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Landscape Science and Landscape Ecology: Considering Responses to Global Challenges

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Book of Abstracts

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The Book of Abstracts comprises a series of papers which consider the landscape spatial organization, land cover dynamics, changes in ecosystem functioning, landscape resilience to natural and man-made disasters, such as wildfires, floods, droughts, biodiversity loss and pathogen outbreaks. The special sections cover issues of landscape assessment and planning, land use and land management.

The edition is recommended for a wide audience engaged in theoretical, experimental and practical issues of integrative physical geography, landscape ecology, land use science, higher geographical and ecological education.

Plenary session

Challenging issues in contemporary landscape science

Alexander Khoroshev

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Landscape science and landscape ecology traditionally have focused on relations between spatial patterns and ecological processes. In Russian-language version most efforts have been concentrated on establishing abiotic processes that generate spatial patterns affecting human activity. In English-speaking world landscape ecology has paid more attention on how patterns affect ecological processes with strong emphasis on biotic interactions. In present-day nature-oriented landscape studies we distinguish six key concepts. 1) Geotopological determinism – the concept that relates biotic and anthropogenic features to abiotic template. Human activity should adapt to topography and geological conditions in order to avoid undesirable ecological effects. This is seen as one of the core issues in landscape-ecological planning. 2) Matter and energy exchange between vegetation, soils, water, and air. Landscape is treated as a kind of reactor that transforms external signals. Quantitative models of soil-water-phytocoenosis relationships provide opportunities for indicative studies, prediction of chain reactions in a landscape, and estimating allowable anthropogenic loads. 3) Integrative and differentiating functions of lateral matter flows. Knowing matter pathways is critical for evaluating possible remote effects of natural and anthropogenic disturbances, projecting buffer zones, and ensuring sustainability of land use. 4) Emergent effects as a result of spatial interactions between landscape units. The focus of applied studies in this issue is projecting appropriate proportions and neighbourhoods of land use units as well as proposals for the compensation effects under anthropogenic impact. 5) Temporal sequence of states. To ensure readiness of economy to future landscape conditions studies deal with characteristic time scales and inertia of components, reversibility of changes, and characteristic range of dynamic fluctuations. 6) Self-regulation and self-organization of a landscape as a complex system. The issues of discrete vs. gradual boundaries, their genesis and possible movements, possibility of several stable states, and bifurcations are crucial for planning future activities in a heterogeneous dynamic landscape.

Plenary session

Health versus Food and Water? What can landscape ecology contribute to solve global challenges and their trade-offs?

Christine Fürst

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Past and the most recent COVID-crises brought back to our minds the intense global social and environmental interdependencies we are faced with in the age of the Anthropocene. Most of the resulting challenges regarding not only human health, but also sustainable development, are related with questions in how to organize best human-environmental interactions under the pressures of climate change, (uncontrolled) population growth, urbanization in sensitive areas and the needs to organize sustainably material and energy fluxes across the globe. Crises such as the current one may bear and reveal manifold weaknesses in global cooperation, but aside from risks they bear also some chances to rethink our strategies in ensuring basic demands. Taking the North-South cooperation in achieving the UN Sustainable Development Goals as an example, this talk will shed a light on how basic principles of landscape ecology could contribute to improve the coherence of global problems and local solutions. For instance, global food chains are considered to be the riskiest component when it comes to human health and well-balanced nutrition. Most of them are motivated by economic considerations, while local capacities are often not sufficiently exploited. Assessments how local and regional capacities can be managed prior to compensate gaps in resource provision are largely missing. This talks will raise future research and research cooperation questions how to overcome such problems through coherent multi-scale and multi-sector based approaches that contribute to better connect humans with their local and global environment.

Plenary session

Using Ecosystem Services Assessment for Integrated Cost-Benefit Analysis of large scale landscape restoration

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Decisions regarding landscape restoration or other interventions in the landscape are still based on incomplete information about the true costs and benefits which leads to continuing loss of natural ecosystems and landscape degradation. One of the barriers to attract funding for large scale landscape restoration is that money spent on nature conservation, landscape restoration and sustainable land management is still seen as a cost and not as an investment with a high return in benefits. More balanced and better informed decisions requires more inclusive, so-called Social- or Integrated Cost-Benefit Analyses (iCBA). Case studies applying iCBA consistently show that the true welfare effects of sustainable land use are higher than those of the non-sustainable alternative, provided all positive and negative externalities are accounted for. To determine the true benefits (or costs) of investing in landscape restoration, guidelines are needed to analyze, quantify and, where possible, monetize the effects of all externalities (positive and negative) of changes in land use and management. In this talk I will illustrate one of these guidelines which has been developed for an organization called Commonland (www.commonland.com) that invests in large scale landscape restoration. As a case study I will use the results of an integrated assessments of the economic costs and benefits of large-scale landscape restoration in a dryland region in SE Spain that is facing serious land degradation. Based on fieldwork between 2017 and 2019, involving many stakeholders, we compared the net-benefits (or- costs) of several farms that are implementing aspects of a multi-functional sustainable land use system (called Almendrehesa, somewhat similar to the traditional land use in this region) with those of almond monoculture, both conventional and sustainable. The net benefits (or costs) of investing in landscape restoration are then derived from the differences in Net Present Value (NPV) between the three land use alternatives.

Our study clearly showed that conventional, financial CBA almost always favors short-term usually non-sustainable land use. Using i-CBA gives much more realistic insight in the true welfare effects of the direct and indirect returns of landscape restoration. An added benefit of this integrated approach is that it enables identification of mechanisms to capture the ‘full value’ of sustainable, multi-functional land use through so-called blended financing mechanisms. Eventually sustainable (land) management will then become the norm, not the exception because it is both financially more profitable for the private land owner and economically and socially more beneficial to the community than non-sustainable land use.

Plenary session

The Eurasian landscapes in transition: major milestones, lessons learned and ways forward

Alexander Prishchepov

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For the last 30 years, the Eurasian landscapes have undergone a drastic transformation with multiple repercussions to the environment and societal well-being. For instance, socio-political changes such as the collapse of the Soviet Union shaped agricultural and cultural landscapes due to widespread agricultural land abandonment. Large-scale environmental engineering projects, such as «Grain for Green» and «Great Green Wall» programs in China, affected the mountainous and dryland landscapes. In this regard, Eurasia serves as a great and unintended area suited for the «Natural Experiments», which would help understand these large-scale implications on the landscapes' resilience. There has been great progress in assessing such transitions, thanks to the methodological and technology developments for the last 30 years and thanks to the great efforts of national and international research initiatives and programs. During the talk, I will shortly evaluate such major millstones and describe major scientific outcomes about the implications of such large scale transitions and regime shifts on various socio-ecological systems and landscapes in Eurasia, but also the resilience of some of these systems. I will also highlight the plausible direction for future research to fill thematic gaps. The large-scale socio-political shifts and implementation of environmental projects are not rare and have a cascade effect on the landscapes and processes. Therefore, I underscore a strong need for international cooperation to understand better complex landscape transition pathways in Eurasia, local and distal implications in the telecoupled world.

Plenary session

Landscape trajectories under climate change and climate adapted management

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Concern over global change has prompted debate about whether active management can accelerate landscape adaptation to novel conditions, maintain resilience, and continue the provision of ecosystem services. Forest scientists and managers have proposed many innovative approaches including facilitated migration, genomic interventions, restoration silviculture, and many others. Few of these innovations have been tested at broad scales because of the difficulties of testing them at scale and because the full effects may not be known for decades. My lab and I use forecasting to test innovative solutions to global change and to assess how they may interact with climate futures and novel disturbance regimes. Forecasting does not provide predictions about what will or will not succeed or fail. Rather, it provides information about potential trade-offs and costs and can inform the discussion before innovations are executed at broad scales. Our results suggest that landscape structure and function will decline as the magnitude of climate change increases. This decline will be highly variable across landscapes and is dependent on both natural and managed resilience. Climate adaptive management could maintain or even increase ecosystem services although radical interventions may be necessary. We conclude that for any landscape, a range of landscape trajectories are possible and that comprehensive management efforts have the potential to redirect trajectories towards more positive outcomes.

Plenary session

Navigating 768 million Hectares of Woods: Obstacles and problems of forestry reform

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Although Russia has approximately 20.1% world forest area and 1/4 of world timber reserves, the main problem of the country's forestry sector is a shortage of wood raw materials, as well as degradation of economically viable forests in old-developed regions. Incentives for long-term investments to improve the quality of the forest fund are absent, and the regulatory framework is imperfect and insufficiently protects the interests of investors. An analysis of the initiatives of federal forest management bodies shows that the only explanation for the formation and maintenance of the existing situation in the forest industry is the desire the relevant departments to use ecologically and economically unjustified pretexts for the state budget implementation. Effectiveness of spending is frequently not assessed, as a result occurs misinformation of the country's authorities. Situation analysis demonstrates that several forest management models coexist in Russia. One of them is the model set by the Russian Forest Code (2006), it is likely to sustain at areas leased for large logging companies for the long term. Some initial signs of more intensified forest management are visible there. Another model is typical extensive model – 'wood mining'. This system evolves back to the Soviet times. There is an ambition to revitalize state-owned forest management enterprises or / and the state-owned all Russia wide corporation responsible for reforestation and logging at areas which are not leased for private companies. Forest data is largely absent and existing one is unavailable for state or public control. Funds available for forest management are misused. Federal forest management bodies ignore the fact that lack of available timber resources is due to lack of effective reforestation. Reforestation methods in use and those used in the past do not ensure establishment of economically valuable forest stands to replace those logged or burned. Reforestation is focused on production of plantlets and planting with no weeding and thinning of planted or natural young stands. Criteria to assess success of reforestation based on species composition are not developed and not established. Imitation of reforestation does not help to solve the problem of economic value degradation of secondary forests, including those growing in the most productive zone – Central European Russia. Authorities ignore exceptional values of intact forest landscapes for preservation of biodiversity and global climate change mitigation. In 7 years since the Russian Forest Policy has been approved not a single National Forest heritage site has been established to preserve forests from exploitation. Despite strategic documents approved in 2013–2018 forest management authorities continue supporting extensive forest management and make no substantial steps towards transition to more intensified forest management. One of the first steps should be calculation of rent fee based on rented area, but not on a volume of logged timber.

Plenary session

Landscape evolution and climate changes in the forest zone of European Russia during the Holocene

Elena Novenko

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The Holocene environmental history and climate changes was reconstructed by multi-proxy records of pollen, plant macrofossils, testate amoebae and charcoal from 6 model areas located in different landscapes within the forest area of European Russia. The obtained results show that the main area of European Russia was occupied by birch-pine forests in the early Holocene. Climate warming at about 9-8.8 ka BP (thousand calibrated years before present) caused significant changes in vegetation almost synchronously all over European Russia. At this time, spruce forests spread into the northern part of the modern taiga zone. The plant cover of the territories located in the taiga and broadleaved forest vegetation zones did not change throughout the middle and late Holocene, despite remarkable climate fluctuations. Transformations of landscapes were caused only by human impact. Vegetation dynamics in the areas located in the modern zone of coniferous-broadleaved forests were influenced by expansion of spruce, which occurred transgressive from North to South. The phases of expansion of spruce forests coincided with the stages of cooling and increase of climate humidity.The next, almost synchronous boundary of changes in the landscape structure in all key areas is defined as the last 300 years. During this period, modern anthropogenic landscapes were formed.

Plenary session

Forest-climate interactions in a changing environment: field measurements and modeling results

Alexander Olchev

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The forest-climate interactions are key topics of numerous modern experimental and modeling studies. They are mainly focused on both the possible effects of changing climate on structure and functioning of forest ecosystems and biogeophysical feedbacks (positive or negative) from forest cover/land use changes to climate conditions at local to global scales. The forests influence climate in multiple ways: absorbing the carbon dioxide (CO2) from the atmosphere and storing it in wood, leaves and soil; affecting release and absorption of methane (CH4) and nitrous oxide (N2O); changing the surface evapotranspiration, soil water storage, precipitation and runoff; affecting the surface radiation and energy budgets (albedo, latent and sensible heat fluxes, Bowen ratio). The highlight questions what nowadays should be answered are: How the modern climate changes influence the forest communities in different geographical regions?; How affect deforestation and afforestation processes the biogeochemical cycles and climate system?; What is effect of forest fires on current and future climate conditions?; How respond the forest communities to extreme weather events? etc. To answer these key questions the multifaceted experimental and modeling studies are obviously required. Whereas the field experiments allow to discover and explain the main mechanisms and causal relationships of the forest - atmosphere interactions, the models of different scales (from local to global) and complexity can be successfully used to describe and predict the forest-climate interactions under present and future climate conditions.

1. Landscape spatial structure and dynamics - LSSD

Session 1.1. Landscape field research – methods and approaches, the structure of data, and problems of sample plots data extrapolation to polygons

Hosts: Dmitry Chernykh, *Institute for Water and Environmental Problems SB, RAS, Russia*, and Svetlana Solodiankina, Sochava Institute of Geography SB, RAS, Russia

Description:

Remote sensing data greatly facilitate landscape research and raster-based visualization of landscape properties. By the moment, field landscape mapping is commonly based on spatial identification of holistic homogeneous territories and does preserves its relevance. However, a lot of unsolved questions still remain. For example, what should be treated as homogeneity, how to identify the principal factor in spatial segmentation of a landscape, how to prove the legitimacy of extrapolating data obtained at local sample plot scale to a broader scale. The problem of extrapolating dynamic characteristics of a landscape such as annual biological production, geochemical flows, etc. is even more acute as compared to extrapolating its spatial features. During the session, we will discuss the approaches to landscapes field research; mandatory and optional lists of landscape features to be collected in the field survey; the structure and classification of landscape attributes; the intersecting parameters; the formalization of data and its options; the application of reference books and classifiers; the means for standardization of field descriptions; the problem of extrapolating data from sample plots to polygons; the landscape mapping; the databases and GIS for data collection, search and visualization. At the end of the section, we invite everyone to participate in the workshop Collaborative web service «Landscapes information facility». Its purpose is to discuss the structure of data, approaches and copyright regulation. It's vital to create an information system to store and retrieve landscape research data similar to Global Biodiversity Information Facility (GBIF) or Forest Observation System. We welcome the specialists to share their experience in creating open data bases, especially in legal aspects of it application and regulation.

1. Landscape spatial structure and dynamics - LSSD

Session 1.1. Landscape field research – methods and approaches, the structure of data, and problems of sample plots data extrapolation to polygons

Mapping forest and wetland landscapes in West Siberia

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To assess the impact of climate change on the carbon cycle and greenhouse gas emissions in natural ecosystems, data on the spatial distribution of natural landscapes classified according to their productivity, the type of succession dynamics and the rate of greenhouse gas emission are needed. The report provides a summary of studies on mapping forest and wetland ecosystems in Western Siberia using satellite data. Mapping of forest habitats is necessary to understand the dynamics of ecosystems under effects of climate change, forest fires and anthropogenic impacts. Landsat data were used to map forest composition in the middle and northern taiga zones based on training data from several ground survey sites, distinguishing between upland and wet forests, the fractions of deciduous and coniferous species linked to the stages of succession after felling and fires. The combined use of optical and radar remote sensing data for a more detailed classification of forests by productivity classes and age appears promising. To assess methane emissions from the entire territory of Western Siberia, a typological map of wetlands was prepared using Landsat satellite images with a resolution of 30 meters. Wetland mapping made with supervised classification using data of all channels except thermal. Training sets were prepared based on methane flux survey data and high-resolution satellite images. Two typologies were developed, including: 1) 9 wetland complexes (used as legend for wetland mapping), 2) 7 bog ecosystems (for scaling up the chamber observations of methane emission). The fractions of the wetland micro landscapes (ridges and hollows) in bog complexes were calculated using high-resolution satellite images. Using the results of high-resolution wetland mapping with full regional coverage, an improvement was achieved over the earlier methane emission estimates based on combination of 25 km scale paper maps and partial satellite imagery coverage at test sites.

1. Landscape spatial structure and dynamics - LSSD

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Regional features of lithological genesis of landscapes of the Central Chernozems Region

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The genesis, evolution, dynamical structure, and stability of the landscapes of the Central Chernozems Region largely depend on the lithogenic basis, which is usually identified as a complex of geological and geomorphological features of the territory, that include the stratigraphy and lithology of rocks, ancient and modern plate tectonics and relief. Essentially, the lithogenic basis is the zone of the most active hypergenesis. Under the conditions of the terrestrial landscape area, lithogenic basis includes biopedogenic, lithogenic, and lithohydrogen geohorizons. In the research process it was found that the landscape-forming role of the lithogenic factor in the studied region is observed everywhere. However, it varies from leading role to supporting, depending on combination of modern landscape genesis factors and the lithogenic factor. In the case when the lithogenic factor predetermines the genesis and evolution of landscape complexes, thus called «litho-landscape-genesis», peculiar natural complexes – lithogenic (petrogenic) landscapes – are formed. So, it is relevant to study the regional features of litho-landscape-genesis and to take them into account in practice. There are two main groups of sedimentary rocks that take part in the structure of the lithogenic base of the landscapes of the Central Chernozems Region: carbonate and silicate rocks. Differences in the physico-mechanical and chemical properties of the rocks are reflected in the energy and mass exchange of substances involved in the landscape genesis. As a result, preconditions are created for the evolution and differentiation of landscapes, for the formation of their diversity and sustainability. This is reflected in the structural and genetic landscape system of the Central Black Earth Region. An analysis of the regional features of the indication of litho-landscape-genesis, as well as mapping and classification of structural elements of the lithogenic base of landscapes of the Central Chernozems Region, allow us to conclude that the differentiated character of litho-landscape-genesis is closely related to the structure and properties of the lithogenic base, i.e. the landscape-forming role of carbonate and silicate rocks of the region. Taking these features of litho-landscape-genesis into account would contribute to a deeper scientific and technical comprehension of the landscape ecology in the Central Chernozems Region leading to a reasonable optimization of methods in the natural resource management.

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Session 1.1. Landscape field research – methods and approaches, the structure of data, and problems of sample plots data extrapolation to polygons

Application of landscape-typological forest map to analyses of conifers sustainability in reserve «Stolby» (East Sayan mountains)

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In recent years, the large unpredictable and abrupt changes in the state of dark coniferous forests have occurred in the south of the Krasnoyarsk region. These changes were caused by forest fires and outbreaks of forest pests, which destroyed many thousands of hectares, primarily Siberian fir and mixed dark coniferous forests (Siberian fir, Siberian spruce, Siberian pine). The trigger mechanisms of these disturbances in the forest states were associated with climate changes, which contributed to the invasion of new species of insect pests and pathogenic fungi. The localization of coniferous forests damage is clearly detected by space images. «STOLBY» is one of these affected forest mountain landscapes (about 50 000 ha). The purpose of this report is to examine this territory using our created electronic landscape-typological forest maps (created by GIS), satellite images (Landsat, Sentinel, etc.), and to evaluate the sustainability of conifers in different mountain terrains and forest types. Forest inventory data for different years, statistical methods for groups of forest types - spectra of ecological-coenotic groups, ordination and other methods were used to identify the relationship between coniferous species, forest types and environmental factors. It is shown that dark coniferous forests, concentrated at altitudes over 400-500 m in the upper belt on watersheds are damaged by 70-80% in some localities. The lower belt named «subtaiga» with Pine and small-leaved forests (200-500 m) is much less damaged, and they are successfully recovering Scotch pine, birch and aspen, and even Siberian fir. Habitats in which Siberian fir has replaced Siberian larch in recent decades, are identified in the upper dark coniferous taiga forest belt (500-800m). As well as other sites where fir has been preserved for decades (more than 50 years) under the canopy of a pine forests as a large undergrowth, but was not included in the stand composition, were identified. Siberian pine population is localized on an area of 735 ha in the mountain taiga belt. This species is damaged to a lesser extent than Siberian fir but forest fire remains a dangerous factor for him. In the opinion of specialists, it is promising to expand the area under Siberian pine stands in sites suitable restoration of dark conifers. Giving the «Stolby» reserve the status of a national park allows you to begin the implementation of this plan as an experiment on parts of its territory, using the landscape basis.

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1. Landscape spatial structure and dynamics - LSSD

Session 1.1. Landscape field research – methods and approaches, the structure of data, and problems of sample plots data extrapolation to polygons

Assessment and mapping of structural parameters in forest landscapes based on highly detailed three-dimensional remote sensing data

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The algorithms based on highly detailed remote sensing data for quantitative estimates of various structural and functional parameters of forest landscapes at the levels of sample plots as well as for individual trees are actively developing since the mid-2000s. Nowadays one of the most effective and cost-efficient solution for remote assessment, monitoring and prediction of basic forest stands variables is becoming the use of digital air (UAV) photogrammetry data allowing to reconstruct and accurately analyze the three-dimensional structure of forest stands from individual trees and sample plots to landscape level. We present elaborated approaches to the acquisition and preprocessing of UAV optical images and video frames data to produce highly detailed three-dimensional models characterizing both vertical and horizontal structure of forest stands in different landscapes conditions. The more crucial among these models are photogrammetric point clouds and resulted from their filtering and classification canopy height models (CHM). We have tested elaborated approaches and data processing flowcharts for the northern boreal sparse forests at the Kola Peninsula, for planted deciduous and pine stands in the low mountainous region of Central Caucasus as well as for abandoned agricultural lands with fast tree overgrowth in the landscape zone of broad-leaf forests, central part of European Russia. Several algorithms of automated segmentation and classification have been developed and validated to directly identify and map such basic characteristics at the levels of sample plots and whole stands as the distribution of trees heights and diameters, forest canopy closure, density of trees in stands. We also demonstrate how the obvious and known limitation of UAV photogrammetry revealed in dense forest stands – the significant lack of data under the upper tree canopy – can be overcome with combining multi-temporal UAV data (i.e. for leaf-on and leaf-off conditions) or simultaneous survey of lower canopies and ground at the same plots from the terrestrial laser scanner.

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Session 1.1. Landscape field research – methods and approaches, the structure of data, and problems of sample plots data extrapolation to polygons

Reconstruction of landscape structure of sewage fields from sugar industry and its dynamics as reasoning for sampling scheme of soils and soil carbon balance estimations

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The forest-steppe landscapes of the European Russia is a significant region of sugar beet cultivation and associated sugar production industry both historically and currently. The overwhelming majority of sugar factories located here still use the biological treatment of their wastewater on sewage fields, which are usually isolated from the industrial sites and occupied significant areas (1,5–3 sq. km) along local watersheds. Both abandoned and active sewage fields have rather distinctive and special landscape pattern but these systems are very poorly studied as a complex phenomenon in the structure of anthropogenic landscapes or as spatially and environmentally significant type of land use (the only most comprehensive study in this field belongs to Yu. G. Tyutyunnyk, 2016, 2019). For the two key areas of sewage fields in Kursk region – the one abandoned with the closing of the sugar factory in the late 1990s and the other still in use from the early 1950s we reconstructed the spatial and temporal heterogeneity of their contemporary landscape structure. This reconstruction was done by means of multi-temporal analysis of archive aerial and contemporary satellite and UAV imagery with high spatial resolution. The gaps in this prolonging image time series was completed by NDWI spectral index series (McFeeters, 1996) obtained from Landsat imagery. As a result, the small-scaled maps of reconstructed natural landscapes structure and contemporary one were compiled and chrono-functional zoning was elaborated for the territories of two sewage fields. Based on these findings we organized the scheme of general soil sampling and repeated survey of geochemical and microbiological soil conditions, as well as multi-seasonal estimates of CO2 efflux from soils. Results of these surveys have demonstrated that the each chrono-functional zone have a specific set of soil types and of current soil ecological conditions. Periodically watered lagoons of operating sewage fields is a powerful source of CO2 to the atmosphere while abandoned lagoons with successive trees and shrubs overgrowth are characterized with background level of soil CO2 efflux.

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Session 1.1. Landscape field research – methods and approaches, the structure of data, and problems of sample plots data extrapolation to polygons

Regularities of the dynamics of floodplain landscapes

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Floodplain landscapes are characterized by the most dynamic and youthful features in comparison with any watershed landscapes. The structure of the floodplain landscape at a given time is the result of its development, dynamics and functioning in the present and previous years. The main processes of the landscape functioning are the transformation of solar energy, moisture circulation, soil formation, lateral movement of air masses, biological circulation of substances and seasonal dynamics. All of them are determined by heat and moisture supply. Consequently, the most important «conductor» of the functioning of any landscape is the seasonal climatic rhythm. But floodplain landscapes are also distinguished by the fact that, along with the climatic rhythm, a large, and in some places a decisive role, is played by the flood cycle. These two cycles, superimposing and complementing each other, create a unique life cycle of floodplain landscapes. The high-water cycle assumes periodic flooding of floodplain geosystems with hollow waters. It is expressed through a specific functional factor - the level and duration of floodplain flooding. The level and duration of floodplain flooding determines the degree and duration of the flooding of habitats with water and depends on the width of the floodplain, its height above the river, surface relief, and the type of vegetation on the floodplain. Floodplains of most large rivers are characterized by the presence of several surfaces of different levels. In relation to the river's edge, they can be called high-altitude levels and duration of floodplain flooding. The differences between these surfaces are associated with a certain frequency of recurrence and duration of floods. Consequently, the level and duration of floodplain flooding determines the vertical differentiation of floodplain landscapes. Another factor is closely related to the level and duration of floodplain flooding - the depositing of alluvium (alluviality). Alluviality characterizes the thickness and texture of alluvial sediment deposited on the surface of the floodplain after the decline of hollow waters. Alluvial sediment creates secondary superimposed landforms, is the main parent rock, is a valuable natural fertilizer, and affects the development of flora and fauna. Another important factor in the dynamics and evolution of floodplain natural complexes is the erosion-accumulative activity of the water flow - the river. The erosion-accumulative activity of the river has had and continues to influence the formation and development of all natural complexes of the floodplain. The regularities of functioning and dynamics revealed during the study of floodplain complexes should be taken into account and used in the conduct of economic activities in the floodplain and the development of floodplain landscapes

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Session 1.1. Landscape field research – methods and approaches, the structure of data, and problems of sample plots data extrapolation to polygons

45 years of research on landscape dynamics at the Lesunovo station in the South-Eastern Meshchera

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The Lesunovo landscape station is located in the north of the Ryazan region, in the Meshchera lowland (about 55º N and 41º E). The station is located in a zone of mixed forests, on the border of two types of landscapes - moraine-water-glacial and fluvioglacial. The key feature of the station is that it is located in economically developed geosystems and allows, in contrast to stations in protected areas, to trace changes in geosystems during socio-economic changes (Landscape collection, 2013). The station was founded by I.I. Mamai in 1976. A detailed landscape map was created for the profile strip (scale - 1: 2000, mapping unit - facies). Here, an original method was developed for studying the intra-annual and long-term state of landscapes (Mamai, 1992). Annual surveys of landscape dynamics have been continuously conducted at 31 control points for 45 years (Landscape collection, 2013). The summer observation program (July, August) at the control points includes: weather, soil temperatures (at a depth of 20, 40 and 80 cm), soil moisture, flooding with water, phenological development of plant species, anthropogenic changes. Winter observations (March) include the determination of the snow thickness, moisture content in the snow, depth and degree of soil freezing (Mamai, 1992). External influences are characterized using a meteorological station and a hydrological post. During 45 years of observations, the area was overgrown with forest. The yield of herbage has decreased. The depth of freezing and the thickness of the snow mass decreased, the snow cover became unstable. The frequency of dry years has increased, and soil moisture has generally decreased. High spring floods on the Gus River have become a rarity; now autumn and winter floods are more typical. In recent years, thanks to beaver dams, once drained lands have been intensively swamped. In conclusion, we would like to emphasize the importance of the development of scientific field stations outside protected areas, which will make it possible to fully characterize the changes in the economically developed territories, which, in fact, form the human environment. Landscape collection (Development of ideas of N.A. Solntsev in modern landscape studies) / ed. doctor of geographical Sciences I. I. Mamai. M.-Smolensk: oikumena. 2013. 330 p. Mamai I.I. Dynamics of landscapes. Study methodology. M.: Publishing house of Moscow University, 1992. 168 p.

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Landscape mapping as a basis for analizing the educational potential of geosystems

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In the areas frequently visited by tourists it is a long-felt need to analyze the cognitive (enlightening) potential of geosystems in order to increase knowledge about the unique natural features of the territory, as well as to form environmental awareness and environmental responsibility of recreants. The Tunkinskaya depression (Tunkinskii National Park, Republic of Buryatia, Russia) is an ideal recreational experimental area that integrates natural-scientific and environmental-educational (educational) functions of geosystems. The central part of the depression was chosen as a representative site, where various orographic elements are represented within relatively small areas - from the alpinotype highlands of the Tunkinskie Gol'tsy range to the swamped bottom of the depression with a complex system of the watercourses of the Tunka river and its tributaries. The natural differentiation of the modern landscape structure is complicated by human-induced (recreational) impact - thousands of vacationers annually come to the unique natural objects of this territory. The medium-scale landscape mapping of the key site as part of the study shows its differentiation into categories of landscape structures according to the types of zonal-altitudinal-belt environmental conditions, which differ in morphological and phytocenotic properties, as well as features of natural and anthropogenic transformation. The main factors of landscape discreteness are the morphological features of the surface structure of hummock-and-hollow topography. The dynamic nature of the functioning of geosystems is reflected in complexes with natural vegetation and their derivative biocenoses formed in the process of agricultural and pyrogenic transformation. The variable states also include complexes formed in river valleys during the manifestation of debris flow activity. The image obtained, gives a reliable idea of the current state of geosystems, can serve as a scientific basis for identifying their educational functions. In the framework of environmental education events, the landscape map is the basis for analyzing representative areas for the development of negative phenomena induced by human activities (activation of exogenous processes, loss of environment-forming functions of animal habitats, extermination of valuable and unique vegetation species, etc.). Cartographic demonstration of transformation extent and duration of restoration process should inform recreants about the need to preserve the natural conditions for the sustainable development of geosystems.

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1. Landscape spatial structure and dynamics - LSSD

Session 1.1. Landscape field research – methods and approaches, the structure of data, and problems of sample plots data extrapolation to polygons

Invariants of Dynamic Geosystem

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The landscape cover is a complex dynamic system, the state of which is described by the ratio of the main thermodynamic parameters (temperature, entropy, etc.) at each time moment. Then invariants can be defined as the order parameters of this system. They are slowly varying variables that determine the dynamic structure of process. The concept of invariants as a time-stable spatial structure in a landscape was proposed by V.B. Sochava (1961). However, their calculation has become available due to accumulation of long-term series observations from satellites. Therefore, the main goal of our research is to develop a method for extracting landscape invariant using multispectral measurements from Landsat satellites. In this study, the calculation of invariants is performed on the example of a functional variable - air temperature. The study was implemented in the Central Forest Biosphere Reserve, Russia (zone of the southern taiga), where sufficiently large areas of forests that was not influenced by anthropogenic impact. The method of main components was used to calculate the invariants of the states of geosystems reflected in the Landsat 4.5.7.8 images. The influence of vegetation and topography on spatial structure of invariants was revealed using regression and correlation analysis. In addition, we analyzed meteorological data to establish a relationship between invariants and weather conditions before and at the time of surveys. Two invariants describe about 65% of temperature variations from 1984 to 2017. The first invariant represents the structure of thermal fields in winter, and the second in summer. Morphometric relief indicators describe 22% of the temperature in winter and 26% in summer. The cross and maximum curves are the most important indicators for the winter invariant, and the elevation and the slope are most affect the summer invariant. Vegetation cover determines 54% of the temperature in winter and 68% in summer. An analysis of meteorological data showed that the more days weather conditions did not change, the better the invariant describes the spatial structure. The order parameter best describes the Landsat image (80%) when the air masses did not change during 6 days in the study area. The results showed that the invariant based on Landsat images reflect time-stable states of landscape cover. The principal component method can be applied to time series of any multispectral measurement variables and their various transformations.

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1. Landscape spatial structure and dynamics - LSSD

Session 1.1. Landscape field research – methods and approaches, the structure of data, and problems of sample plots data extrapolation to polygons

Field studies of mountain geosystems: difficulties in data collection

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Spatial data is the foundation of our real world. Rapidly developing methods for obtaining and processing information bring new opportunities, including in mountain landscape science and provide a significant improvement in the quality of research. Investigations of mountain geosystems, as well as of all geographic systems in general, are usually based on highlighting them on satellite images, either by field surveys, further landscape analysis and synthesis, mapping and zoning. Currently, in addition to generally accepted geographical research methods, there are more modern methods, such as, for example, aerial photography from pilot and unmanned aerial vehicles. In the past few years, UAVs have become perfect and affordable and have found full use in the study of mountain geosystems. Adverse environmental conditions and inaccessible places in the mountains make UAVs an ideal solution for obtaining geospatial data and further creating digital models of geospatial. That is, improving the strategy and technical base of research has led the researcher to move from direct contact with the studied object to remote methods of studying it. In the fields or offices conditions an analysis, measurements by topographic and thematic maps, aerospace images are performed, literature and stock data are systematized. Using expeditionary methods, the obscure properties of the object under study are clarified, solving problems associated with identifying of landscape properties, the relationships of its components, and the spatial structure of landscapes. To study the current status of the landscapes used the geosystem regional-typological approach of the Siberian geographical school tested in different regions of Siberia. At the topological level, such an approach provides a possibility of monitoring the state of landscapes, their factorial-dynamical characteristics as well as taking into consideration the typological features of geosystems of a different rank and spatial dimension. The main unit of mapping at a scale of 1:50 000 is the facies representing homogeneous natural and naturalanthropogenic geosystems of a topological level. Landscape maps of the key areas at the topological level were compiled in terms of the graphical model of the hierarchy of geosystems for the Baikal region.

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Session 1.1. Landscape field research – methods and approaches, the structure of data, and problems of sample plots data extrapolation to polygons

Analysis of landscape- geochemical maps for ecological assessment of the northern part of Western Siberia

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The task of the work is to identify links between landscape features of the territory and geochemical characteristics of the background state of the natural environment. The object of study is the territory of the Nadym-Tazov interfluve, located in the northern part of the West Siberian region within the boundaries of southern tundra, forest tundra, northern and middle taiga. The relief formations are the Upper Quaternary sandy and sandy-clayey sediments. The map of landscape- geochemical zoning at a scale of 1:1000000 shows 10 provinces. The NRP - natural resource potential of landscapes is considered as an integral indicator of landscape conditions. For each province the values of its two components are determined: RP- resource potential (determined by vegetation productivity) and EP- ecological potential (determined by the conditions of substance migration). To estimate RP, the province's average phytomass t/ha was used (calculations carried out by V.N. Tyurin, 2018). EP estimation is based on morphometric indices and characteristic of the soil forming substrate. Geochemical characteristics of the background state of landscapes include:1.Calculation of PRF - the geochemical background indexes of the components of the natural environment (mineral soils, peat bog soils, bottom sediments and waters of surface watercourses and reservoirs) - the average for each province of the content of elements-indicators and oil products.2.Calculation by provinces of indicators of background geochemical structure – coefficients of: a)water migration Kwm; b)biological uptake of peat Kbt; c) lateral differentiation Kl. The data analysis results made it possible to establish: - existence of reliable correlation links between the average characteristics of PRF mineral soils and bottom sediments for most of the defined trace elements (V, Cr, Mn, Co, Ni, Ga, Zn, Sr, Ba, Pb); - presence of a reliable quantitative relation between EP values and the average content of the leading trace elements (PFR values); - presence of a reliable quantitative relation between the RP value and the values of the background structure indicators Kwm, Kbt, Kl. The conclusions obtained show that the territorial distribution of geochemical background characteristics (PRF) depends primarily on azonal conditions (topography, soil-forming rocks); the variability of indicators of the geochemical background structure (Kwm, Kbt, Kl) is determined by zonal factors (climate, vegetation).

1. Landscape spatial structure and dynamics - LSSD

Session 1.1. Landscape field research – methods and approaches, the structure of data, and problems of sample plots data extrapolation to polygons

Approaches for exploring the structure and functions of geosystems on the example of seven study areas near Lake Baikal

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The structure of the landscape has a significant impact on its functions. Landscape functions are considered as the final expression of the functioning processes of landscapes as systems of interrelated components: rock, soil, water, air, and biota. The geosystem concept formulated by V. Sochava and the factor-dynamic approach for facies classification elaborated by A. Krauklis are a theoretical and methodological framework of this research. Fieldworks were conducted in Baikal region in summer seasons from 2010 to 2020 years. Landscape characteristics databases, classifications of geosystems and landscape maps (shape-files) were prepared for five study areas: 1 - on the Barguzinsky Range (database link: https://www.researchgate.net/publication/337944255_Barguzinskij_hrebet), 2 - Ol'khon island (https://www.researchgate.net/publication/337944449_ostrov_Olhon); 3 - on the Primorsky Range (https://www.researchgate.net/publication/337944189_Primorskij_hrebet); 4 – on the Olkhinsky Plateau (https://www.researchgate.net/publication/337944349_Olhinskoe_ploskogore); 5 - on the Khamar-Daban Range (https://www.researchgate.net/publication/337944184_Hamar-Daban. For the study areas in the Priol'khonye (https://www.researchgate.net/publication/337944435_Priolhonskoe_plato) and delta of Selenga (https://www.researchgate.net/publication/337944191_Selenga), the geosystem classification was compiled based on the factor-dynamic approach and existed the landscape maps were updated. Based on the data of the landscapes maps, field research and the results of the regression analysis of the dependence of geosystem functions on influencing factors, assessment maps of geosystem functions are compiled: species and phytocenotic diversity, phytomass stock, carbon storage in the tree stand, potential soil infiltration ability, geosystem susceptibility to erosion processes (only for the steppe geosystems).

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1. Landscape spatial structure and dynamics - LSSD

Session 1.1. Landscape field research – methods and approaches, the structure of data, and problems of sample plots data extrapolation to polygons

The use of ground and remote spectrometric observation methods to determine the state of ecosystems

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Vegetation is sensitive to changes in the conditions of growth associated with both natural and anthropogenic factors. Changes in the state of individual plant species and vegetation cover in ɲeneral allow them to be used as indicators of natural and anthropogenic processes, expressed in different values of the spectral characteristics of the studied surface. Spectral images of plants and other surface types can be used to interpret the state of ecosystems reflected in satellite images. They are necessary for creating and updating libraries of reference spectral images — reference databases containing values of the spectral brightness coefficient of objects on the earth's surface obtained under standardized conditions. Satellite images are increasingly used to identify features of the underlying surface, mainly vegetation, as well as rocks in areas devoid of vegetation cover. The purpose of this work is to analyze the possibilities and limitations of using ground-based spectrometry methods for decoding satellite images and creating libraries of spectral images of plants. The research was carried out on the Kola Peninsula under conditions of technogenic impact and on background territories. Long-term research shows the ability of vegetation to selectively reflect falling solar radiation depending on its species composition and plant condition. The analysis of the possibilities and limitations of using ground-based spectrometry methods for decoding satellite images and creating libraries of spectral images of Arctic plants allowed us to establish that the main objects being decoded can be distinguished by spectral brightness curves: species of trees, shrubs, mosses, lichens and herbaceous plants. Measurements by 4-channel and hyperspectral spectrometers give very close values of the spectral brightness coefficient of the same samples, but hyperspectral data provide additional information in the near and mid-infrared parts of the spectrum, the interpretation of which requires additional research. The spectral brightness coefficient of birch leaves clearly indicated chlorosis and necrosis, even if a small part of them is affected. Experimental measurements show that humidification of lichen samples can act ambiguously (both increase and decrease the values of their spectral brightness coefficient). The influence of species features and habitat conditions is clearly reflected in the spectral image of different plant species.

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1. Landscape spatial structure and dynamics - LSSD

Session 1.1. Landscape field research – methods and approaches, the structure of data, and problems of sample plots data extrapolation to polygons

Information systems for collecting, searching and disseminating spatial data about landscapes

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So far, researchers, planners, designers, managers, and others have to spend an unacceptably long time searching for the required landscape data, even if they exist. In the past few months, we have tried to inventory the sources on the Internet about the landscape data and map coverage of the territory of Russia for the time period from 1959 to the present. The group of maps and atlases available on the Web is extremely small; the vast majority of them duplicate existing paper editions. There are few or no landscape datasets intended and suitable for direct use in the GIS, not necessarily published, but publicly available in various formats. Almost aren't used opportunities for data access and display data via the WMS/WFS service of the Open Geospatial Consortium. Different regions vary enormously in the landscape-cartographic investigation state. There are the difficulties of searching for analog and digital landscape maps, spatial datasets in library collections, bibliographic source summaries, and databases. The community of environmental specialist has to recognize the need to complete spatial metadata about the landscape data and maps on the proposed geoportal «Landscapes of Russia» as a web-based digital platform, similar to the existing Russian and foreign samples, providing access to the data discovery, view, download and transformation services, as well as allowing spatial data services to be invoked. The creation of an open multi-user interactive network platform «Landscapes of Russia» will help to disseminate the landscape approach among specialists of various profiles and makes data available for various scientific, educational, and practical purposes.

1. Landscape spatial structure and dynamics - LSSD

1.2. Landscape heterogeneity and hydrological processes under change: observations, modeling, and outcomes

Hosts: Dmitry Pershin, *Lomonosov Moscow State University, Russia*, and Vsevolod Moreydo, *Water Problems Institute of RAS, Russia*

Description: The land surface is the critical zone linking hydrosphere, lithosphere, biosphere, and human activity. Water plays a crucial role in this system. Water flows shape the landscape structure, and on the other hand, landscape heterogeneity largely determines water storage, partitioning, and movement. However, the interaction between the landscape structure within catchments and river runoff is yet not fully understood. The response of each landscape component, and the runoff itself, under changing conditions, can be assessed with a large degree of uncertainty. Climate change has affected many parameters of the global water cycle in recent decades (particularly the precipitation/evaporation ratio). Both ecosystem functioning processes and water flows are highly sensitive to such shifts. Furthermore, involving land use/land cover changes and various natural disturbances (fires, droughts) in this system, we consider a significant lack of knowledge about interactions in the landscape-catchment system and major uncertainties for modelling and forecasting. This section brings together a variety of studies that focus on interactions between water flows and landscape/ecosystem heterogeneity. Presentations cover research at various spatial scales from plot and catchment scales to regional and global scales. The talks will focus on the broadest possible set of methods: modelling, in situ measurements, remote sensing technics, and experimental research. We also welcome works related to snow hydrology and research in permafrost regions, which are particularly important for Northern Eurasia. The goal is to showcase regional work and focus on combining landscape-ecological and hydrological methods, which will potentially enhance our understanding of ongoing changes in the landscape-catchment system and prediction of future shifts.

Spatio-temporal patterns of evapotranspiration across Poland: understanding the dynamics and drivers

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In temperate climates where precipitation recharging the soil water and groundwater resources is highly variable in space and time, the quantification of evapotranspiration remains an important issue. Given the importance of green water fluxes for the maintenance of ecosystems, a fundamental understanding of their quantities and dynamics is required. As recent observations reveal a widespread soil moisture drying across Europe, it is important to evaluate how does it influence the magnitude of evapotranspiration. The specific objectives of this study are the following: (1) to assess the evapotranspiration patterns as a consequence of summer meteorological droughts and (2) to track evapotranspiration stress during droughts that occured across Poland in the 21st century. Here, datasets produced by the Global Land Evaporation Amsterdam Model (GLEAM) are used in the analysis. Driven by RS data, GLEAM provides simulations of land surface stages, including soil moisture and evapotranspitation (Martens et al., 2017, Miralles et al., 2011). The effect of soil water deficit on vegetation functioning is investigated by applying the evapotranspiration-based drought indices reveailing the detectable signature. Evaporative Stress Index reflects the anomaly of the actual evapotranspiration to potential evapotranspiration ratio while the Soil Moisture Index detects the observed dryness of a soil relative to the plant's ability to extract water. The evolution of drought indices is examined on a background of precipitation and meteorological conditions. The occurence of 2015 drought across the country (as the most extreme) is assessed by using the nine classes scale of standardized anomaly indices. Drought propagation is revealed through the change of the drought signal as it moves from anomalous meteorological conditions to the soil surface, root zone and is translated into evapotranspiration flux reduced by decreased soil water reasources. Literature: Martens B, Miralles DG, Lievens H, van der Schalie R, de Jeu RAM, Fernández-Prieto D, Beck HE, Dorigo WA, Verhoest NEC (2017) GLEAM v3: satellite-based land evaporation and root-zone soil moisture, Geoscientific Model Development, 10, 1903–1925, doi:10.5194/gmd-10-1903-2017 Miralles DG, Holmes TRH, de Jeu RAM, Gash JH, Meesters AGCA, Dolman AJ (2011) Global land-surface evaporation estimated from satellite-based observations, Hydrology and Earth System Sciences, 15, 453–469, doi: 10.5194/hess-15-453-2011

Catchments landscape features impact to the runoff of Zayachya river basin small rivers (southern part of the Arkhangelsk region) at summer low-water period

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The formation of runoff and the chemical composition of small rivers mostly depends on the local catchment features, due to which their hydrological and hydrochemical regime may not be characteristic for each terrestrial ecosystem rivers. The data of existing hydrological gauges are often insufficient to reveal the patterns of small rivers flow formation. Therefore, more detailed studies are required to identify the key factors in the formation of their runoff. Case studies were carried out in the basin of the Zayachya river – small river flowing in the Ustyansky district of the Arkhangelsk region. It belongs to the Northern Dvina and, accordingly, the White Sea basin. The total length of the river is 42 km, the catchment area is 154 km2. 12 section lines have been selected in its basin: 3 - on the main river, and 9 - on tributaries. Hydrometric measurements and water sampling for chemical analysis are carried out in each of the sections several times a year. Some of them were conducted in the period of stable summer dry season, when all watercourses are approximately in the same state, which allows them to be compared with each other to identify spatial patterns. For each section line, water discharges measured during the period of stable summer dry season were averaged. The obtained values are called QSL (characteristic summer low water discharges), and their division by the area of catchments of rivers results in MSL (characteristic summer low water flow modules). QSL.for different sections have exponential dependence on the stream orders (N, determined by the A. Scheidegger method). Previous studies by Department of Land Hydrology (MSU) showed that such dependences are typical for the basins of middle rivers. In the small rivers selection these dependences usually have a large scatter of values. This case study shows that a similar dependence is possible for the basin of a single small river. Values of MSL are decreasing with an increase of the forest cover of catchments. Despite the fact that usually the presence of a forest in a catchment leads to a decrease in the intra-annual irregularity of the runoff, which should be accompanied by an increase in low-water runoff modules, in this case the situation is opposite. Most likely this is caused by the occupation of forestless catchments with arable land, which also helps to reduce the intra-annual irregularity of the runoff. This is confirmed by the increasing dependence between MSL and the percent of arable land on watersheds.

