of agriculture, as it caused the populations to become denser and, because of this, they are named as "crowd diseases", which evolved from illnesses similar to those that have affected domesticated animals, since 10,000 years BP.

Crosby (2011) reports that farmers and villagers, from the first large human settlements in the Old World, unintentionally ended up cultivating many of the villains of the animal world, because when the nomadic lifestyle was replaced with the sedentary lifestyle, due to agriculture and increasing domestication of various animals, led to the emergence of pests, which entered into direct competition for the food produced and stored to meet the needs of people and herds, now in abundance, and consequently bringing their diseases, which found fertile ground to multiply due to population concentration.

The viruses circulated among humans and cattle, causing, for example, one moment human smallpox, the next bovine smallpox. Dogs, bovines, and humans, in turn, when exchanging or combining different viruses led to the emergence of three new diseases, one for each species: distemper, rinderpest, and measles, respectively. From the contact of humans, pigs, horses, and domesticated birds with wild birds, we acquired the flu, producing effects that pass from one to the other (CROSBY, 2011).

All of this was extended to other parts of the world as long-distance trade and invasions of other lands occurred, leading, in parallel with the cultivation and rearing of new species of plants and animals, to the development of new diseases and their mutations (CROSBY, 2011). This resulted not only from the increase in the number of people living together and their closer contact with other living beings but also as a result of intense changes in the original ecosystems.

Human history is full of examples in which viral diseases spread rapidly, causing the death of thousands to millions of people, such as the Black Death in Europe, in the 14th century, and Ebola, between the end of the 20th and beginning of the 21st century.

In a pioneering study on the identification of risk factors for the development of diseases in humans, Taylor *et al*. (2001) found 1,415 species of infectious organisms known to be pathogenic to man. Eight hundred and sixty-eight of them (61% of the total) can be transmitted between humans and animals and 175 are associated with diseases considered "emerging".

In this context, tropical regions with a more recent rate of deforestation, due to their high biodiversity, still unknown, and because they have undergone intense changes in land use, are highly imbalanced, have the highest risk of zoonoses, and are directly related to emerging diseases, such as in the case of the Amazon, as several scientists have been warning (KEESING *et al.*, 2010; ALLEN *et al.*, 2017; NAVA *et al.*, 2017).

Vilela *et al*. (2020) foresee that more than 10,000 km of roads will be built or improved throughout the Amazon, from the implementation of 75 road projects in South America, in the next five years. This will probably increase employment opportunities, reduce transport costs, and support regional development; however, this process will also, directly, and indirectly, increase deforestation, causing intense changes in vegetation cover, in addition to creating vectors for the occurrence of new human diseases.

Therefore, based on the above, the main biodiversity hotspots also correspond to "hotspots" of potential diseases, which may affect human populations as soon as these environments are intensely altered and more people begin to inhabit them.

It is worth mentioning that, according to a recent study by researchers from universities in the United States, Australia, and the United Kingdom (ANDERSEN *et al*., 2020), the new coronavirus is the result of natural evolution and have a molecular structure similar to those of already known viruses, which affect bats and pangolins, evolving in one of these animals and being transmitted to humans. Therefore, several conspiracy theories on this global problem are discarded, although they are very popular on social networks, where fake news about this pandemic have been increasingly spreading.

In this case, the contact of wild animals with humans led to the dissemination of the virus, which evolved into a pandemic, given the ease and speed this virus infect humans, as well as the circulation of people around the world. Based on what has already been said here, the history of humanity is full of examples in which certain diseases spread very quickly, contaminated, and

caused the death of many people; however, for the first time, it is observed a worldwide spread, which may establish a historical landmark concerning a new global reality from now on.

Rohr *et al*. (2019) made a direct link between infectious diseases, population growth, and food production. According to them, until 2100, uses of antibiotics, pesticides, fertilizers, and water should be expanded to feed an estimated population of 11 billion people, which will increase the contact between humans and wild and domestic animals, favoring the spread of infectious agents. These possibilities become worrying, especially when focusing on underdeveloped countries, which, in addition to the increasing changes in rural and forest areas, have been undergoing a rapid process of population concentration in cities.

Also in this line of reasoning, Ahmed *et al*. (2019) explain that the increase in urbanization in underdeveloped countries leads to several epidemiological and nutritional challenges, as the intensification in the movement of people, food, and commerce provides favorable bases for the emergence of infectious diseases, including zoonoses, particularly when related to poverty and social inequalities in cities.

