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СОВРЕМЕННЫЕ ПРОБЛЕМЫ БИОИНДИКАЦИИ И БИОМОНИТОРИНГА

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Современные проблемы биоиндикации и биомониторинга: Тр. XI Международного симпозиума по биоиндикаторам. – Сыктывкар, 2003. – 505 с.

Настоящий сборник авторы посвящают академику Венгерской академии наук, создателю и постоянному руководителю Междисциплинарной комиссии по биоиндикаторам Международного Союза биологических наук Яношу Шаланки. Большой друг российской науки, выпускник биолого-почвенного факультета Московского государственного университета, Президент Международного Союза биологических наук Янош Шаланки внес решающий вклад в возрождение биоиндикации и организацию международного сотрудничества в этой области. Он был сопредседателем оргкомитета Международного симпозиума по биоиндикаторам в Сыктывкаре.

Сборник включает статьи и доклады, представленные на XI Международном симпозиуме по биоиндикаторам «Современные проблемы биоиндикации и биомониторинга». В книгу вошли работы, освещающие методологические проблемы, перспективы развития и применения биоиндикации и биомониторинга, обобщающие результаты многолетних исследований в этой области, а также статьи частного характера, затрагивающие изучение действия загрязняющих окружающую среду веществ на объекты живой природы.

Издание представляет интерес для биологов и экологов.

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Modern problems of bioindication and biomonitoring. Proc. XI Intern. Symp. on bioindicators. Syktyvkar, 2003. – 505 p.

The authors dedicate the underlying publication to the Academician of the Hungarian Academy of Sciences, founder and permanent leader of the Interdisciplinary Commission on Bioindicators of the International Union for Biological Sciences, Janos Salanki. As a dedicated friend of Russian science, graduate of the Biology & Soil Faculty of Moscow State University, and President of the International Union for Biological Sciences, Janos Salanki put decisive efforts in the development of bioindication and the organization of international cooperation in this field. He was co-chairman of the Organization Committee for the International Symposium on Bioindicators in Syktyvkar.

Book includes reports and articles presented in XI International Symposium on bioindicators «Modern problems of bioindication and biomonitoring». Methodological problems, perspectives of development and application of bioindication and biomonitoring are considered in it. Results of multiyear research in this field are also summarized. The book is of interest for biologists and ecologists.

The Editors
D.A. Krivolutzkii, A.I. Taskaev

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MAPPING THE ENVIRONMENTAL STATUS OF VEGETATION COVER OF THE URALS

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Ranking environmental conditions of any area starts with revealing features and regularities of organization of terrestrial ecosystems (woods, meadows, forest, steppes). Vegetation cover is a structural and functional basis of ecosystems and is always stipuilated floristically, ecologically and historically. It is the indicator of local conditions and precisely responds to all spatial and temporal changes. Total study of vegetation cover, its structure, natural and man-induced dynamics, its geographical and historical conditions is urgent for mapping. Environmental mapping is a new scientific direction serving various researches on resources.

Phytoecological map characterizes environmental potential of a certain area, reflects consequences of man economic activity, fixes changes in ecosystems and natural territorial complexes. Phytoecological map grounds on geobotanical map, itself containing a lot of ecological information. Phytoecological map also includes a landscape map and land use map. Not stopping in details on mapping techniques we note maps are based on system analysis of structural dynamics of vegetation cover and landscape differentiation [1, 2].

Analysis of these maps allows to evaluate dynamic parameters of vegetation state by three variants:

a) vegetation is rather well preserved, no changes in dominants. Prevailing communities are coniferous forests, preserved in fragments in the alpine part of the Urals and on boggy watersheds;

b) vegetation is man-changed, changed dominants: coniferous forests are replaced by derivative – small-leaf woods. Major influence factor is forest cutting;

c) natural vegetation is not preserved, natural phytocenoses are destroyed by plowing, mining or construction, bog drainage etc.

