Soil Threats and Soil Protection in the Danube Region

PROJEKT SONDAR-HUAT

Walter W. Wenzel
Universität für Bodenkultur Wien
Department für Wald- und Bodenwissenschaften
Institut für Bodenforschung

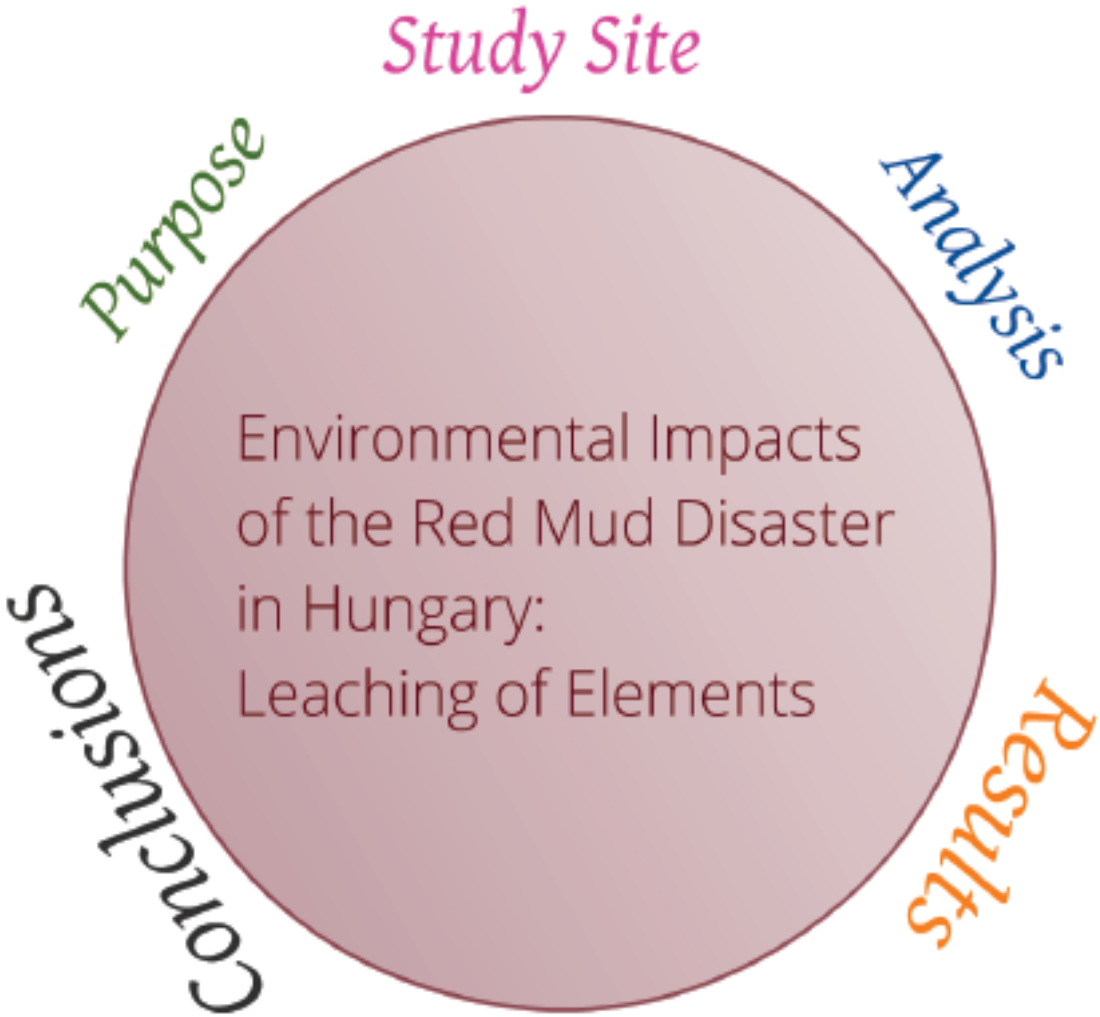
EUROPEAN UNION
European Regional Development Fund

creating the future
Programm zur grenzüberschreitenden Kooperation ÖSTERREICH - UNGARN 2007-2013
AUSZTRIA - MAGYARORSZÁG Határon Átnyúló Együttműködési Program 2007-2013

Content

- A Hungarian Case Study
- A Serbian Case Study
- A Romanian Case Study

The Red Mud Spill in Hungary



EUROPEAN UNION
European Regional Development Fund

creating the future
Programm zur grenzüberschreitenden Kooperation ÖSTERREICH - UNGARN 2007-2013
AUSZTRIA - MAGYARORSZÁG Határon Átnyúló Együttműködési Program 2007-2013

