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NATURAL ZONALITY OF THE FOREST BELT OF NORTHERN EURASIA: MYTH OR REALITY? PART 1 (LITERATURE REVIEW)

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Abstract. The state of the Earth's living cover raises serious concern about its ability to successfully exist and fully implement its ecosystem functions in modern conditions. Hence the need to revise our relationship with the Nature on the basis of modern scientific achievements reflected in the concept of complementarity which is mutual favour of living beings during their lives and after death. Data analysis has shown that complementary relations on the territory of Northern Eurasia were most developed during the Miocene – Pliocene period, which resulted in a huge biodiversity, the highest productivity, as well as the maximum implementation of climate-regulating functions of the Biota. Mass destruction of the giant herbivores of the mammoth fauna who organized complementary systems had global consequences, i.e. changes in the temperature regime, reduction of feed resources, decreased soil fertility, changes in the size and boundaries of ranges of animals, plants, fungi and representatives of other kingdoms as well as the replacement of complementary systems of giant herbivores and grasses by systems dominated by trees which made these landscapes unsuitable for remaining the herbivores. Further transformations of the Biota of Northern Eurasia were determined by human activity.

Keywords: complementarity, biota, giant phytophagous animals, climate, biodiversity, habitat, ecosystem, human activity.

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ПРИРОДНАЯ ЗОНАЛЬНОСТЬ ЛЕСНОГО ПОЯСА СЕВЕРНОЙ ЕВРАЗИИ: МИФ ИЛИ РЕАЛЬНОСТЬ? (ОБЗОР ЛИТЕРАТУРЫ)

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Аннотация. Состояние живого покрова Земли вызывает серьезную обеспокоенность по поводу ее способности успешно существовать и полностью выполнять свои экосистемные функции в современных условиях. Отсюда вытекает необходимость пересмотра наших отношений с природой на основе современных научных достижений, отраженных в концепции комплементарности, т.е. взаимной поддержки живых существ в течение их жизни и после смерти. Анализ данных показал, что комплементарные отношения на территории Северной Евразии были наиболее развиты в период миоцена – плиоцена, что привело к огромному биоразнообразию, высочайшей продуктивности, а также максимальной реализации климаторегулирующих функций биоты. Массовое уничтожение гигантских травоядных животных фауны мамонта, которые организовали комплементарные системы, имело глобальные последствия: изменения температурного режима, сокращение кормовых ресурсов, снижение плодородия почв, изменение размеров и границ ареалов животных, рас-

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тений, грибов и представителей других царств, а также замена комплементарных систем гигантских травоядных и трав системами, в которых доминируют деревья, что сделало эти ландшафты непригодными для дальнейшего существования травоядных. Последующие трансформации биоты Северной Евразии определялись деятельностью человека.

Ключевые слова: комплементарность, биота, гигантские травоядные животные, климат, биоразнообразие, среда обитания, экосистема, деятельность человека.

Dedicated to ***Ivan Grigoryevich Pidoplichko*** *–*
defender of Freedom of the Motherland and the independence of scientific views.

A general trend that has been observed recently – a turn towards narrow specializations – has an adverse effect on the environmental studies first of all. The point is that this discipline, posing the question of causality of phenomena, requires a synthetic approach to analysis, which involves the need to attract and understand data from related sciences.

Walter G. Vegetation of the Earth [1]

Far more than any other species in the history of life on Earth, humans alter their environments by eliminating species and changing ecosystem function, thereby affecting the very future of evolution. This is at least in part because the ecological consequences of the historical losses are unknown and even unimagined…

Donlan C. J. et al. The American Naturalist [2]

It is now clear to everyone that traditional physical and geographical (natural) zones reflect not the modern, but the restored landscapes... the disagreement between physical geography and reality is especially untenable when it comes to teaching it.

Milkov F. N. The man and landscapes [3]

Introduction. The concept of complementarity as the basis for solving the issue of the Human – Nature relationship

The results of the NATURE research conducted over the past centuries have shown that for millions of years it had been developing to improve the ways of interaction between the coexisting and newly emerging species. This was the core issue in maintaining and developing the life on the Earth before the advent of human. Mutual favour of living beings (*complementary relations*) determined the ability of pre-anthropogenic Biota of the Earth to carry out ecosystem functions, among which climate regulation and biological diversity maintaining have currently become the most essential ones. Lack of understanding of the importance of complementary relations in the Nature, which became the focus of research and which was first comprehended only in the past century, has also resulted in poor understanding of the importance of these relations for perceiving the Nature and possibly for its conservation, which is the basic condition for human survival [4, 5]. Currently, the ideas about the huge role of complementary relations in the Nature are widely spreading in the scientific community, but even now they have very little effect on the attitude of the Earth's population to the NATURE (or rather to what is left of the NATURE).

In our opinion, the role of complementary relations in solving the problems of preserving and restoring the Earth's living cover has been ignored because comprehensive research had began at the time when a significant part of the key species and many subordinate species were destroyed by the human, i.e. the integrity of the Earth's Biota was severely disrupted. As a result, many ***complementary systems of species*** that optimized the main functions of the Earth's Biota including the essential functions of climate regulation and maintaining biological diversity ceased to exist [6, 7]. It became an obstacle to creating an optimal habitat for many species, and also contributed to the intolerance of their complexes (communities, biocenoses, ecosystems) to changes in environmental conditions caused by anthropogenic influence that is increasing its unfavourable effect on the Nature. **Understanding the importance of complementary relationships in maintaining the sustainable life on the Earth, we have set a task to analyze and summarize the data on the palaeohistory of the Biota of Northern Eurasia.**

We suppose the Miocene – Pliocene period which was the time of domination of complementary systems of living creatures as part of the hipparion fauna to be an initial stage. Pleistocene –

early Holocene, i.e. the period of complete destruction of complementary systems of living beings due to the mass destruction of giant herbivores of the mammoth fauna by humans is the final stage.

We hope that this analysis will form the necessary basis for reviewing the Human – Nature relations, focusing them on the restoration of natural patterns both in specially protected "fragments" of natural systems in reserves, nature reserves and other territories, and in exploited territories. We suppose that the revision of the Human – Nature relations based on clear understanding of the significance of natural laws that had been forming for millions of years before the beginning of human domination over the Nature is the main condition for the preservation of the Life on the Earth.