Some data indicate that, if the world's urban population was 55% in 2018, projections made for 2050 show an increase to 65%, and about of 90% of this growth will be recorded in Asia and Africa (UN DESA, 2018; AHMED *et al*., 2019). This implies challenges in food security and, consequently, the need to replace traditional agricultural practices with more intensive systems for food production. Therefore, in addition to technical change, this will imply direct spatial effects, because areas, where low environmental impact agriculture is still practiced, will increasingly be used for production more dependent on external artificial inputs, which modify more intensively the patterns of originally dominant environmental systems, in addition to causing environmental fragmentation in forest remnants.

Concerning the latter case above-mentioned, Alirol *et al*. (2011) found that, due to the destruction of forests in Cambodia, Thailand, India, Bangladesh, and Madagascar, many species of fruit-eating bats got closer to urban areas, resulting in more contact of these animals with people and domestic animals, which caused outbreaks of infection with Nipah virus.

Goldberg *et al.* (2008), Reisen (2010), and Hassel *et al.* (2017) made the same explanation for several new diseases, claiming that, when using natural landscapes to expand agricultural lands and settlements, ecotonal areas are created, where human influences may alter niches of pathogens and favor an increased contact of people with vectors and reservoir hosts (wild or domestic animals), which are attracted by the availability of food, increasing the possibility of transmission; a fact also observed in urban areas, in their contact with peri-urban rural areas (HASSEL *et al*., 2017).

The European Commission data on world urbanization (https://ec.europa.eu/knowledge4policy/foresight/topic/continuing-urbanisation/worldwide-urban-population-growth_en) are worrying and serve as a basis for some action. In this context, it is observed that:

• The world's urban population is expected to increase from 55% in 2018 (about 4.2 billion people) to 68% by 2050;

• By 2100, about 85% of the world's population will live in cities, which will account for approximately 9 billion people;

• The most urbanized regions in 2018 were: North America (82%), Latin America and the Caribbean (81%), Europe (74%), and Oceania (68%). Asia has about 50% urbanization and 54% of the world's urban population. Africa, with the urbanization of 43%, represents 13% of the world's urban population;

• The level of urbanization in Europe is expected to increase from the current 74% to around 75% in 2020, and 83.7% in 2050;

• The urban population increases considerably faster in developing regions. Africa is expected to be the fastest urbanizing region in the world, with rates ranging from 43.5% in 2020 to 59% in 2050;

• Most of the 43 megacities, with more than 10 million people projected by 2030, will be in developing regions;

• By 2025, China will have more than 220 cities with a population of over 1 million, and 8 megacities with more than 10 million people;

• About 50% of the world's urban inhabitants live in settlements with less than 500,000 people. By 2050, the number of urban residents will probably increase by an additional 416 million in India, 255 million in China, and 189 million in Nigeria.

4. WHAT TRACK CAN WE FOLLOW?

Concerning the occurrence of diseases due to changes in ecosystems, Diamond (2002) asks what can be done to ensure that agriculture only guarantees our happiness. This question, of course, can be extended beyond the primary sector of the economy and also to increasingly urban lifestyles, although this only increases the challenge of finding answers.

Even though the situation is increasingly worrying and difficult to resolve, we agree with Ellis (2018) when he says there are better and worse Anthropocenes, with a chance of building a better future, depending on what humanity, as the main force that creates and maintain systems, comes to decide.

Among so many alternatives indicated by science, some of them, if do not fully ensure our happiness, will probably at least mitigate the consequences caused by our environmental abuses, with sufficient knowledge by researchers to be suggested as viable technical alternatives.

Beginning with the discussion on conservation units, despite being well managed, as defended by Kremen and Merenlerder (2018), their establishment is not sufficient, although fundamental for the survival of remnants of the original biodiversity. There are also political, economic, and physical limiting factors, in addition to the fact that many specimens, particularly animals, do not necessarily live confined to these units, exceeding their borders at least occasionally. In this case, in parallel to these areas, it is necessary to undertake management based on conservationist attitudes in lands used for the development of economic activities.

In cultivated land, 12% of the area, according to Ramankutty *et al*. (2008), should be used for diversified agricultural systems, using agroecological management which, in addition to promoting biophysical conditions and ecological interactions favorable to agricultural production, minimizes several negative environmental consequences related to simplified agriculture, maintaining crop yields and profitability, improving food security and means of subsistence of small farmers, of which 94% own lands of less than 5 ha (ALTIERI, 1999; RAMANKUTTY *et al*.,

2008; KREMEN; MILES, 2012; IPES – FOOD, 2016; LOWDER *et al*., 2016).

In large properties, some agroecological techniques can reduce the use of pesticides, resulting in similar or even higher profits when compared to chemically intensive agriculture (DAVIS *et al*., 2012). Furthermore, according to Gaudin *et al.* (2015) and Kremen and Merenlender (2018), the use of many agroecological techniques can maintain or increase yields, without necessarily increasing cultivated lands, which implies producing without expanding deforested areas.

