LANDSCAPE PATTERN STUDIES - TRADITIONS AND PERSPECTIVES

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Landscape ecology

Convergent development of landscape science and landscape ecology

spatial pattern and lateral interactions in the framework of matrix concept

biotic

biotic+abiotic

3d dimension of a landscape

Causal relationships landscape pattern - landform genesis

emergent properties

increased interest in chorological aspect at a wide range of spatial scales and multiplicity of spatial patterns

“horizontal structure” or “landscape morphological structure

vertical structure” composition and interactions of “*geocomponents*”

East-European landscape science (physical geography)

LANDSCAPE SCIENCE
Development of spatial pattern concept

1950 **"Objective reality": physiography-based morphological units**

1960 *"Individual events are subject to explanation only in intersections of mutually independent series of reasons"*

1970 Long-term stationary research

Patterns multiplicity

1980 **Patterns:**

Geostationary **Cellular** **Genetic-morphological**
Biocentric-network **Matrix**
Paragenetical

1990 **Geocirculation** **Vectoral**
Biocirculation **Isopotential**
Basin

2000 **Positional-dynamical/Catena**

2010

2020 **Synergetic effects resulting from superpositions of multiple independent structures**

Radial relationships between geocomponents

Inter-geocomponent interactions can occur only between natural processes and bodies having comparable time and space scales

Concept of partial geocomplexes (partial geosystems)

Concept of characteristic time and space scales

Concept of hierarchy

2d Tobler's law of geography: "The phenomenon external to an area of interest affects what goes on inside"

Which ecological factors are scale-specific?

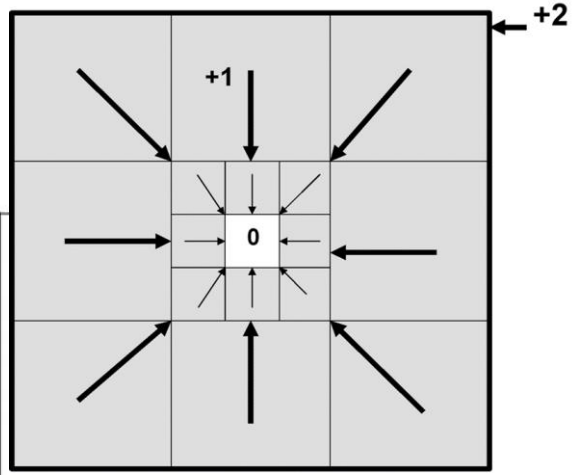
Which scale level is appropriate to explain spatial variability of landscape attributes or dynamics

