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The current forms of nature use either disturb or destroy natural ecosystems, the functions of which create and stabilize environmental conditions suitable for human life. The authors of this article propose to switch from the strategy of intensive consumption of natural resources to an economic model that would maintain natural environmental regulation and ensure the sustainable development of civilization. The environment-oriented concept of nature use developed by the authors is based on the principle that we should first preserve the environment-forming functions of biotic communities and the diversity of living organisms.

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An Environment-Oriented Concept of Nature Use

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Humankind needs food, freshwater, and energy to exist on the earth. These resources are created with the functions of the current biotic communities (for example, soil fertility and pure water) or were created by them in the past (hydrocarbon fuel, the base of modern power production, is a result of the accumulation of organic matter by the biosphere in previous geological eras). The atmospheric composition, stable climate, and other equally important conditions that ensure human life on the earth are also maintained by the communities of living organisms that regulate the balance of biospheric processes. However, the current renewable resources are nearing the upper limit of the biosphere's restoring capacity or, according to some estimates, have even exceeded this limit. It is not by chance that many specialists emphasize the necessity to fundamentally change the strategy of nature use [1–6].

THE LIMITS OF LIVING NATURE'S RESOURCES

Food production is based on agriculture. Agrocenoses occupy about 40% of the land surface today and should be viewed as the currently largest biome of land. Plowing inevitably leads to the development of soil degradation processes, the intensity of which has already reached 13 million hectares a year. The velocity of soil erosion in the agrocenoses is one to two orders of magnitude higher than the velocity of soil formation under natural vegetation [7–9]. Over the past 40 years, increase in crop yield has been determined by the intensification of agricultural production due to the use of fertilizers, pesticides, and herbicides, as well as to irrigation, which was accompanied by increase in energy and water consumption and environmental pollution. In particular, nitrogen and phosphorus flows in land ecosystems have increased two to three times as a result of the use of fertilizers [7]. Thus, the pressure of agriculture on the biosphere embraces not only land but also water and energy resources.

The earliest sources of nutrition for people were products extracted from the natural animal and plant populations (hunting, fishing, etc.); only fish and seafood have preserved their economic significance to date. These resources are being used practically to the full, which is proved by the dynamics of global catch and the state of the main trade hydrobiont species [10, 11]. The aggregate catch of fish from sea and internal water bodies in the late 1990s stabilized at 92–93 million tons a year. This stabilization was determined by a decrease in fishery reserves, the use of which had been growing during the second half of the 20th century and reached an excessively high level by the beginning of the 21st century. If the current scale of the exploitation of global fishery reserves remains unchanged, 80% of the resource taxa of fishes and marine invertebrates may lose their commercial importance by the mid-21st century [11].

During the second half of the 20th century, the consumption of freshwater resources cardinally increased. The volume of water intake from rivers and lakes doubled, and water reserves in storage reservoirs increased by four times (there are more than 45 000 dams with a height of more than 15 m in the world today compared to 5000 dams in 1950). More than 50% of accessible freshwater drainage, including subsurface renewable sources, is used annually, and, as is forecast, water consumption will grow by another one-third by 2025. The growth of water consumption is compensated at the expense of nonrenewable reserves of "fossil" waters, which are largely exhausted; hence, freshwater resources are also nearly exhausted [7, 12, 13]. One-third of the countries in the world experience water deficit; meanwhile, the density of the population in many water-poor regions (in Asia

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first and foremost) is extremely high [14]. It is forecast that water deficit in the world will increase in the near future, which is stressed in the Concept of the Long-Term Socioeconomic Development of the Russian Federation up to 2020.

The water balance of land was radically disturbed by the anthropogenic destruction and transformation of natural ecosystems. For example, forestland has decreased almost two times, and this process continues at a rate of about 7.3 million hectares a year. The majority of the remaining forest areas have suffered a considerable anthropogenic impact: primary and subfossil forests occupy only 36% of the total forestland in the world [15]. Further exploitation of forests (deforestation) is limited by the danger of degradation of their environment-forming functions, although timber resources are far from the critical state today.

Present-day energy resources are mainly fossil fuel, which yields 80% of primary energy production. The aggregate reserves of hydrocarbon fuel, accumulated by the biosphere in previous geological epochs, are still large enough. Energy supply is restricted by the ability of the biosphere to accumulate emissions from fuel combustion. Sixty percent of the increase in the atmospheric concentration of carbon dioxide since the beginning of the industrial revolution in Europe occurred in the last 40 years. A possible warming by 2°C is viewed as the "line of conditional safety." To avoid this, it is necessary to decrease fuel consumption and not to introduce 50% of the explored oil, gas, and coal reserves into commercial use [16]. Thus, energy development is currently limited as a result of the disturbance of natural ecosystems and the decrease in the capacity of their regulatory functions.

With allowance for special attention to global climate change, the majority of recent studies devoted to the functioning of ecosystems are focused on the regulation of carbon turnover. The "carbon function" of ecosystems serves as an integral index of the ratio of the main processes in living systems: photosynthesis and breathing. The natural balance of these processes, as quantitative studies show, has been disturbed significantly by people, and the ability of ecosystems to accumulate the growing anthropogenic emissions of carbon dioxide is, most likely, expiring. In the second half of the 20th century and in the early 21st century, the accumulation of carbon in ecosystems has been growing more slowly than its anthropogenic emission [17]. Despite the increase in the aggregate global indices of photosynthesis activity on land by 3.8% from 1981 through 2003, territories where it is stably decreasing are expanding. In 1991, a decrease in bioproductivity was registered on 15% of land areas, while in the early 2000s, it was on 24% [18].