State of Northern Eurasian Biota during the analyzed period

To analyze the pre-anthropogenic state of the Biota of the territory under consideration, we chose the Miocene – Pliocene period, the time of dominance of the hipparion fauna and the formation of "grass biomes" that determined the structural and functional features of the landscapes in the analyzed period. The mammals of the hipparion fauna were widespread in Eurasia and North America 12 to 2 million years ago. It is reasonable to consider the hipparion fauna as a whole the basis of the ancestral fauna that dominates vast areas of Europe, Asia, Africa and North America [8]. Apart from hipparions, ostriches and gazelles (inhabitants of forest-meadow-steppe landscapes), transitional fauna between the Miocene and the Pliocene also included forest species, i.e. marten, chalicotherium, etc. Beavers, mastodons, hipparions, and primitive squirrels were the typical representatives of the Miocene genera of Eastern Asia and North America in the transitional fauna.

The list of common species of hipparion fauna in Africa and Europe included giraffes, mastodons, hipparions, antelopes, and rhinos; and the fauna of Europe and North America shared beavers, mastodons, hipparions, giraffes, hornless rhinos, deer, antelopes, gazelles, sabre-toothed tigers, indricotheres, hyenas, zorils, ostriches, hares, and pikas [9–14].

The hipparion fauna originated in the early Neogene in Eurasia and supported *"complementary systems" – a large number of coexisting species united by the environment-forming activities of key species* – as single entities. Complementary, i.e. mutually agreed systems of living beings mastered and transformed landscape complexes of river basins where forest, water body, meadow, steppe and swamp plots existed as single formations of interacting vertebrate and invertebrate species (herbivores and predators), plants and representatives of other kingdoms united by the environmental activity of the giant herbivores of the mammoth fauna. The mosaic landscape of the Pliocene – Miocene provided the necessary living conditions for various species of herbivorous and predatory animals, i.e. hipparions, rhinos, mastodons, elephants, giraffes, bulls, antelopes, hippos, hyenas, sabre-toothed cats, and many other creatures.

To date, huge data on cohabiting animal species in different regions of the analyzed territory has been accumulated. For example, I. G. Pidoplichko collected 50 thousand bones of different species in 1940s–1950s in Odessa catacombs, Ukraine. Researchers still consider his data a standard for the characteristics of forest-meadow-steppe landscapes of the Pliocene of Northern Eurasia. According to the data obtained, these landscapes were shared by animals that have separated by now: beavers – in river valleys; bears, lynxes, badgers, hares, foxes, hedgehogs, wood mice, and deer – in forests and on forest edges; hyenas, ferrets, mole rats, hamsters, corsacs – in steppes; camels and ostriches – in steppes and deserts, etc. [15–18].

One of the most significant processes of hipparion fauna formation is the emergence and development of ***"grassy biomes"*** – communities where the grasses were indicative of complementary relationships in the systems of living creatures of the analyzed territory. This process was caused by the herbivores' shifting from feeding on leaves and branches of trees, shrubs and dwarf shrubs to feeding on grasses. The most essential role in the formation of herbal biomes belonged to grasses, the shoots of which have the greatest, among other herbs, ability to grow after being bitten off due to intercalary meristems stimulated by saliva of herbivores. Conjugate evolution of plants and phytophagous animals (elephants, mastodons, mammoths and other giant herbivores as well as horses whose digestive system as compared to other herbivores is most adapted not only to soft food, i.e. growing and developing plants, but also to coarse food – dry shoots of grasses and other herbs (grassland litter) determined the dominance of forest-meadow (forest-clearing) ecosystem complexes in the analyzed territory [19–21].

The hipparion fauna and flora of this period had become most powerful by the Pleistocene. The combined activity of the complementary systems that had formed by that time and included vertebrates and invertebrates (terrestrial and soil animals), various plants, fungi, bacteria, and other creatures provided an exceptionally high level of plant product usage, reaching record values of

30–60 % for communities with giant mammals. Mortmass, i.e. the remnants of the grassland litter, was processed by saprophages. Coprophages and scavengers rapidly consumed a significant mass of excrements and corpses of herbivores and predators. This mutual adaptation between plants, primarily herbs, and animals of different types – phytophages, predators, coprophages, scavengers, etc. – accelerated the biological cycle and, shortly, laid the foundation for the development of animal husbandry in the anthropogenic period.

Although there is some understanding of the importance of soil Biota research as a key link in the functioning of ecosystems, most of the past and current ecosystem studies are devoted mainly to terrestrial organisms. At the same time, the life of underground organisms, according to the current level of knowledge, is characterized by significant biological diversity which means the possibility of sustainable existence and high productivity of complementary systems as a whole as a biotic unity of aboveground and underground organisms. And whereas earlier it was suggested that the underground biota had species and even functional redundancy [22, 23], the hypothesis of redundancy is increasingly questioned now [24–26]. Field experiments show functional insufficiency of soil biota of forest plant communities when it comes to decomposition of decomposition-resistant litter [26]. Because of the nature of the soil environment, the poorly studied complicated soil life is often called a "black box" or even a "black box curse" [27], and the unknown losses of soil life are a "blind zone of global extinction" [26]. The authors highlight the role of soil biota, especially of large key species or ecosystem engineers (earthworms, ants, termites), both in creating a habitat for a huge number of small organisms (mesofauna, fungi, bacteria), and in the spatial and temporal distribution of vital resources (water, nutrients) [28]. Trophic, locomotor and, in general, environment-forming activities of "ecosystem engineers" are unique and at the same time large-scale and essential, and despite the high taxonomic diversity of soil invertebrates there are no functional equivalents to large soil "*ecosystem engineers*". Researchers often emphasize the functional relationships between individual groups of soil biota and certain plant species (for example, highly specialized groups of bacteria, fungi) [29] – but conjugate relationships between giant herbivores, plants, soil, and soil biota are rarely considered in a complementary set of functional relationships. Such a taxonomically and functionally diverse complex of soil Biota could be formed under conditions of high diversity and richness of terrestrial biota during the period of domination of Pleistocene flora and fauna, even according to modern understanding. Processing of both plant litter, and of excrements and animal corpses are the important functions of different groups of soil organisms [30], whose significant reduction or even disappearance is neglected when studying soil life in modern ecosystems. Therefore, new tasks arise, e.g. study of the losses of soil biota together with the losses of large terrestrial species of plants and animals and, finally, study of global extinction of soil biota [26].

Thus, highly productive ***complementary systems***, organized by giant herbivores of the mammoth fauna mainly feeding on highly productive herbs, mostly grasses, as well as various species of herbs, shrubs, dwarf shrubs, and undergrowth of trees of different species were formed during the Miocene – Pliocene. Manure and other waste products of giant herbivores and the related species, as well as animal corpses, plant debris, etc., were actively processed by the huge population of soil Biota.

