USE OF AN INTEGRATED APPROACH FOR ASSESSING SOIL REDISTRIBUTION IN THE VOROBZHA RIVER BASIN

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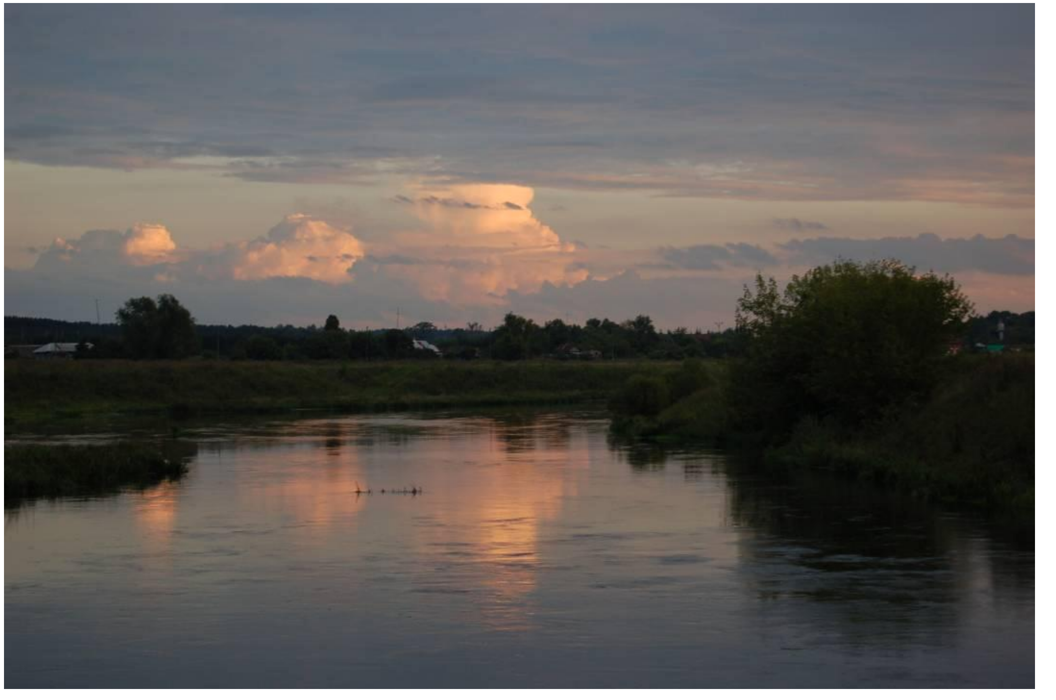
Introduction

1/Problem of soil degradation and landscape transformation

2/Study site and methods applied

3/ Results and discussion

4 Conclusion

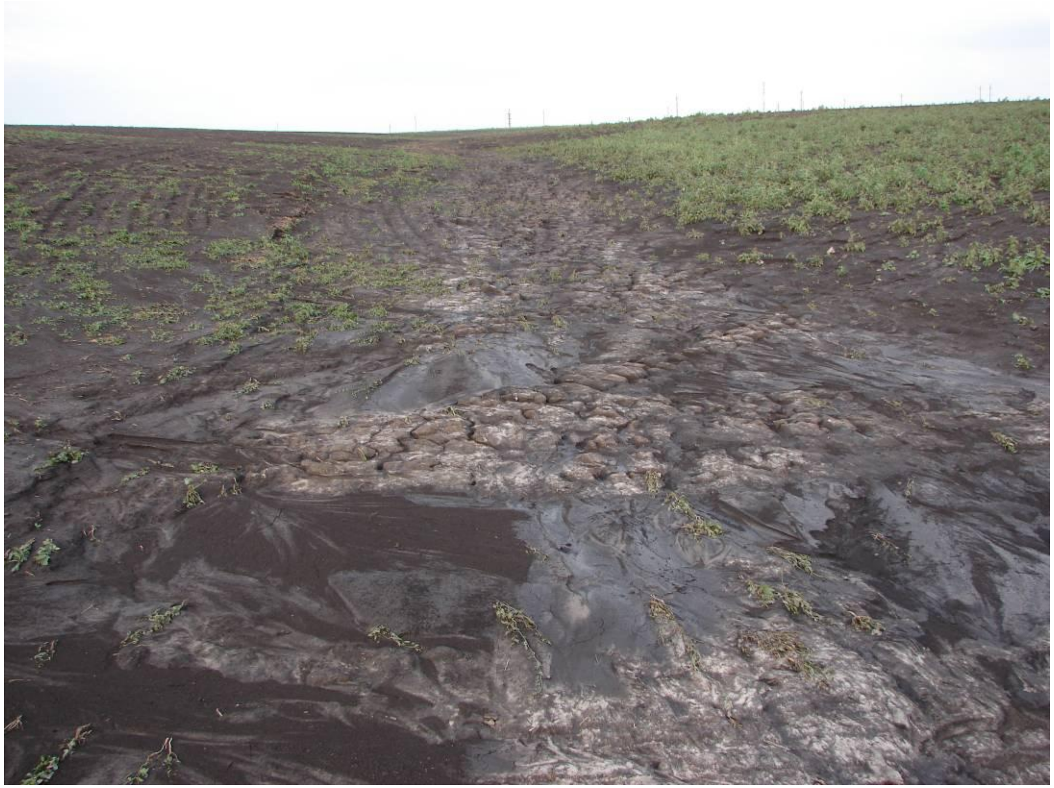


Problem of soil degradation and landscape transformation

Serious erosion was observed in Chernozem zone of European Russia, where areas of cultivated lands since the end of 19th century reach 75-80% from total area.