The Red Mud Spill in Hungary

Bauxite Residue

What is it?
- also called "Red Mud"
- byproduct during alumina production
- mainly composed of iron and aluminum

Problems & Risks
- highly alkaline due to the Sodium-Hydroxide content
- mostly ponded storage - low wt%-solid storage
- trace element concentrations within the mud

Treatment - Remediation - Utilization
- mainly neutralization of the slurry
- until now no significant utilization

The Red Mud Spill in Hungary

The Red Mud Spill in Hungary

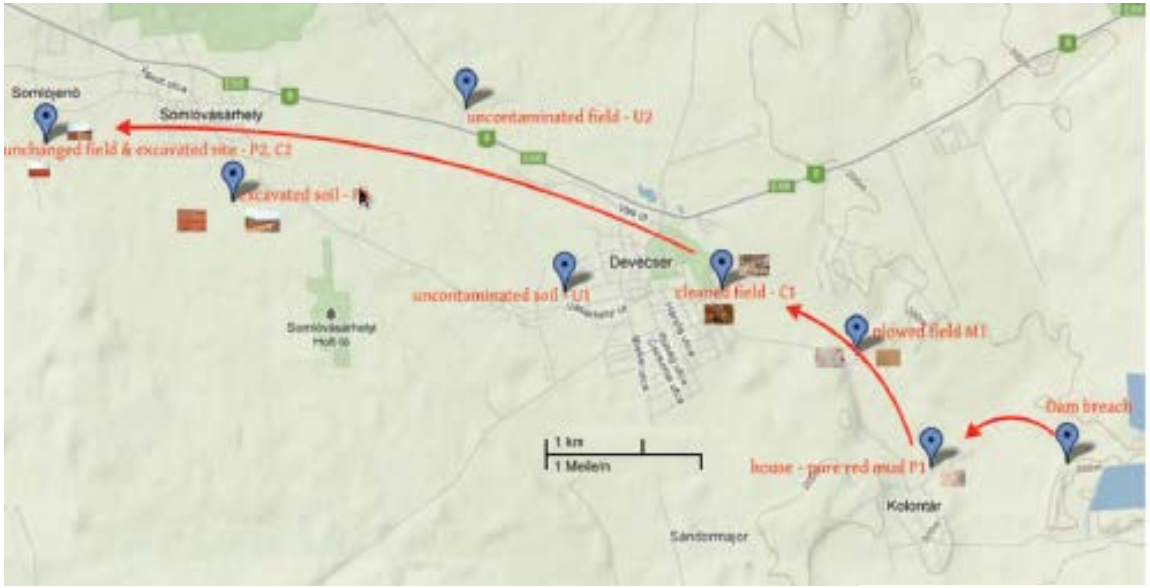
Accident

- release of ~ 700.000 m^3 red mud
- affected area: ~40km^2
- pH: 11-12

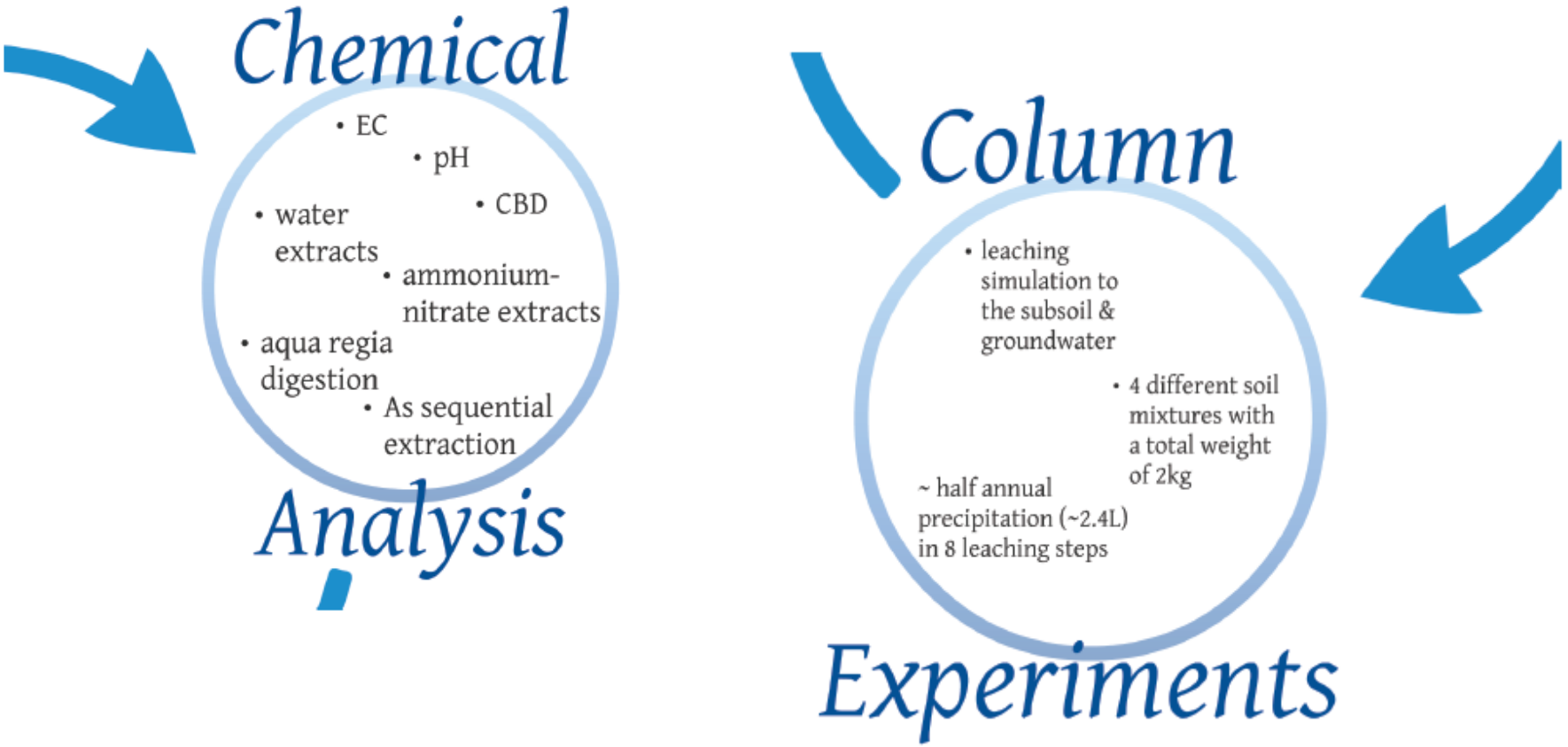
The Red Mud Spill in Hungary

Sampling

- 3 types of pure red mud: P1, P2, P3
- plow-mixed soil M1
- 2 types of cleared soil: C1, C2
- 2 uncontaminated samples: U1, U2



The Red Mud Spill in Hungary



The Red Mud Spill in Hungary

Mixtures

- C1 - cleaned soil
