Morpho-hydrographical structure and geo-ecological framework of Green Belt of Fennoscandia. Ecological corridors and barriers

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2 –Geo-ecological frame and functional relationships

Geo-ecological framework is represented as a system where a PAs of different status spatially related by undisturbed, slightly disturbed or quickly restorable natural areas that are ecological corridors.

Geo-ecological framework in the taiga zone provides functional relationships such as:

- between protected areas

-with the surrounding commercial (logging) territories;

-It provides and supports:

-environmental sustainability;

-the intensity of regenerative processes of natural ecosystems;

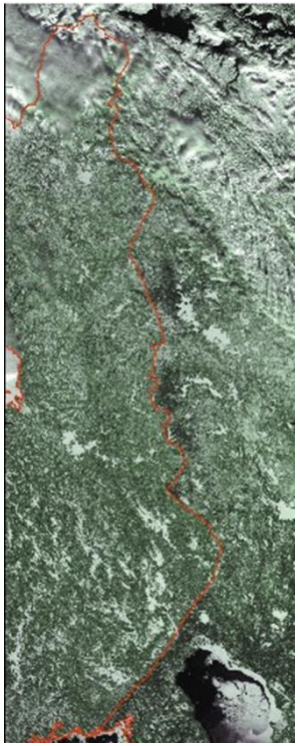
- diversity of species and habitats (BGC)

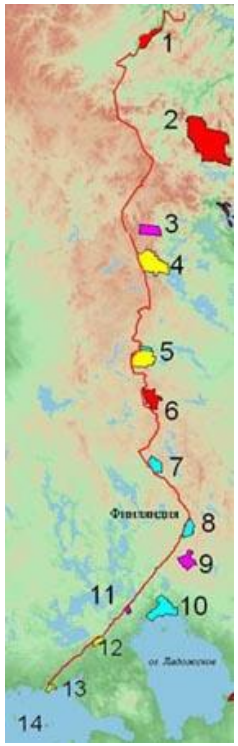
-satisfied conditions for inhabitant soutside protected areas.

Scientific and organizational problem of creating an ecological network is to choose the natural basis for linking protected areas, that is to form actual ecological frame. Role of a PAs should change from ecological reserve to ecological distributor

3- Bordershut. Near the boundary PA's

Large fragments of natural taiga had been preserved in Russian territory along the border with Norway and Finland, from the Barents Seat ot he Gulf of Finland, for the distance about 1300 km. Those ecosystems survived due to practically complete prohibition of economic activity in the border zone of the former Soviet Union.





Satellite pictures of the near border territories (including the GBF) and scheme of allocation of existing and planned protected areas.

20 years of international cooperation led to the creation of reserves, national parks, landscape reserves and other protected areas along the border. Total area of these PA is more than 1 million hectares, of which 800 hectares are concentrated on Russian territory.

4 - It must be agreed that indigenous taiga ecosystems in the form of the Green Belt of Fennoscandia (GBF) are not preserved for scientific reasons, but it was for political reasons, it is so a "random-ecological" phenomenon.

-Hence there are some difficulties to mark the boundaries of the Green Belt of Fennoscandia, as well as any other similar cross-border bodies as the holistic natural and cultural-historical object.

5-Further steps tocreate the network ofprotected areasof GBF

Ecological corridors and barriers (1)

Rightly was pointed out that "the development stage of GBF by simply increasing the square of protected areas is near to its completion and now is becoming increasingly urgent to create a single well-balanced system" - to create the Ecological Network, in which existing PA's have to play role of the frame [A. Titov et al, 2009].

- According to the Concept of the Development of Systems of Protected Areas in the Russian Federation, 2003, the ecological framework is that:
1 - the "totality of natural areas, which is providing the stability conditions of the natural environment, as well as the preservation of the natural biological diversity."
- That way:
Existing and proposed protected areas are actually only a totality of objects as a few key elements which are spatially divided now yet. Functional relationships between protected areas are "provided as the system of multi-level's an ecological corridors."

6 -Further steps tocreate the network of protected areas of GBF

Ecological corridors and barriers (2)

2 -Formation of ecological frame of the region should be based also on the identification of environmental barriers, primarily universal, such as:

-natural:

- climatic;

- orographic;

- hydrographic;

-anthropogenic:

-restorable, which are close to the natural:

-drained mires and paludified forests;

-fragmented forests;

-greatly transformed and permanent:

cities and industrial zones;

-agricultural lands;

- linear constructions - roads, power lines, etc.