Both water erosion during spring snow-melting and heavy rain-storm are occurred here. Maximum soil losses during only one rain can reach 200 t/ha.

During 20th century area of cultivation lands slightly decrease because of urbanization, abounded tillage of steep slopes .



Vorobza river basin, Kursk region

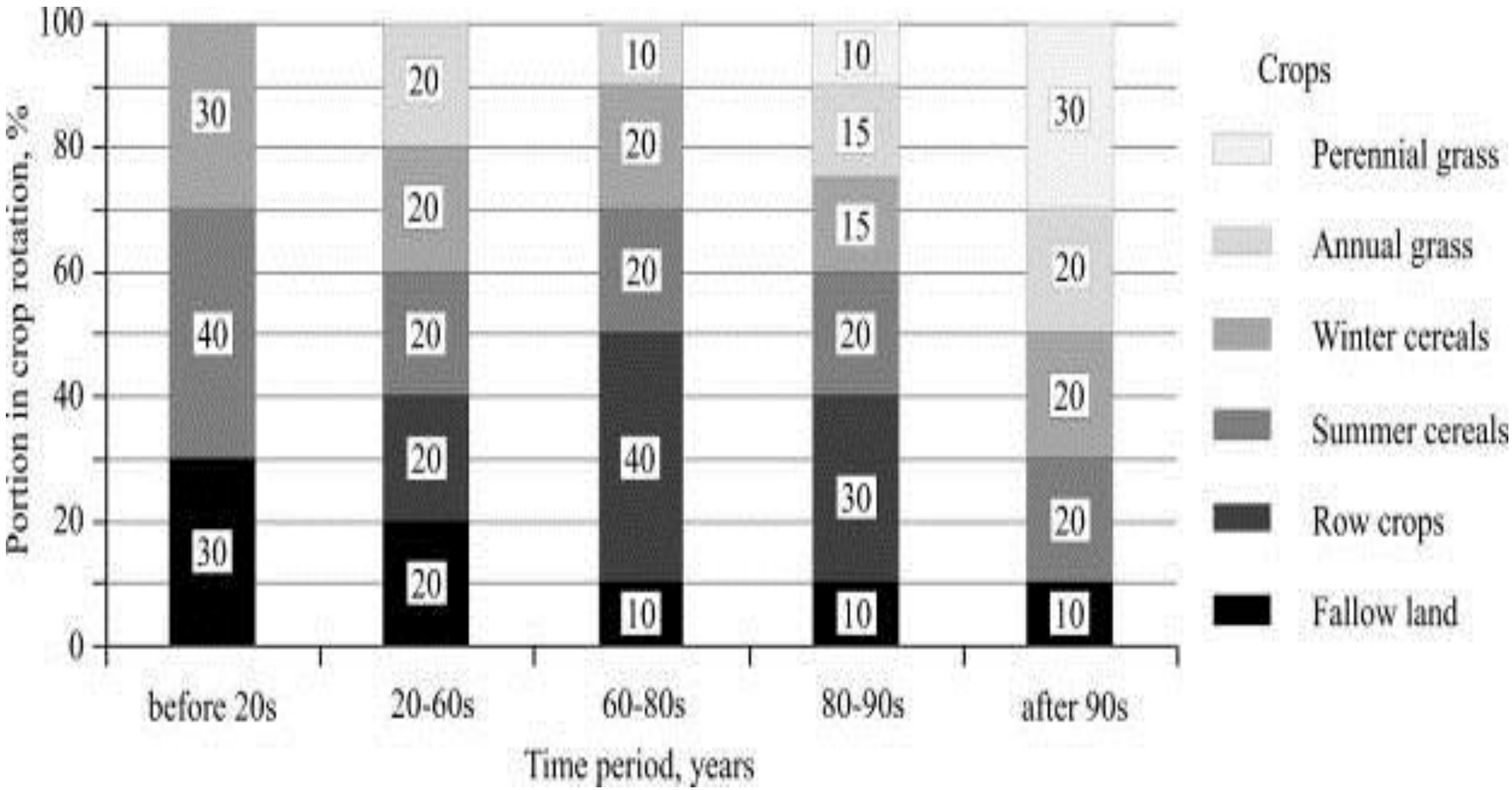
Vorobza river basin, Kursk region

- **Basin area 231,6 km^2**
- **The most part of area are cultivated**
- **Several ponds and reservoirs with known time of dam construction are located within the Vorobza river basin. Some of them is fulfill by sediment and usually have no water during second half of summer**

