International Conference on Land and Water Degradation
Magdeburg, 2009

Transformation of River-beds and Flood-lands of the Amur-river Left-bank (Russian) Inflows under Urbanization

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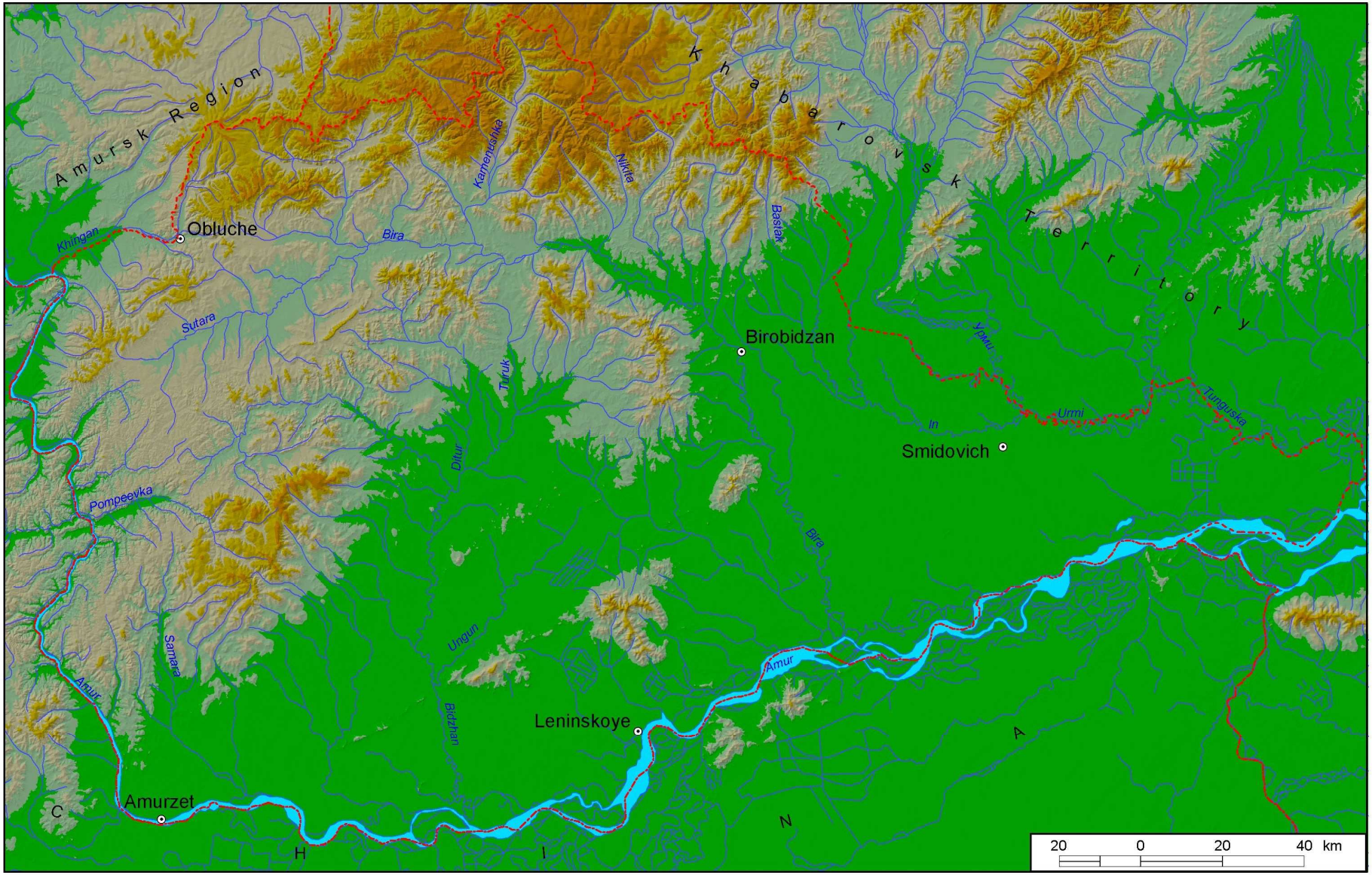
The map of the Russian Far East and the Jewish Autonomous Region