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Digital mapping of topsoil water stagnation in forest-steppe

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Spatial heterogeneity of topsoil water stagnation reflects the landscape water-cycle dynamic and its mapping is of particular importance for regions with intensive agricultural land use. In our research, we hypothesize that the surface and subsurface water redistribution process determines the spatial heterogeneity of topsoil water stagnation. To test our hypothesis, we conducted studies in two key areas in the forest-steppe zone, the center of the East European plain with contrasting soil moisture-regime. Kurskiy key site (35 ha) located in the Central Russian Upland, characterized by free-drainage condition due to deep groundwater, the loesslike loams parent material, and the dense network of shallow hollows on flat interfluves. Kirsanovskiy (390 ha) key site located on a slightly undulating poorly dissected interfluve with low hydraulic conductivity parent material in Volga Upland. The input data for analysis are high-resolution digital elevation models and the values of water-stagnation coefficient of 76 points in the Kurskiy site and 91 in the Kirsanovskiy site. The water-stagnation coefficient is the ratio of the optical density of alkaline soil extract (closely dependent on the soil-water regime) to pyrophosphate extract (quite stable and similar in different forest-steppe soil). The larger the coefficient, the prolonged the soil saturation with water. The landscape process (surface and subsurface water redistribution) was simulated using SIMulated Water Erosion (SIMWE), implemented in open-access software GRASS GIS. The spatial variation of the topsoil water stagnation was determined through a linear regression analysis in which the dependent variable was the water-stagnation coefficient at the description points, and the independent variables were the simulated parameters of redistributed runoff. The runoff redistribution values alone determine the water-stagnation coefficient with the accuracy of more than 80% for both key sites. Thus, we have confirmed the leading role of the landscape process (the moisture redistribution) in the formation of spatial heterogeneity of topsoil water stagnation in two different key sites with contrasting drainage conditions. In the Kurskiy site, the topsoil water stagnation is predicted for about 5% of the total area, in the Kisranovsky site – for about a third.

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The impact of fluctuations in the level of the Caspian Sea on the coastal landscapes and synergistic effect of processes

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In the article the main stages and impact of Caspian Sea level fluctuations on the north-eastern coastal landscapes (coastal area in Atyrau and Mangistau regions of Kazakhstan) for the period of 1978 to 2014 are considered. Land cover changes and distribution of negative geo-ecological processes (salinity, flooding) were identified based on the use of Landsat 1977, 1987, 1998, 2013 multispectral satellite images. Normalized Difference Water Index (NDWI) was calculated to identify the water table. On the basis of the values of brightness characteristics and synthesis of Landsat satellite images channels the article explains the correlation between vegetation and coast moisture conditions during transgressive phases and emergence of saline areas in the receding coastline. The author's research objective was to evaluate the degree of sea level fluctuations impact (high, moderate, low) on different types of observed landscapes which have been exposed to marine transgressions in different geological epochs. As a result, the main conclusion was made that the intensity of the impact of sea level fluctuations on coastal landscapes to a large extent depends on the terrain, formed during long transgressive phases (1977 - 1995 years, the earliest- and late Caspian transgressions) which also connected with groundwater depth level, wind-driven waves zone of impact and the main characteristics of land cover. The author emphasizes that the study of modern areas affected by flooding will help to determine «risk flood zone» and to define danger levels of areas for a different economic activities development.

Hydrological conditions and vegetation reconstructed from a mountain peatlands archive in north macroslope of the Western Sayan mountain: A multi-proxy approach

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The purpose of this collaborative research is to document how Holocene climate variability affects the landscape evolution in the Valley of Buyba River. We analyzed 5 peatland locations in an area of the river catchment. Sediment cores were taken from the central part of the peatland landscape. The age of the cores was found through radiocarbon dating. Within the northern macroslope of Western Sayan, the start of bog forming occurred asynchronously. Bog's age decreases with the increase in the absolute elevations. At the highest elevation of 1656 m, the process of peat accumulation started 460±80 years ago, after a significant reduction of snowfields. The most ancient peat layers were found at the altitude of 1320 mand in elevations down the slope and were aged 2950±110 years or more (up to 5000 years). Over the period from 5000 to 4000 years ago, there were dryer and warmer climate conditions in the research area. Slopes of trough valleys were covered with sub-alpine shrubs of dwarf birch and alder, the tree layer was absent. According to the pollen analysis, the participation of tree vegetation (Pinus forest with Pinus sibirica and Betula sect. Albae) was higher at the foothills. Sometimes, at an altitude of 1650 m peat deposits were not formed, only isolated remains of plant detritus were found in much younger gravelly-clay sediments. Analysis of minerals in the peat layer and the dynamics of accumulation of Na, Al, Ti (INAA-method) indicate that the time interval l500-2200 years ago was characterized by most stable hydrological conditions with the least amount of allochthonous contaminants. On the peatlands, sedge and sedge-moss plant communities developed. The main plant species which grew in the peatlands included Carex altaica (Gorodk.) V.Krecz, Carex limosa L., Tomentypnum nitens Hedw., Aulacomnium palustre (Hedw.) Schwaegr., Warnstorfia exannulata (B.S.G.) Loeske., Thelypteris palustris Schott, Baeothryon caespitosum (L.) A.Dietr. During the last 500 years, an increase of allochthonous contaminant inputs to swamp sediments is observed. The main causes of the increase may be a reduction of the forested area, a sharper contrast of summer and winter temperatures, and a more rapid melting of snow in early summer. The last cause led to increased levels of floods. Eutrophic-mesotrophic sphagnum communities (Sph. warnstorfii Russ., Sph. subsecundum Nees, Sph. angustifolium Jensen., Sph. fuscum (Schimp.) Klinggr.), which are presently common, began to develop in the peatlands since 500 years ago.

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Landscape reaction to activation of exogenous and endogenous geological processes affecting the permafrost stability (north of Western Siberia)

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The report examines landscape resilience to the intensification of dangerous geological processes in areas of permafrost distribution in the southern tundra, forest tundra, and northern taiga. Object of study: the territory of the Nadym-Tazov interfluve - the central part of the Yamal-Nenets Autonomous District, occupying the north of the West Siberian region (oil and gas development). The interfluve has a glacial and aqueous glacial relief (the Sartanian Neopleistocene horizon). The research carried out by the Ecozont Centre of the Federal State Unitary Enterprise «Aerogeology» is based on remote methods, environmental monitoring and fieldwork. Factors affecting the potential sustainability of the studied landscapes: geocryological conditions, swampiness; soil engineering properties, drainage. It is especially important to assess the impact on environmental changes of the nature of permafrost rocks (MMP) with their relatively known stability in different landscape zones. In the process of research the following are created: a landscape map with a scheme of exogenous geological processes (cryogenic processes prevail), a scheme of lineaments to predict endogenous processes and exploded maps of the geochemical situation. Retrospective analysis of multi-temporal images on space and aerial photographs allows identifying areas of changes in different landscapes taking into account latitudinal features. Azonal factors include geological structure, relief and composition of landscape forming thicknesses (geological-geomorphological basis). The characterization of dangerous endogenous geological processes is related to the fact that the relief reflects deformations associated with the manifestation of newest and modern movements, which partially inherit the folded and rupture structures of the doyur foundation and the sedimentary cover. Lineament analysis allows identifying (with geophysical data) active fault zones. Fractures are not visible on the surface due to the cover of relief-forming Quaternary sediments, but can be reflected in the details of the relief and land cover. Given the conditionality of the correlation, in these zones deep fluids increase the temperature of frozen sequences, activating cryogenic processes. Conclusion: On the Nadym-Tazov interfluve one can observe zonal and azonal types of distribution of dangerous geological processes associated primarily with the nature of MMP, which helps to determine the relative stability of landscapes to anthropogenic pollution and natural anomalies.

1. Landscape spatial structure and dynamics - LSSD

1.3. Stochastic and deterministic modeling of landscape structure: processes and metrics

Hosts: Vladislav Sysuev, *Lomonosov Moscow State University, Russia*, Alexey Victorov, *Sergeev Institute of Environmental Geoscience RAS, Russia*

Description:

The session will focus on review of available methodical tools aimed at stochastic and deterministic modeling of structure-forming processes in a landscape. We are planning to focus on quantitative DEM-based classifications using geomorphometric parameters that describe force geophysical fields as well as using remote sensing data. We are interested in demonstrating examples of deterministic modeling based on differential equations, experimental modeling, and field and laboratory measurements of processes. The supposed list of structure-forming processes of interest subject to modeling is as follows: runoff, sheet and streambed erosion, glacial matter transportation, morainic and glaciofluvial accumulation, relic and actual permafrost processes related to climate change, aeolic transportation and aeolian abrasion, avalanche-related landforms development, biogenic relief development, biological production, animals' activity and its influence on patterns development, vegetation cover as a factor of landscape pattern development.

Geographic Information Science in Landscape Studies: Stochastic and Deterministic Modeling

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The methodology of geographical information science (GIScience) is based on a number of principles that form the theoretical foundation of modern geography: spatial relation (Tobler 1970) and spatial heterogeneity (Anselin 1989), modifiable area unit problem (MAUP, Openshaw 1984). The latter state that analysis of geographical information strongly depends on a choice of basic spatial units (Goodchild, 2019). Goodchild (1980) and P.Burrough (1981) demonstrated that many geographic phenomena exhibit fractal behavior, that are controlled by the scaling laws (Mandelbrot, 1977), perhaps, not yet well understood as fundamental physical principals of landscape self-organization and evolution. Modern theoretical framework of landscape modeling is based on McBratney et al. (2003) proposition of the SCORPAN model for soil mapping based on soil forming factors (climate, organisms, relief, parent material and time), that additionally takes into account space location to estimate spatial dependency. Landscape processes are the results of complex interactions of different multiscale environmental factors, which are connected with each other in nested hierarchies (MacMillan et al., 2004). P. Burrough's notion of the landscape dynamic is based on a unified stochastic and deterministic relationship between nature components acting as landscape forming factors. P. Burrough's (1983) was the first to propose the fractional Brownian noises (fBn) model to account for situations where differences of soils have been caused by superimposed, independently acting soil-forming processes having different weights and acting at separate, discrete scales. Landscape catenary system can be used as an example of the gravity-driven material translocations, where in steep and convex slopes the material is eroded, and then is transported downhill and accumulated in concave or foot slopes. This mechanism of soil translocation demonstrates a short-range spatially autocorrelated variation in soil properties along the catena. Geostatistics proposes modeling the spatial autocorrelation among point measurements using the variogram, which shows the degree of spatial correlation of landscape parameters. Vertical curvature is a measure of relative deceleration and acceleration of gravity-driven flows, while horizontal curvature characterizes those parts of the landscape, where divergence or convergence of lateral flows occurs. In spatial landscape modeling we apply Laplacian - a measure of the global curvature of the random field (Hristopulos, 2020).

Geophysical analysis of landscape polystructures

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The objective identification of landscape cover units is very important for sustainable environmental management planning. The article proposes a method-algorithm for describing the formation of landscape structures which is based on the classic landscape analysis and applies the parameters of geophysical fields. The main driving forces of all structure-forming processes are the gradients of gravitational and insolation fields, parameters of which were calculated using the digital elevation models and the GIS-technologies. A minimum number of principal parameters are selected for typological and functional classification of landscapes. The number and importance of parameters were identified basing on the results of numerical experiments. Landscape classifications elaborated on the basis of standard numerical methods take a fundamental geophysical value. In this case, a concept of polystructural landscape organization is absolutely logical: by selecting different structure-forming processes and physical parameters, different classifications of landscapes could be elaborated. The models of geosystem functioning are closely related to their structure through boundary conditions and relations between parameters. All models of processes and structures are verified by field experimental data obtained under diverse environmental conditions.

Altitudinal landscape systems of plain

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Vertical differentiation of landscapes of plain is a universal property of qualitative geosystem changes depending on differences between absolute and relative heights. Altitudinal differentiation of landscapes is a multiscale phenomenon, which characterises geosystems of different taxonomic ranks. Within the plane, they occur as sites, landtype, landtype association, districts and sections, a certain altitudinal grouping of which makes it possible to identify altitudinal landscape systems (ALS) morphologically and dynamically. The formation of vertical differentiation of landscapes and ALS is initiated by a change in the intensity of vertical movements of the earth's crust, causing thus 1) an altitudinal transformation of the territory, and an increase of the difference in height between watershed and base surfaces; 2) an increase of the potential energy of surface runoff and slopes between the watersheds and thalwegs; 3) an increase in a speed of water flows and, thus, their kinetic energy; 4) an increase of the depth and density of erosive dissection; 5) a formation of a landscape pattern and aspect differences of slope surfaces; 6) a stabilization of the insolation mode of the slopes of various aspect; 7) the formation of morphologically and dynamically similar ALS. Connecting this, the identification of gradation of ALS of different taxonomic ranks, in which landscape-forming processes will form conditions, leading to the differentiation of dynamically unified landscape groups, – is the main line of altitude-landscape analysis. The taxonomic scheme of ALS includes the following taxon: 1) divisions are distinguished by the type of contact between contrasting environments (altitudinal differentiation of land landscapes and depth differentiation of aquatic geosystems); 2) classes are divided according to the elevation difference of the first-order morphostructures (mountains-plains); 3) subclasses are distinguished by the differences in the radiation balance (ALS of the polar belt, temperate belt, etc.); 4) types are based on the elevation of plane (lowlands-uplands); 5) subtypes are classified according to the prevailing landscape-forming processes (valley-interfluve); 6) families are divided according to the zonal location of geosystems; 7) genus are divided according to the local elevation differences (deep incut, slightly incut); 8) forms are separated according to the features of the geochemical units (eluvial, trans-eluvial, etc.); 9) subforms are based on the differences in altitude elevation on the locality (low and high floodplains, etc.)

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What is the shape of a tree? Detecting vegetation patterns by assessing similarities in high resolution elevation models

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The study presents an approach for detecting landscape, vegetation or terrain patterns in a three-dimensional context, emphasizing the role played by the local geometry of the surface model. The core of the associated algorithm is represented by the cosine similarity applied to elevation sub-matrices of regularly gridded digital elevation models in combination to reference models. We developed an accompanying software instrument compatible with a GIS environment, which allows as inputs locations in the elevation model, based on field data, pre-defined geometric shapes or their combination. We exemplified the approach for a study case dealing with locations of scattered trees and shrubs. In this case, the variation of the pairwise similarities between trees is better explained by the computation of slopes. Further, we considered a predefined shape, the Mexican Hat wavelet. Its geometry is controlled by a single number, for which we found ranges of best fit between the shapes and the actual trees. Finally, a suitable combination of parameters made it possible to determine potential locations of scattered trees. Overall, the approach is suitable to quantitative analyses relying on elevation models and could be applied for comparison/detection of other vegetation patterns, geomorphologic features or whole 3D landscape patterns.

The state of dynamic balance in the thermokarst plains with fluvial erosion and the natural risk assessment

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The research deals with natural risk assessment techniques for landscapes in the state of dynamic balance, taking the thermokarst plains with fluvial erosion as an example. These landscapes develop under the influence of thermokarst, thermoabrasive and thermal erosion processes, which provide a complex and dissonant interaction, leading to the following: - new initial thermokarst depression appear, - the thermokarst depressions grow in size independently on each other as ponds (lakes) due to thermal abrasion, - at any occasional moment, the lake can be drained due to fluvial erosion and transform into a khasyrei and the depression stops growing because of a lack of water. The mathematical model of the morphological pattern for the thermokarst plains with fluvial erosion (the variant of the asynchronous start) gives us the solution. The model uses the approaches of the mathematical morphology of landscapes, such as the application of the random process theory. The analysis of the model shows that after a long time, the processes of generating thermokarst lakes and transforming them into khasyreis pass into the state of the dynamic balance. At that, the distribution density of thermokarst foci and their average sizes, the affection by the process, as well as the average sizes of khasyreis tend to some final values; the distribution of the lake areas should obey to a particular «integral-exponential» distribution, and that of the khasyreis - to the exponential one. The results of verification of the obtained theoretical conclusions in 18 key sites located in different natural environments show that the proposed mathematical model of the morphological pattern of the thermokarst plains with fluvial erosion is confirmed in the variant of the asynchronous start. Thus, the risk assessment to a linear structure to be affected by the thermokarst process within the thermokarst plains with fluvial erosion should take into account the state of the dynamic balance of the morphological pattern of the landscape, that is, the constancy of the named parameters and types of distributions. Using the formulas for these parameters and distributions from the grounded model allows us to obtain expressions for the impact probability of a linear structure within the thermokarst plain with fluvial erosion for a given time. The parameters necessary for the assessment can be obtained from remote sensing data.

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Studying Baer Knolls Landscapes in North Caspian Region

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Baer knolls are unique geomorphological objects situated in Caspian lowland near the big deltas of Volga, Ural and Emba. Those subparallel ridge landforms have aroused in time of Caspian Sea regression. The genesis of knolls relief is still disputed among researchers. Nowadays Baer knolls are semi-arid landscapes with compound spatial structure that include deserts, salt marshes, dunefields and water areas. Current dynamic trends of North Caspian landscapes caused by the complex of factors. We focused on two aspects of landscape structure. First is landscape pattern presented by knoll`s linear patches. Second is the vertical morphological structure of ecosystems. The study of pattern included GIS and statistical analysis of linear and point metrics. It revealed lognormal and Poisson distribution for most cases. The study of vertical structure was based on landscape profiles, which were created during the field research. 5 types of landscapes with Baer knolls were classified based on comparative analysis of structure aspects. Aeolian erosion, salinization and pasture digression are recognized as most hazardous factors for Baer knolls ecosystems. We also identified many similarities in pattern`s features with other arid geographical objects such as Aral Sea, Qinghai Lake, Chad Lake. Study results consider very important issues of arid coastal ecosystems such as desertification, water level fluctuations, and exogenous processes. North Caspian is a multicultural region which economy strongly depends on ecosystem services (tourism, fishing, cattle breeding) so we assume current landscape studies may become a basis for the land use changes. Some conclusions of the research may be used as an additional method for spatial monitoring of arid coastal ecosystems.

Predicting plant species diversity in forested landslides zones using geostatistical methods

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Landslides, like most natural disturbances, facilitate the evolution of new plant species. Hence primary-derived topographic variables are essential in characterising the spatial variability of abiotic conditions for plant species diversity. However, the aggregated role of terrain attributes summarized into a single composite indicator of species diversity is still not well understood. Within the Outer (Flysch) Upper Carpathian region, south Poland, we analyse the integrated role of slope and aspect derived from a 1m digital elevation model (DEM) into transition locations, reflecting microscale variability in abiotic condition on the landscape. We then summarized high-density transition locations into a composite indicator, convergence points density (CPD). Our objective was to use CPD to improve the predictability of the number of species (NoS) (herewith referred to as species diversity) counted on 40 sample plot. Hence, we applied ordinary least square regression (OLS) and compared the performances of three geostatistical methods; Ordinary kriging (OK), Ordinary cokriging (OCK) and regression kriging (RK) in predicting and mapping species. Our results showed a relatively high correlation ($r \approx 0.68$) between CPD and the specie diversity compared to single or interacting terrains attributes through OLS. Furthermore, OCK and RK generally improved the prediction of NoS from CPD. However, RK outperformed both OK and OCK, decreasing the root mean square error (RMSE) by 33% and 15% respectively. Regression kriging was also more robust to limited sample size as well as to topographic heterogeneity than either OK or OCK. Hence, we conclude that a denser sampling of species diversity and or a more robust composite indicator, possibly including vegetation and soil indices is probably needed to improve these results. Notwithstanding these limitations, our results highlight the potential of integrating primary DEM attributes in building compositional indicators of species diversity which can also be applied as the first step in conservation planning in similar terrains. Keywords: Terrain attributes, ordinary kriging (OK), cokriging (OCK), regression kriging (RK), species diversity, convergence points density, forested landslides.

Structure and functional organization of landscapes of Matyra-Voronezh interfluve on Tambov plain

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The case study of soil-landscape connections as one of the subsystem of structure-forming and functional organization was offered by Dokuchaev and Glinka in the end of 19 century. Soil diversity and its dependence on natural factors (such as relief position, depth of groundwater) has significant practical use as well as scientific interest, because such researches help to understand functional features and landscape potential for planning and management. In this study soils are considered as an indicator of intercomponent interactions and can be used for landscape-cover dynamics monitoring. In the research relief is used as the main factor of differentiation. It determines direction and intensity of material and energy flows as well as defines other components states. The key area is characterized by prevalence of non-draining area type due to bedrock features and flat surfaces. For modeling 256 soil points with determinative attributes were used. DEM (with spatial resolution of 25 meters) was created for derivative features calculation. Thirty DEM-based parameters were calculated in «SAGA» program, the Simulation of Water Erosion model (SIMWE) was calculated in «GRASS GIS». In order to increase percent of accuracy the area was divided into 2 parts – valleys and interfluve positions. Soil-landscape connection simulation was implemented with the use of 3 methods: discriminant analysis, random forest and supported vector machine in «STATISTICA» and «Rstudio». The verification of models was made according to own field surveys, soil maps and by 30% of samples. Obtained models show quantitative soil types dependence on soil-forming factors: relief properties, runoff, SIMWE. The accuracy has variation approximately 6% for interfluve areas and 17% for valleys. In virtue of modeling the prediction of soils for every pixel was made, and according to study of structure of soil cover (Fridland, 1972) morphological structure was derived. Results define that hydromorfic and semi-hydromorfic lands on the interfluve plain occupy more than 80% of the area. The most important factors of differentiation on the interfluve are connected with water distribution and migration while in valleys these factors determine erosion intensity and accumulation. Results consist of series of maps and conclusions that demonstrate the diversity of conditions and the dependence of natural components on each other and morphometric indicators.

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GIS-based Landscape Map of Sayano-Shushenskiy Biosphere Reserve

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Although most of the special landscape research in the reserves were carried out in the tradition of classical landscape science (Chernykh, 2015), the landscape mapping methodology is being improved in the direction of automating the process of identifying landscape units. This approach is based on using geographic information systems (GIS), digital elevation models, and remote sensing data (Gorbunov et al., 2017, 2019). Usually, however, analyze mostly only one or two major factors, rather than combinations of multiple available (Diaz Valera et al. 2008; Corbanea et al. 2015). We developed a semi-automated technique of classification and mapping of environmental conditions (habitat) types as a natural basis of thematic mapping. This technique is based on an analysis of climatic, orographic, soil, and hydrological factors (Ryzhkova & Danilova 2012). The technique was implemented on the example of forest cover mapping in Southern Part of Near-Yenisei Siberia (Ryzhkova et. al., 2016). An aim of this work is to present this approach to create a landscape map of the mountain test area in the Sayano-Shushenskiy Biosphere Reserve, situated in the mountains of Middle Siberia (91°45'50"E, 52°11'23"N). Classification of geosystems of Sayano-Shushenskiy Reserve includes the following hierarchical levels: subclasses of geoms, groups of geoms, geoms and facies. The concept of geom corresponds to concept of landscape type (Konovalova et al, 2005). An unsupervised classification was done using a preliminary number of classes obtained from an analysis of topological transects that were built using DEM (SRTM). We established the boundaries of these classes base on a two-layer (elevation and slope) image classification by Isodata. To develop the units of high level a segmentation of DEM was carried out with help of Trimble e-Cognition. Then the layers of segmentation, climatic and soil data, and initial classes were crossed. We identified land cover classes relatively similar in morphometric relief parameters, topographic position and soil-hydrological conditions corresponding to certain landscape types and their combinations. A legend of landscape map contains 38 units - facies groups combinations. Geological, relief, and climate parameters, soils and dominant vegetation characterize every unit. The proposed approach using objective quantitative parameters of environmental factor and relief allows dividing natural continuum of land cover into discrete parts.

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1. Landscape spatial structure and dynamics - LSSD

1. 4. Multidimensional landscape modeling and its practical application

Host: Alexander Krenke, *Institute of Geography RAS, Russia*

Description:

By the early 21st century, physical geography and landscape science received an intensively developing measuring system of multispectral and hyperspectral remote measurements in a wide frequency range, containing information on a wide range of processes occurring in different parts of the ecosphere at various spatio-temporal scales. At the early stages analysis of multispectral remote measurements and development of various indices were commonly based on the reflection ratio of two spectral channels. Later, methods for extracting multidimensional quasi-discrete images based on various classifications and for identifying boundaries based on segmentation procedures were developed. Now, the research focus is the assessment of the fundamental thermodynamic variables that potentially create the basis for the study of non-equilibrium processes and self-organization of geosystems or states of landscape cover. Whereas in the 20th century, geography and landscape science concentrated efforts on answering the question «how natural phenomena and functional parts of a dynamic system are interrelated in space and time», in the 21st century the main question is: «why are they related in this way?» This objective requirement for geography, which is a science that simultaneously operates with space and time, allows us to talk about analytical landscape science focused on identifying the mechanisms that generate the behavior of dynamic systems at different spatio-temporal scales. Its basis should be a system of appropriate scale-related remote and field measurements. This section is devoted to the methods of structural analysis of geodynamic systems using field measurements and remote sensing data. The main topic of the section is the methodology of a comprehensive description and modeling of ecosystems, the relationship between models and observable data as well as approaches to the structural description of landscapes as a system and modeling specific components of landscape cover aimed at determining the properties that affect human activities.

Landscape pattern studies - traditions and perspectives

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The term «landscape» was introduced into Russian scientific literature in 1913. Since that time a lot of competing conceptions about landscape structure have been developed. Though traditional genesis-based approach with strong focus on abiotic factors is the most widely applied, today landscape is treated as multifaceted and multifunctional phenomenon, a complex system that requires multiplicity of projections to reveal essential relations between geocomponents and spatial elements. The presentation contains a review of approaches and concepts used in Russia to describe landscape structure: genetic-morphological, positional-dynamical, paragenetical, biocentric, biocirculation, basin and catena approaches, and the concept of chorions. Landscape map provides information on various types of landscape structures though one of them is commonly chosen as basic frame. The choice of basic type of structure used for mapping is dictated by expected practical application.

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Spatial pattern analysis of forest ecosystems of the Moscow region

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Current study of the spatial structure of landscape cover (spatial pattern) is based on assessment of the mosaic and fragmentation, or in other words, the spatial pattern. Since the end of the twentieth century approaches based on the quantitative metrics of the landscape cover structure, including fragmentation under the influence of anthropogenic factor, are being developed. This is in particular the metrics of area, perimeter, neighborhood (connectivity), contrast, diversity. The relationship of metrics with the parameters of species diversity, ecosystem sustainability, as well as the relationship with the behavior of individual species is confirmed. Our study aims to study of the relationship between various types of spatial structure and abiotic, biotic and anthropogenic factors (composition and structure of forest phytocenoses; topography, soil cover, road density, population, industrial emissions). In the course of the work, the following tasks are solved: 1) development of a large-scale map of the forest cover of the Moscow Region; 2) calculation of spatial fragmentation metrics; 3) classification of forest cover patches by metrics and identification of types of spatial patterns; 4) identify factors of the formation of the forest spatial structure . The study area is the Moscow region. Object of study - forest cover presented as the coordinated hierarchical system of territorial and typological units (ecological-phytocoenotic classification). Source materials: a database of about 1800 geobotanical descriptions, remote sensing data, vector spatial data. Methods: interpolation of geobotanical descriptions using the maximum entropy method, classification methods K-means, discriminant analysis. Results: the map of forest vegetation for the study area was obtained. It is shown that spatial metrics demonstrate a connection with the geographical position of the sections, as well as with the affiliation of the sections to certain classification units in the range of formations or groups of associations. The potential use of fragmentation metrics in studies of the sustainability of forest ecosystems is estimated.

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Prospects for using Trends. Earth module for assessing land degradation neutrality at the local level

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The results of applying the Trends.Earth module to calculate the Land degradation neutrality on the example of key sites in the forest-steppe landscapes in the Samara and Kursk regions of Russia, are considered. The main issues and challenges are: low spatial resolution of the default Modis satellite data, insufficiently detailed classification of land cover types to reflect the specifics of the landscape pattern at the local level, proposed types of land transformations do not reflect the specifics of degradation processes. To increase the accuracy of the assessment, we used a series of multispectral images Landsat 4-5, 8 from the standard atmospheric-adjusted Landsat collection Level 2 (spectral brightness coefficient at the earth's surface level) collected for the growing season. Space images were classified using Kohonenn's self-organizing neural networks by combining neural network analysis of space images with object-oriented methods to generalize the classification results (using the Thematic Pro software module of the Scanex Image Processor package). To mitigate errors related to the quality and number of images collected for different years and to the mismatching of shooting dates a special algorithm was developed for analyzing the dynamics of land cover, including the creation of multi-time composites. By use of this algorithm, it was possible to clearly divide the types of land cover of the studied test plots, as well as to develop the maps of land cover dynamics. The algorithm used is flexible for using a variety of input data. It allows receiving data on land cover changes using materials from various spacecraft, and using a different number of images for building seasonal composites.

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Tundra and forest of the Russian Arctic: landscape basis for modelling of dynamics in the modern warming

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Our attempts to develop a unified approach to accounting for the succession dynamics of forest vegetation at the Northern limit were not successful because we encountered at least three views on the nature of the transition zone from forest to tundra. The first is an original biogeographic and zonal phenomenon that has a relatively permanent range, often identified as a zone/subzone or forest-tundra biome. Climate intra-century cycles peculiar to the Arctic (about 60 years) are not able to turn it into a forest or tundra due to a small «characteristic time». The second view is confirmed by the concept of «relative treelessness» and the similarity of the distribution of podburs and podzolic alfegumus soils under the Northern taiga, forest tundra, and even southern tundra. If we analyze the climate parameters of the Eurasian forest tundra, it is clear that they correspond to the climate of the Northern taiga. The third view gives priority to tundra as inheritors of the periglacial environment, which allowed the presence of trees and shrubs, but on the terms of the so-called incubation (independence) of the lower tiers, which represented the zonal tundra. The climatogenic dynamics of the forest boundary in the Russian Arctic under global warming is analyzed. The problem is considered from the view of the contemporary biogeographic and succession status of forests on its northern limit using remote analysis and ground-based verification methods. Three variants of the forest to the tundra penetration were identified: (a) the forest recovers its position on cut-over areas; (b) the forest is expanding its area, occupying the «new» tundra habitats within its millennium-long dynamics; (c) forest «penetrates» to the tundra, using the conditions of short-term temperature anomalies. It is shown that the character time of formation / restoration of the «zonal forest» in the contact zone with the tundra is at least 200-400 years, i.e. equal to its succession cycle. By remote methods, the landscape features of the advances of the forest to the tundra in regions were traced: along river valleys, from valleys to terraces and watershed's slopes, and on watersheds - from margins of forests and forest islands. The relatively short periods of warming in the Russian Arctic do not allow moving the «zonal borders» of the forest to the north, but can only maintain ones in a permanent dynamic state.

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Geoinformational modeling of landscape diversity of the West Siberian plain

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The landscape structure of the territory is a complex multidimensional system. Multidimensionality poses significant challenges for research. It is possible to overcome the barrier of multidimensionality with the help of methods of decomposition (regionalization), aggregation (typification) or justification of the choice of simple indicators reflecting a complex of factors. An example of aggregation is a landscape map of a territory. It is the unification of many individual landscapes into classes, types and species based on features that reflect their basic characteristics. In the process of geoinformation modeling and quantitative assessment of the landscape diversity of the West Siberian Plain, different-scale landscape maps were analyzed; other information was collected according to a unified scheme. The values of the Shannon diversity index (H) were calculated and the cartographic visualization of the derived electronic diversity maps using GIS was carried out (Baryshnikova, Krupochkin, 2006; Krupochkin, Baryshnikova, 2007). This made it possible to obtain: a series of digital thematic maps of diversity, to establish correlations between different types of diversity and the factors of their formation. The most important factors were identified: positional factor; morphometric indicators of relief, bioclimatic potential; the degree of continentality of the climate, the density of the river network, the diversity of the soil cover and the species composition of organisms. The use of the Shannon index made it possible to study landscape and biodiversity in unified units of measurement. Geoinformation modeling of landscape diversity, based on the calculation of the Shannon diversity index, makes it possible to study, assess and monitor, establish the spatio-temporal relationship of different types of environmental diversity and choose a strategy for its conservation.

Thermodynamic characteristics of tropical deciduous forests of South Vietnam

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Based on the Landsat 5, 7, 8 multispectral survey of tropical Vietnam monsoon deciduous forests of South Vietnam (Kattien Nature Reserve), the parameters of solar energy conversion by landscape cover are calculated - the main components of the territory's energy balance and measures that reflect the complexity of the structure of the system that converts solar energy: albedo, absorbed solar energy, energy costs for evapotranspiration, accumulation in the system (carbon accumulation), heat dissipation into the environment, costs for the production of biological products, heat flux from the active surface; increment of information on Kullback, entropy of reflected solar radiation, self-organization parameter according to Forester, multiplicity parameter Q. Consideration of 18 survey dates for different seasons from 2013 to 2018 made it possible to identify the invariants (order parameters) of the dynamic landscape cover system for each thermodynamic variable. Based on the principal component method, two invariants are obtained for each thermodynamic variable, which reflects the seasonal state of the landscape cover 1 — the state before the wet season (February – May) and 2 –after the wet season (September – February). Thus, the presence of two different states of landscape cover corresponding to the winter and summer conditions for boreal forests has been established. However, if for the latter in winter, the greater the influx of solar energy, the greater both the heat flux and the costs of evapotranspiration, then for deciduous tropical forests at any given time - the greater the influx of energy, the higher the temperature and evaporation. The ratio of invariants of the main thermodynamic variables determines the type of thermodynamic system at each specific point (pixel) of the landscape cover. Based on the classification of the study area according to the values of the invariants of variables for the growing season, a map of the types of dynamic system (landscape cover) is obtained. For the main types of thermodynamic systems, the seasonal dynamics of variation of the leading thermodynamic variables is considered. Based on field data (198 points on the transect with a step of 20 meters), the dependence of the invariants on the composition of the stand was assessed (prevailing species in the basal stand area).

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Theoretical and methodological substantiation of borders and integrity in landscape cover on the basis of remote sensing

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The problem of the reality of borders has been the subject of discussion for two hundred years since the beginning of the formation of geography as a science. It is difficult to overestimate the practical significance of this problem, based on the concept of boundaries, on this basis any form of landscape cover segmentation is performed, whether it be a geobotanical special map or forest inventory. At present, remote sensing data are the main tool for spatial assessment of the state of the landscape cover (and, therefore, its typification). However, the segmentation of individual images does not provide an unambiguous division of landscapes, moreover, the very «intensity» of division as a rule is taken out of parentheses. This problem can be considered from the most general positions - the representation of the ecological space as a set of invariant factors obtained on the basis of the observed reflections in different spectral ranges (in this case, the system can be considered as thermodynamic) and the search for spatial variability to display these factors with different spatial frequencies. The proposed approach solves several related problems that require the use of various methods. The first main task of extracting order parameters is carried out by the principal components method applied to the remote sensing dataset. With the proposed approach, the order parameters reflect the stationary state of the system unchanged in time and, therefore, are identical to the invariants for the considered time interval. The study of boundaries in a given space should theoretically reflect functional changes in ecosystems from the point of view of thermodynamics. The boundary is defined as the maximum distance according to the Euclidean metric (or other form of metric) relative to neighboring pixels. The boundaries are calculated for different spatial frequencies, which, according to the Kotelnikov sampling theorem, should give objects of different hierarchies. Obviously, at a low frequency, the variety of boundaries is significantly less than at a high frequency. Many boundaries are often very fragmented at low frequencies. At high frequencies, closed boundaries are often distinguished, highlighting small objects. Also there is a difference in boundary «thickness» representing different types of boundaries. The analysis method used can be applied to time series of any variable of multispectral measurements and their various transformations.

1. Landscape spatial structure and dynamics - LSSD

1.5. Transdisciplinarity in landscape research: landscape synthesis from nature and human perspective

Host: Dmitry Marinskikh, *University of Tyumen, Russia*

Description:

The session discusses the possibilities and limitations of a transdisciplinary study of landscapes for planning and management in global context and in Russian conditions. We supposed to consider landscape as an object of integrative landscape research, which is understood holistically as a unity of natural, socio-cultural and perceptual-aesthetic aspects, which corresponds to the first scientific definition of the landscape by Alexander von Humboldt as «the total character of the Earth's terrain». The problem field of landscape research in the context of «Anthropocene science» is considered. The importance of conceptualization of the landscape as a socio-ecological system and as a cultural landscape is proved, supposed its study based on integration of structures and processes of the biophysical components of the landscape with a human and his activity, studied based on sociocultural approaches. Transdisciplinary interaction in landscape research of representatives of natural sciences, social sciences and humanities, policies and practices (stakeholders) is assumed, as well as involvement in research procedures of the population («citizens science») to solve problems of the «real world» using participatory approaches. It is proposed to identify promising topics of landscape research that need a transdisciplinary methodology. The following issues are proposed for discussion at this session: 1. Transdisciplinarity as a modern methodology for interdisciplinary landscape research; 2. Transdisciplinarity methodology for the design of research projects in landscape science; 3. Transdisciplinarity as a driver of sustainable landscape development; 4. Traditional knowledge and traditional practices of indigenous peoples for sustainable landscape development; 5. Transdisciplinary landscape science for human wellbeing and improving quality of life; 6. Case studies of transdisciplinary landscape research at various scales and in different geographical conditions.

Ecologically meaningful geospatial structures as a pivotal subject of landscape ecology

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Landscape ecology despite its already long history still lacks an universal generally accepted theoretical apparatus and vocabulary of concepts. This is one of the reasons of the still modest application of the methods and tools of landscape ecology in territorial planning and nature conservation. Ecologically significant geospatial structures are suggested as an ultimate research subject of landscape ecology. The «ecology» part of landscape ecology means an approach that is characteristically centered towards a certain subject, which can be connected to any living entity in the widest sense, including biological communities as well as an human seen either as a biological organism or as a subject of social relations and economic activities. A subject of ecological relations should bear a degree of independence from influencing ecological factors, being able to adapt to as well as to change the latters to a certain degree. Ecological significance (significance from a viewpoint of certain subject) serves as a touchstone for choosing the criteria for the selection and classification of properties, structures and regularities for landscape-ecological study. The concept of site (ecotope) is proposed as a basic one for landscape ecology, being defined as a part of geospace with relatively homogenous ecological factors, from a viewpoint of a certain subject. This concept encompasses the material properties of the place (its climate, soils, water regime, etc.) as well as its relative location (situation), which as seen from a geographical perspective influences and explains the former. Sites form spatial structures of two sorts: 1) characteristic patterns, either isotropic (mosaics) or anisotropic (zonal structures); 2)paradynamic systems parts of which are connected with material and energy flows (vivid example being a river basin). A set of methods and techniques could be applied to distinguish and classify sites, specifically – the methods of ordination (e.g. Ramensky, Whittaker, ter Braak), biospatial distribution modeling (e.g. Austin, Franklin, Elith), environmental stratification (e.g. Bunce, Metzger, Jongman). Methods for the analysis of natural biota responses to ecological gradients and methods for evaluation the suitability of environment for human land uses share many features and can be united under the common paradigm. Modern data sources, like detailed remotely sensed imagery, DEMs, and other digital geodata, and analysis tools like modern machine learning techniques tuned for the geospatial data analysis could effectively be brought to use.

Transdiscipline approach to study the degradation of the Altai permafrost's landscapes

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Geography in itself is a prime example of trans-disciplinary science with the broadest subject area of research. The subject of study of geographers include both the natural shells of the planet Earth (the atomosphere, hydrosphere, lithosphere, biosphere) and, of course, the main thing - human, with the widest range of their life needs. Therefore, it also includes ecological disciplines and social, economic, political and other human-centric subspecies of geography. The state of permafrost rocks in the Greater Altai is the main subject of my research. Cryosphere has undergone significant changes over the past decades, following strictly in line with the planetary situation of climate change. These changes are manifested in the active degradation of permafrost and often related destructive phenomena, sometimes threatening the local population. This situation shows that this problem is not only concentrated in the abstract field of pure geocryology knowledge about the structure, physics, chemistry of frozen soils, mechanisms of freezing and thawing, but also the impact of all this complex of processes on the life and economic activities of people living in permafrost territories. Transdisciplinarity, in my field of scientific interests, is represented by the creation and further practical use in research the geoinformation systems. Such databases, created with the help of GIS, can collect all basic and related data for the studied areas. GIS may include of the permafrost state, hydrological network, geological mapping, and meteorological conditions during the period of instrumental observations, et al. By collecting and systematizing disparate data from different geography disciplines, through systematic geo-information analysis, we can present the processed data in an understandable and accessible way for specialists from various related research disciplines. Presenting the results of research to the local population, local authorities, press, etc., in a simple, clear and understandable way is also an important aspect of working with such GIS. The potential practical relevance of such works for interdisciplinary research, such as archaeology, can also be highlighted. The most famous archeological findings in the Altai were made at the opening of the burials, carefully preserved in permafrost. Knowledge of the state and trends of permafrost conditions can help in planning archaeological research by showing which sites need priority attention due to the potential destruction due to permafrost melting.

Modelling and Monitoring of an Ecological Landscape Potential of Mongolia at Present and in a Changing Climate

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Among 195 countries of the World, Mongolia is the least populated country, having 2 people/km2. Climate change over Mongolia and associated changes in Ecological Landscape Potential, ELP, and Climate severity that characterized human comfort and wellbeing have been studied. Climate change by the end of the century (the 2080s) was calculated from twenty general circulation models CMIP5 (www.ipcc-data.org) as simple ensemble means of January and July temperatures and annual precipitation for scenarios RCP 2.6 (moderate warming) и RCP 8.5 (extreme warming). On average, July and January temperatures would increase by 2 to 6oC and by 4 to 8oC and annual precipitation would increase by 50-150 mm respectively in RCP 2.6 and RCP 8.5 climates over Mongolia. The January temperature anomalies were greater in the north and July temperature anomalies were greater in the south. Climate severity would decrease by the 2080s. Most of Mongolia being «extreme severe» and «severe» would turn to be «severe» and «moderate» respectively; some areas would even become «relatively favorable» depending on a climate change scenario. ELP (accumulated temperatures greater than t>10°C multiplied by a moisture index) of most Mongolia is currently «very low» and would change by one category to «low» and to «medium» by fragments by the 2080s. The contemporary «low» categories of EPL result from insufficient moisture. By the end of the century both temperature and precipitation are predicted to increase. However, the lowest precipitation anomalies were predicted in desert regions which would worsen moisture conditions. To conclude, climates predicted in Mongolia by the end of the century would be milder and warmer without significant aridization. ELP would increase by one-two categories that would promote Mongolia to be more favorable for human life and sustainability. Our predictions are of great geopolitical importance as Mongolia is a key country to put into practice the transcontinental Initiative «One Belt - One Way». This Initiative is a reconstruction of «The Great Silk Road» from China through Mongolia and Russia to Europe in its modern form. Presently, remote sensing methods are being developed for monitoring changes in both vegetation structure and productivity and population density.

This work was supported by the Russian Foundation for Basic Research, Project No 19-45-240004; 20-05-00540; 20-010-00990

(Post)traditional knowledge in 'dwelling' perspective: ad hoc adaptation to the ruinized Siberian infrastructures and landscapes

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The transdisciplinary project aims at studying the transformation of terrestrial Western Siberian ecosystems, landscapes and climate. The research benefits from the data obtained on the one hand through long-term environmental monitoring, and, on the other hand, from the series of interviews and quantitative surveys. The design of the study and the conceptual framework implies the creative clash of languages and types of knowledge in the process of transdisciplinary data interpretation: scientific, local knowledge, rumors, subjective perceptions of climate change. While landscape exploration produces scientific knowledge, local knowledge comes from investigation of experiences produced by encounters and the dialogue with the environment and practices of adaptation to it. To what extent is the local knowledge ‘traditional’ and ‘indigenous’? How does the local knowledge correspond with the scientific knowledge within ecological context? Landscape exploration implies intervention: both creating and destroying activity. The Soviet approach to landscape development involved rich infrastructural and social network, which covered areas, transforming them from ‘natural wilderness’ into the ‘useful environment’. This intervention characterized by «high frequency» of presence and widespread use of technology predetermined the destiny of these areas after the collapse of Soviet Union. In the areas where the effort to tame and manage the Nature had been at its peak, after weakening of economic and infrastructural presence of the State, it has «sprung off» after the maximum «compression», generating the most tangible breaks from a social point of view. Thus post-Soviet landscape generated new kind of challenge: instead of natural wildness, the problems were now caused by the destruction of previously created infrastructure. Rethinking the wreckage became a certain type of reflective knowledge that comes into a dialogue with traditional indigenous knowledge. I propose to look at the adaptation to collapsed and reassembled Ob' river landscape, within the framework of Anna Tsing's 'Third nature' concept and Tim Ingold's 'dwelling and living' perspective. These approaches overturn the logic of sustainable development. Firstly they show how sustainability comes from a reassembly of ruins and secondly it questions the heuristic value of 'traditional knowledge' as such in a context of the mosaic ethno-cultural map of Western Siberian communities.

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Transdisciplinarity and landscape synthesis from nature and human perspective: opportunities and limitations

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The report discusses the possibilities and limitations of a transdisciplinary study of landscapes for planning and management in global context and in Russian conditions. We supposed to consider landscape as an object of integrative landscape research, which is understood holistically as a unity of natural, socio-cultural and perceptual-aesthetic aspects, which corresponds to the first scientific definition of the landscape by Alexander von Humboldt as «the total character of the Earth's terrain». The problem field of landscape research in the context of «Anthropocene science» is considered. The importance of conceptualization of the landscape as a socio-ecological system and as a cultural landscape is proved, supposed its study based on integration of structures and processes of the biophysical components of the landscape with a human and his activity, studied based on sociocultural approaches. Transdisciplinary interaction in landscape research of representatives of natural sciences, social sciences and humanities, policies and practices (stakeholders) is assumed, as well as involvement in research procedures of the population («citizens science») to solve problems of the «real world» using participatory approaches. It is proposed to identify promising topics of landscape research that need a transdisciplinary methodology.

Transdisciplinary perspectives of mountainbiking in landscapes

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During the last decade, mountainbiking got increasingly popular as recreational activity in mountainous landscapes. From Landscape Ecological and Geoinformatics perspectives, we consider mountainbiking not only as an interdisciplinary but transdisciplinary study subject. Landowners with a particular subject related local stake interplay with Alpine Associations offering, creating and maintaining trails and tracks for hiking and biking, or public authorities (nature conservation) ruling the use of landscapes. These rules relate to juridical aspects (laws), which particularly have to be considered in relation to the hunting law and riding in forests. Besides environmental, political and social aspects, economic aspects play an important role when looking at mountainbike (tourism) destinations with their local markets, job opportunities, and infrastructures. When looking at mountainbiking as a sport, also federal and national cycling federations with trainers and supporters in need of a proper training environment come into play. Transdisciplinary perspectives of mountainbiking require a solid synthesis of planning and management aspects consolidated in an integrated, holistic endeavour, which cannot be met when missing one of the before mentioned actors.

2. Natural hazards - NH

2.1. Investigating degradation, desertification or simply land use change?

Hosts: Vera Schreiner, *Martin Luther University, Germany*, and Burghard Meyer, University Leipzig, Germany

Description:

Goal of the session is to discuss to compare Russian and European research entrances of landscape ecology on degradation, desertification and especially on irreversible changes in the context of land use changes. The Sustainable Development Goals (SDG) integrate important aspects on land degradation neutrality as well as the green strategy for Europe formulate the goal of climate change neutrality both general as well formulation these in the context of resilience. A key problem not solved here in the scientific discussion is still the geographical scale of the ongoing or envisaged land use changes (e.g. Aral Lake or simply a small dry out lake in Europe after the last drought season). The problem of extreme events is especially focussed here on climatic changes of temperature, precipitation and wind characteristics and their influences on land uses and land functioning/ecosystem provision. A change in e.g. wind speed in arable landscapes may increase the wind erosion risk in drought periods. How can the problem of degradation, desertification or land use change be characterised and renewed reformulated to the goals of resilient systems and both land degradation and climate change neutrality? New entrances to clarify degradation and desertification processes are needed in the context of the scale of change for land use planning, indicator concretisation, monitoring and policy advice.