History of land cultivation within *the Vorobza river basin*

- According of historical maps intensive cultivation began in around 1859-60th
- Till the end of 19th century area of cultivation lands exceed about 80% from total area.
- During 20th century until 1991 area of cultivation lands slightly decrease because of formation of several bank and slope gullies
- During 1991-2009 part (maximum 10-15% from total area) of tillage was abounded because economical reasons
- After 2009 the most part of previously abounded lands is cultivated

Crop rotation used for the Vorobza river basin during 20th century



Vorobza river basin, Kursk region

INTEGRATED APPROACH FOR STUDY SEDIMENT REDISTRIBUTION DYNAMIC FOR SMALL RIVER BASIN

Detail study of sediment redistribution for first order valley catchment

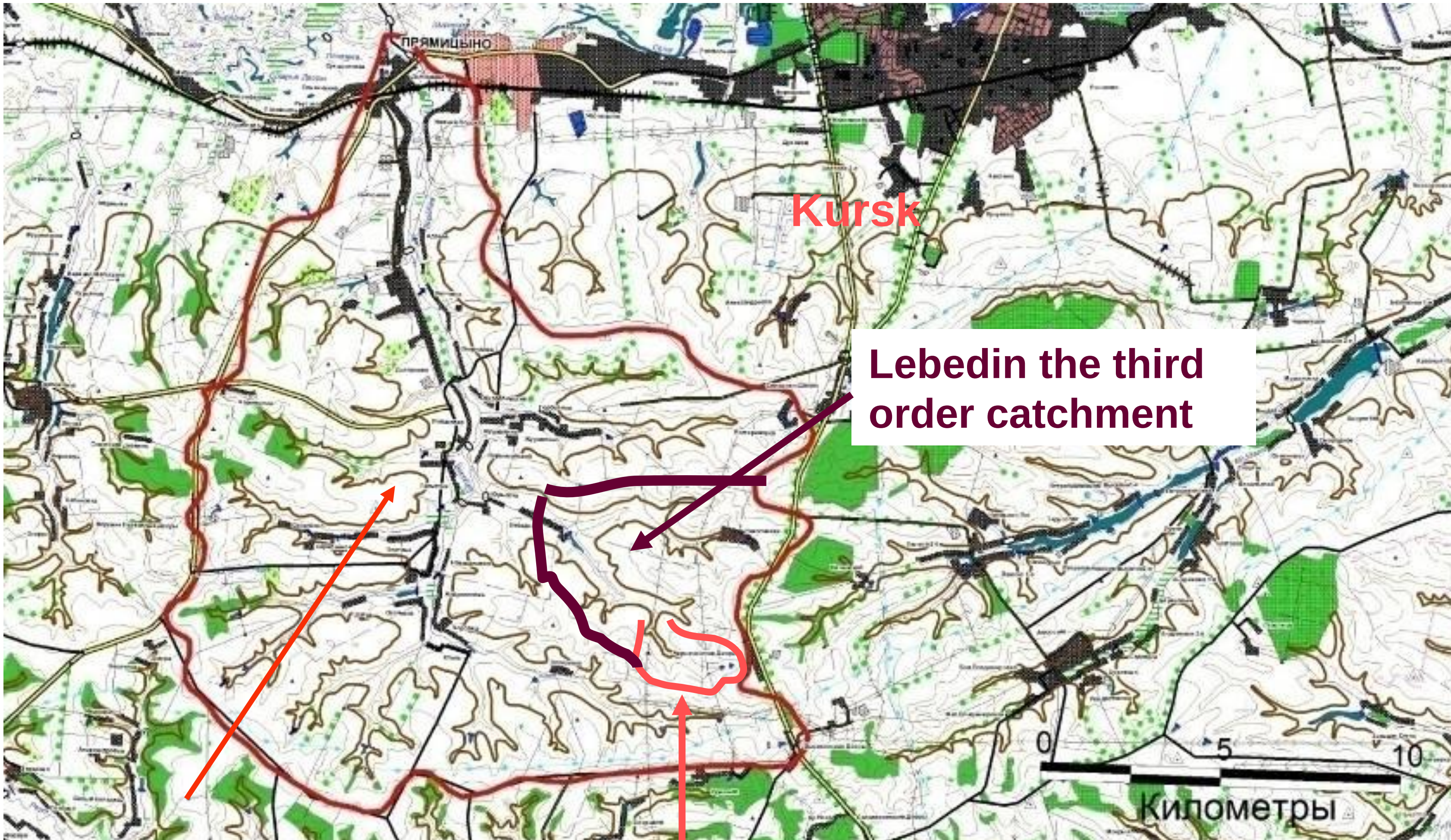
→

Evaluation of sediment budget for third order valley catchment

→

Evaluation sediment redistribution dynamic for the Vorobza river

Location key study catchments within the Vorobza river basin



Methods evaluation of soil redistribution rate and sediment budget

- Soil morphological method
- Modified version USLE (rain-fall erosion) and State Hydrological model (erosion during snow-melting)
- Geomorphologic mapping
- Application of ^{137}Cs tracer for evaluation soil loss/gain (^{137}Cs budget), deposition rates for different time intervals and sediment budget calculation

