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Saturation of biological diversity and human activity

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Abstract: Human beings constantly interfere with nature by means of their activity. Their role in shaping the current natural world is indisputable. The problem of saturation and unsaturation in nature conservation relates to the degree of genetic diversity, flora and fauna species and ecosystems, which are managed by humans. This paper makes an attempt at answering the question as to whether one can speak of saturation in terms of biological diversity. For this purpose the issues related to attempts at defining biological diversity are described. As a result, human impact on the surrounding natural environment is discussed. To illustrate the above issues, two cases of human interference in the natural environment, characterized by rich and poor biodiversity, are discussed.

Introduction

Can we say with any certainty that biological diversity may be saturated[2]? Of course not; especially when many ecosystems are not fully recognized. Furthermore, we do not know all the species living on the

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[2] Saturated, i.e. when abiotic components are fully used by the biotic nature.

Earth. *According to a fairly common belief, contemporary science knows only a small part of the plant and animal species in the world. Some state that the number of known species constitute about 10% of all the species in the world. Although a great number of species remain unknown too us, the number of those currently known ranges from 5 to 30 million. More than a half of these are found in tropical forests* (Wiąckowski 2008: 358). It is also true that we often do not know all the functions that the particular species known to us perform in the ecosystem. As a consequence, we do not have a complete picture of mutual interactions between different species. The result is that we also do not know all the consequences of the possible impoverishment of the ecosystem. Thus, we do not know all the causes of species extinction in the situation when human activity is not the direct cause.

We can only use simulation to predict the effects of flora and fauna impoverishment.

Contemporary trends in scientific research are related exactly to the causes and effects of the biodiversity decrease. Human impact on the natural environment is an important issue. We can consider indirect causes such as climate change, acid rains and the ozone hole expansion. Some of the examples of a direct impact of human interference on the biosphere are habitat fragmentation, reducing the surface of natural ecosystems or hunting animals.

Therefore, we can certainly discuss issues concerning unsaturated biological diversity. The focus of the discussion is the extent of responsibility and the impact of our interference related to biological diversity. The purpose of this article is an attempt at describing human impact on the natural environment and the consequences of human actions. Therefore, in the first part of the article the concept of biological diversity is introduced. This diversity can be seen through the prism of many aspects. The second part contains a description of the three levels of biodiversity. Then the reader's attention is directed to human activity and its influence on living organisms. As a result, natural consequences of human activity on the natural world are shown.

1. The concept of biological diversity

In the literature of the subject the term *biological diversity* is identified with *biotic diversity*, although the synonymous term *biodiversity* is more often used. Colloquially speaking, the meaning of this term is the diversity of organisms on all levels of nature organization. There are several applicable scientific and legal definitions of biological diversity. They are commonly known and included in regulations of international conventions.

The *Convention on Biological Diversity* defines this concept in the following way: *the diversity of all living organisms coming from, among others, terrestrial, marine and other aquatic ecosystems as well as ecological complexes of which they are part. This applies to the diversity within a species as well as between species and ecosystems* (A: art. 2). A considerably shorter definition can be found in the Polish legal act on the protection of nature: biological diversity – *diversity of ecosystem-inhabiting living organisms within a species and between species as well as diversity of ecosystems.* (B: art. 5 p. 16). On the other hand, in scientific literature we can encounter biologists' and naturalists' attempts at defining the concept of biological diversity. For example, E.O. Wilson writes that biodiversity *is the variety of organisms considered at all levels, from genetic variants belonging to the same species, through sets of species, genera, families and higher taxonomic units; it is also the diversity of ecosystems, which consist of groups of organisms living in particular habitats and of physical conditions prevailing there* (Wilson 1999: 49). According to M. Makomaska-Juchiewicz, the concept of biological diversity combines the concepts of nature conservation and sustainable development. Protection of biological diversity is to be closely related to sustainable use of biological diversity and is to be applied to the entire natural space used by people, rather than only to selected areas. This implies the necessity to reconcile the economic policy of the state with conservation of biological diversity. It also means that various economic sectors should cooperate in this field (Makomaska-Juchiewicz 2007: 55).