The state of vegetation cover was ranked by two indices: transformation and degradation. First was defined as a ratio of total transformed area (derivative or completely transformed) to primary vegetation area, the second one as a ratio of transformed vegetation area within a certain territorial complex to its general area. Though the indices are not universal, they allow to rate and develop a scale reflecting studied processes in mapping models.

As an example we present ranking the status of vegetational cover at three levels: local, sub-regional and regional. The levels are interconnected, but each of them is characterized by temporary and spatial ecological and dynamic features.

Local level. « Map of anthropogenous transformation ecosystems of Kamenskii area of Sverdlovsk region» (m. 1:100000) is published. [3].

Map legend is presented as tables, containing quantitative data on ecosystems (woods, meadows, mire) status in landscape areas considering their safety, or data on man-induced development.

On the basis distribution of indexes three degrees of transformation are established: weak, middle, strong. For wood ecosystems the index of transformation varies from 0.4 up to 5.6, for meadows - from 3.0 up to 41.5, for mire – from 0.2 up to 2.0. On a map the transformation of ecosystems is reflected by colour scale, in a fig. 1 – shading.

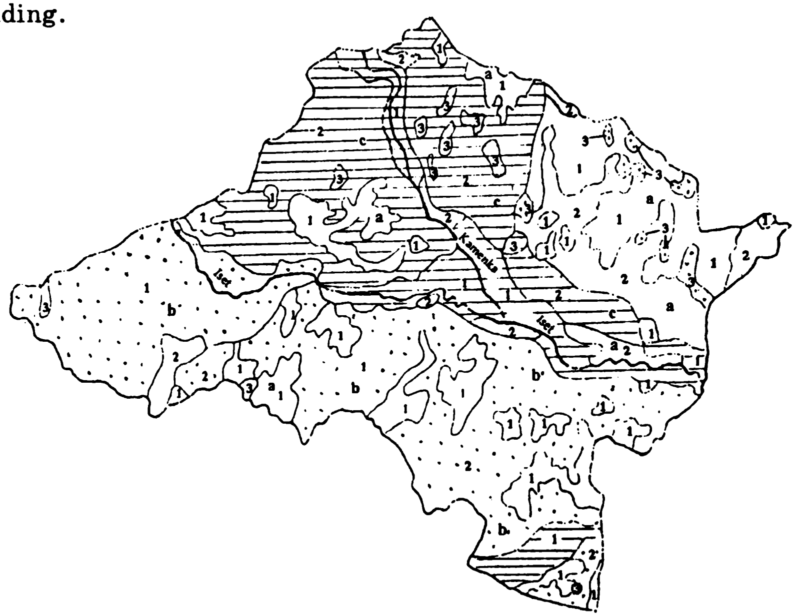

Figure 1. Area degradation in landscape areas.
Landscape areas: 1 – Maminskii birch-pine forest-steppe; 2 – Prikamenskii meadow-birch forest-steppe; 3 – Travianskii bog-meadow-birch forest-steppe; 4 – Sipavskii lake-meadow-birch forest-steppe; 5 – Kamensko-Isetskii pine-birch forests; 6 – Sinarskii pine-birch forests.
Degradation levels: I – 50-55%, II – 56-66%, III – 67-80%, IV – 81-85%, V – 86-90%.

Wood ecosystems are most transformed in Kamensko-Isetsk and Sinarskii landscape areas. In the past, these areas were occupied by pine forests on ancient limestone terraces. Pine woods in these areas covered over 90% of territory. Now afforested area is 50-65%, and pine woods occupy 14.7%. They can not regenerate into initial state earlier than 100 years later, under condition of no man press.

Meadow ecosystems are most transformed in Prikamenskii and Sipavskii landscape areas. They were widespread there in the past and occupied 82 and 76% of area, now only 2 and 6% among arable land. Species composition in these areas has greatly reduced: in Prikamenskii – by 62.6%, in Sipavskii – by 42.4%. There proceeds unification of meadow communities, losing taxonomic pool. The restoration of meadows in these landscape areas is impossible, but changing meadows into woods is possible.