The unprecedentedly high rates of development of the world economy and global environmental changes in the 20th century have radically changed the world over the last several decades, i.e., during the life of the current generation. From 1960 through 2000, the world's population doubled, from 3 to 6 billion people, and it reached 6.8 billion people in 2009, while the global GDP has increased by almost six times over the same period. Food production increased 2–2.5 times, and primary energy production, 2.9 times [7].

The period of demographic transfer from hyperbolic growth of the population to its stabilization coincides with the radical restructuring of the mechanisms of civilizational development and with qualitative changes in the system of "human being–biosphere" relations. Although the principle of the "demographic imperative" [19] states that this transfer is determined by the self-development laws of civilization rather than by the limited nature of external resources, it is evident today that the exhaustibility of biospheric resources is beginning to affect the further development of civilization.

The resource base of humankind is widening owing to new technology (new energy sources and resource-saving technologies). The "technological imperative" states that population cannot overrun the limits specified by the developed technological niche [20]. Technological innovation was the leading factor of economic growth in the second half of the 20th century: the use of new technologies ensured up to two-thirds of GDP growth in the member countries of the Organization for Economic Cooperation and Development from 1947 through 1973 [7]. However, the development of technology does not remove global environmental restrictions and often even makes them tighter. During the scientific and technological revolution, many new industries appeared; they increased resource consumption many times, as was the case, for example, with such water-intensive industries as nuclear power production and polymer chemistry [12]. The intensification of agriculture increases the "environmental price" for the output of products and the pressure on the environment [7, 9].

The current rate of development of resource-saving technologies is unable to compensate for the anthropogenic pressure on nature. At the same time, the current scientific–technological level of development does not make it possible to ensure a full-scale replacement of natural regulatory mechanisms of the environment by artificial analogs. In particular, no closed system of subsistence has been created so far even for one person or a few people.

Along with the demographic and technological imperatives, the development of humankind is currently determined by the "environmental imperative," described by N.N. Moiseev, because the problem of interrelations between society and nature is becoming a factor that largely shapes civilization.

In the second half of the 20th century, the economy grew and life improved largely by the exhaustion of natural resources and the degradation of the regulatory functions of ecosystems [7]. As for the present day, environmental stabilization and climate change lead to conflict socioeconomic situations in different countries of the world. Climate change is very importance for the prospects of Russia's socioeconomic development and environmental safety, which was stressed in the *Assessment Report on Climate Changes and Their Consequences on Russian Territory* (2008) [21] and in the draft Climate Doctrine of the Russian Federation (2009).

Climatic instability increases the possibility of local and global food crises in the near future. It is forecast that the sustainability of agricultural production will decrease owing to more frequent superhot periods [22], inhomogeneity in precipitation, and increased water deficit, especially in regions where the water-regulating function of natural ecosystems has been weakened [23].

A large-scale decrease in the area of natural ecosystems, accompanied by the destruction of the planet's biodiversity, inevitably leads to a decrease in the regulatory potential [5]. People have already either destroyed or significantly changed half of the productive land ecosystems (territories covered by vegetation), i.e., disabled half of the "biospheric machinery" of environmental regulation. Previously, the consequences of anthropogenic disturbances of ecosystems led to local and regional environmental damage, while today we see global consequences of this process [7, 8].

The Amsterdam Declaration on Global Change of 2001 stresses that, with regard to a number of key parameters, the scale of change in the earth's nature is unprecedented and surpasses the limits registered for at least half a million years. Today, the earth is functioning in a new state, that of the noosphere, as V.I. Vernadsky characterized it in the first half of the 20th century: human activity has become the most important geological factor. The question of singling out a new geochronological era, the Anthropocene, has been actively discussed [24] (note that the concept of the upcoming anthropogenic era, or "human kingdom," were proposed by G. Buffon and L. Agassiz back in the 18th and 19th centuries).

THE SIGNIFICANCE OF ECOSYSTEMS' REGULATORY FUNCTIONS

The resource role of living nature is determined primarily by its environment-forming functions, which balance the global processes of mass–energy exchange; regulate the rates of the biological circulation of matter and energy in the air, water, and land spheres; and create a friendly and stable environment for human life and health. Hence, the only economically justified form of living nature use is preserving and restoring its environment-forming functions, its capacity to reproduce, and its stability under natural and anthropogenic changes. The ideas about the machinery of environmental regulation as a necessary condition of human existence are based, on the one hand, on the global concepts of Vernadsky's biosphere, J. Lovelock's Gaia, and biotic environmental regulation [25] and, on the other, on the environmental studies of regulatory mechanisms inside populations, species, communities, and ecosystems, which made it possible to particularize the ideas about their environment-forming functions.

The main environment-forming functions of natural biological systems and ecosystems are the following:

- maintaining the biogeochemical cycles of matter;
- maintaining the gas balance and humidity of the atmosphere;
- stabilizing climatic indicators (including decrease in the intensity of extreme natural phenomena, such as floods, droughts, heat, hurricanes, and typhoons);
- forming a stable hydrological regime and natural water self-purification;
- forming the biological productivity of soils;
- ensuring biological treatment of organic debris and waste processing; and
- ensuring biological control over communities and species of high economic and medical importance.