Soil morphological method

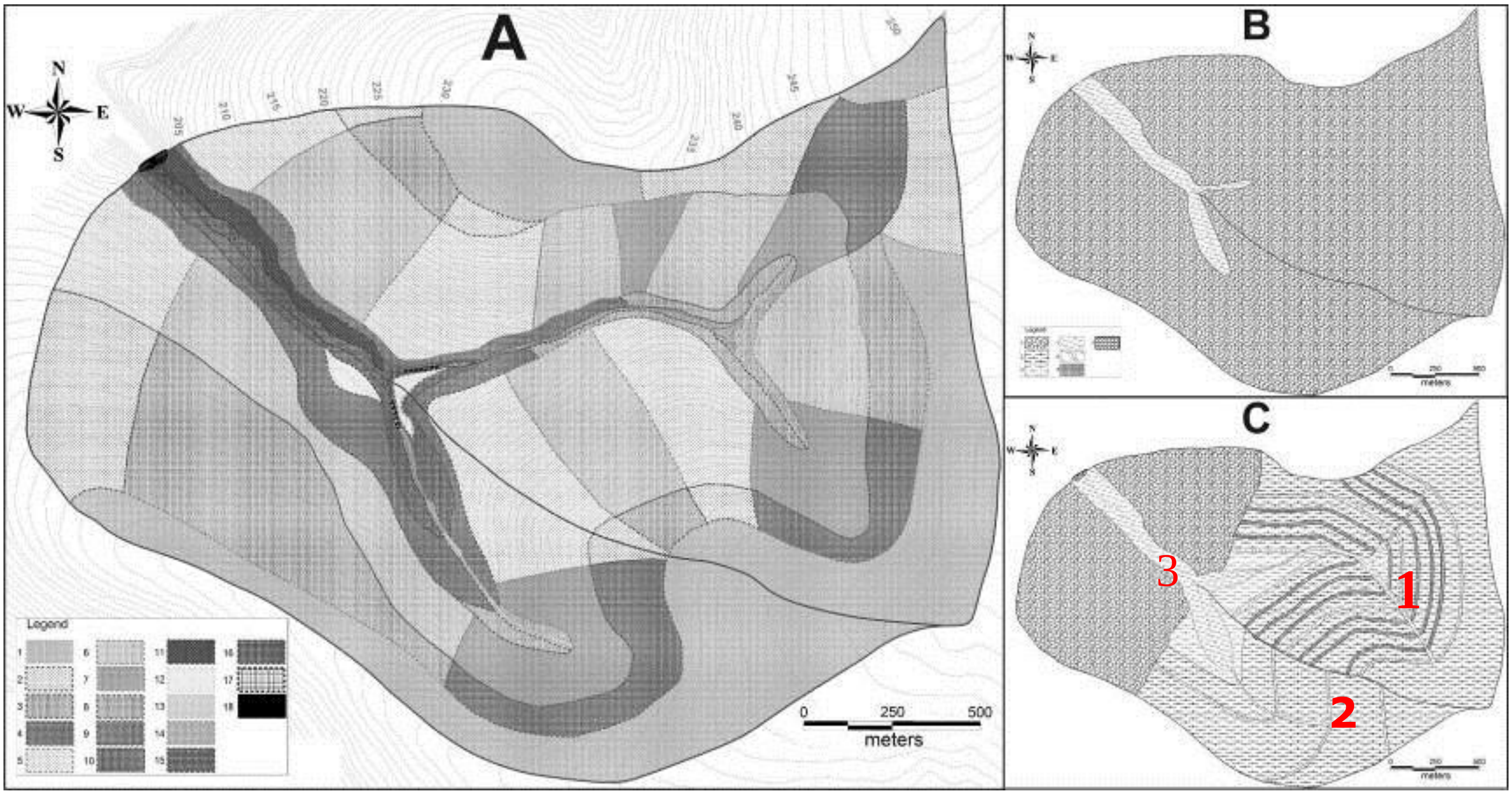
Undisturbed

Moderately eroded

Severely eroded

Aggraded

A: Geomorphic map of the Gracheva Loschina study catchment



B: Land use before 1986. C: Land use after 1986

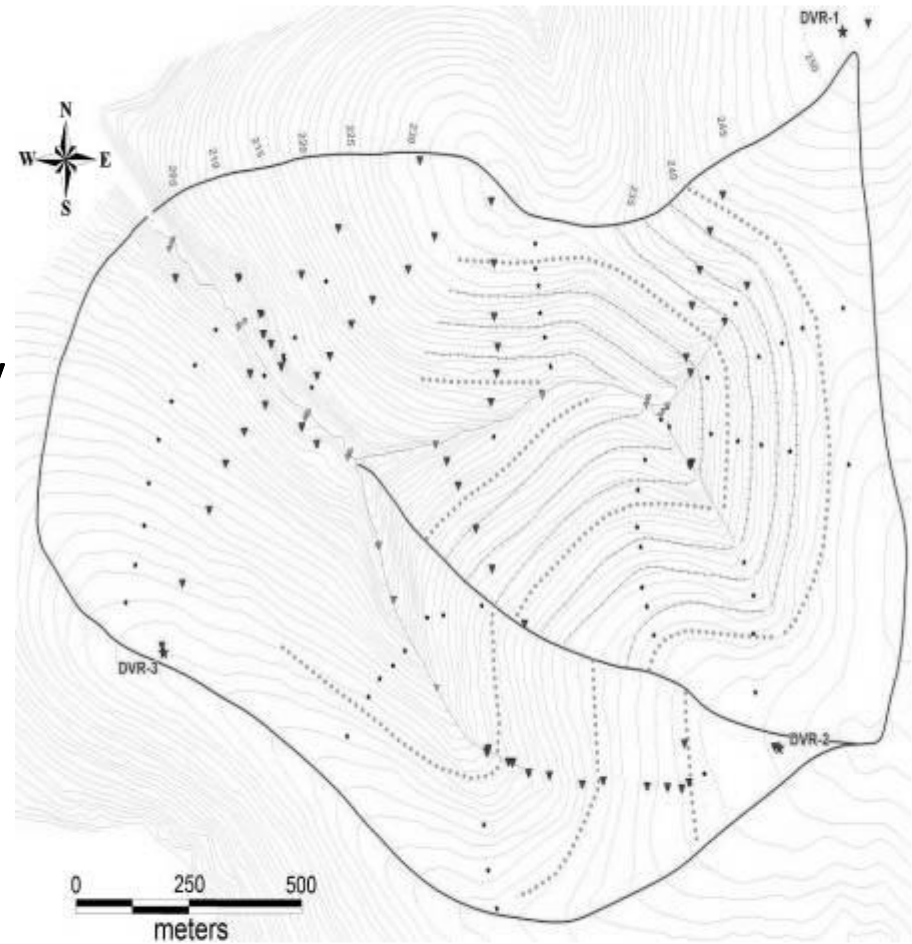
Determination of deposition volume for different time intervals

- Incremental sampling was made for the several pits along the valley bottom
- ^{137}Cs and magnetic spherules content was defined for each layer
- Area of deposition zone was evaluated on the base of detail geomorphologic mapping
- Peaks of ^{137}Cs concentration for 1964 (bomb-derived ^{137}Cs) and for 1986 (Chernobyl-derived ^{137}Cs) were defined