Marsh ecosystems underwent the greatest changes in Pricamenskii landscape area, their areas decreased. In past they occupied 4% of area, now – 1%. It is necessary to note that bogs are intensively used as hay fields or grasslands, they are transformed into shrubs or woodland. Their reclamation till initial state is impossible. Simultaneously, lakes transform into mires with sedge and reed communities.

The «Map of man transformation of ecosystems Kamenskii area» allows to determine environmental situation, for further use of natural resources, representing distribution of highly protected natural areas.

Indices of man -induced degradation show percentage of man-transformed landscape (cutting, plowing, construction etc.).

Five levels of degradation (fig. 2). Greatest man transformation is registered in Prikamenskii, Kamensko-Isetskii and Sinarskii landscape areas (82-90%).

Considering high transformation of ecosystems and degradation of natural-territorial complexes, it is revealed that 69% of Kamenskii area is under ecological disaster.

Subregional level. «Phytoecological map of Sverdlovsk region» (m. 1:1500000) is published [4]. Methodic grounding of compiling «Phytoecological map of Sverdlovsk district» are published earlier [5].

Basic parameters of intact or transformed vegetative communities in zones and territorial – landscape complex are submitted in tables.

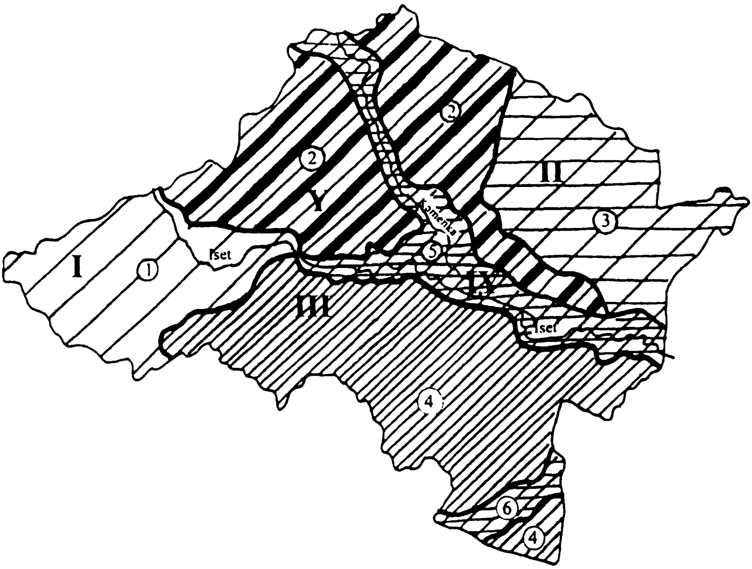

Figure 2. Man transformations of ecosystems.
Ecosystems: 1 – forest; 2 – meadow; 3 – boggy
Transformation degree: a – low; b – average; c – strong.

Alpine zone divisions of vegetation cover are encoded by color. Color reflects alpine, foothill or plain landscapes. Indices also show man transformation. Four transformation degrees are distinguished: low (index lower than 0.2), moderate (up to 1.0), strong (up to 10), catastrophic (over 10) (fig. 3). The lowest index of man transformation is registered in mountain tundra, open boreal woodland, boggy and northern taiga, where primary vegetation prevails. Moderate transformation is in forest communities of middle taiga. Here primary coniferous forests mix with derivative. Afforested sub-zones (southern taiga, sub-taiga and forest steppe) suffer severe man transformation, when transformed area 2-4 times exceeds the primary vegetation area. Forest steppe vegetation is endangered, where meadow steppes and primary woods are completely lost, transformed : primary vegetation ratio is 30:1.

Six levels of degradation with the following values (%) are distinguished: up to 10; 30; 50; 70; 90; over 90 (fig. 4).

It is established that forest-steppe areas of Sverdlovsk district are highly used for agriculture, landscape structure and ecosystems

Figure 3. Man transformation of zone divisions of vegetation cover.
Transformation degree: 1 – low; 2 – moderate; 3 – strong; 4 – catastrophic.