2. Natural hazards - NH

2.1. Investigating degradation, desertification or simply land use change?

Land degradation assessment using the ESAI framework in the Czech Republic: what is the situation compared to formally more affected countries?

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The ongoing climate change in combination with the change of land use is expected to bring many negative consequences with the land degradation (LD) being among the most serious. As one part of a strategy to combat desertification in Medeiterranean countries, the Environmental Sensitivity Assessment Index (ESAI) was developed to identify the most vulnerable areas. In the last few years, the consequences of climate change became more apparent also in countries not affected by desertification such as Central and Eastern Europe, contributing to the overall fragility of local socio-economic systems. The need for assessment of the vulnerability to LD in reaction to changes in ecological and socio-economical changes is rising. Our study contributes to this issue by quantification of the risks of LD in the Czechia by adopting the ESAI framework. The sensitivity to degradation was estimated based on a set of variables grouped into four themes (climate, soil, vegetation, and land management) and processed as map layers in prevailing scale of 1:10 000. A score system was then applied, based on the estimated degree of correlation between the various factors and LD, to produce the classification into 8 levels of sensitivity. The results showed that surprisingly high proportion of the country lies in the critical level of sensitivity. The highest percentage was observed in the most accessible lowland districts devoted to intensive crops. Main LULC drivers in these areas are agricultural intensification as well as urban sprawl. The main conclusions of this study include following findings: i) the sensitivity to LD for the whole of the Czechia can be assessed on a detailed scale using ESAI framework; the method is therefore suitable for the national, regional and even local levels and is suitable also for other Central and Eastern European countries with a temperate climate and ii) the relative level of risk of LD in the Czechia according to ESAI is very high, even comparable to Mediterranean countries such as Italy or Greece. In the light of climate change, national and regional policies are definitely requested to face with the increasing sensitivity of formally non-affected countries, taking stock of the 'Mediterranean' experience in assessing and managing land sensitivity to degradation.

2. Natural hazards - NH

2.1. Investigating degradation, desertification or simply land use change?

Soil erosion and soil compaction as important indicators for the assessment of land degradation neutrality in Russia: case studies

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For agricultural lands the core LDN indicators such as land cover and soil organic carbon are challenging since they could be considered as invariants. LC reflects a long-term land use structure, and SOC stability is the result of using organic fertilizers. The study of land productivity by direct methods is problematic due to the crop rotation. Additional indicators can be more important in these cases. The possibility of using Soil Erosion (SE) and Soil Compaction (SC) were studied in Kursk and Krasnodar regions of Russia . The SE was suggested as an important complement to global LDN indicators. It can be interpreted through such indices as «Rate of soil loss» (ton/ha yr) and «Total soil loss» (thou tons, in certain area during selected time period). At local level the set of indices can be wider and site-specific, including those obtained through remote sensing by using universal classifier; the example was tested. It was found by using these indices that despite the general trend of reduction of the area of arable land, the dynamics of erosion processes are multidirectional. In at least half of Russia 's economic regions, a LDN state evaluated according to the SE indicator has not been achieved over the past 30 years. For many Chernozem soils compaction is the leading degradation process. As a result of long-term farming it is manifested in a decrease in the quality of the arable horizon, which determines a deterioration of soil moisture regime water supply of plants during the growing season, and soil drought. To establish LDN goals for such lands, an original approach is proposed that uses as a comparison (baseline for assessing LDN) those soil conditions which provides the maximum potential crop productivity, against the general UNCCD approach for using average productivity for a certain period. Using this approach for soybean as the crop most sensitive to moisture supply and soil compaction helped to study the mechanisms of reducing productivity due to the soil compaction and the violation of moisture supply in critical phases for soybean growing. Knowledge of these mechanisms made it possible to group fields using a set of indicators of moisture availability, and through this to select the farmland for improvement, and to predict the achievement of LDN while applying conservation technologies.

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2. Natural hazards - NH

2.1. Investigating degradation, desertification or simply land use change?

Degradation of ecosystem services since 1850 analysed by land use changes and landscape metrics

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Land use changed landscape structure and ecosystem service provision fundamentally over the last 170 years in Central Europe. We first reconstructed land use changes for two case study areas by using historical and current serial cadastral maps, historical documents and digital aerial photographs for time steps 1850 and 2018 of ownership allotment level. Land use change analysis shows for the first case study in the intensively used agricultural area of Jesewitz a significant decreased percentage of grassland from 9.2% (1850) to 4% (2018) and an increase of the build up area from 1.2% (1850) to 3.8% (2018). For the second study area in the low mountain region of Ilsenburg (Harz) the analysis shows also a significant decrease of grassland from 11.6% (1850) to 4.2% (2018). Build up areas strong increased from 15.7 ha to 151.7 ha. Other land use types have remained relatively stable over time. New types of land use were added between 1850 and 2018 (recreation area, compensation area). Second, landscape metrics analysis were applied to calculate selected landscape metrics on landscape level for several land use types (total area, agricultural area). The comparison of landscape metric values between 1850 and 2018 suggested that related ecosystem services such as erosion prevention and biodiversity lose their natural potential. Over time devastation of vegetation structures has brought habitat degradation and a dramatic biodiversity loss. Erosion risk hazard has increased strongly since 1850. Furthermore, historical data and landscape metrics calculation must be critical checked in regard to their information quality.

2. Natural hazards - NH

2.1. Investigating degradation, desertification or simply land use change?

Land Degradation, Desertification and Land use change

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The presentations introduce the titles thematic into the context of the (global) carbon budget. The contribution of land use changes on carbon fluxes is observed since centuries and has been long time the key factor of carbon emissions. Generally, the land use change discussion is not well interlinked yet into the work about degradation and desertification. A discussion on degradation of landscapes has to take the problems by terms as resilience, systems behaviour and (ir)reversibility into the focus of research since a degradation or desertification have to be clarified by measured factors and indicators. The measurement of land degradation neutrality therefore has to become based on factors and linked to a realistic time horizon for clarifying any dominance of land use changes to the degradation and desertification problem in landscapes. In this problem context the presentation shortly analyses three examples 1. Aridification in a landscape in Hungary caused by a set of landscape factors (more or less influenced by land use). 2. The time scale problem in degradation discussion in a context of the last 200 years for a German arable landscape measured on soil-based ecosystems services. 3. The problem of landscape complexity (by a large set of indicators) for the description of the numerous desertification processes mainly caused by the initial key land use change from steppe to arable in a South Siberian landscape. The presentation concludes by a statement on key problems not known in landscape ecology in the title's context.

2. Natural hazards - NH

2.2. Ecosystem services of erosion regulation - research methods, historical and statistical trends, value assessment

Hosts: Ralf-Uwe Syrbe, *Leibniz Institute of Ecological Urban and Regional Development, Germany*, and Yurij V. Ryzhov

Description:

Due to a changing climate and land degradation, it is both expected and experienced more frequent and more extreme erosion and weathering processes. We would like to collect and discuss recent advancements and novel approaches for research and assessment of erosion regulation services as well as successful examples of mitigation implementation and overcoming the threat. We welcome contributions investigating a range of topics: 1. indicators of erosion regulation services (type of cover, slope parameters, vegetation cover, soil texture, and etc.); 2. the major factors that affect the water and wind erosion and models of influence; 3. the factors and processes controlling rill and gully erosion; 4. monitoring and measurement techniques; 5. gullies and badland dynamics and modeling approaches; 6. mapping areas exposed to erosion; variability in the processes and rates of erosion; 7. soil retention and the capacity to prevent and mitigate soil erosion and landslides; 8. measuring the dynamical interplay of erosions; 9. soil erosion modeling tools; 10. soil erosion following post-fire and logging; 11. quantification of erosion and weathering in space and time; 12. on-site and off-site effects of soil erosion; 13. value assessment of erosion regulation services; 14. mitigation planning of water and wind erosion. Contributions are welcome from field, experimental, and modeling to methodological and conceptual studies across all temporal and spatial scales.

Nationwide Assessment of the Ecosystem Service Regulation of Soil Erosion by Water in Germany

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The Biodiversity Strategy of European Union demands a nationwide assessment and mapping of ecosystem services for all member countries by 2020. Germany has developed an indicator set for the most important ecosystem services (ES). Indicators are calculated in a way that allows to be recalculated regularly. Therefore, the method also is used for monitoring the ecosystem services and their changes. The calculation is presented using the example of the ES «control of water-bound soil erosion». This service corresponds to the capacity of the ecosystems to resist the soil erosion effect caused by water. Near-natural ecosystems often resist erosion to a higher extent than areas in use, whose erosion rates depend on natural parameters and factors related to use. The actual service, and therefore the main indicator, captures the protective effect of the ecosystems against soil loss, calculated from the difference of the annual losses and the hypothetical erosion rate without vegetation. Avoided water erosion is surveyed every three years. In Germany, the avoidance of erosion through ecosystems amounts to 467 million tons of soil per year. But the actual erosion rate increases slightly on about 7 % in from 2009 to 2012. On average, ecosystems in Germany avoid 14.8 t /ha of annual erosion. A secondary indicator describes the nevertheless existing soil erosion of about 45 million tonnes per year, which occurs mainly on sloping farmland, but also on tailings piles of mining areas. Overall, the current erosion is only about one tenth of the avoided, i.e. an annual average of 1.4 t/ha. This value has increased by 2.5 % since 2009 due to the changed cultivation spectrum on arable land (more maize). Another secondary indicator shows the contribution of small structures (e.g. hedges, tree rows, woody plants) in arable land to prevent erosion. In total, small structures can prevent half a million tonnes of soil loss in Germany.

Experimental studies of water erosion and deflation in steppe landscapes of the Priol'khonie

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On the Priol'khon plateau (on the coast of Lake Baikal), there is a need to monitor erosion processes and quantify the transfer of matter. More than 70 complex landscape investigations have been made to fix the characteristics of soils, vegetation, and relief, as well as the stage of digression. Experimental studies of landscape degradation processes were made: denudation (water and wind erosion), compaction and disturbance of soil cover, change, and simplification of the species composition of vegetation, decrease in the projective cover of wood, and grass vegetation. As a result of fieldwork and experimental measurements, landscape GIS and databases were formed for the study area, including the characteristics of various landscape types, the type of the recreational impact, and the stage of degradation. Statistical analysis of data experimental measurements on the transfer of silt by rainfall simulator was performed. According to the multiple regression equation, the contribution to the formation of soil and silt drift is primarily made by the digression stage and the steepness of the slope; secondly, the amount of fine sand in the upper soil horizon and the projective cover of the vegetation. The results of experimental measurements of silt transport by rainfall showed that the values of this indicator vary significantly (0.01–52.4 g / m2 for 10 min of irrigation). Maximum correspond to transformed territories (stages 4 and 5 of digression) with the low projective cover of vegetation (from 0 to 20%) and with a slope of 7° or more. The deflation study was carried out using a complex of traps (dust collectors) together with a particle counter at different heights, which allowed a relative quantitative assessment of soil transport volumes (from 54 to 245 g / m3) in different types of landscapes. To identify factors that influence the concentration of small particles (0.0003-0.01 mm) in the air due to wind erosion in the territory of Priol'khony, a statistical analysis was performed. According to its results, in close proximity to the earth's surface (0.5 m), an increase in particle concentration is associated with a wide range of factors. While with an increase in height above the soil surface (up to 2 m), the steepness of the slope and the granulometric composition of the upper soil horizon have a predominant positive effect.

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Studies of gully formation in steppe landscapes of the Priol'khonie

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The geomorphometric analysis is used for the drainless region located in the Western Baikal region - the Priol'khon plateau, whose territory under the intense recreational impact. The surface curvature maps were compiled on the base of ALOS digital elevation model data with a resolution of 30 m. Maps of slope steepness, horizontal, vertical, and general curvature were obtained by using geoinformation analysis, and statistical coefficients of these indicators for the study area were determined. A geomorphological interpretation of the spatial distribution of the areas of erosion and accumulation was made from the point of view of the development of hazardous processes (in particular linear erosion) initiated by anthropogenic activities. Analysis of geomorphometric parameters of the territory showed that denudation processes prevail in the study area. It was also determined the territory has significant potential for the development of erosion-accumulative processes. Areas of accumulation have been associated with the development of linear erosion forms as gullies. In addition to the ancient erosion network, these zones include the lower parts of the coastal slopes, as well as combe in the slopes of ridges of various exposures. It was revealed that the gullies that developed along top-soil roads are located within the designated accumulation zones. Orthophotomaps of areas with the largest gullies were obtained by unmanned aerial vehicle (UAV) Phantom 4. As part of monitoring studies in the territory of Priol'khony repeated measurements of the morphometric parameters of the gullies were carried out using fixed reference points. The general features of changes in the morphology of gullies are as follows: a) collapse and flatten the sides; b) reducing the length of the side slopes by reducing the depth of the erosion form.

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Wind regime of the southeast of the West Siberian Plain as a risk factor for the development of soil deflation in agricultural landscapes

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The article analyzes in detail the wind regime of the cold period of the year (CPY) (october-april) and assesses the deflationary danger of soils in the southern part of the Tomsk region. The source materials were historical-geographical, cartographic, literary sources, wind speed data for the cold period of the weather stations Tomsk, Pervomayskoye located in the subtaiga zone and Bakchar - in the southern taiga subzone. For the key section (20 km to the south-east of Tomsk), were used data from observations of the Tomsk aerometric station, located among agricultural land in an open area (1991-2015). Hourly data on wind speed and direction were analyzed for 2006-2015. The ratio of the percentage composition of physical clay (less than 0.01 mm) and physical sand (0.01-1.0 mm) was proposed to be called the deflationary hazard indicator (DHI). This indicator is determined for the upper soil horizons (0-10, 10-20 cm). The value of the DHI is distributed as follows: 0-0.3 - very much pliable; 0.3-0.6 - very pliable; 0.6-1.2 - moderately pliable; 1.2-2.0 or more - slightly pliable. Soil deflation occurs unevenly in time and space and is cyclical in nature from 1-2 to 5-6 years. In the snow layer, up to 824-1848 g/m2 of aeolian particles accumulate during the years of active manifestation (2012). Deflation is most intense in the cold period of the year in the little-snowy winter during blowing snow. In addition, the process develops unevenly due to the influence of the meso-and micro-relief of arable land. Aeolian deposits in the snow layer are closely related to the soils of the region, the humus content reaches in them 5.1%.

2. Natural hazards - NH

2.3. Wildfire as a global phenomenon: long-term fire dynamics, ecosystem response and fire management

Hosts: Elena Novenko and Alexander Olchev, *Lomonosov Moscow State University, Russia*

Description:

Fires is a major factor strongly influencing all natural, economic and social processes. Climate changes in the recent century, land abandonment, drought, flammable forest and plantations and urban sprawl resulted in increasingly extensive and dangerous forest fires in different regions of the World. An assessment of ecosystems response to fires is an important scientific problem that demands multi-proxy investigations on global, regional and local scales. Expertises in the modern status of landscapes and in projections of future changes are impossible without an understanding of fire as a global phenomenon during a long period based on evidences of landscapes dynamics and fire frequencies in the past. Such knowledge would enable us to improve management options in terms of adaptation of ecosystem services to climate change and mitigation of negative impacts of fires. The session is aimed to bring together the specialists with backgrounds such as fire dynamics, fire risk management, fire effects on vegetation, fauna, soil and water, working in the fields of geography, biology and paleoecology. The proposed session will focus on the following resect topics: 1) fire frequencies and environmental changes in different regions during the Holocene and the recent past; 2) satellite monitoring of forest fires; 3) landscape factors of fire spread and containment; 4) ecosystem dynamics under different natural and human-driven fire regimes; 5) post fire vegetation recovery, forest management and biodiversity conservation.

Wildfires as a driver for Mid- and Late Holocene vegetation dynamics in the Central European Russia

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Wildfires were of the most important phenomena in the forest vegetation zone of European Russia through the Holocene. New multi-proxy records of environmental changes from four key areas, located in different landscapes: southern part of Valdai Upland (south taiga), Meshchera lowlands and Mordovia State Natural Reserve (mixed coniferous-broadleaf forests) and Mid-Russian Upland (broadleaf forests) are presented. Palaeoecological analyses of peat cores for pollen, charcoal, peat humification, plant macrofossils and testate amoebae with dating using radiocarbon have shown that fire frequency affected significantly on the Holocene vegetation dynamics. According to obtained results, the beginning of human occupation of the areas is clearly marked by increased fire activity. Medieval time (at about 1000 cal yr BP) and Modern Period (the last 300 years) were marked by high fire frequencies all over the East European Plain. In the model area, located in the Meshchera lowlands and Mid-Russian Upland a significant increase in fire frequency was revealed around 2000 cal yr BP (Early Iron Age) and highest concentrations of micro- and microcharcoal were recorded for the last millennium, frequency of fires reached 8 fires per 1000 years. However, periods of increased fire activity occurred prior to the occupation of these areas by human. The highest frequency of fire in all model areas was determined for the periods 9000-6000 cal yr BP and 3500 – 2500 cal yr BP. Fire-free interval ranged from 15- 20 to 120 years. According to data available, the influence of anthropogenic factor during these time intervals was low. Archeological findings is rare in vicinity of the peat cores and no pollen or plant macrofossil indicators of human impact were detected. Evidently forest fires were coursed by climatic reason. The regional climatic reconstruction inferred from pollen and testate amoebae data these periods revealed high temperatures and dry summer conditions.

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A multi-proxy reconstruction of wildfires, peatland development and regional vegetation changes in subarctic NE Fennoscandia during the Holocene

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Arctic and subarctic ecosystems undergo extensive transformations because of considerable climate change, which leads to pronounced changes in land cover, vegetation composition and degradation of permafrost. These dynamics in turn cause climate feedbacks, particularly by affecting carbon cycling and release of greenhouse gases. However, the scale of this transformation is not uniform across northern landscapes. A better understanding of past long-term environmental changes in the subarctic regions is crucial for mitigation of the possible negative effects of climate warming in this vulnerable region. We conducted a multi-proxy reconstruction of wildfires, regional vegetation changes and peatland development for north-eastern Fennoscandia (Russia) during most of the Holocene. To that purpose, we performed plant macrofossil, pollen, testate amoebae, peat humification, loss on ignition and radiocarbon analysis of the peat deposits from a mire around lake Vodoprovodnoe (Kindo Peninsula, the Republic of Karelia). Our data indicate that the peat deposits started accumulating before 9147±182 cal. yr. BP as a result of paludification of the area adjacent to the lake. The vegetation cover in the area was mainly typical for the northern taiga zone, except for the period ~7800–5600cal.yr. BP, when it generally resembled the middle taiga zone. The vegetation cover and peatland were greatly affected by reoccurring fires, which can be partly related to human activity. These events were associated with an increased proportion of birch in the vegetation cover (as a pioneer species) after fire events or due to water level decreases. Since approximately 600 cal. yr. BP, the peatland and the surrounding vegetation reached its current state and since that time has only recorded minor changes. Overall, our results suggest a considerable and unexpected role of fires in the postglacial dynamics of subarctic peatlands. This highlights the need to understand the role of natural and human-induced fires under future climate warming scenarios in subarctic regions.

Wildfire effect on atmospheric precipitation regime

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For Russia, the risks of forest fires are common and have long-term growth trend of the areas covered by forest fires. Smog and haze from forest fires spread on a huge area (thousands of km on the wind rose). Due to the cloud seeding effect the rain clouds, colliding with smog and haze, produce precipitations on this border. Thus, the clouds get around the sources of forest fires and do not penetrate inside this area. In the area of forest fires a stable Siberian anticyclone was stable for a few months and exacerbated the drought in the area; these leads to growing number of forest fires. The high pressure zone creates a flow of descending air masses, which is presses the smog and soot from forest fires to the low altitudes, and aggravate the environmental situation. Inside the area of blocking anticyclone there is a scarcity of precipitations and the consequent reduction in river flow and water availability. The zone of stable Siberian anticyclone blocks the propagation of Atlantic cyclones and cyclones formed in the collision of hot air masses from the South and cold – from the North. The cyclones propagation are slowing down and most precipitation falls in a limited area, thus monthly rainfall can fall in one day, causing flooding, flash floods and severe flooding. We studded the severe flood on the Amur River from May till October 2019 with the help of the water-level data by stations in Gorodekov and Pashkovo. Independent variables: daily burned areas from forest fires in Siberia and the Far East of Russia, according to Avialesoohrana data. Dependent variables: Amur River water-level by the stations. Nonlinear regression model (double logarithmic) was built on data from June 10 till September 4, 2019. The Amur River water-level by station Gorodekov on 61.2% can be explained due to the daily burned areas from forest fires at the Far East of Russia. For checking the significance of the equation we use Fisher's exact test. The equation is considered statistically significant at all levels. Not extinguishing forest fire in the so-called «control zone» is necessary and sufficient condition for falling down a large amount of atmospheric precipitation in the south of Siberia which could cause catastrophic floods in the Amur River basin. The dust and smog concentration in atmosphere is a significant factor for predicting droughts, floods and natural disasters. This can be applied to heavy precipitations and floods associated with Smog and Haze from the forest fires.

Wildfire as a factor of ecosystems sustainability in Australia and Canada

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Regular wildfires support balanced development of sclerophyll forests in State Victoria (Australia) and as well as boreal forests in province Alberta (Canada). Fire practice has a long history in these regions. It is a major part of local Aboriginal culture and a means supporting flammable landscapes in productive state. Governments of Australia and Canada recognize the rights of native peoples on land and elaborate programs on the fire management with the participation of indigenous communities. Both governments promote implementation of a special practice of fire management based on Aboriginal experience. The goal of the research is to set the pattern of cause and effects between fire spread occurring during the fire management in Victoria and Alberta and to reveal key factors related to these processes. In order to achieve this goal it was necessary to solve following tasks: to study specifics of the fire management practice implemented by native peoples; to analyze dynamics of fire cases occurring during last 40 years in these regions and to assess scales of burned areas; to set correlation links between fire cases, scales of burned territories, and between key environmental, infrastructural, and social factors. Basing on literary materials and statistical data on wildfire cases since 1980s, on geospatial data on distribution and dynamics of fire-prone plant communities' locations, and on results of correlation analysis of fire cases with environmental, infrastructural and social factors author reveals the following patterns: (1) Indigenous carry out controlled burning prescribed by the governments. Such burning allows supporting flammable landscapes in productive state. (2) During the last 40 years burned areas in Alberta increased up to 3,5 times. By contrast, in Victoria burned area decreased in 3,4 times at this time. (3) Yarely about 30% of burned areas in Alberta and 40% in Victoria are subject to erosion. Statistical data on prescribed and wild fire cases in Alberta and Victoria have shown, that since 1980s: (1) fire cases are strongly correlated with duration (number of days) of dry periods ($r = 0,56$ in Alberta; $r = 0,58$ in Victoria); (2) the higher density of aboriginal population, the more frequent fire cases are ($r = 0,60$; $r = 0,57$); (3) the risk of burning settlement on small populated rural areas is higher, than on densely populated suburban and urban places (r ranks from 0,47 to 0,52); (4) the higher density of settlements, the fire cases more occur ($r = 0,78$; $r = 0,76$).

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Fire influence on different forest type in the Shumilikha Valley (Barguzinsky Nature State Biosphere Reserve)

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Natural forest fires occur regularly in coniferous forest geosystems in mountains near Lake Baikal. Due to the climate aridization fires have become more severe and unpredictable in the recent decade. We can learn more about influence of this natural disaster on various geosystems in Protected Areas where forest fires have been recorded and suppressed for many decades. Barguzinsky State Nature Biosphere is located on the western slope of Barguzinsky ridge in Northeastern shore of Lake Baikal. Since its inception in 1916 fires have been recorded almost every year. Only a few were spread by visitors and for the past 40 years all fires have been natural primary caused by dry thunderstorms. Last devastating ground and crown fires happened in 2015. Three 20 x 20 meter monitoring plots were established in the Shimilikha Valley, the southmost river watershed known for a waterfall and mountain ecotrail leading to it. Their aim is to assess vegetation recovery to analyze natural processes and also to plan further ecotourism activities. Here the fire spread five km deep and almost one km wide in the valley. Monitoring occurs in mountain slope geosystems: larch and dwarf pine forest (500 m above sea level); Siberian pine and Scots pine forest (700 m above sea level); fur and Siberian pine forest (1000 m above sea level). Because of difference in fire intensity and steepness recovery varies a lot. On the first plot we notice numerous dwarf pine seedlings, single larch seedlings. It shows slow recovery of original forest vegetation. On the second plot, there are birch seedlings and active grass growth meaning the recovery will go through deciduous forest succession. On the third plot, where fire intensity reached its maximum, grass grows fast but there are no coniferous seedlings. Possibly, forest recovery will take at least several decades. We see the same grass succession stage on all plots but tree stand recovery is different everywhere. The study shows overall positive trend in vegetation recovery and low erosion process. The five-year monitoring allowed us reopen the uphill trail with certain rerouting in the most vulnerable sites for minimal visitation in 2020.

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2. Natural hazards - NH

2.4. Transformation of The Arctic and Subarctic Landscapes under Climate Change and Human Impact

Host: Larisa Zotova, *Lomonosov Moscow State University, Russia*

Description:

Permafrost landscapes occupy one-fourth of the world's land area and they are currently under intensive pressures of modern climate warming and anthropogenic impacts. The structural and functional organization of northern geosystems is determined by the permafrost temperature and ice content, depth of seasonal thawing, protective vegetation properties. These factors determine the cryogenic processes development such as thermokarst, thermal erosion, solifluction, frost heave and others. The mechanical damage arising during the operation of engineering facilities and mining, are widespread in the cryolithozone and intensify these processes. The landscape sustainability in the permafrost zone is the ability of landscapes to resist the activation of cryogenic processes. So, hazardous geoecological situations within high latitude areas are defined by an abrupt of cryogenic processes activation and radical biota change. Understanding the dynamics and stability of permafrost landscapes, predicting their future evolution, finding solutions to environmental problems and developing adaptation strategies to the changing climate are critically important today. Permafrost-landscape classifications and mapping are also very necessary for studying the natural environmental trends in «cold» regions. Thus, all studies of permafrost landscapes regarding theoretical aspects, new research methods, observation data analysis, and predictive modeling are welcome. The following topics must be discussed: 1. The methods of permafrost landscapes studies; 2. Permafrost landscapes classification; 3. Cryogenic landscapes stability to the exogenous processes activation. 4. Lithocryogenic and bioresource state of northern geosystems, environmental problems; 5. The effects of vegetation cover on the cryogenic landscapes state under climate warming; 6. Estimating and mapping the landscape sustainability and geoecological situations to current climate change and anthropogenic impacts; 7. Mapping, remote sensing, and geographical information system (GIS) modeling; 8. Infrastructure deformations in the Arctic and Subarctic under the influence of cryogenic processes, environmental measures; 8. Adaptation to environmental changes.

Content and emission methane in the soils of permafrost landscapes of Western Yamal, Russian Arctic

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Enormous reserves of greenhouse gases have been accumulated in the Arctic permafrost, which can directly affect to global climate. A continued increasing air temperature leads to permafrost degradation and the release of additional greenhouse gases such as carbon dioxide (CO2) and methane (CH4). CH4 is the most active greenhouse gas, affecting the greenhouse effect at 25 times stronger than CO2. In Arctic ecosystems, CH4 formed mainly a biogenic way due to the activity of methane-forming microorganisms (methanogens), which are anaerobes. Anaerobic methanogenesis occurs in tundra soils, swamps, bottom sediments of lakes, and accompanied by the emission of CH4 from the surface. During freezing in autumn, CH4 is concentrated in its lower part. In some cases, CH4 can shift down (wring out) into the frozen stratum by a few meters. In this study, the CH4 content was determined in the upper thawed soil layer and the underlying horizon of frozen sediments in the area of the Marre-Sale permafrost station, located on the western coast of the Yamal Peninsula. Also was carried out a work to determine the emission of CH4 into the atmosphere for the dominant landscapes of a typical tundra of the study area. The highest CH4 content was observed for the most waterlogged landscapes such as the swampy areas of the river floodplain and the erosion landscapes of ravines and water runoff depressions. The average CH4 content in such landscapes was about 2.4-3.5 ml [CH4] / kg (up to 9 ml [CH4]/kg). For landscapes on the moistened surface of the polygonal tundra and the slightly drained flat surface, the methane content is on average 1.5-2.5 times lower (about 1-2 ml [CH4] / kg). Actually no methane was found for the landscape of the flat surface of a slightly moistened tundra (on average 0.4 ml [CH4]/kg). Analysis of the methane content in the upper layers was carried out up to depths of 2-3 m. This allowed us to identify an increase in methane content with a depth from the table of the frozen horizon to a certain maximum value at a depth of approximately 0.8-1.2 m. The data of the δ13C [CH4] isotope content confirmed the assumed biogenic origin of CH4. A stable positive flow of CH4 to the atmosphere was observed for the landscape of the swampy areas of ravines and water runoff depressions. The maximum recorded values of CH4 flux reaching 2.6 mg[CH4] *m– 2 * h– 1. At other key sites, the maximum flux did not exceed 0.2–0.6 mg[CH4] *m– 2 * h– 1.

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The role of cryogenic processes in reducing the stability of the infrastructure of Arctic settlements

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Climatic parameters and anthropogenic impact actively influence the change in permafrost properties. It is known that in the last 30-40 years in the Arctic regions, maximum trends have been observed in increasing outdoor temperature; precipitation regime changes significantly. An increase in the intensity of exploration of the Arctic is fundamentally changing the conditions of heat and mass transfer in the system «atmosphere - permafrost», a «new reality» is being created in the formation of landscape-permafrost conditions in the settlements of the Arctic. Our field observations and analysis of information on the state of infrastructure in the permafrost zone showed that very negative changes are occurring in the engineering-geocryological situation. Currently deformed: about 25% of buildings and structures in Norilsk, 80% - in Vorkuta and Dikson, 60% - in Igarka, 80 - 100% - in small settlements of the Arctic, etc. Our studies have shown that the causes of mass deformations of engineering infrastructure can be combined into four main groups: 1) the negative effects of dangerous cryogenic processes; 2) the impact of the natural-destructive processes of the Earthquake, etc.); 3) the «contribution» of climate warming, however, for example, in the Norilsk industrial region it does not exceed 10-15%; 4) the deterioration of the socio-economic situation in the northern regions. When assessing the negative role of hazardous cryogenic processes on the infrastructure of the Arctic, the emphasis is on the following areas: a) reduction in the bearing capacity of frozen foundations; b) an increase in the forces of frost heaving in a seasonally changing thaw layer; c) activation of destructive cryogenic processes (thermokarst, thermoerosion, movement on slopes, etc.); d) intensification of cryogenic destruction of the material of underground structures. Ensuring the sustainability of infrastructure in the Arctic is impossible without permafrost, which reacts sharply to changing climatic factors and technological impacts in various landscape and geocryological conditions.

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Vegetation and climate changes in the north-western part of Putorana Plateau during the last millennium

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Palaeoecological research were focused on the western part of the Putorana plateau in vicinity of the lake Lama, which belongs to The Pyasina river basin. Multi-proxy studies including pollen, micro- and macrocharcoal, peat humification, plant macrofossils and testate amoebae analyses with AMS radiocarbon dating were carried out for the peatland Gervi is located within the lake terrace of the Lama Lake. The peatland is covered by open Larix woodlands with a dense understorey of Duschekia fruticosa and Betula exilis. The thickness of peat is 57 cm and underlay by silt with clay. The peat accumulation began at 1280 cal yr BP. Obtained results showed that Pinus-Picea-Larix woodlands, occupied study area between 1280 and 960 cal yr BP. Picea obovata is very rare in plateau Putorana and grow in protected habitats in river valleys in the south-western part of the plateau at the north-eastern limit of its natural range. A relatively high amount of Picea pollen and presence of Picea stomata and bark in peat core suggest a northward shift of Picea natural range by climate warming during the Medieval warm period. Conspicuous peaks of microcharcoal and appearance of Onagraceae and Gelasinospora indicated a high fire frequency during this period that encourage to increase in proportion of pine and birch forest in plant cover. Macro-charcoal analysis revealed a relatively high CHAR-index and 6 fire peaks during this period (approximately 1 fire episode per 70 years). During the period from 960 cal. year BP to the present time a proportion of trees (Larix, Picea, Pinus) declined in plant cover while the share of shrubs Betula sect. Nanae and Duschekia fruticosa increase significantly. The proportion of typical arcto-alpine species Selaginella selaginoides noticeably increased while other spores become less frequent. The value of micro-charcoal particles reduced to a few percent. CHAR-index decreased; no fire events were detected between 960 and 100 cal. year BP. The last 100 years were characterized by increase of CHAR-index and high fire frequency that could be a result of human activity in the region.

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Some aspects of unified cryogenic processes monitoring program

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The problem of monitoring and accounting of cryogenic processes arose at the very beginning of the development of the permafrost zone, when, due to underreporting of the permafrost factors, infrastructural objects were subjected to destruct almost immediately after their construction. At present, monitoring of cryogenic processes is mainly carried out in anthropogenically developed territories: the mitigation against processes is mainly carried out along the main oil and gas pipelines, along roads and railways. With the advent of remote sensing techniques, the study of cryogenic phenomena and processes has become devoted to areal changes that make it impossible to evaluate the modern mechanism for the development of processes and to identify their regional features. Due to climatic changes, the intensity of certain (especially «warm») cryogenic processes has increased, and therefore the question of a detailed study of the formation of cryogenic processes in «new reality» arises in the changed environmental conditions. Of course, during the 20th century, permafrost scientists in the Soviet Union and the United States did a great job of studying the mechanism for the development of cryogenic processes, which should first of all be used for modern monitoring, but it is necessary to have continuous modern series of direct field observations of the processes for further forecast. There are several huge international scientific programs established in the 1990s devoted to monitoring the thermal state of permafrost: TSP and CALM. These programs cover data on monitoring permafrost temperatures in deep boreholes, as well as data on the depths of the active layer, but we still have no programs, focused on cryogenic processes monitoring. What is needed is the development of uniform methods for the long-term monitoring of processes. The paper discusses the main classifications of cryogenic processes, reveals the general parameters necessary for the selection of triggers and suggests the conception of the «model» territories for the monitoring. Model territories are territories with the process distribution, where the degree of its manifestation is maximum. The main methods of monitoring processes and phenomena has studied. On this basement we created projects of the monitoring sites for the five chosen processes.

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Snow cover as marker of air pollution of natural and industrial landscapes within the polar zone of the northwestern Siberia

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Atmospheric deposition of pollutants in the polar regions of Western Siberia has not been studied in detail, despite the fact that industrial activity within this territory has significantly increased over the last few decades. The aim of the present study was to evaluate the impact of the oil and gas industry on the atmospheric deposition of trace elements in polar regions of Western Siberia and to access the human impact on the Subarctic landscapes. Snow samples were collected within the Pur-Taz interfluve from three areas that differed in the type and intensity of anthropogenic influence: 1) the background area; 2) the urban area - Tazovsky settlement; 3) the Zapolyarnoye gas field. Particulate and dissolved forms of Fe, Mn, Ni, Cr, Cu, Pb, Zn and Cd were determined using an atomic absorption spectroscopy. In order to evaluate the degree of pollution, Contamination Factor (CF) and Pollution Load Index PLI was calculated. In comparison to the background sites, the anthropogenically affected areas were characterized by significantly higher values of pH and specific electric conductivity. In the background area, Zn, Cd and Mn were found mostly in dissolved forms, while Fe, Ni and Cu – in particulate forms. In the anthropogenic areas, especially in the vicinity of the Tazovsky settlement, there were increased proportions of particulate forms of all trace elements. Our results confirmed an earlier conclusion that the majority of elements in snow samples from the north of the Western Siberia are encountered in particulate forms. In the vicinity of Zapolyarnoye gas field, we have noted a significant variability of elemental composition. The maximum values for the concentrations of Fe, Cu and Mn exceeded their minimum values by 77, 68 and 48 times, respectively. Based on our calculations of the Contamination Factor, Fe, Mn, Zn and Cu were the most hazardous pollutants in the vicinities of gas wells. A similar combination of pollutants was observed in the vicinity of the Tazovsky settlement. Based on the PLI values, the almost ubiquitous contamination of snow was revealed within Tazovsky settlement and Zapolyarnoye gas field. It is shown that gas development has a negative impact on landscapes.

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The experience of estimated permafrost maps creation on a landscape basis for environmental purposes

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The assessment and mapping within permafrost areas during the economic development should be considered in terms of landscapes sustainability to the cryogenic processes manifestation. Their structural and functional organization are determined by the permafrost temperature and ice content, depth of seasonal thawing, vegetation heat-insulation properties, self-recovery rate and etc. These factors influence the lithocryogenic state of the landscape, decrease landscape stability, and, as a result, activate cryogenic processes such as thermokarst, thermal erosion, solifluction, frost heave and others. The mechanical damage arising during the operation of engineering facilities and mining intensify these processes even more. The assessment procedure includes a selection of main permafrost and biotic factors, methods of their comparison, ranking anthropogenic pressure, calculating the integral coefficients for clustering landscapes, evaluation mapping. To create these maps at various scales we use landscape indication methods, decryption satellite images, expert assessments, statistical calculations, and GIS - analysis. The following types of maps are described and presented: • potential landscape sustainability to mechanical disturbances • the permafrost-biotic state; • geoecological situations; • cryogenic processes activation; • environmental zoning. The first map of cryolithozone landscapes stability for Western Siberia (scale 1:4,000,000) was created by N. Shpolyanskay in 1993. The methodical approach was based on an analysis of the leading factors influence to landscapes stability under loading. The rank of each factor is evaluated by an expert score (now for more correct evaluation we suggest defining the score dimensionality using the so-called «quality cents»). All legends to landscape maps are compiled by us in graphical form. In the horizontal rows, zonal vegetation types of landscapes are shown, vertical columns correspond to the genus of landscape. Thus, the digital landscape map is composed of two thematic layers - relief and vegetation. To determine the types of geo-ecological situations, two maps shude be compared - anthropogenic load and landscape sustainability. The atlas maps of cryogenic processes activation edited by N. Tumel, compiled also on the landscape basis, have been introduced into seven ecological atlases. They have universal value, allowing us to analyze information about cryolithozone landscapes for environmental management.

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The problems of sustainability of Svalbard infrastructure in the context of changing climatic and landscape-permafrost conditions

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The Svalbard archipelago is the «world leader» in existing trends in climate warming in the Arctic. The trend towards an increase in air temperature in Longyearbyen over the past 30 years has been 0.1° C per year, and by 2080-2100 a number of models is forecasted that the average annual air temperature will increase by 3 ... 4° C. Following the change in atmospheric parameters, the permafrost temperature also increases at the level of zero annual fluctuations, the current warming trend is from 0.06 to 0.15° C per year. Such rates of change in climatic and landscape-permafrost conditions pose a great danger to infrastructure facilities on the archipelago. In addition to changes in the engineering-geocryological characteristics of frozen soils during their warming and a decrease in their strength characteristics, a complex of exogenous (primarily cryogenic) processes is activated. The numerical simulation showed that the increase in the thickness of the seasonal thawing layer by 2050 in the strongly icy clay of sea terraces typical of the developed part of the archipelago can be 17% in relation to modern indicators. Following an increase in seasonal thawing, the tangential forces of frost heaving will increase (for Longyearby, this indicator will increase by about 15%). Due to the high ice content of clay deposits, soil precipitation during thawing will increase significantly. The combined impact and unevenness of the processes of precipitation and heaving of soils in the seasonally thawed layer are a big threat primarily for linear infrastructure on the archipelago. The situation is aggravated by anthropogenic impact, for example, anthropogenic flooding, arising from poor design of the culvert facilities. All settlements of the archipelago have a coastal location, which makes them especially vulnerable to the activation of thermal abrasion, the rate of which increased significantly in the early 21st century: the coast retreat rate at all hospitals for the period 1991-2011 years higher than in 1960-1990. The large ruggedness of the relief causes the widespread occurrence of slope processes in the archipelago. Degradation of glaciation leads to an increase in the flow of meltwater and the formation of green and snow flows, cryogenic landslides.

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Methane content in the upper permafrost and active layer of Western Yamal, Russian Arctic

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Methane concentration in ground ice and frozen Quaternary sediments of the Kara Sea region has a substantial variability. Methane content in the active layer of different dominant landscapes of typical tundra is extremely variable too. High methane concentrations are found in marine clays with the presence of Massive Tabular Ground Ice (MTGI). The sands which freeze simultaneously with sedimentation have lower methane concentrations. High concentrations of methane in permafrost is attributed to migration and conservation of methane in ice bubbles under advancing freezing fronts, which is supported by the isotopic content of methane. The microbial origin of methane confirms that methane in permafrost is not related to seepage or migration of mantle methane through permafrost. It also confirms the non-atmospheric origin of massive tabular ground ice bodies widely present in the study area. The highest mean methane concentrations were found in wet polygonal tundra (8516 ppmV), bogs (4507 ppmV) and bottoms of the water tracks (3681 ppmV). These types of landscapes, which together compose almost 40% of typical landscapes of Western Yamal can be a significant source of methane emissions to the atmosphere. The landscape types that are characterized by good drainage, primarily sands and blowouts, have little methane available. Northwest Siberia has experienced one of the highest rates of climate change with increasing air temperatures, increased thaw depth and permafrost warming with these trends likely to continue in the future. The upper part of the coasts in the region is composed by ice-rich marine clays characterized by high methane content. Permafrost degradation due to climate change will be exacerbated along the coasts where declining sea ice is likely to result in accelerated rates of coastal erosion, especially in areas with presence of MTGI, further releasing the methane which is not yet accounted for in the models. Methane fluxes measured in typical tundra of Western Yamal are approximately 2 times lower than those measured in Alaska. The estimates of methane in various types of permafrost and ground ice are therefore an important contribution in regional assessments of the methane emissions from permafrost and as validation to the Earth System Models.

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Changes in landscape and permafrost conditions in Vorkuta and their impact on the state of the infrastructure

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It is generally known that the degree of landscape response to disturbances is directly dependent on the content of underground ice and the presence of finely dispersed composition in loose sediments, on the thermal resource and the nature of the manifestation of permafrost-geological processes. The climate of the Arctic is rapidly changing, in particular, there is a tendency to increase air temperature. Such climatic changes lead to processes that form the modern landscape of the Arctic territories, as well as deforming anthropogenic objects, which requires constant monitoring of the state of engineering structures. As a result of field research in Vorkuta, the main problem zones were identified in the city and surrounding villages. For these zones were analyzed the main causes of deformations of buildings and structures related to changes in permafrost conditions and the activation of cryogenic processes. Taking into account the trends to further change in climatic conditions, numerical modeling of the parameters by 2050 of engineering and geocryological parameters was carried out: the power of the seasonal active layer, the precipitation of thawing soils, the tangent forces of frost heaving and the bearing capacity of frosted foundations. The forecast showed that an increase can reach 9-10% in the power of the seasonal active layer under lithological conditions typical of Vorkuta. The greatest danger for Vorkuta is the increase in precipitation of thawing soils due to the high ice content of the upper layer of frozen rocks. As a result of soil subsidence during its thawing, there are deformations of the pavement, pipeline structures and building walls. Soil bearing capacity will decrease by 30% by 2050. Quantitative estimates of deformations of structures due to permafrost degradation make it possible to forecast the intensity of destructive processes in the future. The development of Arctic natural resources significantly affects the state of permafrost, which makes it necessary to assess the scale of destructive cryogenic processes and create prognostic models of dynamics.

The role of climate and anthropogenic factors in the forest fire dynamics in the Western part of the Putorana plateau (Northern Siberia) last 1300 years

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The role of climate and anthropogenic factors in the Forest fire dynamics in the Western part of the Putorana plateau (Northern Siberia) last 1300 years In the context of modern climate change in the Arctic region, the study of past environmental changes is becoming increasingly important. This study aimed to the reconstruction of forest fire history determined by climate and anthropogenic factors for the Western part of the Putorana plateau (Northern Siberia). Macrocharcoal particles (size >125 μm) were analysed to reconstruct fire history. Pollen analysis was used for reconstruction of the climate, human and forest fires impact on the vegetation cover of this territory in the past. Peat sediment core from the peatland Gervi (N 69º28'22; E 91º26'50) was used for analysis. The peat column length is 64 cm. The chronology of the study is provided by 3 AMS-radiocarbon dates. Peatland Gervi has 3 stages of forest fire frequency. The first stage from 1300 cal. year BP to ~900 cal. year BP characterized by 6 fire peaks (approximately 1 fire episode per 65 years) with high CHAR-index. Pollen analysis indicates for this period of warmer climatic conditions (Medieval Climate Optimum). Indicators of fire activity (Onagraceae, Gelasinospora) is found in pollen spectra. The middle part of the peat column dated ~900–100 cal. year BP has 2 fire peaks. We suppose that these peaks may be random events. This period corresponds to the Little Ice Age and according to pollen analysis is characterized by the predominance of sparse larch forests and treeless areas. The last stage (from ~100 cal. year BP to the nowadays) has only one fire peak with high CHAR-index. We suppose that relatively high CHAR for last ~100 years caused by the modern climate changes and active anthropogenic influence, which began in this region only in the 20th century because this area is remote and difficult to access.

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2. Natural hazards - NH

2.5. Cryolithozone landscape dynamics under climatic changes

Host: Timofei Orlov, *Sergeev Institute of Environmental Geoscience RAS, Russia*

Description:

A broad scope of up-to-date investigations involves landscapes with permafrost soil occupying vast areas, mainly in the Northern hemisphere (Russia, Canada, China, Alaska). In particular, many pieces of research deal with thermokarst landscapes. Different issues concerning the evolution of cryolithozone landscapes are especially urgent because of the climatic change. The practical importance of the topic results from a necessity of the behavior prognosis for engineering structures within the cryolithozone. The suggested session is expected to consider the following issues: 1. Patterns of landscape dynamics in the cryolithozone; 2. The impact of climate change on the cryolithozone landscape dynamics; 3. Modeling the landscape dynamics in the cryolithozone; 4. Dynamics of cryolithozone landscapes and natural risks; 5. The use of remote sensing in studying the landscape dynamics in the cryolithozone; 6. Dynamics of lacustrine thermokarst plains and thermokarst plains with fluvial erosion in the cryolithozone; 7. Sustainability of permafrost landscapes and methods for its assessment.