- M1 - plowed soil (0.4:0.4:0.2)
- M2 on top of C2 (0.8:0.2)
- P2 on top of U2 (0.65:0.35)

The Red Mud Spill in Hungary

pH, electrical conductivity & BET specific surface area

- pure red mud samples: high pH & EC
  (note the difference in EC of P1, P2 and P3)
- low (typical) values for uncontaminated soil
- elevated values for cleaned soils

Table 3: pH and electrical conductivity of *red mud*, cleared soils and uncontaminated soils

	pure red mud			plowed soil			cleared soil		uncontaminated	
	P1	P2	P3	M1a	M1b	M1c	C1	C2	U1	U2
pH	10.13^{a}	10.14^{a}	9.96^{b}	8.2^{f}	8.74^{d}	8.24^{f}	8.49^{e}	9.04^{c}	6.99^{h}	7.87^{g}
EC [mS m^{-1}]	646^{a}	237^{c}	307^{b}	43.5^{e}	53.6^{d}	26.1^{g}	29.7^{f}	53.8^{d}	7.5^{h}	24.2^{g}
SSA[1] [m^2 g^{-1}]	8.8873 ±0.048	17.3233 ±0.12	12.6291 ±0.076							

[1] BET specific surface area
pH values & eC values followed by the same letter within a row do not differ significantly according to LSD test, $\alpha < 0.05$

