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Review Article

Ecological-Plant Complexes of the Land

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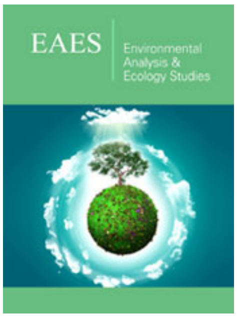

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Abstract

The article considers a method for creating a map of the Earth's ecological and plant complexes based on the ordination of vegetation by two leading environmental factors-heat supply (via the radiation index) and moisture supply (via ....). Similar maps, as experience has shown, can be created for other structural levels of vegetation. Maps allow you to predict possible changes in vegetation cover with a change in one of the above environmental factors.

Keywords: Multidimensional analysis of the ratio of vegetation to ecological factors; Ecology-phytocenotic complexes; Ecological stability of plant communities; Vegetation cover; Vegetation structure; Vegetation productivity; Dynamics of land cover

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Introduction

For a number of tasks in the field of ecological and geographical analysis of vegetation of different typological levels (from local to planetary), it is effective to use the method of multidimensional analysis of the ratio of vegetation to environmental factors Semkin [1], largely based on information statistics. Ecological and geographical analysis of vegetation cover showed that the distribution of zonal vegetation types is caused by certain combinations of heat and moisture. The most convenient way to reflect the dependence of the distribution of vegetation on the leading environmental factors is the direct ordination of vegetation. The vegetation ordination shows the optima and pessimal conditions of vegetation types, which is reflected by the indicators of ecological compliance determined on the basis of the Dice coefficients.

The ordination of vegetation with the determination of the level of ecological compliance is the basis for the compilation of the correlation ecological-phytocenotic (ecological-plant complexes) of the Earth. Vegetation with a high level of ecological compliance occupies ecological optima in which it is most environmentally sustainable. Vegetation cover transformations are most likely in ecotone areas. Here, the vegetation is most sensitive to the ongoing environmental changes. In this regard, such areas are the most vulnerable, they are characterized by increased indication properties. Therefore, the organization of biosphere stations for monitoring the natural environment in these places is most preferable. The methodological aspects of the multidimensional analysis of the ratio of vegetation to environmental factors for the tasks of mapping ecological and phytocenotic complexes of different structural levels of vegetation cover and drawing up ecological passports of forest communities (using the example of forest types) and forest-forming species are presented.

Environmental passports are of great importance for the restoration of forests with increased environmental sustainability, optimization of forest management and protection of forest vegetation. In addition, they contain information necessary for modeling (restoring) the ranges of the original forest taxa. The analysis of the state of the biological components of the biosphere over the past centuries indicates an increase in the anthropogenic load on nature. Therefore, the problem of assessing the impact of human activities on the environment and predicting possible changes in the components of the biosphere and, first of all, the vegetation cover, on the state of which the state of the animal world, soil, etc. depends, is becoming more acute. In this regard, it is of particular importance to anticipate the most likely changes, first of all, in the structure, productivity, biological diversity of vegetation cover from the perspective of climate change and other environmental factors, largely due to human activity. The system of monitoring, control and management of natural complexes is officially called environmental monitoring. Environmental monitoring is a complex hierarchical system for monitoring nature. Its highest level is global monitoring, which is based on a series of national systems for tracking natural components.

Vegetation cover monitoring is an integral part of global monitoring. Its separation into an independent structure of the general system of tracking nature is due to two reasons. First, vegetation is one of the most important natural components. Secondly, vegetation is an integral indicator of the state of the aboveground part of the biosphere, and the size and nature of changes can be used to judge changes in ecosystems at different levels. For many applied tasks, it is of great importance to establish certain dependencies between environmental factors and vegetation. Forest zoning, as well as correlation geobotanical maps, are directly related to these issues. If the experience of mapping forest zoning is quite large and there is an extensive literature on this issue, then there are few publications on the method of compiling correlation geobotanical maps, or as they are also called ecological and phytocenotic complexes (Books, 1976; Sochava, 1979). Ecological and phytocenotic maps are compiled to identify patterns of distribution, spatial and species structure of vegetation, as well as potential biological productivity, depending on the leading environmental factors.

In our opinion, the tasks of vegetation cover monitoring should include identifying patterns of vegetation cover structure and its dynamics, establishing parameters of the invariant vegetation structure, determining the ecological and anthropogenic stability of plant communities at different taxonomic levels, predicting changes in the structure and productivity of vegetation due to anthropogenic impact and climate change. All these components of monitoring are closely related to each other. In most cases, solutions to problems of an applied nature relate to relatively small territories, commensurate with administrative areas, basins of small rivers or tributaries of large river systems. Such a level, in contrast to the planetary, regional, climate-related factors and associated with larger projects, often, including a number of states, refers to the so-called landscape level, which has the specifics of natural conditions of a purely local nature-its own features of geomorphological, soil conditions and other local, in many respects specific, unique for this level of vegetation. The specificity of botanical-geographical relations at the landscape level, as well as at the local level, including the population, is determined by those of a higher hierarchical level, including the planetary one.