The above-mentioned attempts show that it is difficult to precisely define all living organisms, and thus the biosphere. For this reason, biological diversity is considered at three levels, namely genetic, species and ecosystem ones. These levels are interrelated and influence one another. It is impossible to consider one level in isolation from the others. It happens, however, that certain authors when writing about biological diversity issues concentrate only on the species level. This is so because the species level is the central and the best recognized level of diversity.

Biological diversity is also linked to the issue of determining the state of biosphere richness. The easiest way of measuring and estimating biodiversity is the determination of the number of species. Estimating biological diversity at the species level can often be erroneous, especially in the so-called apparent centers of biodiversity (Adamski 2007a: 48). This phenomenon can be observed in the areas located within the boundaries of several habitats (within the boundaries of an ecotone). Single species, occurring in borderland habitats, may live in such an ecotone.

2. Three levels of biological diversity

The above-mentioned division of biological diversity into three levels (genetic, species and ecosystem ones) according to the hierarchical pattern, is somewhat artificial, but to a large extent it allows us to capture the methodological differences in the undertaken studies depending on the level of biodiversity. This level also allows us to systematize the knowledge gained, which affects the transparency of the published study results.

The level of genetic biodiversity is an elementary level of biodiversity. It is the genetic diversity that forms the basis of species and ecosystem diversity. Before the introduction of precise research on molecular genetics, the genetic level was studied indirectly, e.g., by defining the number of subspecies within a particular species. Currently, in spite of the fact that it is possible to analyze this level precisely, genetic research is not carried out on a large scale. In the literature of the subject the

concept of genetic diversity is usually narrowed down to the analysis of the concept of a particular genus, species or population.

According to E. Symonides, in the case of flora and fauna, *with high probability one can expect continuous decline of genetic diversity in many wild species and even higher taxa* (Symonides 2007: 315). Genetic diversity and maintaining its proper value is very important as far as the stability of the biosphere is concerned. Decrease in diversity may have a negative impact on a population. This is so because decline in a gene pool means lower flexibility of the population's reactions to changes in the environment. In short, such a population is much less able to adapt to changes taking place in an ecosystem. Consequently, the longevity of such a population becomes reduced.

Another phenomenon associated with reducing a gene pool of a species is related to inbreeding depression. This phenomenon occurs in a small population in which closely related individuals begin to breed. However, it is noteworthy that the reduction of a gene pool also has positive consequences, which occur when the decrease in genetic diversity is a result of natural selection or other evolutionary processes. Problems may occur in the case of a sudden increase in a gene pool of a given population. Such a genetic variation may happen when the genetic material of the populations of the same species which were isolated from each other begin to mix.

The level of species diversity, in comparison to the remaining diversity levels, is a relatively well-recognized area of the biosphere as it constitutes the diversity of flora and fauna. For this reason, the term "species diversity" was used earlier in the literature of the subject than the term "biological diversity". This level is an efficient tool when it comes to the protection of nature. This is so mainly because of two factors. The first one, which was mentioned earlier, is connected with the state of our knowledge about particular species. Secondly, all changes in the composition of these species can usually be quickly and easily noticed.

It is worth remembering that there is geographical variation, which is manifested by species diversity. This phenomenon was described by

Wallace in 1787, but it is not fully explained. *There are three universal and very clearly visible tendencies: (1) the number of species is bigger in hot regions and decreases as we go from the equator towards the poles, (2) the number of species on land is larger than the number of species in seas and oceans, (3) the number of species decreases together with the increase of the height above mean sea level* (Weiner 2008: 309). These tendencies are true for both the total number of all the species on the Earth, as well as for particular taxonomic groups.

One of the difficulties related to estimating the level of biological diversity is the method of calculating it. It might seems that it is enough to add up all the species existing on the Earth but the percentage share of a particular species in relation to the others is also important. The measures currently in use take the frequency of particular species into account[3]. Natural valuation remains an unresolved issue. In a simple method of calculation, particular species are given the same value regardless whether they are common or rare. Therefore, it may happen that the environment, in which there are fewer species, will be more valuable in terms of quality than a similar environment with a larger number of species.

