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Introductory Chapter: The Main Directions and Tasks of Pure and Applied Biogeography in Solving the Global Problems of Our Time

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Pure and applied biogeography is the study of the spatial and temporal distribution of taxa, life forms, communities, biomes, and natural or human-influenced ecosystems of our planet in large scales.

Biogeography is one of the oldest life sciences, because already since Alexander von Humboldt's work (1769–1859) it has been a theoretically grounded discipline.

Phytogeography and zoogeography are classical subdisciplines of biogeography that study the spatial and temporal distribution of plants and animals, the flora and fauna. Also important recent subdisciplines are island biogeography [1, 2], phylogeography [3], spatial population genetics [4], paleobiogeography [5], systematic and evolutionary biogeography [6–8], fragmentation, metapopulation and landscape biogeography [9–11], gradient analyses [12], and ecogeography [13].

However, many new theoretical trends have emerged recently [14, 15], a number of new methods are used [16], and biogeography has gained outstanding social significance through the effects of human land use on natural communities [17].

The fastest growing trends in biogeography are those that are closely related to quantitative ecology [18–20]. Quantitative ecology is one of the most important disciplines of our time, which is an indispensable part of ecology, environmental science, agricultural sciences, research methodology, biometrics, and also biogeography. Quantitative ecology is about the application of biomathematics, environmental informatics, and biostatistical methods in life and environmental sciences that relate to data collection, data analysis, modeling, monitoring, evaluation, and data communication tasks of supraindividual organizations. Quantitative approach has great significance in biogeography where large quantities of observation, measurement, experiment, or literature data are available in complex systems, processes, or phenomena.

1. Global problems

Overpopulation is in the center of the global problems of humanity. Overpopulation is the primary cause of many other global problems, which are also influenced by some other minor factors. These global crisis phenomena are closely related.

- Overpopulation is the cause of an increase in the ecological footprint of humanity. This is manifested in the destruction of natural ecosystems, depletion of natural resources, pollution of air, water, and soil [21], an increase in anthropogenic climate change, global biodiversity loss, land-use restructuring [22], and urbanization problems.
- Overpopulation increases density and decreases personal space and per capita resources. The human-ethological consequence of these is the growing aggression that is manifested in crimes, terrorism, revolutions, wars, and so on.
- Overpopulation and urbanization increase the severity of global health problems and increase the risk of pandemics.

There are a lot of synergistic interactions between these phenomena, for example:

- Decreasing natural ecosystems (tropical rain forests, moderate forests, bogs, marshes, sea-side habitats, and coral reefs) reduces the biosphere's climate control capacity.
- Growing populations are mining and burning more and more fossil fuels, which increases greenhouse gas emissions and the rate of global warming.
- Global climate change increases demand for adaptability, living costs, poverty, and social aggression and enhances migration.
- Global climate change further undermines the living conditions of natural ecosystems.
- Global climate change creates conditions for outbreaks of new epidemics (through area change of parasitic, vectorial, and pathogenic organisms).
- Reducing biodiversity reduces the biosphere's adaptability (through decreasing functional redundancy).
- The deterioration of people's living conditions increases the number of people in extreme poverty, which further aggravates overpopulation.

These problems are further aggravated by the growing social differences between people, the problems of low schooling of people in poverty, and the lack of political unity of mankind (195 nonaligned nation states).

To address problems, overcome the overcrowding, reduce the per capita ecological footprint, tighten coordination of human activity, reduce social disparities, strengthen social solidarity, environmental protection, nature conservation, and climate protection, improve the education level of humankind, and improve public health, resources may be concentrated on vital

scientific research. This way we can develop a sustainable global society in a healthy environment and rich biosphere.

In solving our global problems, biogeographical research plays a key role in four main areas:

- Origin and protection of biodiversity
- Global climate change issues
- Water issues, aquatic ecosystems
- Sustainable agriculture, biological pest control issues

2. Biodiversity

In the maintenance and conservation of our planet's biodiversity, knowledge of current biogeographical patterns [23], Earth-historical changes [24, 25], and speciation processes [26] have outstanding importance. Many areas of biodiversity are still completely undiscovered nowadays [27].

The ecological effects of global climate change also have a significant impact on biodiversity, flora and fauna, through biogeographical patterns [28–31].

In the field of nature conservation, a fundamental change of paradigm became necessary due to climate change. The previously dominant “in situ conservation,” which is to preserve existing ecological conditions in present habitats, is not always a realistic goal. Consideration should be given to active “eco-engineering” interventions that support the spatial shifts of natural communities as adaptation options. In this, the biogeographic knowledge and the identification of climate-analogous areas could have great importance. It is obvious that such studies should combine analyses of current and Earth-historical biogeographic patterns with climatic scenario-based predictions.

In the biogeographical research on biodiversity, the following key issues can be identified:

- Tropical rainforests, coral reefs, and other biodiversity hotspots
- Natural and near-natural habitats
- Human-influenced habitats and invasions
- Cross-border phenomena
- Paleobiogeography of biodiversity
- Conservation biogeography
- Biogeography of ecosystem services
- Applied biogeographical research in service of sustainable agriculture and organic farming

3. Climate change

Climate change—in close connection with overpopulation, global species extinction and biodiversity crisis, and social crises—is the biggest challenge for mankind in our history. An adequate and stable global climate system is the most basic living condition of the biosphere, and as a part of it, human society and even all other living conditions are dependent on climate. This climatic system also determines the basic biogeographic patterns of our Earth. The fact and the anthropogenic origin of climate change are supported by evidence of a multitude of research findings and observations. With regard to these two things, there is an unprecedented degree of consensus in the scientific world.