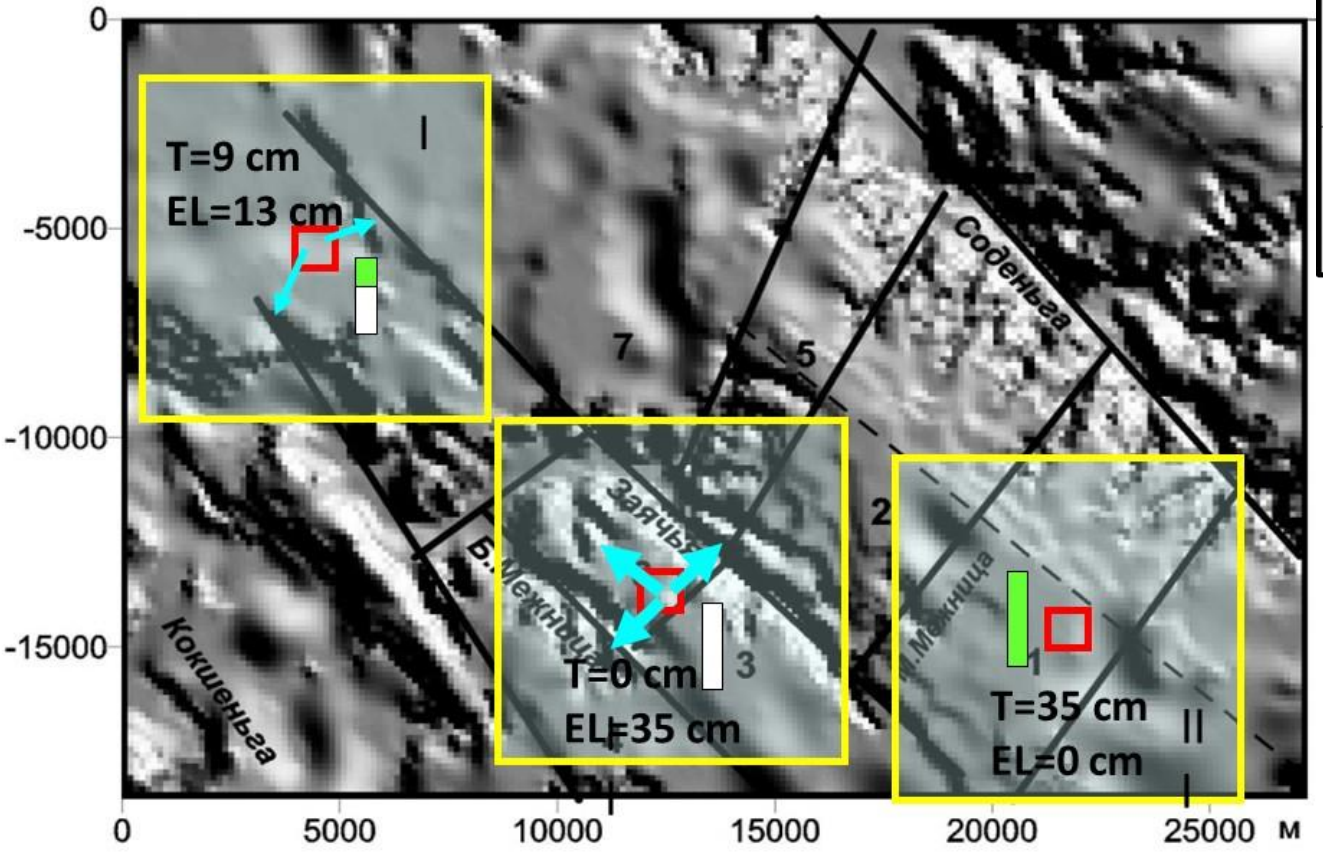
Whether a unit interacts with spatial context by the whole set of properties or by groups of properties separately?

What is the size/shape of neighboring area (spatial context, higher-order geosystem) that affects processes in a focus unit?

If the combination of spatial units in some neighboring area changes, the properties of the focus unit will change as well

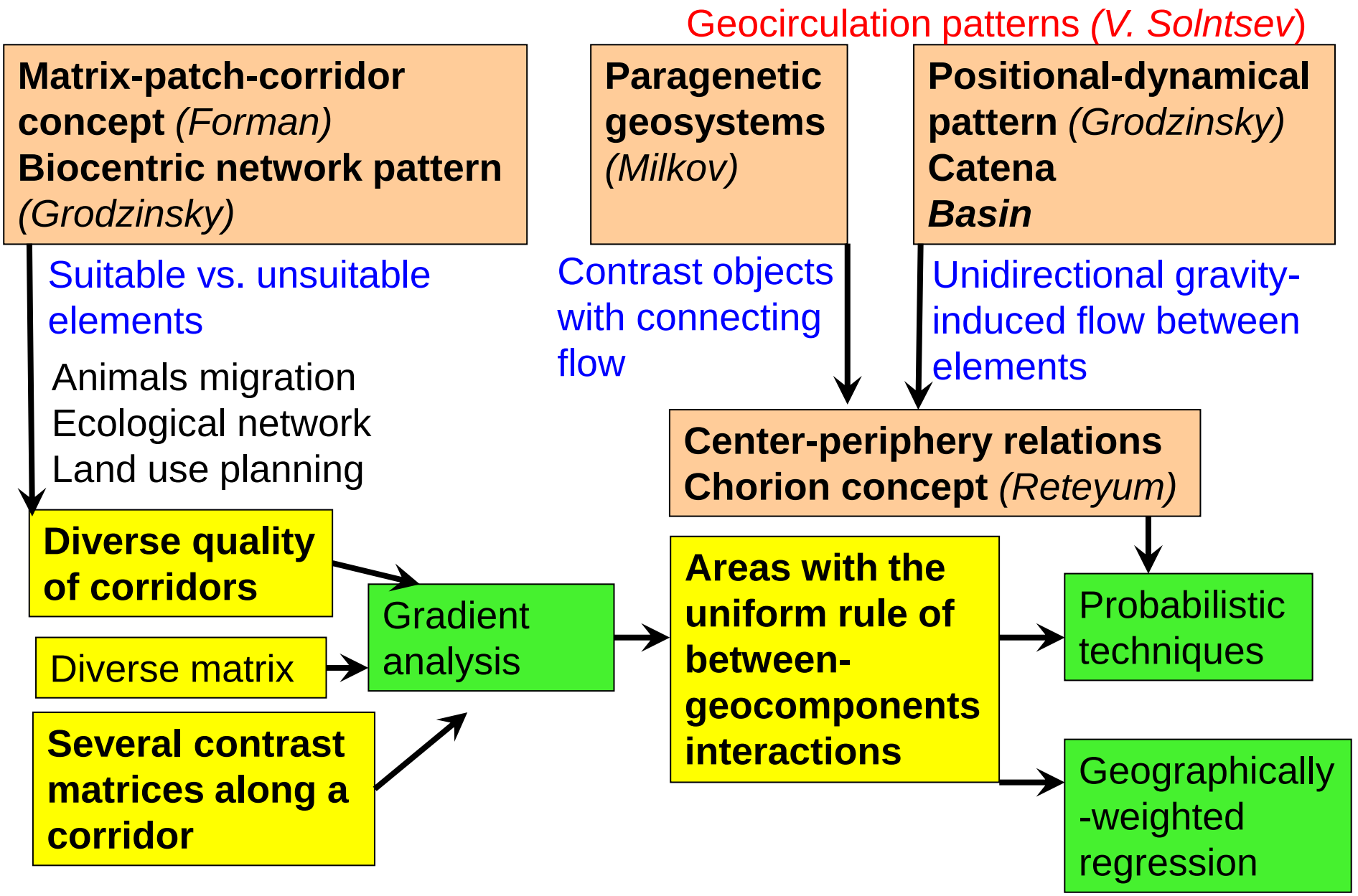
Need to compare quality of statistical models designed for several hypothetic higher-order geosystems