Evaluation of sediment redistribution in Gracheva Loschina catchment (the first order catchment) for different time intervals

Location of sampling points within the Gracheva Loschina catchment

- 4 reference locations were sampled for determination of initial ^{137}Cs fallout
- Each morphological type of slopes was characterized by several transects
- 6-7 samples for determination of ^{137}Cs inventory were taken along the each transect

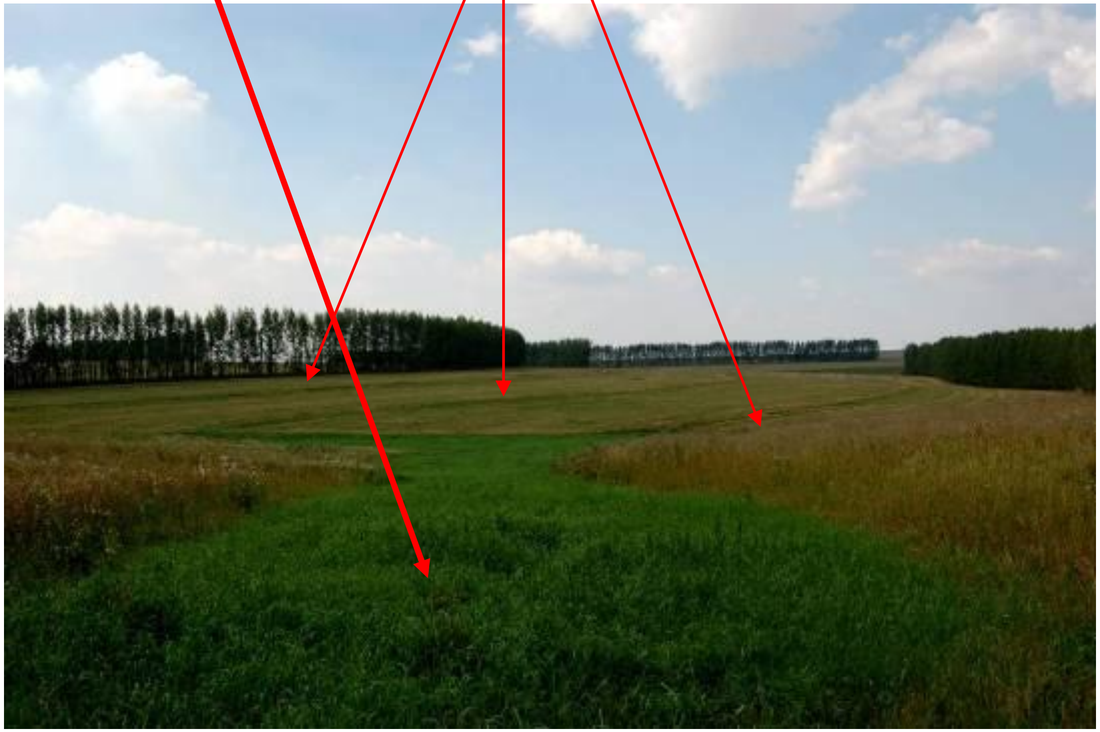


General characteristics and ^{137}Cs inventory (Bq/m^2) statistics for the reference sites

