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Biodiversity and Ecosystem Services – Management Principles in the Russia and International Processes

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The collection contains materials of the international conference "Biodiversity and Ecosystem Services – Management Principles in the Russia and International Processes" (Moscow, 19–20.11.2019). Known options for evaluating ecosystem services and biodiversity are discussed, as well as ways to integrate them into natural resource management policy and practical applications.

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Introduction

The conference is organized as part of the TEEB-Russia project, which aims to initiate the formation of an evaluating system for ecosystem services in Russia and integrating their value into the economy and decision-making process. Ecosystem services are defined as all types of benefits that people receive from wildlife, including the maintenance of acceptable environmental conditions, the production of wood, feed and other types of biological resources, and the cognitive, aesthetic and cultural significance of nature. The concept of ecosystem services makes it possible to optimize the use of natural resources, to obtain sustainable benefits from the functioning of ecosystems and not to cause serious or irreparable damage to natural complexes.

Ecosystems and ecosystem services in Russia are of key importance for the well-being of the population and the sustainable economical development of the country's regions. However, today in Russia we observe an unbalanced approach to the assessment and use of ecosystem services, in which priority is given to such forms of natural goods using that give immediate and direct profit – for example, the irrational use of forest resources and profit from the recreational use of natural areas. Such economic practices lead to the degradation of ecosystems and biodiversity, undermining their future ability to perform ecosystem services, including the maintenance of a favorable environment and the sustainable provision of natural biological resources to the population and economy.

The formation of a monitoring and accounting system for ecosystems, biodiversity and ecosystem services in Russia is an important step towards their conservation and sustainable use. The formation of such a system should begin immediately, since many ecosystems and valuable components of biodiversity are rapidly being lost.

Russia has sufficient scientific potential to start such work. The results of the TEEB-Russia project contain the main methodological approaches for the formation of ecosystem accounts in the country within the natural and economic accounting system (SPES), which allows us to start a step-by-step discussion of this issue by interested authorities.

Ecosystem accounts should include indicators of ecosystem health and biodiversity, as well as natural science and economic indicators of the amount of ecosystem services performed by ecosystems and used by people. It is necessary to assess the current changes in these indicators as a result of human activities and forecast of their dynamics in the future under the influence of global climate change.

The assessment of recreational ecosystem services: main approach and first results

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In this study the volume of recreational ecosystem service was calculated through relative natural indicators – approximate norms of the recreational capacity of land cover various types. The aim of the study is to calculate the supplied volume of recreational ecosystem services. The supplied volume is calculated as the maximum number of people who can visit the suburban areas for a short rest (for walking, picking mushrooms and berries, organizing temporary parking, etc.) without harm to ecosystems during the weekend during the year. The suburban area was chosen as a potential weekend recreation area. The size of the suburban area is proportional to the city population (Lappo, 1997): more than 1 million people – 50 km; 0.5–1 million people – 30 km; 0.1–0.5 million people – 25 km. Such size of the suburban area are approximate and can only be used for preliminary studies. Our assessment takes into account the suburban areas around the cities with a population of more than 100 thousand people in the European part of Russia. The study used two territorial units of assessment – 50*50 km squares and subjects of the Russian Federation located in the European part of Russia.

A vegetation map was used to determine the areas of different ecosystems within the territorial units of assessment. The maximum permissible one-time recreational load was calculated on the basis of ecosystem area values. The study used a methodology for calculating the recreational loads on ecosystems outside the city, this methodology approved in the Russian Federation at the state level (Temporary Methodology..., 1987). The methodology takes into account: 1) tourism types (excursions, planned tourism, amateur tourism, mass everyday recreation), 2) type of forest or meadow communities (actually the type of ground cover of natural complexes). We used indicators of mass daily rest for ecosystems. For example, for a dark coniferous forest, the one-time recreational load is 0.7 (person/ha), for a meadow – 2 (person/ha), for a swamp – 0.1 (person/ha). The authors of the methodology explain that the norms of recreational loads can be adjusted depending on the age of plantations, the length of roads and trails, the degree of atmospheric pollution, and other factors. We did not take these factors into account when evaluating the supplied volume. The permissible one-time loads were multiplied by the ecosystem area (within 50-km of squares and subjects of the Russian Federation) and by 7/2 coefficient to calculate the permissible load on the weekend. 7/2 coefficient determines the rest of the weekend.

The results show that Moscow oblast, Perm oblast and the Republic of Bashkortostan are leaders in terms of the amount of recreational ecosystem services supplied. Mixed forests dominate in suburban areas in these regions. This type of forests is characterized by high rates of one-time recreational load. The Moscow oblast stands out especially, as it has the maximum area of the recreational zone around the cities (due to the large number of large cities). The minimum values of the supplied volume of recreational ecosystem services are in the Murmansk oblast and the Nenets Autonomous Okrug, as well as the Republic of Ingushetia and the Kaliningrad oblast. These regions have small suburban areas due to the cities size. These are test results. Of course, it is necessary to take into account land availability for recreation. For example, recreation is not possible on military lands or private enclosed areas. Recreational infrastructure must also be taken into account, as well as forest fragmentation.

Summing up, the entire urban population can have a weekend vacation in suburban areas in almost all subjects of Russia. The volume of services supplied is 2–3 times higher than the urban population in most subjects of the European territory of the Russia. Only in 5 subjects of the Russian Federation – Nenets Autonomous Okrug, Murmansk oblast, Moscow region (calculated together with Moscow), Kaliningrad oblast and the Republic of Dagestan – not all urban population can have a weekend vacation in nature in the suburbs.

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The natural complex of Moscow and the activities of the Moscow city Society for Nature Defense for its protection

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Until 1995, all natural areas of the Moscow city were officially defined as “green spaces”. However, their great value for the human health was not in doubt. In 1995 the concept of a “Natural complex” introduced. “The Natural Complex (NC) is a set of territories with a predominance of vegetation and (or) water bodies, performing mainly environmental, recreational, recovery and landscape-forming functions", i.e. providing ecosystem functions and services or environmental safety. As a whole, the NC forms the ecological network of the city.

The main ecosystem services in Moscow are: regulation of temperature and humidity, noise and wind reduction, dust retention by tree crowns, air ionization, which is especially important for the health of citizens, carbon dioxide and the harmful compounds absorption, oxygen excretion, the formation of the natural environment for animals, the creation of a favorable visual landscape for people and others. For 1 year the city's green spaces (58 000 ha according to satellite imagery) hold 2.3 mln tons of dust, produce 580,000 tons of oxygen, 812,000 tons of carbon dioxide are absorbed, reduce air temperature up to 10ºC and, accordingly, increase the relative humidity up to 10–13 %. The amount of oxygen released in 1 year absorb a little more 1.9 mln people, or 318,000 cars, and the absorbed amount of carbon dioxide is 11.6 million people, or about 37,000 cars (Minin, 2014). According to climatic indicators, Moscow today seems to be located in the forest-steppe or steppe zone (Isaev, 2005). Ecosystem services of the steppe zone of Russia are $230–385 per 1 ha per year (Tishkov, 2010). The total monetary expression of the "effect of existence" of the Moscow's green spaces by the most approximate estimates is $17,835,000 per 1 ha per year.

Especially protected natural areas (OOPT) are the main part of the NC. Their status is currently determined by the Law from July 6, 2005, "About the scheme of development and location of protected natural areas in Moscow". Moscow has the world's largest urban network of OOPT, with 122 areas with a total space of over 17.5 thousand hectares.

Now there is the distortion of evaluation priorities functions of the green areas of Moscow. Over the past 15 years, more than 100 species of meadow plants and more than 400 species of invertebrates have disappeared from the city (Volkova, 2013). Over the past 10 years, under the pretext of creating "comfortable" conditions of life, many destructive projects for the natural ecological framework were implemented Moscow and are ruinous for its budget. They can be classified as "environmentally harmful subsidies" that discourage sound environmental management practices (TEEB, 2009).

The organization of new protected areas has practically stopped, and the changing of legislation and environmental management started after 2010. In 2012 the protected areas were allowed to build sports, recreation and social facilities. In 2013 a number of them were transferred to the Ministry of culture. In 2018 the Department of environmental protection subordinated to the Department of Housing and communal services. On July 2017, the law on renovation was adopted. As a result, Moscow may lose about 2.7 thousand hectares of trees ($48,154,500,000 per year). Moreover, the parts of the protected areas are regularly withdrawn for construction of buildings and urban infrastructure (metro, highways, etc.). Over the past decade, Moscow's natural heritage has suffered huge losses, which were enormously expensive for its budget and taxpayers. Moscow city Society for Nature Defense, forming in 2011, conducted a lot of public environmental expertises of urban planning, were held two major scientific and practical conferences, a series of hearings in the Moscow State Duma, published hundreds of materials in the media etc. As a result, reconstruction plans in some protected areas were revoked. Thousands of Muscovites find out the truth about threats to their natural heritage and violations of their right to a favorable environment.

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Reliability of statistics and environmental protection

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Quite often, researchers make conclusions based on statistical or other generalized digital data provided by Government agencies. However, reliability of the data used in this case usually is not evaluated, analyze of inaccuracy of the Russian “environmental” statistics indicators was very limited.

Such problems are often caused not by intentional misrepresentation of the data (although this element is sometimes present in enterprises' reporting on environmental impacts), but by a lack of interest and absence of approaches that allow for appropriate assessments.

Considered indicators. For understanding and qualitative assessment of the situation, we considered individual statistical indicators of water pollution, air pollution, waste generation, forest fires. In addition, single parameters related to economic data and public administration were evaluated.

Naturally, not all aspects related to environmental protection were investigated. However, according to the author's opinion, existing research outcomes are quite demonstrative and allows one to give certain preliminary estimates.

Some examples. It is impossible to make a general assessment of the reliability of statistical information. It depends on the parameter itself – and even for the same type of parameters (for example, statistics on the discharge of various substances by enterprises) it can be completely different. Some results of pollution measurements, information from reports of economic entities, data from government agencies (except for directly pollution measurement data), certain elements of financial, regulatory and other information of an "administrative" nature are presented below.

Oil spills and their release to the environment. According to Roshydromet[1] (based on measurements of concentrations of oil and oil products), the northern rivers transport about 200–300 thousand tons of oil and oil products per year through cross-sections closest to the Arctic Ocean. This is significantly less than the amount of oil that pollute the environment as the result of spills – since a significant part does not reach the water body, and even less is reaching the remote cross-section). At the same time, according to the reports of the oil companies, publishing this information, about 2 thousand tons of oil fall into the environment over the year. Thus, we can talk about more than 100-fold "inconsistency".

Waste. According to the 2017 State report on environmental protection, about 38 billion tons of waste was accumulated in the Russian Federation, and 3.2 billion tons were disposed of in 2017. At the same time, according to the authorities of the Krasnoyarsk Krai[2] (province), only outside of organized waste disposal sites in that province there are about 40 billion tons. In the Russian Federation (according to the GRORO[3], the state register of waste disposal sites) 18 billion tons of waste were disposed only in 2017. This database contains disposal amounts data only about part of objects; approximation to all objects allows one to estimate in 35–41 billion tons the total mass of waste disposed annually in 2017–2018. Thus, the "inconsistency" is about 10 times.

Total nitrogen discharge data. According to 2017 State Report, total annual nitrogen discharge was 28.5 thousand tons, and ammonium nitrogen – 55.5 thousand tons. However, ammonia nitrogen is considered as part of the total nitrogen. The problem in accounting of nitrogen discharges is obvious.

Elements of financial and regulatory information. Fee for the emission of dioxins in 2016–2017 was 12.8 rubles per ton. At the end of 2017, it was raised by billion times.

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[1] Russian Federal Hydrometerological Service.

[2] State Budget Entity "Center of realization of activities on nature use and environment protection" of the provincial Ministry of ecology and rational nature use (ГБУ "Центр реализации мероприятий по природопользованию и охране окружающей среды" Министерства экологии и рационального природопользования края).

[3] According to November 2019 data.

Subsidies to manufacturers of wheeled vehicles during past few years for unclear reasons were included in the Federal Budget in expenditures section "Environmental Protection". These subsidies account for approximately 60 % of the specified budget section and should not be included in environmental expenditures. Therefore, the real budget is not more than 40 % of the declared. Thus, the "inconsistency" is at least 2.5 times (since other "non-subject" expenses are included in this section).

For 29 carcinogens out of 50, the MPCs[1] (which are currently in force in the Russian Federation) exceed the acceptable risk level (1.0E-4), for seven of them that excess is more than 100 times.

Other indicators. Without going into details, one can note problems with the reliability (and/or accuracy) of such data as emissions from mobile sources (also due to deficiencies in the officially approved methodology), the inconsistency of measurements data from Rospotrebnadzor[2] and Roshydromet, the difficulty of comparison of generalized hydro biological data on pollution (due to changes in the sets of studied cross-sections), etc.

Conclusions:

1. A number of statistical and other generalized digital data provided by state bodies[3] are contradictory, data obtained by different methods and/or from different sources can differ by tens or hundreds of times.

2. In order to be able to use the generalized statistical and other considered digital indicators without doubt, it is necessary to conduct their research in order to assess reliability and / or accuracy.

3. Within this context, use of any indicator is acceptable only after assessing the adequacy of its "measurement"[4] (i.e., is the process of "measurement" taking place; and which parameter is actually measured).

4. Usage of the measured indicator theoretically, requires estimation of error. However, such estimates are extremely difficult for the generalized parameters related to the state of the Environment and its protection. Therefore, at present it is advisable to compare its values obtained from various sources[5] to make a decision on the usage of the indicator.

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[1] Maximum Permissible Concentration.

[2] Russian Federal Service for Surveillance on Consumer Rights Protection and Human Wellbeing.

[3] Data related to the Environment and its Protection.

[4] E.g. data on budget expenditures.

[5] For example, Roshudromet and Rospotrebnadzor.

Pilot economic assessment of ecosystem services and ecosystem assets in the TEEB-Russia project

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As part of the second stage of work on the TEEB-Russia project, a methodology for economic assessment of ecosystem services (ES) and assets was proposed, taking into account the socio-economic and natural-territorial features of Russian regions A preliminary economic assessment was conducted for the following ES categories (Bukvareva, Zamolodchikov, 2018):

– production services;
– regulatory services;
– recreational services.

The necessity of a special approach to the economic assessment of ES is dictated by the presence of externalities (external effects) in the economy and by market failures for environmental goods and services The methodological basis of the assessment is the concept of overall economic value, which allows us to determine the direct and indirect cost of using ecosystems, the cost of deferred alternatives and the cost of existence (Economics of Preservation..., 2002).

To determine the cost indicators of ES, it is advisable to use the methods developed by the TEEB project (2008–2014), the World Bank, and the OECD (Dixon et al., 2000) as a result of many years of practical research in the field of environmental impact assessment.

Methods can be merged into three groups:

1. Methods based on market prices.
2. Methods based on the prices of surrogate markets, or methods of identified preferences (replacement costs; transport and travel costs; preventive costs; hedonistic methods).
3. Methods of declared preferences (willingness to pay or willingness to receive compensation for a specific change in the quality of the environment).

The first group of methods mainly helps to determine the direct cost of use (production services), while the methods of identified and declared preferences are suitable for evaluating regulatory and cultural services (indirect cost of use), as well as the cost of existence. The cost of a deferred alternative can be represented as discounted benefits, or Net Present Value (NPV), from using the ES in the future.