Redistribution of soil moisture and drainage depend on vertical and horizontal relief dissection and results in various peat/podzol ratios in taiga

LATERAL INTERACTIONS AND RESULTING EMERGENT EFFECTS – THE CORE OF THE LANDSCAPE CONCEPT

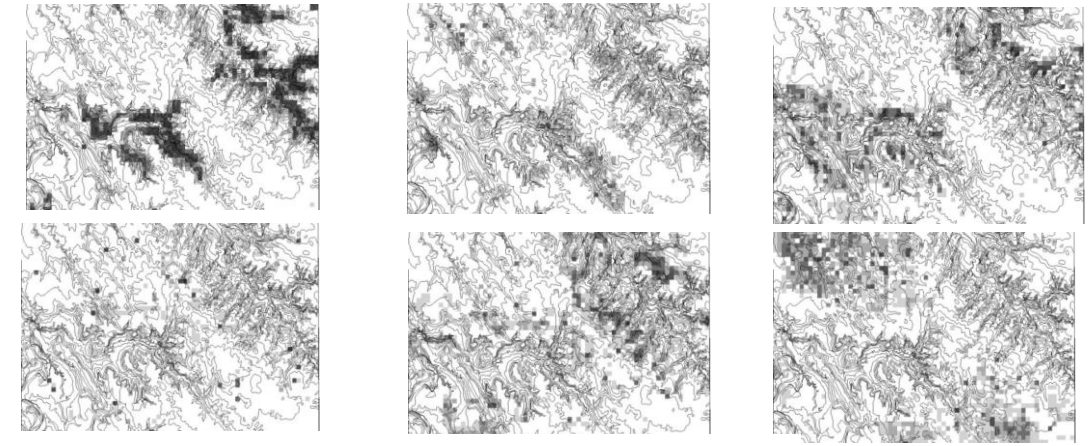


Within the framework of the center-periphery (chorion) concept:

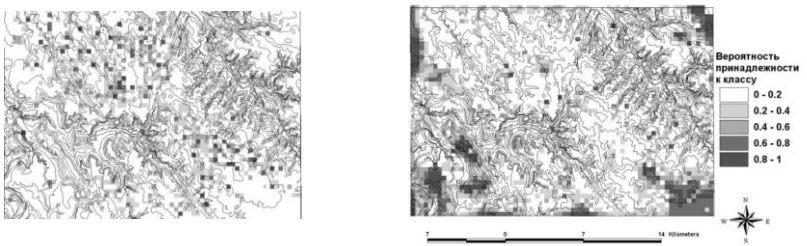
- **The core is treated as a site with maximum manifestation of a system-forming factor.**
- **Decrease of probability is interpreted as a decreasing control of a core over the area under its influence.**