All this must be taken into account for the optimal solution of specific problems and tasks. Such a systematic approach involves the use of a large arsenal of modern methods in the field of mathematical analysis and modeling, geobotanical mapping, geoecology, plant ecology, biogeography, and other sciences and scientific areas. Many papers have been published on these issues. But of particular importance are the works in the field of identifying quantitative correlations between the leading environmental factors and vegetation, as a basis for the development of mathematical models. At the end of the last century, there were new directions and "points of growth" in the theory of cartography (cartonomy, cartosemiotics, geoiconics), conceptually, methodically and practically formed geoinformation mapping. At the same time, ecological mapping is an independent branch Berlyand. At the same time, the creation of operational maps based on aerial and space surveys, which are practically updated in real time, is of particular importance, which allows automating the mapping process.

The conceptual basis of a new direction of knowledge-geoeconomics-is being formed on the basis of the interaction of modern cartography, remote sensing and geoinformatics [2]. The newest and most promising direction in cartography is geoinformation mapping (GC)-automated mapping based on GIS and cartographic databases. The essence of the GC is information and cartographic modeling of geosystems. It has emerged and is developing as a natural extension of complex, synthetic system mapping. In line with this direction, we have conducted studies that are combined in one methodological way to compile correlation geobotanical maps of different levels of structural and functional organization of vegetation-from global (planetary) to landscape with the use of GIS technologies and integrated cartographic programs [1,3-5].

Study of the issue

Ecological maps one of the leading components of which is vegetation, are of particular importance for solving applied problems related to environmental monitoring. Maps in the field of geobotanical mapping, geoecology - correlative geobotanical maps created at the Institute of Geography of Siberia and the Far East under the direction of Academician V. B. are becoming more important. Although there are no correlations on these maps between the leading environmental factors (the radiation dryness index and the annual radiation balance) and vegetation in the mathematical sense, there is only a territorial compatibility of the contours. We used this experience in the compilation of correlation maps (ecological and phytocenotic complexes [5,6]. In these studies, the correlation between environmental factors and vegetation cover indicators is characterized by a measure of ecological compliance, which determines the ecological stability of vegetation. this is reflected in the methodology for compiling correlation geobotanical maps or ecological and phytocenotic complexes.

Objects, materials and methods of research

Different materials were used, depending on the level and scale of the research. At the global (planetary) level, the main source of initial information was the maps from the Physical and Geographical Atlas of the World. The vegetation map of the world on a scale of 1:60,000,000, compiled by Sochava VB [7], was chosen as the main one; the maps of environmental factors from the same atlas were used: "Radiation Annual Balance" and "Radiation dryness Index" of the Earth, compiled by Budyko MI [8]. At the landscape (phytocenotic) level, the results of field work with the participation of the author were used directly-on the stationary site of the "Upper Reaches of the Bolshaya Ussurka River". Coupled cartographic analysis is applied at each structural level of vegetation cover. At each level, the material was collected using a regular seki based on a biogeographic grid for the tasks of monitoring vegetation cover. The dimensions of the elementary cells are adequate to the areas of detection-a well-known concept in geobotany, as the optimal size for scanning vegetation, providing objective research results. At each structural level of vegetation, the material was collected in the upper-left corners of the elementary cells, in the form of squares, a regular grid. The remaining corners of the cell were also the upper-left corners of the neighboring cells. The dimensions of the elementary cells of the regular grid at the global level in translation to the real surface were 240 x 240km, on the landscape (phytocenotic) - 50 x 50m. On the smallest scale of the Atlas vegetation map, vegetation types are taken as the main typological structure of vegetation. These are the largest taxonomic divisions of vegetation, corresponding in most cases to specific biomes. The quantitative conjugacy of vegetation with environmental factors was determined by the Dyce-Bray formula.