According to our estimates, the main part of the total cost of ecosystem services in the country is regulatory services, more than 90 %. Production and recreation services make up a small part of the total cost, less than 6 % and less than 1 %, respectively. The greatest contribution is made by regulating the carbon cycle, which was estimated by the market price method applied to the global carbon market, and regulating the runoff volume, water treatment by land and water ecosystems, which was estimated by the replacement cost method and by water resources reproduction costs. Water erosion prevention and air purification, defined by the prevented damage method, and flood damage reduction by the compensating cost method, accounted for a small portion of regulatory services. The main part of production services is accounted for wood products and natural pasture products, which are calculated using the market price method according to Federal service state statistics data, taking into account the rent approach. Recreational services are estimated by the method of transport and travel costs and willingness to pay. Ecosystem services in value terms contribute to Russia's GDP. The share of ecosystem services in GDP was 1.4–3.5 % of GDP, depending on the estimation method used and the prices applied.

Various approaches to the economic valuation of ecosystem assets were also analyzed, based on the value of ecosystem biological reserves (for production services and carbon) and the value of the provided (potential) and used amount of ES (for regulatory services). The following preliminary estimates were received:

– in terms of biological reserves and potential volume of ES over 10 and 30 years, ecosystem assets are 7 and 12.5 times higher than fixed assets;

– ecosystem assets are 3.2 times higher than fixed assets in terms of the potential volume of ES over 10 years;

– according to the used volume of ES over 10 and 30 years, the share of ecosystem assets is 19 and 58 % of fixed assets.

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The Project TEEB-Russia overview

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The project TEEB-Russia is implemented by the Biodiversity Conservation Center (Moscow) in cooperation with the Leibniz Institute of Ecological Urban and Regional Development (Dresden). The project is commissioned by the German Federal Agency for Nature Conservation (BfN) with funds from the German Federal Ministry for the Environment, Nature Conservation, and Nuclear Safety (BMU). The project is also supported by the Ministry of Natural Resources and Environment of the Russian Federation.

The first project phase (2013–2015) was resulted in the first pilot national assessment of Russia's ecosystem services (ES) in physical terms. Units of assessment were subjects of the Russian Federation. The assessment was based on Rosstat open data and published cartographic and statistical materials. The amount of ES provided by ecosystems (potential volume), the amount of used ES, as well as the degree of ES use and the degree of satisfaction of the need for ES were estimated. Of the 31 services analyzed, 1/3 (11 ES) were quantified, 1/3 (10) were scored, and for the remaining 1/3 of ES, the task of evaluating them in the future was formulated. Based on ES estimates for the subjects of the Russian Federation, approaches to comparing regions and the development of interregional relations in ES use and maintenance were proposed. The results are presented in Volume 1 of the Prototype of the National Report on Ecosystem Services of Russia (Bukvareva, Zamolodchikov, 2018) and on the project website (http://teeb.biodiversity.ru/en/).

The second project phase (2018–2019) is aimed at elaboration of approaches to develop Experimental Ecosystem Accounting within the framework of the System of Environmental Economic Accounting SEEA-EEA (System of Environmental..., 2014), which the Ministry of Natural Resources and Environment and Rosstat are implementing in Russia. In accordance with SEEA-EEA framework, we included in the second phase indicators of ecosystem assets (including indicators of biodiversity), ES and human impact on them. Based on the analysis of these indicators and the relationships between them throughout the country and the European part of Russia, a preliminary methodological basis has been formed for the development of SEEA-EEA in Russia at the national level. A preliminary economic assessment ecosystem assets and services of Russia was also made.

The main conclusions from the TEEB-Russia project now are as follows.

– Ecosystem assets and services of Russia have a crucial influence on people well-being. ES volume is comparable with the needs of the population and the economy, both in physical and in monetary terms. Moreover, the volume of climate regulating ES provided by Russian ecosystems makes Russia a global environmental donor.

– The currently used ES value is several percent of GDP, however, the distribution of this value across regions is extremely uneven and, in many regions, used ES exceed 10 % of GRP.

– A few key ES in some regions of Russia no longer cope with the task of maintaining favorable environmental conditions. Such ES include providing runoff volume by terrestrial ecosystems, water purification by freshwater ecosystems, and air purification by suburban forests.

– The total value of ecosystem assets in Russia, estimated by the stocks of biological resources and carbon and the potential volume of regulating ES for several years, exceeds the cost of fixed assets in the economy. The distribution of the value of ecosystem assets across regions is extremely uneven: in the center and in the south of the European part, the value of ecosystem assets is less than fixed assets in the economy, but in the rest of the country it can be several times higher than fixed assets.

– The preliminary estimates obtained need to be clarified, but they already show the order of magnitude of the possible damage from the degradation of ecosystem assets and services, which can impede economic growth, cause a noticeable decrease in total national wealth and living standards.

– The TEEB-Russia project is fully consistent with the ideology of global and international processes, combining the objectives of biodiversity conservation and sustainable ES use, such as the Convention on Biological Diversity, IPBES, TEEB, and thus, contributes to the advancement of Russia in this field.

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Biodiversity Indicators in the Experimental Ecosystem Accounting in Russia: Experience of the TEEB-Russia 2 Project

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One of the main objectives of the TEEB-Russia 2 project is the development of approaches to introduce Experimental Ecosystem Accounting in Russia (System of Environmental..., 2014), including indicators of ecosystem services (ES) and ecosystem assets (ecosystems). The most important indicator of the "quality" of ecosystem assets is biodiversity, as it plays a key role in the ecosystem functioning and ES provision (IPBES, 2018, Chapter 3).

To solve this problem, an analysis of correlations between indicators of biodiversity, natural conditions, state of ecosystems and ES was made at the national (the whole territory of Russia) and subnational (European territory of Russia (ETR) scales, as well as within individual ecoregions (tundra, northern and southern taiga, mixed forests, forest-steppe, steppe, semi-desert). At the national/subnational scale, both negative (e.g. between species richness of birds and plants and water-related ES) and positive (e.g. between species richness and the degree of anthropogenic transformation of territory) spatial correlations were revealed. How should these correlations be interpreted for decision making? For the given examples: should we expect an increase in water-related ES, if biodiversity declines and should we expect an increase in biodiversity if anthropogenic disturbance increases? In both cases, the answer will be "no", since at this scale correlations do not reflect causal relationships between biodiversity and other indicators but detect simultaneous changes in all indicators along the latitudinal gradient of natural conditions, primarily climatic ones.

It is also shown that relationships between the same indicators can be different at different scales. For example, when switching from the whole ETR to the scale of individual ecoregions, the positive correlation between species richness and the degree of territory transformation increases in the group of weakly-transformed ecoregions (tundra, forest ecoregions and semi-desert), but it disappears in the group of strongly-transformed agricultural ecoregions (forest-steppe and steppe). Obviously, in these regions, the positive factor of simultaneous improvement of natural conditions in parallel with increased ecosystem transformation stops working and negative anthropogenic impact on biodiversity appears. In the group of arid ecoregions (forest-steppe, steppe, semi-desert), the negative correlation between species richness and water-related ES revealed for the entire ETR is replaced by a positive correlation.

Preliminary findings about the use of biodiversity indicators in the Experimental Ecosystem Accounting in Russia are as follows:

– at the national/subnational scale, correlations between biodiversity indicators and indicators of ES and state of ecosystems cannot be a direct basis for decision-making, but they are important for identifying regional specificities;

– monitoring the dynamics of biodiversity indicators at the local and regional levels is extremely important, since at the local level (at the level of individual ecosystems) biodiversity is a key factor in ecosystem functioning and its decrease indicates the degradation of ecosystem functions, and therefore the most important ES;

– interconnections between biodiversity and indicators of ES and state of ecosystems are different at different scales, therefore, solutions developed at one scale (for example, national) cannot be automatically transferred to other scales (for example, local or regional);

– the Ecosystem Accounting in Russia should be regionally differentiated, that is, it should take into account the degree of anthropogenic transformation and natural conditions in the regions, particularly, low species richness in the northern regions do not make them less important for maintaining ES and preserving biodiversity as a whole.

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Logging impact on soils (on the example of the Komi Republic)

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Boreal taiga forests represent the largest biome of the Russian Federation. These forests play the key role in regulating climate on the entire planet. Forest soils contain approximately 30 % of the planetary pool of soil carbon (Scharlemann et al., 2014). Clearcutting leads to significant changes in the forest cover and forest soils. Tree logging is one of the major anthropogenic factors affecting forest soils. Active use of taiga forests began long ago, though the most significant changes in taiga ecosystems took place in the second half of the 20th century, after the appearance of heavy machines for tree felling, skidding, and hauling wood. Technologically, in dependence on the type of wood skidding, the plots differing in the character of the technogenic impact on the ecosystems appear in clearcutting areas. The least disturbed plots are called apiaries. The plots with soil disturbances in the course of skidding (skidding trails or technological corridors) and timber storage and loading are also distinguished. The portion of apiaries, skidding trails, and loading sites reaches about 59–71, 18–29, and 6–15 % of the total logging area.

The restoration of vegetation after clearcutting of coniferous stands proceeds through several stages with changes in the species composition of the trees and dominant plants of the ground cover and corresponding changes in the qualitative and quantitative composition of plant litter coming onto the soil surface (Dymov et al., 2012; Osipov et al., 2019). Microclimatic parameters affecting the regimes of soil functioning are subjected to significant changes on clearcutting plots. The soils of felled areas are generally warmer than the soils under coniferous forests and are characterized by the higher daily amplitude of temperatures (Dymov, Starcev, 2016). Tree felling in the middle and northern taiga of the Komi Republic leads to changes in the ratio between surface and soil runoff and in the hydrological regime of permanent watercourses and chemical compositions of surface waters (Dymov, 2013). Soil changes on physically undisturbed areas differ from soil changes on skidding trails and timber storage and logging plots (Dymov, 2018). Different patterns of successional changes are observed in the strongly disturbed soils of skidding trails and timber storage and loading plots. In these soils, litter horizons are removed under the impact of heavy vehicles. A gradual restoration of the litter horizon takes place upon revegetation of these plots. In most of the types of forests, the soil pH values increase in comparison with those in the native soils (Dymov, 2017).

The character of changes in the morphological and physicochemical properties of the soils of clearcutting areas displays some general regularities and is largely controlled by the specificity of physical conditions of clearcutting areas, i.e., their water regime and their microclimatic parameters. These changes depend on the character of reforestation. The major changes of soils on apiary plots subjected to minimal mechanical disturbances are related to the development of gleyzation and changes in the morphological properties of the litters and upper mineral horizons. The illuviation of organic matter into the upper mineral horizons and the formation of iron and iron–manganic concretions in the soils of clearcutting areas are usually enhanced. The consequences of tree felling can be traced in the soils of post-felling successions for about a century.

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Carbon capture and storage service by ecosystems of Russia

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Carbon sequestration and deposition are among the most important environmental services. Carbon is sequestred, or deposited, in biomass, dead organic matter and soil. We are to consider the distribution of characteristic scales and times for carbon sequestration and deposition in key biomes in Russia: forests, swamps, and grassy biomes (meadows, steppes, and arable land).

Soil is the most conservative carbon storage pool. Thus, in forests with various violations of vegetation cover, the carbon content in the soil changes slightly compared to the biomass pool. The soil carbon pool is replenished from the dead organic pool and decreases due to soil respiration and leaching of carbon from the soil. Over time, biomes such as forests and grassy biomes of non-Chernozem areas establish an equilibrium between carbon input and emission. The exception is the soil pools of swamps and chernozems, which can grow indefinitely, accumulating incoming carbon. In this regard, reservoirs of swamps and chernozems can be considered as places of long-term accumulation and storage of carbon in natural ecosystems. Currently, they make up a pool of about 100 Pg of carbon.

Table

Reservoirs and carbon balance in the main biomes of Russia (Pg C)*

	Forests	Swamps	Meadows, steppes, arable land
Biomass	37,5[1]	0,9[2]	0,0831[3]
Dead organic matter	10,3[1]	–	0,1419[3]
Soil	144,5[1]	84,1[2]–100,9[4]	28[5]
Subtotal	192,3	85,0–101,8	28,225
Budget	0,205[6]–0,546[1]	0,0376[4]	0,092–0,112[3]

* 1 Pg = 10^{15} g

[1] – Shvidenko, Shchepashchenko, 2014; [2] – Songen et al., 2005; [3] – Bazilevich et al., 1988; [4] – Babikov, Kobak, 2016; [5] – Stolbovoy, Savin, 2018; [6] – Zamolodchikov et al., 2013.

Forests have a zero carbon balance in the long term. In other words, all carbon absorbed as a result of photosynthesis returns to the atmosphere during respiration and organic matter destruction, either as a result of slow changes, or abruptly as a result of various impacts (fires, logging, insects etc.). There are no unlimited carbon pools in the modern biota of forest ecosystems.

Considered biomes differ significantly in the rate of reaction to external changes (including climate). Thus, grassy biomes (meadows, steppes, arable land) are the most changeable, where the NPP (Net Primary Production) value and the rate of organic accumulation varies significantly from year to year, depending on weather conditions (Bazilevich et al., 1988). Forests are more conservative. Here, the system's response to external changes requires a significantly longer time-on the order of the tree's lifetime, that is dozens of years. Currently, we are reaping the benefits of reduced forest use in the 1990s and have significant positive carbon runoff to forests, but under all scenarios, runoff will decrease in the coming decades, and it is possible that forests will switch to carbon emissions in the second half of the century.

Finally, the characteristic response time of swamp biomes to climate changes is hundreds of years – this time lag reveals the relationship between the intensity of peat accumulation and climate parameters (Babikov, Kobak, 2016).

In general, with a carbon content in the Earth's atmosphere of about 800 pG (IPCC, 2013), the potential of terrestrial ecosystems in Russia to absorb greenhouse gases is small. However, it is possible to identify tactical and strategic measures for managing Russian ecosystems to mitigate the effects of climate change. Tactical measures include the management of grass and forest biomes. The management of these biomes can lead to rapid changes in the modes of absorption of carbon emissions.

In strategic terms, attention should be paid to swamp biomes, which may be the most significant long-term carbon storage reserve in future centuries.

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TEEB and TEEBAgriFood

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The Economics of Ecosystems and Biodiversity (TEEB) is a UNEP-hosted Initiative that aims to make the values of ecosystems and biodiversity visible so that they are recognized, demonstrated and captured in decision-making. In 2014 TEEB launched the TEEB for Agriculture and Food (‘TEEBAgriFood’) project. TEEBAgriFood provide a comprehensive economic evaluation of the ‘eco-agri-food systems’ complex and demonstrates that the economic environment in which farmers operate is distorted by significant externalities, both negative and positive, and a lack of awareness of dependency on natural, social and human capital. This presentation sets out the detailed rationale for TEEBAgriFood and sets out – using the case of agroforestry – evidence to support our assertion that, once positive and negative externalties are included in assessments, the answer to the question of ‘what is best for livelihoods and biodiversity outcomes?’ also changes.