Studies into the structural–functional organization of ecosystems' biotic communities show that the stability of natural biological systems and the efficiency of their functions, including environment-forming ones, are determined by diversity at the populational, specific, cenotic, and biospheric levels [5]. Hence, the entire existing biodiversity should be viewed as the key biospheric resource.

From the economic point of view, the destruction of ecosystems and their functions should be viewed as the loss of the main resource funds. In recent years, different countries have been developing mechanisms of including ecosystem functions in the real economy. The World Bank's assessment of the "net national savings" shows that the inclusion of losses associated with the disturbance of natural communities in integral economic indicators can substantially change the countries' national balance [7]. Temporary GDP growth achieved at the expense of excessive exploitation of natural resources leads to losses in the country's natural capital and undermines the possibility of its sustainable development in the future.

THE ENVIRONMENT-ORIENTED CONCEPT OF NATURE USE

The understanding that the planet's resources cannot maintain an unlimited growth of population and its needs was formed long ago. Suffice it to mention the works by T. Malthus, *Dialectics of Nature* by F. Engels, the models developed by J. Forrester and D. Meadows along the lines of the program of the

Club of Rome, and Moiseev's forecasts. The problem was to determine the limit of the biosphere's ability to maintain a definite population and resources for consumption, in other words, to determine "the capacity of the biosphere."

The present-day state of the main biospheric resources, including the natural resource of environmental regulation, shows that humankind has come very near to the limit, although we do not know the precise limits of the biosphere capacity. In particular, despite active studies in climatology, we are unable to give a reliable and clear forecast of the reaction of biota and its carbon-accumulating function to the current climatic trend.

The rate of decomposition of the biosphere exceeds the speed of its cognition. According to some estimates, taxonomists have described about 10–15% of living organisms, and the majority of endangered species remain unknown to science. Some types of ecosystems, such as, for example, the European steppes, are practically destroyed, and their fragments can be found only on specially protected territories. Under these conditions, even in the absence of the precise assessments of the biosphere capacity and forecasts of its development, it is necessary to take radical measures targeted at decreasing the consumption of biospheric resources and restoring natural ecosystems. This position corresponds to the "precautionary approach" formulated in the Rio Declaration of 1992, which envisages effective measures to protect the environment if there are threats of serious or irreversible damage even in the absence of full scientific certainty.

To overcome the current environmental crisis, it is necessary to change both nationally and internationally the existing fundamental approaches to nature use and the priorities in the significance of the regulatory functions of biotic communities. To accomplish this, it is necessary to develop a new concept of nature use, which, in essence, should be environmentally oriented because it primarily focuses on the assessment, conservation, and use of the environment-forming functions of living nature. We merely pose the task of developing such a concept in this publication and propose a version of its main theses as the first step to begin the discussion.

• The key natural resource is entire living nature (communities, species, and populations), whose environment-forming functions regulate environmental conditions and stabilize the balance of the biosphere. This resource should have the status of an economic category.

• Biodiversity serves as the basis of the sustainable and effective functioning of the planet's subsistence biological systems.

• The priority task of controlling natural biological systems is maintaining and restoring their environment-forming functions.

• A system of normative indicators of the environmental state and anthropogenic impact should include the characteristics of the environment-forming functions of natural biological systems. Environmental review of any economic project (including biotechnological and nanotechnological ones) should envisage the assessment of its influence on the environment-forming functions of natural biological systems.

• The task of increasing the output of biological products should be solved primarily at the expense of artificial, environmentally safe, bioproductive systems; the use of the biological products of natural ecosystems (fishery, seafood trade, and timber production) is admissible only if their structure and environment-forming functions are preserved.

The development of a new strategy of nature use should be performed at the state level and should include the legislative, scientific–technological, and research blocks necessary to implement it.

THE SUBSTANTIATION OF THE THESES OF THE NEW NATURE USE CONCEPT

As opposed to other natural resources, the exploitation of which leads to the disturbance or destruction of natural ecosystems, the use of the regulatory functions of biotic communities not only allows but also requires preserving the structural–functional organization of the ecosystems. Since the overwhelming majority of the present-day forms of nature use are associated with the disturbance of natural communities and populations, the questions of how the effectiveness of environment-forming functions depends on the level of ecosystem disturbance and to what degree anthropogenically modified ecosystems may perform environment-forming functions are of fundamental importance. Traditionally, the answers to these questions were sought by specialists in different scientific disciplines (forest science, hydrobiology, soil science, and others); recently, however, they have come to be viewed as an independent integral task.

The general ideas about the role of biodiversity in performing ecosystem functions and changing them in the course of the development of environmental communities make it possible to assume that the exploitation of ecosystems by human beings, associated with the withdrawal of biomass, the disturbance of structure, or transfer to earlier succession stages, weakens the functions of environmental regulation. Numerous studies show that the disturbance of the natural diversity of species leads to a decrease in the majority of the indices of ecosystem functioning [5]. In the course of the succession of environmental communities, the closed nature of nutrition elements reaches its maximum, the mechanisms of biocenotic regulations improve, and the internal environment of the communities stabilizes. Hence, undisturbed climax (mature) communities have the most advanced environment-