Complexes of complementary systems combined a significant (possibly the complete) land Biota of Northern Eurasia and were able to fully implement the main ecosystem functions of the living cover including continuous maintenance of life flows in a significant range of climatic conditions. Judging by the incredible boost in life which can be estimated by the current constantly updated palaeontological data, the Miocene – Pliocene was the time of maximum development of the Biota of Northern Eurasia [8, 9, 12–14, 22].

Anthropogenic myths in understanding the history of Earth's Biota in the Pleistocene – the period of a human's total domination over the NATURE

There are fierce discussions about this period, caused not so much by a lack of data, as by "a significant turn towards narrow specialization" or "*bias of opinion*" *– something G. Walter warned about.* Late Pliocene and Pleistocene was the time of the greatest events in the history of the Earth's Biota, i.e. the onset of the "ice age", advent of human ancestors, disappearance of a lot of large and giant mammals that were key species of Pleistocene landscapes.

History of the development of the "ice age" concepts

The reasons for significant changes in the Earth's living cover in the Pleistocene – Holocene were not completely clear as, for over two centuries, there had been a raging debate about the existence of an ice age that could cause the climate change and determine changes in the composition and structure of the Earth's Biota and the formation of modern "natural" zones. Below is the history of the formation of glacialist ideas. Studying various natural phenomena, researchers found in river valleys and on flat territories, a large number of *erratic boulders (Latin erraticus = wandering)* i.e. stones with traces of striation. Initially, erratic boulders were considered as traces of the flood described in the Bible. Then Ch. Lyell [31] formulated the drift hypothesis, which had earlier been stated in the Russian literature by M. V. Lomonosov [32] who explained the formation of erratic boulders in the following way: "*Frosts and ice show their strength on the hard stone, and the earth experiences a lot of changes caused by them, and, especially by ice. Full of spring waters, great rivers raise their heavy winter coverings and, ripping off parts of the banks, pull them downstream by the rapid flows. They crash, come close to the shores and hit them with the immense forces that undermine and break the steep banks, also ripping off rather large islets, whereas they themselves break with a great noise. Stones frozen into the banks during the winter leave the banks and the mountains and are swept down"*. And this is how the follower of M. V. Lomonosov – I. I. Lepekhin [33] described his observations on the Kurya river (a tributary of the Northern Dvina): "*If you have a look at the banks and surrounding low places, you will see there a large number of stones that could not have emerged here. Such "newcomers" mostly come with the spring ice, which removes the stones frozen in it, sometimes of great weight, from their natural sites to faraway shores..."*.

In contrast to the views of M. V. Lomonosov and Ch. Lyell, L. Agassiz [34] put forward another hypothesis of erratic boulder spread and the nature of their striation. He argued that such boulders "represent one of the main proofs of the glaciation of the Earth and of the specific age in its history, i.e. the ice age".

Thus, the basis and the starting point of these hypotheses is a different interpretation of the formation and spread of erratic boulders (and other erratic material) and the appearance of striation on them: the drift hypothesis, with icebergs, sea, lake and river ice as the main factor of drift, and the glacial hypothesis, where the main factor of drift is believed to be glaciers, not only mountain, but also plain ones, which moved and delivered erratic material up to the South of the Russian plain, i.e. hundreds of km from the Scandinavian shield or many hundred km from Novaya Zemlya. According to the ideas of the glacial hypothesis proponents, powerful sheets with up to 3.5–4.5 km-thick ice buried the blooming plains of Europe, North America, and Northern Asia. Glacialists considered it as an established fact that glaciers did not just bury the sea and land but also plowed and carved into the rocks of crystal shields – in the Baltic and in the Canadian shield – extremely deep fjords and trenches, numerous lake basins and skerries, drumlins and roches moutonnees. Wandering glaciers created furrows and hatches in the crystalline rocks and polished them. Scientists suppose that glaciers crushed bedrock into blocks and boulders, incorporated them into their bodies and moved thousands of kilometres [35–38]. These ideas of glacialists came into sharp contradiction not only with the results of research of geologists and biologists, who quite reasonably developed the drift hypothesis [39–44], but also with the paleontological data that had been demonstrated earlier in the classical works of I. G. Pidoplichko [15–19] and confirmed by modern data of radiocarbon chronology [45–47].

Accepting at face value the concept of glaciologists about the presence of vast areas covered with ice in the Pleistocene or simply not discussing it researchers contribute to the preservation of unsubstantiated ideas in biology, blocking the process of understanding and restoration of the full-fledged Earth Biota which is the main condition for the sustainable existence of Nature and, consequently, of the entire mankind.

Cover glaciers of the Earth. Given the enormous importance of the "ice age" question for solving modern problems of conservation and restoration of Earth's Biota, we found it necessary to explain a possible solution by citing fragments from the public work of V. G. Chuvardinsky [43, p. 11, 12] which should be used in school and university teaching.

"*To date, glaciologists, geologists, drilling engineers and geophysicists have studied the dynamics and patterns of movement of cover glaciers throughout their thickness and sections in different parts of the globe. The results of full-depth drilling of the ice of Antarctica and Greenland, carried out under International projects, are of special and unique significance. Thorough study of many kilometres thick ice columns, as well as the study of vertical ice cliffs and the study of ice in tunnels punched in the base of glaciers, yielded unexpected results. It turned out that instead of the thicknesses of debris-containing ice stuffed with huge blocks and boulders (as it is usually depicted in diagrams* *and drawings in textbooks on general and quaternary geology and geomorphology); only inclusions of sandy clay loam and fine-grained matter are found in the continental ice. Even in the basal layers of glaciers – where it is customary to find powerful bottom moraine filled with huge blocks and iron-like boulders... the glacier body contains only small lenses and clumps of clay and sandy and loam matter are found as well as rare sand grains... "Thus, contrary to the canons of the glacial theory, the ice sheets does not cut, plow, or rip open the underlying rocks, does not form exaration relief or create various kinds of glaciotectonic" structures. They do not include blocks and boulders and after they have melted, they can leave only a thin cover of sandy clay loam sediments".*

Permo-Carboniferous glaciation *– from the paper of V. G. Chuvardinsky* [43, p. 1–3]. *"The hypothesis of Permian-Carboniferous glaciation first appeared in the middle of the 19th century on the basis of finds of tillite outcrops and striated boulders in India and Australia. Later similar boulder deposits were found in the Southern and Equatorial Africa, Europe, Kazakhstan, South and North America, and on the Arabian Peninsula. Last of all, tillites were discovered in Antarctica. In one and a half or two centuries, the glacial hypothesis has become an irrefragable theory and, together with the theory of a powerful Quaternary glaciation, has been widely introduced into the Earth sciences and unconditionally considered a fundamental, landmark scientific achievement. At the same time, during this period scientific teams from different countries – botanists, zoologists, palaeogeographers, climatologists and geologists – collected the richest unique dated factual material on the fauna and flora of the late Palaeozoic, the time of formation of powerful coal deposits". Summarizing these works, one can conclude that in the early Carboniferous the climate on most of the Earth's land surface was almost tropical. In this warm and humid climate, forests of giant tree ferns and various seed plants have spread widely...". At this time, around 30 % of the world's black coal reserves were formed. Plant prints-based analysis of these deposits made it possible to compile a comprehensive characteristic of the richest Permo-Carboniferous flora...".*

Confirmation of this conclusion by V. G. Chuvardinsky is provided by data on Carboniferous forests of this time [48, 49]. A comprehensive analysis of Pleistocene events in relation to the living soil cover of Northern Eurasia is presented in the monograph [50] and in a series of articles [51–54].