Left-bank inflows of the Amur-river in JAR



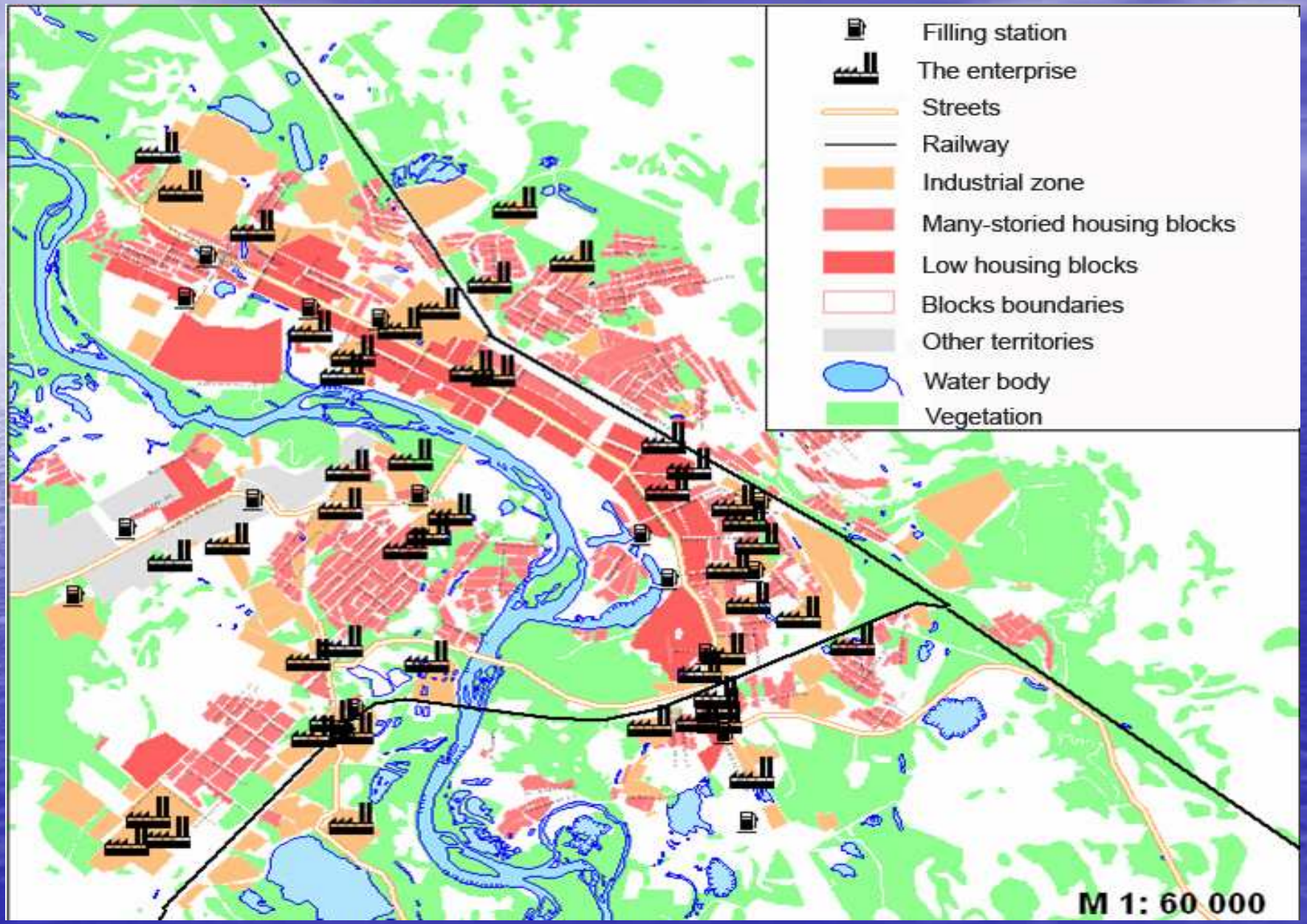
Birobidzhan - the administrative center of the Jewish autonomous region