In the background of this phenomenon, there are a lot of causes in strict connection with each other like overpopulation of mankind, the fossil fuel production and burning since the industrial revolution, the rapid eradication of forests and natural wetlands, industrial and transport pollution, unsustainable agricultural practices, and the rapid urbanization. Human activity is causing the greatest damage and dangers by breaking down the healthy functioning and regulatory capacity of the Earth's biosphere, eradicating primeval forests and rainforests, draining bogs and swamps, and reducing forest cover. The importance of grazing is also well known in the diversity of nature or near-nature grasslands [32].

There are a number of well-founded and less well-founded opinions about climate change today, but there are some important points that are beyond dispute:

1. The climate determines the living conditions of ecosystems and, at the same time, human society, which are also reflected in large-scale biogeographical patterns.
2. Past climate changes have always had significant ecological impacts, mass extinction of species, new species becoming dominant, and a fundamental change in landscape.
3. The history of the Earth shows a great deal of climate changes, so it must be our basic attitude that, because climate is variable, it changes and the biogeographical and social consequences can be very serious if we are not prepared for them.
4. A better understanding of the relationship between climate and biosphere should be seen as one of our most important research tasks because the existence and prosperity of humanity depend on it.
5. Today, it has become an undeniable fact that the collective activity of mankind is a decisive field-altering, environment-changing factor of our planet, which, besides everything else, also has a significant impact on climate.
6. In our time, global crisis phenomena (biodiversity crisis, raw material and energy problems, consequences of overpopulation and climate change) interact with one another in a synergistic way.

Natural ecosystems provide carbon dioxide binding and storing functions, feedback processes, and in a number of direct and indirect ways regulate the climate in a biogeographical scale, and provide retention and dispensing of leaking residues, as well as the development of favorable

micro- and mesoclimate. More recently, it has come to light that seaweeds emit dimethyl sulfide [33] and some pine trees emit terpenes from themselves [34, 47] as a result of rising temperature and carbon dioxide level; these can effectively promote cloud formation and so cool our planet. In addition, there are probably many ecological phenomena and processes so far unknown to science that have a prominent role in the biological regulation of climate [35] and which could also help the survival of the civilization of mankind if we understood and recognized them in time.

In the biogeographical research on global climate change, the following key issues can be identified:

- Climate control potential of different biogeographical units
- The impact of climate change on different biogeographical units
- The role of climate in spatial and temporal biogeographical boundaries and ecological collapses
- Range and time shifts in biogeographical units
- Paleobiogeographical aspects of Earth-historical climate patterns

4. Water and aquatic habitats

Aquatic ecosystems were, for a long time, a neglected area of biogeography, though more than 70% of our planet is covered with water. Water is the foundation of all earthly life, plays a key role in climate change and spatial-temporal patterns of biodiversity, and decisively defines human activity and the possibilities of agriculture.

Climate change and biodiversity crisis issues have a particularly large impact on water, aquatic ecosystems and wet habitats such as oceanic biotopes [36], surface freshwater [37, 38], or groundwater [39]. The state of river water vegetation also has a fundamental effect on animal communities [40].

In the biogeographical research on hydrobiology, the following key issues can be identified:

- Biogeography of oceans and marine habitats
- Biogeography of freshwater habitats and wetlands
- Applied ecogeography of water resources and soil types
- Dynamic biogeography, invasions, and mix-up of communities

5. Sustainable agriculture

The creation of a sustainable and adaptable agriculture is not merely a technological issue, but it is necessary to rethink the whole natural and socioeconomic system related to agriculture from biological, geographical, and human ecological approaches [41].

Sustainable agriculture means a production system where

- The productivity of the agricultural area does not decrease.
- The production does not lead to an increase in the environmental load.
- Soil, air, and natural waters do not get polluted (exceeding their degree of ecological self-purification).
- Soil does not erode.
- Greenhouse gases do not exceed the amount of absorbed quantity during production.
- The quantity and quality (nutritional value and safety) of products produced satisfy social needs.
- The living standards of the family of farmers are ensured.
- Nonagricultural habitats and global biodiversity are also ensured.

The presently dominant conventional agriculture is obviously unable to meet these conditions as agriculture [42]

- is a major source of anthropogenic climate change,
- is a major source of environmental pollution, while
- the productivity of agricultural lands can only be sustained through higher and higher external material and energy inputs (i.e., unsustainable in itself).

For the development of sustainable agricultural systems, only the “high technology” of agriculture is capable: the organic farming *sensu lato*. This includes organic farming, permaculture, agroforestry, and biodynamic farming.

The productivity, ecological efficiency, and cost-effectiveness of organic farming would be very high (much better than in conventional production) if all of these indicators were to be applied to the unit’s environmental use and environmental load.

The global human population boom and at the same time environmental pollution, damaging nature, and land use pose new challenges to agriculture in the field of sustainability and especially organic farming [43]. In this context, the biogeographical researches affect the cultivated plants, weeds, animal pests and pathogens, and their natural enemies [44], as well as the traditional ecological knowledge [45].

In the applied biogeographical research on agriculture, the following key issues can be identified:

- Anthropogenic changes in biogeography, mix-up of flora and fauna [46]
- Biogeography of grown plants, domestic animals, and their potential genetic resources

- Biogeography of weeds, pests and pathogens, and their natural enemies
- Biogeography of soils and soil biological communities
- Ecogeography of climatic patterns in a changing world
- Biogeographical aspects of agroforestry, organic farming, and sustainable agriculture
- Ethnogeographical aspects of traditional ecological knowledge

Ecological and biogeographical research of natural, near-natural, and human-influenced ecosystems has strategic importance in the struggle for survival of mankind and the chance to create a sustainable society.

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