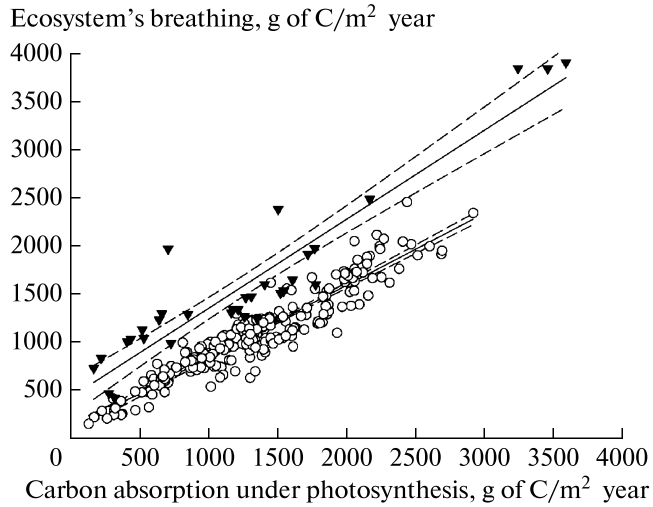

Fig. 1. Carbon release to carbon absorption ratios under respiration and photosynthesis in disturbed and undisturbed ecosystems [27].
The light circlets denote undisturbed ecosystems, and the dark circlets, disturbed ones.

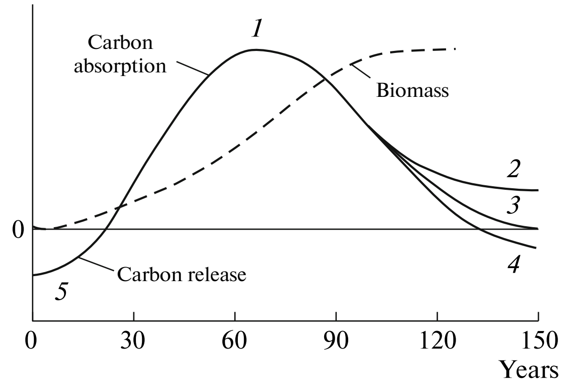

Fig. 2. The perennial dynamics of biomass (dotted line) and carbon accumulation (solid line) under reforestation [32].
(*1*) Maximal velocity of carbon accumulation at intermediate succession stages, (*2*) carbon accumulation by a climax community, (*3*) transfer to carbon accumulation/emission rate balance, (*4*) carbon release under climate and water regime changes, and (*5*) carbon release at early succession stages after logging or a fire.

forming mechanisms. The disturbance of communities most probably leads to a decrease in their environment-forming functions. Similar conclusions may be based on ideas about the role of information in natural ecosystems [1, 25] and about the optimum diversity of biological systems [26].

Below are several examples of the weakening of climate-regulating and water-regulating functions under anthropogenic disturbances of ecosystems.

Carbon cycle disturbances. The role of an ecosystem as a drainage and source of carbon is determined by the ratio of carbon absorption in the course of photosynthesis to the community's aggregate respiration, plus carbon liberation during fires and its anthropogenic withdrawal from this ecosystem. The breathing of natural ecosystems exceeds many times the volume of the entire emission of carbon. The disturbance of vegetation (under deforestation, fires, blowdowns, etc.) and the drainage of waterlogged ecosystems, as a rule, strengthen the processes of organic matter decomposition in soil and mortmass and release carbon dioxide. In land moderate-climate ecosystems, the breathing of the soil reaches more than 50% of total breathing, while the reserve of carbon in soils exceeds several times its content in the phytomass. Hence, the processes in soil should be viewed as a key regulator of the carbon cycle, which has not yet been duly accounted for in calculations. Analyzing data about the flows of carbon dioxide between ecosystems and the atmosphere in different types of the ecosystems in the world clearly shows an intensification of carbon release in disturbed ecosystems compared to undisturbed ones (Fig. 1) [27].

Disturbances in the ecosystem regulation of the carbon cycle are related to changes in the structure of ecosystems as a result of a partial withdrawal of the biomass. It is known that, in the course of environmental successions (successive changeover of communities on a definite territory, such as, for example, under primary soil formation, the restoration of vegetation on cutover and abandoned areas, and reforestation), the cycles of nutrition elements are maximally closed, the mechanisms of biocenotic regulation become diversified, and the community's internal environment stabilizes. Undisturbed climax communities with their most advanced regulatory mechanism can be preserved for an indefinitely long time without external interference.

The reserve of carbon in an ecosystem (biomass, mortmass, soil, peat, or bottom sediments) is maximal in mature communities. Under disturbances of mature ecosystems, associated with the withdrawal of the biomass, they return to the earlier succession stages. A significant part of carbon accumulated in the ecosystem goes into the atmosphere (Fig. 2). After fires, logging, or insect damage, forests become sources of carbon for several years. For example, after large-scale fires in Canadian forests in 2002, carbon emissions exceeded carbon drainage, and it is forecast that this ratio will remain unchanged in the future owing to the increase in the number of fires caused by climate change [28].