The last and at the same time the most general level is that of ecosystem diversity. In spite of its general character, it is most rarely described in scientific research. This is primarily due to the fact that there are some difficulties related to delineating clear-cut boundaries of individual ecosystems. It is impossible to precisely determine the place in which one ecosystem begins and the place in which the other one ends. Currently, it is also difficult to determine whether the ecosystems being described are natural or whether they are - and to what extent - of anthropogenic character.

In the case of the considerable diversity of ecosystems, the following justified question may arise: is the considerable biodiversity of ecosys-

[3] The Shannon-Wiener index $H' = - \Sigma p_i \log_2 p_i$ is commonly used. In this index p_i means the share of the individuals of the *i* species in the total number of individuals observed in a given area.

tems a positive phenomenon? In fact, in the case of a relatively small area the concentration of many different ecosystems is not always favorable to nature. Such areas, which are a result of human activity, lead to habitat fragmentation. In consequence, the demands of big animals needing large areas of forest complexes or big open areas become cut down.

3. Impact of human activity on biodiversity

Humans have always influenced the environment in which they lived. All their activities constitute interference in biological diversity. *The extinction of species is a natural element of life and immanent feature of evolutionary changes but when we speak of the extinction caused by humans we consider it a result of artificial interference in the rhythm and order of nature, despite the fact that humans are nature's integral component* (Głowaciński 2007: 40). Human beings, as living organisms, have achieved a great success by being able to survive in all natural circumstances (often by using technical solutions). Thus, in every place where humans appeared the local natural areas have been significantly changed.

Unfortunately, there are many threats to biodiversity, which result from human activity. The first of these, which should be mentioned, is the fact that people transfer with themselves – both consciously and unconsciously – species from their natural habitat to other new places. Such species, namely those which were brought to a new place, become alien species[4]. The natural factor, which limits the range of species spreading, are abiotic barriers such as seas, oceans, mountain ranges and big open spaces.

The probability of the occurrence of such obstacles which are difficult or impossible to cross increases together with the increase of the distance

[4] Currently the database on alien species in Poland is maintained by the Institute of Nature Conservation PAS in Kraków. This database is available on the website: http://www.iop.krakow.pl/ias/.

from the border of the current geographic range limit of the species to the border of the nearest area which can be colonized (Solarz 2007: 273). The migration of all plant and animal species increases together with the progress of civilization. *The intensified flow of people and products has resulted in the fact that apart from the intentional introductions of species the unintentional introductions has started to gain significance. Due to the development of quick means of transport, it is possible to transfer a species from its natural habitat to any place on the Earth in just a dozen or several dozen of hours* (Solarz 2007: 274). Thus, in the course of their travels, human beings can transport various species in an intentional or unintentional way. As history shows, humans have introduced known and domesticated animals, as well as useful plants to new places. At the same time, humans would take with themselves the specimen of animals and plants purely for esthetic and personal reasons (as souvenirs).

Thus, alien species are the organisms transferred beyond the area in which they naturally occur. Apart from adult individuals, this term applies also to juvenile forms of individuals (e.g., seeds, eggs, larvae) and their parts (e.g., rhizomes), thanks to which species can survive and reproduce. Therefore, the species are alien to the indigenous flora and fauna. As has already been mentioned, these organisms are transferred unintentionally, and sometimes deliberately, by humans. Alien species pose a threat to indigenous biodiversity as they exert a negative influence on ecosystems. Invasive alien species are particularly dangerous. They directly influence indigenous flora and fauna[5]. The simplest example of such an influence is feeding on the encountered plants and animals. A typical predator is the American mink (*Mustela vison*), which contributes to a significant decline in the number of wetland birds (Brzeziński, Romanowski 1996).

A dangerous herbivore feeding on Polish flora can be the muskrat (*Ondatra zibethicus*) – the number of muskrats in central Poland is

[5] Australian nature, in which humans have been deliberately and introducing alien species at various points in time, is a practical example of the consequences of alien species' invasion.

discussed by, among others e.g., Romanowski, Karpowicz 2013. A direct influence on biodiversity is also exerted by numerous parasites, such as Asian blood-sucking *Ashworthius sidemi,* which attacks a part of ungulates in Poland. *Ashworthius sidemi*, which belongs to the *Trichostrongylidae* family, being a typical parasite of the sika deer (*Cervus nippon)* was transferred to the red deer (*Cervus elaphus) and currently it is also found in European bisons (Bison bonasus) (*Demiaszkiewicz et al. 2008). The threat posed by these alien species may also consist in competing for a similar ecological niche, namely the access to food, water, light or breeding sites. An example of such an invasion is the black cherry (*Prunus serotina*). Another direct threat is the possibility of alien species interbreeding with related native species.