Methodology for mapping ecological and plant complexes

The method consists of several stages: 1) the most significant environmental factors of the environment are identified, data on such factors are given on the example of the planetary level of vegetation, a direct ordination of vegetation for the two leading environmental factors with an assessment of environmental compliance is made; 3) the contours of ecological and plant complexes reflected on the ordinations of vegetation with a measure of environmental compliance, to a certain extent, adequate to the environmental sustainability of plant communities, are transferred to the land map at a given scale. With this approach, the maps of ecological-phytocenotic, or ecological-plant, complexes are more consistent with the concept of correlation geobotanical maps. The distribution of zonal vegetation types is determined by certain combinations of heat and moisture. The most convenient form of reflecting the dependence of vegetation distribution on the leading environmental factors is the direct ordination of vegetation (Table 1). Note. Roman numerals indicate the numbers of ecological-plant complexes, RID-the radiation index of dryness. In each completed ordinal cell, the numbers in bold indicate the numbers of ecological-plant complexes, below are the numbers (codes) of vegetation types (the first digit), through a hyphen-the level of environmental compliance, or Dice measures, multiplied by 1000 for convenience. The names of ecological and plant complexes are given in Figure 1, The most characteristic vegetation types are: 1– tundra; 2-boreal; 3-non-morale; 4-shrub-woody subtropical; 5-steppe; 6-extratropical deserts of the northern hemisphere; 7-high-altitude tundra and boreal types; 8-moist evergreen rainforest; 9-deciduous and evergreen variable-moist rainforest; 10-tropical dry forests, sclerophilic forests; 11-tropical savannas; 12-tropical deserts: 13-xerophid wood-shrub subtropical; 14-extratropical deserts of the southern hemisphere. At the planetary level, the annual radiation balance and the radiation dryness index were used. The ordination of the vegetation of the world is in principle largely similar to the table of geographical zoning, which at a qualitative level shows a close relationship of geographical zones, biomes with the radiation balance of the earth's surface and the radiation index of dryness. This allowed us to derive the periodic law of geographical variability [9].

Table 1: Ordination of the vegetation of the world.

Moisture Content (Radiation Index Of Dryness – RID)	Heat Supply (radiation balance, kcal per 1 cm2 per year)					
	Very HS Cold, up to 10	Cold, 10-20	Warm, 20 – 60		Very Warm, 60-80	Hot, over 80
Extremely insufficient moisture RID свыше 3				XIIIXIII 6-38, 14-18	XVIII 12-58, 6-32 01-11-2020	
Insufficient moisture, FID. 2 to 3			VIII 5-16, 6-6	XII 13-12, 14-9 06-06-2021	XVII 10-20, 11-13 13-13	XXI 10-08-2021
Moderate insufficient moisture, FIG. 1 to 2, RID от 1 до 2			VII 5-45, 2-3	XI 3-27, 15-19 01-05-2017	XVI 11-42, 10-35 4-11	XX 9-24, 8-12 10-12-2021
Moderate moisture, RID 0.7 to 1.0,			VI 5-23, 2-23 3-21	X 03-04-2007	XV 4-58, 8-23 9-12	XIX 8-27, 9-4 10-4
Wet, RID 0.3 to 0.7		III 7-24, 2-16 1-16	V 01-02-1975 1-10	IX 07-08-2021 4 - 4	XIV 09-05-2021 8-4	
Excessive moisture, RID up to 0.3,	I 1-24	II 1-63, 7-30 2-8	IV 7-11, 2-9 1-5			