7 -Further steps to create the network of protected areas of GBF Ecological corridors and barriers (3)

This is well known map shows not only the possibility to form a green belts in taiga by means of ecological corridors, but also it demonstrates the real obstacles - environmental barriers, primarily different degree and character of fragmentation of the taiga.

8- General principlesof forming a network of protected areas (PA's). Some concepts and laws.

According to the definition which was proposed in the Concept of WWF on the development of protected area system, "a system of protected areas or ecological network - is a complex of functionally and geographically interconnected protected areas .....which is created in order to be preserve, to restore and to sustain of the natural balance in the environment, biological and landscape diversity".

In one of the last documents of the Government of the Russian Federation: - № 2322-p - "The Concept of Development of the System of Protected Areas of Federal Importance for the Period up to 2020" which has been approved in 22.12.2011, in the part that is devoted to the formation of PAs, only about the creation of new and expanding existing federal reserves and national parks and expanding their buffer zones had been mentioned. In this document has not been mentioned about ecological corridors.

- According to the WWF, at the federal level there are no legislations on environmental corridors in Russia at the moment.

Thus, the formation of geo-ecological framework with using ecological corridors between PA's ofdifferent levels and status in Russia is still in the stage of developing of pilot projects.

9 -The main practical approaches to the formationof ecological corridors

If we summarize a number of publications on the formation of ecological corridors we can mark a following main approaches:

naturally-scientific:

- on hydrographic network;
- on chain of adjacent or neighboring protected areas of different status, when a buffer zones are connected;
- the landscape-typological approache (that is usually considering the hydrographic network);

-socio-politicalandeconomical:

- administrative-territorial;

-according to opportunities or priorities:

-on political cases,
- on economical cases,
- for the purpose of advertising, promotion, social and even nationa lunity, etc.

10 - Brief description of the main naturally-scientific approaches to the formation of ecological corridors

1 – on hydrographic network;

- Formation of ecological corridors along rivers and large lakeshores in the forest zone of Russia is quite logical, since the coastal forests have a protected status.Depending on the length of rivers and square of lakes, those zones have a width from 50 to 500m and along the shores of the largest lakes and seas up to 2-3 km.

Coastal forest ecosystems are provided the best and most diverse of habitats conditions. The farther north you go the better the principle of "water protection forests" can be used for ecological corridors because here the population is extremely rare. Especially the process of desolation of the North in Russia today is rapidly progressing, and restoration of natural habitats here occur most successfully.

11 -Brief description ofthe main naturally-scientific approaches to the formation of ecological corridors
Continuation

The principle of formation of ecological corridors on the hydrographic network used the ready legislative framework of the environment. However, this principle has one system's drawback: zonal natural complexes is actually ignored with this approach, because zonal ecosystems occupy plakors (flat interfluves, tops of watersheds), the highest, autonomous and automorphic habitats that can be remote from the rivers, sometimes, for several kilometers.

Thus, protected areas proposed to bind through predominantly intrazonal and extrazonal ecosystems. In Finland and Norway there is no protection of coastal forest areas.

A - River Valley

B - grass-sphagnum - spruce stand, in running depression.

(A, B) - examples of intrazonal ecosystems;

C - Hylocomium - pine stands on the ridge of indigenous rock with a thin layer of moraine - an example of zonal ecosystems.

12- Brief description of the main naturally-scientific approaches to the formation of ecological corridors

Continuation

2 - on chain of adjacent or neighboring protected areas of different status, when buffer zones are connected;

The second approach to the formation of ecological corridors–that is based on the principle of neighborhood of PAs with different status, that typically include the expansion of buffer zones to the side of adjacent protected areas. Scientific grounds of this kind of structures have not been developed yet. It can be assumed that ecological corridors should go through the territory with the highest combination of diverse of ecosystems, with the absence of environmental barriers, and in Russia it have to consider the water protection forests.

3 – landscape approache (usually considering the hydrographic network);

Third, a landscape approach serves as the base to allocate of the PAs. Landscapes play a significant role as a complex of habitats and ecological continuity.

The geographic landscape is the complex of different types of ecosystems. Consequently, its various inhabitants have their own preferences in the migration routes, places and time of concentration.