The Bira-river in Birobidzhan

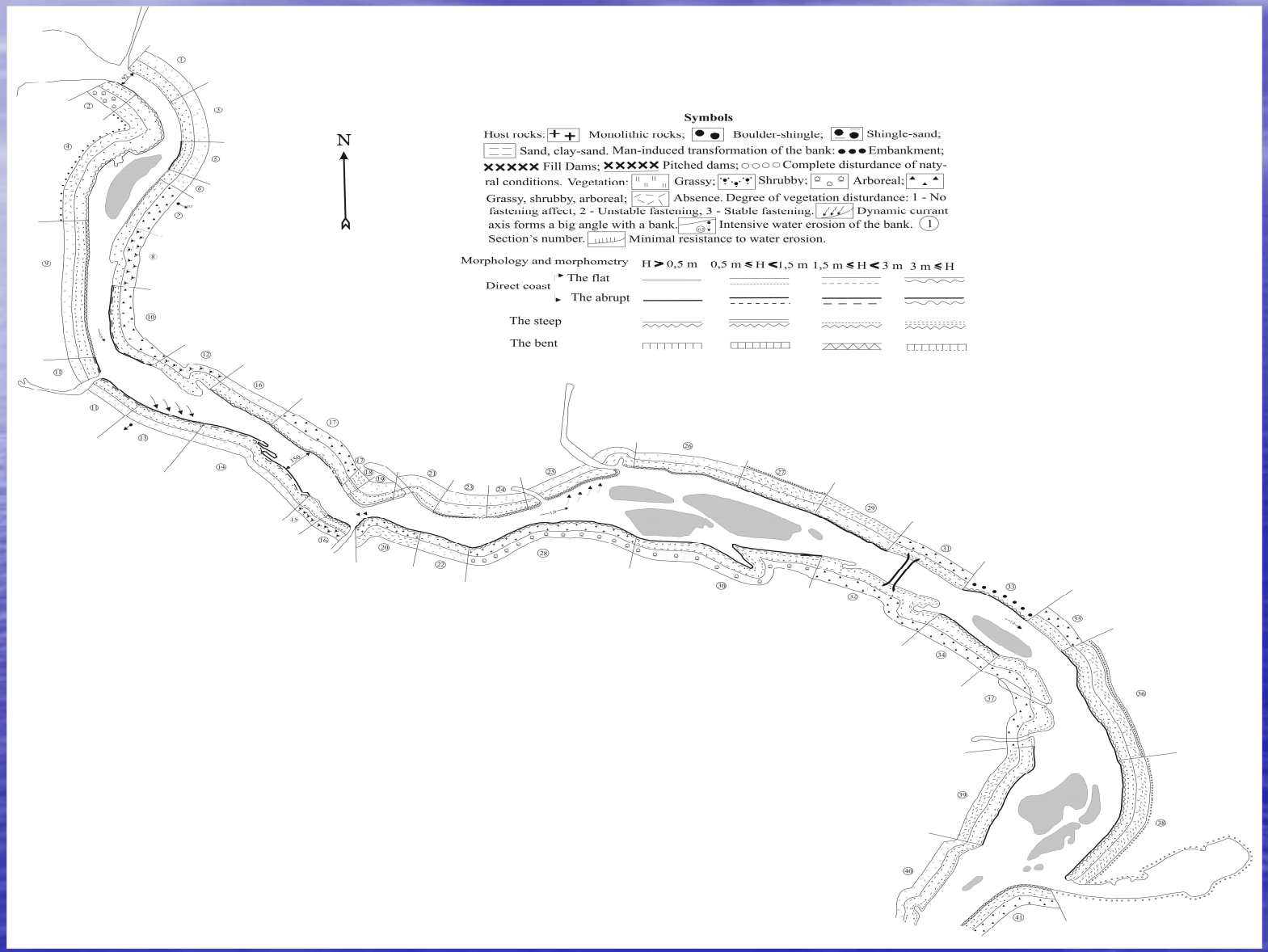
Basic research directions

- Analysis of the built catchment area
- Investigation of the bank slopes stability
- Study of pollutants getting to Bira and their influence on the ecological condition of the flood-lands and river-bed complex
- Analysis of species structure and spatial distribution of coastal vegetation