We provided a detailed description of the ice age disputes as an example of one-sided views on the object of research that can lead to erroneous ideas that hinder the development of science.

Biota of Northern Eurasia in the Pleistocene: highest productivity and huge biological diversity

The discrepancy between the severe, in terms of glaciology, Pleistocene climate and the enormous productivity of the "mammoth" ecosystems of this time (according to biologists and palaeontologists) which nursed the incredible (in terms of population) megafauna, ecologically similar to the modern African one, was called the "paradox of prehistoric pastures". The essence of this process is perfectly demonstrated in the papers of I. G. Pidoplichko [15–19], P. S. Martin [55, 56], N. Owen-Smith [57, 58], and P. V. Puchkov [59–63]. These researchers showed that in the Pleistocene, as compared to the Holocene, the phytocenoses of "mammoth" and other ecosystems enjoyed higher productivity and mosaic of grass communities which were the main food of large phytophages, as well as a predominance of park (not closed) forests and savannas in comparison with unbroken modern forests. Palaeoanalysis of a huge volume of material proves that ***ecosystems that provide food for huge herds of giant herbivores and predators that hunted them were common around the globe throughout the majority of the Cenozoic era***.

They were characterized by high productivity and mosaic, as well as predominance of herbal communities dominated by grasses – the most valuable feed for large herbivores. Pleistocene communities resembled not modern zonal formations – closed forests, meadows, or steppes – but their contact areas which are referred to as "ecotones" in modern terminology. Either the territories passing different stages of vegetation restoration after grazing had ceased. Pleistocene communities enjoyed a significant diversity of Biota and a greater number and diversity of large mammals than the Holocene one. The most significant feature of these communities (for the Earth's living cover as a whole) was the similar composition of animal life forms in the northern and southern hemispheres [64–68]. This determined the formation of similar, in terms of structure and functions, complementary systems in both hemispheres. The solution of this "prehistoric pastures paradox", according to P. V. Puchkov, *"cannot be found in the climatic features of the Pleistocene, ...because similar ecosystems existed on continents with different climates, while maintaining the richest population of large and giant mammals, as well as their accompanying species*"

[60–63]. By comparing palaeontological data and the results of field studies of palaeotropics, modern analogues of Pleistocene ecosystems, the researchers managed to explain the features of the vegetation cover of prehistoric pastures [65–70]. Comparison of the life forms of modern and Pleistocene animal types revealed their complete equivalence in the formation of complementary systems. *This is illustrated by a copy of the original drawing from the article by N. K. Vereshchagin and G. F. Baryshnikov* [64] (Fig. 1).