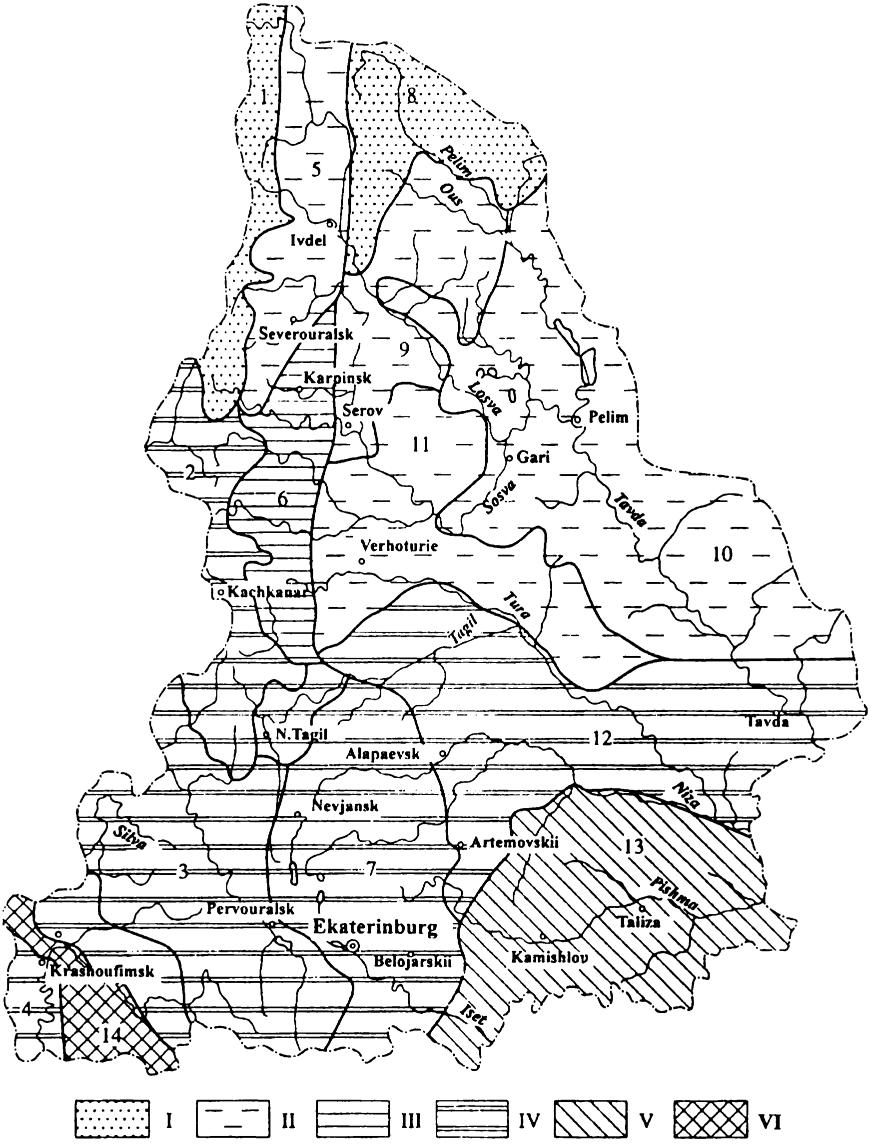

Figure 4. Levels of degradation of territorial vegetation complexes:
1-14 – numbers of territorial complexes.
I-VI – degradation levels: I – 10%; II – 30%; III – 50%; IV – 70%; V – 90%; VI – >90%.

functions are broken, entailing various deeper negative phenomena. 11% of area possesses over such catastrophic status.

Phytoecological map allows to make deeper conclusions about process of urbanization in the area. General man-transformed area for 300 years in Sverdlovsk area makes 80628.75 km^2 in Sverdlovsk district. If we assume, that man factors work in regular intervals, it is difficult to calculate transformation rate. For forests of the Sverdlovsk district it makes ca. 270 km^2/year. If reclamation processes continued with the same speed, it is possible to expect, that northern taiga remains for 55 years, average taiga – 140 years, southern taiga-60 and forest-steppe – 20 years. Already forest steppe are about to disappear.