13 –Brief description of the main naturally-scientific approaches to the formation of ecological corridors

Продолжение

Landscapes of taiga zone characterized by poverty species composition of woody vegetation and ground cover in the whole, but these have "blind", extremely poor, areas or places, which animals are used mainly as a corridors.

- **In the Nordic countries there is no clear common system for the allocation of geographic landscapes, or so-called "geo-ecological systems" – which are a large monogenetic territories consisting on their structural components.**
- **The landscape's criterias are understood differently by a specialists of different countries.**

14 - Formation of geo-ecological framework of the Green Belt of Fennoscandia. Watersheds and catchment spaces

1. Approach-justification

Available experience shows that the universal scheme of forming a system of protected areas is still lacking.

Further development of the Green Belt of Fennoscandia have to create a network to cover the widest of possible diversity of ecosystems and to form of conjugated spatial relationships between these. Solving of this problem requires a natural unifying principle.

Different types of zoning serve to division a single space for relativelyh omogeneous units:

-climatic zones;
- geographic (longitude) sectors;
- landscapes;
- catchment areas.

Extremely degree of areas separation is the river basins that are allocated along the line of the watersheds

In this regard, the question naturally arises - what kind of methods are available to apply these for combine the many natural systems in the space-conjugated system based on environmental criteria if there is the presence of non-systemic political and administrative communication in the form of the state border?

Combining natural space is certainly present within the Green Belt of Fennoscandia – it is its association not only with the state border, but it is connection with long part of the White Sea-Baltic watershed and its spurs - the watersheds of lower rank.

15- Formation of geo-ecological framework of the Green Belt of Fennoscandia. Watersheds andcatchments paces

2. Hydrographic structure and inter-basin space - about structure and functions of background zonal ecosystems

Geoecological frame of the territory is directly related to elevations such as ridges, hills, interfluvial areas which are primary the positive landforms where so-called "plakors" (flat interfluves) had been formed.

During the deglaciation time of high latitudes these territories were first which had been freed from ice, frozen of ground and water. These were a places where there were fixed and evolved mainly zonal ecosystems (taiga, for example). Thus, watershed areas can serve as a basis to unite the plain territories.

Our approach is also bound to the hydrographic network, but it carries a completely different semantic meaning – the unifying.

16- Formation of geo-ecological framework of the Green Belt of Fennoscandia. Watersheds and catchment spaces

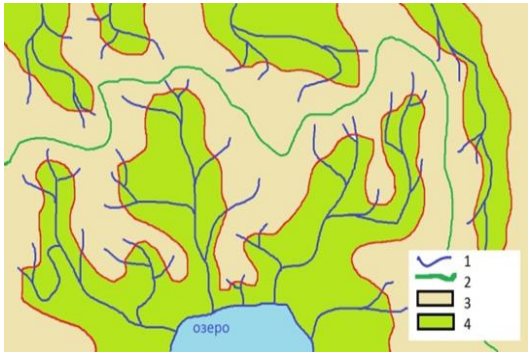
3. Detection's algorithm of morpho-hydrographic structure of a territory.

Two leading components are allocated on a maps in accordance with the plan of the hydrographic network:

1 - poorly drained of water divide areas or watershed spaces (upper stage of relief) and

2 –river valleys, well-drained catchment areas (lower stage of relief).

Empirically we found out that the boundary between these spaces can be a line connecting half of the length of the first order's rivers (or open streams) in the corresponding scale of a map. Choose of the order of river was carried out according to R. Horton (1945).



The scheme of watershed and catchment spaces is showing the algorithm of their allocation. Boundary between these is a line that connects the half of length of the 1st order of rivers. Legend: 1 – river; 2 - the main line of watershed , 3 - space of watershed (the space of water divide , ideally it is singular), 4 - the catchment spaces (always are plural) (Kolomytsev, 1989).

Map.Watershed (gray) and catchment or drainage (white) spaces of Karelia (Kolomytsev, 2001).

17 Formation of geo-ecological framework of the Green Belt of Fennoscandia. Watersheds and catchment spaces

4. Theoretical concepts

The theoretical framework is represented as follows:

Areas on water divide spaces presented as the natural territorial frame within the landscape provinces (geographic subzones), regions (zones) and continents, combining these into a single unit. The hydrographic network is represented here only by fragments of the rivers of the first order and the network is relatively rare.

