Impact of climate warming on the global biosphere

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Abstract. The paper considers the interannual variability of the Living Planet Index (LPI) as a quantitative indicator that characterizes the degree of the global ecological crisis and reflects the general state of the global biosphere. The LPI dynamics since 1970 shows a more than twofold decrease in the number of populations of vertebrates. It is shown that such a decrease in LPI is mainly due to global climate warming. Thus, almost 80% of the LPI variability is accounted for by the global air temperature, and only the remaining 20% are associated with anthropogenic activity. A linear trend describes almost 94% of the LPI variability, and a non-linear trend describes 99%. From the linear trend equation it follows that in 2044 the LPI = 0. This means the onset of ecological collapse. However, it is more realistic that the linear decline of LPI ended, the stage of LPI stabilization in the range 0.30-0.40 began.

1. Introduction

It is quite obvious that rapid climate change and excessive human intervention in the natural habitat can lead to degradation and even irreversible consequences when its recovery slows down and then stops. Due to the imbalance, a rapid decline in biological diversity occurs, i.e. irreparable death of many animals and plants. An important condition for the existence of the biosphere is its diversity, which provides a continuous biochemical cycle of matter and energy flows, maintaining the connections of the atmosphere, lithosphere, hydrosphere, creating the integrity of the natural environment. It is biological diversity that provides stability to the system through many internal and external interconnections and interactions. The biosphere has a large set of feedback control processes and, as a consequence, a set of cyclic processes that allow it to compensate for changing conditions. However, the scale of human activity and the associated use of resources is growing so rapidly that the environment, which has always provided the conditions for our development and growth, is no longer able to compensate for the changing conditions and begins to collapse [1].

According to experts from the World Wildlife Fund (WWF), at present, the anthropogenic impact of human activity on nature is so great that it has come to its critical point. If the current rate of consumption of natural resources and the destruction of the biosphere is not reduced, then "by 2040 our planet will face a Global Ecological Crisis, which may call into question the survival of mankind" [1]. We are talking, first of all, about non-renewable energy resources, water and soil suitable for cultivation of crops. In our opinion, there is some confusion here. It is more correct to talk about a
possible global environmental disaster by 2040. An ecological catastrophe differs from an ecological crisis in that a crisis is a reversible state where a person acts as an active party, and a catastrophe is an irreversible phenomenon, which means the impossibility of returning the global ecosystem to natural conditions [2].

2. Methods and Materials
The ecological crisis should be understood as an imbalance between human society and its natural environment in all its diversity: land, water, forests, wildlife, air [2]. A very large number of people believe that the balance between human society and the natural environment has been violated, and for a long time and already on a global scale. In essence, this means that not only has a global ecological crisis (GEC) begun on our planet, but continues to develop intensively. This is an objective reality, given to us in "subjective sensations" and manifested primarily in what we call a deterioration in the quality of life, which is caused by a widespread deterioration in the quality of food, drinking water and its shortage, air pollution, especially in large cities [3].

It should also be noted that WWF experts clearly ignore the impact of rapid climate change on the global biosphere. However, it is climate change that may become the most important potential threat to biodiversity in the coming decades. There are several reasons why it is more difficult for plants and animals to adapt to global warming. One of them is the extremely rapid pace of change. Average global temperatures are expected to rise faster this century than at any other time in the planet's history, at least in the past 10,000 years. Many species simply will not be able to quickly enough adapt to new conditions or move to areas more suitable for their survival [4].

The Living Planet Index (LPI), which reflects the general state of the global biosphere and is calculated on the basis of collected data on the populations of vertebrates and the average dynamics of their numbers, can serve as a quantitative indicator characterizing the degree of the global ecological crisis. In fact, LPI reflects the ecological state of the planet. It is based on scientific data on the state of 14,152 populations of 3,706 vertebrate species (mammals, birds, reptiles, amphibians and fish) found throughout the world [1].

The purpose of this article is to study the interannual dynamics of the LPI, assess its possible changes in the coming decades, and identify the effect of global air temperature on the LPI.

3. Results and Discussion
The development of GEC leads to a rapid decline in biological diversity, i.e. irreparable death of many animals and plants. The average size of animal populations is showing an alarming downward trend. The LPI dynamics according to [3] from 1970 to 2012 indicates a 58% decrease in the average number of vertebrates (figure 1). Over a period of just over 40 years, the number of populations of vertebrates has more than halved. The available data indicate that the average rate of decline is about 2% per year, with no signs of slowing down yet. True, we must pay tribute that the goal set by the Convention on Biological Diversity [4] of reducing the LPI rate by 2010, in principle, has been achieved. During 2005-2012, biological diversity practically did not decrease [6-10].

Note that in figure 1, in addition to the interannual variation of the LPI, the interannual variation of the global air temperature anomalies (ΔGAT) [5] for the period 1970–2012 is given. It is easy to see that there is a pronounced negative relationship between these characteristics, which is characterized by the correlation coefficient r = 0.90. This means that 80% of the LPI variability is accounted for by the global air temperature, the remaining 20% are associated with anthropogenic activity.

Note that a linear trend describes almost 94% of the LPI variability, and a nonlinear trend describes 99%. Using the linear trend equation, it is easy to determine the year when the LPI will become zero. This is the year 2044, when ecological collapse may occur. From the trend equation for ΔGAT it follows that in 2044 ΔGAT = 1.11°C. Using the linear relationship between LPI and ΔGAT, it is easy to get that LPI = 0.04 in 2044. This is close to the previous estimate.
However, the implementation of such a scenario and the onset of ecological collapse in the 40s of this century seems to be still unlikely. Biodiversity provides the global biosphere system with sustainability through many internal and external interconnections and interactions, i.e. the ability to heal itself. The weakest organisms are dying out, the strong ones eventually adapt to new conditions. As seen from Fig. 1, the rate of LPI decline since 2004 has almost stopped, the global biosphere, apparently, is already adapting to climate change. This is evidenced by the estimate of the LPI according to the nonlinear trend, which in 2044 may be LPI = 0.34. With a high degree of probability, we can say that the linear decline in LPI has ended, the stage of LPI stabilization in the range of 0.30-0.40 has begun.

4. Conclusion

So, we can confidently assert that, despite the combined impact of global warming and anthropogenic activity on the global biosphere, ecological collapse is unlikely in the coming decades. It seems more likely that the beginning stage of LPI stabilization will continue in the range of 0.30-0.40.

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