Reference site	Number of samples	Mean value, Bq/m^2	Range, Bq/m^2	Cv, %	Standard deviation, Bq/m^2
1	2	3	4	5	6
DVR-1	12	9289	5219-11476	22	2062
DVR-2	12	7537	6298-10209	16	1209
DVR-3	12	9063	7206-11021	13	1186
DVR-4	12	8517	6346-10150	13	1112

Types of conservation measures since 1986

Forest shelter belts with ditch between tree lines, contour earth terraces and grass ways.



The post-1986 ^{137}Cs budget for sub-catchments of the Gracheva Loschina catchment characterized by different types of soil conservation measures or their absence

Sub-catchment	Total area, ha	Eroded area, ha/ ^{137}Cs loss, kBq	Deposition area, ha / ^{137}Cs gain, kBq (% from ^{137}Cs loss)		Residual kBq (%)
			Within cultivated areas (including grassed waterways)	In tributary hollow bottoms and main valley bottom	
Sub-catchment with forest shelter belts and grass waterways	52.8	42.3 189606 (100%)	5.5 154620 (82%)	0.3 7954 (4%)	27032 (14%)
Sub-catchment with forest shelter belts, grass waterways and contour terraces	88.1	73.3 926885 (100%)	9.5 834195 (90%)	0.95 24650 (3%)	68040 (7%)
Area without soil conservation measures and the main valley bottom	56.9	48.6 236786 (100%)	1.4 22061 (9%)	1,4 200508 (85%)	14217 (6%)

Evaluation of gross (red numbers) and net (black numbers) erosion rates (t ha^{-1} $year^{-1}$) for different time intervals based on the different methods for study catchment

Method	1857-2006	1964-1986	1986-2006
Soil Morphological Method	15,7		
Erosion model calculation		15.3	6.0
^{137}Cs budget			2,4
Sediment deposition in the valley bottom (vertical distribution of ^{137}Cs)		3.7*	1.5

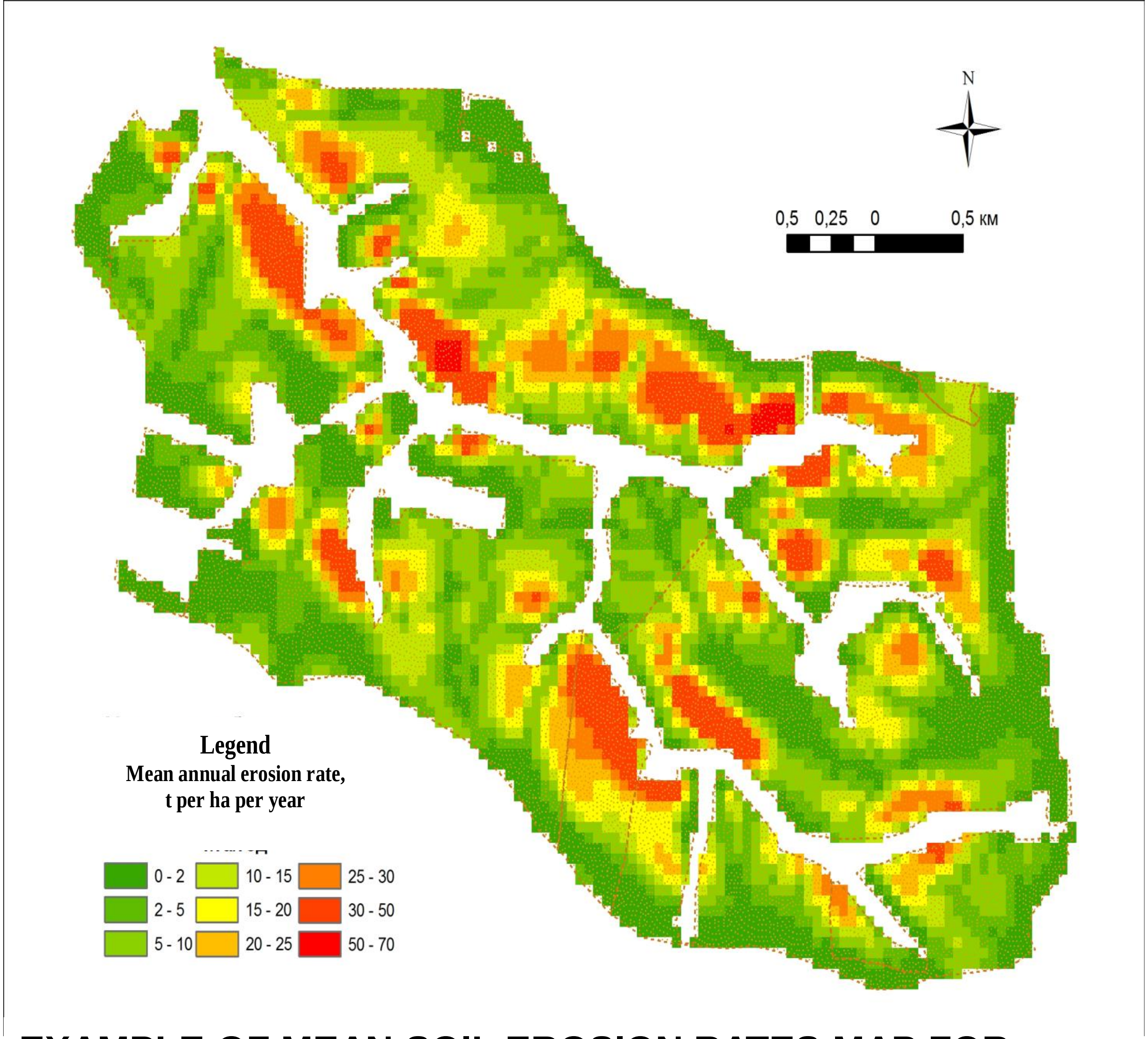
*Do not take into consideration possible sediment transported by temporary flows downstream from catchment area