Another important issue related to the human interference in the natural environment is natural habitat fragmentation. It involves breaching the integrity of the habitat. Infrastructure Line investments comprise the most common reason for such human interference and include, first of all, car routes and railways. Further reasons of interference in natural habitats spring from the need to develop and expand the places, which are favorable to the economy and new building areas. Such cases of interference are made at the cost of natural habitats. *Due to the reduction of habitat areas their space often becomes too small for even populations of animals, which need medium-sized acreages to live in. This problem has been especially well examined on the example of small forest complexes, which are too tiny for certain birds typically living inside forests, to nestle down* (Adamski 2007b: 85). The reflection on the phenomenon of habitat fragmentation requires the adoption of a certain scale. Depending on the size of the habitat, this problem will be true for different species. In other words, each species has different requirements as to the size of its habitat. For some invertebrates, the essential living area is several hundred metres, while the total living area of large carnivores often spans over thousands of acres.

Dividing up each habitat, regardless of species, we have to deal with the phenomenon of the patch size effect, where the effects caused by

reducing the surface of a habitat are disproportionately greater than the habitat itself. It should also be borne in mind that the *fragmentation of a habitat entails the fragmentation of a population. This is the key issue for the protection of nature, because small populations are at higher risk of extinction than the large ones* (Pullin 2007: 90).

4. Natural effects of anthropogenic activity

Biological diversity is unique in the areas of anthropogenic character and differs significantly from the naturally occurring biodiversity. Organisms that inhabit the environment transformed by human beings must have a high degree of ecological tolerance to changes in nature. Such organisms must have considerable species plasticity as far as environmental changes are concerned. To analyze the effects that human activity has on biodiversity, the interference in the two cases should be considered. The first one is when humans interfere in rich biodiversity, while the second one is when this activity relates to a low level of biological diversity. This division is not precise, because it is not easy to determine the measure, which could be used to establish whether biodiversity is rich or poor. However, comparing analogous ecosystems, populations, species, or individuals themselves, it is usually possible to determine whether they represent a rich pool or not.

The first case seems to be evident in the prediction and interpretation of the effects of human activity. However, human interference in rich biodiversity will be considered at all its three levels.

At the intraspecific level, namely at the genetic level, human intervention in recent years is becoming more evident. It is mainly due to genetically modified organisms (GMOs). The majority of modified organisms are plants, which are important for economic reasons. Species are changed and improved by increasing their efficiency, nutritional value or herbicide resistance. Thus, the genes that are not useful and may cause losses from the point of view of human-oriented economy are removed from the organisms. Also, some genes are replaced with other

genes, which are supposed to be more beneficial when growing these plants. *A potential problem is that the changes of the adopted in agriculture cultivation methods and efficient weed control can cause a "domino effect " along the food chain, removing the food of many species of insects, and thus, the food of the birds in the agricultural landscape* (Pullin 2007: 130). It can thus be concluded that genetic modification resulting from human activity is detrimental to organisms, which have a rich gene pool.

Human activity also exerts a negative effect on the rich biodiversity between species - the second level of diversity[6]. A variety of species come to live together in ecological niches, which are characterized by favorable hydrological and geomorphological conditions. These are also the areas in which human beings have always created their settlements. Today, by building contemporary metropolises, humans substantially change the entire habitat. The microclimatic conditions are also being changed, creating heat islands and reducing the sites in which organisms can safely reproduce. Large surfaces of monoculture lawns are being created and the soil is getting covered with asphalt or concrete parking lots, sidewalks and streets. This obviously causes a decrease in biological diversity, mainly in urban areas. *In general, when compared with natural and semi-natural ecosystems, the city biocoenosis is considered to be a poorer structure with respect to the number of species. The spatial transformation process and the lack of mutual ties between various structures of vegetation hinder the full development of the biocoenoses* (Zimny 2005: 76). According to the estimations made by H. Zimny, Polish cities are inhabited by approximately 4000 of the 50,000 flora and fauna species occurring throughout Poland. Thus, the negative human impact on species diversity is undisputed in this case.