It is noteworthy that Russia's forests, as well as its entire territory, remain an accumulator of carbon [30–32], which regulates the gas composition of the atmosphere both continentally and globally. The taiga area of Eurasia is considered one of the main stabilizing

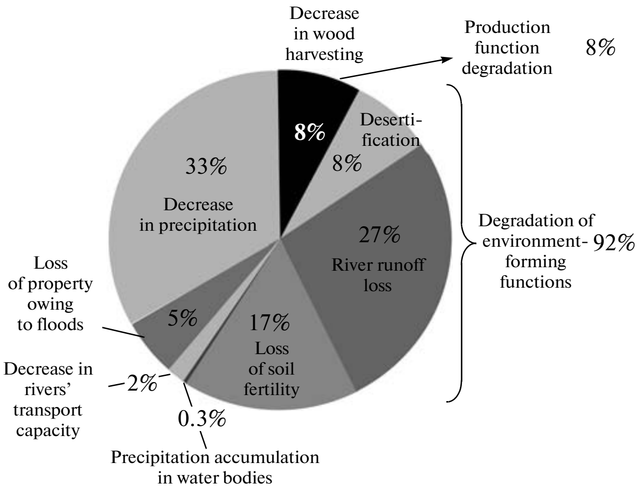

Fig. 3. The structure of economic damage from deforestation in China, early 1990s [37].

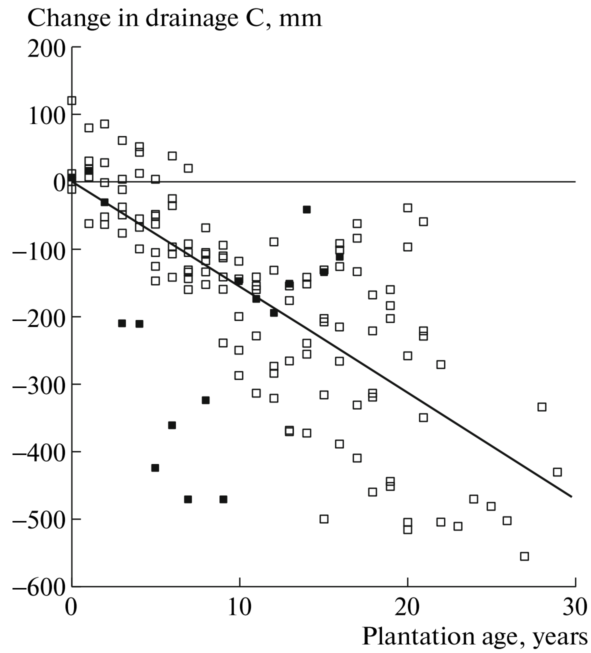

Fig. 4. Changes in river drainage depending on the age of plantations; data based on 26 drainage basins and 504 annual observations [40].

The dark triangles denote eucalyptus plantations, and the light triangles, pine.

centers on the planet along with the tropical forests of Africa and South America.

The largest emissions of carbon take place when the biodynamics of bogs and bogged soils are disturbed. In particular, active peat bog drainage in the Tropics (primarily in Southeastern Asia) in recent years is turning the peat bogs into a powerful source of carbon emissions into the atmosphere [32].

Water regime disturbance of territories. Forests evaporate a huge amount of moisture and form the circulation regime of air masses, precipitation, and temperature regionally, continentally, and globally. They play an especially important role in the formation of the hydrologic regime of even lands situated far from the ocean [33], which was noted back in the early 20th century [34].

It is shown in the example of the Amazon River basin that, under a large-scale deforestation, there is a tendency towards a decrease in river drainage and total precipitation, as well as towards dehumidification and regional warming [35]. As a result of the cumulative action of global climate changes and the economic development of territories, this solid wood, which is the largest in the world, may cross the "boiling point" in the near future, after which the irreversible process of replacing the forest by grassy and savanna-like communities will begin [36]. In China, the large-scale deforestation in the second half of the 20th century caused colossal economic damage (12% of the GDP), which was mainly the result of the degradation of the forests' environment-forming functions, manifested primarily by decrease in precipitation and river drainage (Fig. 3) [37]. Forest devastation on vast territories transforms not only the regional climate but also the global climatic system [38].

The role of bogs in the formation of the hydrological regime is equally important. Bogged forests and rain-fed raised bogs are sources of river and subsurface drainage on plains. They are viewed as priority ecosystems for the regulation of the water regime and the maintenance of water resources [39].

The necessity to account for environment-forming functions in controlling ecosystems. A form of transforming natural ecosystems, such as geoengineering projects targeted primarily against global warming, has rapidly been developing in recent years. This implies fertilizing the oceans, covering glaciers with reflecting materials, increasing the earth's albedo through cultivating definite plant species, cutting trees and bushes in snowy regions, planting forests on deforested areas, etc. In a number of cases, however, attempts to artificially increase bioproductivity and to preserve climatic stability with no account for changes in the entire complex of environment-forming functions of ecosystems lead to additional environmental problems.

A large-scale implementation of geoengineering projects with a lack of knowledge about the interaction between biota and climate and under the absence of reliable forecasts of changes in all the environment-forming functions of ecosystems may lead to unpredictable consequences. We should bear in mind that any changes in the structure of natural biosystems invariably change their regulatory functions. Proceeding from the priority value of the environment-forming functions of natural biosystems, the environment-oriented concept of nature use poses the question of