But is actually the watershed spaces of the plains are consisting of so- called "islands" which are presented as flat interfluves or “plakors”. Because these have a natural fragmentation by semi- or hydromorphic ecosystems (mainly by woody swamps and mires). The bifurcation of runoff from the lakes which located on a watersheds is occasionally observed.

Background zonal ecosystems, which are mostly a oligotrophic ecosystem, are concentrated mainly on the watershed spaces. These ecosystems are under the influence of atmospheric nutrition and therefore have autotrophic development of ecosystems on an automorphic soils.

18- Formation of geo-ecological framework of the Green Belt of Fennoscandia. Watersheds and catchment spaces

4. Theoretical concepts

Catchment area, which occupy the lower level of relief, in any particular location are the territories, where there are about 90% or more of open water surfaces.

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These are the areas of groundwater and talus waters discharge and due to that reason that there are mainly minerotrophic intrazonal and extrazonal ecosystems are distributed here.

The watershed spaces is important to present as a natural geographical or topo- ecological formation having conditional, but clearly defined boundaries according to its own criteria. We can use these topographic structures as a basis in relation to the task - to create the geo-ecological framework of various levels - from the system of regional ecological corridors, linking protected areas, to the interregional and cross-border green belts.

19-Formation of geo-ecological framework of the Green Belt of Fennoscandia. Watersheds and catchment spaces

5. Discussion

There are a number of drawbacks in this method, as in any scheme, even that is based on the natural key attributes. For example:

One of the most significant drawback is the hetero-genetic of united watershed spaces. River basins are separated not only by the linear of watershed boundaries, but by the extensive watershed spaces.

In addition, there are a numberof other principal questions:

-Why half of the length of rivers of the first order was selected, and not a third or two-thirds of their length, for example?

- Perhaps the watershed space have to allocate better according to vertical gradations of average indicators of a local vertex and a base surfaces?

- How is legitimate and justified such a simplistic approach?

20 -Formation of geo-ecological framework of the Green Beltof Fennoscandia, Watershed and catchment spaces

5. Discussion.Continuation

We should contact only to our own experience in the absence of another to answer these questions.

Firstly, various methods of separation of hydro-morphological areas on a maps of different scales led us to conclusion that, if the boundary between the watershed and catchment spaces is conditional, in this case should be retained proportion between the square of watershed and catchment areas.
Axial (main) lines are, respectively, a lines of watersheds and thalwegs- are a river valleys.

Secondly, we proposed morpho-hydrographic circuit that can be the basis for a two-term vertex-base digital elevation model if necessary the detailed of eco-structural study.

21-Formation ofgeo-ecological framework of the Green Beltof Fennoscandia, watershed and catchment spaces

5. Discussion. Continuation

Thirdly, the proposed method of separating of the morpho- hydrographic areas is a universal method for the determination of the basic structural elements of relief on a large territories, such as a predominantly positive and predominantly negative of its shapes regardless of their origin.

This method allows to unite the territory from the terrain and type of landscape to physiographic country and continent with relative ease isolation method corresponding contours. This circumstance in our opinion, can help solve the problem on the formation of geo-ecological corridors.

22- Formation of geo-ecological framework of the Green Beltof Fennoscandia, watershed and catchment spaces

5. Discussion. Continuation

There is another important question - how new and informative is the proposed method to solve the complex of geo-ecological objectives, including tasks of nature conservation?

Three key elements of the relief are discriminated in all textbooks of geography and ecology:

- watersheds,

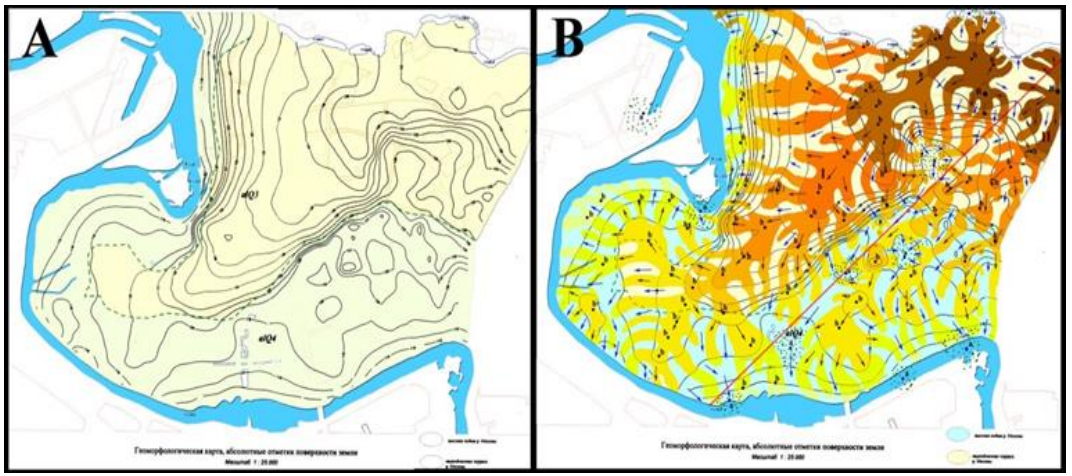
- slopes

- and thalwegs (axis of depressions) with their respective characteristics according to different signs and gradations. This gradation of reliefisthe basis of many classifications-geomorphological, soil, environmental conditions, habitats, etc.

It is the oldest, but extremely actively developing study approach due to of the modern GIS technology.

23 -Formation ofgeo-ecological framework of the Green Belt of Fennoscandia, watershed and catchment spaces

5. Discussion.Continuation



Example of transformation of topographic base into the map of “plastic of relief”.

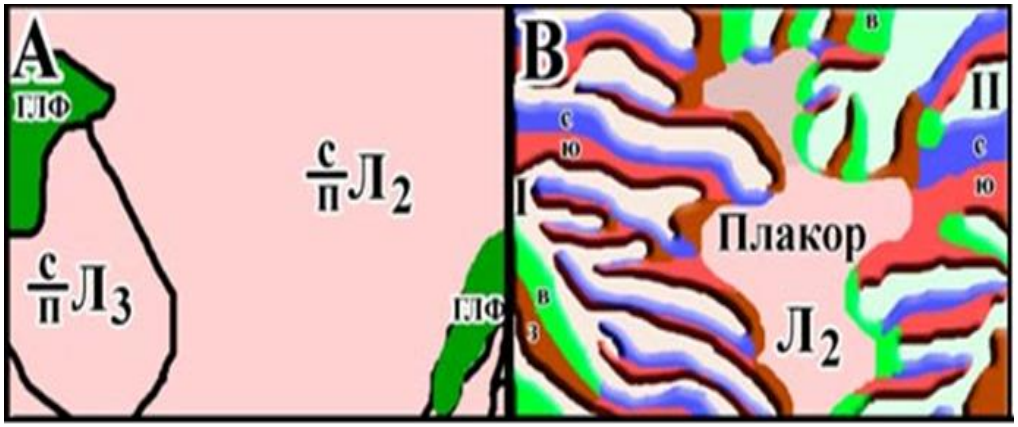
In the original – two maps of the territory of Moscow (Lyublino district) are presented as the traditional approach of environmental scientists (A), as well as using the method of "plastic of relief" (B). M 1:25 000.).

Cited by source: http://www.ibp-ran.ru/main.php?trid = 398

- **- In Russia developed a mapping method of “the relief plastic” or “the plastic of relief”(the relief sculpture), which uses the same principle of differentiation of the territory into two simple elements - convex and concave shapes. However, the line separating these elements of relief conducted under different starting points due to differences in applications.**

24 –Formation of geo-ecological framework of the Green Belt of Fennoscandia, watershed and catchment spaces

5. Discussion. Continuation



The example which is show the isolation of flat interfluve (placor, ie, the main elements of watershed areas) selected by method of “plastic of relief”.

In the original –the example as the traditional method of soil mapping, based on the identification of the same type of soil contour (in static state) and an example of the creation of soil maps based on method of “plastic of relief” which displays a dynamic (streaming) of space. Cited by source: http://www.ibp-ran.ru/main.php?trid=398

Thalwegs never divided, but can be divided the watersheds according to method of "plastic of relief". Morpho-hydrographic method our proposed, by contrast, provides for mandatory separation thalwegs on the half of their length (or rivers of a first order), but never (ideally) not intersect the watershed spaces, which are serves as the territorial framework.