- surface area varies among samples, between typical silt & clay numbers

The Red Mud Spill in Hungary

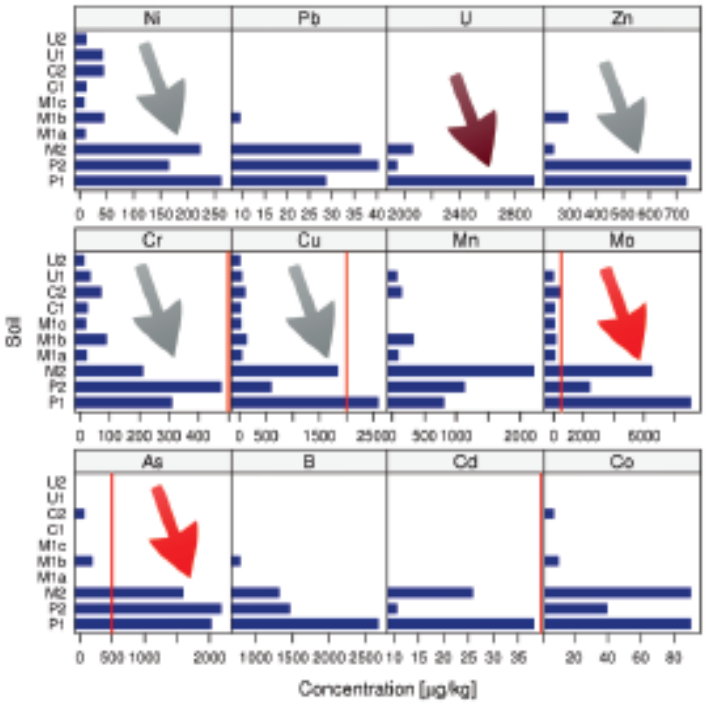
Water extractable elements

for pure red mud samples:

- all measured elements are elevated
- arsenic & molybdenum above all limits
- uranium peaks
- Ni, Zn, Mo, Cu high

Anion measurements

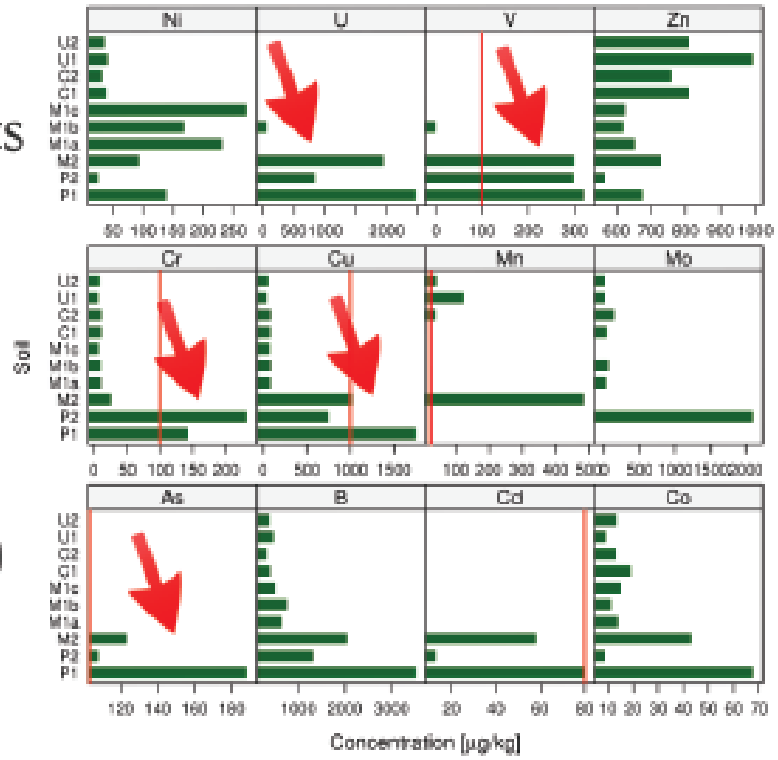
- also pure samples elevated
- Chlorite, Nitrite, Nitrate, Sulfate above limits



The Red Mud Spill in Hungary

pure red mud samples:
more elements above limits
than with water extracts:

- vanadium
- copper
- arsenic
- chromium
- uranium (limit at 5/25)