Alongside with degradation come processes of vegetation restoration. Grounding on mapping data, forest restoration rate was calculated. Restoration period till original forest state is equal to life expectancy of one forest generation. It takes a small-leaf forest 150 years to transform back into coniferous forest and reach economic maturity. Restoration rate of cut areas was determined, too: 255 km^2 per year (plant cover transformation rate and its restoration rate differ only slightly). It is possible to predict restoration of coniferous forests by 2145 on condition that man factor will be removed and contemporary climate will preserve.

So, «Phytoecological map» gives us a complete concept of typical environmental conditions in the area.

Regional level. Rating of state of vegetation cover of the whole Urals is carried out on the basis of plant-geographical subdivision (m. 1:7500000) [6] (fig. 5). On the circuit the provincial and zone categories of regional dimension are reflected basic. Ecological differentiation of vegetation cover of the Urals grounded on the degree of its man-induced transformation, with a special attention to Sverdlovsk district, most studied. Province, as a most convenient category, served basic area unit in ranking environmental state of vegetation [7].

Four ecological zones (fig. 6) are distinguished:

1. Zone of normal environmental situation, corresponding to low man transformation of vegetation cover. It covers the following area: East-European-West-Siberian tundra, North-European and Kama-Pechora-West-Urals open boreal woodland and dark coniferous forests of northern taiga, North-European and East-Urals-West-Siberian pine forests of northern taiga and larch open woodland.

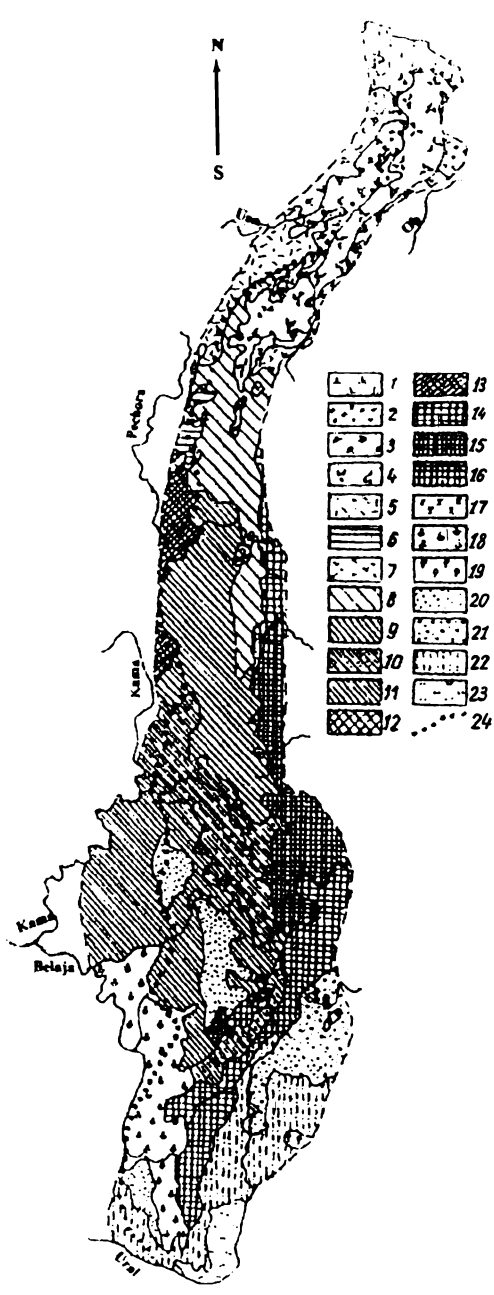

Figure 5. Map-scheme of vegetation in the Urals.

Tundra. East-European-West-Siberian: 1 – grass-moss and dwarf shrub-lichen northern tundra; 2 – dwarf shrub southern tundra; 3 – shrubby southern tundra; 4 – alpine tundra, mounds and rock stream.

Dark coniferous forests with broad-leaved forests and open woodland.

North-European: 5 – birch-spruce open boreal woodland; 6 – spruce and birch-spruce forests of the northern taiga.