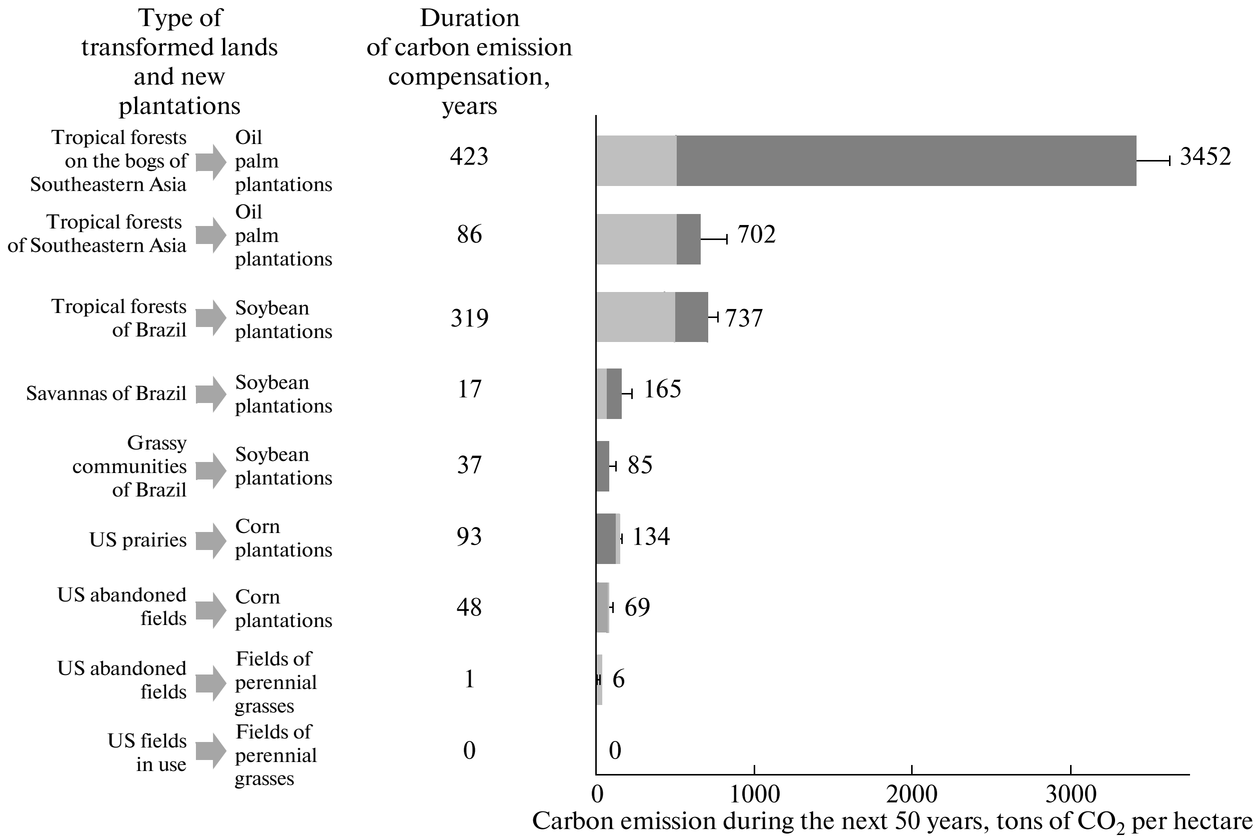

Fig. 5. Carbon release under the transformation of natural ecosystems into biofuel plantations [43].
The dark background corresponds to the level of carbon release from soil and peat, and the light background, to the level of carbon release under the destruction of vegetation.

adjusting the targets of controlling these functions. For example, over the last several decades, different countries have been implementing projects targeted at artificial afforestation to accumulate carbon. Under arid climate conditions, planting rapidly growing wood species alien to a given region has led to a significant decrease in river drainage (Fig. 4) [8, 40]. In a number of regions, such as, for example, in the Republic of South Africa, active works are under way to overcome negative consequences from the spread of alien wood species and to restore the grassy and bushy communities typical of this region [41].

Biofuel production is believed to be a method of solving the climate problem. To accomplish this, plantations of sugarcane (Brazil), oil palm (Indonesia), and other crops are being expanded [42]. However, gas balance studies, performed in different regions (South America, Southeastern Asia, and the United States), show that soils, peat, and the litter emit large amounts of greenhouse gases to the atmosphere where natural ecosystems are turned into plantations. This emission may exceed carbon accumulation tens and hundreds of times in the obtained products, depending on the culture and edaphic–climatic conditions in question. For example, in the Amazonian region and in Malaysia, it will take 300–400 years to compensate for the emission of carbon by the obtained biofuel (Fig. 5) [43].

Russia is developing projects on fuel production from timber and peat (website of the Russian National Biofuel Association). These projects require a special review to assess their impact on the environment-forming function of bog and forest ecosystems. In particular, in planning peat fields, it is necessary to take into account the consequences of the destruction of the water-regulating role of bogs, as well as additional emissions of carbon into the atmosphere, which, most likely, will exceed the “carbon” price of the obtained fuel.

The use of biological resources invariably elucidates the contradiction between the task of obtaining maximally sustainable harvest yield and that of maintaining their environment-forming functions [26]. Strategies of controlling biosystems in these aspects are different. For example, to maximize the withdrawal of biomass from a natural community, optimal are the early and intermediate stages of its succession, which are characterized by high production indicators, while, to preserve the environment-forming functions, undisturbed climax stages are the best. In exploiting individual populations, the strategy oriented to the maximal crop is targeted at the maximal use of its production. This leads to a significant decrease in the energy flow through the population and weakens its ecosystem functions.

Under the resource exploitation of natural biosystems with account for their environment-forming functions, the strategy of control should be combined with the task of obtaining the maximally sustainable crop and the optimal "mixture" of tasks on preserving environment-forming functions and obtaining bioproducts.