The the Lebedin catchment

1/ Dam was constructed in the catchment outlet in 1956. It is allowed to evaluate the sediment budget for the most part of the cesium period and hence to define the possible errors in evaluation of soil losses from cultivated land (erosion model calculation);

2/ The Gracheva Loschina catchment is the part of the Lebedin catchment. Sediment redistribution was evaluated for the Gracheva Loschina catchment based on very detail study. In the result sediment budget was calculated for three time intervals;

3/There are no any villages and paved roads in the Lebedin catchment, so only typical agricultural disturbance is influenced on sediment redistribution.



EXAMPLE OF MEAN SOIL EROSION RATES MAP FOR THE LEBEDIN CATCHMENT FOR PERIOD 1964-1986

Mean annual erosion rates and total soil losses from cultivated slopes of the Lebedin catchment for three time intervals and for entire period after dam construction (1956) in catchment outlet

Time interval	Mean annual erosion rate, t ha^{-1} $year^{-1}$	Total soil losses, t
1956-1964	8,5	83912
1964-1986	10,6	287769
1986-2008	6,8	191848
Mean for period 1956 - 2008	8,6	**563529**

Total sediment deposition in the valley bottoms of different orders (Lebedin catchment) for different time intervals

Valley	Order of the valley	Sediment volume for different time interval, t		
		1956-1964	1964-1986	1986-2008
Gracheva Loschina	1	1260	5044	250
	2	2814	11256	10553
Other valleys	1	5591	22365	16773
	2	12665	50661	39579
	3	7156	28625	28625
Total volume in valley bottoms upper pond		29486	117951	95555
Pond		46769		
Total volume in valley bottom		289761		

Percentage of sediment re-deposited in different deposition zones of the Lebedin catchment for period 1956-2008

Deposition Zone	Part of sediment re-deposited in given zone, % from gross soil losses	
	Range according observation	Mean value
Within arable lands	2-25	10
Near the lower edge of cultivated fields	5-30	8
Valley banks	2-7	4
Uncultivated part of hollows (former bank gullies)	4-10	6
Bottom of valleys including pond	-	51
Away beyond the pond	8-12	10
Residual balance	-	11

Part of sediment transported from the Lebedin catchment to the Vorobza river valley for different time intervals

Time interval	Total gross soil losses, t (based on corrected empirical model calculations)	Sediment volume in valley bottoms, t (based on cesium dating)	Sediment deposition in pond, t	Part of sediment possibly transported from Lebedin catchment, %
1956-1986	297345	151438	39754	13/26*
1986-2008	153478	100465	7015	4,5/7
1956 - 2008	450823	289761	46769	10/16