Permafrost landscapes evolution under climate changes. An example of Western Yamal

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Permafrost plays an important role in global climate change and the functioning of natural and human systems in Northern Eurasia. This work presents long-term climate, and permafrost monitoring data analyses at Western Yamal Permafrost station. Climate warming in the western part of the Russian Arctic continues since 1970s and resulted in increase of mean annual air temperature from -9.4 to -5.4°C from 1970 to 2019 at the study region. The average rate of warming is 0.07 °C/year. Mean summer temperature (JJA) increased from 5.5 to 6.9°C over the same period with a rate of 0.03°C/year. Mean winter temperature (DJF) increased from -22.0 to -18.0 °C with a rate of 0.08 °C/year. Total precipitation increased from 208 to 350 mm over the same period. The landscape classification was performed for the station area. Dominant landscapes were determined, and soil and vegetation characteristics were evaluated. Permafrost temperature and active layer monitoring was established in each landscape type. It was found that increases in precipitation observed in the region lead to waterlogging of dominant landscape types. Results of active layer monitoring allowed to classify sensitivity of all dominant landscapes to climate change. Dry and moist landscapes are characterized by the thickest active layer and highest rate of active layer increases. For example, sand blowouts have thickest active layer, which increased from 126 cm in 1979 to 143 cm in 2019. Wet and waterlogged landscape are characterized by thinnest active layer and lowest rate of change. For example, active layer in peatland landscape increased from 40 cm in 1978 to 52 cm in 2019. Landscape variability and snow characteristics determine high spatial variability of mean annual ground temperature (MAGT), which in increasing following climatic trends. MAGT in landscapes located in topographic depressions is 1.5 to 2.0°C higher that on the relatively flat surfaces of third marine terrace and was -4.0 to -4.8°C in 1979 and increased to -2.2 to -2.7°C in 2019. The average rate of MAGT increase was 0.04°C/year. MAGT in landscapes located on flat topographic surfaces was from -5.8 to -7.7°C in 1979 and increased to -3.5 to -5.0°C in 2019. The results of monitoring of permafrost characteristics such as MAGT and active layer thickness confirmed that characteristics of landscapes determine sensitivity of permafrost to climate warming.

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Modeling dynamically stable areas within the cryolithozone under climatic change for thermokarst risk assessment

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Searching and studying relatively stable areas when global climatic change provokes process activation in the Cryolithosphere is a particularly urgent problem. The stability assessment provides an essential criterion for the valuation of the whole Cryolithozone permanence and irreversibility of its changes. The plains with broad development of both thermokarst process and fluvial erosion are among the areas in question. For thousands of years, thermokarst lakes have appeared there due to thermokarst and have been dried by fluvial erosion and other processes. They could repeatedly fill with water or exist as khasyreis (drained lakes) where smaller secondary thermokarst lakes could originate and be drained again. These plains occupy vast territories within the Russian Arctic. The authors did mathematical modeling of morphological patterns developing under these processes. We produced several variants of these models taking into account synchronous or asynchronous lake emergence and different situations, including changing climate. We got a specific integral exponential distribution of lake areas indicating the state of dynamic balance for these plains. Empirical testing of the suggested models involved 17 key sites using space imagery with spatial resolution from 2 m/pix (Corona, 1964-1975) to 0,5 m/pix (DG, 2013-2019). The climatic changes were revealed by reanalysis. These 17 key sites are representative for large parts of Russian Cryolithozone. The empirical testing showed that eleven key sites have integral exponential distribution for the lake areas confirming the state of dynamic balance despite the climatic change. However, two key sites showed no correspondence to any of the examined distributions, which we interpreted as a state shift due to climatic change. Direct comparison of changes in the size of the lakes with climatic parameters revealed the most pronounced negative correlation between the trend of temperature anomalies in the first half of the year and the change in the average area of the lakes between the two testing periods. The correlation between the sum of monthly trends of temperature deviations for the year and the amplitude of the average size of the lakes is positive and equal to 0.52. The next step of the study will be to map these dynamically stable areas.

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Stable carbon isotopic composition of Late Pleistocene and Holocene soils of in Baikal region (South-Eastern Siberia)

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The results of studying the carbon stable isotope composition of soil organic matter in the Baikal region are presented. δ13C content in soils formed in different time varies from –30.00 to –21.36‰, which indicates the formation of their organic matter from C3-vegetation biomass for at least the last 35 thousand years. In the sequence starting with rather dry soils of the Priol'khonie and Selenga upland to the forest-steppe soils of the Upper Angara region, with its more humid conditions, and further, to the taiga soils of southern Central Siberia, there is a marked decline of the δ13C values in organic matter, and this is a bright example of the δ13C part dependence on soil moisture, namely, precipitation during the vegetation period. Reconstruction of precipitation, performed on the basis of δ13C values, indicates a gradual aridization of the climate starting from the Late Glacial period with a maximum drying in the Middle Holocene, while in the Late Holocene the level of humidization increases. A trend towards a gradual decrease in moisture is also observed during MIS-3. The climate was supposed to be most humid during the formation of the Early MIS3 soils. In the range of 36–31 kyr BP humidification decreased and became comparable to modern. In the MIS-3 finale, climate humidity is below the current level.

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Supersaturation and evasion of carbon dioxide by surface waters in the north of Western Siberia

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Sensitive aquatic northern ecosystems have a large impact on the concentration of carbon dioxide - the most powerful greenhouse gas - in the atmosphere and, as a result, on the entire biogeochemical carbon cycle. In acid natural waters with weak ionic strength, a significant proportion of the total dissolved CO 2 occurs as free CO 2 (Hope et al., 1995). Fresh water in contact with the atmosphere might be expected to be in equilibrium with the atmospheric pCO 2 but because of additional effluent from different sources balance shifts and ecosystems can act as a source or sink of carbon. West Siberian territory is the one of the largest wetland areas of the world due to which it plays an important role in global CO 2 emission dynamics. This report presents how carbon dioxide is exchanged between aquatic ecosystems and the atmosphere, and what physical-chemical properties of water determine this GHG`s values. We measured the CO 2 concentrations and flux from 6 thermokarst lakes and a huge palsa bog. We sampled locations on the North of Western Siberia, in the discontinuous permafrost zone: at the northern boundary of the northern taiga subzone. CO 2 concentration in waters (at a depth of 5 cm) were measured using the «headspace equilibration» method. Then, the partial pressures of CO 2 (pCO 2) was determined by complex calculations (Halbedel, 2015). Gaseous losses from the water surface to the atmosphere (evasion) were determined using the direct floating chamber method. All thermokarst lakes except one was supersaturated with respect to the atmosphere, the average pCO 2 value for surface waters of them 2810,9 ± 578,1 ppmv (±SE). In palsa bogs pCO 2 varied from 2321,2 to 124141.9 ppmv. These objects are significant sources of inorganic carbon to atmosphere as evidenced by direct evasion data, which is 243,6±89,3 mg/m 2 /hr for lakes and 205,8±11.8 mg/m 2 /hr for palsa bogs. One of the thermokarst lakes was differ: pCO 2 here was 329,9±62,9 ppmv, CO 2 efflux from surface was -26,1,6±4,3 mg/m 2 /hr. Thus, lakes can be sink or small source of carbon dioxide. 1. Diane Hope,Julian J.C. Dawson,Malcolm S. Cresser,Michael F. Billett., 1995. A method for measuring free CO2 in upland streamwater using headspace analysis // Journal of Hydrology 2. Halbedel Susanne, 2018. Protocol for CO 2 sampling in waters by the use of the headspace equilibration technique, based on the simple gas equation; second update

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Water regime effect of palsa mire on peat soil biological activity in permafrost zone

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Predicted climate change causes permafrost degradation and changes in soil moisture regime of palsa mire. It will lead to a change in soil organic matter mineralization rate, additional CO2 efflux into the atmosphere and can increase the transfer of dissolved organic matter into aquatic ecosystems. The aim of this work is to study the effect of soil moisture dynamics on biological activity of palsa mire peat soils. In august 2018-2019 we studied four contrasting environmental sites of Palsa Mire complex (E72°51'04,20» N65°17'43,36», North-Western Siberia, Russia): frozen peat mound (FPM, thaw depth 0.5 m) and fen without permafrost. Landscapes change cyclically due to the thawing and formation of permafrost. Respectively, FPM move to fen and vice versa In a field we measured CO2 efflux, active layer thickness, soil temperature and soil moisture in 0-20 cm layer. The contrast between different sites of the wetlands and their environmental variability may be explained by the presence of permafrost and their active layer thickness. To simulate water regime changes during thawing of permafrost conducted a series of field experiments. The influence of wetting / drying on the biological activity of peat soils was studied. 1) There are sites on the FPM with similar vegetation, soil, temperature, but with different moisture. 2) Plots were watered for soil moisture increase. 3) Soil samples were transplanted from dry conditions of the palsa to wet conditions and vice versa. A year later, samples were taken from displaced soils for analysis of dissolved organic nitrogen (DON), basal (BR) and substrate-induced respiration (SIR) in laboratory. 1)Our results indicate the FPM sites to be the «dry» (33,6 ± 12,6%) and the Fen site as the «wet» (56,1 ± 2,8%). Such contrasting environmental variables caused the differences in CO2 efflux from sites. The highest CO2 efflux was attributed to the wettest site (Fen, 240 mgCO2 m-2h-1) and the lowest to the driest site (FPM, 153 mgCO2 m-2h-1). 2) Surface wetting did not reveal significant differences in CO2 efflux. 3)Established that after wetting of soil samples efflux of CO2 increased by 1.3 times, and after drying of soil samples decreased by 1.8 times. The biological activity (DON, BR, SIR) of wetted samples increased significantly (2-4 times). In the dried samples, there was a decrease in biological activity (1.5-4 times). Dissolved organic carbon (DOC) did not change. Thus, in wet conditions, the biological activity of peat soils is generally higher than in dry.

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2. Natural hazards - NH

2.6. Landscape epidemiology: environmental risk factors and disease distribution

Hosts: Svetlana Malkhazova and Varvara Mironova, *Lomonosov Moscow State University, Russia*

Description:

Many diseases are associated with particular landscapes. They include zoonoses (infections with natural nidality), anthroponoses (such as malaria, geohelminthoses, etc.), sapronoses (e.g. cholera). Landscape epidemiology deals with spatial dynamics of pathogens, their hosts and vectors populations' interactions within natural environment. Also, there are some non-infectious diseases (e.g. geochemical endemies, diseases associated with environmental pollution) that may be associated with particular landscapes. Climate and land use change, anthropogenic influence on landscapes may lead to emergence of some new and increase in incidence of the old diseases, widening of natural habitats of disease hosts and vectors and other health-related issues. This session will consider the most important approaches related to landscape epidemiology problems: 1. identifying and mapping areas of distribution of diseases, their vectors and hosts in relation to the landscape structure; 2. spatial differentiation of host and vectors populations; 3. computer modelling of structures of hosts, vectors, and pathogens populations in relation to landscapes; 4. meteorological events affecting the spread of diseases in relation to the landscape structure, with special reference to the global warming; 5. evolution of landscapes, anthropogenic influence and predicting the related spread of diseases; 6. indicators and predictors of landscape-associated diseases and their monitoring; 7. methods of geospatial analysis and cartography in landscape epidemiology; 8. remote sensing and spatiotemporal analysis in landscape epidemiology; 9. disease surveillance, prevention and control by ecologically friendly methods with reference to landscape structure; 10. landscape approaches in the study of disease spread in urban settings.

Medico-geographical features of the Arctic region of Russia

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The Arctic region belongs to areas with an extreme natural environment. The most important components of the natural environment that determine its extremeness are geochemical, biotic, and climatic factors. At the same time, the climatic component of the extreme natural conditions is considered as prevailing in comparison with the others, since it affects human and animal organisms more intensively, as well as due to the scale of the territories it covers. The climate determines the structure of the incidence of both the indigenous and the non-indigenous populations, while the latter who moved to the northern regions from the south is more susceptible to various diseases, having no innate adaptations for living in high latitudes, in contrast to the indigenous peoples. In connection with the intensive development of natural resources in the Arctic, a special place is occupied by natural focal infections, the pathogens of which inhabit the natural environment. The most important problems of the Arctic regions from a medico-geographical point of view are the following: (1) adaptation of indigenous people and newcomers to the harsh climatic conditions of the environment; (2) difficulties in supplying medicines and providing medical care in the hard-to-reach Arctic regions; (3) climate changes and associated landscape modifications, leading, inter alia, to changes in the spread of natural focal diseases, as well as diseases transmitted through food and water; (4) the emergence of new and recurring infections among indigenous and newcomers. Thus, diseases caused by live pathogens play an important role in shaping the health level of the population of the Arctic regions. For them, the most important in the epidemiological and medico-geographical terms are brucellosis, tularemia, anthrax, trichinosis, opisthorchiasis, alveococcosis, and rabies. The question of the possible penetration of hemorrhagic fever with renal syndrome into the northern regions in connection with the advance of the bank vole range to the north, as well as tick-borne encephalitis and ixodid tick-borne borreliosis in connection with the possible expansion of the taiga tick range is discussed.

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Modeling risk factors for the spread of West Nile fever (on the example of the Volgograd region)

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Since its first manifestation in 1997 in the Astrakhan region, West Nile fever (WNF) has been actively circulating throughout Russia and spreading over new territories, which makes the problem of this dangerous infection especially urgent. WNF is referred to as emerging and re-emerging viral infection. The distribution of its agent is associated with vectors (mosquitoes) and birds, both of the semiaquatic and synanthropic habitats, as well as with abiotic and socio-economic factors. Volgograd Oblast is one of the most affected regions in Russia. We modeled the risk of WNF spread for the territory of Volgograd and its surroundings, basing on the information about the places of human infection in 2010-2011 and locations of virus detection from the environment. In total, 53 cases of infection were used in 2011, 166 in 2010, and 29 points with the locations of the virus. Landsat7 and Landsat8 images with a spatial resolution of 30 m from 2010 to 2011 were used to assess the vegetation cover, water bodies, and the temperature of the earth's surface. The assessment of natural and socio-economic factors affecting the transmission of WNF in Volgograd and its suburbs was carried out using the maximum entropy method (MaxEnt). Based on the results of the modeling, a map of the risk of WNF was created. The territories with a higher possibility of infection are located mainly within Volgograd and its satellite cities, along the banks of rivers, lakes, and gullies. There are diverse habitats for vectors and reservoirs of the virus over these territories. Areas with a reduced risk of infection are located mainly over a distance from cities, water bodies, and the main region's waterway - the Volga. This is probably due to the low population density, low urbanization of the territory, and, as a result, mosquito feeding mainly on birds. The most probable sites of WNF infection are the periphery of the city, built up with private houses and located along gullies and rivers. They have a green area that attracts semiaquatic and synanthropic birds, which bring the virus and are its reservoirs. The presence of both water bodies and residential houses increases the diversity of mosquito habitats, and, therefore, their number. Besides, mosquitoes in these biotopes can feed on both birds and humans, thereby ensuring the active circulation of the pathogen and an increased incidence of WNF.

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Modelling a potential range of anthrax in the Arctic region of the Russian Federation under the current and future climate

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We present the study on assessment of the potential suitability of the Arctic territories of the Russian Federation to re-emergence of anthrax in humans and animals due to re-activation of preserved soil foci under the current climate as well as for the projected climate by 2100. The study is based on the assumption that the existing locations of anthrax burial sites may be treated as indicators of favorable environmental conditions for anthrax pathogen survival and, hence, all areas with a similar set of environmental parameters may be detected and categorized as potentially dangerous. We used the data on anthrax burial sites in Arctic region of Russia (N = 357) for 1882 – 2016 collected from publications of the Ministry of Agriculture. For modelling, a method from a category of Environmental Niche Modeling methods was applied, namely «a modeling algorithm with maximum entropy principle-based optimization» (or just MaxEnt). A number of environmental factors, such as soil type and pH, altitude above sea level, vegetation cover type and a set of climatic parameters were used as input explanatory factors. Maxent model demonstrated a good predictive ability (AUC = 0.969). A map was created that shows the most suitable areas for anthrax re-emergence in the south of Arkhangelsk oblast and Republic of Karelia, north of Murmansk oblast, south of Krasnoyarsk krai and central parts of the Republic of Sakha (Yakutia). The following variables were found to most contribute into the model demonstrating good correspondence to the findings of previous studies: soil pH, annual mean temperature, soil type, vegetation cover type, annual precipitation at temperatures below 0°C and maximum average daily air temperature. Using the set of climate variables projected with CMIP5 climate models ensemble until 2100 under the RCP8.5 scenario we obtained a suitability map for future climate that suggests a dramatic increase of suitability over the whole study area. A particularly strong rise of suitability can be noted at the Yamal peninsula and along coastal areas of Yamal-Nenets autonomous district, Republic of Sakha (Yakutia) and Chukotka autonomous district. The results of our study attract attention to the expected elevation of anthrax burials re-activation risks due to thawing permafrost that requires enhanced surveillance measures and proper containment of registered burial sites.

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Modern methodological approaches to assessing the landscape and climatic potential of resorts

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In recent years, many resorts have been under pressure from global, regional and local natural and anthropogenic processes associated with significant climate change and increased urbanization. The importance of the resort, its potential and attractiveness is determined by the state and efficiency of using natural medicinal resources in resort practice (bioclimate, landscapes, thermal and mineral springs, mineral pelloids, water objects, etc.). For the modern organization of sanatorium-resort treatment and health-improving recreation, it is necessary to assess the landscape-climatic potential of the resort (LCP), which is a special natural healing resource and is based on a variety of signs (criteria) of health-improving and pathogenic properties of elements of the bioclimate, recreational landscape and ecological environment. Methodical approaches. The methodic is based on an integral modular approach using unique multifactorial information about the natural environment. In order to unify methodological approaches to the assessment of LCP for sanatorium-resort treatment, the authors for the first time propose a stylized scale for the qualitative integral assessment of various indicators of bioclimate and recreational landscape for the organization of effective resort treatment and health-improving recreation based on the use of methods of natural climatolandscape therapy. The following groups of indicators of the landscape-climatic potential of the resort are considered: landscape potential of the resort; bioclimatic potential of the resort; ecological potential of vegetation. To compare the different indicators, the method of scoring is used, which is widely used in balneology and recreational geography. Results. The presented bioclimate indicators make it possible to conduct a detailed analysis of the health resort potential and prospects for the development of the resort, as well as to identify risk factors for recreation and treatment. Taking into account the level of landscape and climatic potential allows you to create a natural science basis for climatic and landscape treatment, identify areas with high-quality landscape and climatic healing resources and assess the risks of environmental factors, permissible recreational loads and the level of pollution of the natural complex. The application of the methodology made it possible to conduct scientific researches of the state of natural medicinal resources of mountain regions of the North Caucasus for the purposes of resort medicine.

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Environmental conditions for the spread of focal infections in the north-west of Smolensk region

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For the territory of the Smolensk region, which is characterized by a high population density, and therefore a higher probability of infection with natural focal infections, the problem of the spatial distribution of natural focal infections seems to be urgent. Tularemia, chosen as a model to identify natural conditions that are directly or indirectly related to its preservation, in the Smolensk region is characterized by high activity of foci. Long-term persistence of infection in the environment is explained by the resistance of the pathogen itself, by favorable conditions for it. To identify the landscape confinement of tularemia, a database was created, including geographical coordinates of places where people were infected with tularemia and places where cultures of infection were isolated from environmental; time of disease registration; source of infection. To determine the reliability of the modeling results in 2018–2019, the fieldwork was carried out at the test site within the boundaries of the national park «Smolenskoe Poozerie», which made it possible to take into account the structure of the forest cover, the potential of the food base, including during forest fires, the structure of populations of rodents and their infection. Observations of the dynamics of the number of animals were carried out seasonally, the total length of the transects for the indicated period was 17.1 km. During the observation period, more than 3.5 thousand trap-days were set and 369 animals were captured. The main territorial unit of a large-scale study within the Smolensk region was the focal area of tularemia – this is an area of epidemic manifestation of infection. This concept does not apply to the system of subordinate zoning units and can be used in relation to territories of different ranks. Analysis of the distribution of the aggregate of focal areas according to the gradations of the hypsometric map shows that most of the known foci are located at heights of 180–220 m. Analysis of the influence of the qualitative composition of soils on the distribution of tularemia revealed that tularemia most often occurs on sod-podzolic, alluvial and sod-podzolic-gley soils, which can be considered a prerequisite for the existence of infection in nature. The results of large-scale modeling have been confirmed by field studies. From the point of view of epidemic significance, special attention should be paid to the number of Myodes glareolus and Apodemus uralensis.

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Landscape and epidemiological modeling of the risk of dirofilariasis spread in Russia

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Dirofilariasis is helminthiasis caused by a nematode of the genus Dirofilaria. This disease mainly affects mammals, and humans are a random host and biological dead end for the parasite, and therefore the disease often has a severe course. The principal warm-blooded host of dirofilariae is the canine family species, mainly dogs. Dirofilariasis is transmitted through Culex, Aedes, and Anopheles mosquitoes. Since the spread of dirofilariasis depends on the presence of vectors, the climate has a great influence on it. Climate warming contributes to the expansion of the range of mosquitoes to the north. European Russia is a zone of stable risk of transmission of dirofilariasis due to global climate change, favorable natural and climatic conditions, as well as the presence of a high infection with dirofilariasis canines. This work aims to analyze the influence of the climatic factor on the spread of dirofilariasis. To do this, we simulated the spatial distribution of the incidence of dirofilariasis using geospatial analysis tools. The method of modeling ecological niches with optimization according to the method of maximum entropy (Maxent) was chosen. This method is used when modeling ranges of species based on the known locations where the species was found (presence data) and geospatial variables that characterize the landscape and climatic conditions. The method allows modeling the potential range of the studied species, as well as the potential nosoareal of the disease, which is determined by the range of its pathogen. For modeling, the most general climatic parameters that can affect the transmission of dirofilariasis were used: mean annual air temperature, mean annual precipitation, the maximum temperature of the warmest month, and minimum temperature of the coldest month. As the main parameter is air temperature, the most important climatic factor is thermal conditions. The average annual precipitation does not have a significant effect, since the greater part of the nosoareal lies in areas with normal and insufficient precipitation (southern forest, forest-steppe, and steppe zones) and with significant interannual fluctuations. The most favorable territories of European Russia include the Black Earth Region, the Rostov Oblast, the Krasnodar Kray and the Crimea. The resulting model generally corresponds to the models published in the scientific literature, based on different principles, which suggests that the method used is suitable for further study of the risk of dirofilariasis spread.

West Nile Fever Risk Assessment in European Russia Based on the Analysis of Climate Variables

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West Nile Fever (WNF) is a vector-borne natural focal viral disease transmitted mainly by mosquitoes, predominantly among birds. Humans and other mammals are accidentally involved in the circulation of the virus and cannot transmit the infection. This work aims to identify the ecological and geographical prerequisites for the spread of West Nile fever in Russia. The analysis of the epidemiological situation with WNF in Russia was carried out and the contribution of climatic variables to the spread of WNF was estimated. We assessed the suitability of climatic conditions for West Nile virus (WNV) transmission using the degree-day method. Based on the data obtained, we demonstrate the growth of the sums of effective temperatures (ET). At the same time, the increase in the duration of the season of effective infectivity of mosquitoes was not tracked down. The changes in the sums ET coincide with the increase in the average air temperature for the epidemiological season but go at a higher speed. This creates favorable conditions for the development of the virus in the mosquito, as with an increase in ET the circulation of the virus is more efficient. The most favorable situation for the development of West Nile virus (WNF) is in the Caspian region. In this territory, there is a further improvement in the conditions for the circulation of WNF due to an increase in the sums of ET.

This research was funded by the Russian Science Foundation (Grant 17-77-20070 «Assessment and Forecast of the Bioclimatic Comfort of Russian Cities under Climate Change in the 21st Century»)

Assessment of the contribution of landscape and epidemiological factors to the reintroduction vivax malaria local transmission in the Moscow region in 1999-2008

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The reintroduction of vivax malaria remains possible in temperate regions that had been freed from it. This is why the question of determinants and drivers of malaria re-emergence does not lose its relevance and requires new approaches. Between 1999 and 2008 Russia experienced a flare-up of transmission of vivax malaria following its massive importation. More than 500 autochthonous cases occurred in European Russia , the Moscow region being the most affected. The study aimed to identify geographical determinants of autochthonous transmission. The degree of favourability of climate for vivax malaria was assessed using data from 22 weather stations. For geospatial analysis, the locations of each of 405 autochthonous cases detected in the Moscow region have been ascertained. A MaxEnt method was used for modelling the territorial differentiation of Moscow region according to the suitability of infection re-emergence. We calculated the key indicators of climate favorability for malaria transmission, viz. the sum of effective temperatures, the duration of the season of effective infectiveness, and a new integral index of climate favorability. A dramatic increase of all three indicators, which accelerated after 1984, and high spatial heterogeneity among them were demonstrated. Meteorological conditions were extremely favourable for malaria in 1999, 2001 and 2002. Most likely, the urban heat island additionally amplified malaria re-introduction: the degree of climatic favorability is especially high in the densely urbanized areas of Moscow megacity compared with the suburban and rural areas. The greatest number of cases occurred at the northwestern periphery of the city and in the adjoining rural areas. A significant role was played by rural construction activities attracting migrant labour, vegetation density and landscape division. A cut-off altitude of 200 m was observed, though this factor did not play a significant role at lower altitudes. The malariogenic potential in relation to vivax malaria was high in Moscow region, albeit heterogeneous in this regard. This recent event of large-scale re-introduction of vivax malaria in a temperate area can serve as a case study for further research.

This research was funded by the Russian Science Foundation (Grant 17-77-20070 Assessment and Forecast of the Bioclimatic Comfort of Russian Cities under Climate Change in the 21st Century)

2. Natural hazards - NH

2.7. Mountain landscapes: indicators of climate changes and suppliers of ecosystem service

Host: Dmitry Chernykh, *Institute for Water and Environmental Problems of the Siberian Branch of the RAS, Russia*

Description:

Mountain environments are fragile, marginal and people living in mountainous areas are exposed to environmental stressors as well as human stressors. Scientific topics of the section are: 1. The role of landscape information to climate change assessment in the mountains. 2. Mountain landscapes and their patches as paleo-environmental; archives and the indicators of modern climate change. 3. The use of landscape metrics as indicators for climate change in the mountains. 4. Assessment and mapping of the capacity of mountain landscapes to provide material, regulatory and cultural ecosystem services.

Russian Altai landscapes as indicators of climate change and suppliers of ecosystem services

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Russian Altai is the part of Altai-Sayan ecoregion – one of the 200 priority areas identified by World Wide Fund for Nature for biodiversity conservation. The Russian Altai is located in the transition zone from the humid climate to arid climate and it is the territory of natural contrasts. It is practically the north of Inner Asia in «miniature». The main goal of this study was to evaluate the potential of Russian Altai landscapes as indicators of past and current climate change and as suppliers of ecosystem services. Based on the analysis of the author's landscape map, the possibilities of identifying landscapes-indicators for monitoring of climate change and assessment of ecosystem services are shown. We believe that priority for long-term ecological research and monitoring for change could be given to landscapes-indicators.

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Dynamics of glacial landscapes of the arid part of Altai

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Glacial recession in the arid areas of the Altai mountains (Central Asia) after the LIA maximum has been studied based on multiyear in-situ monitoring, satellite imagery analysis, and paleo reconstructions. Arid part of Altai stretches for about 600 km from north-north-west to south-south-east between 51 and 46 N. Though this area gets less than 400 mm annual precipitation, the mountain ridges here are currently glaciated, due to altitudes reaching 3800-4400 m a.s.l. Aridity and summer temperatures increase from the north-west to the south-east resulting in the corresponding changes of the ELA from about 3000 m a.s.l. than 3800 m a.s.l. in the south. 18 centers of glaciation within the region have been studied, comprising over 860 glaciers with a total area of about 477 km2. According to our reconstruction in the maximum of the LIA the area of the glaciers was about 1036 km, which is over 2 times bigger than now. Glacial shrinkage for individual glacial centers was within the range of 100-43%, with clear negative dependence of the average area of a glacier in the LIA. The ELA increased by about 100 m on average. The glacial recession was uneven with periods of glacier stabilization in the 1960-s and late 1980-s-early 1990-s. Following the period of rapid temperature increase between 1995-2005 smaller glaciers retreated synchronously, larger valley glaciers started to retreat fast after 2010, reaching the rates of retreat of 40-80 m year-1. Glacial retreat is accompanied by the formation of proglacial lakes with high potential outbursts risks. In Mongun-Taiga mountain massif 21 lakes with a high risk of outbursts have been revealed.

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Holocene paleovegetation reconstruction of the Eastern Sayan mountain peatlands (north-west macroslope) using a multi-proxy analysis

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The study is devoted to the reconstruction of the Holocene palaeoecological conditions of the northwestern macro slop of the Eastern Sayan (Krasnoyarsk region). Today this research area is poorly studied in contrast to the eastern macro slope (Bezrukova et al., 2004, 2016). The object of research was peat deposits in the valley of the Mine River. Mine River is between the slopes of the Kuturchinsky and Koysky ridges. The total thickness of the core was 2.40 m (peat - 2.05 m, clay with plant remains - 0.35 m). Dating was carried out on the Poznań Radiocarbon Laboratory, Poland. The calibrated age in the depth interval 1.35-1.40 m was 1121 ± 42 cal.BP, in the 2.30-2.35 m - 7970 ± 23 cal.BP. In the Mina River floodplain, the beginning of peat accumulation was started in the first half of the Holocene climatic optimum. According to the results of macrofossils analysis of peat was established that the lower part of the core (2.05-1.40 m) was composed of eutrophic wood peat, the upper part was formed by mesotrophic sphagnum peat (which start to form at 1121 ± 42 cal.BP). Such a sharp change in the type of peatland vegetation may indicate a significant change in the water and mineral peatland nutrition and, in general, to the transformation of the climate in the region; this may be a response to the Medieval Warm Period (MWP).In general, in the core, the wood component predominates in the composition of the pollen spectra (on average, 50-55%, mainly dark conifers). The main dominant of Pinus sibirica (on average 40% of the total arboreal). The maximum pollen of this species (55.3%) was recorded in the range 4200-4700 cal BP, the maximum ash content of peat was also noted, which may indicate a general increase in moisture and increase in erosion processes. The per cent of Abies pollen does not exceed 13%, Picea does not exceed 16%, and Pinus sylvestris pollen is 8-12% and can be considered an invasive one. Betula sect. pollen was recorded. Albae 1-2% with a maximum of 5.4% in the surface sample, Betula sect. Nanae ranges from 12 to 20% on average. In the range of 630-700 cal.BP, which corresponds to the first stage of The Little Ice Age (LIA), there is a decrease in the wood component up to 25% and an increase in the proportion of spore species to 65%; among arboreal ones (75% on Betula sect. Nanae). Subsequently, against the background of the recovery of wood plants, two more intervals of a decrease in the content of arboreal pollen to 28.5% (380-440 cal.BP) and to 31.5% (250-315 cal.BP) were noted.

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Geochemical parameters of Katun range high-mountain landscapes as indicators of environmental change

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Altai mountain landscapes are located in the center of Eurasia. They are surrounded by steppe plains that are subject to significant anthropogenic use. High-mountains geosystems are natural geochemical landscapes. However, changes in the environment cause changes in the geochemical parameters of these landscapes. Geochemical studies were carried out as part of monitoring on the territory of the Katunsky reserve. Atmospheric aerosols and surface waters were selected as the main components of geochemical landscapes of the Katun range. These are the most dynamic components of these landscapes in the high-mountains zone. Observation points for atmospheric aerosols were established in Autonomous geochemical landscapes in the Western part of the Katun range and at the foot of the Mountain Belukha. Sampling was carried out by a field aerosol complex using AFA-HA20 filters. Surface water sampling was carried out along the Upper Katun river basin from the main river and in the key channels of all major tributaries. The chemical composition of aerosols and waters was determined by plasma mass spectrometry (ICP-MS). The results of studies of atmospheric aerosols showed that the surface atmosphere corresponds to the natural indicators. However, in the South-Western air mass movement, there is an increase in the content of anthropogenic elements. The chemical composition of surface waters changed slightly during the research period. Anthropogenic influence was observed locally. In conditions of rapid environment changes, constant geochemical monitoring is necessary for vulnerable high-mountains landscapes. Geochemical monitoring determinates the natural and anthropogenic influences on the geosystems.

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Calculating of ground freezing as a stability factor of the slope processes

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Ground thermal regime, despite the simplicity of measuring the ground temperature, remains today an insufficiently studied field of soil physics. For determination of influence of air-temperature and snow cover thickness absolute values and the dynamics on the ground freezing and thawing depth and ground and construction stability on it, a number of ground freezing models is developed. So for example for his ground freezing depth estimation scheme, V.A. Kudriavcev characterized warming and cooling action of snow cover on the ground depending on snow accumulation regime and on its duration and suggested an equation for estimation of ground freezing depth including snow cover thickness, its thermal properties and amplitude of yearly air temperature oscillations. In the rock ground freezing modeling Haberkorn A., Wever N., Hoelzle M., et al. the model Alpine3D consisting of the 3d atmospheric processes model coupled with the 1d energy balance model SNOWPACK was used. In this work, since during the construction of debris flow and snow avalanche protecting installation in the mountain regions the problem of fixation and stability of these constructions under the conditions of seasonally or permanently frozen ground arise. For this reason on the basis of the developed calculation scheme, the freezing depth of the soil is estimated based on data on the thickness of the snow cover and air temperature for the Terskol weather station for the Elbrus region for winter periods 2015/16-2019/20. The calculating scheme for ground freezing is constructed on the basis of three layer media heat conductivity problem (snow cover, frozen and thawed ground) with phase transition on the boundary of frozen and unfrozen ground. Heat balance equation includes phase transition energy, inflow of heat from unfrozen ground and outflow to frozen ground, snow cover and atmosphere. The heat flux is calculated on basis of Fourier law as a product of heat conductivity and temperature gradient. It is supposed, that temperature changes in each media linearly. The results of ground freezing depth calculations indicate that ground under the snow cover stays frozen in the Elbrus region from December to April. At the same time, the ground under the snow-covered surface freezes, according to calculations, on average by 20 or more cm. If the snow cover is partially or completely blown away, the ground may freeze to a depth of 1 m or even more and lasts for a longer period. Thus, the proposed method allows us to evaluate soil freezing as a factor of soil stability for the protection construct

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Development of mire «tundra» in mountains of Kyznetski Alatau

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Mountain mires in the mountains of south of West Siberia, are very poor studied in contrast to the mires of the lowland areas. A Study of the peat monolith from mire outcrop drained by the Usa River (the right tributary of the Tom River, the Ob River basin) with a total thickness of 2.68 m was performed in Kuznetski Alatau Mountains. Coordinates of study site are 53.78649 ° N and 88.27233 ° E, elevation - 273 m above sea level. The mire is a shrub-sphagnum meso-oligotrophic bog, covered with dwarf forms of tree birch and free-standing drying trees of Pinus sibirica. Peat samples were studied using plant macrofossil analysis. An assessment of the local moistening conditions of mire was made using the ecological scales of moisture created by Ramensky L.G. (1956). Peat exposure was dated by the radiocarbon liquid scintillation method. In common 9 dates were obtained that were calibrated using the IntCal13 calibration program (Reimer et al., 2013) using the Bacon algorithm for the R software environment (Blaauw and Christen, 2011). The described stratigraphy of the peat deposit indicates a classical picture of mire formation by overgrowing a shallow water reservoir in the Early Atlantic (at the beginning of the Holocene climatic optimum) with the subsequent development of the eutrophic swamp. Further development of the lowland swamp proceeded through change of following stages: Carex - Eriophorum - Scheuchzeria plant associations. The age of sedge eutrophic peat at the depth of 2.31-2.32 m is 5809 cal. yrs BP. In general, an ecological curve of moistening of mire demonstrates decrease of local moisture with increase of peat thickness with some fluctuations. The maximum values of moisture equal to 98.7 and 98.3 steps was observed in the intervals: 2.46-2.35 m (6670-6055 cal yrs BP) and 1.71-1.65 m (2700-2390 cal yrs BP). Sphagnum communities develop on the mire starting from 2180 cal yrs BP. Sphagnum peat at the depth of 1.61-1.45 m is characterized by a high degree of decomposition. It is likely that during this time interval there was a sharp change in mire conditions associated with reduced water supply. The mire passed into the meso-oligotrophic stage of development (wet meadow moistening, from 81 to 84 stages) with the spread of S.magellanicum and S.angustifolium on the ridges and S.balticum in the wet hollows. At this stage of the mire development, the periods of increase in moisture were noted at the depth: 1) 1.10-1.16 m (up to 91-92 steps, 1289-1247 cal yr BP) and; 2) 0.15-0.26 m (up to 88-89 steps, 492-303 cal yr BP).

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The new cycle of extreme exogenous processes in the highlands of the Central Caucasus

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The study is dedicated to extreme exogenous processes (EEP) associated with the accumulation and movement of clastic material – landslide-talus and debris flows, being cyclical and are subject to the complex effect of several factors. The novelty is their joint consideration. The cycle of EEP development, during which some processes stipulate each others, can last for several years. We analyze the main factors in the formation of EEP: air temperature, precipitation, frost weathering and seismicity at the end of the previous cycle and during the current one in the Cherek Balkarsky river basin, where we conduct monitoring research since 2009. It is assumed that the processes associated with the accumulation and movement of clastic material - landslide-talus, talus and debris flows are cyclical and are subject to a complex effect of several factors. Novelty of the research is in joint consideration of these factors. Here the cycle is between 3 and 6 years. Large debris flows in the study area descended in July 2017, before that – in the summer of 2012. The cycle of EEP, such way, lasted 5 years. The prerequisites for its completion in the summer of 2017 were joint activity of several factors, and, to a large extent, not immediate, but early. And already in July, large gatherings were preceded by a significant increase air temperature, which, thus, served as a «trigger», and a violent summer flood. Since then, there has been an accumulation of debris material - local landscapes go through the next cycle. Air temperature variation in winter 2019/20 was not quite traditional for the cold season in the study area. Average monthly values of November and December were the usual. However, the transition from warm the cold season was sharp. Summer of 2019 was cool – its values are unusually low for this time. Moreover, the coldest month of summer was July, traditionally the warmest. The low July temperature neutralized the abundant precipitation that fell this month in terms of their contribution to the EEP activity: the melting of glaciers and snowfields in the highlands was weak. Winter 2019/20 was extremely little snow. Accordingly, the avalanche activity this season was very weak. The channel processes in spring 2020 are also poorly developed. Seismic activity in 2019 in the study sites did not appear. Thus, the state of the main EEP factors in 2019 did not contribute to the active flow of the latter and the accumulation of debris. Factor indicators in the winter season 2019/20 suggest a low activity of EEP in the summer of 2020.

Critical wind speed on trees in riparian areas: A methodological model

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Abstract The natural fall of trees in riparian areas is an important source of coarse woody debris for mountain streams, improving fish habitat and influencing stream morphology. This research presents the results of a physical and probabilistic model to estimate the probability of a tree falling into the stream including the effects of tree lean and wind direction of conifers near a stream in a stand in the Maule´s Coast Range, Chile. One hundred and fifty trees were measured in this study area. A systematic sampling method was applied in each stream. The sample plots were defined as a rectangle of 20 m x 50 m located each 30 m on both sides of the stream. The total area sampled was 3 ha. In every sample plot all trees were measured. Results of this study indicate that tree lean is not a major factor with respect to influencing tree blowdown for the range of tree lean data collected from coniferous trees along streams in the study area.

3. Historical landscape ecology - HLE

3.1. Long-Term Socio-Ecological Transitions: Towards Energy—Landscape Integrated Analysis of Global Land Use and Cover Change

Hosts: Victor Matasov, *RUDN University, Russia*, and Joan Marull, *IERMB, Autonomous University of Barcelona, Spain*

How farming energy flows historically have interacted with land systems? Land-use systems created by farming, animal husbandry and forestry can be seen as a spatial imprint of the biophysical flows driven by farmers, herders and lumberjacks in different bio-cultural landscapes over the world. This approach opens a bridge between two methodologies, which have been kept separated so far: the socio-metabolic accounting of energy through puts and balances of farm systems, and the landscape ecology metrics used to assess how different land cover patterns affect ecological processes and farm-associated biodiversity. It requires new models able to integrate long-term social metabolism and landscape ecology analysis, and find out the levels of land use heterogeneity and energy availability that may host greater species richness and related ecosystem services. These aims are relevant in a world facing a dilemma between increasing land use intensity to meet the growing demand of food, feed, fibres and fuels, while avoiding at the same time a dangerous biodiversity loss. Conservation biology has a long-lasting debate between land-sparing and land-sharing approaches to biodiversity maintenance, and it is increasingly acknowledged the role of functional land-use mosaics.

3. Historical landscape ecology - HLE

3.1. Long-Term Socio-Ecological Transitions: Towards Energy—Landscape Integrated Analysis of Global Land Use and Cover Change

Applying thermodynamics to understand the links between energy, information, structure and biodiversity in human-transformed landscapes

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Both in natural and in human-made agroecosystems, biodiversity can be understood as a direct function of landscape complexity and an inverse function of energy dissipation. The main difference between them is the external energy driven by farmers' information that transforms natural ecosystems into agroecosystems. If this is true, can an energy-information-structure model predict biodiversity in cultural landscapes? To that aim, we have developed an Energy-Landscape Integrated Analysis (ELIA) that measures the energy stored through internal loops (E) and the information incorporated into the energy network of agroecosystems (I), to correlate them with the resulting patterns and processes of cultural landscapes (L). This approach integrates the energy flow accounting of agricultural landscapes from an Ecological Economics point of view, and the Landscape Ecology metrics that assess the functional structure of their land covers. ELIA uses the E-I-L indicators to predict the biodiversity location in human-transformed landscapes. We have tested this model on biodiversity data through two different taxonomic groups, butterflies and birds, in the metropolitan region of Barcelona (Spain). The results show positive relationships between butterflies and birds species richness with ELIA, and especially with the variable I: information. This emphasizes how different strategies of agricultural management combined with nature conservation can be approached at some optimal points in the relationship between the energy-information-structure of cultural landscapes and the biodiversity located on them. The ELIA modelling opens a new research agenda that will be very useful for designing more sustainable agroecosystems, metropolitan green infrastructures and land use policies.

3. Historical landscape ecology - HLE

3.1. Long-Term Socio-Ecological Transitions: Towards Energy—Landscape Integrated Analysis of Global Land Use and Cover Change

The energy trap of industrial agriculture in North America and Europe (1830-2012)

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Early energy analyzes of agriculture revealed that behind higher labor and land productivity of industrial farming there was a decrease in energy returns on invested energy. However, recent improvements in the production and use of inputs have raised them somewhat. Most of these analyzes only consider the external inputs at the crop level, concealing the important role of internal biomass flows that livestock and forestry recirculate within agroecosystems. What happens if we study the energy performance of agroecosystems as a whole, including livestock and forestry activities? What if we adopt a circular bioeconomic approach by accounting for the energy returns to external inputs, to internal biomass recirculation, and to all inputs spent? What if we extend observations back in time when past organic agriculture still prevailed everywhere? Applying an innovative circular approach to different agroecosystems in North America and Europe from 1830 to 2012, we found a general trend toward lower external and total energy returns with only little or no increase in internal returns, and some outliers. Statistical analysis reveals that this energy trap has been mainly driven by dietary and forest transitions to more meat and fewer wood components in agricultural products. Both drivers involved a structural disintegration of agroecosystem components by an industrial management increasingly linear and polluting on a global, regional and local scale. Overcoming this energy trap requires nature-based solutions that increase the circularity and complexity of agroecosystems to reduce current dependence on fossil-fueled external inputs. Highlights • Most farm energy analyzes consider one return on external inputs from a linear view. • We account the returns to external, internal and all inputs in a circular analysis. • Internal energy circulation that supports agroecosystems' reproduction is accounted. • The role of integrated management of forest, grassland and cropland is considered. • Dietary and forest shifts drove farm systems to low EROIs trough structural changes.

3. Historical landscape ecology - HLE

3.1. Long-Term Socio-Ecological Transitions: Towards Energy—Landscape Integrated Analysis of Global Land Use and Cover Change

Socioecological Integrated Analysis of the Green Infrastructure. Transition Scenarios for Land Use Planning of the Barcelona Metropolitan Area

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Urban development and the sprawl of transport infrastructures have disregarded the crucial function of metropolitan landscape in provisioning human well-being and biodiversity. This research aims to contribute to the challenges of Planning for Sustainability by proposing a Socioecological Integrated Analysis (SIA) to support the Land Use Master Plan in the Barcelona Metropolitan Area, to conciliate urban development with the performance of surrounding open spaces. The paper evaluates four different land cover scenarios (current, trending, alternative and potential), and two kinds of agricultural management (conventional and a socioecological transition towards organic agriculture). The results suggest that although there are significant improvements on job provisioning and nutrient-cycling closures (circular economy), certified organic agriculture is not enough to overcome some trends of industrialized agrarian systems such as low energy efficiency or poor improvements in greenhouse gas emissions. The results also show a crossed effect between social metabolism and landscape ecology where changes in the management could affect the landscape functioning while changes in the land covers are particularly affecting the resource use. Then, deeper changes that consider together land use and metabolic flows are required to promote more sustainable agroecological transitions. The SIA model is an important conceptual and methodological step forward that facilitates the transition towards sustainable land use policies.

3.1. Long-Term Socio-Ecological Transitions: Towards Energy—Landscape Integrated Analysis of Global Land Use and Cover Change

Formation of the main types of anthropogenic landscapes of Russia in the early stages of the socio-natural history

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As a result of the long-time and intensive human activities many features of the landscapes of Central Russia have changed and their structure has become more complicated. Anthropogenic factor of landscape development and transformation joined the natural factors already in the Holocene; and in the last 2000-2500 years its influence became comparable with the latter. During the different historical periods natural landscapes were exposed to various economic impacts: agriculture, forestry, industry, water-economy, recreation, transport, etc. The first anthropogenic landscape complexes emerged with the transfer from the appropriating type of economy to producing one. In Central Russia such transition, or the Neolithic revolution, dates back not earlier than the Bronze Age. During that period the land became a means of work. Landscape-transforming anthropogenic influence stemmed from the development of cultivation and grazing, formation of permanent settlements and specific features of their spatial distribution. During the Meso-Neolithic stage only anthropogenic modifications of natural landscapes were formed; and in the Bronze Age there were already anthropogenic-derivative and even anthropogenic landscape complexes. Some of them are preserved till now. These are the pastoral agrogeosystems with flood-plain meadows and woodlands. At the turn of IX-VIII centuries B.C. there was the expansion of the tribes of the Iron Age in Central Russia. Along with cattle breeding the cultivation, both slash-and-burn and field, gained an important role in the economy. Artificial fortifications were built around ancient settlements: ground walls with palisades and deep ditches at not protected sides. As a rule settlements were located in those parts of river valleys where the landscape structure was extremely complex and included a plenty of diverse and even contrasting natural territorial complexes that allowed developing a «flexible» integrated economy. In the Iron Age the development of permanent long-term settlement and agricultural structure had led to the formation of true anthropogenic and cultural landscapes. The main types of anthropogenic landscape complexes of that time were settlements, located on the capes and spits between the banks of rivers and the gullies opening into them; and pastures which occupied floodplain and valley-gully natural-territorial complexes. At the same time the most extensive original natural-anthropogenic landscape complexes with slash-and-burn cultivation and long period of fallow lands were formed.