Human activity may also be detrimental to the third level of biodiversity, which constitutes the ampleness of various habitats. Ample ecological niches, that is the areas rich in clean running water, good

[6] More information on the extinction of species can be found in: Pullin 2007, Symonides 2007, Weiner 2008.

insolation and favorable climatic conditions, which are components of many ecosystems, also attract human beings. Such areas are chosen due to their fertile soils from which high yields can be obtained. In the case of agricultural crops, unfortunately, there is a significant risk of the occurrence of the so-called monocultures, namely the occurrence of one dominant plant species in a given area. Obviously, such activities limit the number of species and reduce the number of individuals belonging to the species, which occur in a particular area. For example, as a result of applying significant changes to a habitat, the number of invertebrates decreases. The degree to which a habitat has been impoverished under the influence of agriculture depends, of course, on the type of agricultural economy that was run in a particular area. The difference between conventional and ecological types of agriculture is described by A. Augustyniuk-Kram (Augustyniuk-Kram 2012). This description is made using the example of the diversity of soil fauna.

When demand increases, people expand the areas suitable for economic use. This is often done at the expense of natural habitats. The degree of such mechanisms increases intensifying the previously described fragmentation of habitats. Thus, diversity of ecosystems decreases.

Human activity may be assessed differently when biodiversity is low at a given level. To provide an example, in the case of genetic diversity people can, in certain situations, enrich the DNA in genetically modified organisms. However, such organisms, despite apparent and measurable benefits, which they bring, are left without scrutiny. It happens that released organisms are introduced into the environment without prior long-term studies of the consequences of such actions. Therefore, it is difficult to predict how this kind of human interference may influence the remaining levels of biodiversity. *The genes which provide positive characteristics, such as herbicide resistance or tolerance to salinity may be transferred to wild varieties leading to the widening of their niches and the creation of "superweed" varieties that will win the competition with native plants and reduce biotic diversity* (Pullin 2007: 130). Thus, it is impossible to determine whether such genetic changes are a positive

or negative phenomenon. In some cases the interference in genes of particular species may be a tool for nature protection.

When species composition is poor, human activity could theoretically improve it and lead to an increase in species diversity. An example of such activities is the re-introduction of extinct native species to local natural areas and, indirectly, also the restoration of endangered species in natural areas (restitution). On the other hand, human activity in built-up areas cannot be unequivocally evaluated. New species, i.e. those that have not occurred before in a given territory, are introduced to the urban areas by human beings. What is more, these species are often invasive alien species whose presence has a negative impact on native flora and fauna. It should also be noted that flora of urban areas is mostly made up of alien species. A significant part of the species occurring within cities is to a great degree shaped by people. The species, which are introduced, are often selected according to aesthetic criteria, for example, at squares, on lawns and in parks. Also, plants are planted for purely utilitarian and economic reasons. Trees and shrubs planted along traffic lanes are selected according to such criteria. An important criterion is that they do not make streets dirty when they release sap in the spring and that the leaves falling down in the autumn could be quickly picked up. Therefore, the following question can rightly arise: is the increase in the diversity of species, achieved most often at the expense of native species; a phenomenon beneficial to the local ecosystem?

Human activity, in cases of poor biodiversity of the ecosystem, can lead to an increase in the number of different types of habitats. However, it may turn out that in the same area a bigger number of ecosystem types will be created, but their size will be smaller. Thus, the habitats existing earlier will be reduced, which in turn affects the species occurring in them. Therefore, one cannot determine unambiguously whether this is a positive or negative phenomenon.

Conclusions

Although biodiversity is sometimes difficult to define clearly, as a biological phenomenon it is an important component of nature conservation. All levels of biological diversity are interlinked and influence each other. The changes, which are the easiest to observe, are the ones occurring at the species level in the environment. Currently this is the level best recognized by scientists. A degree of species diversity can also be quite easily examined. However, instead of speaking about saturation in biological diversity, one can only speak about unsaturation. Due to the fact that the entire biodiversity of the Earth is not precisely known, it is difficult to define the threshold from which diversity can be defined as saturated.