Probabilistic landscape mapping:

- **Areas with perfect adaptation of soils and vegetation to abiotic environment classes**
- **Areas with similar probabilities for sustaining several stable states**



Discriminant analysis

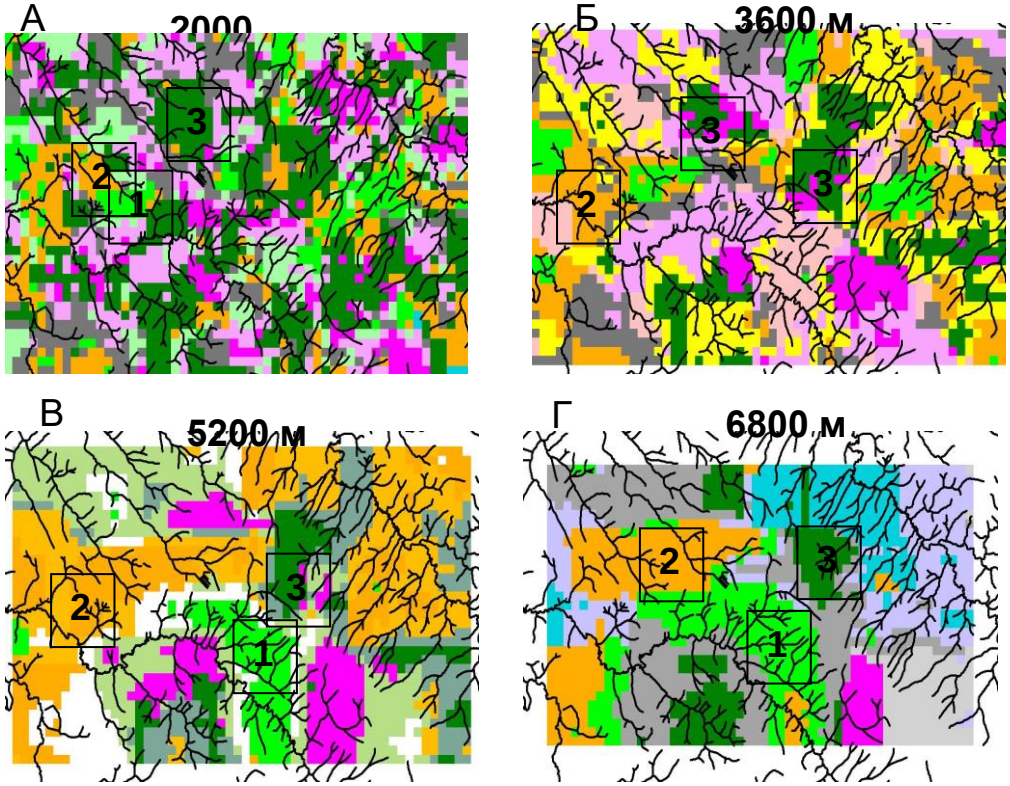


Nutrient-sensitive and moisture-sensitive attributes as related to topography classes

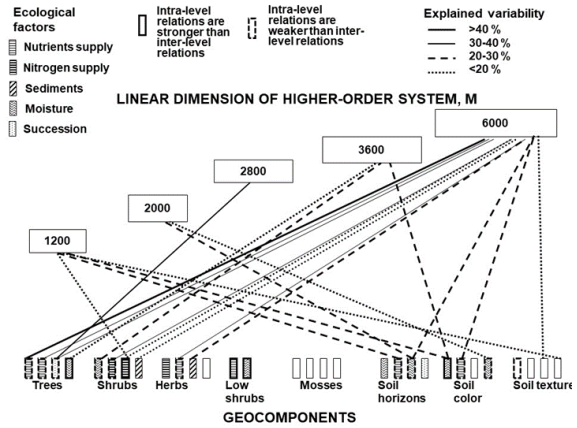
SPATIAL PATTERNS OF BETWEEN-GEOCOMPONENT RELATIONSHIPS

Types of relationships (regression coefficients) between vegetation and relief vary in space