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The role of the Upper Volga part of the Great Volga Route in the formation of environmental management systems and the settlement structure of the region

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The great Russian river Volga turned out to be the pivotal artery for settlement and development of the Central and Northern parts of Russia, formation and development of Russian ethnicity. It is in the landscapes of the Upper Volga basin the core of the Russian state originated and matured. The formation and functioning of waterways occurred due to the formation of a network of forts along them, later many of them became famous and significant ancient Russian cities. Research is conducted on the basis of a historical and geographical approach, on two hierarchical levels: for the entire Upper Volga segment and for the key areas. The research covered the initial period of social-natural history of this region, from Stone Age till late medieval period. The research included processing and analysis of numerous published and archive materials of the area and subjects of studies, as well as complex landscape and historic-archeological field work on the key areas in the regions of ancient Russian cities. Beginning with the Mesolithic-Neolithic, this basin of the Upper Volga was densely populated. A whole placer of sites is marked along the shores of the Seliger and the Upper Volga lakes and the Volga valley. In the Old Russian period, a permanent and rather dense settlement network was formed along the banks of the Volga and its tributaries. This region is becoming one of the key areas of the Slavic settlement and the formation of the ancient Russian state. A landscape-ecological analysis of the spatial distribution of the historical cities of the Upper Volga showed that at an early stage in the Old Russian period places for the construction of cities (protocities) were as a rule chosen on the most important sections of the waterway, taking into account their safety, with a relatively simple landscape structure, on low relief elements. This is typical for such cities as Dubna, Uglich, Myshkin, Yaroslavl, Rybinsk. Further on, from the XII-XIII centuries, cities began to be established mainly in river valleys on steep banks, for example, Rzhev, Zubtsov, Staritsa, Tver, Kashin, Kalyazin, Romanov, Ples, Kostroma. The conducted research showed that ecological features of landscape to a great extent predetermined the ways of settlement and economic development of the Upper Volga basin. In all historical periods one can observe clear determinancy of settlement structure and systems of environmental management from concrete landscape and ecological conditions, determined, in turn, by ecological characteristics and morphological structure of the landscape.

3. Historical landscape ecology - HLE

3.1. Long-Term Socio-Ecological Transitions: Towards Energy—Landscape Integrated Analysis of Global Land Use and Cover Change

Forest, Agriculture and Ecosystem services. A Socio-Metabolic Perspective on the United States Forest Transition, 1870-2012

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Forest conservation and reforestation have been widely acknowledged as some of the key measures of global climate change mitigation, given the fact that growing forests sequester carbon that would otherwise accumulate in the atmosphere. Forests have been identified as the main carbon (C) sink in terrestrial ecosystems, absorbing the equivalent of 60% of total atmospheric fossil fuel emissions per year. While globally, deforestation is a dominating trend in the tropical regions, forests are growing in many countries of the boreal and temperate zone. However, whether forests act as C sinks or sources is dependent on the medium and long-term C dynamics in biomass and soils. Forest transitions, i.e. shifts from a phase of net deforestation to reforestation, have been identified in several industrialised (e.g. North America, Europe), as well as industrialising countries (e.g. China, India, Vietnam, Costa Rica, Puerto Rico, Vietnam,...). Understanding the dynamics of forest transitions and their drivers requires long-term perspectives in order to assess the potential contribution of forests to climate change mitigation. The forest transition in the United States is characterized by a significant increase in Carbon stocks in the main C pools of forest ecosystems (biomass, deadwood, litter, soils) on relatively stable forest area. This observed increase of C in forest ecosystems is mainly driven by biomass thickening on intensively used commercial timberlands with distinct regional trajectories. Growth in biomass stocks is accompanied by a surge in timber extraction. We argue that this forest thickening was not only the result of environmental change or increasingly scientific forest management, but also of fundamental shifts in the role forests played in domestic resource use. Drawing on the concept of provisioning ecosystem services, we investigate major drivers for forest biomass use throughout the 20th century, including forest grazing, fuel wood, and timber harvest. Human appropriation of net primary production (HANPP), and Material- and energy flow analysis (MEFA) provide the methodological basis for this analysis. We relate regional biophysical trajectories of forest change to altering levels of biomass harvest pressure for different purposes (i.e. livestock forage grazing, human use of wood for energy and material purposes), and highlight how reductions in forest grazing and fuel wood use were enabled by industrialization and accompanied substitution processes in the livestock and energy systems.

3. Historical landscape ecology - HLE

3.1. Long-Term Socio-Ecological Transitions: Towards Energy—Landscape Integrated Analysis of Global Land Use and Cover Change

Socioecological Changes in Russian Forest-Steppe Agrolandscapes Since mid-19 century: Muraevnya Case Study

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Socioecological changes can be divided into two main categories: the structural changes, which are obvious when comparing the land use for the two time periods, and functioning changes, that can be studied with the energy balance method. Energy balance is an approach that aims to assess all of the processes within the ecosystem since every flow and mechanism regarding the ecosystem can be presented as an energy flow. This approach also helps to evaluate the efficiency of the agroecosystem, and, therefore, is useful not only in theoretical models but also in regards to real-life farming systems. The case study area is located on the border of present-day Ryazan and Lipetsk regions, the territory of P.Semyonov-Tyan-Shansky'' manor, in the northern part of the forest-steppe ecotone. Both in the 19th century and today, the territory is mainly used for agriculture, and the overall land-use mosaic has stayed the same - cropland is the dominant type of land use in the area. Although the land cover and land use remain mostly the same for the past 250 years, the spatial determinants and socio-economic drivers which led to the said mosaic have drastically changed due to the depopulation of rural areas and the transformations of agricultural technology. The energy balances for two time periods show that the functioning of the agroecosystem has changed mainly because of the shift in technology which led to reusing less biomass inside the ecosystem and using more external energy in form of fertilizers and machinery. Those changes, in turn, made the agroecosystem less resilient, while its total produce has more than doubled. The energy efficiency of the agroecosystem has plummeted from 7 in the 1860s to 0.1 in 2016. Even though this evolution may seem unpromising, it is in no way unique - external flows prevail in the majority of today's agroecosystems, and that's why farmers get to harvest much more than they could in the 1860s.

3. Historical landscape ecology - HLE

3.2. Environmental history of forest landscapes

Hosts: Olga Trapeznikova, *Sergeev Institute of Environmental Geoscience RAS, Russia*, and Victor Matasov, *RUDN University, Russia*

Description:

The forest zone of Eurasia remained a zone of gathering and hunting for a long time. However, agriculture gradually began to develop in it, but it could hardly feed a gradually growing population and thus was always accompanied by additional crafts, oriented to the natural resources of vast forests and bogs around. The session deals with the history of the taiga zone development and assimilation, as well as the study of the forming landscape economic complex. We invite geographers and historians to discuss the following issues: 1. historical and modern dynamics of forests and bogs under natural and man-made influence; 2. rational environmental management and sustainable development in the taiga zone in historical retrospective; 3. historical aspects of ecosystem services in the forest zone; 4. agrarian development of the forest zone and the current state.

Dynamics of species composition of post-agrarian forests based on remote sensing data

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The economic activity is one of the significant factors in the formation of modern forest cover. We studied the forest changes at the key site, which is situated in the basin of the river Ugra middle flow. It is the moraine-fluvioglacial plain, composed by clay-sand sediments. The soils are sod-podzolic. The native forests are spruce with oak and lime, and pine with lime at the sandy sites. The Ugra river is the old border of Moscow state. There are many ancient settlements of different periods (from 8th century till 13th century). We studied the forest change around five villages from the end of 18-th century to the beginning of the 21st century. Forest percentage continuously increases during this period (from 6% to 86%). In the last century, abandonment of farmlands and reforestation on them has the wave character. The field abandoned after the social-economic crisis. And the forests with the same age appeared at these fields. We could propose that in the 19-th century the process of reforestation has the same character. So we have the forests with the same age – 15-20 year forests (forests appeared after collapse of the USSR), 70-75 year forests (after WWII); 150-120 year forests (after the Emancipation Reform of 1861); 200 year forests and places which covered by forest at least 300 years (the area of such territory less than 1%) The forest species composition is classed using Sentinel images. The study area is covered by coniferous (spruce – 11% spruce-pine – 10% and pine – 2% forests) and small-leaved deciduous forests 33% and small-leaved-coniferous forests 31%. The forests with different tree stand have well-defined connection with previous land-use. The coniferous forests grow mainly within the territory, which covered by forest during the last 80 years. The farmlands abandoned after WWII overgrew by small-leaved and mixed forests. Using the large scale space images of Corona project and modern space images we studied the tree species change during the last 47 years. The percentage of pine and spruce significantly increased in forests of all ages. Assessment of forest overgrowth on farmlands after the last two crises (collapse of the USSR and the WWII) shows the differences in these processes. Now, coniferous stands are more often formed in the fields at once, bypassing the small-leaved stage. This may be due to forest cover increase and an increase of conifers trees in the forests surrounding the fields. The study was supported by the RFBR, grant No 18-05-00723.

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Comparative characteristics of the structure and chemical composition of the soil cover and soils of a typical and unique fir-tree

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Currently, the modern forest cover of the Earth, including the northern boreal forests, has a significant role in maintaining the climate and hydrological regime. Most of these forests are bilberry-green moss spruce-fir (BG), but unique fragments of preanthropogenic forests preserved in refugiums are tall herb spruce-fir (TH). A comparison of the unique type of forest with typical taiga forests will make it possible to assess the changes that have occurred after the transformation of the forest cover of Northern Eurasia, which can be further used to develop methods for the phased restoration of their ecosystem functions. The aim of this study was to assess the species richness, productivity and chemical composition of the ground cover of BG and TH spruce-fir of the Northern Urals. In each type of forest, 50 cm2 monoliths were selected to the depth of the root zone (n = 54 and 45 for BG and TH, respectively), from which live plants of all types were selected, their species affiliation and the ecological-coenotic group (ECG) were determined. In each type of forest, soil samples (3 repetitions) were taken by the envelope method from each horizon. The concentration of Mg, Al, P, S, K, Ca, Mn, Fe, Zn was measured in plant and soil by X-ray fluorescence analysis. The basis of the ground cover in BG spruce-fir is cereals, and compared with the BG flora, the share of boreal species in them is 28% lower, while the share of non-moral and nitrophilic species, on the contrary, is 20 and 14% higher, respectively. The chemical composition of plants depends on their affiliation of ECG and the type of forest in which they grow. The highest content of Ca, K, P, and Mg was found in representatives of boreal shallow grass and tall grass of both types of forests, and Al, Fe, Zn, Mn and S are shown for BG spruce-fir. Comparison of the chemical composition of soils (horizon O and A) of the studied forest types revealed that Ca, Mg, K, Zn, P and S are 50% higher in burozems, and Al, Fe in podzols, which is determined, to a greater extent, high litter of the ground cover enriched with these chemical elements. Thus, as a result of the study, it was shown that in unique tall herb spruce-fir, the soil cover has a wider floristic diversity compared to that of typical bilberry-green moss spruce-fir, which, in turn, was reflected in a decrease in the circulation of macro- and microelements in the plant-soil system.

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300 years history of forest use in protected nature reserve (Kaluga region, Central Russia)

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The modern forest structure and its spatial configuration are determined by various natural and socio-economic factors and legacies of previous forest management. Our study area - Kaluzhsky Zaseki Natural Reserve - is situated in Central Russia. First nature conservation activities started here at the end of the 16th century due to defense needs at southern border of Russian State. Our aim was to reconstruct the dynamics of various types of forests since 18th century on a local scale. We utilized Landsat-5, 7 and 8 images for the period from 1986 to 2018 to make supervised classifications of land cover using random forest method. They were verified according to the state forest survey data and field observations. We obtain natural factors (such as landscape features, topography, soil nutrient and moisture supply levels, etc.) from digital elevation model and landscape map to describe spatial distribution of forest types. We also used socio-economic features (such as distance from settlements, road network, administrative boundaries, population density, etc.) that were calculated in SAGA-GIS from historical maps and satellite images. According to historical data and literature, periods of forest management regimes were compiled, including time and spatial area of the reserve, cutting and planting of different types of forests. We applied ensemble modeling (combination of random forest, NNET, logistic regression) to identify the contribution of natural and socio-economic factors to spatial distribution of forest types. This allows us to reconstruct long-term forest change for earlier periods up to the 18th century. The results showed that typical deciduous forests preserved here from the beginning of the 18th century. The share of oak increased due to planting in the middle of the 18th century, and the share of aspen and spruce increased during the Soviet period. Traces of earlier impacts are now can be seen only in the soils.

Historical transformations of forests in the taiga zone of European Russia

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Since people have people settled in the taiga zone, we can speak about two types of forest dynamics: either natural or anthropogenic. Their role changed over this period. At first, before the first millennium BC, low people density and their activity did not play a significant role in forest dynamics. First agrarian activity concentrated at non-forested floodplains because of the lack of necessary tools for deforestation. The situation changed in the Iron age when slash-and-burn agriculture spread all over the area. Slash-and-burn agriculture involves large areas because fields change their position after several years when natural soil fertility sharply decreases, and new pieces of forests should be cleared of trees. The slash-and-burn agriculture changed vast areas within the taiga zone, but we really do not know how much forest grows in the former fields, but we must take into account that in some places, it lasted until World War II. At the beginning of the second millennium AD and notably, since the 12th century arable farming prevailed with constant cultivation around little villages (farms). In that period, the farther forests were from the villages, the less they were transformed by human influence. As the Russian state developed, it became to control the state of some forests such as the 'Great Abatis Line' extended from Bryansk to Meschera. It was a chain of woods with special fortification lines, created by Moscow authorities to protect the country from the Crimean-Nogai Raids from the South. When «Troubles» were in Russia at the end of the 16th and the first part of the 17th century, the population of the western and central parts of Russia decreased, and the majority of settlements with their agricultural zones disappeared and were replaced by forest. A change in the settlement pattern accompanied the following population recovery, and rare but comparatively large villages appeared instead of numerous little farms. To some extent, this arrangement of forest and agrarian areas preserved until the end of the 20th century. Since the 18th century, we have had state cadasters for all sites, including agrarian and forest areas. Unregulated use of forests decreased, although the minimum forest area was at the end of the 19th century when rural areas within the taiga zone were the most populated in history. We currently have another stage of population decline and, therefore, reforestation.

3. Historical landscape ecology - HLE

3.3. Rural development and land use / land cover change: modern trends and major driving forces

Hosts: Oxana Klimanova and Alexey Naumov, *Lomonosov Moscow State University, Russia*

Description:

Despite of rapidly progressing urbanization, modern world requires a scientifically based strategy of rural development. This strategy should relay on complex approach, taking in consideration both natural and human features of rural areas and their interactions. Rural areas should be seen as a whole, comprising the environment, economy and society and studied at the most detailed regional level as possible. Modern methods of geographical analysis as remote sensing, GIS, and other offer major opportunities for research in this field. At the same time, rural-urban interactions, technological development of the agri-food sector, agricultural colonization, green economy progress and other processes make rural landscapes ever more diverse and the mission of their research becomes more and more complicated. Our aim is to learn from experiences of rural areas transformations in different countries and regions of the world and also discuss classical and innovative approaches and methods of land use and land cover changes analysis. Landscape science is indeed the most fruitful platform for reveal modern trends in development of rural areas and their driving forces and try to formulate responses to global challenges which their sustainable development is facing.

Farmland and the urban – an arena for sustainability transitions?

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Urbanization and agricultural land use are two of the main drivers of global changes with effects on ecosystem functions and human wellbeing. It is believed that due to the long development history of 'mature' cities and to their existing infrastructure, the resulting path dependencies are difficult to change. Nevertheless, urban agglomerations are considered to provide a fertile medium for creativity that can promote the innovation of transformation pathways towards sustainability. This presentation envisions the development of urban green infrastructure (GI) taking into account peri-urban agricultural land as a fertile medium that offers an opportunity to promote sustainable urban development. It discusses how the inherent GI principle of multifunctionality can contribute to the generation of co-benefits that are considered crucial to trigger transformative processes. Co-benefits generate shared motivations igniting collaborative dynamics. As a self-reinforcing cycle of mutual trust and understanding, this legitimizes and stimulates ongoing collaboration, sustaining principled engagement, and vice versa. An ongoing collaboration supports future processes of problem-solving and the unfolding creativity reveals new pathways, thus, promoting transformational and systemic change. The case study of a transdisciplinary approach will be presented conducted in a so called urban learning lab that provide evidence supporting this hypothesis. It shows how complex relationships between different needs, values, their synergies and conflicts can be considered to negotiate strategic objectives, including the identification of priority functions, comprising key functions and additional functions in meaningful bundles. Consequently this case study show suggests that linking peri-urban farmland with the GI concept is a promising field of action that can lead to the development of new pathways for urban transformation towards sustainable urban development. Finally, it illustrates how to evolve sustainable pathways that deal with land use competition and facilitate synergies that can maintain farmland and lead to a rethinking of the urban-rural divide.

Landscape transformation in Lower Silesian landscape parks in Poland and its driving forces in the years 2006-2018

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For many years, man has been considered to be one of the basic driving forces of changes in the landscape. On a local scale, landscape changes are particularly noticeable and assessed. Various types of protected areas are created to protect the most valuable landscapes. One of the most problematic forms of protection in Poland are landscape parks. On the one hand, they include the most valuable landscapes, but on the other hand they remain in economic use, providing residents and tourists with various types of landscape services. For this reason, monitoring of landscape changes taking place within landscape parks is necessary to properly manage these forms of protection. Knowledge about the types of changes and the forces causing them is a key element in preventing negative landscape transformations. The main objective of the study was to assess the nature and scale of changes that took place in the landscape within twelve Lower Silesian landscape parks in the period 2006-2018, as well as to assess the possibility of using the landscape change index (LCI) to monitor transformations in selected areas. Obtained research results were verified on the basis of direct interview method with employees of landscape parks. The research on twelve landscape parks in Lower Silesia showed that the LCI is an excellent tool for monitoring the intensity of landscape changes. However, it depends on the accuracy of source data. To this extent, a possible source of data is the transformed Corine Land Cover database. The highest LCI was found in parks where natural disasters took place, which destroyed huge areas of forest. Analyses confirmed that a particular intensification of transformations took place in the years 2012-2018. Changes in forest landscapes were the most frequently observed and noticeable change. Of the remaining types of changes, transformations of non-forest landscapes into forest landscapes were most often identified. The main reason for such changes was the expansion of the forest in places of abandoned arable land, meadows and pastures. On the other hand, direct interviews showed that despite small areas, changes in non-forest landscapes are the most crucial for the perception of the landscape within the parks.

LUCC trajectories applying for defining the types of rural areas: the theoretical approach

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The presentation proposes an approach for analyzing the transformation of LUCC as a complex phenomenon that affects the change of the functions of rural areas. On the examples of the Smolensk region – one of the regions of Central Russia - it is shown that due to the reduction of farmlands in the 1990-2010 the most part of the rural settlements of the region now performs agro-recreational and environmental functions. Rural settlements with similar functions form meridional bands that reflect the intensity of the socio-economic poles of attraction - the Moscow capital region and the Republic of Belarus. Some patterns from different parts of Russia are also discussed to define reasons and purposes of such changes in rural areas.

Energy transition and Andalusian rural landscapes (Southern Spain)

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Due to its ambitious policies, Spain has achieved a very successful implementation of renewable energy (RE) projects, which peaked in 2000-2010. Over the first decade of the 21st century decentralized energy infrastructures have spread quickly through rural areas in Spain. In some cases, they have transformed land use practices and rural landscapes. These infrastructures have often been a source of tension, triggering the emergence of new attitudes towards landscape. The aim of this paper is to analyse the impact of energy transition in the Andalusia Autonomous Community (Spain) in order to understand the role of the changes of rural landscapes character and the role of new renewable energy landscapes in the energy transition in the Southern Spain. We consider energy landscape as a multi-layer landscape characterized by one or more elements of the energy chain comprising combinations of technical and natural sources of energy within it. The paper is elaborated in the scope of the on-going project «Adaptation to sustainable energy transition in Europe: Environmental, socio-economic and cultural aspects (ADAPTAS)» (Ministry of Economy, Industry and Competitiveness and State Research Agency of Spain, and European Regional Development Fund, CSO2017-86975-R).

Some aspects of contemporary land use changes in Croatia – vineyards case study

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Located at the crossroads of the Pannonian basin, Mediterranean and Dinaric Alps, Croatia has favorable soil and climatic conditions for the development of agriculture. However, Croatia has faced intensive land abandonment during the last thirty years. Major reasons for that have been the transition from planned to the market economy, CRn War of Independence (1991-1995), strong growth of the service sector (especially tourism), mostly elderly population in rural areas, small plots, and property issues. In general, the used agricultural area is decreasing while the share of forests and woodlands is increasing. This paper aims to present the current situation with vineyards as a land use category and identify the factors that have influenced the changes in vineyard areas in Croatia. Both archival and contemporary data and GIS will be used to analyze the data and visualize the results. Vineyards are a land use category especially susceptible to social and economic changes. During the 1880s there were almost 180,000 hectares of vineyards of Croatia, in the 1950s 100,000 ha while nowadays vineyards cover around 20,000 ha. Although the area under vineyards is decreasing, there is a difference between small traditional vineyards cultivated for personal needs, threatened to completely disappear, and newly-planted vineyards which surface is increasing. New winemakers are often successful on the market because they produce high-quality wine. This is, among other reasons, the result of Croatia's accession to the EU in 2013, which enabled it to gain access to the new markets and receive subsidies for agricultural production. Also, after 2013, there has been a considerable growth of organically farmed land in Croatia. Although this refers mainly to pastures and ploughlands, organically produced wine is more lucrative than the conventional one. Small family farms are the main bearers of the new vineyard cultivation, however, the majority of them cultivate less than 1 ha. The main winegrowing regions in Croatia are located in its littoral (insular and coastal belt of Dalmatia and Istria) and continental part (Eastern Slavonia and Central Croatia). Regional clustering of wine growing is, therefore, present, but it is not pronounced.

Climatic changes as the backgrounds for sustainable land use in the Central Russia

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During the warm trend period (1970-2015) the climatic changes in the Central Russia territory are characterized by the average annual air temperature increase as 1.5-2˚C. A clear relationship between the temperature growth and the average cereals yield has been revealed: the correlation coefficient in some regions was 0.6-0.75. At the same time, the climatic trend favorable for land productivity coincided with a large-scale reduction in arable areas, due to economic reasons, especially in forest Non-chernozem regions. During 1990-2015 total sown areas in the Non-Chernozem zone reduced by more than half: from 28.8 to 13.3 mln ha, cereal crops - from 13.4 to 7.3 mln ha; in European Russia , arable lands decreased by 33%, from 87.0 to 59.0 mln ha in total. In fact, because of climate changes the natural zones shifted to the north in the Central Russia. Thus, the maximum increments of the normal grain crops yield during the warm trend period are observed in the agrolandscapes of forest-steppe, deciduous forests and the southern coniferous-deciduous forests. In these regions, yield increases from 50 to 100%. At the same time, in these regions, about 16 mln ha of arable land dropped out of circulation. Sustainable agricultural land use implies agrolandscapes adaptation to climate changes. This is the optimization of the land use, crop structure, returning abandoned lands, or the natural development of post-agrarian lands. In general, it is necessary to advance commercial crop production to the north; in particular, the expansion of grain crops within zones of deciduous and coniferous-deciduous forests due to returning lands. In the northern Non-Chernozem agrolandscapes with the maximum land reduction, it is advisable to return only the best lands. In general, climate warming in European Russia is a favorable background for sustainable land use, restoration of abandoned lands and rural development.

Modern rural development in Russia: typology of regions

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Russia is one of world leaders by area of rural territories, but this enormous resource is not being efficiently used. By total amount of rural population – 37,3 million inhabitants it stays only in the bottom of the 2nd top ten countries, and this number is shrinking. Geographical diversity of Russia and unequal progress of market economy explain extreme differences in rural areas development. Some of them became depressive and semi-abandoned, while other experience an agri-business boom and suffer from exhausting land use. A tool for understand these differences is a complex typology of rural areas. We present the results of the first approach to this kind of typology of 85 units of Russian Federation (regions). Our research is based on statistical data analysis, including characteristics of demography, settlement, land use, agriculture and social infrastructure. Standard proceeding of cluster analysis was applied, 8 types of regions were defined and mapped. We can conclude that more than 2/3 of Russia is represented by sparsely populated and nearly not affected by agribusiness rural areas, which loose population due to aging and migration. These are the northern regions of European and Asiatic Russia. Decline of agriculture there brought to drastic but positive changes in land use as natural afforestation. The main disadvantage of these regions is remoteness and poor social infrastructure. In the regions with the most favorable natural conditions for agriculture, rural development depends on demographic ‘wellness’ and geographical proximity to urban agglomerations. On the close urban periphery rural areas experience urban sprawl, whereas agriculture is a secondary economic activity. In the breadbaskets of Chernozem zone and European South agribusiness holds all the suitable land and heavily uses it. Commercial crops area reaches ¾ and even more of the corresponding administrative regions territory. Land and labor productivity levels are both high, with obvious consequences for land degradation. The observed differences between administrative regions raise questions on specific policy measures for rural development. Until 2019, it was considered by Russian authorities as a secondary aim after agribusiness support. The new state program of complex development of rural areas approved in 2019 focuses on alternative ways of rural development, which seeks typology of regions as scientific justification.

Evolution of peat soils under changing climatic conditions across the Nero Lake basin (Upper Volga, Russia)

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In recent decades signs of global warming were indicated in changing of some climatic characteristics in Rostov Lowland in the Upper Volga basin (200 km north of Moscow). Above all the rise of annual temperature should be noticed. During the time period of 1991-2018 the annual temperature of the territory increased by 1.2°C compared to climatic norm. Besides, winters got warmer and absolute temperature minimum increased from –40°C to –35°C during the latest 30 years. Vegetation period become longer approximately by a week that resulted in grow of active temperatures (> 10°C) sum by more than 150°C. Climate changes formed new tendencies of moistening. For example, annual precipitation increased by 20% versus climatic norm. As the temperature and humidity have been increasing in the study area, changes in soil properties become apparent. We compared the soils of 1984-1988 investigation period with the same soils studied in 2018. This chronosequence provided an opportunity to assess the mid-term soil changes resulted from changing climatic conditions against the background of a change in land use. The studied soils are located within the second terrace of the Nero Lake which is one of the largest lake in the Yaroslavl region. In this study we concerned on peat soils, many of which were saline. The previous land use was arable lands and pastures, and now they are abandoned. Comparison with the soil investigation made 30-35 years ago revealed change in some properties of current soils sampled at the same locations. All the modern results showed less concentration of soluble salts in the studied soils. Thus, the current soils are classified as slightly salty or not salty. The pHwater values of peat soils either increased or there was no significant difference (no more than 10%) between the soils of the earlier investigation and the present soils. In most cases content of soil organic carbon and total nitrogen dramatically decreased within 10-20 cm of the soil surface, and vise versa the ash content increased. All the studied soils were carbonate. During the period between these two investigations in some peat soils carbonate content has become higher. As we already gave some examples of changes of mineral soils in the Yaroslavl region we believe listed differences of soil properties are of systematic character and were induced by climate changes.

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The need for landscape-oriented approach to agrarian land use optimization for sustainable rural development (a case study of Belarusian Polesie)

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The modern territorial structure of agricultural land use of the Belarusian Polesie is due to large-scale land reclamation, considerable area (> 560 thous. ha) of radioactive contaminated land, as well as the enlargement of agricultural organizations in recent decades. This led to the rise of negative territorial and organizational consequences, expressed in the excessive remoteness of agricultural land from economic centers and settlements, the deterioration of transport accessibility to them, the development of land degradation processes. In combination with the ongoing phenomena of decrease of the rural population and reduction of humane settlements, this leads to marginalization and the formation of depressed agrarian regions. In this regard, the actual and practically demanded is the optimization of agricultural land use, aimed at finding the most economically and environmentally feasible options for organizing its spatial structure on a landscape basis using GIS technologies. Solution this problem, the following was performed: 1) created the structural and logical model for the optimization of agricultural land use using GIS technologies; 2) revealed regional patterns of agricultural development of lands in the landscapes of Belarusian Polesie; 3) development recommendations on optimization of agricultural land use at three territorial levels: regional, subregional and local; 4) developed a geographic information model for the formation of ecological restrictions on agricultural land use, taking into account landscape factors. It has been established that 14% of the region's territory is characterized by a mismatch of landscapes with the degree of their agricultural suitaible, and 15,2 % of the territory is characterized by pronounced environmental instability, by 13,4 % of agricultural lands need for the land use transformation.

The review of National Coastal Management in Peru

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Proper management of marine and coastal areas and their ecosystems is of the upmost importance in this country. Almost 60% of the population and a substantial segment of the economy are concentrated on coastal territory, which barely accounts for 13% of the surface area of the country. In addition, this is the natural region with less water resources but has generated the majority of recent economic growth. Artisanal fishing stands out as one of the predominant economic activities for management consideration. The analyses of national coastal management include follow trends: Policy, Normative, Institutions, Strategies, Instruments, Information, Education, Resources, Managers and Participation. The results obtained are of great interest due to important advances that have been found in a number of these management elements (normative and instruments). Other results point to opportunities that could potentially have a great impact in the future (policy and institutions). However, deficiencies have also been detected and consequently it is recommended that they be corrected urgently (managers, resources and participation). Peru is currently working with other international institutions with the aim of advancing the definition of its National Policy in Integrated Coastal Zone Management, and its corresponding National Programme. Important decisions related with the contribution of regional and local scale to national efforts are key decisions in this process.

3. Historical landscape ecology - HLE

3.4. Transformation of the Eurasian grassland landscapes: the patterns, drivers and implications

- In memory of Manfred Frühauf -

Hosts: Alexander Prishchepov, *University of Copenhagen, Denmark*, and Ksenia Myachina, *Institute of Steppe, RAS, Russia*

Description:

The Eurasian grasslands are vulnerable ecosystems and play an important role in global biogeochemical cycling, host biodiversity, but also important for the economy and societal well being. The Eurasian grasslands have been substantively altered by massive agricultural expansion during the 20 century and recent partial or complete deactivation/ abandonment of farming in some parts of the Eurasian grassland belt. However, the patterns of land transformation across the Eurasian grassland belt still remain elusive, as well as implications for the landscape re-configuration and various ecological processes. Concurrently, other pressures, such as a change in climatic conditions may alter the ecosystem functioning of the Eurasian grasslands. We invite the talks that present the recent advances in research on the landscape-change processes across the Eurasian grasslands, the interplay among the different components of grassland landscapes and recent progress about the understanding of the driving mechanisms of grassland transformation in Eurasia. We are interested in various types of grassland communities, including steppes, meadows in temperate landscapes, grassland communities in the Arctic. We particularly invite the studies stemming from landscape ecology, landscape science, land-use modeling and spatial analysis. Studies with the elements of Earth Observation are also welcomed, but have to reflect the major scope of the session and the conference.

Revealing multiple trajectories of the Eurasian steppe landscape reconfiguration with satellite imagery

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During the 20th century, the Eurasian steppe landscapes, undergone the drastic land-cover change triggered by state-induced projects, such as J. Stalin's «Transformation of Nature» and N. Khruschev's «Virgin Lands Campaign». Earth Observation provides unique technology to trace landscape reconfiguration since the late 1960s. By bringing the example of Russia 's Orenburg province in the dry steppe belt of Eurasia, we highlight major land-change transformations documented with satellite imagery since the 1960s and until 2018. We show with Corona and Landsat imagery how agricultural expansion resulted in a decrease of steppes until the 1980s followed by a partial recovery by 1990. Further, we documented with Landsat and Sentinel-2 satellite imagery an increase of the size of steppe patches until 2018 that were often found in areas with low productivity of grasslands. A systematic interpretation of very-high-resolution imagery available circa 2010-2018 for entire Orenburg province revealed ongoing fragmentation of steppe patches, due to oil and gas development, formal and informal roads and other than agriculture land uses. While a partial restoration of steppe landscaped due to cropland abandonment can be considered as a positive sign, concomitant human modification of steppe patches for an alternative to agriculture land uses is worrisome, because it decreases an ecological and esthetical value of the steppes. In sum, our study showed a pathway to how new technologies, such as satellite remote sensing, machine-learning, cloud computation, could shed light on long term land-use and land-cover change in the steppe belt. We also show how land-use legacies, such as impacts of state-induced programs on steppe landscapes and allow evaluate existing land-use policies.

The formation of oilfield techno-geosystems in Volga-Ural steppe

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Around one fifth of the world's oilfields are located in semi-arid steppe lands. Here, oil extraction activities produce what can be referred to as Oilfields Techno-Geosystem, which are comprised of natural and technogenic elements that operate as a single system. For more than 15 years were utilized traditional geoecological approaches and GIS analysis methods to study the landscape within the oilfields of the Volga-Ural region of southwestern Russia. As a result, the stages of Oilfields Techno-Geosystem development were identified. The stages include: 1. - initial operating time of oil extraction, 2. – operating time with growing production of oil, 3. – operating time under maximum production of oil, 4. – operating time with declining production of oil, 5. – final operating time of conservation and abandonment of wells (end of production). Each operating stage is characterized by different levels of landscape transformation. These levels are affected by the number of oil well pads, the share of oil access roads within the total road network, the share of land disturbed by oil production, as well as the share of oil well pads located in close proximity to watercourses. Basically, characteristics of Oilfields Techno-Geosystem include: landscape fragmentation, reduced biodiversity, changed plant and soil communities, altered carbon cycle balance, formation of heat islands by gas flares. Accordingly, three basic principles of Oilfields Techno-Geosystem include: 1. Reversible and nonreversible transformation of landscape components, leading to horizontal and vertical structural landscape changes. 2. Diffused and linear landscape transformation through a series of the superimposed mechanical, chemical, thermal and noise interactions that change the landscape's natural composition. 3. Temporal changes related to oil development, with incremental landscape disturbances. It was found that after oilfields are plugged and abandoned, Oilfields Techno-Geosystem characteristics endure in the environment. Elements of oil extraction such as abandoned wells and equipment, tailing ponds, abandoned access roads and disturbed soils, become integral components of the area. Remediation efforts tend not to offset the characteristics of Oilfields Techno-Geosystem, underlining the importance of geospatial accounting and fieldwork. Appropriate regulations and enforcement, priorities and incentives could help improve these outcomes.

What Influences Farmers' Intentions to Recultivate Abandoned Farmland? A Case Study of the Ethnic Buryat Republic

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Russia holds untapped potential to increase agricultural production. Agricultural land abandonment is widespread in and some lands can be recultivated. To better understanding the farmers' intentions to recultivate abandoned farmland, our study focused on the Buryat Republic. The region is located within the Far East Territory of the Russian Federation. The population is about 1 million people, 66% are Russians and 34% belongs to other ethnic groups. There, ethnic culture and traditions influence the specifics of agriculture development and principals of land distribution. From 1990 to 2018, sown area dramatically declined by 82% in the region which resulted in significant decrease of domestic food provision down to 50-60%. The study aimed to understand the opportunities and major limitations to recultivate abandoned lands. Our primary research objectives were: (1) distinguish major actors, who are willing to recultivate abandoned lands; (2) assess the desired land use on recultivated abandoned lands; (3) disentangle the institutional and socioeconomic barriers of abandoned land recultivation. We conducted 150 face-to-face structured interviews with farmers in ranging socioeconomic, environmental and ethnic settings in 2018. The questionnaire contained questions about farm productivity, social, economic factors and also about behavioral intentions of farmers regarding land use. To highlight determinants and to quantify their effects on framers' behavioral intentions to recultivate abandoned land we employed Bayesian networks (BNs). In sum, the results suggested that young and entrepreneurial farmers and that who are short on land resources would be more engaged in recultivation of abandoned lands for livestock production, compared to other farmers, once institutional and economic barriers will be removed or softened down. Additionally, spatial factors shape indirectly future patterns of agricultural development in the Buryat republic. A farm location plays important role in marginally productive lands of the Buryat republic. The grain farms as well as grain processing companies are located in areas with favorable climatic conditions where the share of aboriginal people is low and the density of people is high. Small-numbered indigenous people, who live predominantly in remote areas from the capital of the region, prefer a nomadic way of livestock production.

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Dynamics of soil organic carbon in steppes of Russia and Kazakhstan under past and future climate and land use

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Cropland expansion is a major cause for natural vegetation loss and carbon emissions. We investigated the impact of the largest historical land conversion to arable land, the Virgin Lands Campaign (VLC) from 1954 to 1963 as well as massive cropland abandonment after 1990 in Russia and Kazakhstan on soil organic carbon (SOC) stocks. We simulated carbon budgets from the pre-VLC period until 2100 with a dynamic vegetation model to assess the effects of observed land-use change as well as future climate and land-use change scenarios until 2100. The simulations suggest that the historic cropland expansion caused emissions of 1.6 x 10^{15} g (=1.6 Pg) carbon for the entire VLC region between 1950 and 1965 compared to 0.6 Pg without the expansion. From 1990 to 2100, climate change alone caused emissions of about 1.8 (+-1.1) Pg carbon. Hypothetical recultivation of the cropland that has been abandoned after the fall of the Soviet Union until 2050 cause emissions of 3.5 (+-0.9) Pg carbon until 2100, whereas the abandonment of all cropland until 2050 leads to sequestration of 1.8 (+-1.2) Pg carbon. For several climate scenarios based on SRES (Special Report on Emission Scenarios) emission pathways, SOC contracted only moderately for constant land use and substantially for further cropland expansion. The variation among climate scenarios was smaller than among future land-use scenarios. This suggests that the effects of land-use change on SOC dynamics may become as relevant as those of future climate change in the Eurasian steppes.

Effects of Land Use and Climate on Soil Organic Carbon in Soils of the Kulunda Steppe

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Soils of southwestern Siberian steppes are under intensive agricultural use since the 1950s, though with interrupted arable use in some areas and with different soil tillage systems. At the same time climate change is taking place, actually shifting the vegetation zones northwards. Here, we investigated into the consequences of arable agriculture and climate change to the soil organic carbon (SOC) storage in the Altai Kray by a space-for-time approach from the forest steppe in the north to the dry steppe in the south. Soil organic carbon stocks generally declined from the forest steppe to dry steppe, and long-term arable land use resulted in a decrease of the SOC storage by 20 to 40% as compared to native steppe vegetation. This decline in SOC also took place below the plough layer, likely indicating lower root deposition and better conditions for organic matter (OM) mineralization. But the relative decline in SOC is independent from the climatic conditions, indicating no interaction of climate and land use. Density separation revealed a dominating heavy fraction, comprising mostly mineral-associated OM, with OC of high apparent 14C age, and a light fraction, dominated by particulate OM, which is considerably younger. However, also the mineral-associated OM represented a prominent source of the OC losses, thus indicating this pool to be at least partly vulnerable to land use change. No tillage and mini tillage agriculture appeared to be a promising tool to improve the soil quality by higher soil moisture, higher crop residue return to soil, higher aggregate stability, and on the long run likely also by higher SOC contents at least in the topsoil.

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Soil temperature and moisture control on soil organic matter turnover in semi-arid steppe soils in north Kazakhstan

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Kazakhstan represents one of the world's largest producers of wheat, providing food for millions of people. The agricultural sector of Kazakhstan is located in the semi-arid steppe zone and considered most sensitive towards future climate change. Globally increasing temperatures and more extreme weather conditions might accelerate soil organic matter (SOM) degradation and, thus, aggravate soil quality. Yet, there is only scarce information on temperature and moisture effects on SOM cycling in intensively managed steppe soils. We incubated topsoils of Chernozems under natural vegetation and agricultural fields with different land-use history under the combination of different temperature (15 and 25 °C) and moisture (pF 2.5 and 3.5) regimes. Emissions of CO2 as well as changes in carbon (C) and nitrogen (N) fractions were determined over 126 days. Results showed that C and N fractions were similarly affected by changes in temperature and soil moisture. Total and organic C decreased in all scenarios; highest losses were observed under cooler and wetter conditions. At lower temperature, concentrations of dissolved organic C generally decreased while warmer conditions caused an increase for most sites. Emissions of CO2 were higher under natural vegetation and, initially, under more humid conditions. However, data suggest that temperature as main driver for C losses. Contents of total and organic N showed variable responses to ambient changes without a general trend. Mobile N fractions (ammonium, nitrate) were quickly produced (within up to 21 days), followed by a slower consumption phase. Net ammonification generally decreased in all cases with higher losses under warmer conditions. For most fields, net-nitrification was higher under warmer and wetter conditions. Dissolved organic N increased in all cases with net-changes generally being higher under warmer and drier conditions. Overall, our data suggest that SOM under natural vegetation is more susceptible to changes in temperature and moisture regimes than SOM in arable land. Given some variation between Chernozem sites, we expect that, beside climatic controls, also site-specific properties such as texture and the quality and composition of SOM govern the overall extent of SOM degradation.

«Effects of agricultural land-use changes on wind erosion risk in the dry Steppes» - Insights of an interdisciplinary project (ReKKS - Innovative solutions for sustainable agricultural land use and climate adaptation in the dry steppes of Kazakhstan and Southwestern Siberia)

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The temperate grasslands of Central Asia have been used intensively for agriculture in the past. However, they also have been subjected to various land-use changes. Due to the political transformation in the early 1990s, many agricultural fields were abandoned while the global demand for crops in recent years led to an on-going recultivation of fallow fields in northern Kazakhstan and southwest Siberia. Turning fallow grassland into arable fields leads to changes in physical soil properties, which results in wind erosion. The risk of soil displacement by wind increases further with weather extremes caused by climate change. Within the international research project ReKKS, extensive mapping of land use and land cover was carried out as well as comparative pedological site surveys. Soil properties influencing soil erosion are currently being analyzed and evaluated. One chronological sequence of recent land-use changes from fallow to arable land is used as a case study to show the changes in soil properties and to describe the methodological procedure for estimating wind erosion risk. These research results will help farmers and stakeholders make decisions regarding sustainable agricultural practices.

Biomass and plant diversity of temperate grasslands with different water regime: Lessons for adaptation to climate change

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Plant diversity and production of biomass have been slightly changing during last years by climate changes in the Czechia. Therefore, it is important to verify and predict the biomass production on the meadows by agricultural and botanical approaches. The aim of our work was to determine the change in species and functional diversity and their contribution to the biomass production in meadow communities. We also tried to predict the biomass production according to the compressed height of meadow. The species composition and production was monitored on three plot triples of dry meadows, mesic meadows and alluvial meadows in the Landscape protected area Czech Karst in the Middle Bohemia (20 km south-west from Prague) and the same types and number of meadows in the unprotected area in the South Bohemia (180 km south from Prague) in the Czechia. Five squares of 4m2 were randomly assigned to each meadow and phytocenological relevés in each square were recorded. The plant biomass of 5 cm above the ground was removed from the smaller square of 0.25m2 situated in the middle of each square before mowing in June-July and in August-September from the year 2016 to the present. The compressed height was measured by using a rising plate meter in five points in each smaller square. The biomass was sorted according to the functional groups (grasses, leguminous, herbs) and it was dried in a drying room at 85°C and weighed. According to preliminary results from years 2017 and 2018, the average values of the correlation coefficient for the linear prediction of biomass based on the measured compressed height was higher in cultivated meadows in South Bohemia. Also higher biomass production and a positive correlation between the number of species and dry biomass was found in cultivated meadows in South Bohemia with a lower number of species compared to near-natural meadows in Central Bohemia with lower production and negative correlation. However, with increasing drought caused by climate change, meadows with more species may be better able to withstand weather changes in the future and produce lower but stable biomass production.

The aftermath of transformation - rapid functional but slow species diversity recovery in former arable fields. A study of grass steppe vegetation, Southern Ukraine

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The temperate grasslands are among the most threatened and the least protected biomes in the Earth. Most of their area was transformed to arable land, and only small remnants of their former area survived. Land abandonment observed in some countries, as well as planned land acquisition for the nature conservation purposes may be a chance for passive restoration of temperate grasslands. We used a rare opportunity to study nearly 100-year-long chronosequence of secondary steppe succession on old fields in the Askania Nova Biosphere Reserve and its buffer zone (Southern Ukraine). We aimed to assess what is the speed and overall effectiveness of passive steppe restoration in the Pontic grass steppe zone. We sampled vegetation and soils within 10 m2 plots located within virgin steppe and in old fields abandoned for 6, 15, 31, 50 and ca. 97 years. We found that different vegetation indices were restored in different time: functional characteristics and cover of vascular plants became typical for the steppe already in ca. 15 years after abandonment, species composition became similar to virgin steppe in ca. 50 years, while species richness and share of steppe plants in ca. 100 yrs. We found significantly lower contents of C org. and N tot. in the soil from fields abandoned for 6, 15, and 31 years than in the oldest fallows where no significant differences to reference plots were noted. The chronosequence method of substituting space for time confirmed to be an effective technique for our purpose. We demonstrated that it is possible to achieve a cover of herb layer, and some functional characteristics close to a zonal grass steppe within a decadal time scale. Yet, more time is needed to achieve species composition, and richness, as well as the shares of ecological groups of target steppe community. We conclude that a century-scale is needed to develop vegetation and ecosystem functions close to a Pontic grass steppe, if the old fields are neighboring preserved steppe patches.

4. Landscape assessment and planning - LAP

4.1. Regional and Landscape Aspects of Ecosystem Services Assessments

Hosts: Elena Bukvareva, *Biodiversity Conservation Center, Russia*, and Karsten Grunewald, *Leibniz Institute of Ecological Urban and Regional Development, Germany*

Description:

The concept of ecosystem services (ES) is one of the most rapidly developing areas of environmental policy in the world. It allows to optimize nature management, receive sustainable benefits from the functioning of natural ecosystems and not to damage the living nature. Ecosystems of Russia are of global importance due to climate regulating ES and are a key component of national wealth. However, local and regional ES are not less important because they ensure the well-being of the population and the stability of the economy in the regions of Russia. At this scale, the balance of provided and used ES, as well as ES flows from ecosystems, which provide ES to ES consumers, depend on both natural and socio-economic characteristics of the landscape, as well as geometric features of landscape structure. In the scope of the session is the regional (landscape) scale with a perspective of implementation in practice and the following topics will be discussed in particular: 1. Concept of landscape ES – the specifics and applications for Russia; 2. The impact of landscape characteristics on the provision, demand and use of ES; 3. Estimation of trade-offs and synergies; 4. The impact of anthropogenic transformation of landscapes (ploughing, forest logging, construction of buildings and infrastructure, etc.) on ES provisioning; 5. The importance of biological and landscape diversity for ES provisioning; 6. ES of cultural landscapes; 7. Specific indicators and approaches to landscape ES evaluation; 8. The dynamics of landscape ES: historical changes, current trends and future projections; 9. Examples of the use of ES assessment for territorial planning.

4. Landscape assessment and planning - LAP

4.1. Regional and Landscape Aspects of Ecosystem Services Assessments

Mapping of Landscape Services

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In addition to the popular concept of «ecosystem services» (ES), the term «landscape services» (LS) has come into use. Landscape services are the contributions of landscapes and landscape elements to human well-being. Important reasons for introducing the term LS include the prominent role of spatial aspects, the reference to landscape elements and the landscape character, and the relevance of LS for landscape planning. But there are no strong arguments for replacing the concept of ES by LS; however, we do prefer a situation-related use of both concepts. The presentation will examining the question in which cases a stronger focus on LS would be useful, particularly with regard to case studies carried out in Germany.