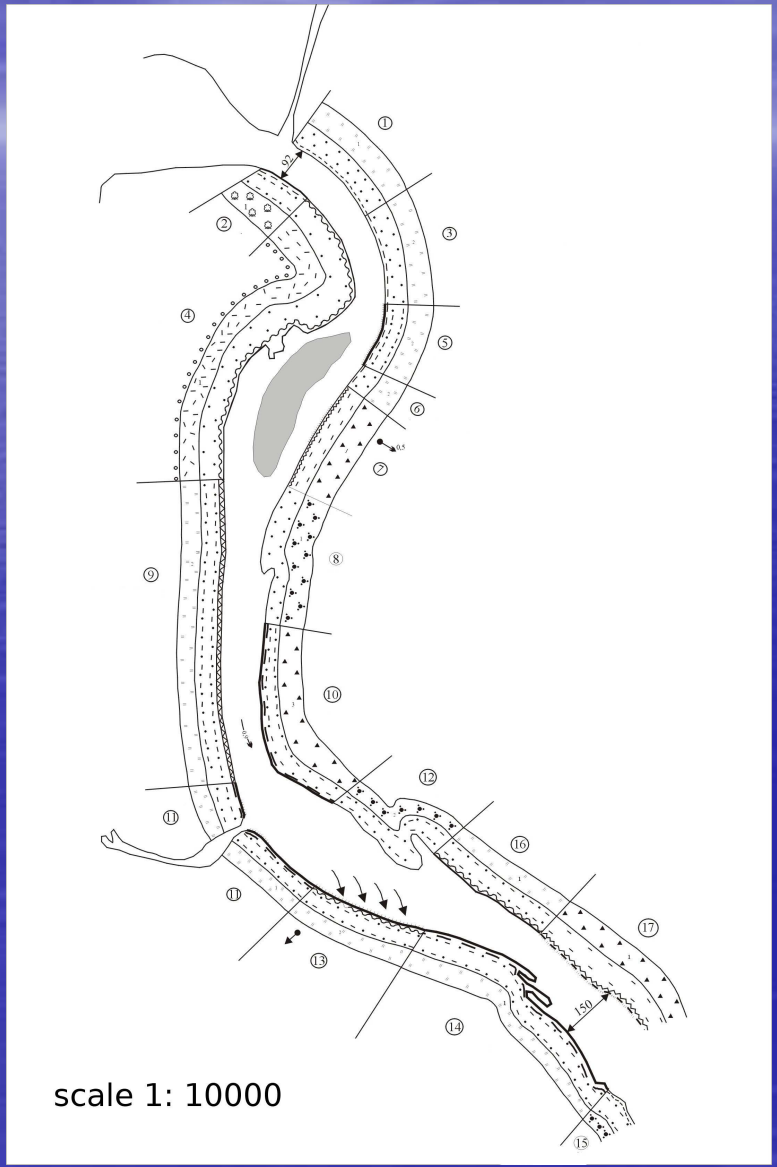
The Bira-river catchment area



Map-scheme of the Bira bank slopes stability



The fragment of the map-scheme



Analysis of the map-scheme

- The unstable sections of bank slopes belong to the overall built left bank of Bira
- The greater part of stable and most stable banks are those completely transformed by man
- The biggest erosion zones (up to 1 – 1.3 м per year) have no protective constructions
- The bank protecting structure intensifies the erosion of former stable opposite banks
- Man-made consolidation of banks intensifies the process of islands displacement

Heavy metals concentration coefficients in the soil and vegetation of the flood-lands of Bira (mg/kg)