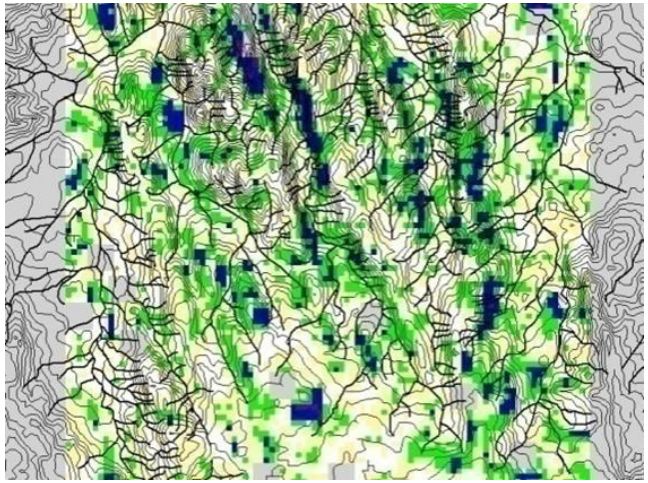
Areal of uniform relationships depend on scale



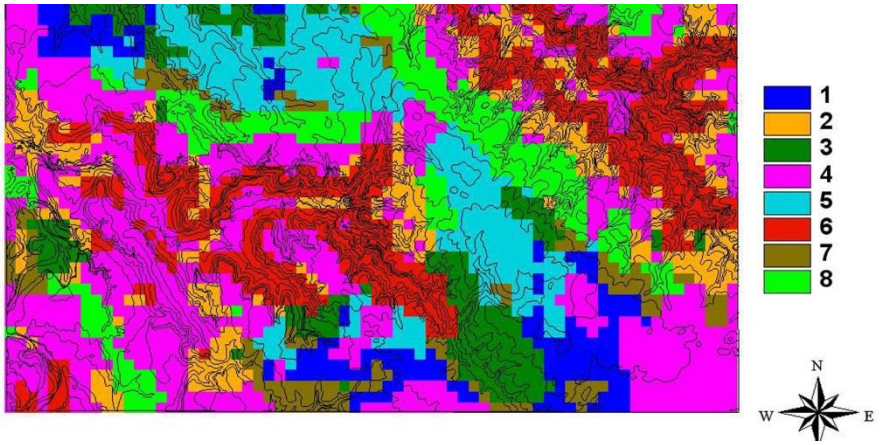
Geocomponent properties respond to various hierarchical levels of geosystems



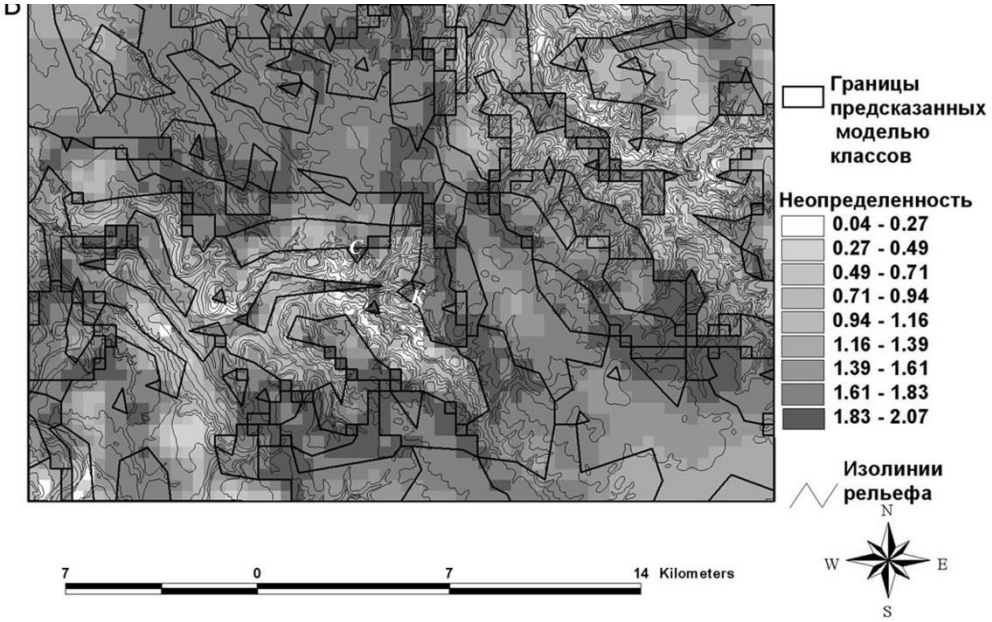
Linkage density (determination coefficient) **varies in space**



Most probable classes of soil-plant cover under known abiotic template



Uncertainty of class membership



Multi-level model of landscape units based on sensitivity to water and nutrients supply and inter-level interactions (constraints imposed by higher-order systems with linear dimensions 1200, 2000, 6000 m)

Spatial patterns affect temporal organization of landscape dynamic attributes.