Quantitative assessment of landscape functions and ecosystem services based on remote sensing data (with the example of test area in West Siberia)

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The system of landscape planning and environmental impact assessment existing in Russia is poorly developed to achieve sustainable development goals. Often, environmental designing for construction needs operational and free information about the condition of environmental components and landscape functions. But environmental quantitative information is paid and closed. Environmental designing is not optimized for modern capabilities. For economic reasons, the environmental and social components are at risk. This problem can be solved using remote sensing materials with open access. Economic efficiency removes the risk for other aspects of sustainable development. Therefore, the development and implementation of methods for measuring landscape functions in practice is relevant today. The study examined the theoretical and methodological issues of landscape functions and ecosystem services concept. The ecosystem services conceptual framework for assessing landscape functions has been adapted and applied to the Kondinsky marshy woodland in Western Siberia. A list of landscape functions has been developed with a comprehensive consideration of the natural conditions of the research area, stakeholder's purposes in oil mining construction facilities, and the requests of participants and actors. The possibilities of a quantitative assessment of landscape functions based on Earth remote sensing open-source data are analyzed. The wood fiber provisioning landscape function was selected for the first step of the integrated assessment. A methodical algorithm for recognizing and quantifying wood fiber provisioning landscape function using GIS was created. Bio-productivity was determined as an indicator of the wood fiber provisioning landscape function. The methodology is based on vegetation indices and also object and pixel supervised land cover/land use classification methods. Ground-based forest observations data, optical and radar remote sensing images with medium spatial resolution are used in classification. An elaborated method allows to apply ecosystem services approach and to perform quantitative mapping of the wood fiber provisioning landscape function at the primary consideration, which is a tier 1 landscape functions assessment.

Ecosystem services assessment based on the geosystem approach as an example of landscapes of the Baikal region

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Structure and functioning of the landscape play important role in the formation of ecosystem services (Grunewald et al., 2014). Poor understanding of the processes underlying the provision of ecosystem services is one of the biggest obstacles to the development of the concept and its practical implementation. Application of the geosystems approach (Sochava, 1978) can be used for the formation of the theoretical and methodological base for ecosystem service assessment. Identification and study of landscapes of different hierarchical levels allow exploring natural phenomena and processes that occur on a certain scale (e.g. the process of humus formation is studied at the local level, the climate regulation - at the regional and global level, etc.). In this research, the assessment of the landscape's capacity to provide certain ecosystem services was conducted at the local level for landscapes surrounding Lake Baikal (south of eastern Siberia, Russia). Landscape maps with a hierarchical classification of geosystems for the four study areas (on the Barguzinsky Range, Primorsky Range, Olkhinsky Plateau and Khamar-Daban Range) served as the basis for the assessment and mapping the landscape's capacity to provide phytomass accumulation, climate regulation, and recreation services. Fieldwork data, remote sensing data, topographic and thematic maps were used as the initial data for research. As a result, assessment maps of ecosystem services were compiled using the landscape-interpretation mapping method and assessment matrix based on quantitative and qualitative indicators (Burkhard et al., 2009, 2012). The data on phytomass stocks, carbon storage in a tree stand, landscape and plant species diversity, and the availability of recreational infrastructure were used as main indicators. The quantitative assessment of phytomass stock and carbon storage in the tree stand was made based on a result of forest inventory measurements.

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Understanding riparian areas: complexity, importance, and biodiversity as ecological corridors

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Defining of riparian land can be complex due to the miscellaneous and transitional nature of the boundary between riparian and non-riparian environments; these areas are also defined within state legislation. Riparian areas are particularly important because they are where land and water meet in the landscape and as a result, support a variety of unique terrestrial ecological processes. Flow water stability can be sustained by the root systems of trees, shrubs and herbaceous. Decreased water stream erosion when of strong flow reduces the loss of valuable land, maintains river courses, and prevents turbid water conditions and the sedimentation of waterways. A highly biodiversity is sustained by the fertile and moist soils of riparian areas. Habitat, food, water and shelter from predators and harsh physical conditions are provided. These areas are safe sites for resting and play a crucial role as a corridor for the movement of plants and animals. Habitat for aquatic organisms is provided by riparian trees and woody rests, which under natural conditions fall into the water. Food for fish and other native aquatic fauna is provided by riparian vegetation in the form of leaf litter, plant debris, fruit, flowers, seeds, and insects. This constitutes the basis of nutrient input into the aquatic environment, and hence is the first link in the food chain. The amount of sediment, nutrients and contaminants from the contiguous land which reach the waterway can be reduced by riparian vegetation. Because it slows the water stream and causes the particles to be deposited on the land before they reach the creek. The roots of riparian plants can take up and remove some of the nutrients and contaminants moving towards the waterway by the underground flows. Shade and shelter provided by riparian vegetation regulate water temperature. Moderate instream temperatures are required by fish and aquatic organisms to live and breed successfully. Algal blooms and aquatic weed infestations can be reduced by the effect of shade, cooler water temperatures and low nutrient levels.

Mapping and zonning of wildlife habitats in primary forest landscapes

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Habitat loss is globally a threat to biodiversity and in managed boreal forests a loss of habitats is the most common factor affecting diversity. Intact forests of Barents region are home to one of the last and the most southern remaining populations of listed wild forest reindeer (Rangifer tarandus) and other vulnerable and protected species. Wild reindeer conservation is an example of such a scenario where complex cumulative effects exist at the core of the conservation dilemma. The species is one of the most sensitive to forestry, climate changes and big disturbances (fires). The range of its population is often thousands of square kilometers. To minimize the impact of their activities and contribute to reindeer conservation, forestry companies can limit the extent and distribution of habitat loss. Because of vast area of range, collaborating between forest users is needed. We try to develop approaches to preserve habitats of wild forest reindeer at range scale. To prepare maps for wildlife habitat assessment we mapped vegetation cover, disturbances, sandy soils and roads. Classification of vegetation cover was carried out on the base of remote sensing, forestry maps and big series of field data. To assign the classes for the selected Landsat 8 pixels, we used the following data. GPS ground data series were available for different years. This information was used jointly with high-resolution images Sentinel2. To classify the LC8 imaging the random forest algorithm (QGis) was used on the base of big training series. To generalize the vegetation map LSL tool was used (Kushneriuk, Rempel, 2011). Modern conservation planning often uses a particular type of habitat model called a resource selection probability function (RSPF). These functions can estimate the probability that a particular piece of land will be selected for use by the species of interest. The models can be used to estimate changes in expected patterns of use based on forecast changes to the landscape. With using of habitat map, field datasets and PSFP of wild forest reindeer we made seasonal habitat assessment for wildlife. This assessment became the basis of 1) conservation zoning of the area 2) monetary estimation of expected damage for wild forest reindeer population under different scenario of forest use. It is scientific basis for the decision making in land use.

Relationship between species richness and ecosystem functioning: what this mean for decision making at different spatial scales

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Biodiversity is one of the key determinants of ecosystem functioning (EF) and ecosystem services (ES). In the TEEB-Russia project, this issue was analyzed for species richness of birds and vascular plants. The causal effect of species richness on EF/ES is manifested in individual biocenoses (ecosystems) where the loss of species weakens and destabilizes EF. Thus, at this scale, declines in biodiversity are a direct indication of the need for conservation measures. At a landscape scale this causal relationship is modified by local conditions which determine a mosaic of various types of biocenoses (ecosystems) – forests, grasslands, bogs, etc. In general, biocenoses adapted to scarce conditions have a relatively low optimal species diversity, which, however, ensures the most efficient EF under such conditions. For example, low-diversity peat bogs are not less valuable for maintaining EF/ES than high-diversity mixed forests. Comparison of biocenoses of the same type, disturbed to different degrees can reveal the effect of biodiversity on EF/ES. Anthropogenic decrease in biodiversity leads to a weakening of EF/ES. Thus, when comparing ecosystems of the same type within a landscape, a decrease in species diversity is a direct indication of the need for protective measures. An important indicator is also the diversity of ecosystems, which must also be preserved. At a larger scale, causal relationships between species richness and EF/ES are clouded by correlations with climatic and geographic conditions over large areas. Negative and positive correlations between biodiversity and EF/ES revealed in the TEEB-Russia project at the national scale in most cases reflect not causal relationships, but the simultaneous reaction of indicators to changes in climatic conditions and the degree of territory transformation. Such correlations cannot be a direct basis for making decisions. For example, negative correlation between biodiversity and water-related ES is determined by the opposite change in these indicators on climate gradient and does not mean that biodiversity should be reduced to maintain these ES. However, large-scale correlations are useful for developing a regionally differentiated approach to ecosystem accounting. The negative dynamics of biodiversity indicators is important at all spatial scales of management. This indicates the degradation of the structural basis of EF and provision of ES and requires measures to conserve or restore biodiversity.

4. Landscape assessment and planning - LAP

4.2. Landscape planning as a perspective tool for cooperation with nature: how to manage matter flows, emergent effects, and context-dependent values

Host: Alexander Khoroshev, *Lomonosov Moscow State University, Russia*

Description:

Determination of nature-based region-specific criteria for land use planning remains the critical challenge for landscape ecology and physical geography. Using the landscape concept for spatial planning procedures implies that planning decisions consider interactions between geocomponents (i.e. parent rocks, water, air, soil, vegetation, animals) and possible chain reactions between them under exterior impact, remote effects «impact here – effect there», and specific emergent effects resulting from combined influences of landscape units. This follows from understanding landscape as a system. The geosystem approach to landscape planning deals with the properties and the internal energy, water and matter turnovers of landscape systems and uses biophysical units as a base for distributing land use types in space. The session will focus on the principal aim of landscape planning, that is how to adapt land use to natural units, to imitate natural flows and processes as perfectly as possible, and to support or create appropriate proportions and neighbourhoods of land use units. The context-based landscape planning is understood as the due consideration for both intrinsic properties of a unit and its value in a broad (regional, national, or international) spatial context. The purpose of our session is to discuss the tools for landscape planning aimed at answering the following questions: 1. What spatial context-based criteria and at which scale should be applied for ecologically safe allocation of land use types in a landscape? 2. How to consider involvement of a landscape unit to matter and energy flows while choosing the appropriate land use type? 3. Which combinations, proportions and neighbourhoods of land use units are needed in various geographical conditions to ensure sustainable landscape functioning and to meet human needs?

Landtype association as the basis for landscape planning

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One of the most important directions of achieving balanced development of the region is the presence of a process of self-regulation of landscapes. For realization of such a condition the analysis of two basic aspects is supposed: functional and territorial, interconnected among themselves. Functional aspect includes the choice of appropriate functions for the landscapes that do not lead to its degradation. It seems expedient to conditionally divide them into two categories: socio-economic (resource) and environmental (environment stabilizing). The territorial aspect of the problem is to determine the optimal ratio of landscapes of the region, performing different functions. As the main unit of analysis for these purposes, it is proposed to use the type of mestnost (landtype association), in the definition of which F.N. Mil'kov puts the criterion of equivalence in terms of economic use. The specifics of regional natural conditions, different age and genesis features of mestnost types determine the presence of a certain heterogeneity in the degree of their stability, productivity, comfort, and, therefore, a certain predisposition to perform resource and environment stabilizing functions. Differentiated approach to the allocation of the optimal share of ecologically stabilizing landscapes allows the use of variants of mestnost types for these purposes. Assessment of their natural and landscape potential allows to state that the medium and deep-cut variants of slope, low variant of terrace, medium and low variants of floodplains, deep and shallow variants of aquatic types, as the most vulnerable to the manifestation of destructive processes, should be used extensively and act as ecologically stabilizing landscapes. Generalized data on the area of variants of mestnost types, obtained as a result of landscape mapping, indicate that the optimal value of ecologically stabilizing landscapes in the Voronezh region should be about 40%. The quantitative indicators, which reflect the difference between the potentially necessary and real areas of ecologically stabilizing landscapes, serve as one of the most important indicators in assessing the landscape and ecological condition of regions and allow to judge about the need to optimize their structural and territorial organization. Formation of an ecologically acceptable structure of nature use, a deficit-free indicator of ecologically stabilizing landscapes also serves as a tool for implementing the concept of landscape and ecological framework of the territory.

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Integrated approach for spatial data assessment to prevent nature management conflicts in the Russian Arctic zone

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Sustainable development is the key message of the recently adopted State documents for the Arctic zone of Russia socio- economic development. This issue is of special importance for the Arctic zone regions of pioneer economic development and territories with low environmental resistance to anthropogenic load. This means that territorial planning will need to solve at least 3 spatially differentiated problems to avoid or mitigate possible nature : social-economic, ecological and environmental (nature hazards, climatic changes etc.). The initial stage of territorial planning for economic development avoiding nature management conflicts needs evaluation of different spatial combinations of environmental, ecological and socio-economic characteristics. Data bases for this evaluation were presented for basic regions of economic development in the Arctic zone of Russia. Data bases were arranged in three blocks which included the following characteristics: environmental block presented spatial data for nature hazards, climate change, permafrost stability, etc. ; ecological- % of impact zones, ecological situation index, ecological externalities rank, ecological framework, etc.; socio-economic- GRP, infrastructure, population density, etc. Panarchy character of regional «nature-economy-population» systems enabled to perform only pair assessments of the mentioned blocks in order to reveal their spatial differences combinations and demonstrate risks for future nature management conflicts emergence. Ranking results were visualized in a map where the selected pair groups were shown for each basic territory using color triangle method. The map demonstrated nature management conflicts risks possessed by economic, ecological or environmental factors in different combinations. Panarchy character of their interlinks stipulates the necessity of modeling of different management variants to provide future sustainable development of the Arctic zone.

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Implementing ecological corridors and ecological connectivity into spatial planning and management

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In the last decades, the ecological connectivity concept is gaining importance in nature conservation, replacing the so-called «island approach», where only isolated areas of well-preserved nature are protected. Contrary to that, ecological connectivity seeks to preserve and connect habitats and create favorable living conditions for species. Providing connectivity is extremely important in areas, characterized by intensive agriculture and urbanization. Ecological connectivity is a prerequisite for well-functioning green infrastructure, another concept, aiming towards achieving environmental, social, as well as economic functions. Despite the abundance of research on ecological connectivity and data about the characteristics and needs of various species on different scales, there is a gap between the research findings and their implementation into spatial planning practice. The project, entitled «Defining ecological corridors on the Slovenian national level as a support to spatial planning, nature and other resources' management» is meant to bridge this gap and to implement the ecological connectivity concept into spatial planning, as well as into sectoral management practices. The three main objectives of the research are: Demonstrating the importance of spatial planning on different levels for establishing and maintaining ecological corridors and connectivity. Finding out where and how multifunctional are these areas and corridors, and where a restriction in use should be applied to prevent conflicts. Identifying (planning) instruments to implement ecological connectivity, especially how ecological corridors can be addressed in regional and local plans, environmental impact assessment and sectoral guidelines. The project started in November 2019. In the first months, we summarized the ecological connectivity and other neighboring concepts' theory, and made an overview of existing studies on different levels (from international to local). Based on these findings, we developed a methodological concept for implementing ecological connectivity into spatial planning practice. We see the concept of ecological connectivity as one of the cornerstones of (sustainable) spatial planning, which should be planned proactively and along with all the other systems. Only then, the Sylvia Crowe's definition of (landscape) planning as «creative conservation», as a concept, where development needs don't overrun conservation demands and vice versa, will be achieved.

Landscape planning as a tool of compatibility of the types of economic use of the territory with the natural landscapes

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Landscape planning (LP) is considered as the basis for sustainable development of the territory, due to the achievement of a coordinated (adaptive) development of the economic subsystem with natural horizontal and vertical connections of three-dimensional modern landscapes. A map of modern landscapes was taken as a basis for LP. It consists of models of the natural and economic subsystems. While studying natural landscape, its positive and negative properties from the point of view of economic use are highlighted, along with its natural features (uniqueness). On the basis of the positive properties of the landscape, the tendencies of further development of the territory are determined; and negative properties are considered, on the one hand, as a limiting factor of economic development, and on the other hand, they are used to develop protective measures. In most cases, LP is focused on spatial organization of the territory, taking into consideration the compatibility of planned landscapes with each other at the level of horizontal connections. At the same time, an important and necessary element of LP is often missed out - taking into account the environment as a separate landscape contour and as the planned territory as a whole. The reconcilability of natural and economic subsystems in vertical connection is realized by evaluating the degree of compatibility of economic subsystem with the natural one and correcting the result with tools of LP. The analysis of the economic component of the planning territory is carried out with the reference to the identification of the place of individual sectors of the economy in the development of the entire region or a country, priority growth area for the development of the territory, fields of specialization, etc. are established. The potential of each landscape contour relative to a given function is estimated. Critical levels of impacts on the landscape are established. An important part of LP concerns environment-forming geosystems which form and restore the living environment of all biotic. For the basis of formation LP main maps are taken: present-day landscapes with a natural and economic component, negative natural anthropogenic processes, ecological condition, ecological network, landscape-ecological restrictions; environmental management conflicts; measures for stabilization of the environment. The realization of LP in the existing spatial planning system is hampered by the practical absence of regulatory framework in most countries of the world.

Landscape-Ecological Approach to Spatial Planning as a Tool to Minimize Socio-Ecological Conflicts

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Landscape heterogeneity generates significant influences on economic activity. Present-day publications in landscape planning more and more focus on participatory approach and communication process. In contrast, we focus on nature-based criteria aimed at proper adaptation of planning decisions to natural landscape pattern. The paper proposes the algorithm aimed at considering geographical context, matter flows, and dynamic processes in projecting ecological network and perfect sites for various land use types as well as for choosing appropriate technologies. We use the example of a river basin in the taiga zone of European Russia, partially used for forestry and traditional agriculture. Landscape map, space images, geochemical data were used to provide rationales for the necessary emergent effects resulting from proper proportions, neighborhoods, buffers, and shapes for lands use units. The proposed spatial arrangement of land use types and technologies ensures coordination of socio-economic and ecological interests and preserves zonal background conditions, including runoff, soils, migration routes, and biodiversity. The allocation of arable lands and cutovers is aimed at minimizing undesirable matter flows that could cause qualitative changes in geochemical environment.

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4. Landscape assessment and planning - LAP

4.3. Envisioning multifunctional sustainably productive and biodiversity friendly landscapes: Mainstreaming Nature Based Solutions beyond demonstration projects in urban and rural areas

Host: Ina Säumel, *Integrative Research Institute on Transformations of Human-Environment Systems, Humboldt University Berlin, Germany*, and Stefan Zerbe, *Free University of Bozen-Bolzano, Italy*

Description:

Accelerated land-use change and urbanization are mayor drivers of global change and affect a sustainable use of natural resources, reduces ecosystem resilience and biodiversity, vanishes traditional landscapes, and jeopardizes regional diversity, coherence and local identity in both urban and rural areas. In this session, we focus on multifunctionality as a strategy for healthy, biodiversity-friendly and sustainable productive urban and rural landscapes. We share experiences with the implementation of innovative concepts for sustainable land management by using historical land use techniques to create a common identity. We search for planning instruments to strengthen environmental justice and health-related ecosystem services for local communities. A promising concept is the mainstreaming of nature-based solutions to enhance social and climate resilience of landscapes. We discuss methodological approaches that create knowledge for the practice and not for the drawer such as the development of guidelines, planning instruments and optimized land use models for application and economic utilization. One plus one is sometimes more than two: A multi-stakeholder approach from citizens to high level decision makers expands perspectives and horizons of experience lead them to new research questions and innovative solutions that provide benefits for everyone. Furthermore, we share experiences to open up new knowledge fields with the help of citizen science in local schools in order to encourage a participatory and emancipatory generation of knowledge with children as curious scientists and informed citizens of tomorrow. The main goal of the session is 1) to review the state of the art of ecological measures, nature based solutions and associated ecosystem services and to analyse knowledge gaps and 2) to open the discussion on strategies for the planning of sustainable and healthy landscapes with an efficient network of multifunctional infrastructures.

Seeking for definition of Edible City Solutions – rub out borders in mind and gain insight in the vast collection of Edible City Solutions

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This manuscript focuses on Edible City Solutions and their development under a variety of parameters and aims to address the following questions: How Edible City Solutions are developing and what we consider to be a value chain in this topic opens up a broad field ECS being part of a societal movement. A good and robust base for this is a decision tree being a fundamental step in approaching to the categorization and clustering of ECS. In this and further publication we collect data through the EdiCitNet market place survey and additional interviews in all EdiCitNet Cities and to the project associated Cities. This gives us an overview and leads to a decision matrix a) which shows the circumstances and conditions when and where ECS are being created intrinsically b) how ECS along a value chain can be part of a sustainable and independent value chain- here we aim at showing that in traditional value chains goods go up the value chain and money flows down the value chain. What results is the vast exploitation of i.g. farmers, producers, distributors etc. What this study is aiming at is a) clarifying the vast pool of ECS and its development and b) reasoning why several ECS are ECS without being UF and UA. Furthermore, we provide a scientific approach to the definition and parameters which allow an integration of ECS into the ECS community and widens by introducing a vast pool of ECS in the narrow alley of public understanding of what ECS are.

Participation in strategy development for food related activities and service in times of Crisis – a journey through 5 case studies in the EdiCitNet project

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Edible City Solutions ECSs are green, economically viable, and societal beneficial solutions and their implementation could prove helpful for cities to overcome the negative effects of crises such as the COVID-19 pandemic. EdiCitNet – a network of 57 international partners including 12 cities – aims to co-develop and co-create Edible City Solutions (ECSs) focusing on enhancing social stability and resilience in the participating cities. For this, EdiCitNet heavily relies on the voluntary participation and contributions of stakeholders (the EdiCitNet City-Teams). Those stakeholders will only offer their time and efforts if they perceive ECSs as beneficial for their city and their livelihoods. The sudden shock of the COVID-19 pandemic caused two things. First, it disrupted the planned participatory stakeholder process in the cities. Face-to-face meetings and workshops were not possible anymore. Second and more severe, it also disrupted the lives of the people in the EdiCitNet cities and put many of them under immense economic and social stress. Under those conditions, it is likely that priorities of stakeholders shift and that their voluntary engagement with the project changes. To address this risk several steps were taken in EdiCitNet: The participatory process was transferred to an online platform and more emphasis was put on how ECSs could help cities to overcome the negative impacts of COVID-19. In the last 6 months, we got the opportunity to see how different EdiCitNet City-Teams in each city reacted to these new circumstances and how their participation developed. In this paper, we have a closer look at 5 EdiCitNet Cities (Berlin, Carthage, Lomé, Sempeter pri Gorici, Sant Feliu de Llobregat) and investigate how their participation changed during COVID-19. Doing so we identify economic, organizational, cultural, and technological factors that influenced the participation and the success of the risk mitigation measures. Our findings help to better understand, how a complex participation process can be managed to face a huge crisis and social isolation and also informs about, if, and how actors perceive ECSs as a solution to overcome COVID-19.

Implementing effective nature-based solutions for stormwater management in cities: design recommendations from a literature review

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The design and location of Nature-based solutions (NbS) in cities influence their performance and effectiveness to address urban challenges. The biophysical characteristics of NbS (e.g. type of vegetation and soil, and the spatial arrangement) determine which functions and ecosystem services are provided, and hence to what extent these solutions achieve targeted goals. Thereby, the design of suitable and effective NbS requires a comprehensive understanding of the functioning and technical development of these solutions. This study reviews a set of scientific articles to condense knowledge about design variables and their impact on the hydrological and pollutant control performance of NbS designed for managing stormwater in cities. The research outcomes allow us to identify the key design variables that play a role in determining the effectiveness of NbS types. Some of these variables include canopy cover, vegetation structure, and composition, plant species, soil type, and size. Moreover, our results provide insights on the performance of different solutions in terms of runoff reduction, peak flow attenuation, and reduction of pollutant concentration. We discuss the role of design variables at diverse planning stages and how these findings can support the design of effective according to different stormwater management goals. Finally, we conclude by providing recommendations about design choices and locations for each NbS type.

The healthy green living room at one's doorstep? Use and perception of residential greenery in Berlin, Germany

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The often-semi-public green spaces of the residential environment, usually created during the building of the houses remains widely understudied and but have pivotal importance for less-mobile people, after-work recreation and healthy development of children. We explore use and perceptions of local greenery by residents using face to face questionnaires in eight socially disadvantaged neighborhoods of Berlin, all exposed to high loads of environmental stressors and belonging to four relevant building types of Central European cities. Greenery of housing complexes of modernism is highly appreciated by local residents. Passive (enjoy sun, fresh air) predominate active uses (meet neighbors, exercising). Residents visit parks once per week but benefit daily from residential greenery. Baseline of judgement differs among respondents with different perspectives of their city. Residents are highly attached to the place but not to their neighbors. This condition can change through the co-creative involvement of residents in the design and management of the residential greenery, in order to encourage social contacts and neighbor's physical activity on the doorstep. Residential greenery can be the social tissue of so called 'disadvantaged' neighborhoods.

Food forest a way out of our current/future crisis?

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Climate change, air pollution, feeding the ever-growing human population, deforestation, green desert, desertification are some of the pressing problems of our current times. Food forest or forest garden seems to present a solution to many of these crises. In our definition, a food forest has the following characteristics: dense vegetation, primarily produce food, multi-layer, Diversified flora, Self-sustainable, regenerative, strong enough to handle climatic events. Food forest is an old concept of some tropical regions that have been recently spread over other tropical and the subtropical regions. Now finding its way to the temperate climate of northern and central Europe too. During this talk, I will argue why we should put more focus on food forest and then I will explore the questions that need to be addressed to understand the scalability and feasibility of such concepts from the European (the continent I have spent my last six years) and Indian (the country that I have grown up) context.

B-diversity partitioning as measure to evaluate land use change and land planning in multifunctional landscape of South America

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Large areas of South American native grasslands (Pampas and Campos) are currently subjected to expanding afforestation with non-native tree species and industrial monocultures of cash crops for the globalized market. To analyze the impact of land use change across different scales, β-diversity provides an effective approximation to integrate the variation of ecological communities from local to regional scale. We surveyed vegetation data from 163 plots distributed in four different land use types (grassland, close native forest, timber plantation and crops). We created land use maps using Landsat 8 images and we calculated landscape metrics at landscape and land use class level. We determined β-diversity across all plots and we explored variation of β-diversity among different land use types and subtypes. We run a distance decay models in order to explore relationships between β-diversity with environmental gradients based on geographical location and landscape metrics. Plant species communities were characterized by high turnover and low nestedness indicating high dissimilarity in composition across country. At landscape scale turnover responded negatively to landscape metrics, in contrast to nestedness. An increase of grassland and crops in the surrounding landscape is direct related to a higher species turnover. Our approach allows us to use β-diversity to create new insight toward land planning with focus on biodiversity conservation in different spatial scales. Our finding revealed high dissimilarity which is the start point to new studies oriented to establish whether high turnover was due to high local endemism is a results of land use change or β-diversity is an emergent property of Uruguayan grassland due to variation of environmental factor across the country. Therefore, conservation politics should consider both the modification of land use cover and recognize the high diversity present in the country.

4. Landscape assessment and planning - LAP

4.4. Social-ecological system dynamics: challenges and opportunities to strengthen the science-policy interface for a sustainable land management

Hosts: Martin Schultze, *Martin-Luther-University, Germany*, Ksenia Merekalova, *Lomonosov Moscow State University, Russia*, and Christine Fürst, *Martin-Luther-University, Germany*

Description:

Understanding social-ecological system dynamics toward a sustainable land management is often hampered by nested human-environmental interactions. The interplay of rising population growth, resource mismanagement and climate changes requests to rethink how humans are related to ecosystems, given the evidence that traditional land practices have been performed on a sectoral basis such agriculture or forestry. This limits cooperative relations (e.g. sharing actionable knowledge) between scientists, practitioners and policy-makers resulting in socio-environmental problems. Thus, resource management is often determined by feedbacks between short-running policy impacts, mid-term societal demands and long-lasting ecosystem health (Cooper & Dearing 2019). Adopting multi-disciplinary concepts will help to strengthen the science-policy interface to make better land management decisions across spatio-temporal scales. The symposium will untangle challenges facing social-ecological systems that are useful to find a common language in sustainable land practices. By integrating smart modelling methods, advanced participatory approaches and environmental governance, a co-production of scientific knowledge as well as stakeholder information will enhance the interface of science-based policy creation. Novel social-ecological practice thinking allows to address (I) practitioner's beliefs, ideas or rationales (II) to quantify sustainable management practices for a (III) sufficient decision-making to reinforce the correspondence between scientists, practitioners and policy-makers. To achieve these goals, we will raise the questions: 1. How can scientists, practitioners and policy-makers interactions be improved to contribute to sustainable land management decision-making actions? 2. What are the substantial knowledge gaps that may hamper the science-policy interface? 3. How may social-ecological practice modelling provide information for a closer research integration into situated decision-making? 4. Finally, the output of the symposium will be summarized in a research paper that synthesizes most important information to provide innovative theoretical and practical approaches to boost the scientific-practice-policy integration for a sustainable land management.

Who owns nature? - How to develop a «successful» environmental governance for the development and protection of biodiversity in the Anthropocene?

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The conservation and restoration of biodiversity is considered to be one of the key challenges of the 21st century to ensure human well-being. One of the most prominent questions in this context is, what kind of governance should be recommended to achieve this goal since it is competing with many other, often contradictory societal aims as expressed by the UN Sustainable Development Goals. The talk will present the first steps of a bottom-up interdisciplinary research initiative which intends to analyze the interactions in the nexus governance-ownership-value systems, the interactions between these assets and their impacts and relationships with biodiversity. A central hypothesis of this initiative is that ownership being either legally or societally grounded («land ownership») or perceived as identity with nature in a given context is a central motivation to protect, restore or at least manage sustainably nature. Ownership is a strong driver of individual or societal value systems related to nature and can determine the way at which scale and how governance instruments (regulatory, economic, community-based, norm-based) are set-up and how efficient these are. The relations between ownership and nature are biased depending on the cultural understanding of the role of nature for individuals and society and the economic relevance of resources taken from nature. There is a need to understand better how individuals and society define their shares in the ownership in nature through restrictions in intervening (from public access restrictions to individual management restrictions) and how this discourse between individuals and society leads to emerging governance approaches. Referring to a bundle of 5 different social-ecological systems across Europe, we will start a multi-level-multi-actor analysis of the nexus considering the different socio-cultural back-grounds and bio-geographic conditions. Many of those regions experienced in the past dramatic changes (industrialization / intensification of agriculture / open cast mining vs. deep societal changes). Consequently, accompanying time series analysis of biodiversity indicators (or proxies) will be implemented to provide evidence how these upheavals impacted biodiversity to learn from the past.

Land system dynamics in North-Eastern Uzbekistan over the past three decades: natural and institutional drivers of change and future trends

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The foothills of the Western Tien Shan on the territory of the Republic of Uzbekistan are characterized by an exceptional variety of natural landscapes and intensive multifunctional land use. This is an area for the development of mountain tourism and beach recreation, agriculture, cattle breeding, forestry and electric power generation. The activity of natural processes (landslides, erosion, etc.) including those caused by humans impose restrictions on the economic use of the territory and affect the functioning of natural and anthropogenic landscapes. Diversity of land use types and their dynamics from 1990 to 2020 is of great scientific and practical interest in connection with the natural and institutional changes. The study was carried out in the winter of 2020 in the Bostanlyk region of Uzbekistan in the surrounding area of the Charvak reservoir. Its aim was to identify the leading drivers of land-use dynamics over the past 30 years. We have compiled different-scale landscape maps based on field, remote sensing and stock materials. A set of multi-seasonal spectral indices was calculated from a series of Landsat images and the landcover classification was carried out using the author's method of index-based classification. The landcover images were obtained for four periods from the 1990s to 2020 which made it possible to trace landcover/landuse dynamics over 30 years. The data from opinion polls helped us to identify the main drivers of land use change and identify the priorities of local residents. The analysis revealed dramatic changes in some types of landcover, such as glacial landscapes, which have almost completely disappeared apparently due to climate change. Changes in other types of landcover associated with agricultural and residential land use reflect more socio-economic and institutional changes. Revealing the dynamics of land use is an important key to understanding both natural-climatic and socio-economic processes. The analysis carried out will make it possible to effectively and efficiently use the available resources in the further development of the region.

Investigating the Relation between Land Tenure Issues and Land Cover Change around the Arabuko Sokoke Forest in Kenya - A GIS-Analysis supported by Qualitative Field Researches

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With a rapidly growing population on the Kenyan coast, land as a crucial resource is becoming scarce. The conversion of forest or bushland into agricultural land in order to provide livelihood for the rural population, exerts particular pressure on the Arabuko Sokoke Forest, which is an important habitat for endemic and endangered species. Secure land rights are considered indispensable to improve living conditions of more than 100,000 smallholders living in around 50 villages surrounding the forest. To initiate measures that can reduce the overexploitation of the forest and at the same time reduce poverty of the local population, both socio-economic factors and land tenure conditions must be identified. The study area, which is composed of three sub-areas, is located near Malindi in south-eastern Kenya. Here, socio-economic and land tenure conditions were studied in order to understand the human-induced changes in land cover. A mixed-method approach was applied to determine the relationship between land cover change, land tenure and related socio-economic factors. Quantitative surveys were performed in the years 2017 and 2018 on-site to identify factors that influence changes in land cover, and in particular to analyze the impact of land tenure on sustainable land use in order to reduce further land degradation. This analysis was combined with land cover data, that was digitized manually in ArcGIS by means of the available historical aerial photographs of 1954 and 1988 as well as of the Pléiades satellite imagery taken 2017. With this data, the land use changes for the last 60 years using the MOLUSCE tool for QGIS and the level of fragmentation using FRAGSTATS, were computed. Using non-parametric tests and dependency analyses, this study statistically examined the effects of land tenure issues on the tree population for each parcel of land. Significant relationships were found between the income of the respondents and the tree population on the plots. In addition, the fragmentation of land cover on a parcel of land seems to differ between interviewees who have inherited their land and those who have purchased their land. The evaluation of the interviews concluded that the majority of the local population does not benefit from secure land rights, sufficient income or education, which can have a negative impact on the incentive to invest in sustainable land use.

UNESCO Biosphere Reserves as living labs for sustainable landscape and tourism management

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UNESCO Biosphere Reserves have gained great importance in Germany. They are legally defined in the Federal Nature Conservation Act and are also relevant in the German Sustainability Strategy. As large-scale protected areas, they represent important landscape types and are representative of the diversity of habitats. Biosphere reserves, however, are rarely 'original' biotopes - much more often they are cultural landscapes with special significance for the preservation of biological diversity and the resilience of ecosystems assigned to them as a whole: Their special richness of ecosystem services is often the result of economic use, for example grazing or wine-growing - and can only be preserved through economic use. Almost all biosphere reserves are located in rural areas and are therefore a concept for these areas' future. Because of the attractiveness of the landscapes and the mostly low environmental pollution, biosphere reserves are also popular holiday destinations and areas for local leisure and recreation. This means that the people in these regions are at the forefront and that sustainable economic forms must be developed together with them. Scientific research has fostered their regional economic impact: alone from tourism German biosphere reserves generate over 120 million Euros. The high quality of the biosphere reserves' work in Germany has regularly been acknowledged by awards, for example as «most sustainable tourism region of Germany». On the European level UNESCO Biosphere Reserves were the pioneers for the participatory development of sustainable tourism at the destination level. The implementation of the «European Charter for Sustainable Tourism in Protected Areas» in this regard has been an instrument which allows identifying a lot of best practice examples. Biosphere reserves exchange their experiences in a World Network, for example through conferences – as the present -, third party funded projects, university cooperation or long-term international partnerships. Within this framework, the Eberswalde University for Sustainable Development has supported for example an ecosystem-based management planning process and the nomination of the Russian-Kazakh Transboundary Biosphere Reserve 'Great Altai' or, currently it supports participatory planning and nomination of the proposed Vishtynets Biosphere Reserve in the Kaliningrad region.

Social actor analysis to better understand agricultural service deliveries to farmers in Sub-Saharan Africa

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The agrarian sector in Sub-Saharan Africa, as the major engine of rural growth and livelihood, has become highly vulnerable to global environmental changes. Negative impacts of extreme climate events, rapid population growth or inappropriate land management cause ecosystem degradation. However, the majority of rural population is still employed in subsistence farming. Thus, agricultural extension services are known as one of the major drivers to reach a sustainable land management by providing socio-economic support and environmental information. To better understand the performance of the agricultural sector, three workshops were conducted along a gradient from Dano (Burkina Faso) via Bolgatanga (North GH) to Sekondi-Takoradi (South GH). A narrative network analysis was worked out with details on relationships between practitioners, governmental organizations and private business. To visualize the network structure and analyze key actor properties, the open source software SocNetV was applied to translate the workshop drawings into abstract models. For the Dano catchment, the analysis identified 13 social groups and 76 arcs between the actors, where producers, cooperatives and public institution were most often mentioned. The network structure reveals a multi-level interdependence among the actors carrying out farming information flow or knowledge sharing. In GH, both workshop results show slight variations between Bolgatanga (23 actors, 73 arcs) and Sekondi-Takoradi (22 actors, 109 arcs). The hierarchical structure determines the relationships, while ministries provide beneficial access to research institutions or training schools, disseminate extension officers or NGOs farming knowledge to land managers. Beside comparing the network structures for Sub-Saharan Africa, the talk will conclude by considering significant findings to provide recommendations for social innovations.

Rethinking the future of the socioecological systems underlying high nature value farmlands

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Farmlands represent the largest terrestrial ecosystems in the Anthropocene. When managed under low-input farming systems, farmlands are associated with diverse cultural and natural heritage around the world. Known as high nature value farmlands (HNV farmlands) in Europe, these farmlands and their underlying farming systems evolved as tightly coupled socioecological systems, and are essential to biodiversity conservation and the delivery of ecosystem services to society. However, HNV farmlands are vulnerable to socioeconomic changes, leading to either agricultural intensification or land abandonment. Here, we use scenarios to envision alternative plausible futures for HNV farmlands and discuss the related management options and expected socioecological outcomes. Departing from an overview of the socioecological pillars underlying the value of HNV farmlands and their delivery of multiple ecosystem services to wider society, examples of high nature value farmlands worldwide are presented. Then scenarios are used to envision alternative plausible futures for HNV farmlands and discuss their implications for land management and expected socioecological outcomes. Finally, focusing on a future where HNV farmlands are embraced as promising 'Seeds of a Good Anthropocene', requirements to guide a paradigm shift towards socially, economically and ecologically viable HNV farmlands are presented and discussed. This research was funded by FEDER Funds through the Operational Competitiveness Factors Program - COMPETE and by National Funds through FCT - Foundation for Science and Technology within the scope of FARSYD project - 'FARming SYstems as tool to support policies for effective conservation and management of high nature value farmlanDs' (PTDC/AGR-REC/5007/2014 - POCI-01-0145-FEDER-016664)

Relocation of Communities from Tiger Landscapes in India: Challenges of Policy and Practice

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One of the traditional methods of Protected Area (PA) management in India has been through the creation of inviolate areas, which necessitates resettlement of existing human communities to fringe areas. In this context, several relocations have been carried across different PAs of the country. However, such programmes have always been at the centre-stage of debate, revolving around an array of ecological, economic, social and cultural concerns. The current study, based on the relocation and rehabilitation programme of Satpura Tiger Reserve, Madhya Pradesh, attempts to investigate the factors responsible for the success of this initiative. In-depth interviews and focused group discussions with communities and other stakeholders reveals that the skillful management of the policy-practice interface has contributed to the successful implementation of the programme. Apart from the adequate financial compensations as enshrined in the policy, the processes of continuous engagement with communities, innovative methods of model villages and hybrid relocation packages, as well as the active participation of social organizations, have been fundamental in addressing the criticisms, which are often levied against relocation programmes. However, the programme, in its current form, also highlights the challenges for the future in terms of incompatible land uses, the possibility of human-wildlife conflict and inequitable socio-economic development of communities. In nutshell, while Satpura's relocation experience provides insights about good practices, which can be replicated in other areas, there is an urgent need to revisit the relocation policy in order to reconcile the objectives of conservation and development at the landscape level.

4.4. Social-ecological system dynamics: challenges and opportunities to strengthen the science-policy interface for a sustainable land management

Towards a regionally specific landscape planning models of multi-functional low-conflict land-use (case study of Charvak area, Usbekistan)

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The landscape is a multi-component system that performs various functions. Functionality is an important concept of landscape ecology because it is capable of maintaining the landscape in a given state for a long time. The landscapes are determined by the interaction of natural and anthropogenic systems. This feature requires more careful public management and landscape planning work. Thus, the main idea of the theory of multifunctional landscapes is the possibility of combining different types of land use. The studied Chimgan-Charvak area of Uzbekistan is characterized by a fairly high proportion of the population employed in the agricultural sector and large areas of protected areas with a limited land use regime. These territories also provide important recreational facilities due to their landscape characteristics. Based on these inputs we conducted a study aimed at minimizing environmental conflicts with the maximum multifunctional land use. The objectives of the research were to detect conflicts in nature management, identify the opinions of local residents and officials and create landscape-planning solutions that could contribute to the rational use of natural resources in the region. As a result of field work 98 landscape descriptions were obtained and 296 questionnaires were collected from 17 settlements during a survey of the population (about land use dynamics and recreational preferences of local residents and tourists). The results allowed us to propose landscape-planning solutions that promote multifunctional and low-conflict land use in the region. The research revealed the possibility of organizing new recreation areas near the Pskem hydroelectric power plant under construction improving the safety of road transport infrastructure at key observation sites. It was identified the need to relocate solid waste landfills situated near agricultural lands to the less valuable and less vulnerable in landscape terms territories. The survey revealed large differences in the cost and quality of services of existing resorts. Planning solutions offer the organization of more budget-friendly recreation sites by creating a network of protected areas and ecological trails, as well as the development of ecological tourism. Almost all of the respondents have a positive attitude to the placement of renewable energy sources near their houses that makes it possible to allocate territories suitable for the construction of renewable energy stations.

4. Landscape assessment and planning - LAP

4.5. Objectification of subjective value and perception of a landscape

Hosts: Eugeny Kolbowsky and Tatiana Kharitonova, *Lomonosov Moscow State University, Russia*

Description:

In the postmodern world, when a person is getting freed from labor, the leisure activities are becoming more in demand. A relaxing person pays more attention and has a greater need for the cultural quality and significance of a place. Therefore, the identification and design of an aesthetically attractive, culturally significant environment is becoming an increasingly important task of landscape science. Cultural symbols and values are personal and subjective, but science does not tolerate subjectivity. The solution of the task requires the development of formal criteria for assessing the attractiveness of a landscape. One of the well-known and widely used criteria is the degree of anthropogenic disturbance of the territory. But does human intervention always deteriorate the aesthetic quality of the environment, and how should urban landscapes be assessed in this case? Can green infrastructure be considered as a major factor of the emotional comfort in an urban environment? How traditional land management created an attractive environment? The other important issue is a spatial visualization of the cultural value of a landscape. Which spatial units most adequately convey landscape integrity that makes the landscape attractive, and how should the landscape neighborhood be taken into account in the process of estimation of landscape attractiveness? We invite speakers to make presentations on the following topics: 1. modern aesthetic theory and assessment of the attractiveness of the landscape; 2. 3D metrics in landscape cultural value assessment; 3. cultural landscape and globalization: why we are concerned about the preservation and rehabilitation of traditional historical landscapes; 4. promising approaches to modeling of cultural landscapes and evaluating related intangible eco-services; 5. perception and attractiveness of urban landscapes in human geography agenda.

Beauty of «wild nature» versus «aesthetics of cultural landscape»: is it possible to have a unified approach to objectification and assessment?

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The new wave of interest in landscape aesthetics is largely related to attempts to evaluate so-called intangible eco-services. The emerged prospects caused by several circumstances among which the development of GIS algorithms of «visual space» modeling («viewshed», «vista», «vantage points»), the approaches to assessment of significant landscape visual features, and the using of Big Data produced by geo-tagged photos web services. There are many publications in which the assessment of «intangible» aesthetic services is directly associated with the density of photo «distribution field» that supposedly confirm the correctness of the estimates made. However, in those rare cases when the total numbers were accompanied by the key images recognition the relativity of results obtained is found out. Which is quite understandable if we turn to the theory and remember that as D.W. Meinig wrote «Landscape is in the eye of beholder». But what exactly in those eyes, or In other words, can we judge within the same approach the aesthetics of Nature and the aesthetics of the Cultural Landscape? Environmental Aesthetic is a complicated branch of science encompassing at least a dozen concepts which could be (somehow roughly) divided into cognitive and non-cognitive aesthetic theories. Non-cognitive theory related to the perception of «Wild Nature», i.e., to the aesthetics of impressions and the effect of «ah (wow)- wondering». Within the framework of non-cognitive aesthetics it is assumed that admiring nature does not require knowledge or previous experience of perception. Perhaps the «click» of the smartphone in the hands of a young person who saw a waterfall perfectly matches this model. However, the Beauty of the world around us, in addition to the possibility of contemplation, provides a whole range of feelings which hardly could be activated within the non-cognitive approach, because they are caused by a chain of more complex associations that refer to knowledge and previous experience. In this sense, the aesthetics of the cultural landscape has a specificity determined by the national landscape iconic or so called «landscape code», and, as a result, by the subjective qualities of the observer. What is the difference and specificity of these two approaches - if we consider them from the positions (and opportunities) of objectification and modeling? The answer to this question is important when we want not just to «count photos», but to get closer to a true assessment of the landscape's aesthetics.

Objectification of landscape perception using remote sensing methods

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The «Belogradchik Rocks» geopark is one of the most famous geological monument in Bulgaria and is currently nominated in the UNESCO geopark network. The main attraction of the aspiring geopark is picturesque rock remnants of red sandstones of the Lower Triassic. More than 70 geosites of scientific, aesthetic and educational values are identified on the territory along with numerous cultural and historical objects. The tourist infrastructure of the geopark includes five primary and secondary ecological routes. An eastern route («Planiniza») and western one («Vedernik») pass two landscapes – one comprised of red sandstones (rocks) and another formed by limestone deposition (cuestas). The goal of our study was evaluation of aesthetic quality of these routes. We used two methods for assessing of aesthetic characteristics of the landscapes: traditional visual evaluation and remote sensing by an unmanned aerial vehicle (UAV). In the course of field studies we evaluated the aesthetic characteristics of each route based on the approach proposed by Lithuanian geographers K.I. Eringis and A.R. Budrunas (1978). This system includes 28 parameters of the aesthetic quality of landscapes. The advantage of the method is that it includes a wide range of elementary indicators in order to minimize subjectivity of evaluation. However, such field surveys are labor intensive and spatially limited by routes. Applying unmanned aerial vehicles (UAV) makes it possible to measure most aesthetic characteristics of landscapes along the routes and beyond them. Aerial photographic survey was done by DJI Phantom. We produced 4 orthophotomaps, digital elevation model (DEM) and image-derived indices. The spatial resolution of these cartographical products is about 1m. Remote sensing allows measuring 21 of 28 aesthetic characteristics of landscapes such as depth and diversity of perspective view, virginity of landscape, number of mountain peaks and slopes; shape of skyline; manmade features and their correspondence to natural landscapes. The remote sensing results are found in good compliance with field evaluation of the routes in terms of their aesthetic quality. The results show high potential of this approach to use for development of touristic infrastructure in geoparks.