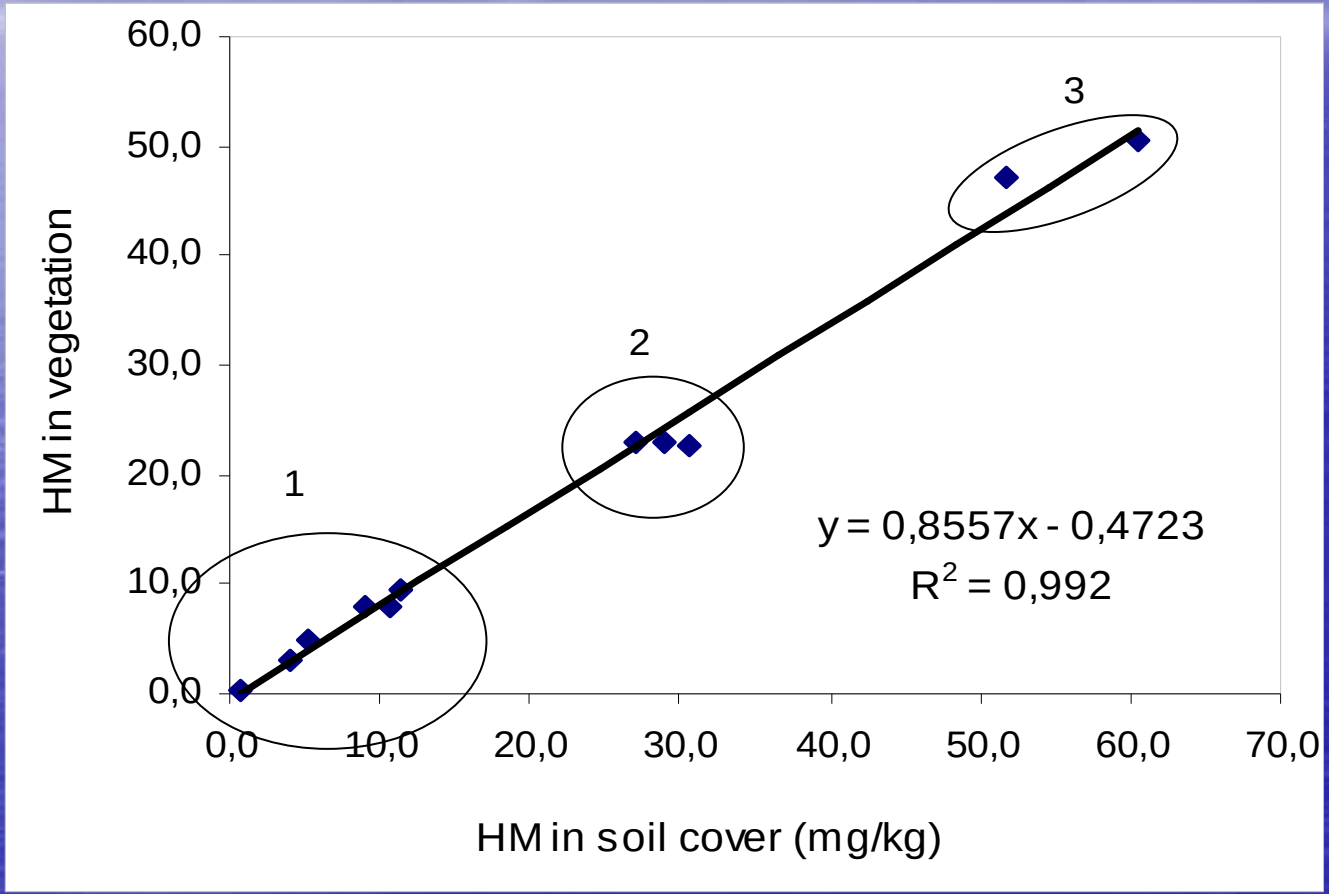
In the soil cover

$$\frac{Fe}{3{,}2} \succ \frac{Zn}{2{,}1} \succ \frac{Cu}{1{,}6} \succ \frac{Pb}{1} \succ \frac{Ni}{0{,}7} \succ \frac{Co}{0{,}2} \succ \frac{Mn}{0{,}1} \succ \frac{Cd}{0{,}06}$$

$$\frac{Zn}{2{,}3} \succ \frac{Co}{2{,}1} \succ \frac{Cu}{1{,}5} \succ \frac{Ni}{0{,}6} \succ \frac{Fe}{0{,}3} \succ \frac{Pb}{0{,}2} \succ \frac{Mn}{0{,}1}$$

In vegetation

Dependence between heavy metals concentration in vegetation and in soil



Influence of the pollution on vegetation in the Bira-river flood-lands

- Deceleration of plants growth both apical and in diameter
- Damage of plants by diseases and premature fall of leaves
- Decrease in the fastening effect of the root system followed by the bank slopes erosion
- Intensive increase of spatial heterogeneity

The mathematical model of spatial-temporal dynamics of plant communities

- We have elaborated a mathematical model for spatial-temporal dynamics of the plants population explaining the mechanisms of emergence of heterogeneous spatial distribution
- In plotting the model, we accounted for interaction of plants situated close to each other and affecting both increase of biomass (new shoots, for instance) and restricted biomass growth caused by competition for resources needed for vital activity

The basic model version

$$\dot{u}_i(x,t) = \int_M \alpha_i(x,y) u_i(y,t) dy -$$

$$u_i^{\gamma_i}(x,t) \sum_j \int_M \beta_{ij}(x,y) u_j^{\rho_j}(y,t) dy$$

- $u_i(x, t)$ - the biomass density of the i-th species in point x in time t
- M - the physical space, the community habitat range
- Parameter γ_i characterizes sensibility of the biomass being suppressed to competitive impact
- Parameter ρ_j reflects the non-linearity of the competitive restriction from the suppressive biomass density

- Kernels $\alpha_i(x, y)$ define the biomass of *i*-th species, «sprouting» from point *y* to point *x*
- Kernels $\beta_{ij}(x, y)$ characterize competitive suppression intensity of the biomass of *i*-th species at point *x* by the biomass of *j*-th species at point *y*