25 –Formation of geo-ecological framework of the Green Belt of Fennoscandia, watershed and catchment spaces

5. Discussion.Continuation

- **It should be noted also that the watershed and catchment spaces have a complicated relief as well as landscape-typological features and complex sub-landscape structure. Whereas the method of plastic relief allocated basic contours of the convex and concave surface, which can be identified as the basic structural elements of sub-landscape levels – such as facies, or monogenetic groups of stows (urochishche).**

- The similarity of the methods has the similar advantages and disadvantages, but the most significant difference between these lies in the fact that the method of " plastic of relief" pursued the aim of visualization of relief's discontinuum and discrete structure of surfaces.

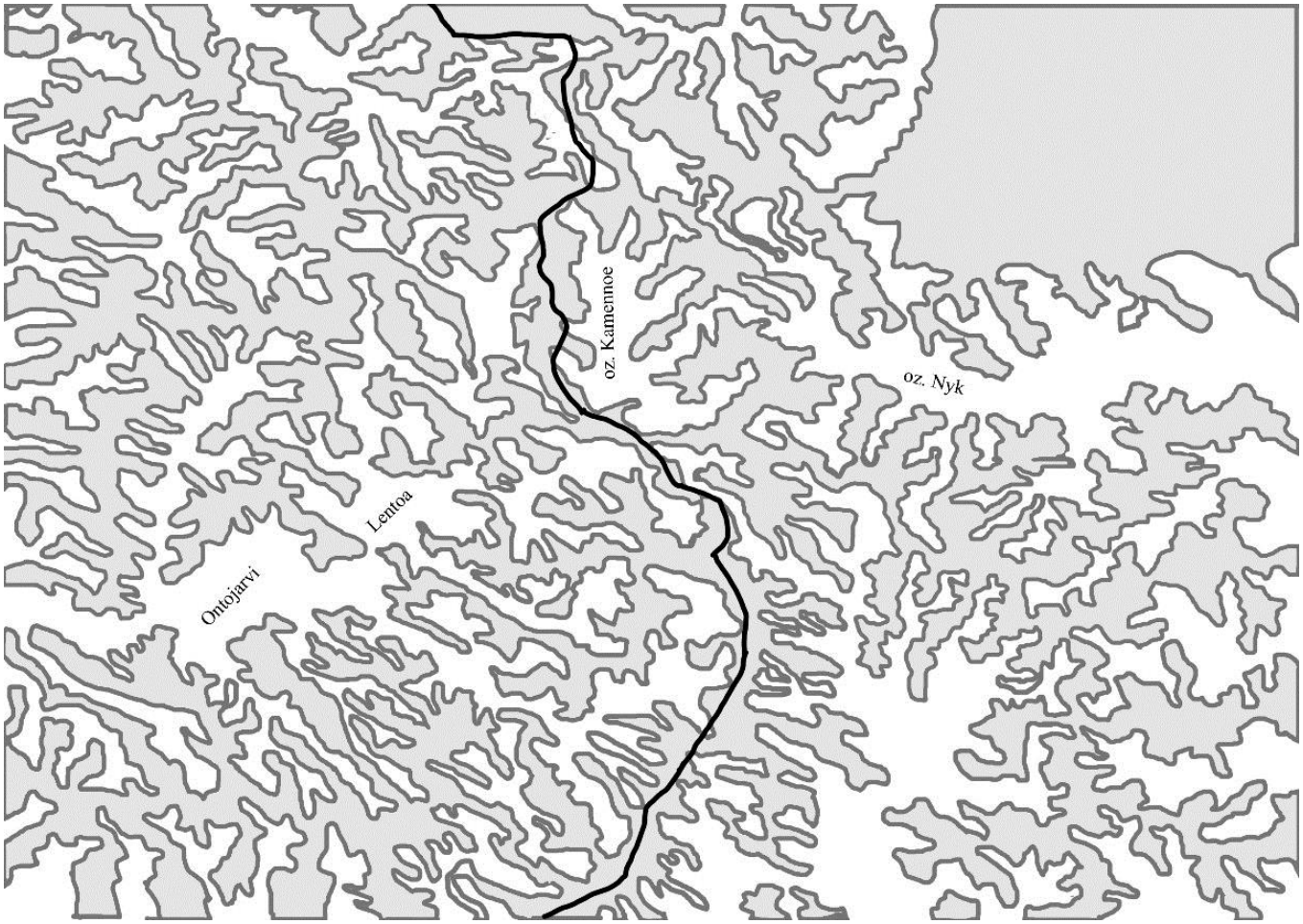
- Whereas the morpho-hydrographic method aims to show the continuum as a geo-ecological framework of a territory.