Kama-Pechora-West-Urals: 7 – birch-spruce with larch open boreal woodland; 8 – spruce forests of northern taiga; 9 – fir-spruce forests of middle taiga; 10 – fir-spruce forests of southern taiga; 11 – fir-spruce with broad-leaved forests of sub-taiga.

Pine forests. North-European: 12 – pine forests of northern taiga; 13 – pine forests of middle and southern taiga. East-Urals-West-Siberian: 14 – pine-larch forests of northern taiga; 15 – pine-larch forests of middle and southern taiga. South-Urals: 16 – pine-larch-birch forests of forest-steppe.

Larch forests and open woodland. East-Urals-West-Siberian: 17 – larch light forests and open woodland.

Broad-leaved forests. East-European: 18 – lime and oak.

Birch forests. Trans-Urals-West-sibirian: 19 – birch and aspen-birch forests of forest-steppe.

Steppe. Adjacent to the Black Sea: 20 – meadow-steppe. Trans-Volga-West-Siberian-Kazachstan: 21 – meadow – steppe; 22 – proper steppe; 23 – herb-sheep-spear-grass. 24 – West border of the Urals.

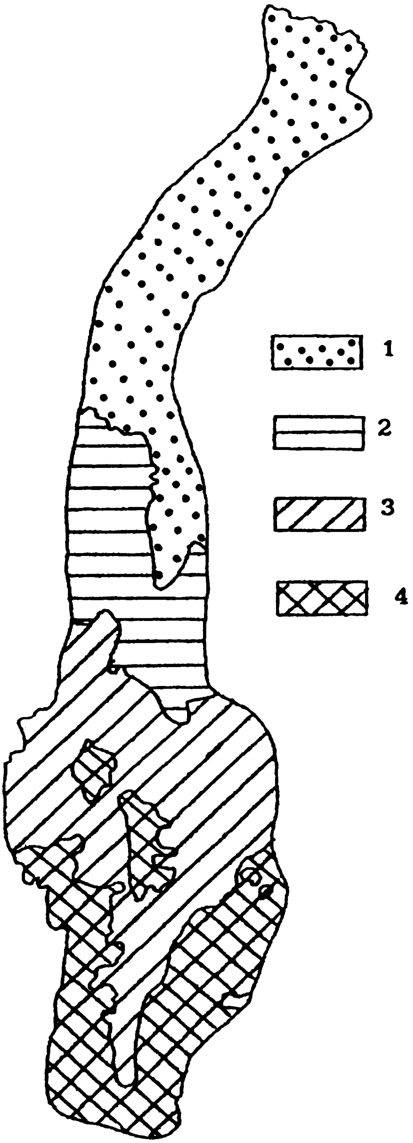

Figure 6. Ecological differentiation of vegetational cover of Urals.

Ecological zones: 1 – zone of a normal ecological situation; 2 – zone of risk; 3 – zone of crisis; 4 – zone of disaster.

2. Risk zone (moderate man transformation) – Kama-Pechora-West-Urals dark coniferous forests of middle taiga, North-European and East-Urals-West-Siberian pine forest of southern taiga.

3. Crisis zone (strong man transformation) – Kama-Pechora-West-Urals forests of southern taiga and sub-taiga, South-Urals pine forests, Ural-West-Siberian birch forests and aspen-birch forests of forest steppe.

4. Zone of disaster (catastrophic man transformation) – East-European broad-leaved forests (lime and oak), adjacent to the Black Sea and Trans-Volga-West-Siberian Kazakhstan steppe.

Quantitatively they are distributed as follows:

1 – 29%; 2 – 16.7%; 3 – 33.8%; 4 – 20.5%.

The highest degradation index (up to 100%) is registered in provinces of broad-leaved forests, steppe and forest steppe.

Thus, ranking vegetation cover by mapping method is carried out. Is shows, that a landscape unit, being simultaneously evolutionary and genetic, can be used in rating the status of ecosystem in different dimensions. Such a methodical approach fits industrial research. Its theory is perspective, since it enables to consider transformation a historical process changing our concept of landscape evolution.

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