Air purification ecosystem services of suburban forest in the European part of Russia

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Air purification is among the regulating ecosystem services, playing an important role in the formation of a comfortable and healthy urban environment. The aim of our research is to assess the consumed volume of absorbed pollutants by suburban forests in the European Russia. By the *consumed volume* we mean the percentage of emissions that was removed by vegetation (*supplied volume* divided by *demanded volume* and multiplied by 100 %) (Bukvareva, 2016). The *demanded volume* we equated with cities' emissions from stationary points, since most plants and industrial zones which are considered to be the main polluters, are usually situated within cities. This data was taken from official website of Rosstat (GKS, 2019). To assess the *consumed volume*, we also need the *supplied volume* – a real amount of pollutants the regional forests absorb.

Vegetation does remove air pollutants; however, the efficiency of this function depends on the vegetation health, particularly on the density and condition of the leaf cover (Ahmad, 2014; Chen, 2002). Different trees absorb a different amount of pollutants. Moreover, their resistance to the pollutants also differ. Thus, the species composition is also essential for the accurate results. All these parameters can be assessed by matching NDVI results with field data. Software (like *iTree*) enables to combine remote sensing and field data to provide the most adequate estimation. Programmes like this can calculate the absorption of the most common pollutants, but to do so they require the total tree cover, leaf area index on a daily basis to account for seasonal variability, the hourly flux of pollutants to and from the leaves, the effects of hourly pollution removal on pollutant concentration in the atmosphere and average tree measurements for all species (Raum, 2019). While the method is quite accurate, it is also time-consuming and inconvenient for a large-scale study. Thus, in this research we used (Nowak, 2018) work for Canadian cities to calculate mean values of SO_2, CO, NO_x and $PM_{2.5}$ absorptions by urban forests. At first, all Canadian cities from Nowak's study were divided into five groups, according to dominant forest type: cities with mainly 1) fir and spruce forests, 2) pine and larch forests, 3) broadleaf forests, 4) small-leaved forests and 5) mixed forests. Next, mean absorption values were calculated for each group (tons per ha) and multiplied by area of each suburban forest type in Russian cities. This parameter we received by clipping buffers (from 3 to 20 km depending on the amount of emissions and natural air pollution potential) around cities on a vegetation map.

The results show that in most cities suburban forests perform insufficient absorption of air pollutants, except two cases: Kabardino-Balkaria republic and Kaluzhskaya oblast. The consumed volume there is more than 100 %. It means that emissions in these cities are quite insignificant and vegetation can absorb much more. Excluding Kabardino-Balkaria and Kaluzhskaya oblast, the mean value of the consumed volume is 2.3 %. Out of 55 districts, in 23 forests remove less than 1 %. These disappointing results can be explained by two factors. First, a great amount of emissions from stationary sources. And second, a low share of tree cover within the buffers that we calculated using M. Hansen map. In most cities' buffers the percentage of forests does not exceed 50 %.

To sum up, it should be stressed that there is still a room for improvement in the methodology of this research. However, this relatively simple and quick calculation without field data enable us to get a picture on the situation with ecosystem services in the European part of Russia.

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Landscape geographic zoning methods for assessing ecosystem services

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Zoning for ecosystem services (ES) assessment requires taking into account the critical issues as follows.

ES assessment within administrative borders may result in wrong decisions due to natural heterogeneity of regions and irregular distribution of ES within their limits.

Combination and amount of ES is determined by properties of natural territorial units and can be described within their boundaries.

Combination and amount of ES may depend on geometrical attributes of natural units or their combinations and may differ much depending on their area, configuration and neighborhood.

Combination and amount of ES may be evaluated differently depending on spatial landscape and socio-economic context.

ES assessment requires consideration for scale of demand and spatial occurrence of a specific ES in the region, country, and in the world.

Demand for ES in a region is more or less directly related either to population density or to degree of ES uniqueness in a regional, national or supernational scale.

We distinguish several principal approaches to zoning for ES assessment.

Using administrative units given that evaluation of landscape types contributions to sustainable functioning of the whole area is available. ES value obtained for a region should be corrected in detail over the territory with due consideration for irregular occurrence of landscape types.

Using the units of physical-geographical regionalization identified according to similar combinations of landscape types. Knowing proportions of landscape types with inherent components properties one can evaluate total area of landscape units providing this or that kind of ES.

Basin units with well-pronounced and unidirectional gravity-induced flows of water and other substances. Relevant information about landscape pattern and proportions of land use types allows identifying the specific parts of a basin that are responsible for ES formation to a greatest extent.

The ES concept implies that demand depends on quantitative and qualitative characteristics of human populations. Hence, the zoning procedure should take into account population density, degree of settlements clustering and corresponding infrastructure. It is well-known that districts of ES production and consumption may not coincide in space and be connected by various types of spatial relations (Burkhard and Maes, 2017). Therefore, there is one more specific type of zoning procedure.

Identifying so-called “connection districts” unified by material or intangible flow of ES from production sites to consumption sites. The key approach is to evaluate gradient of some natural property which is oppositely directed in relation to a gradient of a certain social phenomenon.

Since various types of ESs may occur on the same territory in either synergetic or competitive relations we believe that the specific type of zoning is needed as follows.

Identifying regions with uniform types of relations between natural and socio-economic phenomena. The relations may be described by regression methods and classified by values of equations parameters and coefficients of determination. The method of Geographically-Weighted Regression (Fotheringham et al., 2002) is the most relevant tool. By this one can distinguish, for example, regions where arable lands and forests compete for the same landscapes vs. regions where they provide ESs in different landscapes. In the former case proportions of arable lands and forests are positively related but both of them are negatively related to the proportion, say, of mires. The worse drainage, the less is the opportunity for both plowing and cutting, and vice versa. On the contrary, in the other hypothetic region arable lands and forests are negatively related to each other. Hence, a man should decide which land use type has priority since they compete for the same landscape units. Then, the planning decision aimed at enhancing anti-erosion ES involves supporting a certain share of forests among plowed areas.

Specific kinds of zoning are possible based on combinations of digital raster maps which may be composed from vector maps as well. If critical values are known one can determine the share of landscape units which is needed to provide ES. Then the regions differing in gradations may be identified and mapped. For example, anti-erosion ES is characteristic for the forests on the steep slopes, composed of loess-like loams in particular. The units may be ranged according to anti-erosion function of forests based on proportion of such forests in a district.

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Ecosystems of a megalopolis: state regulation dysfunctions

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"...Denn, Herr, die großen Städte sind
verlorene und aufgelöste;
wie Flucht vor Flammen ist die größte, -
und ist kein Trost, dass er sie tröste,
und ihre kleine Zeit verrinnt..."
Rainer Maria Rilke, 1903

Conceptually, at this stage of research, two blocks of important problems have been identified that have a socio-cultural, geopolitical, and taking into account the vast territory of Russia biosphere dimension: development and implementation of strategic research into a risk-based approach (to assess risks and answer to the question “What will happen if...”?) and the problems of uncontrolled growth of cities, especially megacities.

The relevance of the development of scientific research aimed at implementing a “risk-based approach” has increased as a result of the Presidential Decree of 04/19/2017. No. 176 “Strategy for the environmental safety of the Russian Federation” (Strategies for the environmental safety of the Russian Federation …, 2017), as well as “Strategies for the spatial development of Russia” for the future until 2025. according to which the formation of one and a half dozen megacities will continue in Russia.

The project “Big Moscow” appeared in July 2011 due to an increase in the area of the capital by 2.35 times. According to the director of the New York City Department of Urban Planning Purnima Kapoor (Program of the Moscow Urban Forum, 2016), the population of the city did not exceed 8 million people, despite the ongoing implementation of projects for its renovation.

The problems of state regulation dysfunctions are caused by the de-ecologicalization of industrial production and law enforcement practice in the field of implementation of environmental legislation and environmental policy: such an important principle as the priority of public health has fallen out of documents defining environmental policy and law enforcement practice (Federal Law on Environmental Protection, 2006).

During 2001–2006 in Russia, documents of title aimed at optimizing nature and resource use have been approved: “Land Code” – approved on 10/25/2001, “Town Planning Code” – approved on 12/29/2004. “Water Code” – on 06/03/2006, “Forest Code” – on 04/04/2006: according to numerous experts, the burning forests of Russia in the summer of 2010, 2018 and 2019 should be considered as environmental disasters, caused, inter alia, by the implementation of the provisions of the Forest Code.

In the Environmental Doctrine of the Russian Federation (2002), approved by Government Decree No. 1225-r on August 31, 2002, the main factors of the degradation of the natural environment of Russia are the weakening of the state’s management, primarily control, functions in the field of nature management and environmental protection;

The author's project by Professor M. Ya. Lemeshev (Lemeshev, 2017) is one of the ways to overcome the existing dysfunctions in state regulation of the country's development and the problems of uncontrolled growth of megacities.

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Mapping and assessment of ecosystem services in Russia's largest cities: the first results

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In Russia, the study of urban ecosystem services is still at an initial stage. The report aims to give an idea of already developed and applied approaches for assessing ecosystem services of the largest Russian cities with population over 1 million people that concentrate 22 per cent of the country population. According to the existing world practice as ecosystem services of urban ecosystems we understand the benefits or preferences provided to the residents of the city by its green infrastructure (GI). This concept in its content is close to the term's ecological framework and green spaces. Urban green infrastructure is a set of multifunctional interconnected unsealed spaces within the city limits. In the system of urban planning regulation, these territories may have different status and departmental affiliation and their use is regulated by different documents.

The use of ecosystem services assessment methodologies already developed for European Union cities (EEA, 2011) in Russia is limited by the lack of standardized publicly available geospatial data on the status and location of green spaces in cities. Difficulties also arise with the calculation of used ecosystem services. Thus, the lack of adequate information on the attendance of city parks makes it extremely difficult to calculate their real demand by the population, and, consequently, the volume of services used. The absence of adequate assessment of biological diversity does not allow to draw conclusions about the degree of implementation of the environmental function in both urban protected areas and elements of green infrastructure that do not have a conservation status.

Classification and evaluation of urban ecosystem services used in this study corresponds to the generally accepted system of their division into 4 groups but has a certain urban specificity. For example, in cities, air purification services from gas and suspended particle pollution, reduction of heat island influence, noise reduction and provision of recreational facilities are becoming more important.

The first stage of the assessment was the inventory and mapping of elements of the green infrastructure on the basis of existing global geospatial databases (Global Forest Change, 2016) and open geoportals (Open Street Map-OSM), as well as materials of remote sensing of high spatial resolution. Using these sources, maps of the elements of the green infra-structure were compiled for 15 largest cities (except Krasnodar), where the categories of elements of GI with tree and non-tree cover were identified. On the basis of the OSM classification, additional categories suitable for recreational use have been identified.

The calculation of the proposed volumes of ecosystem services was carried out on the basis of the obtained data on the area of GI elements by multiplying them by appropriate coefficients. The proposed volume of air purification was calculated according similar data on canadian cities (Nowak et al., 2018), adaptation to climate change based on empirical indicators established on the basis of data on various cities of Europe and North America (Forman, 2014). The data on the estimated attendance of urban parks and recreational capacity of different types of forests were used to assess recreational. The required volume was calculated on the basis of available statistics on emissions from stationary sources and vehicles, as well as population data.

The results on the ratio of the provided and required volume for air purification services and recreational services, as well as the provided volume for the service of adaptation to climate change and food production are obtained. On the basis of the calculation of the index of fragmentation of elements of green infrastructure the services of biodiversity conservation were assessed. Analysis of remote sensing data in 2000–2016 it allowed to reveal spatial tendencies of change of elements of green infrastructure in connection with the course of processes of urbanization and to express thoughts on influence of these processes on transformation of ecosystem services.

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GIS modeling of intangible environmental services using the example of landscape aesthetic properties: possibilities and problems

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Cultural services are perhaps the most difficult category of ecosystem services (ES) to assess (Costanza et al., 2011), which is determined by the very idea of them as intangible benefits for people provided by ecosystems (Millennium..., 2005).

Indicators of aesthetic ES potentially provided by the landscape can serve as its qualities, affecting the assessment of its beauty by a person. Moreover, any quantitative estimates of these indicators suggest a preliminary solution to the question of what is considered a demanded service (Burkhard et al., 2014).

A key step in the development of quantitative approaches to assessing the aesthetic qualities of landscapes was the recognition that the parameters of landscape mosaics (the so-called land cover) show a reliable connection with the parameters of perception. In other words, landscape metrics (for example, metrics modeled in the Fragstat) directly affect the generalized assessments of landscape beauty.

The development of GIS-modeling has led to the representation of visual basins (viewsheds) which may limit the spatial perception of observer. The volume of aesthetic services provided by landscapes is influensed by the presence of so-called vantage visual points which allow the observer to see objects located inside viewshed. Hence another factor factor in assessing the supplied volumes of landscape aesthetic services is their accessebility.

Assessment of aesthetic ecosystem services in the European part of Russia

As operational-territorial units of assessment, 50*50 km areals were used. To increase the overall accuracy, the initial assessment of a number of parameters (for example, topography) was carried out using viewsheds, and then generalized over a given grid of 50*50 km.

The provided (potential, capacity) volume of aesthetic services was assessed as "objective" aesthetic properties of the landscape inherent in it regardless of the presence of observers. The following indicators were used to assess the aesthetic properties of the landscape:

A) terrain features: Height Above River, Slope, Topographic Openness, Variety of Heights Within Viewshed, Variety of Landform Within Viewshed;

B) aesthetic properties associated with mosaics of land use and land cover: Landcover Types Variance, Patch Size Coefficient of Variance, Area Weighted Mean Patch Fractal.

The terrain parameters were obtained in the SAGA software package on the basis of the publicly available Digital Elevation Model ASTER GDEM 2 and were processed in the framework of a standard algorithm:

deriving a raw thematic raster (for example, a slope) from an original DEM;

classification and normalization of the raster on the 10 intervals selected by the Natural Breaks method;

cleaning and generalization of the raster using the ArcMap tools "focal statistics", "boundary clean" to get rid of "noise";

extraction of raster values for the matrix of viewsheds to obtain an attributed raster of viewsheds;

extraction of the parameter value from an attributed raster of viewsheds with the "zonal statistics" tool (option "median average") for a grid of squares 50*50 km.

The integral aesthetic assessment of the relief was calculated according to the formula:

IRV = LndFV * [(HarVarnce+Slope/100000) + OpenMean)], where:

IRV – Integral Relief Variety,

LndFV – Variety of Landform Within Viewshed,

HarVarnce – Variety of Heights Within Viewshed,

Slope – Variety of Slope Within Viewshed,

OpenMean – Topographic Openness.

The aesthetic significant parameters of the land use mosaic and natural vegetation cover were obtained by modeling in several steps.

1. The original raster of vegetation cover and land use Eurasia Land Cover Characteristics Data Base Version 2.0, which includes 17 types (IGBP Land Cover Legend), has been reclassified into 5 types of landscapes: open natural, open artificial, semi-closed, closed and mosaic landscapes.

2. The eighteen different metrics characterizing the dimension and shape, as well as the overall fractality and fragmentation of the land cover mosaic (the so-called Fragstsat metrics) were calculated In Patch Analysis extension for ArcMAP (using the power of a Windows virtual machine on a Google platform) for more than 2300 squares units (50*50 km).

Based on literary analysis, three metrics that directly determined the aesthetic properties of the landscape were selected: the Variety of Types of Land Cover, the Coefficient of Variability of the Patch Size, and the Weighted Index of Fractality of the Patches.