Few examples from low-mountainous steppes, the Southern Urals

Research focus:
superposition of various types of spatial patterns

Research object: NDVI seasonal dynamics

We classified intra-seasonal increments of NDVI (33 pairs of dates)
5 dynamics classes: background increment (mode), high and low (positive and negative) deviation from the background (modal) increment

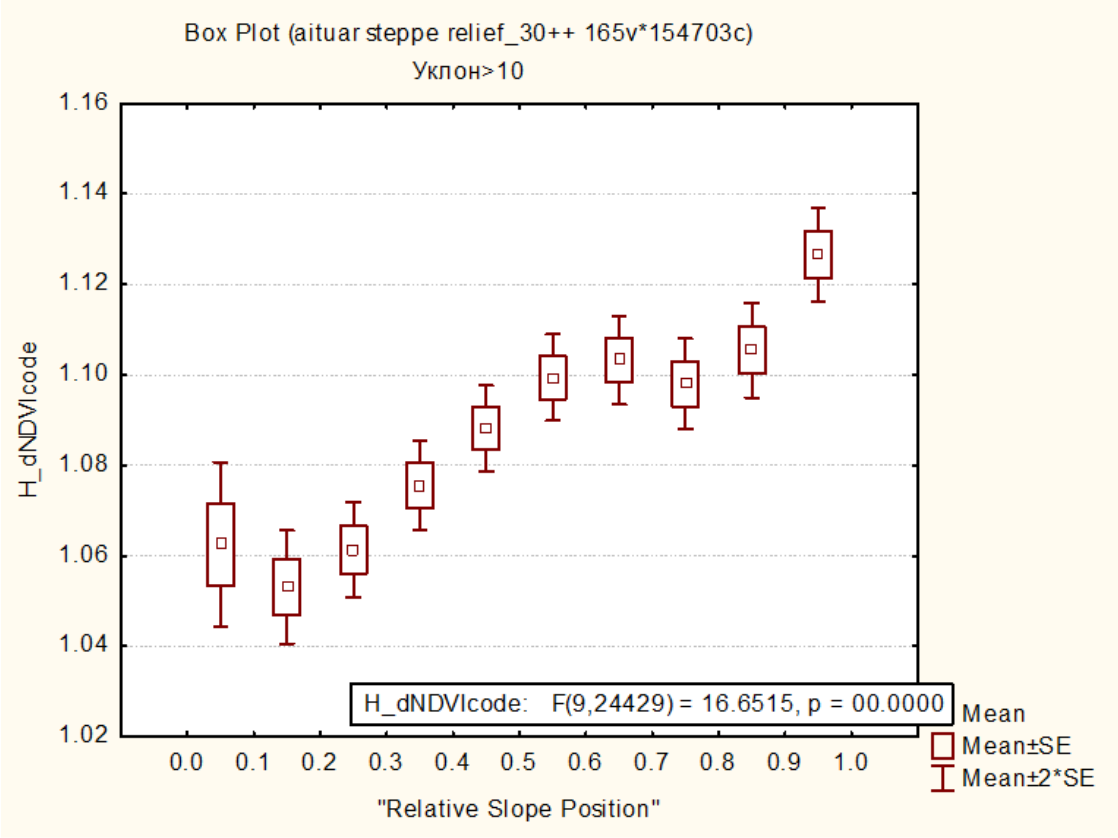
Dependent variables:
- frequency of dynamics classes for each pixel
- Shannon's entropy from frequency of NDVI dynamics classes (measure of instability)

Independent variables:
- topographic variables
- share of vegetation classes in close neighbourhood

Positional-dynamic patterns distort topographically-driven (geostationary) patterns of NDVI seasonal dynamics