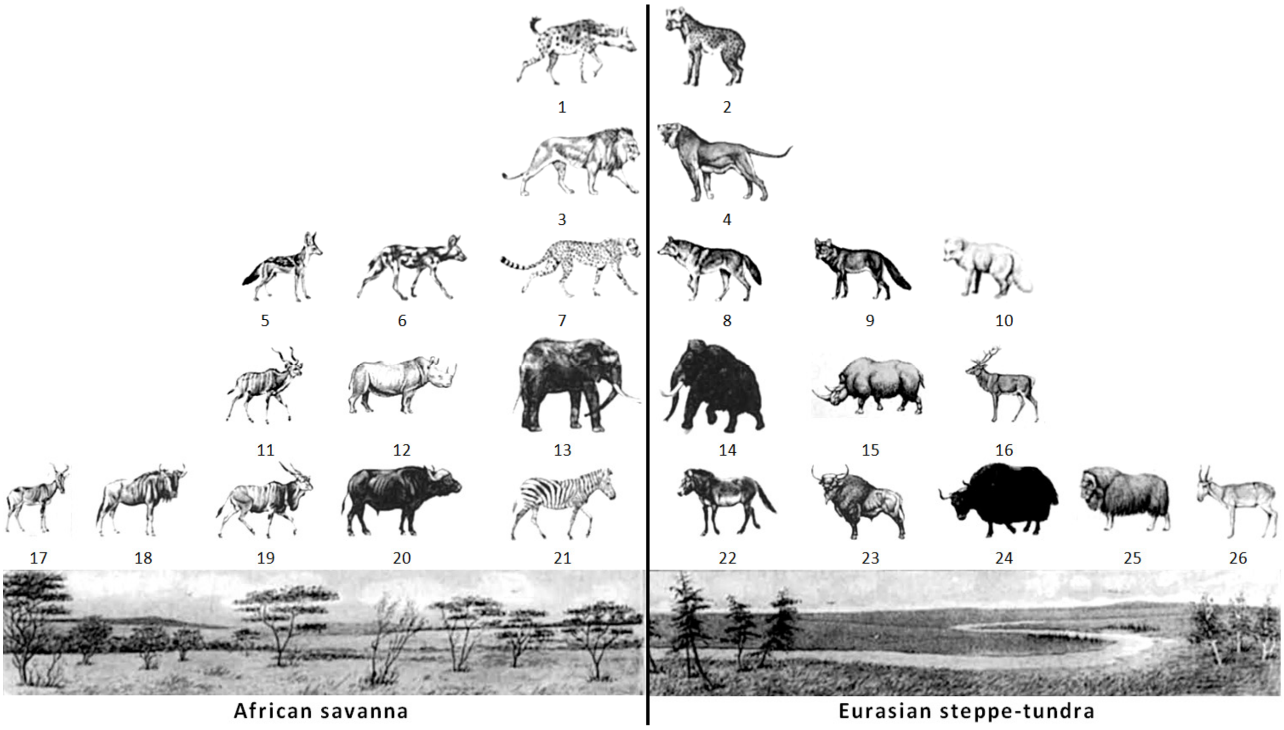

Fig. 1. Schematic comparison of the faunas of the African savanna and the Pleistocene steppe-tundra (by N. K. Vereshchagin & G. F. Baryshnikov, 1992) [64]: **the fifth level (consumers of carrion)**: *1* – spotted hyena (*Crocuta crocuta* Erxl.) and striped hyena (*Hyaena hyaena* L.); *2* – cave hyena (*Crocuta spelaea* Goldf.); **the fourth level (predators of the second order)**: *3* – African lion (*Panthera leo* L.); *4* – cave lion (*Panthera spelaea* Goldf.); **the third level (consumers of ungulates and rodents, active predators of the first order)**: *5* – jackals (*Canis mesomelas* Schreb, *C. adustus* Sundev.); *6* – African hunting dog (*Lycaon pictus* Temm.); *7* – cheetah (*Acinonyx jubatus* Schreb.); *8* – wolf (*Canis lupus* L.); *9* – dhole (*Cuon alpinus* Pall.); *10* – arctic fox (*Alopex lagopus* L.); **the second level (animals consuming herbs, leaves of shrubs, twigs and bark)**: *11* – kudu (*Tragelaphus strepsiceros* Pall., *T. imberbis* Blyth); *12* – white rhinoceros (*Ceratotherium simum* Burch.); *13* – African elephant (*Loxodonta africana* Blum.); *14* – mammoth (*Mammuthus primigenius* Blum.); *15* – woolly rhinoceros (*Coelodonta antiquitatis* Blum.); *16* – maral (*Cervus elaphus* L.); **the first level (consumers of herbs, forbs, and grass)**: *17* – African gazelles (*Gazella granli* Brooke, *G. thomsoni* Giinth.); *18* – African gnu (*Connochaetes taurinus* Burch.); *19* – topi (*Damafiscus korrigum* Ogilby), hartebcest (*Alcelaphus buselaphus* Pall.); *20* – African buffalo (*Syncerus coffer* Sparrm.); *21* – zebras (*Equus qreyvi* Oust., *E. burchelli* Gray); *22* – Eurasian horses (*Equus latipes* V. Grom., *E. lenensis* Russ.); *23* – transbaikalian bubalis (*Parabubalis capricornis* V. Grom); *24* – primitive bison (*Bison priscus* Boj.); *25* – musk ox (*Ovibos moschatus* Zimm.); 26 – saiga (*Saiga tatarica* L.)

Apart from the complete equivalence of complementary systems, as well as modern and Pleistocene types of animals, their feeding resources and the ways in which they were used by members of trophic chains, were also completely identical.

According to field data, the increased productivity of African savannas is a consequence of grazing which accelerates the turnover of substances and energy. Large phytophages consume 17–94 % of primary production and return to the soil the substances extracted earlier with urine and manure. Researchers have discovered that damaged plants tiller more intensively than undamaged ones due to the presence of intercalar meristems. Repeated grazing is more effective there than on untouched grass (that is why double or multiple hay cuttings were formed in agriculture in chernozem regions).

Damaged plants stay green longer in the dry season and build up biomass faster during the rainy season. Studies have also found that large and especially giant animals create a favourable habitat for other dwellers of complementary communities. During grazing, the ability of compensatory growth weakens, but pastures do not degrade due to seasonal migrations of phytophages and the removal of some individuals by predators, as well as the death of some animals of old age and diseases. ***This method of using pastures, i.e. joint grazing of animals that are fundamentally different in terms of intensity and methods of resource consumption – is fundamentally different from modern grazing.***

As a result of different animal species using different feeds and at different times, the forage resources of prehistoric pastures did not decrease. Pasture degradation was prevented by different phytophages suppressing different plants at different times, and pasture restoration ensured that different mammals and birds spread seeds of forage grasses [55–63]. Researchers have found that the increased mosaic of vegetation occurs due to uneven grazing, trampling and fertilization of pastures by animals. Mosaic plots differ in nanorelief, soil structure and humidity, nutrient content and composition of soil fauna. This increases the diversity of vegetation, regardless of the composition and abundance of phytophages. Model reconstruction of Pleistocene communities demonstrates the highest efficiency of resource use based on the principle of complementarity. The data obtained by researchers on the species composition and patterns of the existence of the Northern Eurasian Biota in Wurm combined with data from researchers of African savannas, have challenged the idea of Wurm as one of the most severe, in terms of climate, periods of the Pleistocene; according to contemporary ideas, the function of climate regulation was carried out by herds of large and giant herbivores [60–72].

Special attention should be paid to the fact that the discrepancy of data from different fields of knowledge shows the need for reconstructions of the Pleistocene climate based on the mutually agreed desire of representatives of different specialties to find a way to solve the "ice age" problems. However, this will only be possible if, in addition to the data from geography, geology, geomorphology, climatology, and other natural sciences, we will be able to assess the climate-regulating role of pre-anthropogenic Biota on a parity basis based on Palaeoanalysis of the prehistoric Biota of the northern hemisphere and to compare these data with the data from analogues where it is advisable to use complementary animal systems currently existing in the southern hemisphere [64] as well as a huge amount of palaeontological data on the dominance of large and giant herbivores in Northern Eurasia in the Pleistocene and part of the Holocene.

It should be noted that, accepting at face value the concept of glaciologists about the presence of vast areas covered with ice in the Pleistocene or simply not discussing it researchers contribute to the preservation of unsubstantiated ideas in biology, blocking the process of understanding and restoration of the full-fledged Earth Biota which is the main condition for the sustainable existence of Nature and, consequently, of the entire mankind.

Climate-regulating role of the Biota of Northern Eurasia in the pre-anthropogenic period

The need for model reconstructions of the Pleistocene climate to find out the reason for the huge productivity of prehistoric pastures in a climatically unfavourable period raises the issue of the presence of a climate-regulating role of BIOTA – a powerful self-preserving system whose main goal is to maintain the sustainable existence of all living beings united in complementary systems by giant herbivores of the mammoth fauna.

Although the remarkable achievements of palaeontology allow us to reconstruct the composition and structure of pre-anthropogenic ecosystems, the influence of pre-anthropogenic Biota on the climate has not yet become a relevant topic for researchers, despite some attempts made [73]. These and many other palaeontological data, as well as data from field observations, raise extremely important questions about the possibility of assessment the sustainable existence of modern Biota and the forecasts related to its development under various human influences. According to glaciologists, the climatic conditions of Wurm were unsuitable for the life of a significant part of the northern hemisphere Biota species [34–38]. However, palaeontologists discovered and dated the bones of exactly those animals that, according to glaciologists, could not have lived in the Northern hemisphere in Wurm [68] (Fig. 2).