At present, a way to overcome the contradiction between obtaining useful production and preserving ecosystem functions is the use of different agricultural and forestry technologies implying a partial preservation or simulation of natural processes (sustainable forestry, "organic" agriculture, adaptive agriculture, etc.) [8]. However, it is still unclear which strategy is optimal: the combination of obtaining useful bioproducts with preserving the regulatory mechanisms of biosystems or the differentiation of these tasks between undisturbed natural ecosystems and high-tech closed productions. Until this question is solved, "environmentally friendly" economic variants will be good for developed territories (for example, the development of sustainable forestry in old forestry regions) but cannot be viewed as a sufficient base to develop undisturbed natural ecosystems.

These examples show the necessity of a complex account for environment-forming functions in exploiting natural ecosystems and populations and creating artificial ecosystems for different purposes.

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The environment-oriented concept of nature use should become a turning point with regard to the natural systems of regulation of biospheric processes formed by the current biodiversity. According to this concept, natural systems are the key biospheric resource that ensures human existence at present and will ensure it in the future.

Russia has the largest potential of natural ecosystems, the environment-forming functions of which are the basis for the regulation of biospheric processes nationally, continentally, and globally. Understanding the value of this global process and including it in the process of planning and economic and political decision making will be an important step to the sustainable development of the national and world community. The environment-oriented concept of nature use is necessary to ensure environmental safety, to improve the life quality and health of the population, and to transfer from the raw material economy to innovative development. This approach will allow Russia to become a leader in the rapidly developing system of international relations in the environmental sphere because, in the future, a country's place in the world rating will largely depend on its contribution to maintaining biospheric balance.

REFERENCES

1. V. G. Gorshkov, A. M. Makar'eva, and K. S. Losev, "A Strategy for the Survival of Humanity Is on the Agenda," Vestn. Ross. Akad. Nauk, No. 4 (2006) [Her. Russ. Acad. Sci. **76**, 139 (2006)].
2. G. A. Zavarzin, "The Antipode of the Noosphere," Vestn. Ross. Akad. Nauk, No. 7 (2003) [Her. Russ. Acad. Sci. **73**, 387 (2003)].
3. M. Ch. Zalikhanov, K. S. Losev, and A. M. Shelekhov, "Natural Ecosystems as a Crucial Natural Resource of Humanity," Vestn. Ross. Akad. Nauk, No. 7 (2006).
4. N. S. Kasimov, Yu. L. Mazurov, and V. S. Tikunov, "The Concept of Sustainable Development: Its Perception in Russia," Vestn. Ross. Akad. Nauk, No. 1 (2004) [Her. Russ. Acad. Sci. **74**, 48 (2004)].
5. D. S. Pavlov and E. N. Bukvareva, "Biodiversity and Life Support of Humankind," Vestn. Ross. Akad. Nauk, No. 11 (2007) [Her. Russ. Acad. Sci. **77**, 550 (2007)].
6. E. D. Sverdlov, "The Return of the Rev. Thomas Malthus," Vestn. Ross. Akad. Nauk, No. 9 (2004) [Her. Russ. Acad. Sci. **74**, 522 (2004)].
7. *Millennium Ecosystem Assessment: Ecosystems and Human Wellbeing: Synthesis* (Island Press, Washington, 2005).
8. J. A. Foley, R. DeFries, G. P. Asner, et al., "Global Consequences of Land Use," Science **309**, 570 (2005).
9. A. A. Zhuchenko, *Ecological and Genetic Basics of Russia's Food Security* (RBOF "Znanie" im. Vavilova, Moscow, 2008) [in Russian].
10. *The State of World Fisheries and Aquaculture* (FAO, Rome, 2008).
11. B. Worm, E. B. Barbier, N. Beaumont, et al., "Impacts of Biodiversity Loss on Ocean Ecosystem Services," Science **314**, 787 (2006).
12. V. I. Danilov-Danil'yan and K. S. Losev, "Water Consumption and Deficit: Envirionmental Aspect," in *Global Environmental Problems of Russia,* Ed. by F. T. Yanshina (Nauka, Moscow, 2008), pp. 5–27 [in Russian].
13. *Global Environment Outlook 4 (GEO4): Environment for Development* (UNEP, Valletta, 2007).
14. *Living Planet report 2008* (WWF–World Wildlife Fund for Nature, Gland, 2008).
15. *Global Forest Resources Assessment 2005: Progress towards Sustainable Forest Management* (FAO, Rome, 2006).
16. M. Meinshausen, N. Meinshausen, W. Hare, et al., "Greenhouse-Gas Emission Targets for Limiting Global Warming to 2°C," Nature **458**, 1158 (2009).
17. J. G. Canadell, C. Le Quere, M. R. Raupach, et al., "Contributions to Accelerating Atmospheric CO_2 Growth from Economic Activity, Carbon Intensity, and Efficiency of Natural Sinks," Proc. Nat. Acad. Sci. USA **104**, 18 866 (2007).
18. Z. G. Bai, D. L. Dent, L. Olsson, and M. E. Schaepman, *Global Assessment of Land Degradation and*

Improvement 1: Identification by Remote Sensing (Report 2008/01) (FAO/ISRIC, Rome, 2008).