Integral aesthetic quality of landscape cover and land use (Integral LCVF) was evaluated by the formula:

Integral LCVF = LndCvrV * [(PSCoV / 1000) + AWMPFD)], where

LndCvrV – Landcover Types Variance,

PSCoV – Patch Size coefficient of variance,

AWMPFD – Area Weighted Mean Patch Fractal.

3. At the final step, the integral estimates of the aesthetic quality of the relief were combined with the integral estimates obtained for the vegetation cover and land use mosaic. The resulting distribution of total assessments of the aesthetic

quality of the landscape reflects the advantage of territories with a rugged (usually mid-mountain) topography and pronounced mosaicity with a high degree of participation of semi-open and semi-closed natural types of vegetation.

The used volume of aesthetic ecosystem services (**ES flow**) is defined as the total number of people observing the landscape when they make a trip, relax or just visit a particular area or a different place. It is not possible to make a direct assessment of the volume of **aesthetic ES flow** based on the analysis of media photo services in the framework of this project due to the closed API codes of the corresponding services in Russia.

Nevertheless, as a necessary condition for using the service, we carried out a special modeling of the accessibility parameter within the watersheds, that is, a combination of factors determining the possibility of contemplating the landscape (Burkhard et al., 2014).

Accessibility and ability to contemplate the landscape was assessed based on the following characteristics:

– the sum of the vantage viewpoints occupying the dominant position (on the tops and apical surfaces of positive landforms) within the viewsheds;

– sum of viewpoints located at the intersection of roads with aquatories (rivers, shores of lakes and reservoirs);

– total length of buffer road sections along water bodies;

– total length of the road sections crossing the expressed landforms taking into account their relative value for the aesthetic qualities of the landscape.

The integral assessment of accessibility and observability of landscapes, generalized for squares of 50*50 km, revealed extensive regions in the Northern part of European Russia with high indicators of aesthetic quality however almost inaccessible to observers.

The final combination of estimates of the provided volume of aesthetic services and the possibility of their use can be obtained in various ways. If it is assumed that the possibility of observation is a key factor in perception, then the resulting assessment may be the product of the integral index of aesthetic quality of landscapes and the integral index of accessibility.

Since we were not able to to examine landscape aesthetics through geolocated social media data, a selective calculation of the number of geolinked photo of nature was carried out for separate squares units (50*50 km) in the north, center and south of European Russia. In this way some patterns were revealed:

– the number of photos decreases markedly with distance from cities, and the larger the settlement, the more pronounced this dependence;

– pronounced mountainous and rugged topography increases visibility zones, tracks and points of possible observation, which in turn increases the possibility of using their ecosystem services, despite the physical inaccessibility of some peaks and mountain ranges;

– the north of the mapping territory is characterized by the presence of extensive almost inaccessible areas and areas with zero visibility, which makes the volume of used aesthetic ecosystem services negligible;

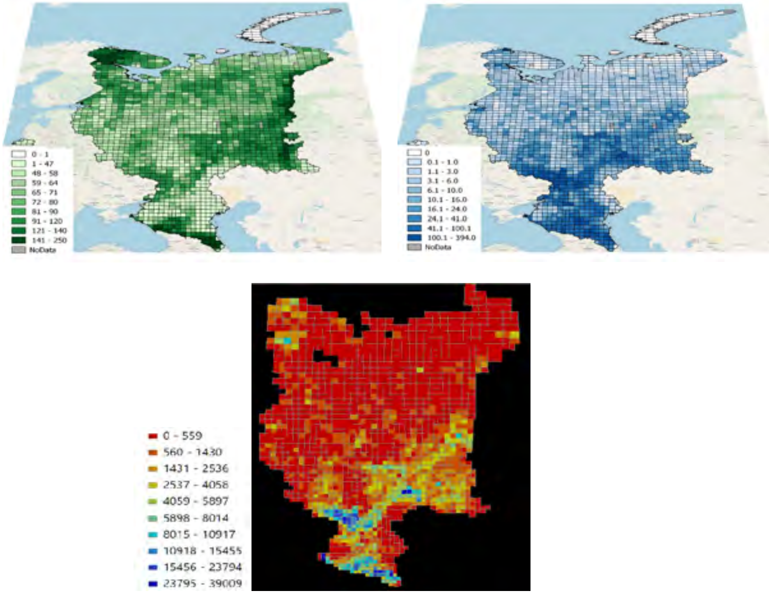

*Fig 1. An overall assessment of the provided volume of aesthetic ecosystems services and the possibility of their use: a) the potential volume of services is an integrated index of the aesthetic landscape quality taking into account the features of relief, vegetation and land use; b) the ability to use services – an integrated index of accessibility and observability of landscapes; c) a generalized index of the volume of services provided and the possibility of their use (*ecosystem service flows)

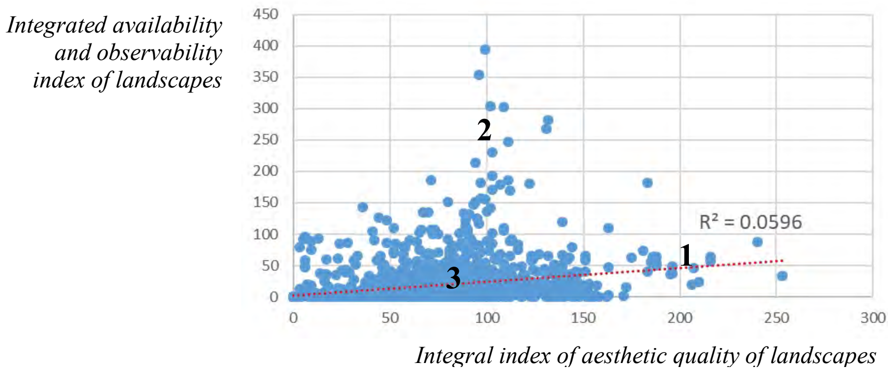

*Fig 2. The ratio between the indicators of the potential aesthetic services provided and the possibility of their use (each point is a separate square of 50*50 km)*

– monotonously plowed agricultural areas with vast fields on a flat topography almost devoid of fragments of natural vegetation also have low rates of current use and rarely become the subject of photographing.

The scale level adopted in this study can be considered as limiting with respect to the validity of the findings. Of course, the larger the scale and the smaller territorial units of assessment, the more correct and interpretable the final result will be.

Estimates of the aesthetic ecosystem services used are difficult to separate from the use of recreationally important components of other ecosystem services, such as clean air and water in recreational areas (the recreational component of regulatory services), mushroom or/and berry picking, recreational fishing and hunting (the recreational component of production services), the ability to observe birds (a recreational component of information services), opportunities for active and extreme tourism, which can be especially important for hard-to-reach areas. In this sense, the methods of simultaneous accounting of recreational and aesthetic components of different ecosystem services categories require improvement both to avoid double counting of the services used, and for their more correct assessment.

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Problems of modeling and assessment of erosion hazard in the calculation of environmental regulating services functions (on the example of the Central Federal district and the European territory of Russia)

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The ability of natural ecosystems to withstand the effects of soil erosion caused by both linear and planar washout is commonly assessed as one of the most important environmental regulating (supporting) services. At the same time, in Russia, the model for calculating soil erosion has not been officially approved, and the comparison of useful world practices has not been carried out.

The classic empirical model of W. Wischmeier is used in Western Europe and North America to calculate current and avoided erosion according to the universal equation of soil losses (USLE, 2008), which takes into account the impact of precipitation, soil erodibility, erosion potential of the relief, the mosaic of land use and the intensity of soil protection management.

In a modified form (Syrbe at al., 2017), the equation is as follows:

W = 0.224 * R * K * LS * C * P, where

W – "annual water erosion", t/ha,

R – rainfall erosivity factor,

K – erodibility soil factor,

LS – topography factor with L – slope length and S – slope steepness,

C – management factor (soil cover),

P – factor of the erosion protection measures (soil protection).

In this paper, an attempt is made to simulate these parameters at two spatial scales and for two types of operational-territorial (spatial) units

For the Central Federal district (CFD) the assessment was carried out on a network of municipalities and rural areas within 17 administrative regions of the Russian Federation, for the European territory of Russia (ETS) – on a matrix of 50*50 km.

The **rainfall erosivity factor (R)** was calculated according to the formula of the Hessian Agency for Nature Conservation, Environment and Geology taking into account the total layer of precipitation for the summer months (RWARM) and the regional coefficient.

The **soil erodibility factor (K)** determined using the Map of Soils Types and table of potential erodibility for the soils with different texture and mechanical composition according to manuals DIN 19708 (2005), Working Group Soil (Boden, 2005), HLUG (2016).

To calculate the **topography (LS) factor** according the Unit Stream Power Erosion and Deposition methodology (USPED) we used a digital elevation model and a watershed`s matrix for European territory of the Russian Federation in the elements of which (third-fourth stream order basins) the parameters of slope length and slope steepness were extracted.

To assess the **land use factor (C) (land cover)**, we used an Open Street Map vector layers (landuse, vegetation, poi-polygon and others), maps for 17 administrative regions of the Central Federal district (CFD). As a result, composite land use mosaics with different C coefficients were obtained (forests, shrubs, meadows and pastures, parks, quarries, urban areas, etc.) and extracted firstly for the watershed matrix, then for the administrative districts.

Management (P) factor calculation was carried out by preliminary extraction of various green infrastructure elements (wood, forest, grassland, meadow, scrub, bush, heath, wetland objects) from the OSM polygonal layers, taking into account their dimension (area and linear length) and the subsequent selection of those elements that are located near field contours.

At the last stage of assessment, three parameters were calculated: referential or potential erosion (Wpot), current erosion (Wact), and prevented (avoided erosion – Wavd) which represents the difference between potential and current (actual) erosion : Wavd = Wpot – Wact.

The obtained results correspond to the values given for local models; for example, in Belgorod region (Smirnova at all, 2012) where the average values of the current erosion approximately 2.5 t/ha, while greatest value along erosion systems more than 15 t/ha.

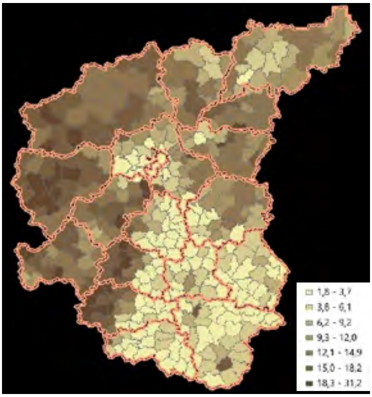

Fig. 1. Potential erosion CFD t/ha per year

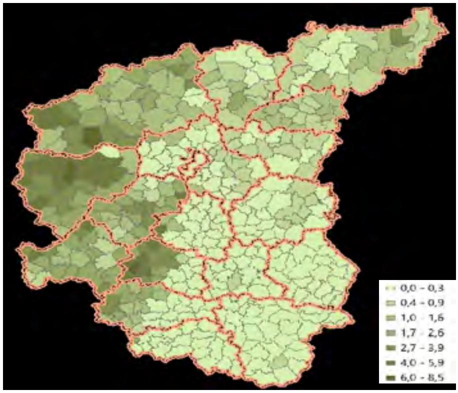

Fig. 2. Avoided erosion CFD t/ha per year

Modeling experience has shown that the potential for optimization of the assessment is associated with a number of steps.

1. For a correct assessment, it is more expedient to use river watersheds as natural operational-territorial units, since it is within the boundaries of the watersheds – from the watershed down to the bottom of the valley – that a regular transformation of the sloping surface runoff occurs, which is directly reflected in the intensity of erosion

2. It is necessary to develop and regularly update to update the database on land use in general and the actual contours of agricultural land – in particular, which will allow accurate assessment of land use (C) factors and the effectiveness of erosion risk management (P) factor .

3. Soil erosion maps should be updated (on a unified classification basis), that, in turn, requires digitization and updating of soil maps of RF administrative regions, which were previously carried out at the scales of 1: 50 000 and 1: 200 000, respectively, and were at the disposal of the former land management committees.

4. For a correct assessment of the topographical LS-factor especially at the regional and local levels not a DEM but the DTM (digital terrestrial model) should be used – for example, commercial ALOS DTM.

5. The model can be improved if additional indicators are included in the assessment, in particular: loss of humus content in percents of the initial one, erosion of soil horizons A-B, degree of erosion of the humus horizon, eroded soil area and ravine dissection. This approach allows, by the way, to monetize this type of ES.

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Economic drivers behind land consumption: empirical evidence from Bavaria (Germany)

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This study aims to quantify the municipal tax-revenue effects of increases in built-up areas. The assumed existence of these effects is one of the key reasons for ongoing land consumption on the part of the municipalities in Germany. Some previous case studies have however suggested that these effects may not be large enough, especially in rural municipalities, and would thus make land development unprofitable. We estimate the effect of built-up industrial and commercial (BIC) area change on business tax revenues in cross-sectional instrumental variable estimations. Based on detailed data for Bavaria, we find that an increase in municipal BIC area has a significant and positive tax-revenue effect. The size of this effect differs sharply between urban and rural municipalities and between cities with different population densities. The positive overall effects become much smaller when large cities are excluded from the sample. Based on these findings, we reflect on the tradable planning permits scheme recently discussed in the literature on land use in the context of policies aiming to limit land consumption. In addition, we relate our estimates to the average municipal costs for land development and undertake a number of robustness checks.

Fires in natural areas of Russia under conditions of changing climate

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The fire season in our country has become year-round, and the number of winter fires has increased. The borders of the fire-prone zone have shifted very much to the North.

The fire season of 2019 was one of the most severe in the entire history of observations, the general trend is rather to increase the number and area of fires.

People's attention to the problem of fires has grown significantly.

As a result of the ban on grass burning, intensive educational work and, in some regions, probably due to an increase in the amount of land involved in agriculture, the number of fires in the spring period associated with grass burning is significantly reduced.

The area of fires is growing in the so-called “control zones” (in territories where active fire control is not conducted).

The absolute majority of fires (even in actively unprotected areas) are caused by human activity (they occur near roads, logging sites, localities and riverbanks).

We see many mechanisms for implementing a positive feedback loop between fires and climate change. This includes carbon dioxide emissions, methane emissions from melting permafrost, deforestation, black carbon emissions, and growing economic burden on preserved forests (when a forest is burned in one place, devastation is forced to shift to another). While changing climate conditions are creating more favourable conditions for the development of fire (increase the duration of the warm period, the growing number of droughts, blocking anticyclones, drying of forests due to shifting habitats of insect pests, etc.). In addition, probably, mechanisms of the influence of fire and weather take place – for example, the formation of storm clouds and blocking anticyclones over the extensive fires, etc.)

We forecast an increase in the number of peat fires in regions where such fires were not previously common. This may affect both previously drained and undrained swamps. This can also be an additional factor that increases the negative climate change and affects people's health negatively.

We are convinced that the problem of fires is extremely urgent, including in connection with climate change (both as the cause of these changes and as their consequence). And the main mechanism for solving this problem can be a change in people's opinions and behavior, a change in accepted norms of behavior, practices in agriculture and forestry. Our country now has a unique experience of combining the efforts of society and the government in this issue, for example, the Federal information campaign against fire "Stop the fire!".