Geodiversity of South-Eastern Altai and methods of its assessment

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The South-Eastern Altai mountains characterized by a variety of natural conditions, landscapes, relief-forming processes and landforms that determine the appearance of its unique geodiversity. At its core, geo-diversity is a unique and irreplaceable resource, closely related to the biodiversity, nature management and sustainable development of the region, and its elements are significant for scientific, educational, tourist and recreational interest. Geodiversity plays an important role in the formation of tourist destinations, the development of local tourism clusters and the formation of geotourism – a new and promising social phenomenon. Geo-diversity needs to be evaluated, taken into account and conserved. Evaluating significance requires measuring it, and measurement is only possible when qualitative features can be expressed quantitatively, in quantities that can be compared. The main evaluation criteria for the geotouristic significance of elements of geo diversity are scientific and educational significance and its attractivity. Scientific significance is determined by the role of the element of geodiversity in the formation and formation of scientific views on the natural history of the Earth and consists of morphostructural integrity, scientific fame and rarity of the element. The high information potential of the elements and the possibility of using them as illustrative examples in educational activities determine the educational significance. The degree of educational significance of the geodiversity element is determined by its representativeness and information security. The attractiveness of a geo-diversity element depends on its availability and infrastructure availability. For each of the indicators of scientific, educational significance and attractiveness of elements of geodiversity, ordinal evaluation scales have been developed on a scale of 1 to 4 points. So, on the basis of summing the values of the assessment indicators, the scientific, educational significance and attractiveness of the element of geodiversity is evaluated. Further, an integral assessment of the geotouristic significance of the elements of geodiversity is carried out. The evaluation geotouristic significance of geodiversity elements of the South-Eastern Altai set two elements of exceptional geotouristic significance, fifteen elements of high geotouristic significance and 24 elements of middle geotouristic significance.

Human perception of landscapes – two approaches tested in the suburban area of Wrocław, Poland

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Land use management in the municipality requires spatial planning decisions based on landscape evaluation. While expert knowledge is arguably central aspect of landscape evaluation, importance of local resident knowledge and perceptions in land use management processes cannot be overlooked and involving residents in the planning processes is required by legislation. In this study we applied user-dependent subjectivist approach and user-independent formal assessment to evaluate landscape. We used indicators of landscape diversity, naturalness and uniqueness for formal assessment of landscape quality. With the use of Public Participatory GIS survey, we collected data about important places for local society in terms of environmental, aesthetic, cultural value and personal experiences. Using the collected data, we identified areas of highest perceived landscape quality, created perceived landscape quality profiles for the areas and finally compared these to the formal assessment results. The results indicate that in the suburban setting agricultural landscape is evaluated generally high in terms of environmental and aesthetic value. Comparison of citizen-dependent and citizen-independent assessments indicates that with the use of formal assessment we can only predict what people perceive environmentally valuable. According to the results of this study, more factors for landscape evaluation should be considered in the land use management and planning purposes.

Formal assessment of aesthetic quality of urban landscapes

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Formal assessment of aesthetic attractiveness of natural landscapes is usually based on evaluating such criteria as perspective depth, relief morphology and habitat diversity, colorfulness, and shape of vegetation, etc. Human disturbance always stands at the negative side of aesthetics scale – the higher level of hemeroby, the less is the score. Papers which discuss perception of urban space focus on architectural environment and viewsheds formed by architectural elements and greenery. In this context, urban aesthetic value becomes very subjective and hard to be embedded into integrated assessment and mapping of urban landscapes functions. In our research we try to find formal criteria for assessing the aesthetic quality of urban landscapes that can be used in the interpretation of satellite images. The urban landscapes of Tyumen became the model territory for the study. The criteria that can be obtained from the satellite images have been selected - the type, height and density of buildings, the share of the green spaces in the built environment in general and of woody vegetation in particular. The city parks were studied separately, where we checked the influence of recreational infrastructure on their aesthetic attractiveness. Respondents were suggested to rate 10 sets of pictures of more or less similar sites differing in a certain aspect of urban environment. The sample consisted of students and staff of geographical department of Tumen State University, the reference group that influences current and future urban planning policy. Sociological research has shown that: 1. The density of vegetation contributes to the aesthetic attractiveness of recreational areas only; vegetation is not a significant factor within urban areas. 2. Moreover, the residents of Tyumen consider densely built up quarters with high buildings to be the most aesthetically attractive; 3. Historical wooden buildings of the late 19th - early 20th centuries do not attract respondents. The regression analysis of the expert assessment of the entire set of photographs showed that the three factors that determine the attractiveness of urban areas for local residents are: the height and density of buildings (positive relationship) and the age of the building (negative: the newer the building, the better it is perceived). We see that a modern city dweller perceives the urban environment not in terms of its aesthetic qualities in the classical sense, but as a message. New development and ubiquitous pavement inform residents that they are living in a modern thriving city, and they appreciate it. When residents need a message that they live in an ecological environment, we expect that the density of green spaces will come to the fore. At present moment, the assessment and mapping of the attractiveness of Tyumen's urban landscapes, obviously, should be based on the height and density of buildings and the abundance of forest parks with dense vegetation.

5. Land use and land management - LULM

5.1. Landscape Studies and Tourism Management of Protected Areas

Host: Natalia Luzhkova, *FSE «Zapovednoye Podlemorye», V.B. Sochava Institute of Geography SB RAS, Russia*

Description:

Nature conservation is an important tool in land and water management. Natural landscapes constitute Protected Areas (PAs) with various statuses and preservation regimes. The fragility of certain landscape components, landscape structure and uniqueness substantiate assessment and establishment of a new PA. Land use restrictions in many typical and fragile ecosystems all over the world have shown the effectiveness of preserving the pristine environment for future generations in nature reserves, national parks, and wildlife sanctuaries. At the same time, wildlife, a high variety of landscapes, their attractiveness increased the demand for tourism in protected areas. National and natural parks have created an established practice of host visitors, but other categories of protected areas, such as nature reserves and wildlife sanctuaries, still have difficulties in regulation of tourist flows. Even in the well-managed protected areas, an ever-growing number of visitors causes problems: an increase in the anthropogenic load, landscape degradation, soil erosion and other. Research methods may vary significantly depending on the type of landscape and the intensity of visits to protected areas. But they are all based on the study of landscapes, their structure and features that help to create a special tourist infrastructure, to manage the flow of tourists and to predict possible negative impacts on nature. We invite speakers to study the following and related topics: 1. The study of landscapes, their components and value for managing tourism and recreation in protected areas; 2.Peculiarities of tourism management in protected areas with different landscape conditions; 3. Anthropogenic impact assessment for visitor flow regulation; 4. Creating infrastructure for different types of tourists; 5. Providing accessible environments to disabled people; 6. Ecosystem services assessment for tourism development in pristine landscapes and PAs.

Landscape studies as the basis for ecological tourism in the «Utrish Reserve»

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The studies have been done to reveal currant ecological state of forest landscapes of the Black Sea coast within the North-Western Caucasus of Russia for the development of ecological tourism in this area. Its organization is vital for the region which is one of the most popular sites for recreation in the country. Besides it's distinguished by formation of unique sub-Mediterranean landscapes with high biodiversity including rare and endemic species of flora and fauna which undergo different anthropogenic affect. To protect these landscapes «Utrish Reserve» with two marine areas was created in 2010. It has a small size and is surrounded by settlements, agriculture lands and different objects of recreation which impact nature in its marginal zones, decreasing the possibility of restoration the disturbed geosystems. So ecological tourism as one of the most informative and gentle types of recreation with orientation to ecological education and enlightenment, to the benefit of local people may be one of the effective measures of conservation nature in this region. The complex of methods such as field landscape-geobotanic profiling and mapping, analyses of remote sensing data of high resolution, phytomass and productivity determination was used during the study to characterize the territory. For the first time, large-scale landscape maps were compiled; the main factors and basic regularities of the spatial organization and current ecological state of landscapes were revealed. The territory of Reserve and its surroundings are characterized by complex landscape structure due to the mountain relief and position in the contact zone of sea and land with ability of geosystems of seism gravitational landforms. The main role in the differentiation of the landscapes and vegetation diversity was defined by tectonic and geological structure, exposure, steepness and shading of the slopes, distance from the sea and anthropogenic effect. Knowledge about landscapes and its components and the maps of the Reserve and its surroundings were used as the basis for organization of ecological trails as one of the effective measurements for ecological education of recreants and local inhabitants (especially of the young people). Three main trails of different lengths and different themes were suggested. All ecological trails acquaint the recreants with the main features of the landscapes and interesting objects of the Reserve, however, they pass in its marginal parts and surroundings.

Russian-German project activities in Romincka Forest – towards a UNESCO biosphere region 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, relatively unencumbered environment as well as many cultural-historical peculiarities. In 2007, the Working Group on Nature Conservation and Biodiversity under the Agreement between the Governments of Germany and the Russian Federation on Cooperation in the Field of Environmental Protection identified the Romincka Forest as priority area for environmental cooperation. This was the starting point for various Russian-German project activities. In 2012, as a first outcome, the central part of the forest landscape on the Russian side was declared as regional Nature Park «Vishtynets». The park aims at the protection and restoration of the natural potential of the Romincka Forest, and it serves to recreational purposes. The promotion of sustainable forms of use is not yet one of the park's explicit goals. This is also reflected in the current zoning of the nature park, which neither includes the settlements nor the open highland surrounding the forest characterized by fields and meadows. Especially these areas offer great potential for near-natural management, for example sustainable tourism or organic farming. Before this background, current Russian-German project activities aim at the nomination of the Romincka Forest as UNESCO biosphere region. In this context, a development zone is to be created that surrounds the nature park and functions as a model zone for sustainable development. Therefore, protected area managers, representatives of the municipal administration level as well as experts from Russia and Germany discuss, among others, potential and framework conditions for promoting environmentally sound tourism in the region. The elaboration of communication strategies, potential studies on regional development are among the results as well as the creation of podcasts, image films or brochures. The project outputs will be part of the nomination for the inclusion of the region into the UNESCO World Network of UNESCO biosphere reserves. Project partners are the Michael Succow Foundation, BTE Tourism and Regional Consulting, University for Sustainable Development Eberswalde and the Nature Park «Vishtynets», in close cooperation with the Ministry of Natural Resources and Ecology of the Government of Kaliningrad Region.

5. Land use and land management - LULM

5.1. Landscape Studies and Tourism Management of Protected Areas

Identification of the most unique landscape units by an example of Anykščiai district municipality

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The common goal of the research is to contribute to scientific knowledge of Lithuanian landscape. The concrete goal is to create a methodology of the division of landscape surroundings and identification of the most unique landscape units in Anykščiai regional park. In Lithuania there is no unanimous methodology of the division of landscape surroundings so far. So, this methodology offers new and summarized method of how to divide landscape surroundings and identify the most unique areas of landscape in order to adapt it to tourism. To realize the concrete goal, these tasks have been set: 1. To analyze literature sources; 2. To present conception of landscape surroundings; 3. To present territory parameters of landscape surroundings; 4. To present the classification of landscape surroundings; 5. To present the examples of landscape surroundings territorial differentiation; 6. To present visual potential of landscape surroundings; 7. To make typological analysis of landscape surroundings. 8. Highlight the most unique landscape areas. The following methods were used in this work: literature analysis, cartographic analysis, database analysis, mapping method. Considering that the concept of landscape surroundings is not completely clear, this work aims to present the concretized concept of landscape surroundings and to identify landscape features that define the size and boundaries of landscape surroundings. Having discussed all the above mentioned aspects, the author introduces the classification and methodology of the division of landscape surroundings. Besed on this methodology, author makes and presents cartoschemes of landscape surroundings of Anykščiai district municipality and the most unique landscapes in Anykščiai district. Also, the work discusses the diversity of landscape surroundings in Anykščiai district. This area is characterized by landscape features. Thus, this methodology makes it easier to identify and delineate landscape boundaries, define its boundaries and identify landscape differences, and provides landscape cartographic visualization capabilities that could be used to represent different landscape features, such as natural and anthropogenic parts of the landscape, to identify the most unique landscapes. The results of the work are reflected in the maps of Anykščiai landscape areas.

5. Land use and land management - LULM

5.1. Landscape Studies and Tourism Management of Protected Areas

Landscape mapping as a base for educational tourism planning in Davsha Bay in Barguzinsky Nature State Biosphere Reserve

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Educational (or ecological) tourism plays an important role in territorial development and nature conservation in Protected Areas. While giving access to a tourist destination we can limit human influence on surrounding landscapes. This strategy is crucial for Russian nature reserves where fragile ecosystems maybe affected by uncontrolled visitation. Keeping vast land untouched, complex studies are conducted within selected ecotourism areas. Landscape maps serve as a base for detailed research, planning and further monitoring. The aim of the study is to create a landscape map for evaluation of opportunities for educational tourism development in Davsha Bay. Davsha Bay is the main educational tourism destination in Barguzinsky State Nature Biosphere Reserve. We divide the bay area into three sections: vast pristine landscapes, field station «Davsha», trails. Altitudinal zonation and relief of the locality determine landscape distribution. Facing the Lake, western slopes on the first flat Baikal terrace are covered with green moss and Ledum palustre L. lurch forest typical for so-called fake sub-goltsy. Mixed forest of Pinus sylvestris L., Betula pendula Roth, Pinus sibirica Du Tour and Larix czekanowskii Szafer are located on the second Baikal terrace on Southern and Northwestern slopes. Dark taiga grows on well drained soils of steep Northwestern slopes and upland parts of the crest ridges on the cape. The reserve headquarters were in Davsha for nearly 50 years as a settlement of 130 inhabitants. Later the village transformed into the field station «Davsha» with a few all-year round staff however some natural landscapes had already been changed under anthropogenic influence. Trails have been the main means of transportation in the reserve due to its remoteness and strict conservation regime. Trails' density is relatively high because of old management tracks, patrolling routes, scientific paths, numerous shortcuts across «Davsha», plus the area abounds with animal tracks. The «Davsha Bay» ecotrail is the main visitor route; for 13km it stretches along the shoreline and loops on the ridge in the north. We consider trail corridors as anthropogenically changed sites. GIS mapping reflecting the current stage of natural and anthropogenic sites is important for further ecotourism development. Landscape maps serve as an efficient framework for monitoring of on-going changes. They show the best possible scenarios for linking attractive landscapes to existing infrastructure with minimal damage to the nature.

Landscape-typological forest maps in development of recreational forest management and ecotourism

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One of the actual problems for recreational forest management and ecological tourism in Krasnoyarsk region is lack of such information in the forest inventory databases and regional GIS. Remote sensing information and ground truth data along with the maps of landscape and vegetation cover structure may serve as an issue of new knowledge about diversity, seasonal state and attractiveness of different landscapes within Krasnoyarsk region and especially in the mountains of Yenisei River basin. The favorable factors of recreational forest management in the region are the rather warm and suitable climate, a great diversity of virgin and many-aged forest ecosystems, mountain landscape zonality, contrasts of northern and southern slopes and unique biodiversity of wild nature. Diversity of landscapes situated along the road from Krasnoyarsk to Kyzyl is supplemented with various seasonal aspects of vegetation cover during the year. These aspects are typical of forest-steppe, mixed subtaiga, mixed chern forest, dark coniferous taiga, subalpine woodlands and meadows, mountain tundra and alpine meadows (Suleimanova et al., 2019). A series of multi-scale maps created during last years with use of forest inventory data and GIS-technology (Korets et al., 2016) demonstrate the landscape structure of mountain ridges and landscape-typological maps of forest cover created by the authors for three Reserves («Stolby», «Sayano-Shushensky Biosphere Reserve», part of Native Park «Ergaki»). All of them are located in the West and East Sayans, they belong to the basin of Yenissei («Priyeniseiskie Sayany») and serve as objects of monitoring in our study. The tasks of developing scientific ecotourism are various for the Reserves but the landscape maps recently created allow one to give more realistic and precise prognoses of forest cover dynamics after destroying by pests, wildfires, thunderstorms and the other factors. References: Korets, M.A., Ryzhkova, V.A., Danilova, I.V., and Prokushkin, A.S. Vegetation cover mapping based on remote sensing and digital elevation model data // Int. Arch. Photogramm. Remote Sens. Spatial Inf. Sci., XLI-B8, 699-704, doi:10.5194/isprs-archives-XLI-B8-699-2016 Suleymanova Zh.R., Nazimova D.I., Korets M.A. Landscape-ecological approach to the recreational forest use in the mountains of the south of Krasnoyarsk Krai // Sibirskij Lesnoj Zurnal (Sib. J. For. Sci.). 2019. N. 2: 3–15. DOI: 10.15372/SJFS20190201

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5. Land use and land management - LULM

5.2. Coadaptation and coevolution of human-nature interaction in agricultural landscapes

Host: Daniil Kozlov, *V.V. Dokuchaev Soil Science Institute, RAS, Russia*

Description:

The thousand years heritage of the agricultural management (mechanical, chemical, biological, informational) and adaptive management developed in the process of coadaptation of natural and social systems do not compromise the demand for research and development support in agriculture in modern era. The conflict between the intensification and greening trends in agriculture is among the headlines of the 2030 Agenda for Sustainable Development and can be viewed as a grand challenge for research and development globally. Placing crops and new varieties in optimal ecological niches, creation of the optimal aeration and water supply in the root zone, sustainable plant nutrition and crop protection can be done in the framework of landscape-and-ecologically adapted agriculture. This section is devoted to theoretical issues of optimizing the socio-economic and ecological functions of agricultural landscapes, methods for land agroecological assessment and monitoring, technologies for maintaining the environmental stability of agricultural landscapes, restoring degraded ones and creating new agricultural systems with desired properties. Multi-disciplinary contributions on the trade-offs in and across multifunctional landscapes to accomplish good socio-ecological system managements are very welcome.

Co-adaptation and co-evolution of society and nature in farming system

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The thousand years heritage of the agricultural management (mechanical, chemical, biological, informational) and adaptive management developed in the process of coadaptation of natural and social systems do not compromise the demand for research and development support in agriculture in modern era. The conflict between the intensification and greening trends in agriculture is among the headlines of the 2030 Agenda for Sustainable Development and can be viewed as a grand challenge for research and development globally. Placing crops and new varieties in optimal ecological niches, creation of the optimal aeration and water supply in the root zone, sustainable plant nutrition and crop protection can be done in the framework of landscape-and-ecologically adapted agriculture. This section is devoted to theoretical issues of optimizing the socio-economic and ecological functions of agricultural landscapes, methods for land agroecological assessment and monitoring, technologies for maintaining the environmental stability of agricultural landscapes, restoring degraded ones and creating new agricultural systems with desired properties.

The work was done with the financial support of the Ministry of Science and Education of the Russian Federation and experimental developments in the framework of the implementation of the Federal Targeted Program «Research and Development in Priority Areas of the Scientific and Technological Complex of Russia for 2014-2020». (Agreement No. 075-15-2019-1939 of 10.12.2019) With a unique project identifier RFMEFI60719X0302.

5.2. Coadaptation and coevolution of human-nature interaction in agricultural Introduction: Co-adaptation and co-evolution of society and nature in farming system

Geographical selectivity of agricultural and rural development in Russia

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Russia is one of world leaders by area of rural territories, but this enormous resource is not being efficiently used. By total amount of rural population – 37,3 million inhabitants it stays only in the bottom of the 2nd top ten countries, and this number is shrinking. Geographical diversity of Russia and unequal progress of market economy explain extreme differences in rural areas development. Some of them became depressive and semi-abandoned, while other experience an agri-business boom and suffer from exhausting land use. A tool for understand these differences is a complex typology of rural areas. We present the results of the first approach to this kind of typology of 85 units of Russian Federation (regions). Our research is based on statistical data analysis, including characteristics of demography, settlement, land use, agriculture and social infrastructure. Standard proceeding of cluster analysis was applied, 8 types of regions were defined and mapped. We can conclude that more than 2/3 of Russia is represented by sparsely populated and nearly not affected by agribusiness rural areas, which loose population due to aging and migration. These are the northern regions of European and Asiatic Russia. Decline of agriculture there brought to drastic but positive changes in land use as natural afforestation. The main disadvantage of these regions is remoteness and poor social infrastructure. In the regions with the most favorable natural conditions for agriculture, rural development depends on demographic ‘wellness’ and geographical proximity to urban agglomerations. On the close urban periphery rural areas experience urban sprawl, whereas agriculture is a secondary economic activity. In the breadbaskets of Chernozem zone and European South agribusiness holds all the suitable land and heavily uses it. Commercial crops area reaches ¾ and even more of the corresponding administrative regions territory. Land and labor productivity levels are both high, with obvious consequences for land degradation. The observed differences between administrative regions raise questions on specific policy measures for rural development. Until 2019, it was considered by Russian authorities as a secondary aim after agribusiness support. The new state program of complex development of rural areas approved in 2019 focuses on alternative ways of rural development, which seeks typology of regions as scientific justification.

The limits of applicability of biome-based planning for landscape adaptive agriculture in changing climate

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The heterogeneity in micrometeorological fields and yield potential is expressed in the spatial variation of the limiting factor L, and the controlled intensity of the planned land management m also has a spatially distributed nature, i.e. m can «adapt» to the value of L. With the development of the theory and practice of landscape-adaptive farming, it was shown that the range of «tuning» is large and allows to confidently solve the problem of increasing productivity in the most productive areas while maintaining ecosystem functions in the remaining part of the landscape. The choice of the zonal farming system (agricultural bioproductivity zones), where «adjustment» occurs within, is considered to be a steady-state function of the climate. However, although climatic averages move gradually in a changing climate, the change in macrocirculation patterns that determine aridity, waterlogging, and temperature extremes occurs quite sharply. The objective of this study is to identify the margins of applicability of landscape-adaptive agro-technologies that have proven to be effective in the climate of the 1980-1990 to a currently changing climate. The example is taken from the boundaries of the forest-steppe and steppe zones in the Central Russia and Volga Region. It was investigated how the regional time trend in limiting agroclimatic factors L correlates with the variation within the reference zonal systems, as well as between the systems. In terms of the extreme value of limitation, the influence of spatial variability, expressed as the variation of the harmful meteorological extreme frequency (as drought), on the stability of the yields of the territory is studied. The compromise of «distributed» agrotechnical measures m between obtaining a positive effect and going beyond the limits of expediency with macrocirculation shifts is quantified.

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5.2. Coadaptation and coevolution of human-nature interaction in agricultural Introduction: Co-adaptation and co-evolution of society and nature in farming system

Towards an ecologically adapted agriculture: the role of landscape structures

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An increasing human population and food demand call for a more efficient agricultural production and intensified agricultural practices. Mechanised farming depends on larger fields and uniformity, leading to increased landscape homogeneity which results in biodiversity loss. The halt of this loss has not only been postulated in international (Sustainable development goal 15) and national calls (biodiversity strategies) but is of major importance for the functioning of farmland ecosystems and provisioning of services such as crop pollination and pest control. Thus, ecological infrastructures are promoted through European agricultural policies and similar schemes in many countries. However, the context dependent and sometimes controversial results of their evaluation, question their actual efficiency to foster biodiversity. Most often overseen, their spatial configuration is important for most mobile species in addition to the amount and suitability in a landscape. Furthermore, region-specific effects of the landscape configuration for selected species guilds as well as methods to predict such relations for agricultural decision making have not yet been investigated in depth. In this study, birds have been monitored in two contrasting agricultural landscapes in Switzerland. To investigate the impact of landscape ecological infrastructures (e.g. hedgerows) on biodiversity, we define and quantify their composition and configuration in the landscape, and weight their importance for different species guilds. Detailed spatial agricultural management (such as crop production, soil cultivation, fertilization, etc.) and structural variables (e.g. composition and connectivity of ecological infrastructures) have also been associated in the analysis. The outcome will help to add a novel landscape component to e.g. the current Swiss Agricultural Life Cycle Assessment for biodiversity (SALCA-BD) to improve prediction of land-use management impacts on biodiversity. In addition, the data will be used for local prioritization of land-use management options such as an efficient placement of ecological infrastructures in the regions investigated in order to maintain environmental stability of agricultural landscapes and develop sophisticated future land-use policies favouring productive agriculture through ecologically sustainable management of agricultural landscapes.

Lands and farming systems of the Central Chernozemic region of Russia

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The modern Russian agroecological landscape evaluation is based on identification of areas with specific hydrology, soil and terrain constraints to crop, that are named as agroecological groups of lands. Agroecological group of lands - areas that are similar in terms of the cultivation conditions of a given crop or a group of crops with similar agroecological requirements. The map of agroecological groups of lands is the base for differentiating crop rotations and agricultural technologies by farm fields. In this regard, large-scale studies were carried out at two key areas in Central-Chernozem region: the Central Russian Upland (Kursk region) and the Oka-Don Lowland (Tambov region). The studies included digital mapping with identification of agroecological groups of lands and their quality assessment. It was find, that the territory of the Central Russian Upland is characterized by normal moisture conditions, leaching water regime, silty-loamy soil texture. It was determined that the intra-landscape variation of moisture capacity as an indicator of soil quality for agriculture is associated with the topography of the interfluves and the erosion. The most of area is covered by automorphic and semihydromorphic types of lands. Besides them, about half of all area is covered by eroded type of lands. These areas are at risk of erosional degradation of the Chernozems. There are some restrictions on cultivation of crops for them. The Oka-Don lowland intra-landscape soils diversity is very high due to a flat topography of interfluve with lots of depressions. The soils of drained interfluves with a short-term overmoistening and a groundwater level below 6 meters are of the highest quality. In addition, hydromorphic lands with groundwater above 6 meters are distinguished. The soils of these areas are meadow-chernozems occupy about 72% of the total area of the key site. They are at risk of overmoistening and, locally, waterlogging degradation. Such lands are suitable for cultivation of perennial grasses, winter wheat, soybeans, sunflowers and others.

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5.2. Coadaptation and coevolution of human-nature interaction in agricultural Introduction: Co-adaptation and co-evolution of society and nature in farming system

Assessment and management of risks of land degradation in the Central Chernozem Region (Russia) as a result of water erosion

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Soil erosion is very dangerous process of agricultural land degradation. Water erosion risk assessments are conducted worldwide (Jin et.al., 2017; Plambeck, 2020; Prasuhn et.al., 2013; Rosas, Gutierres, 2020; Sharda, Mandal, 2018, etc.). The existing methods are based on soil erosion rates, practically without taking into account the degree of soil cover degradation. We assessed the degree of soil degradation and the risks of soil erosion in two districts of the Belgorod region (with a total area of arable land 1.5 thousand sq. km). The rates of soil erosion were calculated by the WATEM/SEDEM. Actual degree of degradation was conducted by the field surveys (in 1272 sampling points). Calculated and actual degrees of soil degradation highly correspond to each other in both districts and parts of the districts. The proportion of eroded soils (with the thickness of the humus horizon dict various scenarios of soil erosion risks for various land use parameters, which is important for the management and sustainable development of agricultural landscapes.

The work was done with the financial support of the Ministry of Science and Education of the Russian Federation and experimental developments in the framework of the implementation of the Federal Targeted Program «Research and Development in Priority Areas of the Scientific and Technological Complex of Russia for 2014-2020». (Agreement No. 075-15-2019-1689 of 06.12.2019) With a unique project identifier RFMEFI60419X0222.

5.2. Coadaptation and coevolution of human-nature interaction in agricultural Introduction: Co-adaptation and co-evolution of society and nature in farming system

New formed landscapes and soils as legacy of sugar industry

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For the first time, landscapes formed at functioning and abandoned sugar waste treatment areas (Kursk region, forest-steppe Chernozem zone) have been studied. In Russia, industrial production of sugar from sugar beets was widely established in the early 19th century. Sugar production wastes discharged into specially constructed dump and sump systems contained lime, organic matter, nitrogen, phosphorus, potassium, as well as an admixture of other elements. In the second half of the 20th century, the development of non-waste technologies led to the abandonment of many waste storage areas. However, despite new technologies, wastewater treatment facilities are still required, and together with abandoned sites form a significant part of the local landscape in the regions of the sugar industry. For more than 50 years, landscapes have formed with a specific regular relief, seasonal watering-drying of settling ponds, displacement of native species by thickets of highly invasive boxel maple (Acer negundo), dense reed (Phragmítes austrális) and tall grass. Strongly alkaline soils, rich in organic matter, were formed. Soilscape is also complicated by fields and plantations treated in the past with sugar production wastes that have changed the properties of soils, while increasing their fertility. Newly formed soils are not typical for zone of leached and typical chernozems and grey (forest) soils; they do not fit into the cells of the Russian classification (2004) and their position in the international classification (WRB) needs to be clarified. New formed landscapes that store large amounts of organic carbon have become an integral part of the environment of the sugar industry regions. Comprehensive soil, geobotanical, and landscape-geochemical studies of territories affected by the sugar industry in the past and present have not yet been carried out. These studies are necessary to expand the horizons of the studying anthropogenic landscapes and soils and their role in influencing local environment.

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5.2. Coadaptation and coevolution of human-nature interaction in agricultural Introduction: Co-adaptation and co-evolution of society and nature in farming system

Biological contamination of soils as a form of agricultural landscapes degradation

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For thousands of years, agricultural practices have stimulated the evolution of harmful organisms in addition to crop growth. The range of harmful organisms for agriculture is very wide - from viruses to weeds. Evolutionary processes in the host-parasite system have led to the biological progress of parasites capable of causing epidemics in agroecosystems. The forms of degradation of agricultural landscapes include biological contamination. Biological contamination Psf soil can be reversible or irreversible. The latter can be fatal, for example, anthrax animal burial grounds. Rapid climate changes in recent decades are responsible for the melting of glaciers and the degradation of the cryolithozone. This transforms the landscape and increases the risk of paleo pollution, as we have shown for deer pastures in Yakutia. The process of transatlantic bio-invasions (Columbian exchange), which began half a Millennium ago, significantly transformed the agricultural landscapes of both the Old and New world. But in addition to the exchange of cultivated plants, there was (and still is) an exchange of parasitic biota, which sometimes has disastrous consequences. An example of irreversible soil contamination is the expansion of the sugar beet cyst nematode range. A model for managing the nemation in crop rotations is proposed.

5.2. Coadaptation and coevolution of human-nature interaction in agricultural Introduction: Co-adaptation and co-evolution of society and nature in farming system

Flood Retention and Impacts on Agriculture in Austria

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Policy Coordination Flood is a national research cooperation of the Federal Institute of Agricultural Economics, Rural and Mountain Research (BAB) and the University of Life Sciences (both in Vienna), financed from the Austrian Academy of Sciences, running from 2019 to 2021. It analysis the flood risk management especially in mountain regions from a policy coordination perspective. It investigates the flood risk management in three fields of interactions: (i) flood retention in head-waters, (ii) flood storage on agricultural land and (iii) flood protection and land development. BAB' s work is on creating a data base to get clear about the dimensions of potential flood affected agricultural areas by means of GIS analyses, to comprise current policy models of flood risk management by means of stakeholder and expert interviews and to improve such models and decision making processes by integrating all relevant stakeholders in workshops. Flood storage is ideally realized in areas with a low damage potential. Agriculture is expected to provide the needed space. Interim results of GIS analyses of detailed current agricultural land use, potential flood risk areas, and characteristics of soils and environment show the amount and the characteristics of affected agricultural areas. This should raise the awareness of the importance of specific agricultural areas and of the importance to differentiate among agricultural areas. On the one hand landscape and soil properties and the current agricultural land use can positively or negatively impact the runoff situation and the amount of damages. On the other hand also economic issues have to be taken into consideration, ranging from effects on specific - maybe high value - areas and the business of single farmers to macroeconomic food security considerations with the aim to protect the favoured areas for food and feed production. Interim results show methodological approaches and first area balances which provide more clarification about the scale of the potential risk.

5. Land use and land management - LULM

5.3. Urban Green Infrastructure and Ecosystem Services

Hosts: Ralf-Uwe Syrbe, *Leibniz Institute of Ecological Urban and Regional Development, Germany*, and Liliia Sulkarnaeva, *Tyumen State University, Russia*

Description:

Green Infrastructure is a strategically planned network of high quality natural and semi-natural areas with other environmental features. The primary purpose of these areas is to deliver a wide range of ecosystem services and protect biodiversity. This explicitly includes green infrastructure in urban areas. This relatively new planning approach is promising in order to address both the environmental and social problems of modern cities. It is potential for that, and first experiences with the application shall stand in the focus of this session. Thereby, there is a strong need in valuation, assessment, and use for the specification of several kinds of urban ecosystem services. In particular, the linking-up of urban green elements; a complement to the so-called „Grey Infrastructure», which comprises the transportation, water and energy networks should be regarded and used for innovative contributions to city planning. The scientific concept and its implementation bear many challenges that should be addressed. Contributions dealing with the concepts of green infrastructure and ecosystem services, in general, are welcome. In particular, we would like to encourage talks that address the particular challenges providing new approaches, methods, experiences and implementation examples about: 1. the multi-functionality of urban green; 2. the several kinds of green and blue spaces which are part of the urban green infrastructure; 3. their contribution to people, biodiversity, and climate change adaptation; 4. trade-offs between urban ecosystem services and biodiversity; 5. the connectivity between green spaces at different scales; 6. multi-scale and multi-object approaches of green infrastructure; 7. Nature-Based Solutions, i.e. actions enhance nature’s ability to deliver multiple valuable ecosystem goods and services; 8. How green spaces in cities do significantly enhance the well-being of urban residents. Contributions are welcome from field, experimental, and modelling to methodological and conceptual studies across all temporal and spatial scales.

Green urban development plans: land use and economic development for long-term perspectives

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Although the concept of the «green» city is not new, since the time of the modernist urban boom the many urban planning solutions used in post-soviet countries as well as in Belarus remain not relevant to the advanced green development. One of the main pitfalls of the problem is urban planning approach with an emphasis on development of «grey» technical infrastructure leaving to urban landscape only predominantly decorative and recreational functions. Institutional separation and lack of strategic vision at municipal level are expressed in the lost sight of operational tools that landscape territories might provide for sustainable urban development. The novel practice to provide every city with a «Plan for Public Green Territories» is, however, but only fixation of current land use without any attempt to integrate actions and to reach synergetic effect in provision of urban infrastructure to meet the needs of the city residents. The recent decision for the start of sustainable landscape development was elaborated in Belarus by UNDP «Green Cities» Project being realized in 2017-2021 under the Ministry of Natural Resources and Environmental Protection. Supporting green urban development in small and medium-sized cities the Project facilitated the formulation of 7 strategic documents – Green Urban Development Plans aimed to create comfortable, environmentally-friendly, safe «green» cities. To perform greener, most of the pilot cities need to incorporate a lens of sustainable landscape into their neighborhood planning, according to urban strategies and design leader. They should «reset», updating to a new, more relevant «version» of the city. Each Plan is unique though there are common priorities in the strategies of different cities: resolution of the most pressing issues includes enlargement and development of the system of landscaped green areas, as well as an alternative use of resources affecting environment and deployment of nature-based solutions. Provision of sustainable landscapes ensures a sustainable functioning of the city's economy as well as improves ecological services of terrestrial ecosystems. According to locally tailored action plans the landscape territories will become spaces for recreation, walks and sports, and will also play an important role in climate mitigation, airing, water management, natural sanitation of urban areas. Water and green areas will become cohesive through the creation of the missing elements of the network.

Historic green areas and monumental trees as a boost for the effective planning of the green infrastructures

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After the second world war, most of the Italian cities have seen a dramatic urban growth. In most of the cases, the urbanization phenomenon didn't take into account the standards of the Italian regulation for the urban green on the one side, neither of the existing ecosystemic features on the other side. This fact has led to a critical fragmentation of the territory, with a negative impact on the public health and on the quality of the environment itself. Nowadays, the development of new linear infrastructures for the public transport offers, indeed, the chance to re-connect the fragmented environments providing tools for the enhancement of the urban green areas and the improvement of the public health. The present research is based on the assumption that the historic urban green areas can play a significant role in giving a relevant impulse for the effective development of the linear infrastructures, when conceived as green-blue corridors oriented to the growth of the ecosystemic services within the urban environment. After a first analysis phase, necessary to frame the urban, historic, and environmental features of the case study, the research focuses on the ecological and the social aspects of the urban green, researching its actual role and its potentials. Based on the case study of the city of Palermo, one of the major coastal cities of the south of Italy and the regional capital of Sicily, the study takes into account the role of public and private historic parks, the ecological functions of the EC SCI and SPA areas and the monumental trees as landscape elements of relevant value for the identity of the territory itself. The result is a master plan of green-blue infrastructure strategies, where the actual trigger for the environmental enhancement is the existing structured urban green together with the monumental trees. In conclusion, the method adopted has led to a qualitative improvement of the urban green strategies bringing a contribution towards the growth of the ecosystem services, while giving an answer to the social and health issues within the urban environment.

The Value of Urban Green Infrastructure for Health and Wellbeing as Ecosystem Service – an Empirical Comparative Study For Germany and Czechia

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The quality of life in our cities depends critically on the planning and shaping of urban living space. Health is one of the most important constituents of human welfare in this context and a key factor of sustainable development. Urban nature contributes essentially to the wellbeing of city dwellers and plays a major role in the avoidance of frequent diseases since it makes a good impact on physical and mental health. Because it is difficult to directly observe or measure in particular the psychological wellbeing, it was necessary to ask the concerned persons for a self-assessment. We obtained opinions on and ratings of different greenspace types by face-to-face interviews. These interviews have been conducted in 2018. Surveys among more than 700 people were carried out in Dresden (Germany), Liberec and Děčin (Czechia) in order to find out and compare how the respondents experience and value the effects of urban green spaces to their wellbeing/health status. The questionnaire has been applied respectively in German or Czech language. It consists of three parts: first, an introduction part with information about the area where the interviews took part; second, to inquire the people's perception and appreciation of urban green in general; third, to ask for additional socio-demographical indications. The results prove a high valuation of urban green for preventative health care. The majority of 235 respondents in Dresden stated among others that they feel more relaxed (81 %), happier (70 %), physically better (68 %), more energetic (51 %), and able to concentrate (44 %) after spending time in urban green. Parks, urban forests and rivers were identified as the preferred types of urban green spaces in all three cities, plus a lake (actually a reservoir) in Liberec. The interviews in Liberec reached 275 persons, the survey in Děčín was performed with 209 respondents. The contribution examines the connections between the furnishing of green spaces and the feelings and effects they generate on visitors. Corresponding elements of the urban green infrastructure have been identified and mapped.

The Role of Urban Ecosystem Services in Russian and German legislation

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According to the UN World's cities report from 2018, about 60 % of the global population will live in urban areas by 2030. The growing The Role of Urban Ecosystem Services in Russian and German legislation trend of urbanization is increasingly raising the issue of ensuring health and well-being through equal access to key public services. The city of today is presented as an ecosystem of a smart city. Sustainable development of this ecosystem seeks to find a balance between economic, social and ecological interests in an environment of information and digitalization. While the provision of services like sanitation, waste management, energy and mobility have traditionally been on the political agenda of most countries, the role of ecosystem services in urban settlements often remains in the background. At least the current Covid-19 crisis highlights the importance of ensuring adequate access to cultural ecosystem services in cities, in particular access to urban parks and gardens. Furthermore, regulating ecosystem services such as air cooling is becoming increasingly important in the face of climate change. Finally, providing ecosystem services, such as food production, is becoming increasingly important in urban settlements. However, the regulations in Russia and Germany do not clearly define ecosystem services, or even urban ecosystem services. Consequently, no basic principles have been developed for further planning of cities with regard to ecosystem services. In Russia, as in Germany, an effective legal framework for implementing ecosystem services in cities requires a multi-level approach, since urban planning takes place at different levels of public administration - federal, regional and municipal level. The presentation will analyze Russian and German legislation on public services in cities. It will look at how the current legal framework can be improved to take better account of urban ecosystem services and ensure their effectiveness and quality. Special attention will be paid to the responsibility for the organization and provision of urban ecosystem services on different levels of public authorities, the role of interaction between public and private actors involved in the provision of services, and how public participation in urban planning and quality control of ecosystem services can be ensured.

Urban Management Strategies by Connectivity Assessment of Grassland Patches

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The urban lawns represent a significant part of urban greenery and intensively manage by frequent cutting regime, which has a negative impact on the urban environment (Ignatieva et al., 2015). Low-intensity management benefits the richness of plant species in urban grasslands (Filibeck et al., 2016; Rudolph et al., 2017; Chollet et al., 2018; Norton et al., 2019; Sehrt et al., 2020) and positively influences soil microbial communities (Fierer, 2017) and the diversity of arthropods, including pollinators (Lowenstein et al., 2014) and parasitic Hymenoptera (Bennett and Gratton, 2012), it also provides advantages for other animals such as birds (McLaughlin et al. 2014). The high plant diversity with low-intensity management boost the resilience of the ecosystem (Onandia et al., 2019; Thompson and Kao-Kniffin, 2019), and directly increases human well-being (Fuller et al., 2007; Clarck et al., 2014; Lachowycz and Jones, 2013) In urban grasslands natural disperser vectors and source populations are largely missing (Hedberg and Kotowski, 2010; Fischer et al., 2012; Piana et al., 2019). Therefore, the ability of urban sites to function as novel habitats for grassland species may be limited by spatial isolation and missing diaspore pools (Fischer et al., 2013). However, maintaining and/or increasing biodiversity can be restricted by limited dispersal caused by the high isolation and low connectivity of grassland patches within the urban landscape (Hejkal et al., 2017). Greater connectivity between habitat patches contributes to genetic diversity and interaction between species, especially among insect-pollinated and outcrossing plant species (Aavik et al., 2014). In contrast, habitat fragmentation can lead to the extinction of species due to inbreeding (Kong et al., 2010). Connectivity encompasses two elements: functional connectivity, which pertains to the dispersal of propagules or pollen between habitat patches in a landscape, and structural connectivity. Structural connectivity is not a simple concept (Neel, 2008), but it describes the physical aspects of the landscape (e.g., size and proximity of patches) (Auffret et al., 2017) and helps to prioritize grassland patches to obtain the most effective network of environment-friendly, species-rich urban grasslands and ultimately provides useful information for policy makers and managers to plan management strategies.

Prioritization of green infrastructure ecosystem services for Subarctic cities

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Urban green infrastructure services of primary importance for a particular region may differ depending on variations of environmental, ecological and socioeconomic features. Thus, ecosystems services regional prioritization becomes important for practice: it enables to concentrate efforts for their support to provide comfortable life conditions for citizens. Our research concerns European Subarctic. Our model cities were Murmansk and Tromso. The prioritization procedure included studies of local ecosystem services important for citizens of the model cities based on field works, thematic publications, remote sensing and Internet data processing. Firstly, pools of ecosystem services were compared for green infrastructure in forest-tundra zone of the Subarctic and Southern taiga in the Temperate zone. The compared pools concerned supporting (carbon deposition, biodiversity), regulating (climatic exergy characteristics, water filtration), provisioning (wild berries), information (chromatic) and recreation ecosystem services. Variations of these pools importance depending on climatic and socio-economic factors were reviled. Results visualization was presented for both cities.

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Ecosystem services of urban protected areas: the case of Moscow

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Urban protected areas (UPA) as a multifunctional part of green infrastructure realize a set of ecosystem services and are the favorite place for relax and sport activities for urban residents. At the same moment the combination of cultural and conservation services are the most controversial for Moscow. UPA system development in Moscow was being realized unequally, it started in 1983, till the beginning of 2000th the sizes of areas were increased and after that only their number grew. The last years the pace of creation of new protected areas has significantly decreased which also reflects Moscow's urban planning policy. The project aims to propose approaches and methods for measure and compare proposed volume of nature protection and recreational ecosystem services of 13 largest UPA allocated in different parts of city. The use of ecosystem services assessment methodologies already developed for European Union cities 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 main data was taken from open geospatial databases, remote sensing data, urban statistical portals and field studies. The proposed volume of recreational services was calculated on the base of recreational capacity of roads, cycle ways and recreational facilities into limits of protected area. To assess nature conservation services level of species biodiversity and the degree of ecosystem fragmentation (PAR index) were taken into account. The main trends of UPA development in recent times are revealed. The most important one is the increasing of degree of anthropogenic impact due to development of recreational facilities and road density. At the same moment that proposed volume is less than demanded due to lack of well-equipped green spaces in the city as a whole system. The proposed volume of nature conservation services naturally depends on the size of protected area and level of ecosystem’s fragmentation due to roads of different types. By the ratio of two types of mentioned ecosystem services three groups of UPA were defined.

Multi-level approach to green infrastructure assessment: case study of Latin American cities

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Modern Latin American cities are a result of numerous transformation throughout their various historical periods. Landscape and cultural alterations formed a specific structure of green infrastructure (GI). On the one hand, it is an outstanding case, featuring either unstoppable Latin American urban sprawl or careful spatial planning of new cities according to the modern approaches. But on the other hand, the development of urban GI in this area meets not only specific problems, but common ones as well. To define the obstacles to GI's improvement and find the necessary improvement measures, it is vital to make accurate qualitative and quantitative assessment of green zones' state and structure. This research suggests a multi-level approach to GI assessment. The method bases on dividing all green elements between 4 spatial levels depending on their size, type of vegetation and inclusion into the urban core: agglomeration level (urban green belt); urban level (habitat cores); districts level (urban parks); intra-district level (small green areas). In each category elements provide specific ecosystem services, thus require development and assessment in particular directions. In Latin American cities these GI levels are especially distinctive, so by using remote sensing data, we defined and assessed them in 5 agglomerations with different geographical features: Lima, La Paz, Santiago, Rio-de-Janeiro and Buenos Aires. We used 5 indicators in our assessment: total percentage of GI area from the urban area; percentage of tree-cover vegetation from the urban area; GI distribution between spatial levels; green area per capita; greening index (ratio between GI area and unit of area). As a result, the most vulnerable GI levels or their parts were defined. We also produced an integrated GI assessment of 5 cities with different natural features and compared their results, revealing that favorable terrain and climate not always mean better GI condition and development.

A Study on the Contribution of University Campuses to Green Infrastructure in Ankara City, Turkey

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Ankara, capital city of Turkey, is known as a university city due to plenty of universities with large green campuses. These green areas provide significant support for the city's green infrastructure system. In this study, the oldest ones among the university campuses in Ankara (Ankara University, Gazi University, Hacettepe University, METU and Bilkent University campuses), which already settled down are evaluated in terms of ecosystem services they provide. Regarding to ecosystem services, the parameters including carbon sequestration, biodiversity and habitat provision, surface flow regulation and aesthetic value were taken into consideration in order to determine the university campuses' contribution to the city's green infrastructure system.