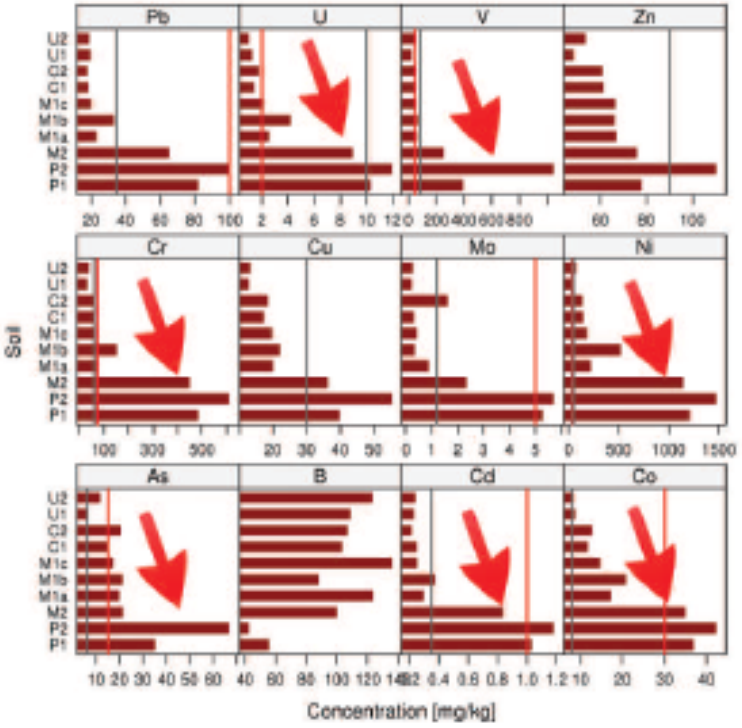


The Red Mud Spill in Hungary

aqua regia extractable elements

pure red mud samples:
almost all elements above regulatory limits

- Cr, Ni, U exceed by far
- V, As very high
- Cd, Co, elevated



The Red Mud Spill in Hungary