Monitoring bio- geodiversity and ecosystem health by traits, remote sensing and data science approaches

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Ecosystems fulfil a whole host of ecosystem functions that are essential for life on our planet. However, an unprecedented level of anthropogenic influences is reducing the resilience and stability of our ecosystems as well as their ecosystem functions. The relationships between drivers, stress and ecosystem functions in ecosystems are complex, multi-facetted and often non-linear and yet environmental managers, decision makers and politicians need to be able to make rapid decisions that are data-driven and based on short- and long-term monitoring information, complex modeling and analysis approaches. A huge number of long-standing and standardized ecosystem health and monitoring approaches of bio-and geodiversity exist and are increasingly integrating remote-sensing based monitoring approaches. Unfortunately, these approaches in monitoring, data storage, analysis, prognosis and assessment still do not satisfy the future requirements of information and digital knowledge processing of the 21st century. This presentation presents new concepts of monitoring of bio-and geodiversity and discusses the requirements for using Data Science as a bridge between complex and multidimensional Big Data in environmental health.

It became apparent that no existing monitoring approach, technique, model or platform is sufficient on its own to monitor, model, forecast or assess forest health and its resilience. In order to advance the development of a multi-source ecosystem health monitoring network, we argue that in order to gain a better understanding of ecosystem health in our complex world it would be conducive to implement the concepts of Data Science with the components: (i) digitalization, (ii) standardization with metadata management after the FAIR (Findability, Accessibility, Interoperability, and Reusability) principles, (iii) Semantic Web, (iv) proof, trust and uncertainties, (v) tools for Data Science analysis and (vi) easy tools for scientists, data managers and stakeholders for decision-making support (Lausch et al., 2019, 2018, 2016).

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Mapping of ecosystem services in protected areas managed by the FSE "Zapovednoe Podlemorye"

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FSE "Zapovednoe Podlemorye" manages three large protected areas in the northeastern part of Lake Baikal including Barguzinsky State Nature Biosphere Reserve, Zabaikalsky National Park (ZNP) and Frolikhinsky Wildlife Sanctuary. Assessment and mapping of ecosystem services (ES) are seen as a management tool for evaluation of limitations for tourism development based on qualitative ES analysis (Palomo et al., 2015).

The ZNP is a popular tourist destination. At the same time, it is the smallest (269,000 ha) and the least visited (40,000 people per year) of three national parks in the Central Ecological Zone of Lake Baikal Natural Territory. Its compact location and natural mountain and water borders allow keeping most of the land in pristine conditions. A half of territory is under strict conservation regime (strictly protected and protected zones) and the other half is open for recreation and tourism development (recreation, management and extensive traditional land-use zones). However, some natural attractions are located in areas under strict protection (it leads to trespassing) and several recreational sites experience massive tourist impact. Thus, ES assessment and mapping are required for the entire territory to balance visitor flows and enforce conservation efforts.

As a first step, a landcover map corresponding with CORINE international classification and forest inventory database allowed us to divide the territory into deciduous forests, coniferous forests, wetlands, shrubforest, communities, beaches, rock outcrops, sparse forests, burnt areas, agricultural land, urban areas, lakes. An assessment matrix with 31 ES types helped to conduct rapid assessment of the ES and compare different territories (Ecosystem Services, 2017; Burkhard, 2009). However, the landcover did not reflect properties of certain geosystems such as alpine and subalpine landscapes which led to low evaluation of cultural ES there (Istomina, Luzhkova, 2017). As a second step, a set of tourism-related ES was selected for further assessment and mapping based on geosystem maps on a level of group or classes of facies. Following ES were included: regulating (stage of digression, amount of sand in soil), provisioning (stand of timber, biomass production, productivity of berries, herbs, Siberian pine cones), cultural (ground flatness, wetness, presence of beaches, viewpoints, sightseeings). They received a percent, point (0–4) or descriptive evaluation. Four mountain routes with 'high', 'moderate', 'low' and 'no' anthropogenic impact was mapped. ES assessment and mapping showed additional attractive sites and fragile areas where tourist trails should be rerouted. In case of pristine wilderness, the approach helps to make a decision regarding development in the future.

The same method was applied in Davsha Bay, the main ecotourism destination in Barguzinsky Nature Reserve. There we considered supplementary sightseengs and short trails. As a result, ashore area looked more suitable for additional infrastructure development than hills due to possible soil erosion and wildlife disturbance.

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Assessment of pollination ES in TEEB-Russia project, problems with assessment of this service in Russia

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Pollination of crops by wild animals is considered as one of the ecosystem services (Vallecillo et al., 2018).The ability to assess this service is constrained by heterogeneity of the participants – plants and insects (there are no non-insect pollinators in European Russia).

Firstly, different crops depend on cross-pollination in a different extent, because most of them can produce some fruits by self-pollination. Not for every crop grown in European Russia there are relevant (if any) data on their dependence on cross-pollination. Moreover, this dependence is not species-specific and is influenced by environmental conditions and even sorts (Lopatin et al., 2008).

Secondly, many insects from several orders can pollinate flowers including crops. The existing methods of ES assessment are based mostly on bees. Despite they are important pollinators but neglecting other groups should be overcome (Rader et al., 2016). Besides, there is functional diversity even between different groups of bees – even honeybees and bumblebees which are close relatives modify their activities differently on temperature (Nielsen et al., 2017).

The precise evaluation of pollination efficiency of different insect groups on different crops seems impossible due to a large number of factors and assessment of pollination as ES is inevitably based on expert opinions (Vallecillo et al., 2018). However, we believe that we still need more data to make our assessment more robust. Moreover, we need data from European Russia because applicability of assessment methods from other geographical regions is questionable due to differences in climate, soils, insect abundance and agricultural practices.

So, the assessment of pollination ES in TEEB-Russia is rather rough. Demand for pollination was assessed on regional scale based on proportional area of insect-pollinated crops among all cropped land. Supply for pollination (relative pollination potential) was assessed both on regional scale and on scale of 50x50 km^2 quadrates based on area of natural ecosystems adjacent to cropped lands, weighted by supposed bee abundance. Raw data were transformed to scores (low, reduced, increased, and high).

With this rough assessment, it can be concluded that, on the studied scale, pollination ES in European Russia is used quite effectively: both supply and demand for it grow from north to south. This latitudinal gradient is more pronounced in demand and obviously explained by climate. Both supply and demand again decreased near the Caspian Sea due to arid climate. Low supply rather than high demand causes excess or shortage of pollination ES, respectively, in certain regions. Possibly this inconsistency is brought about by a different degree of conservation of undisturbed ecosystems supporting pollinators and underestimation of this factor in the distribution of the cropped areas.

Pollination ES is currently suffering from a global pollination decline. Its reasons are not fully understood and require further study (Vanbergen et al., 2013), but, apparently, the main ones are habitat fragmentation and degradation, as well as the pesticide use.

To improve our supply assessment, more accurate evaluation of bees (and, possibly, other pollinators such as hoverflies) abundance in different ecosystems of European Russia and dependence of their activity on weather conditions is needed. It is worth considering that data over several decades old are most likely irrelevant, since they do not reflect the current situation with the bee communities, which could be affected by climate change, habitat fragmentation and the pesticide use.

To improve our demand assessment, more accurate evaluation of crop dependence on cross-pollination is needed, as noted above. Also use of cultivated honeybees and bumblebees for crop pollination could be taken into account because they can meet the demand to a large extent.

It is worth noting that assessment will remain scored even after such improvement, since obtaining data for taking into account all local characteristics is extremely time-consuming and most likely will not justify the resources expended.

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Valuation of ecosystems and their services in Central Asia

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Central Asia is a vast and diverse region, ranging from Siberian boreal forests to the Caspian Sea and from the Central Asian steppes and deserts to the Tibetan plateau and Himalayan mountain range. Recognised internationally for its species richness and levels of endemism, several of its ecosystems are identified as areas crucial for the conservation of global biodiversity. With several of its ecosystems identified as playing key roles in supporting national economic activities and sustaining livelihoods at a local level identified as under serious threat, it is clear that a 'business as usual' approach is not sustainable for future, or indeed current, generations. In looking for a new approach to sustainably deliver human health and well-being, an approach receiving increasing international attention is that of an ecosystem approach (EA). A framework to engage with environmental values in a more holistic and equitable manner, an EA recognises that ecosystems are fundamental to human health and well-being and that their physical, chemical and biological components are interdependent. However, rather than a new approach per se, an EA can be seen as an approach to support the integration of data from a range of disciplines to inform policy-development and delivery from a more holistic perspective. Current research challenges include the need to develop a detailed understanding of the process and mechanisms through which ecosystem functions link to human health and well-being, and how this knowledge can inform policy development.

In a Central Asian context, the Regional Environmental Centre for Central Asia (CAREC), in partnership with the Norwegian Government, is leading research into the applicability and impact of an EA within the region. Reflecting on activities which commenced in 2008 till 2017, a report with the aim to provide a comprehensive synthesis of CAREC EA activities in Central Asia over the last ten years was developed. It provides a timely opportunity to document experiences and progress made to-date, to develop evidence-based recommendations to enhance the sustainability of EA research and mainstream its use within policy development and practice at a regional and national level. Hence this report provides an independent review of five EA case study areas; two located in Kazakhstan, one in Kyrgyzstan and one in Tajikistan. The case study review process involved a combination of field visits, stakeholder interviews and desk-based review of internal and external project documents. These activities directly informed an assessment of the use of alternative ecosystem service (ES) tools (e.g. payment for ES, ecosystem mapping, economic valuation, engagement of local communities) and identification of regional institutional and legislative conditions and opportunities for the introduction / mainstreaming of an EA in national strategic planning processes.

The results of this independent assessment indicate the potential for an EA to support Central Asia's transition to a more sustainable development pathway. A series of notable successes (the novel use of the payment for ecosystem services and best practice in relation to stakeholder engagement) and areas for further development (need for greater clarity over ecosystem and ES mapping methodologies) are highlighted, and a comprehensive set of recommendations to enhance the delivery and sustainability of an EA within a Central Asia context developed. Key recommendations include the development of common Central Asian ecosystem and ES typologies and scoring systems to support their consistent application throughout the region. A further major recommendation relates to facilitating an EA in practice; the need to map ES terminology to the Central Asian policy sphere, development of policy briefings on the 'what, why and where' of integrating ES knowledge within a range of legislative areas such as national Water Codes, ecosystem monitoring programmes, biodiversity strategies and land use planning frameworks. Such work is urgently required to ensure that developments to-date are consolidated and to begin the process of capacity building within the Central Asian policy and practitioner communities.

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Ecosystem services as a driver for the restoration and wise use of wetlands and peatlands: experience from German-Russian project on peatland restoration

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The restoration of natural ecosystems is an effective means to meet key global targets, such as the Aichi Goals of the Convention on Biological Diversity, Nature-Based Solutions promoted by UNFCCC decisions and the Paris Agreement, and Sustainable Development Goals. Recognizing its high priority, the United Nations General Assembly declared 2021–2030 the UN Decade on Ecosystem Restoration. The restoration, sometimes even creation of ecosystems is becoming a critically important line of action for nature conservation in densely populated regions on a global scale, and in the central and southern regions of European Russia, at national level. Ecosystem restoration (ecorestoration) offers a wide range of social and economic opportunities. The direct benefits of ecorestoration projects are more and more associated with job creation, small businesses and remote areas development. The examples are provided by flagship ecorestoration initiatives launched in Brasil, China, and Africa's initiative of Great Green Wall of the Sahara and the Sahel. The assessment of the indirect benefits of ecosystem restoration connects us to the concept of ecosystem services. Our presentation aims to demonstrate the capacity of ecosystem services assessment for the evaluation of the ecorestoration project effectiveness.

The Russian-German project on "Restoring Peatlands in Russia for Fire Prevention and Climate Change Mitigation" (PeatRus) implemented under the International Climate Initiative is an example of successful efforts of the Russian and German governments, local authorities, research institutions and NGOs. Since 2011, the project has supported peatland management solutions resulted in a notable decrease in fire incidents in a total area of 94,000 hectares in eight constituent entities of the Russian Federation. This includes 64,000 ha of restored hydrological features, with restored peatland ecosystems covering 22,000 ha. The remaining area has been addressed by management and infrastructure solutions.

The costs of ecorestoration activities vary between 30 and 120 EUR per hectare. The average greenhouse gas (GHG) emissions reductions are estimated at 12 CO_2eq*ha*annum based on the preliminary national assessment of GHG emission factors. In the present condition of carbon market remaining underdeveloped, an integrated approach to ecosystem services assessment would help in evaluating the effectiveness of ecorestoration projects. We suggest that the TEEB approach should be applied to the cost-benefit analysis of the 30 implemented pilot projects on peatland restoration. The Ramsar Convention has provided a number of guidelines for specific wetland ecosystem services assessment also tested in peatlands of Russia (Bobylyov et al., 2001; Yampolsky, 2010; Sirin et al., 2010). The concept for peatland restoration targeted ecosystem services discussed recently (Bonn et al., 2016).

The cooperation between the Russian-German projects of PeatRus3 and TEEB-Russia 3 will help to integrate the ecosystem restoration measures into broader economic development and planning frameworks at national and local levels, and to ensure sustainable success and legislative consolidation of this approach. The first stage of such an assessment could be the economic assessment of ecosystem services provided by undisturbed ecosystems, of their losses in the course of ecosystem disturbance, as well as costs-benefits of restoration projects. Based on preliminary discussions, we come up with a proposal to perform cost-benefit analyses for ecorestoration projects giving due regard to the loss/restoration of ecosystem services.

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Indigenous people's concepts of ecosystem services

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At the beginning of the twentieth century, answering the question of the writer M. Prishvin why Lapps are considered nomadic, the Sami reported: *"That's why nomads: ...One lives at the stone, another at the reindeer lichen forest, the third-at the Iron Varaka. In the spring, Lapp fishes for salmon near the rivers, on Elijah's day he moves to the lake, in half of September-again to the rivers… Around Christmas – in the churchyard, in pyrt… They are nomads, because the lappet lives with fish and deer. In hot weather, deer moves to the ocean from the mosquito. The man behind him. So God has shown us, he rules, he is the Creator"* (Prishvin, 1987, p. 229). The quotation reflects the continuous complexity of the use of ES in the Sami, which is based on the features of the local landscape, the change of seasons, observations of the behavior of objects of natural use (deer, fish, birds, animals). Also, using simple examples, the Sami explained their rules for using natural resources: Lapp never takes more fish or poultry from nature than it needs-but for food, it does not touch a bird or animal with offspring, because it is a sin (ibid., p. 242).

After 90 years, the language of the peoples of the North developed a different rhetoric, they needed to protect their right to their native habitat and traditional way of life. But we are talking about ES for the same complex economy. In the early 1990s, the peoples of the North tried, in accordance with legislation, to register their ancestral lands for use as family lands, the boundaries of which were approved by local governments. But the forestry authorities are still trying to remove forest areas from these lands. Explaining to Federal Forestry

Agency that these areas are key to maintaining a traditional way of life, the communities report: *"There, historically, the inhabitants hid from the hot sun and hid their winter deer… And there is another bottleneck in the area of the Mikchangda River, where we drove our domestic deer to other grazing areas when there were domestic deer. Then, in 1971, all the deer were slaughtered in Ust-Avam and all deer herders were transferred to hunters. Now these are places of migration of wild deer and hunting places... these are places of gathering of wild plants (berries, mushrooms, cloudberries, wild onions, sweet herbs)... there is a place of burial, there is a place of worship of spirits. I remember when I was little, my grandfather used to grease several trees with deer and fish oil. We left the sacrifice (the corpse of a domestic deer) to the bear, which protects the spirit of the dead and allows us to cross those places safely, so that children would not get sick... Now we want to domesticate wild deer again"* (from the letters of G.S., Taimyr. OM archive).