Low-mountainous steppes
The Southern Urals

Shannon's diversity of NDVI dynamics types

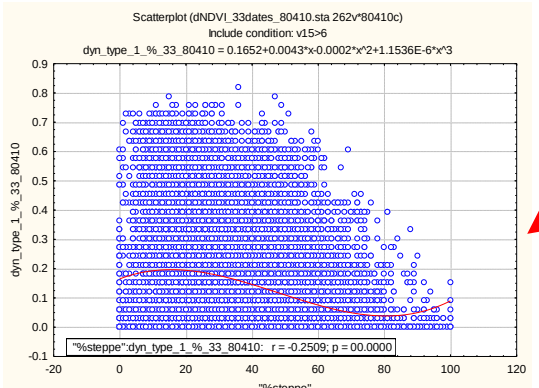


Relative slope position

Instability of NDVI dynamics increases towards lower slopes

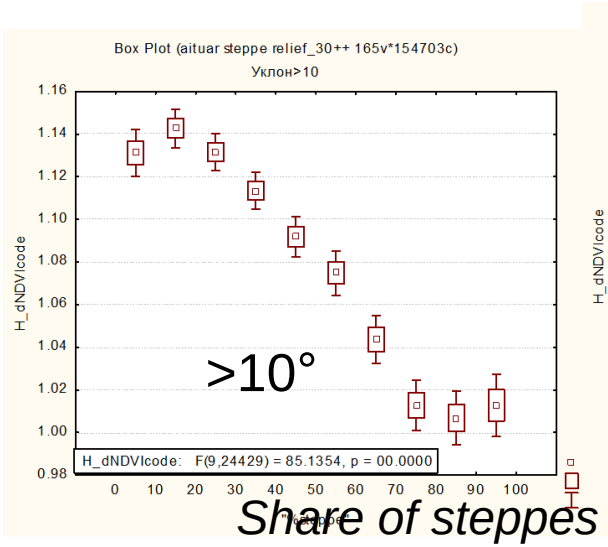
Matrix pattern distort topographically-driven (geostationary and geocirculation) patterns of phytomass (NDVI) seasonal dynamics

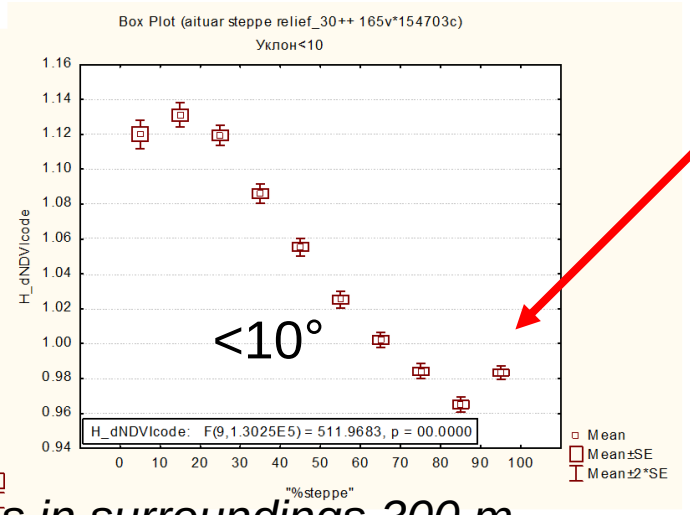
Spatial structure of a matrix (monotonous vs. mosaic) affects dynamics of herbal green phytomass



Gullies:
The more monotonous is the steppe matrix in the vicinity of gullies,
the lower is the frequency of phytomass dynamics with small loss of biomass in summer