19. S. P. Kapitsa, *The Earth's Population Growth Theory: An Essay on the Principle of Demographic Imperative* (Mosk. Fiz.-Tekh. Inst., Moscow, 1997) [in Russian].
20. S. A. Makhov, Preprint No. 63 (Keldysh Institute of Applied Mathematics, Russian Academy of Sciences, 2006), http://www.keldysh.ru/papers/2006/prep63/prep2006_63.html
21. *Assessment Report on Climate Changes and Their Consequences on Russian Territory* (Rosgidromet, Moscow, 2008) [in Russian].
22. D. S. Battisti and R. L. Naylor, "Historical Warnings of Future Food Insecurity with Unprecedented Seasonal Heat," Science **323**, 240 (2009).
23. *Climate Change and Water: Technical paper VI*, Ed. by B. C. Bates, Z. W. Kundzewicz, S. Wu, and J. P. Palutikof (IPCC Secretariat, Geneva, 2008).
24. P. J. Crutzen and E. F. Stoermer, "The Anthropocene," IGBP Newsletter, No. 41 (2000).
25. V. V. Gorshkov, V. G. Gorshkov, V. I. Danilov-Danil'yan, et al., "Biotic Control of the Environment," Ekologiya, No. 2, 105 (1999) [Russ. J. Ecol. **30**, 87 (1999)].
26. E. N. Bukvareva and G. M. Aleshchenko, "The Principle of the Optimal Diversity of Biosystems and Bioresource Management Strategy," in *State Administration in the 21st Century: Traditions and Innovations* (FGU MGU, ROSSPEN, Moscow, 2006) [in Russian].
27. D. Baldocchi, "Breathing of the Terrestrial Biosphere: Lessons Learned from a Global Network of Carbon Dioxide Flux Measurement Systems," Australian J. Botany **56**, 1 (2008).
28. W. A. Kurz, G. Stinson, G. J. Rampley, et al., "Risk of Natural Disturbances Makes Future Contribution of Canada's Forests to the Global Carbon Cycle Highly Uncertain," Proc. Nat. Acad. Sci. USA **105**, 1551 (2008).
29. D. G. Zamolodchikov, A. I. Utkin, G. N. Korovin, and O. V. Chestnykh, "Dynamics of Carbon Pools and Fluxes in Russia's Forest Lands," Ekologiya, No. 5 (2005) [Russ. J. Ecol. **36**, 291 (2005)].
30. *Fourth National Communication of the Russian Federation Submitted in Accordance with Articles 4 and 12 of the UN Framework Convention on Climate Change and Article 7 of the Kyoto Protocol* (Rosgidromet, Moscow, 2006) [in Russian].
31. G. A. Zavarzin and V. N. Kudeyarov, "Soil as the Key Source of Carbonic Acid and Reservoir of Organic Carbon on the Territory of Russia," Vestn. Ross. Akad. Nauk, No. 1 (2006) [Her. Russ. Acad. Sci. **76**, 12 (2006)].
32. J. G. Canadell, D. E. Pataki, R. Gifford, et al., "Saturation of the Terrestrial Carbon Sink," in *Terrestrial Ecosystems in a Changing World (Global Change—The IGBP Series)*, Ed. by J. G. Canadell, D. E. Pataki, and L. F. Pitelka (Springer, 2007), pp. 59–78.
33. V. G. Gorshkov and A. M. Makarieva, Preprint No. 2655, PIYaF RAN (St. Petersburg Inst. Nucl. Phys., Russian Academy of Sciences, Gatchina, 2006).
34. L. S. Berg, *Climate and Life* (Gosizdat, Moscow, 1922) [in Russian].
35. J. A. Foley, G. P. Asner, M. H. Costa, et al., "Amazonia Revealed: Forest Degradation and Loss of Ecosystem Goods and Services in the Amazon Basin," Frontiers Ecol. Environment **5**, 25 (2007).
36. D. C. Nepstad, C. M. Stickler, B. Soares-Filho, and F. Merry, "Interactions Among Amazon Land Use, Forests, and Climate: Prospects for a Near-Term Forest Tipping Point," Philos. Trans. Royal Soc. B: Biol. Sci. **363**, 1737 (2008).
37. M. Yu-shi, N. Datong, X. Guang, et al., *An Assessment of the Economic Losses Resulting from Various Forms of Environmental Degradation in China* (Am. Acad. Arts and Sci., Univ. Toronto, Cambridge, 1997).
38. N. Hasler, D. Werth, and R. Avissar, "Effects of Tropical Deforestation on Global Hydroclimate: A Multimodel Ensemble Analysis," J. Climate **22**, 1124 (2009).
39. *Forests and Water* (FAO, Rome, 2008).
40. R. B. Jackson, K. A. Farley, W. A. Hoffmann, et al., "Carbon and Water Tradeoffs in Conversions to Forests and Shrublands," in *Terrestrial Ecosystems in a Changing World (Global Change—The IGBP Series)*, Ed. by J. G. Canadell, D. E. Pataki, and L. F. Pitelka (Springer, 2007), pp. 237–246.
41. S. Postel, "The Forgotten Infrastructure: Safeguarding Freshwater Ecosystems," J. Int. Affairs **61**, 75 (2008).
42. *The State of Food and Agriculture. Biofuels: Prospects, Risks and Opportunities* (FAO, Rome, 2008).
43. J. Fargione, J. Hill, D. Tilman, et al., "Land Clearing and the Biofuel Carbon Debt," Science **319**, 1235 (2008).