In Kamchatka in 1998 to the Governor of the Koryak Autonomous District in compliance with the local law "On territories of traditional nature use in the Koryak Autonomous district", addressed the Council Itelmes of Kamchatka "Tkhsanom", bringing together indigenous communities and veterans villages of Kovran, Ust'-Khairyuzovo, Khairyuzovo, Sedanka, and Tigil, traditionally settled and engaged in economic activities in the territory from the River Amanina to the River Saicic and practicing traditional forms of nature management, with the requirement to create the area of traditional environmental management (hereinafter TEM). In their message, they list the goals and objectives of the TEM: *"ensuring the sustainable use of natural resources of the territory of traditional settlement and natural use of indigenous and local populations; creating conditions for the sustainable development of traditional industry and crafts of indigenous and local populations – river and sea fishing, hunting of marine animals and birds, coastal crab fishing, reindeer husbandry, gathering, gardening, traditional Handicrafts and crafts related to the processing of fur, leather, bone, wood, cutting stones, weaving from herbs, the manufacture of utensils from plant materials, the development of processing industries of traditional products in compliance with nature-saving standards and technologies that ensure the conservation of biodiversity in this territory"* (OM Archive).

L.S. Bogoslovskaya, who has studied the traditional nature management of the peoples of the North for more than thirty years, summed up her observations in her latest work: "The indigenous population of the North over its long history has been able to develop special strategies for nature management that are adapted to the low level of biodiversity and productivity of Northern ecosystems, as well as have increased resistance to sharp negative changes in natural conditions… Traditional communities of the North maintain the level of biological diversity and productivity of ecosystems necessary for their sustainable existence, with the help of spiritual and cultural traditions, as well as appropriate behavior of the entire society and its individual representatives" (Bogoslovskaya, 2015–2016, p. 178).

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Scientific issues connected with aquatic ecosystem services and their valuation: quantitative assessment using the innovative theory of water self-purification

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Introduction. Scientific issues of valuation (assessment) of ecosystem services attracted attention of researchers (e.g., Bukvareva et al., 2019). In this work, a new approach is proposed by the author to the development of an algorithm and the methodology to valuate services of aquatic ecosystems. The new concept that is proposed for this algorithm was described recently in (Остроумов, 2019), considers several factors and components of aquatic ecosystem services. One of the key factors is the function of aquatic ecosystems toward maintenance and improving water quality. This function was analyzed in detail, inter alia, in the author's theory of water self-purification (Ostroumov, 2004).

Methodology. Details and applications of the innovative theory of water self-purification were given in the book (Ostroumov, 2008). This book proposed taking into consideration the cost of those technological devices and processes which are functionally equivalent to key processes of water self-purification in aquatic ecosystems (Chapter 20 of the abovementioned book). This approach leads to new quantitative valuation of services of aquatic ecosystem (see pages 143–145 of this book) the quantitative assessments which this methodology produces are significantly higher than some more traditional assessments. These quantitative assessments are only preliminary estimates which are not final. They do not take into account some additional factors that would increase the final assessment. Therefore the final assessment will be even higher. Another important aspect of the new approach proposed by the author is a more profound understanding of the useful role of almost all biodiversity of water bodies and streams in water self-purification.

Results. A practically important result is a better seeing of new and very convincing arguments in support of necessity of protection of biodiversity of aquatic organisms in water ecosystems. The content and conclusions of the abovementioned book were approved by a number of experts who published favorable reviews of this book (Published Reviews..., 2008; Ermakov, 2009; Kapitsa, 2009; Rozenberg, 2009; Zimnyukov, 2009). The most recent publications confirmed the value of the theory of ecosystem water self-purification (Ostroumov, 2017).

The approach proposed and substantiated in (Ostroumov, 2008) leads to the valuation of ecosystem services of freshwater ecosystem at the level of at least 271–272 dollars per 1 m^2 per 1 year or more than that – see pages 143–145 of Chapter 20 of the book (Ostroumov, 2008).

Biodiversity plays a key role in performing the ecosystem service of maintaining and improving water quality. Almost all functional groups and almost all taxa of aquatic biodiversity contribute to maintaining and improving water quality. These was demonstrated in our publications (Ostroumov, 2004, 2008), and other publications of the author). Therefore, the protection of the biodiversity is an absolutely firm prerequisite and requirement for protection of one of the key water ecosystem services, namely water quality maintenance and water self-purification.

Conclusions.

1. The minimal assessment (estimate) of the cost of aquatic ecosystem services is at least 300 U.S. dollars per 1 square m per year.

2. The protection of the biodiversity is an absolutely firm prerequisite and requirement for protection of one of the key services of water ecosystems, namely the water quality maintenance and water self-purification.

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Remote sensing indication of regulating ES of European plain forests landscapes

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For the part of the Russian Plain with a spatial resolution of 1x1 km, supporting landscape cover services are estimated – energy characteristics reflecting the conversion of solar energy to landscape cover, namely albedo, incoming and reflected solar radiation (W/m^2), absorbed solar radiation, exergy of incoming solar radiation (evaporation costs, W/m^2), the increment of internal energy (accumulation of organic matter), the increment of information on Kulbak, the entropy of the reflected solar radiation dation, normalized differentiated vegetation index NDVI). Additionally, the parameter q, a parameter determining the correlation of the system elements (that is, self-organization), converts solar energy in thermodynamics of non-additive Tsallis systems for twenty terms in the periods 2002–2003 and 2016–2017. For the first time, for the main part of the Russian Plain, morphometric characteristics of the relief were calculated, reflecting the redistribution of moisture heat, for various hierarchical levels with a spatial resolution of 1x1 km. For four terms, the contribution of the relief to the supporting landscape cover services was estimated: energy consumption for evapotranspiration, accumulation of organic matter, biological productivity, and indicators of the structure and organization of the landscape system that transforms solar radiation. Morphometric variables affecting these services and forms of dependence are highlighted. For the first time, the climate regulation service of landscape cover was evaluated for four terms: the contribution of energy characteristics to the spatial variation of the main long-term climate characteristics – climate control of landscape cover – was quantified. On the basis of discriminant and factor analysis, an original method for quantifying the effect of changes in landscape cover on climate and their mapping was developed and tested. The obtained method allows to allocate the territories that are most important for maintaining the climate of the territory and, accordingly, conduct economic activities taking into account the "climatic value" of the territories.

Thus, as a result of the implementation of this project, the assessment of ecosystem services, their long-term dynamics, as well as changes in the landscape structure of the territory over the past 16 years have been carried out and the relationship between these changes and multi-year climate variables has been quantified (climate-regulating ecosystem service). For the spatial resolution of 1x1 km in pixel, the maps of ecosystem services, their dynamics, and maps showing the scale of changes in the equilibrium of the existing land use system, landscape cover and climate variables were obtained for the study area. According to the results of the spatial analysis of changes, areas in which relations in the climate-landscape-cover system have changed their state toward greater or lesser equilibrium are highlighted.

Biodiversity, Ecosystem Services and Natural Capital – Building bridges between policy and science: ecology, economics and accounting

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The presentation aims to lay the bases for the conference from a German perspective and stimulate discussion. Germany has a strong political mandates to carry out work on ecosystem services and natural capital. The Convention on Biological Diversity and the EU Biodiversity Strategy demand related mapping and valuation work and Germany has been involved in TEEB International from the very beginning. Also TEEB Germany, a comprehensive endeavor to showcase the economic values of biodiversity and ecosystem services in different sectors (e.g. business, climate, city, rural areas) has been realized in the past years. In the meantime a focus lies on ecosystem accounting, which is an even broader approach and challenging task, where different actors and disciplines are involved. The presentation concludes that the integration of ecosystems and their services into land-use decisions (TEEB) and into the regional or national accounting systems (NCA) brings added value for nature conservation and sustainable use of natural resources. However, this economic perspective must not lead to economic take-over of nature conservation policy but strengthen legal regulation and foster financial incentives. It will be crucial to bridge policy, science and different scientific disciplines in order to achieve nature conservation goals.

Vascular plants diversity as indicator of ecosystems quality in TEEB-Russia 2

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Although the territory of Russia has a relatively low biodiversity of vascular plants, the flora of many of its regions is poorly studied. Even in Central Russia, herbarium density is 1.5 times lower than the global average. Based on this indicator, as the unit of analysis of floristic information, we took the administrative district. Its area in most regions of the Central Federal Okrug is slightly more than 1000 km^2.

The Central Federal Okrug includes 18 subjects of the Federation. Due to lack of information, we excluded from consideration the Belgorod, Bryansk, Kaluga, Kostroma, Kursk, Oryol, Smolensk, Tver and Yaroslavl provinces. According to Vladimir, Voronezh, Ivanovo, Lipetsk, Ryazan, Tambov, Tula provinces and the Moscow region (Moscow Province and the city of Moscow), there was enough information.

We used all available information for the entire period of floristic research: herbarium collections, published and manuscript materials. The information received before January 1, 1961 had a coefficient of **1**, later – an increasing coefficient of **2**. Also, decreasing coefficients were set for alien plants, including invasive ones, and increasing ones for especially valuable and protected species.

Subsequently, the calculation data were compared with those obtained by the expert judgment method. In most cases, these estimates coincided. However, in 28 % they differed. We think the differences were caused by the following reasons:

1. Incomplete knowledge of the flora of certain administrative regions. However, even in the well-studied Vladimir region, these estimates also did not coincide in 25 % of cases.

2. The ambiguity of different parts of one administrative district. The western part of the Ryazan district is very much anthropogenically transformed, but in its eastern part the nature is slightly disturbed. The city of Yelets is the largest railway junction of the Lipetsk province, however, in this area there are several valuable botanical objects.

3. The study of alien plants and flora of urban areas. The richness of the territory by alien species is affected not only by the degree of its economic development and anthropogenic transformation, but also by the duration and quality of the special study of alien plants. In the Moscow region, the number of detected species of alien plants exceeds the number of species of natural flora. In the Ivanovo region, where the alien plants are well studied, and the natural flora is poor, the calculation data sometimes could not be corrected even by the method of expert judgment method.

4. Features of the study of local flora. With limited periods of work in remote districts, alien plants are often not studied, and the main attention is paid to the search for rare species of natural flora. Some districts are underserved because they lack botanical features. This leads to the incompleteness of the available information on individual regions and an overestimation or understatement of the value indicator of plant biodiversity.

5. Different quality of regional Red Books and monitoring work on the study of protected plant species.

Thus, the analysis of the collected materials showed that, based on the revealed biodiversity of vascular plants at the administrative district level (that is, on an area of approximately 1000 km^2), the environmental value of this indicator cannot always be adequately estimated. This is evidenced by discrepancies in estimates based on the calculation of available data with expert estimates.

On the other hand, when using cells with an area of approximately 100 km^2 (Aleshchenko et al., 1995; Flora…, 2012), the accuracy of the estimate is significantly increased. Although in this case you should be aware that sometimes areas with low biodiversity of vascular plants can have high conservation value.

Unfortunately, the transition to the study of flora by grid mapping in the coming years in most regions of Russia is impossible. This requires a large investment of time and money, as well as a sufficient number of qualified specialists.

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Linking ecosystem services, landscape preferences and human wellbeing: a case study from Belarus

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Much of the current literature relies on expert-led, top-down processes to investigate connections between landscapes and ecosystem services (ES). Little is known regarding the preferences of residents, and how they correlate land covers with the delivery of ES important for their wellbeing. In Belarus, the ES concept has been introduced in the Strategy and National Action Plan on the Conservation and Sustainable Use of Biological Diversity. According to the National Plan for 2016–2020, the national target 2 (corresponds to the Aichi Biodiversity Target 2) includes the measure on Identification of the legal framework for payments for ES (On the National..., 2015; Sixth National..., 2018). The priority in this direction is the adoption of a resolution of the Council of Ministers of the Republic of Belarus on ES (Правовое обеспечение..., 2017).

One of the main tasks of the Strategy (the national target 1 that corresponds to the Aichi Biodiversity Target 1) is to raise the awareness of the general public, professional groups, and state agencies about the values of biodiversity. The implementation of this task requires to fill gaps in the knowledge of various social groups in Belarus. However, national efforts are mainly aimed at informing people through multiple sources. Individual studies on the awareness of the biodiversity values for people in Belarus have not been conducted. The exception is occasional surveys in the framework of various initiatives. One example is Satio studies on the interest of Belarusians in environmental issues (Измерение..., 2017).

This study aims to identify and locate landscapes that provide multiple ES important for human wellbeing in Belarus. Using the approach presented in Elbakidze et al. (2017), we surveyed 403 urban and rural residents in 48 settlements in the Vitebsk region. In the first part of the survey, respondents were asked to rank the importance of the benefits of landscapes for their personal wellbeing. Benefits derived from land covers were presented as a list of ES based on the Millennium Ecosystem Assessment (MA, 2005). Respondents chose almost all ES as important for their personal wellbeing except for several provisioning services (e.g. bio-, wind and ground energy, etc.).

Second, respondents were asked to identify up to eight land covers that provided the most important benefits for their personal wellbeing. A total of 28 land cover types found in the study area were presented as photos. The set of photos captured a land cover gradient from near-natural forests and water objects to agricultural lands and urban areas. After selecting photos, respondents were asked to explain the benefits that each chosen land cover provided for their personal wellbeing. Analysis of the collected data shows that the majority of urban respondents (50 % and more) identified lakes, rural areas, agroforestry, and middle-age pine forests as the most important land covers for their personal wellbeing. Rural respondents chose lakes and agroforestry, and also pasture as the most important. As the undesired landscape, 43 % of respondents saw clear-cut.

Lakes were most often associated with recreation and other cultural services, such as inspiration and sense of place. Fish as provisioning service and some regulating services had been acknowledged as well. Choosing agroforestry, respondents mentioned all kinds of cultural services. The pasture had been selected more often as a source of cultural services and food subsistence agriculture. Rural area was associated with a sense of place and inspiration for rural respondents, while urban respondents mostly use this landscape as "dachas" (recreation and provisioning services). Among the forest landscapes, the respondents more frequently chose pine middle-age forest for provisioning (wild food subsistence, timber) and cultural services.

Summing up, the answers are often declarative, meaning people say some services are important to them, but they don't mention those services when choosing landscapes. This applies mainly to regulating and supporting services that were perceived by the majority of respondents as something evident. As regards cultural services, nature remained an important source of psychological comfort and health for people. Such public surveys help to understand the request existing in the society on ES delivered by specific landscapes. It can be used for adjusting local policies and planning of public services in the region.

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The development of Modern Mixed Methods for economic valuation of ecosystem services

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The importance of ecosystem assessment is articulated by UN Secretary-General Kofi Annan in his report to the General Assembly “The Millennium Ecosystem Assessment”. The report was the first stage of theoretical and practical research on the assessment of ecosystem services. Further efforts in the field of accounting and assessment of biodiversity and ecosystem services have combined fundamental international studies: UNEP, TEEB (2008–2014), the World Bank's Environmental Department, GEF/UNDP projects “Planning for the conservation of biological diversity”, IUCN.