Mapping and assessment of urban ecosystem services in the city of Tyumen

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A vital role of urban ecosystem services in maintaining sustainable urban development is recognized all over the world. The strategy of living the urban environment development of Russia aims to develop a comfortable urban environment, which advances the need for urban ecosystem services assessment and mapping for Russian cities. However, studies on urban ecosystem services in Russia still not numerous, and most cases are located in Moscow. Tyumen is one of Russia 's most prosperous cities, but unfortunately, with a reduced environmental state. Being one of the oldest cities in Western Siberia (founded in 1586), regional capital during the Soviet period, faced post-soviet housing boom, Tyumen accumulated features of all this period and historical epoch. This fact shows the importance of current urban planning, especially green and blue infrastructure implementation and preservation. Urban ecosystem services assessment could help decision-makers to improve the situation. In this study, we aimed to identify and map ecosystems in the Tyumen city that could provide ecosystem services. We calculate demand and supply ratio of ecosystem services with high local significance: «recreation,» «air quality regulation,» «local climate regulation,» and compare the spatial distribution of ecosystem services' demand and supply. To assess the spatial distribution of demand for these ecosystem services, we mapped population density, location of industrial zones, of supply - we mapped the green and blue infrastructure locations. For population density, urban green and blue infrastructure, and industrial zones mapping, we used ArcGIS PRO software and Open Street Map vector layers, which were verified according to the field observations, local statistic data, and city trees register. Comparison analysis showed that the supply in the center of the city is much lower than the demand, and in the suburbs, the supply is higher. The spots with a significant lack of ecosystem services should be considered for implementing green infrastructure sites.

Thermodynamic characteristics of urban landscapes of Tyumen

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For urban landscapes of Tyumen, based on the Landsat 8 OLI TIRS multispectral survey, the parameters of solar energy conversion by landscape cover are calculated - the main components of the energy balance of the territory and measures that reflect the complexity of the structure of the system that converts solar energy: albedo, absorbed solar energy, energy consumption for evapotranspiration, accumulation in system (carbon accumulation), heat dissipation into the environment, costs of producing biological products, heat flux from the active surface; increment of information on Kullback, entropy of reflected solar radiation, self-organization parameter according to Forester, multi-connectivity parameter Q. Consideration of 23 survey dates for different seasons from 2013 to 2018 made it possible to distinguish the invariants (order parameters) of the dynamic landscape cover system for each thermodynamic variable. Based on the principal component method, for each thermodynamic variable, either two or four invariants are obtained that reflect the seasonal state of the landscape cover: in the first case, the state in the growing season (November-March) and outside it (April-September), in the second - winter (November -February), early spring (March), late spring (April), summer-autumn (May-September). The ratio of invariants of the main thermodynamic variables determines the type of thermodynamic system at each specific point (pixel) of the landscape cover. Based on the classification of the study area according to the values of the invariants of variables for the growing season, a map of the types of dynamic system (landscape cover) is obtained. The obtained types are interpreted on the basis of high-resolution images from the point of view of the number of storeys of the building, the number of tree stands. For the main types of thermodynamic systems, the seasonal dynamics of variation of the leading thermodynamic variables is considered. The practical result of such an analysis is maps of the energy state of urban landscapes, estimates based on them of areas of high turbulence, recommendations for the development of green infrastructure in the towns.

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Urban forests and ecosystem services: a case study of Tyumen

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Tyumen, like many other Russian post-Soviet cities, is experiencing a housing boom. As a result, the urban environment rapidly loses natural elements. Therefore, an inventory of the remaining elements and an assessment of the ecosystem services of the existing green and blue infrastructure becomes relevant. This study attempts to assess the ecosystem services of green areas and the forest-green belt of Tyumen. Retrospective analysis of the state of the green zone of the city was done using GIS tools. The gas-regulating services provided by the three largest forest parks within the city and the forest-green belt of Tyumen's ecosystem services were inventoried and assessed. As a result, population growth, an increasing number of vehicles, intensification of apartment blocks construction led to the fragmentation of urban forests. Currently, the area of the city's green zones has significantly decreased and amounts to 478 hectares within the boundaries of the urban district (5.9 sq. m. per person or 0.68% of the urban district). An assessment of the gas-regulating services of the inner-city forests showed that the demand for the production of oxygen and the sequestration of carbon dioxide is ten times the supply volume. Lost ecosystem services provided by destroyed green areas within the city of Tyumen must be compensated. Therefore, in 2017, it was decided to organize the forest-green belt of Tyumen, taking into account the experience - as stated - of the best national and foreign practices. Currently, the city's green forest belt is the largest in Russia and almost equal to the urban district (66849 ha). The total value of the estimated ecosystem services of the forest-green belt amounted to 12.3 billion euros. However, the configuration of the forest park green belt (the absence of belt elements in the north, northeast, and east of the urban district, where the maximum number of industrial enterprises are), agues the effectiveness of its functioning. The assessment results are approximate and generalized due to the lack of a unified methodology for assessing urban ecosystem services in Russia, and reliable data on the volumes of both provided and consumed ecosystem services. The question of assessing the effectiveness of green and blue urban infrastructure is still under discussion.

Moscow parks as providers of cultural ecosystem services: results of socio-ecological survey

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The study presents the results of the research of cultural ecosystem services (CES) provided by urban parks situated in the city center of Moscow (Russia). The social survey using interviewing on citizens' use and perception of urban green spaces (public parks) was conducted in the summer period 2019 in three parks: Gorky park, Neskuchny Garden / Sad and Zaryadye. The participatory observation was also used in order to reveal the preferences in recreation activities and frequency of park visits. Collected data were analyzed using descriptive statistics methods on the reasons for visiting the park, the advantages and disadvantages of each park. Content analysis was applied to reveal the values attached to the parks. The results show the most popular positive and negative answers of respondents according to their socio-demographic characteristics: gender, age, place of residence. CES indicators used include aesthetic value, recreation activities, therapeutic aspects, and human well-being, perception of several CES, social relations, and sense of place. It was identified that location and accessibility of the park play an essential role for the visiting parks as well as provide the opportunity to socialize and feel a connection to the place of residence (contribute to the place attachment). This comparative study shows that the use of CES is thereby both influenced by the demand side (i.e. one's socio-cultural and personal characteristics and needs), and by the supply side and thus the characteristics of the urban green infrastructural itself. City dwellers highly appreciate the nature and the CES of urban parks that influence their physical and mental states and, consequently, quality of life and well-being.

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5. Land use and land management - LULM

5.4. Green and Blue for Re-Naturing Cities

Hosts: Olga Likhacheva, *Pskov State University, Russia*, and Anton Shkaruba, *Estonian University of Life Sciences, Estonia*

Description:

Green and Blue infrastructure for re-naturing cities is a planning approach with a long history. The value of open spaces with vegetation for neighborhood liveability was recognized decades ago, as reflected in several generations of planning textbooks, and in planning forms of many cities, such as e.g. in «water and green diameters» of fUSSR cities created in the 1970-80s, «green belts» in the UK and the Netherlands or the «finger plan» of Copenhagen. With the global environmental change recognized and operationalized, green and blue also became associated with concepts of «resilient», «climate-neutral», «climate-friendly», «adaptive» etc. cities. City re-naturing became visible in planning agendas and international literature as well, as urban and territorial planning were absorbing concepts of ecosystem services and nature-based solutions (NBS), while attracting and maintaining wild nature to/in cities. A raise of green and blue in city planning discussions and agendas took different or even contrast forms on the ground, due to diverging planning and management priorities. For instance, in most countries within the former USSR, on one hand, there are many incentives to maintain green spaces in cities and to develop NBS (e.g. cultural & recreational needs of citizens, sanitary requirements and building rules & standards, well-advertised best international practices appealing to the youth etc.), but on the other hand, they often crash into the economic and planning realities as well as cultural perceptions & behavioral deadlocks. As commonly observed in the Global North, NBS do not appear to deliver on their promise, because either the expectations were unreasonably high, or the implementation was poor or compromised due to conflicts with competent authorities or expert groups overseeing infrastructure safety, sanitation or environmental quality. Keeping this background information in mind, we invite speakers addressing the following or related issues: 1. Perception of «green & blue» in urban landscape by citizens: what they want, what they get, and how we learn; 2. Dilemmas between «green & blue» and «cheap & neat»: planning priorities and quality of urban landscapes; 3. Enabling and disabling conditions for the development of «green & blue» in urban environments; 4. Urban wildlife and quality of urban environments: a multistakeholder perspective; 5. Management of green & blue infrastructure and NBS, including promotion and access; 6. Knowledge transfer, applicability and replicability of nature-based solutions.

Planning for Nature-Based Solutions in the Urban Area of Valletta, Malta

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Future challenges of urban areas (e.g., climate mitigation and adaptation, air pollution, etc.) have been shown to be promisingly alleviated by Nature-based solutions (NBS). NBS are actions that utilize ecosystem processes of green-blue infrastructure to safeguard or enhance the delivery of Ecosystem services (ES). The analysis of the opportunities for NBS implementation is a crucial step to identify where they can be implemented on the ground. This research presents an approach to identify spatial and planning opportunities for NBS implementation at the city scale. Spatial opportunities refer to the available undeveloped land within the urban fabric. Planning opportunities refer to the current spatial policies that explicitly advocates or provide directions for NBS implementation. The case study is represented by the urban area around Valletta, in Malta, one of the EU countries with the highest percentage of built-up areas and population density. Spatial opportunities are detected by identifying available open spaces within the urban development boundaries through GIS analysis of existing land use data. Planning opportunities are detected by analyzing the land use policy instruments covering the study area, the so-called North Harbour and Grand Harbour Local Plan. The latter analysis aims to identify what are the current policies targeted to widespread or specific areas (e.g., in vacant infill lands, public spaces, etc.) and sites (e.g., in a specific street, square, building lot, etc.) that explicit refer to i) the implementation, enhancement, or conservation of green-blue infrastructure features (e.g., gardens, trees, open green and blue spaces, etc.); and ii) specific urban challenges may be addressed by appropriate ES supply or enhancement. Spatial and planning opportunities are then combined and assessed together to identify what city areas can benefit from NBS implementation on the ground and what not because of the lack of space/opportunities. NBS development in such areas is finally discussed considering possible planning actions and tools to achieve their implementation.

Green Infrastructure to Reduce the Energy Demand of Cities

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Over the past decades, intense urbanization processes resulted in built environments with a severe lack of green spaces and thus with low potential for mitigating the heat stress. Green spaces are the main providers of ecosystem services in cities and play a relevant role, among others, in regulating the local microclimate and in mitigating the Urban Heat Island effect. However, despite their importance, the implementation of green infrastructures still struggles and challenges the lack of available open spaces to be set as new urban green areas. This article addresses the potential effectiveness of trees in reducing the energy demand for cooling and heating in buildings located in urban areas. In particular, the research considers different types of spatial configuration of urban fabrics and urban green, and discusses the expected impact of a series of parameters such as the relative position of trees and buildings, the species of trees to be planted, and the availability of space for new tree-planting. The discussion is based on the results available in the literature, and shows that a sound urban planning strategy aimed at designing an effective green infrastructure can significantly reduce the energy demand of urban fabric while providing new green spaces, implementing climate change adaptation strategies and creating a more safety and energy-efficient environment.

Sustainable Urban Drainage Systems in Eastern Europe: Policy Transfer and Legacy Effects

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Sustainable Urban Drainage Systems (SUDS), as a form of nature-based solutions (NBS), are gaining increasing acceptance in urban planning and design to integrate and re(create) the natural water cycle. While there is substantial evidence that SUDS can deliver a wide range of goods and services, there is a substantial gap between scientific theory and practical implementation. We focused on factors, processes, and strategies, that contributed to SUDS implementation, as well as legacy factors that lead to SUDS success or failure in Belarus, Russia and Ukraine. Analysis of legislative framework allowed us to draw the following conclusions: (1) the lack of effective legislation, and the regulatory constraints on SUDS design, construction, operation, and maintenance is a major barrier to SUDS implementation; (2) there is no full policy incorporation of SUDS to national legal framework, and NBS solutions and SUDS are still «foreign» concept for expert society; (3) approval procedure for the construction documentation does not provide a room for SUDS development due to the lack of the NBS solutions in blueprints and building standards; (4) land regulations do not recognize the function of catching and infiltrating rainfall as one that can be associated with green areas. Main economic considerations included: (1) SUDS are mainly funded by international organizations through NGO projects, and as NGOs with their limited expert and implementation capacity are not effective enough it creates additional barriers; (2) standard solutions save money and time for investors and developers, while ad hoc solutions (such as SUDS) are considered to be a source of additional uncertainties, delays and expenses; (3) paved surfaces are recognized by municipalities as the cheapest way of improvement of urban space. Among social and behavioral patterns, the most persistent were: (1) rejection of wild nature in the city: any wilderness in the urban context is strongly associated with mismanagement, negligence, desolation, and poverty; (2) the profit and effectiveness of SUDS is not evident for experts and city administration; (3) everyday behavioural patterns and social habits are not supportive of SUDS. Based on our findings we conclude that there is a deficit of strategic foresight in urban development. SUDS should appear in national policy documents in order to be taken seriously by municipal authorities and other key stakeholders. SUDS implementation is an iterative process that involves integration across fields and departments as well as adaptive management.

Moscow Parks as Providers of Cultural Ecosystem Services: Results of Socio-Ecological Survey

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The study presents the results of the research of cultural ecosystem services (CES) provided by urban parks situated in the city center of Moscow (Russia). The social survey using interviewing on citizens' use and perception of urban green spaces (public parks) was conducted in the summer period 2019 in three parks: Gorky park, Neskuchny Garden / Sad and Zaryadye. The participatory observation was also used in order to reveal the preferences in recreation activities and frequency of park visits. Collected data were analyzed using descriptive statistics methods on the reasons for visiting the park, the advantages and disadvantages of each park. Content analysis was applied to reveal the values attached to the parks. The results show the most popular positive and negative answers of respondents according to their socio-demographic characteristics: gender, age, place of residence. CES indicators used include aesthetic value, recreation activities, therapeutic aspects, and human well-being, perception of several CES, social relations, and sense of place. It was identified that location and accessibility of the park play an essential role for the visiting parks as well as provide the opportunity to socialize and feel a connection to the place of residence (contribute to the place attachment). This comparative study shows that the use of CES is thereby both influenced by the demand side (i.e. one's socio-cultural and personal characteristics and needs), and by the supply side and thus the characteristics of the urban green infrastructural itself. City dwellers highly appreciate the nature and the CES of urban parks that influence their physical and mental states and, consequently, quality of life and well-being.

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Critical Assessment of Green Cover Planning in urban areas - A case of Gandhinagar city

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This research provides an overview for assessing the existing situation of green cover planning in a planned urban area, coupled with analysis of social function of these green spaces. The work involves data collection and analysis of Gandhinagar city at the scale of city level as well as neighbourhood level, and also the enabling mechanisms involved in the provision and maintenance of urban green cover in the city. With a major shift towards urban areas, the number of people living in cities is increasing hence putting pressure on cities for development. Meanwhile to cope with this growing pressure, the urban green cover is going for a toss. It is an absolute necessity to maintain a balance between grey and green infrastructure to maintain an ecological balance as well as improve the quality of life of the residents. The need to provide and maintain green infrastructure in the city is inevitable. Green infrastructure is looked upon as a contributor to improving human health, air quality, lowering energy demand, increasing carbon storage, expanding biodiversity, increasing land values etc. The planned city of Gandhinagar was taken as a case study to assess green cover in the city. Gujarat's state capital is one of the greenest cities of the country. The study focused not only on the provision of green cover at a city level, but also the user need and perspective at the neighbourhood level, and the enabling mechanisms for provision and maintenance of green cover in the city. This was done through a series of data collection from various sources, generation of image processing maps, surveys and consultations. The status of green cover in the city was assessed through quality and quantity parameters by classifying into its broad types. The bodies responsible for the operation and maintenance of these green spaces were also identified. The neighbourhood level assessment was done through quality and user perception parameters to identify the need of the users. Through the data collected and analyzed it was concluded that Gandhinagar has abundant green cover hence the city's focus must lie in retaining this green status of the city through thorough maintenance.

Critical Assessment of Green Cover Planning in Urban Areas: Case Study-Lucknow, India

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This research is focused on the quantitative and qualitative assessment of the existing green cover coupled with social analysis within the city of Lucknow, India. The work involved the study of relevant literature, data collection, analysis and finally providing strategies to improve green cover within the city. Green cover is broadly classified into tree cover, public greens, private greens, institutional greens, roadside greens, railway greens, forests, national parks, etc., but the main focus of this research is centered towards the public urban green spaces which include parks and gardens, and green corridors. These public green spaces are analyzed at the city level, ward level, and neighborhood level. For the city-level analysis, a quantitative assessment of existing green cover in terms of total green and public green spaces based on spatial distribution, the area under green cover, per-capita green space, hierarchy, and accessibility of green space is done. For the ward level analysis, four wards have been selected based on their location, built density, and built use and were analyzed on a similar line. For Neighborhood level analysis, a qualitative assessment of the green spaces and corridors is done within the identified samples from each ward, posing different built use character. The assessment has also focused on the needs of the people using the parks by conducting the primary surveys. It was necessary to understand the various activities people are involved in and what activities will motivate the people to enhance the park usability. At last, the enabling mechanisms at the national, state, and local levels are studied for the provision and maintenance of green cover. The overall assessment of urban green spaces highlighted issues in terms of the uneven spread of existing green spaces across the city. The green spaces are fragmented within the western part of the city which shows a lack of comprehensive planning. It is required to develop a green link that connects all the green spaces. There is a demand for large green spaces within the city as people prefer to use parks for recreation with more amenities and green cover. The urban local body should assess the nature of the demands of different users before planning and designing green spaces. They should involve the community to participate in the maintenance of parks by leasing out land on a short-term basis to the private investors. For enhancing the green cover, the concept of the green corridor should be developed by identifying the areas for plantation of trees.

Environmental policy narratives and urban green infrastructure: findings from five major cities

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In the context of large and growing urban populations, there is a pressing need to understand how urban spaces can be sustainably planned, developed and maintained for greatest benefit to people and nature and how policy can support this. The use of 'green infrastructure', as a framing approach for integrating urban green space in to urban decision-making has had significant international impact. This paper seeks to describe the urban environmental policy narratives across five different urban areas (London and Birmingham in the UK, and Johannesburg, Durban (Ethekwini) and Cape Town in South Africa), reflecting on the way they have brought green infrastructure concepts in to planning, development and management of urban green spaces. This paper investigates the idea that the broader environmental policy context of a city inevitably shapes their approach to urban green space and its relationship with other policy areas. The multi-method approach is based upon analysis of academic papers, technical reports and policy documents, semi-structured interviews and site visits with academics, practitioners (planners, engineers, environmental consultants), policy-makers and local community actors. The two main areas of inquiry and reflection are: 1) Identifying prevailing narratives and priorities in environmental policy at city-level and 2) Outlining current approaches to policy, planning and management for urban green infrastructure. This work has highlighted significant differences in the approach to urban green infrastructure, shaped by the mix of biophysical, social and economic factors that dominate the policy priorities of each of the cities. Insights from this work aim to support decision-makers by understanding the opportunity space for using 'green infrastructure' in green space policy across a range of different urban contexts.

Critical Assessment of Green Infrastructure Planning in Urban areas, The case of Ahmedabad

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People around the world are currently facing a number of environmental challenges including dangerous and irreversible climate change. Urbanization is increasing rapidly in the world. In India, the rapid and unplanned growth of the cities has increased the pressure on the infrastructure services and the natural resources within the city and its surroundings. Green infrastructure is as vital as other infrastructures like roads, water, sewage etc. Green spaces in the cities such as public and private parks and gardens, open playground, green belt play a vital role as service and natural resource. Mostly green spaces act as amazing public spaces simultaneously It plays an imperative role in urban planning as it contributes significantly towards enhancing ecology, stormwater management, improving air quality, reducing noise, conserving biodiversity, improving thermal comfort, carbon sequestration etc. it is also a valuable public asset and can be a tool for city branding. City greens fall in the prey due to expansion of roads, construction of residential and commercial spaces. The fast pace of urbanization is posing a challenge to the urban green cover in public domain, not only in terms of its provisioning but also in terms of maintaining existing green cover. However, several efforts have been done through JNNURM, AMRUT and other projects. The need for establishing green infrastructure in the cities is inevitable in the near future in India. Improving green cover increases liveability of citizens moreover, also contributes towards adapting to climate change and making cities more resilient. Ultimately it leads towards achieving the Sustainable development goals (SDGs), especially the SDG 11 (Sustainable cities and human settlements). This paper is an attempt to analyse the concept of green infrastructure planning in the context of Indian cities with a detailed study of the city of Ahmedabad. It has critically analysed the urban green infrastructure and its condition in the city of Ahmedabad on the city level, zonal level and neighbourhood level. Also, the study has been done for enabling mechanisms like legal provisions, administrative practices, budget allocation, etc. for its provision as well as its maintenance. Efforts also have been done in the direction of strategic ideas and recommendations for the improvement of green infrastructure in the future.

Ecosystem services provided by blue infrastructure in the Northern cities of Russia

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Ecosystem services play an essential role in sustainable urban development. Their contribution is especially important for Northern cities (situated higher than 60 degrees latitude). After conducting a literature search on urban ecosystem services we found out that most publications are focused on green infrastructure and cities in the moderate climate zone. The same tendency is in Russia – there are only two cases (Archangelsk and Kirovsk, Murmansk Oblast). However, cities in Western Siberian suffer not only with the severe climate condition but also with poor environmental conditions due to the high pressure of the oil and gas industry on natural ecosystems. Northern cities of Western Siberian characterized by much-polluted water bodies, which actualized the water-related ecosystem services assessment for these cities. In this study, we searched for methods and case-studies of water-related ecosystem services assessment in Northern cities; assessed the supply and demand of ecosystem services «freshwater supply,» «food» and «everyday recreation» for the city of Surgut (Khanty-Mansi autonomous okrug); mapped spatial distribution of the demand and supply of ecosystem services «recreation» in the city. We found out that there is a trend towards the development of recreational and cultural ecosystem services in Northern cities, most cases of water-related ecosystem services assessment devoted to the economic assessment by simple calculation based on statistical data. We calculated the supply and demand of water-related ecosystem services for Surgut: the potential for supply the ecosystem service «freshwater» exceeds the demand for this service, and ecosystem services «recreation» and «food» are provided in insufficient volume. However, the high level of contamination of water bodies makes it impossible to provide «food» and «freshwater» services.

Cultural Landscapes and Blue-Green Infrastructure in Urban Planning: Opportunities and Threats of Implementing the European Landscape Convention

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Open and timely communication between planners, municipal authorities, and city residents is increasingly important for the success in urban planning. Development of blue-green infrastructure and preservation of historical landscapes are the areas where this communication is particularly important. EU «ComManaging Municipallity – Communication and Management for Community Involvement in Municipal Governance in Belarus» (COMMA) project aimed to demonstrate ways of improving urban planning and governance practices through cooperation between local authorities and communities, based on pilot projects in Mahilioŭ, Baranavičy, and Čavusy. Mahilioŭ's historical district of Padnikollie is a large green area located in the valley of the Dnieper River. For the most part Padnikollie is still a natural area in the central part of the city. The city authorities expressed interest in re-development of this area to an amusement park with construction of highways, shopping malls and parking areas. The re-development started in 2014 and was put on a fast track in 2017. It was marked by conflicts with nature and cultural heritage conservation watchdog organizations and activists expressing concern over quick developments disregarding and destroying important archaeological artifacts, old trees and wetlands. At the same time, broader public was quite optimistic about these developments, as the area was not easily accessible and gave to many an impression of being unpleasantly wild. To ensure both sustainable management of Padnikollie landscapes and support from local stakeholders, there was a need in the EU experience in public participation and communication strategy development. This provided an interesting case study for the COMMA project, and a part of the district was selected for the project pilot initiative of creating a city arboretum and a community garden. By analyzing all stages of the pilot project implementation and post-project developments, we explore a common assertion (in countries reluctant to sign the ELC) that the framework and tools provided by the Convention are somewhat redundant and that the ELC implementation is essentially a luxury only wealthy countries can afford. We review the impacts of visual contamination, land cover change, leveling of the area, construction of high-rise residential buildings and other changes in the neighboring districts. Our findings suggest that there is a governance gap caused by not implementing the ELC, and this gap has increasingly negative effects on both citizens' well-being and city economy.

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Conflicting perspectives on transformations of urban landscapes: cases from the EU and Russia

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We live in a time of significant transformations of European urban landscapes. There is a growing concern that both unique and regular landscapes will be irreversibly affected by this process, resulting in a loss of landscape diversity and a decrease of quality of life. Our study was focused on the urban systems operating in six European urban regions. The research was conducted in the framework of EU Smart Urban Green project by an interdisciplinary team. For the analysis we selected case studies (1-2 per region) of completed or ongoing urban landscape transformations meeting the following criteria: - being placed in peri-urban contexts, reflecting a clear challenge, with the focus on the «greening» issues and/or actions for the transition to sustainability in peri-urban context; - (possibly) being an implementation of a wider plan, at a larger scale; - availability of data to analyze the decision-making process (from problem recognition to implementation); - diversity of actors involved in the process, different types of conflicts between them; - variety of knowledge used (or excluded) in the process. The received data were used for analyzing policy controversies on (green) urban landscapes and the utilization of knowledge in political decision-making and implementation. The findings from our case studies suggest that: - The municipality and citizen nexus demands for new forums for regular dialogues about plurality of landscape perceptions/needs/arising conflicts (e.g. landscape observatories); and clear contact points and communication procedures. - The land developer and citizen nexus asks for supporting citizen initiatives to illustrate the benefits to land values by more sustainable or citizen-driven co-development. - Participatory «experimental governance»: test plannings, local pilot implementations or temporary experiments reduce investment risks and provide learning opportunities for all involved stakeholders. - Time horizons and level of detail in landscape visions / master plans needs to be reconsidered. Based on the selection indicators (QlandQlife methodology), the results of this study can be used to evaluate the urban sustainability conditions, in order to evaluate how the urban sustainability agenda is framed and what aspects of sustainability are not taken into account.

5. Land use and land management - LULM

5.5. Landscape structure and land use of mountain countries

Hosts: Marina Petrushina, *Lomonosov Moscow State University, Russia*, and Alexey Gunya, *Institute of Geography RAS, Russia*

Description:

Mountainous landscapes play the important role for the preservation of environmental sustainability, biodiversity, water supply of lowland areas, etc. due to their special position in the landscape structure of the Earth. But they are more dynamic and sensitive to the inner natural and anthropogenic impact that leads to the variety of responses to the global changes and often to the deterioration of their ecological state. Increasingly, mountain landscapes are being paid attention to as indicators of global change and as potential niches underlying life support. The landscape approach allows us to create the basis for the synthesis of various-scale changes in the mountains and thereby ensure sustainable resource use. The issues that are at the center of the discussions in the session are the following: 1. Structure and dynamics of mountain landscapes; 2. Ecological role of mountain landscapes in the landscape structure of the Earth; 3. Mountain landscape response to climate change; 4. Specifics of landscape planning and zoning in mountainous areas; 5. Landscape support for development and sustainable development of mountain regions.

Landscape mapping for sustainable development of mountain regions

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Landscapes of different rank and type are operational territorial units for planning economic activity in the mountains. Mapping landscapes is a complex process that combines field research with the analysis of topography and vegetation using available topographic maps and images. For the purposes of sustainable development, it is important to reflect landscape areas characterized by homogeneous conditions of natural resource potential and the risk of hazards. In addition, the characteristics of the cultural value of various landscapes for the local population and accessibility for development are important for the mountains. Mapped landscapes serve as the basis for landscape planning and functional zoning. A comparative analysis of large-scale landscape mapping in Altai, the Tien Shan and the Caucasus will be given.

Planning and management of riparian areas: role, performance, and opportunities to enjoy nature

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Riparian areas are recognized as essential for a few terrestrial-aquatic ecological processes and for the welfare of people. In this context, riparian forests and its peripheral borders have different roles, from providing opportunities for public entertainment, the opportunity to practice a variety of sports, to wellness to enjoy nature in areas close to the urban environment. Riparian areas maintain biodiversity, supply a lot of food, habitat and shade for the waterway and make stable riverbanks. Also, these lands filter nutrients, contaminants and sediment from rainfall runoff and decrease the impact of weeds, improving the quality and productivity of near agricultural grounds, and contributing significantly to increase land values. However, due to the increasing pressure on riparian areas should implement real programs and management techniques to safeguard this environment. Land managers face up to the serious assignment of balancing the needs of people and the community to ensure the integrity and viability of these areas. Know-how to right planning their possibilities should be the focus of our work. Our aim is to bring about a logical debate analyzing their socioeconomic importance as areas of special significance for biodiversity conservation, among other aspects. Scientific viewpoint of how riparian forests and their landscape verges benefit people has increased in recent years to include social, environmental, and economic aspects. Nevertheless, there is a delay and/or lack in the response of the municipality policies. These ecosystems and its landscape could be assumed of as green infrastructures. Research has confirmed that their benefits are optimized by long-term management so riparian forests reach their maximum efficiency. There is full awareness of how forest resources and land use planning permit multifunctional use of ecosystems to increase economic returns.

The radiation balance of various types of forest landscapes of the Crimean Mountains

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Based on reanalysis open databases and GIS modeling results, radiation balance elements values of landscapes with oak, coniferous, and beech forests, which are located in different landscape zones and levels of the Crimean Peninsula are calculated. The aspects of the radiation balance interannual dynamics of the Crimean mountains forest landscapes for the period from 1983 to 2013 are revealed. For oak forest landscapes there are decrease in elements of radiation balance values with increase in height on northern macro-slope of Crimean mountains and the opposite effect on southern macro-slope caused by spatial differentiation of fields of total solar radiation in Crimea. Maximum values of the radiation balance elements among the landscapes with oak forests have middle-mountain durmast oak landscapes of the southern macro-slope, which is due to the high values of the relief steepness in the zone of their formation, almost complete absence of the effects of shading, and closed slopes. The radiation balance values of landscapes with coniferous forests increase from the middle-mountains to the seacoast. This is associated with the growth of values of total solar radiation. The values of effective radiation are decreasing towards the seacoast, which is explained by the amplitudes of growth of the thermal radiation flux of the underlying surface directed towards the atmosphere and counter-radiation of the atmosphere too. It is formed an effect in which the maximum values of effective radiation are characteristic of the middle-mountain pine forests of the southern macro-slope and the minimum values of effective radiation are characteristic of low-mountain coastal juniper ecosystems. This effect caused due to the higher amplitudes of the increase in atmospheric counter-radiation as compared to the thermal flux of the earth's surface towards the atmosphere. The radiation balance formation of landscapes with beech forests is associated with microclimatic features. That determines the excess of thermal flux values of the earth's surface towards the atmosphere and the counter-radiation of the atmosphere in the northern macro-slope ecosystems over the values typical for these elements of the southern macro-slope beech forests. This is provided while maintaining large values of effective radiation on the southern macro-slope.

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Landscape support of functional zoning of the territory of the Argun Museum-Reserve (ChR)

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Mountain landscapes have a special position in the landscape structure of the Earth due to the special role they play in preserving environmental sustainability, biodiversity, water supply for lowland territories, etc. At the same time, mountain landscapes are vulnerable to anthropogenic impacts, landscape-forming processes here are highly dynamic, and there is a variety of responses to global change. Increasingly, mountain landscapes are being paid attention to as indicators of global change and as potential niches underlying life support. The high dynamism and variability of the processes occurring in mountain landscapes does not allow us to reliably assess the directions of changes, justify short-term and long-term development scenarios. Despite the existing arsenal of methods, there are significant gaps in the synthesis of multicomponent studies. Using the principles of the landscape approach can create the basis for the synthesis of various-scale changes in the mountains and thereby ensure sustainable resource use.

Landscape structure and dynamics of the high mountainous regions of the North Caucasus

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Mountain regions are distinguished by metachronous and polystructural landscape pattern as a result of superposition of three types of geographical space differentiation – geostationary, biocirculation, and geocirculation ones. They are most well-defined in the high mountain regions of the Northern Caucasus of Russia, especially of the Western and the Central Caucasus, which are chosen as the main objects of the studies. These areas are distinguished by rocky steep slopes deeply dissected with elevation range up to 1000-1900 m, altitudinal zonation and ability of paragenetic geosystems which are integrated by a variety of lateral flows such as debris flows, snow avalanches, etc. Paragenetic geosystems complicate landscape structure of these regions and play significant role in their dynamics. The main regularities of the landscape structure and its dynamics under the current climatic changes and increasing anthropogenic impact are revealed on the basis of the interpretation of multi-temporal remote sensing data, long-term field landscape mapping and repeated observations on the model sites. The degradation of landscapes as a result of social-economic transformation and nature hazards activity due to the climatic changes are revealed during the last decades. The dynamics of glacier-nival, alpine and subalpine meadow landscapes, the increase of degraded pasture lands in meadow-steppes and reduction in area and diversity of mountain forests as well as the decrease of aesthetic properties of nature and recreation complexes are some negative consequences of the anthropogenic and nature processes effect. Landscape maps of the different scales and large-scale maps on the model sites are compiled and some recommendations on landscape planning of the territory are suggested.

Agricultural land use in the Southeastern Highlands of Australia: specifics and environmental problems

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The Southeastern Highlands (Victorian Highlands) is the one of the main geographical and agricultural regions in Australia. This area is used for sheep and cattle grazing, cereals cultivation, and fruit-growing. The aim of the research is to describe the present-day territorial combination of agricultural land use in the Southeastern Highlands and to reveal environmental problems caused by arable, plantation, and grazing activities. To achieve this aim, it was necessary to solve the following tasks: (1) to study the landscape features of this region and to determine its sustainability to agricultural pressure, (2) to study specifics of present-day agricultural land use, (3) to find out environmental problems, emerging in this region during agricultural development. Basing on analyze of modern geospatial data on land cover, agricultural land use locations, and statistical data on environmental problems related to agricultural activity, author reveals the following patterns in this region: 1) Agricultural land use is strongly integrated in the natural landscapes. (2) Types of agricultural land use deal with relief forms, type of vegetation and soils, climatic features, and water supply: from south to north and from west to east arable lands and replaced by plantations and are shifted by pastures. (3) Plantation areas are expanded to the east due to availability of irrigation resources. (4) Intensity of crop cultivation is higher on fertilized lowland western areas, on higher-rainfall flat sites, on hilly territories lying along the southern foothills, and on areas adjacent to urbanized lands. (5) Pastures are getting less productive from south to north and from west to east; the main reason is the features of the natural vegetation types and lack of precipitation. Agricultural development triggers environmental problems occurring on cultivated and intensively fertilized lands. Nevertheless, these problems have a local impact on the environment. Distribution of erosion, land cover fragmentation, deflation, salinity, and acidification are restrained by ecologically balanced farm management practice, which allows stabilizing land degradation at the level of 7-12% per year.

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6. Университетская школа ландшафтоведения

Малоизвестные причины антропогенных лесных пожаров

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Малоизвестные, но действенные и часто действующие причины лесных пожаров: 1) горящие сигареты, выброшенные из открытого иллюминатора самолёта малой авиации (типа Ан-2); 2) стеклянные банки, брошенные в тайге (в лесу). Причины пожаров, произошедших в этих случаях, скорее всего объявляются «неизвестными». Действие первой причины основано на значительной длительности горения сигареты: примерно 10 минут, что намного меньше времени свободного её падения со стандартной высоты полёта самолёта Ан-2: 1000-1500 м. Вторая причина - следствие оптического свойства стеклянных банок, брошенных на поверхности и превращающихся при определенных углах падения солнечных лучей в настоящие лупы. При попадании воды (после дождей) такая лупа действует еще сильнее. Эти причины действуют безотказно, т.к. хвоя и другой растительный опад хвойных деревьев в сухом состоянии загорается и горит лучше спички. Для предотвращения пожаров по этим причинам необходимо соблюдать элементарные меры предосторожности. В частности - закапывать весь мусор, остающийся после пребывания в тайге (в лесу).

6. Университетская школа ландшафтоведения

Ландшафт как система. Системные исследования ландшафтов – реальный путь преодоления давно существующего кризиса ландшафтоведения

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Ландшафт представляет собой систему, а не комплекс, как его общепринято определяют ландшафтоведы, и состоит не только из элементов (компонентов) (как это опять же принято ландшафтоведами), но и из связей во всём многообразии их и их свойств. Системные исследования, в данном случае - ландшафтов, состоят в изучении ландшафтов как систем: не только их элементов, но и связей, взаимодействий и других системных свойств. - Системный методологический подход будет применён на деле, и будут получены совершенно новые данные не только о строении, но и о развитии ландшафтов в самых тонких, до сих пор не изученных их аспектах, что не позволяют сделать познавательные возможности других методологических подходов, в частности - наиболее широко применяемого комплексного. Так будет преодолен давний кризис ландшафтоведения, заключающийся не только в ограниченных познавательных возможностях применяемых подходов, но и в подмене комплексного подхода (применяемого на деле) термином системного (на словах, декларативно).

6. Университетская школа ландшафтоведения

Отклик почв на современные изменения климата и землепользования

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С середины 1980-х годов современное потепление климата стало наиболее заметным на фоне естественных изменений климата. Изменения климата являются частью изменений окружающей среды, и в том числе, системы землепользования. В настоящее время обнаружены последствия прогресса глобального потепления в климатических параметрах, таких как продолжительность вегетационного периода; гидротермические условия, биоклиматический потенциал, сумма осадков за вегетационный период, степень континентальности климата, характеристики снежного покрова. Исследование отклика почв на современные изменения климата выполнено для Ярославского Поволжья на основе сравнения классических агроклиматических индексов для двух периодов – 1961–1990 гг. и 1991–2018 гг. Показано, что средняя многолетняя сумма температуры воздуха больше 10ºС за 1991–2018 гг. увеличилась на 120ºС по сравнению с нормой 1961–1990 гг., вегетационный период увеличился на 7-9 суток. Отмечается статистически значимый рост значений БКП и уменьшение годовой амплитуды температуры воздуха. Климатообусловленный отклик почв на современный масштаб глобального потепления определяется на основе данных о тенденции постагрогенного развития почв бывших пахотных угодий за период 30–35 лет.

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6. Университетская школа ландшафтоведения

Высотная поясность как объект охраны природы

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Значительное биоразнообразие и высокая степень эндемизма горной биоты усиливают значение горных регионов для территориальной охраны природы. Проведено сравнение степени сохранности высотной поясности в горных регионах Великого Евразийского природного массива (ВЕПМ) и в горах Западной Европы и Кавказа. Проведён анализ репрезентативности особо охраняемых природных территорий (ООПТ) в разных горных регионах в пределах ВЕПМ. Выявлено, что в пределах ВЕПМ высотная поясность как закономерное распределение природных сообществ сохранилась на преобладающих по площади территориях на Сихотэ-Алине, Становом хребте, Северном и Полярном Урале, в Хибинах. Многие значительные по площади ООПТ имеют статус заповедников, то есть для них установлен режим максимального ограничения любой деятельности и вмешательства в природные процессы. Качественным показателем высокой сохранности горных экосистем на всём протяжении по вертикали является обитание животных (сибирская косуля, северный олень), совершающих закономерные, в том числе сезонные, миграции вдоль по высотному градиенту изменения условий. Занимающие небольшую площадь преобразованные территории находятся, как правило, в нижних высотных поясах. В некоторых случаях закономерное высотное распределение антропогенного воздействия вызывает столь же закономерные изменения природных сообществ, в том числе формирование субклимаксных сообществ, соответствующих определённым высотам. Однако пока такие изменения не вызвали существенной фрагментации природных сообществ. Качественным показателем этого служит обитание крупных животных, уязвимых к сокращению площади местообитаний. В горных системах Апеннин, Альп и Малого Кавказа доля преобразованных территорий нарастает от верхних высотных поясов к нижним значительно быстрее, чем в пределах ВЕПМ. Даже национальные парки расположены на территориях, где существующие ныне природные сообщества сформировались под влиянием хозяйственной деятельности (выпас скота и сенокошение), в связи с чем режим охраняемых природных территорий предусматривает активное регулирующее вмешательство в природные процессы, поддерживающее оптимальное состояние природных сообществ.

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Управление экотуризмом на охраняемых территориях после катастрофического воздействия - пандемии COVID-19

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По данным Минвостокразвития, в 2019 г. Российскую Арктику посетили 1,17 млн. туристов - на 5% больше, чем в 2018 году. В начале 2020 г. все страны охватила пандемия COVID-19. В России пандемия коронавируса сильнее всего ударила по популярным у туристов регионам, в том числе по Мурманской и Архангельской областям. Объем финансовых потерь в этих областях в сфере туризма составил 57% за первый квартал 2020 г. Для анализа и принятия оптимальных решений развития туристического бизнеса при катастрофических воздействиях типа пандемии COVID-19, а также анализа динамических процессов и построения сценариев развития туризма в Мурманской и Архангельской областях должен быть организован новый подход. При исследовании туристического бизнеса при катастрофическом воздействии надо создать математические модели, описывающие данный процесс, в основе которых должны быть использованы научные идеи теории катастроф, теории хаоса. Указанные научные подходы были использованы авторами при анализе туристического бизнеса после окончания пандемии в Мурманской и Архангельской областях. Т.е. предложены новые современные подходы изучения динамики туристического бизнеса с целью поднять бизнес на более высокую ступень развития и способствовать устойчивому развитию Мурманскому и Архангельскому регионов.

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6. Университетская школа ландшафтоведения

Современное состояние и рекреационный потенциал среднегорных и высокогорных ландшафтов Военно-Сухумской дороги в долине реки Гоначхир

Зульфира Гагаева, Умар Гайрабеков, Алексей Гуня, Татьяна Дегтярева, Ю.И. Караев, Евгений Колбовский, К.М. Ле Жен, А.В. Лысенко*, Е. А. Лымарь, В.В. Онищенко, Марина Н. Петрушина, Д.А. Третьяченко

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Военно-Сухумская дорога - один из важнейших транскавказских стратегических маршрутов, имеющий сложную историю освоения и динамику ландшафтов, обладающих уникальным рекреационным потенциалом. В виду труднодоступности данных территорий в последние десятилетия здесь проводились единичные полевые исследования, крайне недостаточные для оценки состояния ландшафтов и их динамики. При этом разрабатываются проекты возрождения туризма и реосвоения рекреационных ресурсов Военно-Сухумской дороги. В настоящее время группой ученых под эгидой научной сети СКНС проводятся полевые исследования для оценки современного состояния и рекреационного потенциала среднегорных и высокогорных ландшафтов Военно-Сухумской дороги. В настоящем докладе излагаются результаты полевых исследований первого этапа, охватывающих среднегорные и высокогорные ландшафты северного макросклона Большого Кавказа в долине реки Гоначхир.

6. Университетская школа ландшафтоведения

Ландшафтно-исторический подход в формировании туристского продукта

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Использование новых подходов к формированию туристских программ позволяет разнообразить туристский продукт, тем более что во многих странах мира в индустрии туризма постоянно присутствует спрос на новые турпродукты, в частности, на туристские маршруты, сформированные на базе ландшафтно-исторического подхода. Турист рассматривает место своего путешествия комплексно: природные условия, историю освоения местности, его обусловленность, приуроченность памятников и поселений к определенным ландшафтам и т.д. Объектами такого туризма являются культурные ландшафты и ландшафтно-исторические комплексы - результаты взаимодействия человеческого общества и природы, конкретной хозяйственной и культурной деятельности человека в конкретных ландшафтных условиях. Под культурным ландшафтом (КЛ) понимается целенаправленно созданный сотворчеством этноса и природы антропогенный ландшафт, обладающий высокоорганизованной территорией и оптимальным природопользованием. Это – целостное антропогенно-природное образование, отражающее специфику («культуру») природопользования и духовной жизни этноса в конкретных ландшафтных условиях. Особое значение ландшафтно-исторический туризм приобретает в современный период, так как отличается комплексным естественно-гуманитарным характером и имеет широкие образовательные возможности, способствующие восприятию системы «человек - окружающая среда», как уникального целостного образования. Ландшафтно-исторический туризм может быть востребован как в практике формирования турпродукта, рассчитанного на массового потребителя, так и на особые социальные группы, например, детские, молодёжные, исследовательские (исторические, этнографические, географические и др.). Основные виды ландшафтно-исторического туризма будут определять и содержание туристских экскурсионных программ. Для ученых разных специальностей, студентов, аспирантов будет доминировать научная составляющая, для широких масс населения – познавательная. Разнообразные варианты могут быть предложены в свете образовательного туризма для студентов и школьников от упрощённого содержания до углублённого изучения с упором на отдельные аспекты (формирование этноса, развитие сети поселений, экологические изменения и др.) с анимационным, интерактивным сопровождением.

Работа выполнена по проекту РФФИ № 19-05-00233 и ГЗ №1.8 «Структура, функционирование и эволюция природных и природно-антропогенных геосистем»

6. Университетская школа ландшафтоведения

Дуализм взглядов в становлении антропогенного ландшафтоведения

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На рубеже XIX-XX вв. в России трудами В.В. Докучаева, Л.С. Берга, А.А. Борзова и других ученых зародилось классическое ландшафтоведение, где вопросам антропогенных преобразований ландшафтов уделялось пристальное внимание. В 30-е годы XX в. Л.С. Берг назвал ландшафты, преобразованные человеческой деятельностью, культурными, а А.А. Гожев и Б.Н. Городков – антропогенными. В дальнейшем такое разночтение привело и к разной трактовке таких ландшафтов, вылившееся в горячие споры и дискуссии в научной литературе и географических конференциях. В 50-е годы основными дискуссионными вопросам были два взгляда на культурные ландшафты: 1) культурные ландшафты представляют собой лишь часть антропогенных ландшафтов, измененных целенаправленной хозяйственной деятельностью и 2) все антропогенные ландшафты – это результат человеческой культуры. Новый дуализм взглядов на антропогенные ландшафты проявился во второй половине XX в. с оформлением в ландшафтоведении нового научного направления - антропогенного. Его основоположник Ф.Н. Мильков считал, что к антропогенным ландшафтам следует относить «такие комплексы, в которых на всей или на большей их площади коренному изменению под воздействием человека подвергся любой из компонентов ландшафта» и изучать их должна соответствующая дисциплина. У Ф.Н. Милькова ландшафт – и природное и социально-историческое единство. По мнению его главного оппонента А.Г. Исаченко - ландшафт – исключительно природное образование и необходимо различать четыре группы ландшафтов по степени изменения их хозяйственной деятельностью, а вопросы воздействия человека на ландшафты должны рассматриваться в рамках прикладного, а не антропогенного ландшафтоведения. Следует отметить, что эта дискуссия так и осталась незавершенной. Например, В.С. Преображенского (1997), утверждал, что ландшафтоведение не выживет, если будет считаться не общегеографической, а лишь физико-географической наукой и не станет рассматривать человека по отношению к ландшафту не как внешнюю силу, а как его компонент. И напротив И.И. Мамай (2006), считала, что «Антропогенное ландшафтоведение выполнило свою задачу и начинает тормозить развитие всего ландшафтоведения».

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6. Университетская школа ландшафтоведения

Кафедра физической географии и ландшафтоведения. История и XXI век

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Доклад состоит из двух частей: истории становления, развития, стабилизации кафедры. Вторая часть – постсоветский время. За 1930 по 2020 годы выделено четыре этапа состояния кафедры, которые отличаются друг от друга кадровым составом, научной проблематикой, учебным планом и др. Каждый этап имеет свое «ядро типичности». Современный этап во многом будет охарактеризован показом опубликованных монографий, учебников и сборников с кратким комментарием.

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