26 –Formation of geo-ecological framework of the Green Belt of Fennoscandia, watershed and catchment spaces

5. Discussion. Continuation

PLOT of GEO-ECOLOGICAL FRAMEWORK
Green Belt of Fennoscandia
District – Kostamuksha–Kuhmo

The main White Sea-Baltic watershed is adjacent to Russian-Finnish border to the south of the lake Kamennoe



27 –The expert opinion

- Morpho-hydrographical method allows to allocate a watersheds as the transitional areas which are penetrated through all of the territories and, therefore, these topographical elements are forming the framework and structure of ecosystems as GBF, and these are directly linking the Eurasian continent in the whole.

– Exactly the watersheds spaces on a lowlands on and low mountain areas can perform a unifying function objectively but not the lines of watersheds that are the dividing borders of catchment areas.

Watershed spaces are like the skeleton of the continents. These are the most inert, conservative, old, genetically heterogeneous elements of earth's surface. These unite a zonal, intrazonal, landscape, basin and other components of the environment.

- From the above it follows that the watershed spaces executed not only function of a local environmental, but also bio-geographical corridors. If we take these spaces as a binding basis, it will allow more arguments generate the interregional and international network, or a frame of PAs.

28- Conclusions

- morpno-nydrographic method intended to identify a continuum of geo-ecological framework territory as a binding element of Pas;

- it allows to provide simple binary structure transcontinental territory as a specific space on maps of any scale;

- as opposed to landscape contour whose boundaries are often difficult to determine, a watershed and catchment spaces are determined relatively easily and these have a relative (at least thousands of years) stability of the spatial position;

- watershed and catchment spaces are elements of all landscape types and these allow to identify a continuums between landscapes and their internal structure;

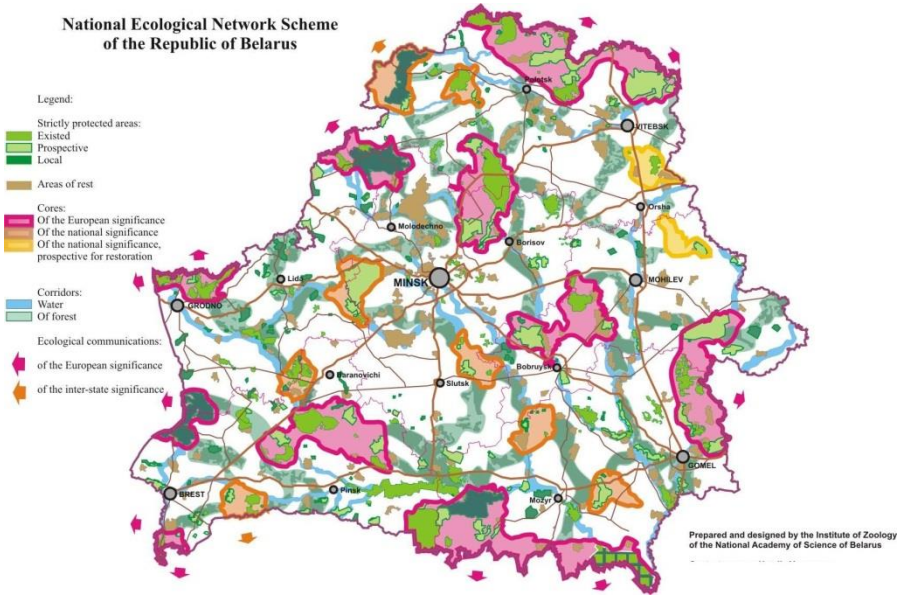
- this method can open a new possibilities for the use of mathematical apparatus applied to the analysis of morphological, structural and functional features of natural objects from new point of view.

- And last but very important point is that the proposed method does not replace or substitute for other methods which are better known and often are using. This method is called to the fact to expand our understanding of nature, to look from new position on its structure and to contribute to the harmony between nature and our civilization.

29 –Examples of regional ecological network

National Ecological Network of the Republic of Belarus

- Country of former USSR



Ecological Network of the Tyumen region

- Russian region