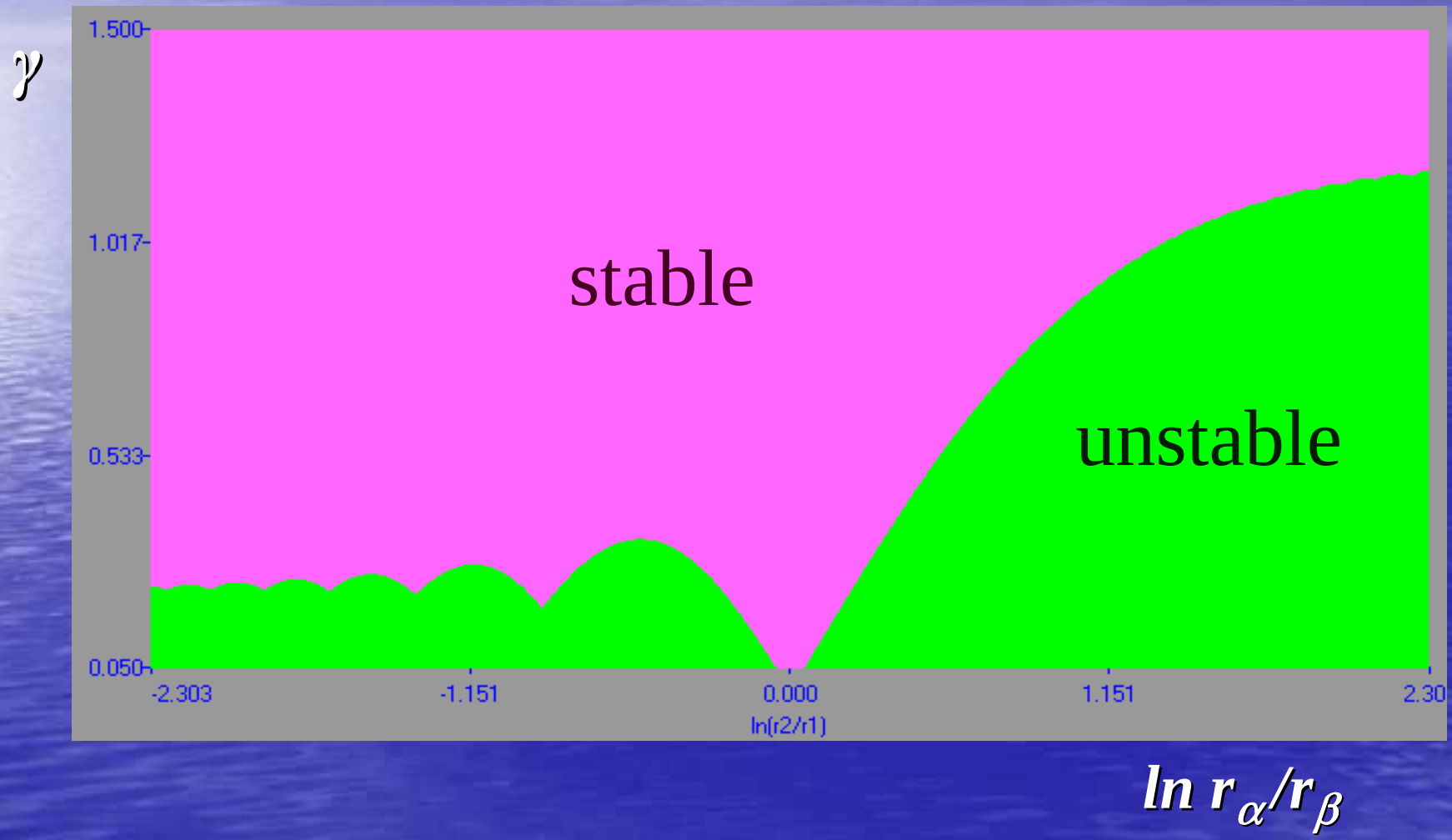
$$\alpha(x,y) = \begin{cases} S_\alpha \exp\left(-\dfrac{2\|x-y\|^2}{r_\alpha}\right), & \|x-y\| \le r_\alpha \\ 0, & \|x-y\| > r_\alpha \end{cases}$$

$$\beta(x,y) = \begin{cases} S_\beta \exp\left(-\dfrac{2\|x-y\|^2}{r_\beta}\right), & \|x-y\| \le r_\beta \\ 0, & \|x-y\| > r_\beta \end{cases}$$