The concept of total economic value has received major development (TEEB, 2010). The concept has been worked out in theoretical and practical terms in various international projects, as well as tested in Russian conditions. To assess ecosystem services, a comprehensive approach is applied that combines all types of ecosystem services: resource, regulatory, supportive and cultural natural services.

Depending on the type and composition of ecosystem services, various assessment methods are used and developed to determine the economic value of ecosystem services and functions that do not have market prices.

The shadow price method uses market prices adjusted for transfers, market failures.

The hedonic pricing method estimates the environmental good at real estate or labor market prices. The method can be used to evaluate regulatory and cultural ecosystem services.

The method of production functions estimates ecosystem services by the mathematical function of changing economic results depending on the growth of resources and services. This method is mainly used to assess regulatory ecosystem services.

The substitute goods and services method estimates an ecosystem service based on prices of similar goods and services with similar market functions

Methods of transportation and travel costs, the method of willingness to pay and willingness to receive compensation are being developed in relation to the assessment of the cultural and recreational functions of the ecosystem. It is assumed that the cost of visiting the natural territory represents the price of the territory. The methods of willingness to pay and willingness to receive compensation are based on identifying people's preferences.

Various approaches have been made to assess the recreational potential of ecosystems. In particular, the recreational services of specially protected natural areas were estimated at the cost of maintaining the areas and the number of visitors to protected areas. As a "proxy" of the value of recreation hotel expenses were offered, calculated at average consumer prices for certain types of cultural and leisure services and the number of visitors.

The results of a study by J. Siikamäki (Siikamäki et al., 2015) seem to be successful. To assess the recreational functions of the ecosystem, the method of transport and travel costs and methods of willingness to pay were used. The annual cost of ecosystem recreational services is estimated by multiplying the forest cover area by value per hectare. In addition to the actual recreation, recreational functions include hunting and amateur fishing. The cost expression of recreational services per hectare of forest for Russia amounted to 1.4 dollars/ha/year or in rubles at the current exchange rate.

Assessing the recreational potential, it is assumed that one tenth of the total area of forest land is intended for recreation. In Russia, with an area of 1184.5 million hectares of forest land and lands of other categories on which forests are located, more than 100 million hectares have recreational value. Then the total assessment of recreational services of forest lands exceeds 10 billion rubles / year. Linking the ecosystem service assessment method with forest area reveals regional differences and efforts to conserve and reproduce forest reserves.

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Experience in assessing Tyumen ecosystem services

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The concept of ecosystem services is currently one of the most actively developing areas of modern world science. After the release of two key collective works – "The Millennium Ecosystem Assessment" (2003) and "The Economics of Ecosystems and Biodiversity" (2010), the assessment of ecosystem services has become an important trend in research.

Ecosystem services are the benefits that humanity derives from ecosystem functions, or the direct and indirect effects of ecosystems on human well-being (Bobylev, Zakharov, 2009). Thus, the concept of ecosystem services seeks to fully identify and assess the diversity of links between human society and the environment.

In preparation for the year of ecology in the Russian Federation in December 2016, at a meeting of the State Council on the issue "On the environmental development of the Russian Federation for the benefit of future generations", a list of assignments of the President of the Russian Federation was approved. One of the tasks (Pr-140GS, p. 1) was the development of an action plan aimed at strengthening Russia's position in the formation of the international environmental agenda, as well as in discussing issues related to the formation of a system of compensation (payments) for ecosystem services, based on an understanding of the role Russia as an environmental donor.

In connection with the introduction of payment mechanisms for ecosystem services and the status of Russia as an "ecological donor' defined at the Rio 10+ Summit in Johannesburg in 2002, the assessment of ecosystem services seems promising (Bukvareva et al., 2015; Bukvareva, Zamolodchikov, 2018). In 2016, the prototype of the national report "Ecosystem services of Russia. Vol. 1. Terrestrial ecosystems services." (Bukvareva, Zamolodchikov, 2018), in which ecosystem services for terrestrial ecosystems of the Russian Federation were assessed. In the prototype of the report, an attempt was made to adapt the approaches and methods for assessing ecosystem services for the conditions of Russia: Russian methods for estimating resource reserves were applied, extrapolated data for the assessment of ecosystem services due to their insufficient completeness, etc.

Studies to determine the feasibility of assessing ecosystem services for the Russian Federation are necessary, since the most commonly used methods for assessing ecosystem services have been developed for Europe and the United States, where natural conditions, the degree of exploration of the territories, accessibility and resolution of primary data for assessment ecosystem services significantly differ from the territory of the Russian Federation.

An assessment of ecosystem services for Russian cities (urban ecosystem services) is characterized by a low degree of studied. Currently, such studies are presented by the assessment of specially protected areas within the city and the translation of foreign experience in the assessment of ecosystem services for Russian cities.

The historical aspect of the formation of the modern appearance and planning system of Russian cities, the high accumulated environmental damage, special climatic conditions, administrative and legislative restrictions (Becker et al., 2012) necessitated the integrated integration of Russian approaches to assessing reserves and resource renewal, environment-forming functions and recreational potential, and world practice according to the assessment of urban environmental services, taking into account the requirements of Russian legislation.

In this regard, the goal of the present study was formulated: an analysis of the scientific papers devoted to the study and assessment of ecosystem services of urban ecosystems, as well as the existing prerequisites for the introduction of an assessment of ecosystem services in the process of Russian urban planning. Example of the city of Tyumen will be used as a case study

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Atlas of Breeding Birds of European part of Russia and testing of its data for the development of bird diversity indicators

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Compilation of atlases is one of the modern methods of fixing the state of fauna in a certain time period. In the end of 1990s, European Bird Census Council (EBCC) has implemented the first large project to create the “European Bird Breeding Atlas” (Hagemeijer, Blair, 1997). At that times, Russia was poorly presented in it. In 2020, the second edition of this atlas will be published under the leading of EBCC, in which gaps in data for the European Russia (ER) was successfully filled. The aim of its creation is to reflect changes that have occurred in about 30 years in the distribution and abundance of breeding birds within Europe.

In Russia, the task has been set of both to present information in a pan-European book and to publish in 2020 the first “Atlas of breeding birds of European Russia” (Kalyakin, Voltsit, 2015). This work is coordinated by the Zoological Museum of Lomonosov Moscow State University, and the work itself is a large-scale scientific and social project, combining the efforts of about 450 researchers – professionals and amateur ornithologists.

Data collection for the atlas throughout Europe is carried out according to a grid of 50x50 km squares (in the Mercator projection). For each of them a list of breeding bird species is compiled, the status of each species is determined (confirmed, probable and possible breeding) and its abundance is estimated on a logarithmic scale (pairs, tens of pairs, etc.). Obviously, the more complete data in such atlases, the more efficiently they can be used, including to evaluate ecosystem services.

The data on 417 bird species in 1628 from 1828 squares of European Russia will be provided in the first Russian atlas. Its publication is the first example of using the established in the Zoological museum of Moscow State University database "Breeding birds of the european part of Russia", which currently includes 166 857 records for 2005–2018 years in 1662 squares. Information from this database, which is most complete at the moment on territory coverage, was selected to develop of indicators of biodiversity and natural ecosystems condition based on bird's data in the TEEB-Russia 2 project.

The development of indicators of bird diversity was carried out on data on 394 species in 1532 squares within European Russia. Additionally, data on Important Bird Areas were used (Sviridova et al., 2016). 8 indicators of bird species diversity and 2 indexes of synanthropization of bird population are suggested. The possibilities of their application at the scales of entire ER, particular ecoregions (Olson et al., 2001) and administrative regions of Russia were investigated.

It is shown that the scale chosen to assess the distribution of bird diversity affects the sensitivity and interpretation of the investigated indicators. As a result, the conclusions obtained by comparing the data for 50 km squares within the ecoregions not always could be applied to the entire area of the ER, and vice versa. Within the ecoregions, more detailed territory zoning is necessary to assess the distribution of birds species diversity. The suggested indicators of synanthropization of the bird population have shown some sensitivity to the level of natural ecosystems transformation, but they need to be further improved. To improve most of indicators a larger set of data on birds, for example on species number and density, is needed. All this requires the establishment and regular updating of databases at the federal, regional and other levels.

In general, obtained results illustrate the need to take into account regional specifics when developing a strategy for monitoring and managing biodiversity and ecosystems.

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Natural Capital Germany: the Implementation of Ecosystem Services in the Frameworks of TEEB, MAES, and SEEA

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The increasing pressure on natural resources and the loss of biodiversity puts the capability of ecosystems at risk to provide the basics of life. The EU Biodiversity Strategy and the international TEEB initiative require to assess ecosystem services, create national maps and monitor occurring changes. Following the first TEEB Reports (The Economics of Ecosystems and Biodiversity), diverse projects at the science-policy interface have further applied and explored a socio-economic perspective on biodiversity and ecosystem services (BES). Over the past decade, national ecosystem assessments have been a prominent approach for mainstreaming concern for intact ecosystems, and for emphasizing the policy relevance of BES research.

Naturkapital Deutschland (2012–2018) was Germany's follow-up to the international TEEB studies (http://www.teebweb.org/countryprofile/germany/). The key focus was on selected societal challenges (climate policy, rural development including agricultural land use, urban development) three main reports and a series of summaries for decision-makers were produced. The aim was to inform decision makers beyond the environmental and nature conservation community, i.e. decision makers from policy fields and sectors potentially causing environmental degradation and the loss of biodiversity, such as agriculture, forestry, traffic, urban planning, building, etc.

To follow the obligations of the EU Biodiversity Strategy 2020 a system of indicators for Germany has been developed. The presentation gives an overview of the ecosystem extent and services indicators for Germany in the context of recent mapping projects. Additionally, it provides the indicator specifications, which are aligned with the EU MAES framework concepts (Grunewald et al., 2017).

The national classification of ecosystems is based on the CORINE Land Cover (CLC) data scheme and considers the European Nature Information System (EUNIS). The ecosystem mapping in Germany make use of the so-called LBM-DE data set, topographical geo-data enhanced by land-use information following to the CLC scheme. The politically most relevant ecosystem services have been selected and assessed by use of quantitative indicators that fit into the EU-wide indicator schemes. The aspects of indicator definition, calculation and coordination with different national experts and authorities will be illustrated using some examples. The German indicator-based approach measures ecosystem services in their spatial expression and temporal change and compares them with specific target values. Many ecosystem services are characterized by a main indicator that captures the essential service and several supplemented side indicators measuring specific aspects. The national mapping and assessment of ecosystem services in Germany is still an ongoing process.

Our economic and social activities are constantly putting pressure on our ecosystems, changing their condition and their capacity to produce the services we desire in a sustainable manner. Against this background, the integration of ecosystems and their services in the national economic accounts seems necessary since it offers considerable potential for improving political steering capacities (Grunewald et al., 2019). Following the international guidelines of SEEA-EEA (System of Environmental Economic Accounting – Experimental Ecosystem Accounting), first monitoring approaches and accounting methods have been elaborated in Germany. Using case studies, the challenges and possible solutions will be shown starting with physical figures and translating them into economic values for ecosystem services. The assessment and valuation methods will be presented by preliminary results.

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Ecosystem assessment and accounting on European Level Approach, Results and Application in Policy

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Establishing a sound method of natural capital accounting with a strong focus on ecosystems and their services is a key objective of the 7th Environment Action Programme (EAP) and of the EU Biodiversity Strategy 2020 as one of its elements. It will help understand better how job creation, economic growth and wellbeing rely on natural capital and will support a number of key strategic EU policies, such as the Europe 2020 strategy.

Action 5 of the EU Biodiversity Strategy to 2020 foresees Member States, with the assistance of the Commission, will map and assess the state of ecosystems and their services in their national territory, assess the economic value of such services, and promote the integration of these values into accounting and reporting systems at EU and national level by 2020.The results of this mapping and assessment should support the maintenance and restoration of ecosystems and their services.

The Working Group on Mapping and Assessment on Ecosystems and their Services (MAES) is steered by the Direction General Environment (DG-ENV), with the participation of the Joint Research Centre of the Commission (JRC) and the European Environment Agency. The MAES analytical framework links socio-economic systems with ecosystems via the flow of ecosystem services and through the drivers of change that affect ecosystems either as consequence of using the services or as indirect impacts due to human activities in general. The MAES is focussing on mapping ecosystem condition and ecosystem services in order to be spatially explicit. Such mapping is done on the basis of the CORINE land cover maps, which are detailed for producing a map of ecosystems from which services can be assessed. Ecosystems condition is specifically addressed in the framework, under the premise that healthy ecosystems (in good status) possess the full potential of ecosystem functions, which also reflects the targets of the environmental directives mainly the Habitat and Bird, the Water Framework and the Marine Strategy Framework Directive. In December 2019, the MAES assessment will provide data for the final evaluation of the EU biodiversity strategy in 2020 and formulation of possible targets for the Biodiversity framework to 2030 and its action plans.

Ecosystem accounts are developed in the EU in the context of KIP INCA, the "Knowledge & Information Partnership for Integrated Natural Capital Accounting" which brings together the European Commission's DG Environment, DG Research and Technological Development, Eurostat and the Joint Research Center (JRC) and the European Environmental Agency (EEA). KIP INCA aims to design and implement an integrated accounting system for ecosystems and their services in the EU by connecting relevant existing projects and data collection exercises to build up a shared platform of geo-referenced information on ecosystems and their services. This system will be consistent with UN guidelines on environmental accounting, in particular the SEEA Experimental Ecosystem Accounting. Two achievements can be mentioned: the land cover accounts produced by the EEA and the Mapping and Assessment of Ecosystems and their Services by the JRC.

The European Environment Agency (EEA) has developed the concept of "ecosystem capital accounting" and published in 2006 the first "Land and Ecosystem Accounts" (LEAC). The first EU 1990–2000 land accounts have been produced for 24 countries on the basis of CORINE Land Cover data. The EEA land cover accounts are updated for 2006, 2012, and 2018 for

39 EEA countries. They are publicly accessible through the EEA website which provides users with a ready-made tool for extracting their own customised land accounts. CORINE Land Cover maps and data have been important for constructing land cover accounts. They describe the geographical patterns of land cover types across Europe, the way they are changing over time and what types of processes are bringing about the various transformations. A typical indicator extracted from land cover account is Urban Land Uptake. EEA land cover accounts correspond to the SEEA Experimental Ecosystem Accounting "ecosystem extent accounts". Complementary accounts cover various land quality issues including land use intensity, fragmentation and partitioning of land, soil sealing or compaction, erosion and soil losses, etc. Detailed land cover accounts contribute to more detailed classification of ecosystems, as the one used in the Mapping and Assessment of Ecosystems and their Services.