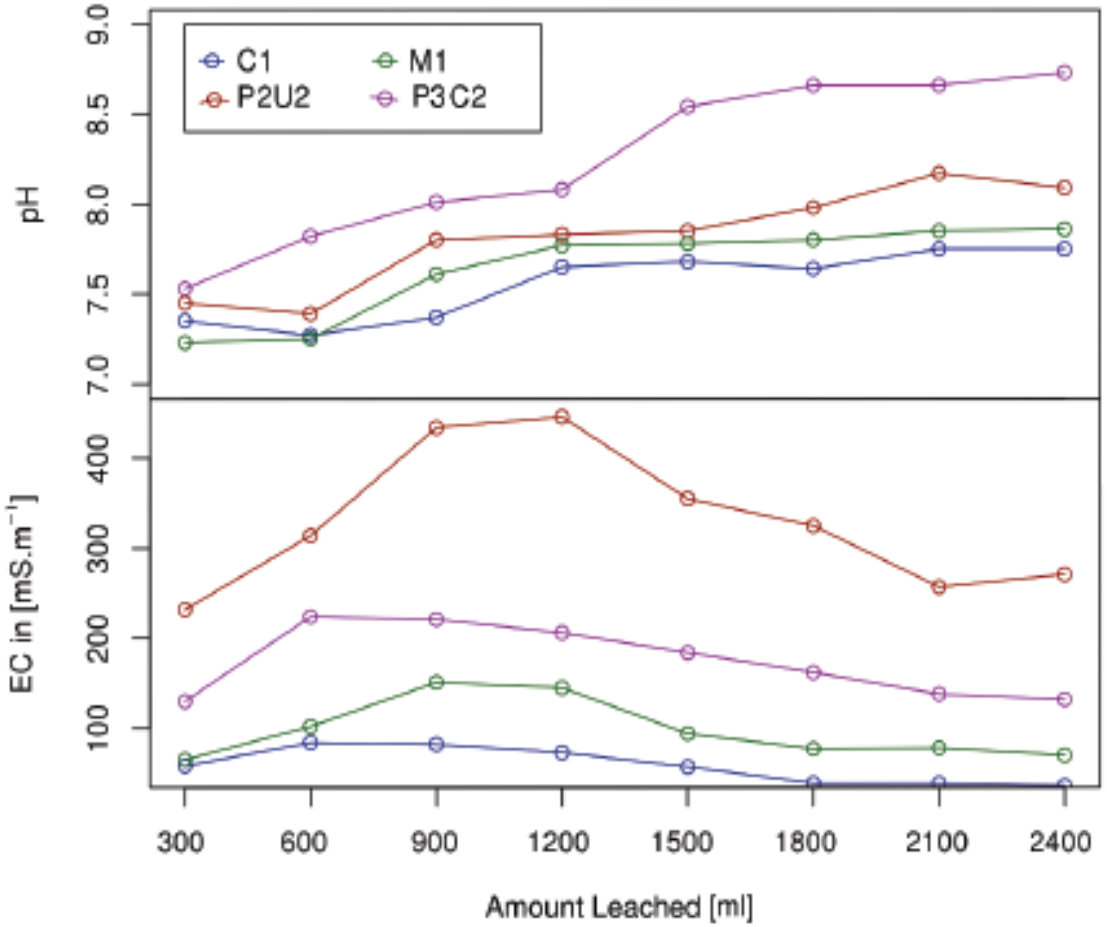
Extract summary

For pure red mud samples

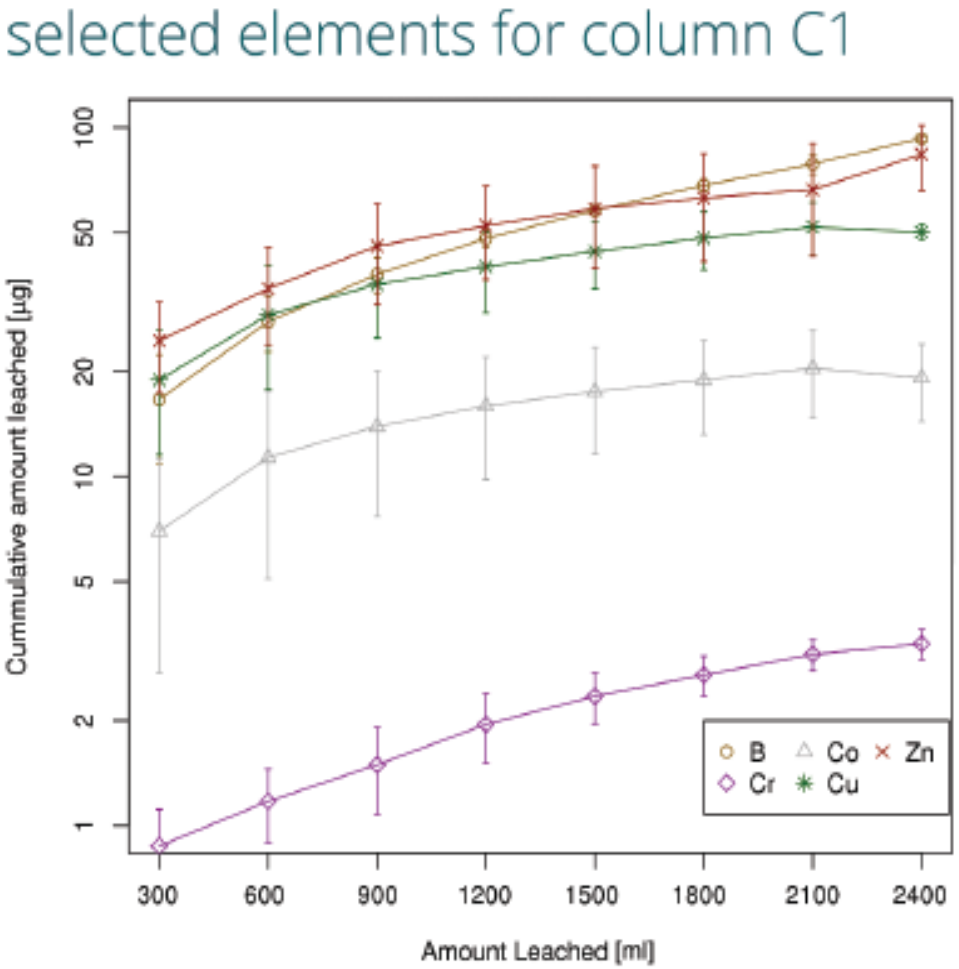
- As above limits within extracts
- U above limits, exceeding cleaned & uncontaminated soils
- Cr, Mo, B & V show high values