For example, a review of palaeontology papers shows that mammoths, cave lions, woolly rhinos, bison, musk oxen, saiga, horses, elks, red deer, wolves, wolverines, brown bears, hares, voles, reindeer, Arctic foxes, lemmings, and many other animals inhabited the Novosibirsk Islands in the late Wurm [52–57].

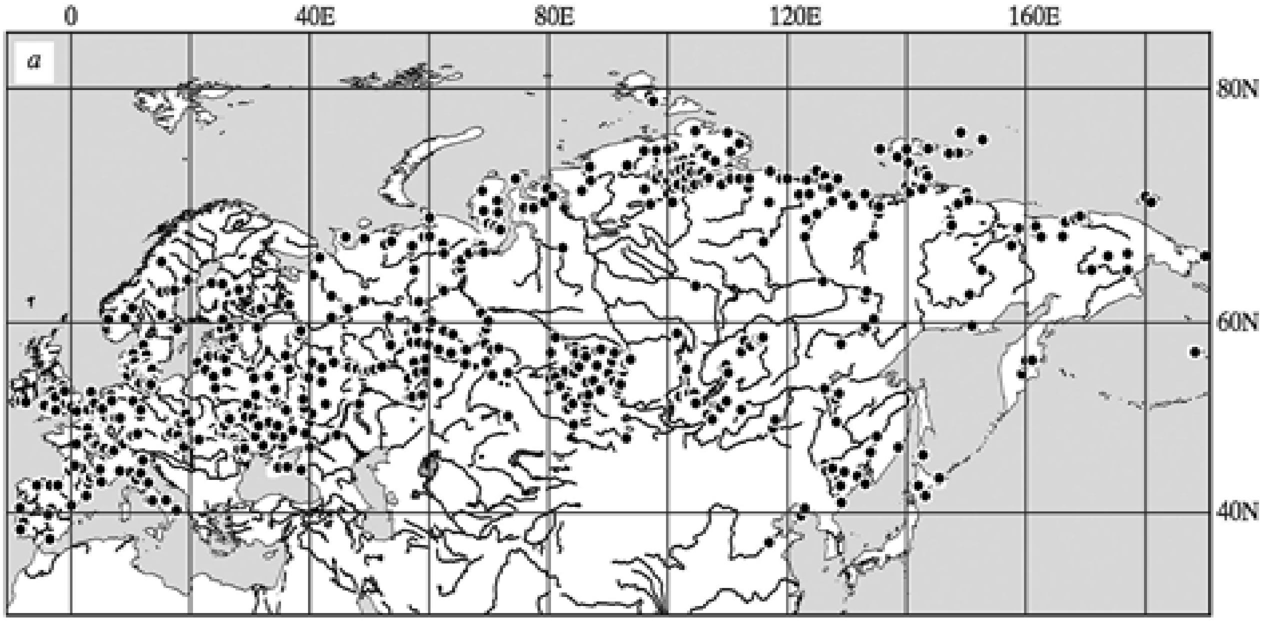

Fig. 2. Late Pleistocene and Holocene mammoth locations in Northern Eurasia (Markova et al., 1995) [74]

In the Middle Urals, in addition to the species listed above, caves were inhabited by the Himalayan bear and porcupine – modern inhabitants of the highlands – and many other animals [66, 67]. To assess the conditions of life in the late Wurm, we give, as an example, a few lines from the work of N. K. Vereshchagin which enable a mental reconstruction of the climate in the late Wurm:

"Judging by the research of massive natural cemeteries of ungulates in river valleys and by the excavations of Palaeolithic sites on the Russian plain and in Siberia, the number of individuals and the weight of ungulate biomass were very large. This weight per area unit was apparently no lower than in the savannas of Equatorial Africa. Individual weight of a number of steppe ungulate species is the indicator of their golden age in the Pleistocene. For example, according to calculations of the skull and skeleton size, the weight of middle Pleistocene bisons in the Volga region reached 1.5–2 tons versus 800–900 kg in modern bisons and European bisons" [72].

Significant advances in solving the "paradox of prehistoric pastures" problem became apparent after generalisation of palaeontological data about the huge variety of giant herbivores of the mammoth fauna that inhabited Northern Eurasia.

The constant increase in palaeontological data indicating the absolute dominance of large and giant herbivores and a huge number of accompanying species throughout the Pleistocene and part of the Holocene [55–72] makes the researchers revise the ideas about the features of the late Wurm and the role of complementary systems organized by large and giant herbivores in maintaining a favourable temperature range for the growth and development of grasses which are the main food of giant herbivores of the mammoth fauna and their accompanying species, as well as for the full development of soil Biota.

Necessity and possibility of assessing the climate-regulating role of Biota before the beginning of the quaternary period. Warming role of giant herbivores of the mammoth fauna

Significant progress in model reconstructions of prehistoric pastures that provide food for huge herds of herbivores including giant herbivores of the mammoth fauna was made possible as a result of model experiments on the inclusion of giant herbivores in modern forest communities [75, 76]. The following results in terms of changes in forest communities were obtained: thinning or severe reduction of the tree canopy; changing the species composition of herbs in general due to a significant increase in the proportion of cereal; accelerated cycles of mineral nutrition elements; increased productivity of pastures; reduced number of fires due to the absence of grassland litter. When modelling the Pleistocene environment the authors concluded that the larger body size of herbivorous mammals than at present is the key to explaining the paradoxical productivity of herbal ecosystems due to more efficient use of plants by large herbivores because of the peculiarities of their digestive system.

The increasing volume of global literature data on farm animals as a significant source of methane due to a huge number of cattle in the world is the evidence of the warming role of Biota. Agricultural animals are characterized by high intensity of CH_4 release as a result of internal fermentation which is typical for the digestive system of ruminants [73, 77–79]. They produce 30 % of global anthropogenic methane emissions [80, 81]. Methane is one of the most important greenhouse gases in the Earth's atmosphere. It retains 21–25 times more heat in the Earth's atmosphere than CO_2 [82]. The data obtained in the remarkable experiments of S. A. Zimov [83] on the reconstruction of pre-anthropogenic Biota largely contribute to the comprehending of the reasons that caused the bloom of the Earth's Biota in the Pleistocene due to the environment-forming activity of giant herbivores of the mammoth fauna.

At the same time, it should be noted that high productivity of grass biomes is due to the ability of intercalary meristems to grow again after being bitten off, being stimulated by the saliva of pasture animals [13, 14]. It is the combination of the ability of grasses to grow again after being bitten off with the features of the digestive system of large grazing animals that leads to the "paradoxically high productivity" of pastures, both prehistoric and modern, provided that the grazing loads on Biota are taken into account.