Since the 1990s Europe has made substantial contributions to the development of the UN SEEA with particular interest on climate change and biodiversity in the context of sustainable development and EU's global responsibility. The European Union is represented in the UN Committee of experts on Economic Environmental Accounting by Eurostat and the European Environment Agency and several member states. The 2019 new European Strategy for Environmental Accounts and its implementation put the Europe at the forefront of environmental accounting. Europe has played a key role in the development of the 2012 SEEA Central Framework and SEEA Experimental Ecosystem Accounting published by the UN. In support to the Aichi Biodiversity Targets adopted by CBD COP10 in 2010, and in particular of Target 2 which calls for incorporating "biodiversity values into national accounting… and reporting systems", the EEA has supported the publication by the CBD Secretariat of technical guidelines for a quick start implementation of Ecosystem Natural Capital Accounts (ENCA-QSP) in the SEEA context. The EU is also funding Experimental Ecosystem Accounting applications out of Europe, in support to the process steered by UN Statistical Division (NCA&VES, SEEA-EEA tests in Brazil, China, India, Mexico and South Africa), in support to the World Bank's WAVES partnership and other international organisations such as the Indian Ocean Commission (Experimental SEEA/ENCA for Mauritius), IUCN (SEEA/ENCA PAPBio in Western Africa) or WWF (SEEA/ENCA ECOSEO for the Guyana Shield).

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Valdai National Park water-regulating services: assessment of the contribution to the state of the Verkhne-Volzhskaya and Nevsko-Ladoga water systems

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The Valdai upland is one of several global watersheds of the planet that preserve the sources of the rivers of the three seas. The creation of a national park in the center of the “Great watershed” has led to a significant increase in the cost of protecting and monitoring the ecosystems that provide water flow for water consumption in the two capitals of Russia, but this function is not compensated in any way. The costs are high for both the local population and small business, which have significant restrictions on explotation. The cost of ensuring the quality of water in lakes and their runoff is high, and there is a question of compensating the park for these costs. This refers to compensation for ecosystem services – "payments for water services..." (Economics of Preservation..., 2002; Principles and methods..., 2002).

The park has at least *3 lake-reservoir systems* covering more than 50 lakes (out of almost 200). They form a high-quality water flow for the upper Volga and Nevsky-Ladoga water systems.

Lake Velye is located to the North of the Lake Seliger. Like its Polnovsky reach, it is entirely located on the territory of the national park. It stretches from North to South for 25 km, has about 200 islands, an average depth of 9–10 m, and an area of 35 km^2.

Lake Valdayskoe is the area without Islands is 19.7 km^2; the average depth is 12 m (max. – 60 m). The dam on the Valdayka River was built in 1958. Consumption of 8–10 m^3/second.

A cascade of Binevsky, Borovnovsky, Razliv and Gorneshinsky lakes-reservoirs on the Shchegrinka River. There are 42 lakes in Borovno cascade system (1.8 km^2)! They, just like the Valdai lakes, are included in the Nevsky-Ladoga system. The local hydroelectric dam was built in 1928. During the construction process, a channel was dug from the Shchegrinka River, and the lowland with small lakes turned into a reservoir (about 5 km^2).

Lakes-reservoirs are of exceptional importance for the development of recreation in the national park. According to the department of environmental education and tourism of the park, more than 20 thousand tourists (about 60,000 in total) visit their shores and aquatoires directly. Lakes play an even greater role in providing Moscow, Saint Petersburg, and other localities with clean drinking water. The volume of this "work" of the park's lakes is huge, but it is not taken into account in inter-regional interactions and calculations.

To identify and evaluate ecosystem services, we used data from remote and ground-based observations and measurements (Belonovskaya et al., 2012; Tishkov et al., 2017). Thus we took into account such indicators of the national park as attendance, maintenance and restoration of ecosystems, the presence or absence of local market of ecosystem services, including recreation and water resource, water regulating services.

Ecosystem services of the park consist of bioproduction, climate and water regulation, assimilation, bioresource, soil protection and information (recreational, etc.) functions. The main share of services falls on bioresources – up to 50 % (table). The water regulatory function remains undervalued due to the lack of payments for water resources and water-saving functions.

From an economical point of view, the calculation of ecosystem services in case of physical (natural) and monetary (currency) valuations was carried out through compensation. Production, bio-resource, climate and water regulating services could be estimated by remote sensing. In some cases, they are supplemented with data on the cost of replacing the landscape's role in ensuring the average annual flow rate. Part of the park's territory belongs to the Volga Basin and the contribution of the flow of the rivers of the Polnovsky reach of the lake Seliger, Velye and other areas, according to our estimates, up to *10–12 l/s per km²* of forest or swamp area of the park. Similar characteristics apply to the Baltic basin.

Table

Ecosystem services of the Valdaysky National Park (Tishkov, 2017)

Some groups ecosystem services	Evaluating the park's environmental services	
	Absolute values and calculation algorithm	$/hectare/year
Climate control systems	The flow of carbon in wood growth and accumulation of peat is 1.0–1.5 t/ha a year	5–50
Water regulation (ensuring flow, etc.)	Compensation through the cost of forests "work", swamps and lakes to regulate water flow	40–50
Water resources (if there is a national market for clean water)	The cost of 1 m^3 of water in Moscow – 38.06 rubles, in Tver – 22.11 rubles, water transportation, for example, for Mosvodokanal – 1.37 rubles/m^3	50–60
Assimilation (neutralization of "extra" biogens, pollutants)	For example, the assimilation of pollution by macrophyte thickets, litter, etc.	5–10
Soil protection (reducing the risk of erosion)	0.5–2.5 % of the cost of restoration at the rate of succession of meadows about 30 years, forests – 200 years	5–25
Bioresources (the cost of harvesting wood, hay, berries, mushrooms, etc.)	Growth of wood up to 2–3 m^3 per year, berries – 10–50 kg/ha, mushrooms – up to 200 kg/ha, etc.	50–150
Information (monitoring costs, etc.)	Inventory of flora and fauna: flora – more than 750 species, birds – about 200, mammals – 60; visit center, museums, etc.	15–20
Recreational (within tourism development)	Every year more than 60 thousand tourists, the entrance fee is 100 rubles/day	10–15
Total, $/hectare per year		**180–380**

Conclusions. In the near future, it is necessary to clarify the volume of water-resource, water-regulatory and assimilation functions of lakes-reservoirs for calculating "payments for services to provide water of a certain quality" in the regions lying downstream. Together with basin administrations and water users, it is necessary to develop optimal schemes for regulating their regime and dispatching schedules, taking into account the peculiarities of the park's nature development and the needs of lake recreation. Monetary estimates of uncompensated costs for maintaining optimal flow volume and water quality are required for calculating compensation, including costs for protection, scientific research, monitoring, development of recreational areas, and so on.

The work was carried out on the topic of the State Task of the Institute of Geography of the Russian Academy of Sciences No. 0148-2019-0007 “Assessment of physical-geographical, hydrological and biotic changes...”.

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Russian-German project activities in Romincka Forest – towards a UNESCO biosphere reserve in Kaliningrad Region (Russian Federation)

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The Romincka Forest is a glacial stamped hilly landscape in the border area between Kaliningrad Region of the Russian Federation, Poland and Lithuania. It spans one of the biggest undivided lowland forests in Central Europe. Among the specifics of the region are above all a high biological diversity, exceptional natural features, the special relief and the relatively unencumbered environment.

Within a meeting of the Working Group on Nature Conservation and Biodiversity under the Agreement between the Government of the Federal Republic of Germany and the Government of the Russian Federation on Cooperation in the Field of Environmental Protection in 2007, the Romincka Forest has been identified as priority area for Russian-German environmental cooperation. This was the starting point for various Russian-German project activities that aim at the conservation and regional development of the Romincka Forest and surrounding region.

As a first outcome, the central part of the forest landscape on the Russian side was declared as Regional Nature Park "Vishtynets". However, it excludes the more densely populated peripheral areas of the hilly landscape. These areas offer great potential for near-natural management, for example sustainable tourism or organic farming. The integration of these sectors can foster the protection of the natural environment of the Nature Park.

Within a current project German experts support Russian stakeholders, in particular the Nature Park "Vishtynets", with the nomination of the Russian part of Romincka Forest as UNESCO biosphere reserve. During the project, different thematic working groups discuss sustainable farming and forestry, sustainable tourism development, nature conservation as well as ways of future participation in the biosphere reserve and develop proposals for implementing measures. Based on this, concepts for zonation, management as well as governance of the biosphere reserve will be elaborated.

The project outputs will provide a basis for the preparation of the nomination form for the official designation of the biosphere reserve under the UNESCO's "Man and Biosphere" Programme. The planned biosphere reserve would be the first one in Kaliningrad Region and the most westerly one in the Russian Federation.

Partners for the project implementation are the Michael Succow Foundation, BTE Tourism and Regional Consulting and the Russian Nature Park "Vishtynets", in close cooperation with the Ministry of Natural Resources and Ecology of the government of Kaliningrad Region.

The project is funded by the German Federal Environment Ministry's Advisory Assistance Programme (AAP) for environmental protection in the countries of Central and Eastern Europe, the Caucasus and Central Asia and other countries neighboring the European Union. It is supervised by the Federal Agency for Nature Conservation (BfN) and the German Environment Agency (UBA).

Assessment of forest ecosystem services for water flow management: from national to local level

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Forests have a serious impact on the hydrological regime of territories. However, existing ideas about the relationship between forest cover and runoff levels, as well as the optimal location of forests in the basin, differ. According to the first point of view, there is an optimal upper limit of forest cover, below which the growth of forest cover contributes to the growth of water protection and water regulation functions, above this threshold, this relationship significantly weakens (Mikhovich, 1981). According to the second point of view, there is a close to linear relationship between forest cover and useful forest functions in relation to runoff over the entire range of values (Rakhmanov, 1962, 1971). Regarding the optimal location of forests in the basin, opinions were expressed both on the desirability of increasing forest cover towards the upper part of the basin (Dubakh, 1951) and on the desirability of an perequation of forests across the basin (Molchanov, 1966; Pobedinsky, 1979). A number of researchers have come to the conclusion that the reason for the decline in river water content in European Russia was not a decrease in forest cover per se, but rather siltation caused by deforestation due to increased erosion (Idzon, 1980). The purpose of this work is to find a generalized dependence of water flow on forest cover that is suitable for use in the entire set of regions that make up the Russian Federation.

In the absence of a common point of view on the question of the quantitative form of the relationship between the increase in forest cover and the increase in flow in the river basin, it is useful to analyze this relationship at the level of the subjects of the Russian Federation. For this analysis, we used data on the forest cover of the RF subjects (according to the State Forest Register), as well as average estimates of precipitation and total annual runoff for the RF subjects obtained from the source (Stolbovoi, McCallum, 2002). The subjects of the Russian Federation differ significantly from each other in terms of climate conditions, being located in various natural zones from tundra to semi-deserts. The functional nature of the relationship between forest cover and total runoff for the subjects of the Russian Federation is determined by the dependence of forest cover on moisture conditions, but not vice versa. To find the dependence between runoff and forest cover, the residuals were first calculated for each subject of the Russian Federation, i.e. the difference between the actual value and the value calculated using the linear regression equation of the relationship between forest cover and total runoff. The relationship between runoff and forest cover can only be detected in those objects whose other characteristics (primarily precipitation) are close to each other. To implement this approach, the subjects of the Russian Federation were grouped by the annual amount of precipitation, namely, falling within the limits of 207–380, 393–436, 484–507, 508–543, 585–780 mm. By comparing samples of subjects of the Russian Federation that populate the specified intervals, it is quite obvious that there is a trend towards an increase in runoff with an increase in forest cover, and this value is 1.35 mm per 1 % of forest cover, which is extremely close to the most common values (10–15 mm per 10 % of forest cover) known from the literature. Thus, the value of the slope of the trend for different ranges of precipitation can be considered as an estimate of the increase in annual total runoff (in mm) with an increase in forest cover by 1 %.

For the considered 5 intervals of annual precipitation, the following patterns can be noted. First, the values are in the range of 10–25 mm for 10 % change in forest cover, which fully corresponds to the range of data available in the literature on the basin level. Secondly, the role of forest cover is maximal at a certain level of moisture, decreasing both at lower and higher values. The decrease in the amount of runoff growth with increasing forest cover is shown in the forest-steppe zone (low precipitation) compared to mixed forests (optimal precipitation). Finally, a decrease in the influence of forest cover when precipitation increases above optimal levels is associated with an overall increase in forest cover, which is also demonstrated in many studies, but is usually interpreted as the presence of a threshold value of forest cover to influence the amount of runoff. The resulting picture smooths out the differences between alternative ideas about the hydrological role of forests, known from the literature.

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Soils of urban ecosystems, environmental and social risks

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The high size and population density of cities form a specific ecological environment. Natural ecosystems, including soils, remain a major element of sustainable urban development: groups of trees along roads, playgrounds, parks, boulevards, football and golf courses, cemeteries, zoos, botanical gardens, greenhouses, forest parks. Specific urban zones include underground communications (electricity and heat grid, sewerage, etc.), a network of electrical transmission lines, garbage dumps. Different types of urban ecosystems vary in functional role in the city and in environmental status, which is closely related to human activity and health.

Features of the soil cover in the city are as follows: urban soils are rich in organic matter, total nitrogen, potassium, and phosphorus. Reduced acidity or slightly alkaline soil solution (pH 6.0–8.5) compared with Moscow forest parks (pH 4.0–7.0) and a reduced redox potential of 100–400 mv (compared to Moscow forest parks 250–450 mv) create favorable conditions for microbial communities, including pathogenic ones, which increases the risk of human morbidity. Pathogenic microorganisms manifest themselves unexpectedly. For example, a soil amoeba of the genus Naegleria can enter the freshwater reservoir from the soil and then into the human body, causing amoebic encephalitis disease. Urban soils are contaminated with heavy metals, the content of which exceeds the maximum permissible concentrations. However, the soils of forest parks in Moscow can be considered relatively "clean" in comparison with other functional areas of the city (Zubkova, Kavtaradze, 2019). Therefore, when assessing the soils of urbanized territories, it is necessary to indicate the type of functional zone.

For many cities, environmental maps have been drawn up, including the distribution of heavy metals in soils. However, the environmental situation in urban areas is very dynamic. In conditions of high concentration of potential sources of pollution (plants, factories, gas stations, roads, etc.), soil maps do not answer the question – who will pay for the pollution and carry out restoration work. In this regard, ecosystem soil services can help humans. Soil accumulates pollutants and dust in its profile, thus clearing the urban atmosphere. Compared to the correlation of man-made elements in soil and in plant emissions, the source of pollution can be identified. The development of this task is needed in the near future, when mandatory damages for pollution and reclamation work will become normal.

In urban soils, easily soluble salts of anthropogenic origin are present. The use of salt reagents leads to anthropogenic salinization of the soil in spring when snow melts, but already in autumn the salt content in the upper horizons sharply decreases due to their removal. However, in spring, a high concentration of salts causes stress in plants. And in 1997–1998, salinization of urban soils caused the mass death of trees in Moscow (Shevyakova et al., 2000). Thus, the high content of readily soluble salts in urban soils in the spring is a risk factor for plant life.

Conclusion. Ecosystem services and soil as an element of the urban environment – in the creation of recreational attractiveness of the landscape, which is expressed for the person in aesthetic pleasure and profit from recreation and tourism (Bukvareva, Zamolodchikov, 2018), but this does not exhaust the ecosystem services of the soil. The soil can "provide" information not only about the pollution of an urban area, but also about the source of pollution, and thus can be included in the assessment of environmental damage. In addition to the ecosystem services, urban soils can create environmental and social risks.

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Biodiversity Conservation Center

The Charitable Foundation “Biodiversity Conservation Center” (BCC) is a professional Russian non-governmental environmental organization. It was organized in 1992 by a group of representatives of the Movement of Nature Protection Volunteer Squads and was established by the Russian Social Ecological Union.

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