The Red Mud Spill in Hungary

pH & EC results - column experiments



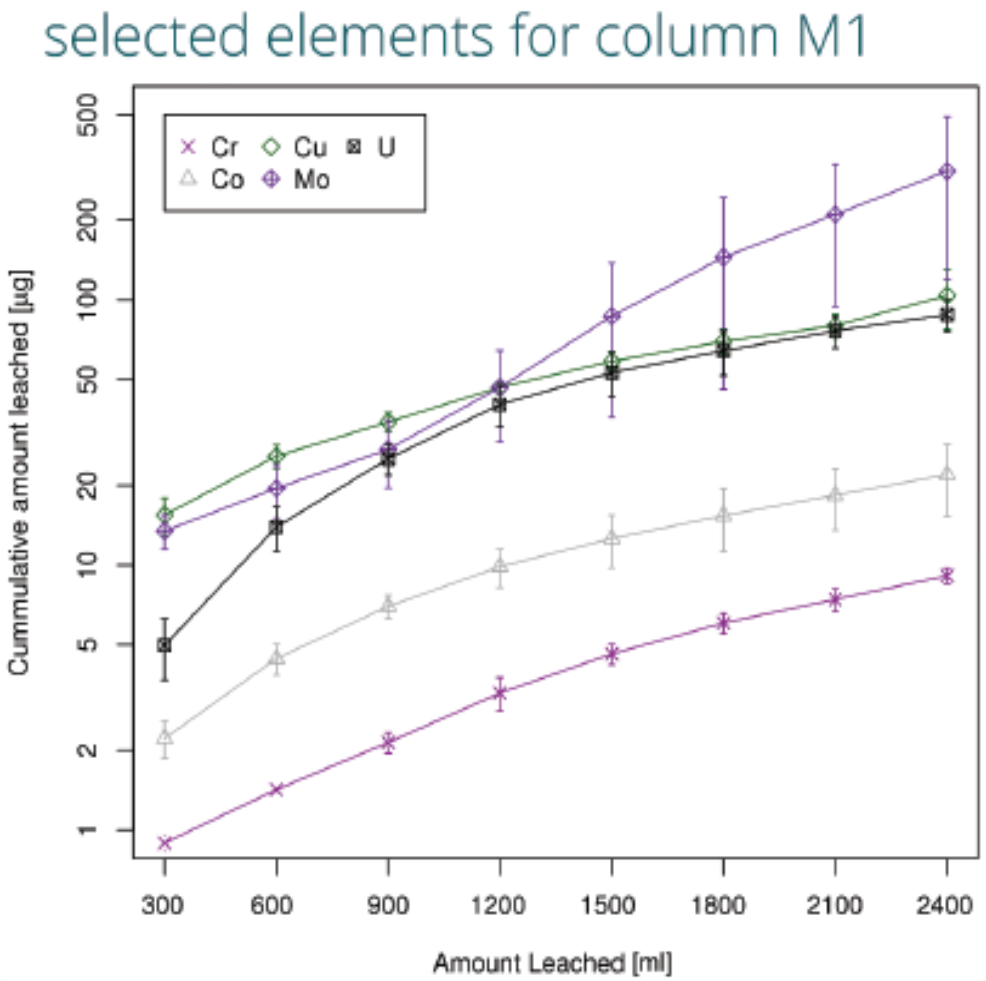
The Red Mud Spill in Hungary



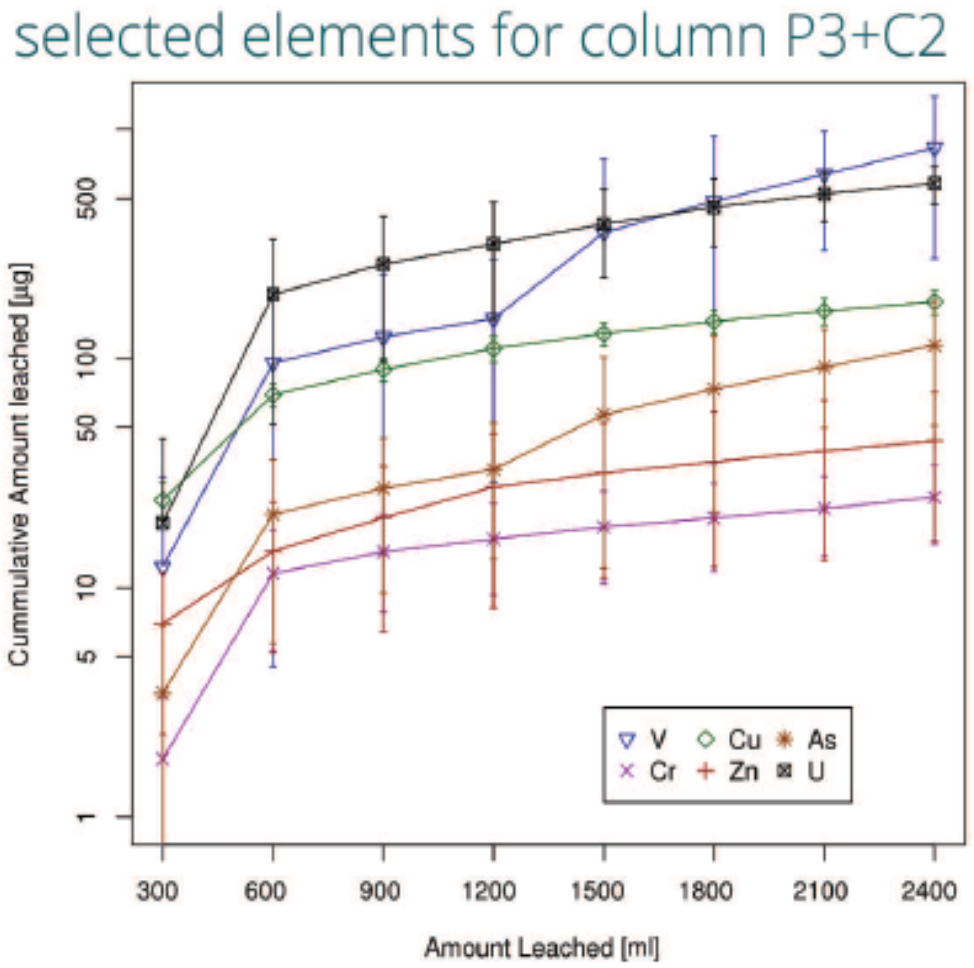
EUROPEAN UNION
European Regional Development Fund

creating the future
Programm zur grenzüberschreitenden Kooperation ÖSTERREICH - UNGARN 2007-2013
AUSZTRIA - MAGYARORSZÁG Határon Átnyúló Együttműködési Program 2007-2013