It should be noted that by P. V. Puchkov and many other authors [59–63] made a similar conclusion about the role of giant herbivores based on the detailed analysis of the Wurm palaeohistory presented in a series of articles under the common title "*uncompensated Wurm extinctions*" much earlier than the studies were conducted [73, 75].

Based on field and model data, P. V. Puchkov reconstructed the "prehistoric" (pre-anthropogenic) forests of the Wurm era. According to his data confirmed by many other researchers, prehistoric forests were highly mosaic, with sparse tree canopy, increased local diversity and high density of large mammals. Giant animals were the factors that improved the habitat of different animals. At that, the concept of "habitat improvement" is better to include the influence of large herds of giant herbivores of the mammoth fauna on the changes in the temperature range of their habitat.

This summary of results of prehistoric forest research conducted by V. G. Puchkov and his colleagues should be considered as the axiom of the complementarity concept. What is worth mentioning is the huge role of soil Biota both in ensuring high productivity of the vegetation cover of prehistoric pastures, and in the warming effect of soil Biota which is complementarily associated with large mammals. Modern studies of soil respiration in fields in Canada show that application of cattle manure increases microbial biomass by 2–3 times, and the release of carbon dioxide also increases proportionally (2–3 times), which leads to increased soil temperature. Mineral fertilizers do not have this effect [84]. However, it is widely known that increasing the carbon dioxide content in modern poorly structured soils can have negative effects on the functioning of all soil life. On the contrary, in the soils where both large burrowing vertebrates (ground squirrels, marmots, etc.) and large burrowing invertebrates (burrowing worms) live, large free spaces are created, and an increase in the content of carbon dioxide to levels that are critical for soil life is hardly likely. Therefore, we can assume that the diversity of burrowing soil animals in the pre-anthropogenic period compensated for the effects of greenhouse gases, which did not have a depressing effect on the soil biota, but had a warming effect.

There is no doubt that this assumption based on the comparison of modern Biota of Northern Eurasia and palaeobiota [50, 84] requires in-depth research with extensive use of model experiments. The highest productivity of pasture ecosystems of the Pleistocene where all the processes of Biota maintaining and developing were determined by giant herbivores of the mammoth fauna, together with the information about the warming effect of herds of modern farm animals [77–82], allows us to suggest that the Biota of the analyzed territory as a whole had a significant impact on the Earth's climate in the Pleistocene.

Degradation of the biota of the analyzed territory in the Pleistocene – Holocene – the time of gradual transition to the total domination of human over the Nature. The rise of the "appropriating" economy, i. e. gradual destruction of complementary systems of forest-meadow-marsh landscapes of Northern Eurasia: the Pleistocene – Holocene

Huge variety of Biota, i.e. species of animals, plants and representatives of other kingdoms that successfully existed in Northern Eurasia in the Pleistocene – early Holocene formed the basis for the rapid growth of the "appropriating economy". Having mastered different types of hunting and having domesticated the dog, people began to rapidly destroy large herbivores in the first place as the most convenient object for collective hunting [85, 86].

To date, a lot of data indicate that large animals and giant herbivores were used for food, construction, making clothing, utensils, tools, and even jewellery. This also indicates the huge resources of

Northern Eurasian Biota and favourable climatic conditions for the existence of all types of Biota in general which led to the rapid expansion of man in the northern hemisphere [55–63, 87].

Climate-regulating role of the Biota of the analyzed territory before the beginning of anthropogenic activity

The need for model reconstructions of the Pleistocene climate, the time of great productivity of prehistoric pastures, raises the question of assessing the climate-regulating role of BIOTA as a powerful self-preserving system, the main goal of which is to maintain the sustainable existence of all living beings united in complementary systems by giant herbivores of the mammoth fauna. Although the remarkable achievements of palaeontology allow us to reconstruct the composition and structure of pre-anthropogenic ecosystems, the influence of pre-anthropogenic Biota on the climate has not yet become a relevant topic for researchers, despite some attempts made [73]. These and many other palaeontological data, as well as the data from field observations, raise an extremely important question about the possibility of assessing the sustainable existence of modern Biota and predicting its development under various human influences.

Uncompensated Wurm extinctions are the time of complete destruction of mammoth fauna giant herbivores and destruction of complementary systems of Northern Eurasia

The process during the part of Wurm under consideration was called "uncompensated extinctions" because before that time, according to scientific ideas, one species had gradually replaced other species as part of evolutionary development of the Earth's Biota, whereas the Wurm was characterized by rapid disappearance of a huge number of animal species, mainly giant herbivores of the mammoth fauna, not accompanied by the advent and development of any new creatures. Mass extinction of representatives of the Wurm Biota (animals and plants) began in the late Pleistocene (130 thousand years ago). Most of them date back to the beginning of the Holocene. Scientists disagree on the possible causes of extinction: some of them suppose climate change to be the main cause, whereas others think it was the destruction by human. At the same time, all researchers recognize that the megafauna, i.e. animals weighing more than 45 kg, was particularly affected.

The first researcher to substantiate the conclusion that the *death of ice age animals (Wurm) is a consequence of the activity of primitive hunters* was Alfred Russel Wallace (1823–1913), a British naturalist, traveller, geographer, biologist and anthropologist [88] whose hypothesis was later repeatedly supported by his followers and then widely accepted [89–106]. All together, these researchers showed that the main reason for the collapse of the ecosystems of the "mammoth steppes" was the palaeolithic revolution, when primitive people have mastered the most advanced methods of hunting large and largest animals as the easiest prey for collective hunting. The influence of primitive man was clearly visible during the studies of palaeolithic sites where bones, skins, teeth, and other animal parts were found and dated that had been used for making tools, clothing, household and other utensils, houses, and even jewellery. The same views had been expressed by his predecessors [67–71].

Despite the absence of the data on the productivity of vegetation cover in the late Wurm, the authors drew parallels between the productivity of "mammoth" pastures and modern African savannas based on similar composition of life forms, sizes, and other characteristics of the species that organized and headed the complementary systems of the northern and southern hemisphere. In the context of the analyzed territory, the collected materials showed that in the late Pleistocene, man actively developed the northern regions of the Earth – the sites of this time were found far beyond the Arctic circle, i.e. in the middle Pechora, in the lower reaches of the Aldan and Lena rivers, in the basins of the Indigirka and Kolyma rivers, in Chukotka, Kamchatka, and Alaska [96, 97]. The mammoth fauna of the Novosibirsk Islands which continuously existed here from 55 thousand to 2.9 thousand years ago included mammoths, up to 2.4 thousand years ago – musk oxen on the Taimyr and until the middle ages – horses in the lower reaches of the Kolyma. In general, more than 1.200 sites and locations of the upper Palaeolithic Age are known in Russia and the surrounding territories, many of them are multi-layered. For example, over 20 monuments representing more than 60 cultural layers are known in the Kostenkovsko-Borshchevsky district on the Middle Don. Evidence of the development of a wide variety of territories is also provided by human settlements in the Caucasus and Pamir mountains, in Central Asia and the Middle East. There are known locations in now waterless and desert areas.