Results of the model research

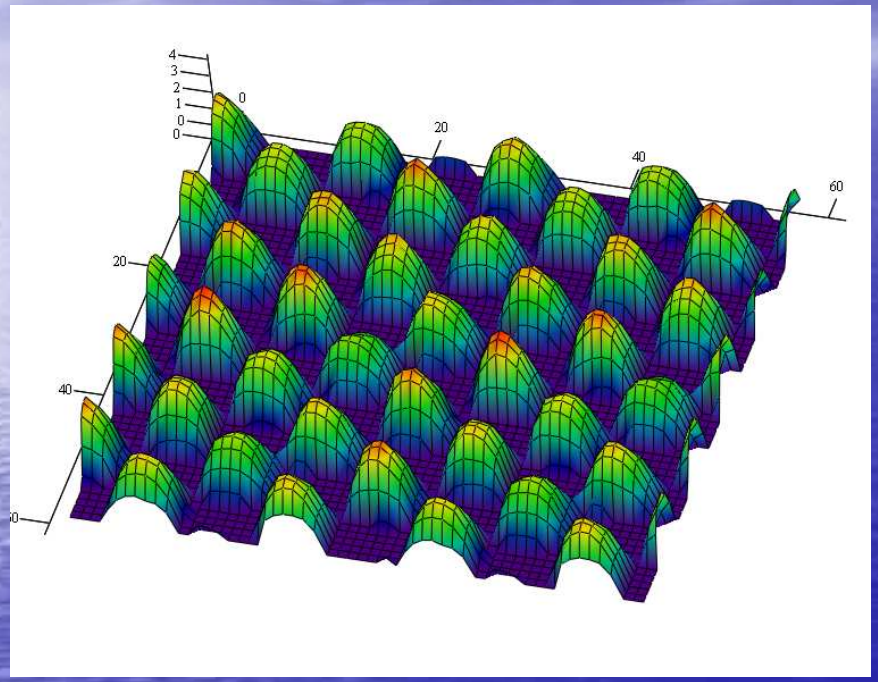
The detailed investigation of the model has shown that increase in the competitive pressure (or reduction of competitiveness) leads to the processes of chaotic self-organization and emergence of intricately structured heterogeneous (spotted) spatial distributions

Bifurcation diagram to loss in stability of spatially homogeneous solution



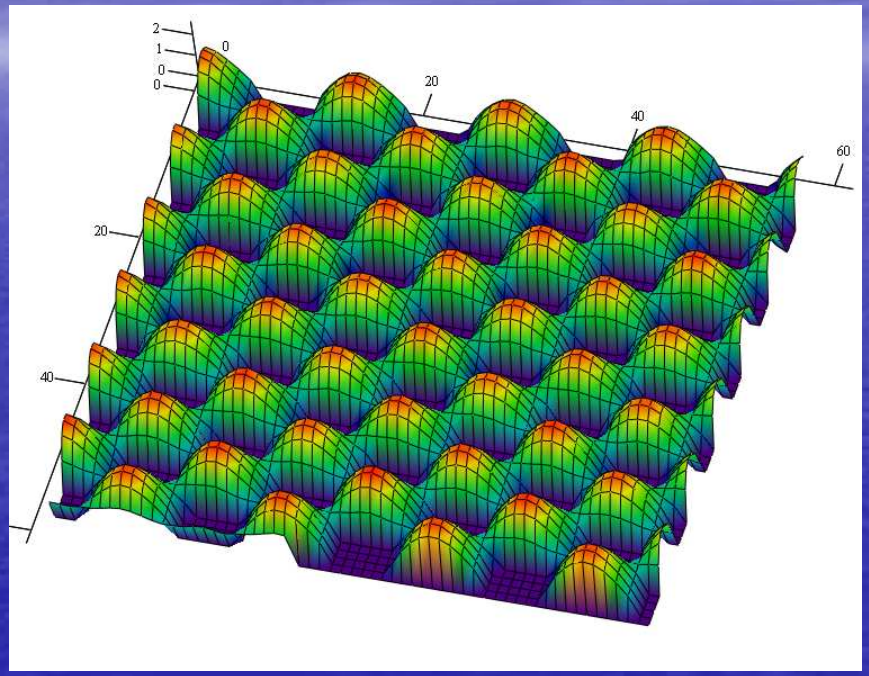
The spatial distributions of solutions on two-dimensional uniform space