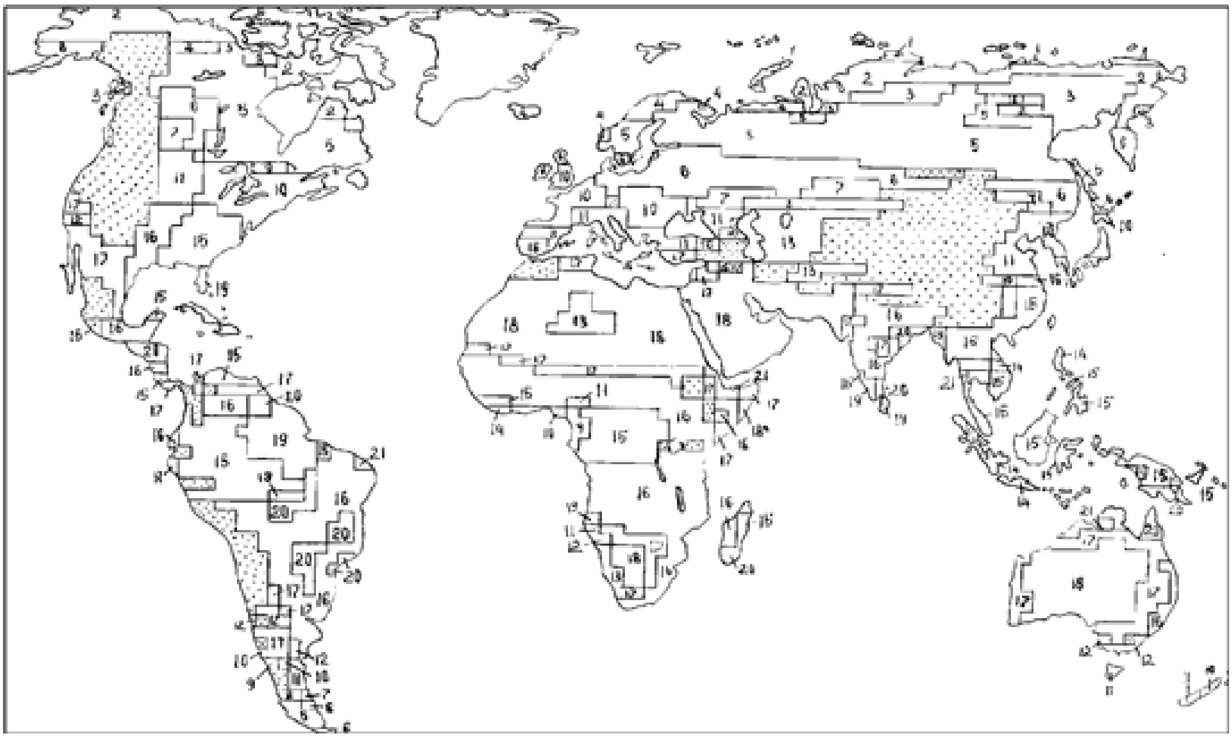

Figure 1: Ecological-plant complexes of the earth.

There are 21 possible types of growing conditions, or types of ecological and plant complexes (ERCs), as a combination of types of ecological conditions and types of vegetation in the world. The distribution of ecological and plant complexes of the world is shown in Figure 1. On the basis of vegetation ordination, an ecological and plant map of the Earth is compiled (Figure 1). The types of ecological and plant complexes shown in the ordination scheme are shown on this map. The contours of the complexes themselves are elongated mainly in the latitudinal direction, which indicates the predominant role of heat supply in the distribution of vegetation, reflecting mainly zonal botanical and geographical relations. As a result of the analysis of the ecological and plant map of the world, the main botanical and geographical relations of the planetary level, the ecological conjugacy of environmental factors and vegetation were identified, which largely determine the structural and functional organization of forest vegetation at other structural levels of vegetation: regional, landscape. Maps of ecological and plant complexes make it possible to directly assess the ecological stability of plant taxa, their changes in various combinations of heat and moisture availability. Such maps, in essence, are a cartographic model of possible changes in the structure under various variants of environmental changes. Vegetation with a high level, an indicator of ecological compliance occupies ecological optima and is the most environmentally sustainable. At the global level of the structural organization of vegetation, changes in the structure and, consequently, in its productivity in ecotone areas are most likely.

Here the vegetation is most sensitive to the changes taking place. In this regard, such areas are the most vulnerable, they are characterized by increased indication properties. Therefore, the organization of biosphere stations for monitoring the natural environment, primarily vegetation cover in such places is most preferable. The map of ecological and plant complexes of the Earth) clearly reveals the patterns of spatial distribution of vegetation. Each level of heat supply, characterized by a sum interval of 400°, corresponds to a specific subzone of vegetation. Another pattern, called Buks II [10] provincial, reflects the dependence of the typological composition on the radiation index of dryness under equal conditions of heat supply. The quantitative relationships between the combination of gradation of the leading environmental factors and syntaxons can be used in predicting the structure of the vegetation cover structure in the course of environmental monitoring. In addition, as the experience of our research has shown, the identified botanical-geographical relations at the planetary level of vegetation cover can be used to identify dynamic processes in the combination of climate change and anthropogenic impact, through restoration (modeling) the structure and productivity of the original, or indigenous, vegetation cover and comparison with the modern one will allow us to assess the size and trend of these transformations of the plant world. The combined influence of heat and moisture supply determines forest vegetation conditions, which is used for geobotanical, forest vegetation, botanical and geographical zoning, making classifications of forest communities on an ecological and phytocenotic basis, climatic ordination of high-altitude forest vegetation belts, and allocation of high-altitude forest cover divisions.

Conclusion

The method was used in the preparation of maps of ecological and plant complexes that are adequate to correlation geobotanical maps. These results are used in the study of the forest formation process, cartographic modeling of the areas of the original taxa of vegetation cover, optimal places of growth of forest-forming rocks. The obtained research results allow us to draw up multi-level ecological and phytocenotic complexes that combine structural divisions of vegetation cover and higher levels, which are in many respects conceptually similar to the classification of multi-level forest types, They can be used for monitoring tasks not only of vegetation cover, but also in the field of ecological geography, as well as for other tasks. These research results can be used for a wide class of applied problems - in forestry practice (production of forest crops, reconstruction of low-value plantings, etc.), to predict the most environmentally sustainable forest vegetation and its dynamic processes in connection with different scenarios of climate change, and for other environmental monitoring tasks [11,12].

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