The intensity of development of resources in Northern Eurasia in the Upper Palaeolithic is also evidenced by the production of jewellery: necklaces, tiaras, and bracelets; beaded clothing appears; netting, knitting, and, in some areas, weaving become widespread. The first textile samples are 26 thousand years old. They were found in the sites in Moravia (Central Europe). Nettle and hemp fibres were the raw materials for the first textile.

At the same time, the rite of burial is being formed, the most famous point being the Sungir site [94] in Vladimir Oblast, discovered in 1955. Data on food, clothing, and tools of labour and hunting, as well as on the manufacture of jewellery, indicate favourable climatic conditions for the humans inhabiting the territory of Northern Eurasia in the late Wurm – the last and one of the most severe glacial eras according to glaciologists.

In addition to the diversity of the animal world, which is clearly revealed during studies of sites, palynologists highlight the diverse nature of the flora. Modern tundra, steppe and forest species were found in the same spore-pollen spectra of the late Pleistocene [92, 99].

According to researchers, the Wurm is characterized by a small share of pollen from trees and shrubs and a large share of herbal pollen, mainly from the grass, goosefoot, and pink families, as well as from the *Artemisia*, *Ephedra*, *Dryas* genera, etc. [102]. Among trees, the r-strategy species – representatives of the genera Betula, Salix, Pinus, etc account for the maximum share of pollen in the spore-pollen spectra. According to the researchers, the main feature of the Wurm nature is the predominance of non-forest landscapes and the predominance of grasses in the vegetation cover. It should be noted that ideas about the impact of key Wurm species on vegetation cover and the formation of late Pleistocene landscapes resulted from using the biological and ecological analogues method [96–98] which became possible due to in-depth study of the environment-transforming role of the African elephants and other savanna dwellers.

The huge environmental impact of herbivorous species of the mammoth fauna (and, first of all, the mammoth itself) suppressed the development of trees on uplands creating advantages for grasses [99, 100]. The late Pleistocene vegetation cover was not similar to the modern one: open spaces were combined with forest areas, while ecotone communities were widely represented. According to palaeontologists and zoologists, cryogenic steppes of Northern Eurasia in the Wurm era were inhabited by the trogonterium mammoth, Khazar mammoth, southern elephant, cave lion, cave bear, Etruscan rhinoceros, woolly rhinoceros, saiga, and Equus latipes. Forest-meadow complexes were inhabited by the elk, red deer, wolf, wolverine, brown bear, reindeer, Arctic fox, Siberian and hoofed lemmings, elephant, forest wolf, and European bison.

55 thousand to 9 thousand years ago the Novosibirsk Islands were home to the trogonterium mammoth, Khazar mammoth, southern elephant, cave lion, cave bear, Etruscan rhinoceros, woolly rhinoceros, saiga, up to 2.4 thousand years ago – to the horse, up to 2.9 thousand years ago – to the musk ox and other large animals [58, 59, 71, 72]. Forest-meadow complexes: the elephant, forest wolf, brown bear, red deer and European bison. To date, these data have been recorded in the works of palaeontologists and reflected in map material, which allows us to estimate the losses of Biota species in Northern Eurasia and, first of all, of the mammoth fauna giants.

The influence of the primitive man on Biota was discovered by analyzing bones, integumentary tissues, the contents of stomachs, as well as clothing and utensils made from animal skins, bones and teeth. At the same time, studies by palaeontologists of houses, utensils, weapons for hunting, etc. clearly explain the so-called "uncompensated Wurm extinctions" paradox. In the harsh environment of the Pleistocene described in numerous writings the productivity of "mammoth" ecosystems that fed megafauna, which was ecologically similar to the African one, is quite surprising. Since such productivity cannot be explained by modern ideas about the "possibilities" of prehistoric ecosystems, it is called a "tundra steppe paradox" or a "prehistoric pastures paradox " [92, 93]. **This name suggests that researchers, having opted for incredible narrow-*mindedness, simply did not take into account the huge palaeontological data on the almost complete destruction of mammoth fauna giants in the northern hemisphere.***

This scientific "blindness" is especially ironical at the present time, when the vast world literature testifies to the mass destruction of giant herbivores of the northern hemisphere whose organizing role determined the huge productivity and territorial dominance of forest-meadow-steppe complexes of complementary systems headed by giant herbivores that were almost completely wiped out at the first stages of the development of the appropriating economy. The integration of palaeontological data and reconstruction of the ranges of animals and plants resulted in quite a reasonable assumption that the appearance of the belt of dense forests in the analysed area during the late Pleistocene – first half of the Holocene is the result of the death of the giant herbivores of the mammoth fauna; and the formation of modern natural systems resulted from the conversion of ranges and total or partial destruction of key plant and animal species due to anthropogenic influences [86, 87, 106, 107].

Conclusion to part 1

Almost complete destruction of giant herbivores of the mammoth fauna has led to catastrophic events listed below:

1. Changes in the temperature range of complementary systems due to the termination of the warming effect of huge herds of giant herbivores of the mammoth fauna and a significant reduction in the warming effect of soil Biota, primarily due to the disappearance the excrements of large herds of animals which were the most important resource for its sustainable functioning.

2. Reduced soil fertility due to the lack of excrements of giant herbivores as well as the degradation of the soil biota complex.

3. Decreased productivity of herbal complexes due to the absence of giant herbivores, whose saliva stimulated tillering and regrowth of grasses, as well as due to the lack of biogenic elements getting into the soil with excrements.

4. Changes in the size and boundaries of the ranges of animals, plants, fungi and representatives of other kingdoms due to changes in the local climate caused by the destruction of giant herbivores.

5. Replacement of complementary systems with the dominance of herbs which are the main food of herbivores by the systems with the dominance of trees and shrubs which grow slower and therefore make such systems unsuitable (or hardly suitable) for the remaining herbivores.

Thus, the spontaneous development of the Biota of Northern Eurasia ended during the late Pleistocene – early Holocene when the appropriating economy led to significant degradation of the Biota as a whole. At this stage, the natural development of the Biota stopped, and a close look at the palaeohistory of individual fragments of the Biota, described as "natural zones" revealed that they are anthropogenically determined formations at different stages of degradation.

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