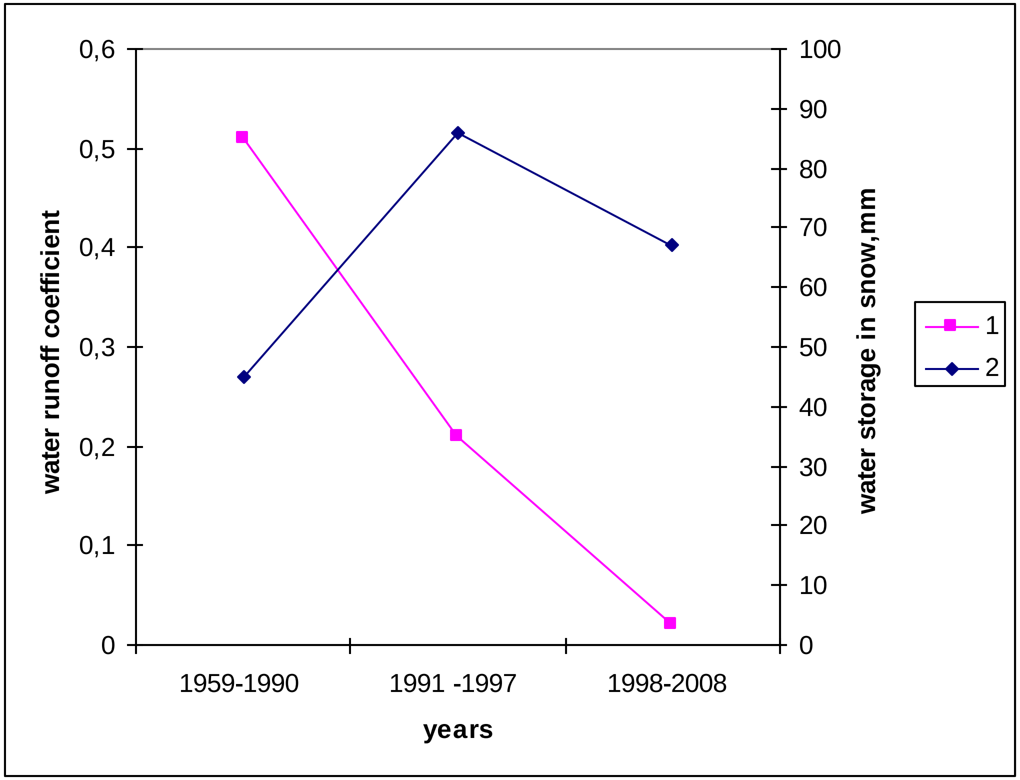
*** - numerator - from total soil losses; denominator – from deposition in valley bottoms.**

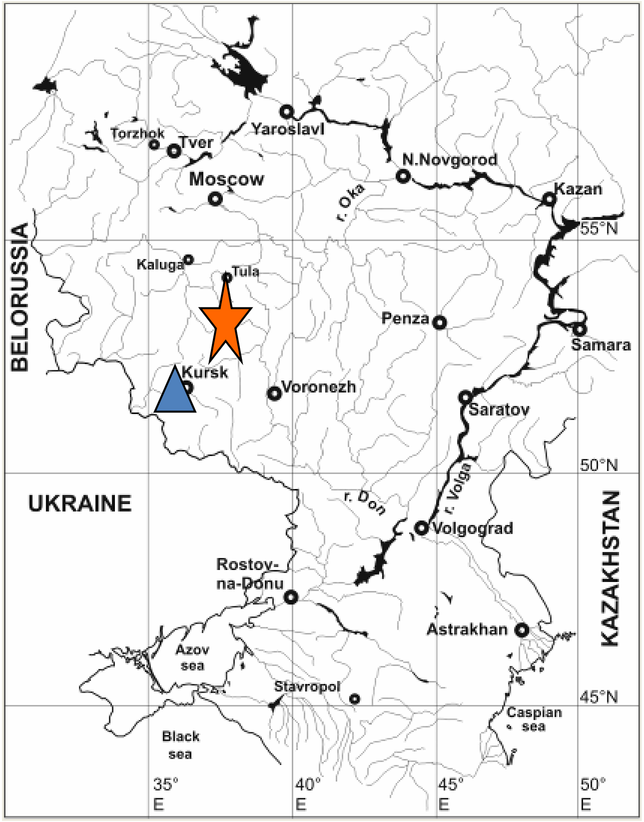
Overbank sedimentation rates on the River Vorobza floodplain (mm year^{-1}) for the two time intervals considered on ^{137}Cs vertical distribution curves

	Deposition rates	
Time interval	**1986-2008**	**1964-1986**
Upper cross-section (sampling point V-1)	**1.2-1.6**	**Not available**
Lower cross-section (sampling point V-2)	**1.2-1.6**	**10.7-11.1**
Extent of decrease	**7.8**	

Decrease of spring snowmelt runoff for the last decade according field observation during 50 years in Chernozem zone (based on monitoring

data of Novosil experimental station, the Zusha river basin





1 - water runoff coefficient from slope during snow melting;

2 – water storage in snow before snow melting

Location on Novosil experimental station

Vorobza river

Conclusions

- Calculated mean erosion rates for period 1956-1964, 1964-1986 and 1986-2008 were 8,5; 10,6 and 6,8 respectively
- However for some part of cultivated slopes erosion rates reach 50-70 t per ha per year.
- About 30-35% from total volume of eroded sediment re-deposited within the cultivated fields, on the lower edge of cultivated fields, in uncultivated part of hollows and on the valley banks
- Dry valley bottoms are the main location for sediment storage. About 50% from total volume of eroded sediments is re-deposited here.

Conclusions

- Before 1986 about 13% from total soil losses or about 26% from total deposition in valley bottoms is transported downstream by temporary watercourses
- After 1986 part of sediment transported downstream decrease in more than 3 times, because of decreasing surface runoff and erosion during snow-melting if compare with previous time interval.
- During last two decade volume of sediment transported to the Vorobza river valley decrease preliminary in 3 -3,5 times. Overbank sedimentation rates decrease proportionally.

Acknowledgements

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