Share of steppes in surroundings 300 m





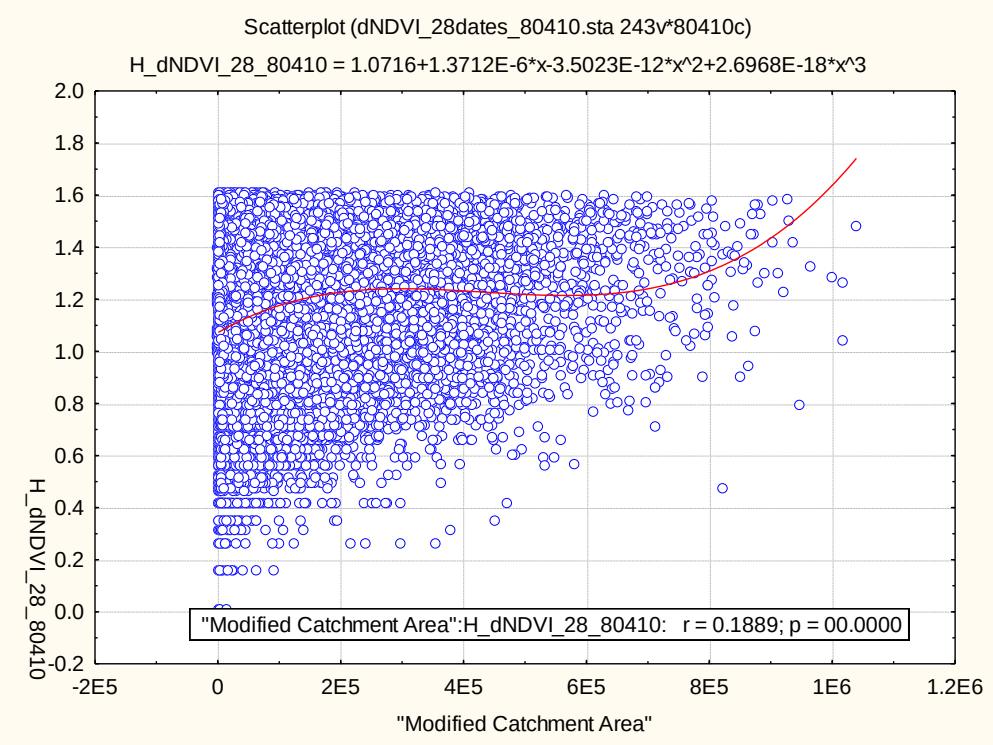
Slopes:
The more monotonous is the steppe matrix,
The higher is stability of phytomass dynamics (similar to background phytomass imcrement)

Share of steppes in surroundings 300 m

Geocirculation patterns distort topographically-driven (geostationary) patterns of NDVI

The larger is the catchment area, the higher is instability of phytomass production in gullies.

Shannon's diversity of NDVI dynamics types



Low-mountainous steppes The Southern Urals

High diversity of types of NDVI dynamics if catchment area is low

Low diversity of types of NDVI dynamics if catchment area is high

Biocirculation patterns distort topographically-driven (geostationary and geocirculation) patterns of NDVI

Morphometrical features of relief

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Principal Components Analysis

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NDVI=F(Relief, PCA)

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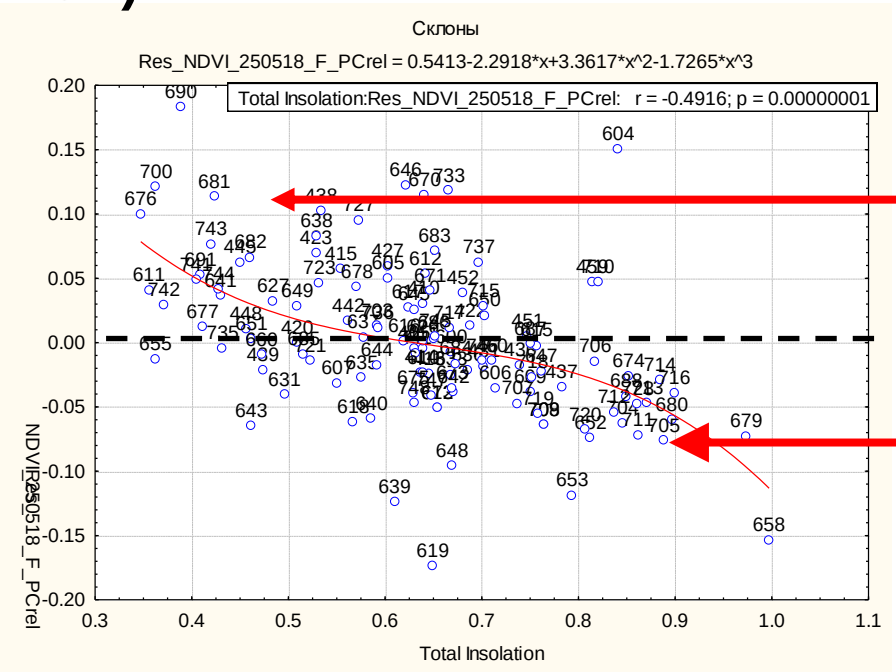
Low-mountainous steppes
The Southern Urals

Residuals



Phytomass is larger than predicted

Phytomass is smaller than predicted

North-facing slopes

South-facing slopes

Total insolation

CONCLUSIONS

Research priorities in landscape pattern studies are seen as follows:

- **Synergies induced by superpositions of independent types of spatial patterns**
- **Variability of relationships types in space**
- **Response of geocomponent attributes to various hierarchical levels of geosystems**
- **Response of temporal organization to spatial patterns**
- **Forecast of functioning stability based on analysis of spatial patterns**