Mcneely (1994) argues that the best way to maintain biodiversity in forest ecosystems is by combining protected areas, multiple-use areas managed by the local population, natural forests managed extensively for sustainable production of wood and other products and services, and forest plantations carried out intensively for producing firewood and cellulose. This diversity of areas with complementary uses may provide humanity with a range of options capable of establishing better sustainability and adaptation to cyclical changes that will continue to be recorded on Earth.

In the case of freshwater ecosystems, they are essential to maintain hydrological connectivity and biodiversity conservation, among other functions (KREMEN; MERENLENDER, 2018), both in rural and urban areas, which implies protecting these areas of a more intense economic use, paying special attention to riparian vegetation.

Moreover, measures to reduce the world population and consumption are very important. In the latter case, reducing food waste and the use of energy and water are essential (BONGAARTS; SINDING, 2009; SANDERSON; WALTSON; ROBINSON, 2018).

Otero *et al*. (2020) emphasize the need to review economic growth policies on a world scale, which are, in general, dissociated from biodiversity issues, in which social priorities would replace the dominant idea of economic growth in GDP. Also, many data show that, in addition to the increasing environmental damage, this model has led to more exclusion than inclusion of people, despite economic growth in countries such as the USA (OTERO *et al*., 2020).

In the case of urban areas, they have their complexity, given the most intense changes caused by human activities, with systems that still need to be more and better investigated and understood (FIGUEIRÓ, 2015).

Among the existing alternatives for the conservation of nature in urban environments, those described by Sukopp and Weiler (1986) and Sukopp and Henke (1989) stand out, besides the contributions made by Newman (2006) and Figueiró (2015):

• Optimize public green areas in private spaces, avoiding concentration in a few and large parks;

• Create connections between green areas, through ecological corridors;

• Reduce the density of urban constructions;

• Do not eliminate organic matter deposited in green areas, which is part of the food chain for fungi and various animals;

• Use native plants in green areas, enhancing their ecological functions;

• Keep some empty lots free of urban construction as areas of ecological recovery.

Special attention should be paid to the tourism sector worldwide, mainly to the so-called mass tourism, which has to be rethought. China, Italy, Spain, France, the United Kingdom, and the United States have been, to date, without obeying any order, the countries most affected by the new coronavirus, both in the number of infected people and deaths. All of them represent the destination of many tourists who come from within their own countries and mainly of those who are from outside their borders. These large clusters intensify traditional environmental problems (generation of waste, pollutants, water use, etc.) where they occur, and the possibility of spreading viruses, inside and outside visited countries, as shown by the statistics of this pandemic. Brazil also stands out for the high number of infected people and deaths from this disease; however, for reasons not linked to the tourism sector.

There is also a need to increase investment in scientific research, as many important countries have experienced retrenchment in this field, in the current world scenario, both because of economic and ideological reasons. Particularly in Brazil, the recent budget cuts for postgraduate courses and the decrease in the number of public notices to promote scientific research by the federal government, the main financier of this sector in the country, indicate a threat of incalculable short-, medium-, and long-term consequences for the whole nation.

Nor does it help, as has been proposed in some government discussions in Brazil, to benefit certain areas as a priority for this type of investment to the detriment of others. Science must be seen as a whole. Hierarchizing it is not a sensible attitude since the problems faced by society every day are varied, have different origins, and do not respect borders, especially the artificial ones.

5. FINAL CONSIDERATIONS

Today, we live in a moment of history to a certain extent similar to the period of political mistrust and discontent that generated the crisis of the 1960s in different regions of the world. This directly affects science, which has also been very questioned, whether due to the incomprehension of many people who do not understand that it is not a question of being completely sure of everything, or whether because academic knowledge does not benefit everyone, indistinctly, as defended by some enlightenment ideas. Even so, it seems science has never been needed as much as today and, if we find a cure or at least a relief for this pandemic and others that may come, we believe it will come from science.

In the Pandora myth, only hope remained inside the box. Some interpretations of this story lead us to understand hope as part of the evil inside the box, as it would make people imagine that they could control the future, remaining thus in a state of constant illusion (BRANDÃO, 1991). Digging deeper into this myth, another version explains that the box was actually an amphora, which was used to store grain and was filled only through effort and work (BRANDÃO, 1991). Therefore, its content symbolizes the human condition of working to find answers to our fears, creating other possibilities. Understanding this myth as a way of orienting ourselves in real life, we chose to believe in the second version of this ancient story.

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