By "beautifying" the environment, human beings contribute to significant changes in biodiversity. The natural effects of human activity presented in the article do not instill optimism. When the degree of natural diversity is high, people contribute considerably to its reduction. However, when it is low, human activity may lead to an increase in the level of diversity. However, despite of the short-term improvement to the situation, further consequences may be disastrous for the entire biosphere. Therefore, the final assessment of human activity is difficult.

Biological diversity is unsaturated in the human environment. It should also be noted that besides biological diversity itself, its quality is in many cases equally important. It may turn out to be true that biological diversity is maintained or increased at the expense of much more valuable genes, species and ecosystems. To prevent the decline in biodiversity, people should limit or at least control their excessive interference in it. Therefore, the protection of biodiversity, combined with sustainable development, is an efficient means of nature conservation.

Bibliography

Literature:

Adamski, P., 2007a, *Czym jest bioróżnorodność i jej ekologiczne uwarunkowania,* w: Grzegorczyk M. (red.), „Integralna ochrona przyrody", wyd. IOP PAN, Kraków, 45-49.

Adamski, P., 2007b, *Fragmentacja siedlisk i jej ekologiczne konsekwencje*, w: Grzegorczyk M. (red.), „Integralna ochrona przyrody", wyd. IOP PAN, Kraków, 85-88.

Augustyniuk-Kram A., 2012, *Rolnictwo ekologiczne a właściwości gleby i jej różnorodność biologiczna,* Studia Ecologiae et Bioethicae, 10(2012)1, 45-63.

Brzeziński M., Romanowski J., 1996, *Norka amerykańska*, Łowiec polski 4, 19-21.

Demiaszkiewicz A. W., Pyziel A. M., Lachowicz J., 2008, *Stan zarażenia żubrów w Puszczy Białowieskiej helmintami w sezonie zimowym 2007/2008*, European Bison Conservation Newsletter Vol 1 (2008), 42–52.

Głowaciński, Z., 2007, *O antropogenicznym wymieraniu gatunków*, w: Grzegorczyk M. (red.), „Integralna ochrona przyrody", wyd. IOP PAN, Kraków, 39-43.

Makomaska-Juchiewicz, M., 2007, *O ochronie różnorodności biologicznej* w: Grzegorczyk M. (red.), „Integralna ochrona przyrody", wyd. IOP PAN, Kraków, 55-68.

Pullin, A. S., 2007, *Biologiczne podstawy ochrony przyrody*, wyd. PWN, Warszawa.

Romanowski J., Karpowicz K., 2013, *Występowanie piżmaka w centralnej i wschodniej Polsce w latach 1996 – 2007*, Studia Ecologiae et Bioethicae, 11(2013)1, 49-61.

Solarz, W., 2007, *Inwazje biologiczne jako zagrożenie dla przyrody i gospodarki*, w: Grzegorczyk M. (red.), „Integralna ochrona przyrody", wyd. IOP PAN, Kraków, 273-280.

Symonides, E., 2007, *Ochrona przyrody*, wyd. UW, Warszawa.

Weiner, J., 2008, *Życie i ewolucja biosfery*, wyd. PWN, Warszawa.
Wiąckowski, S., 2008, *Ekologia ogólna*, wyd. Oficyna Wydawnicza Branta Bydgoszcz – Kielce.
Wilson, E. O., 1999, *Różnorodność życia*, wyd. PIW, Warszawa.
Zimny, H., 2005, *Ekologia miasta*, wyd. Agencja Reklamowo Wydawnicza A. Grzegorczyk, Warszawa.

Legislation:

(A) Dz.U. 2002 nr 184 poz. 1532, *Konwencja o różnorodności biologicznej*, sporządzona w Rio de Janeiro dnia 5 czerwca 1992 r.
(B) Dz.U. 2004 nr 92 poz. 880 ze zm.**,** *Ustawa z dnia 16 kwietnia 2004 r. o ochronie przyrody*.