a



D2

b

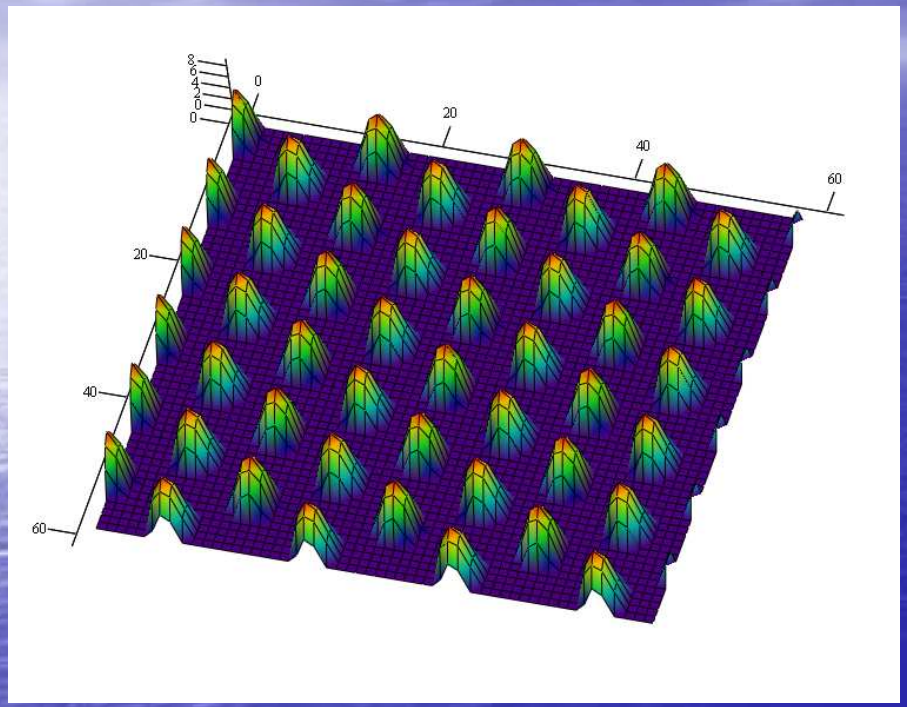


D3

	r_a	r_β	γ
a	**7**	**7,5**	**0,9**
b	**7**	**10,0**	**0,9**

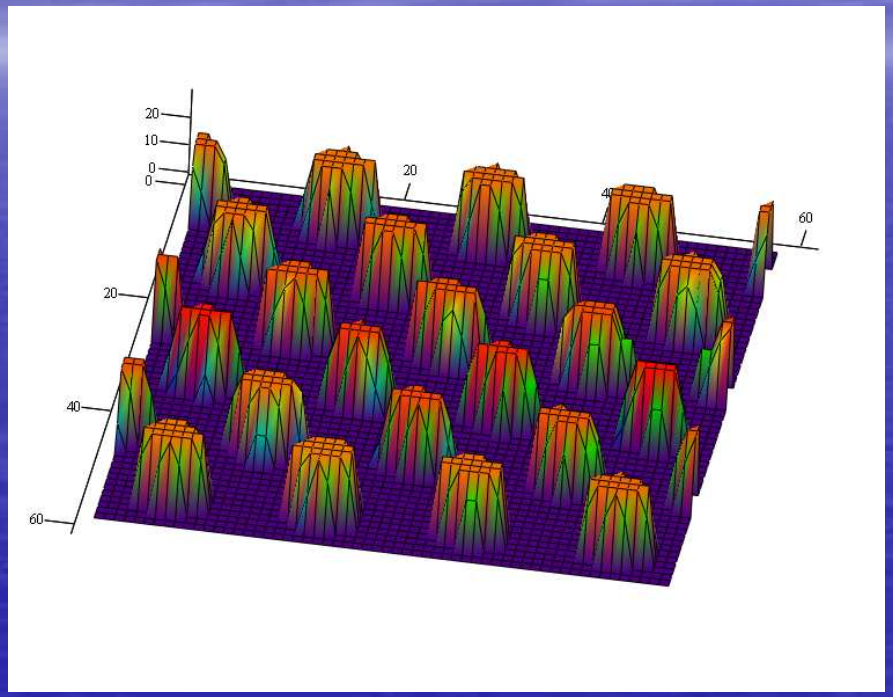
The spatial distributions of solutions on two-dimensional uniform space

c



D4

d



D1

	r_α	r_β	γ
c	7	9,0	0,98
d	8	8,2	0,90

The spatial distribution of coastal vegetation

The conclusion

- Urbanization of the catchment area changes the surface flows direction leading to the bank slopes destruction, contamination of soil, vegetation and water
- The bank slopes stability depends on their attachment to a housing complex and availability of bank protective constructions
- Man-made consolidation of banks causes intensive displacement of islands
- Contamination of soil causes augmentation of spatial heterogeneity in the flood-lands vegetation distribution that leads to reduction of plants root system fastening effect and strengthens the bank slopes erosion

The obtained results are the basis for both the scenarios of the flood-lands and river-bed processes analysis, and for the elaboration of recommendations on regulating surface flows in urban territories

Thank you for your attention!