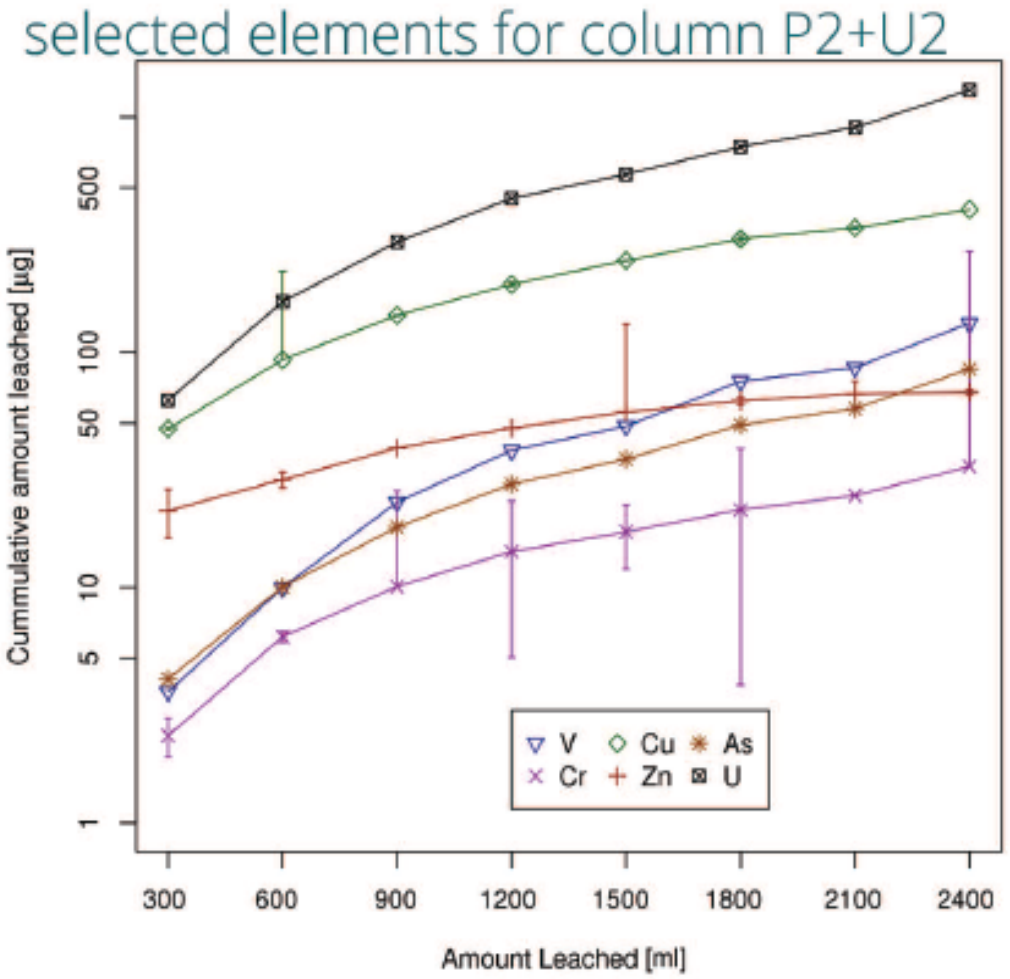
The Red Mud Spill in Hungary



The Red Mud Spill in Hungary



The Red Mud Spill in Hungary



EUROPEAN UNION
European Regional Development Fund

creating the future
Programm zur grenzüberschreitenden Kooperation ÖSTERREICH - UNGARN 2007-2013
AUSZTRIA - MAGYARORSZÁG Határon Átnyúló Együttműködési Program 2007-2013

The Red Mud Spill in Hungary

Column Summary

- Only a slight increase (1) of pH at the bottom of the column
- peak of EC in eluate of columns with pure red mud

- C1: generally low concentrations
- M1: steady concentrations of elements in the eluate, especially Mo, CU and U
- P2+U2: high levels of As and U, but flattening out
- P3+C2: high levels of U, V, As and Cr, flattening out

Soil Erosion in Romania

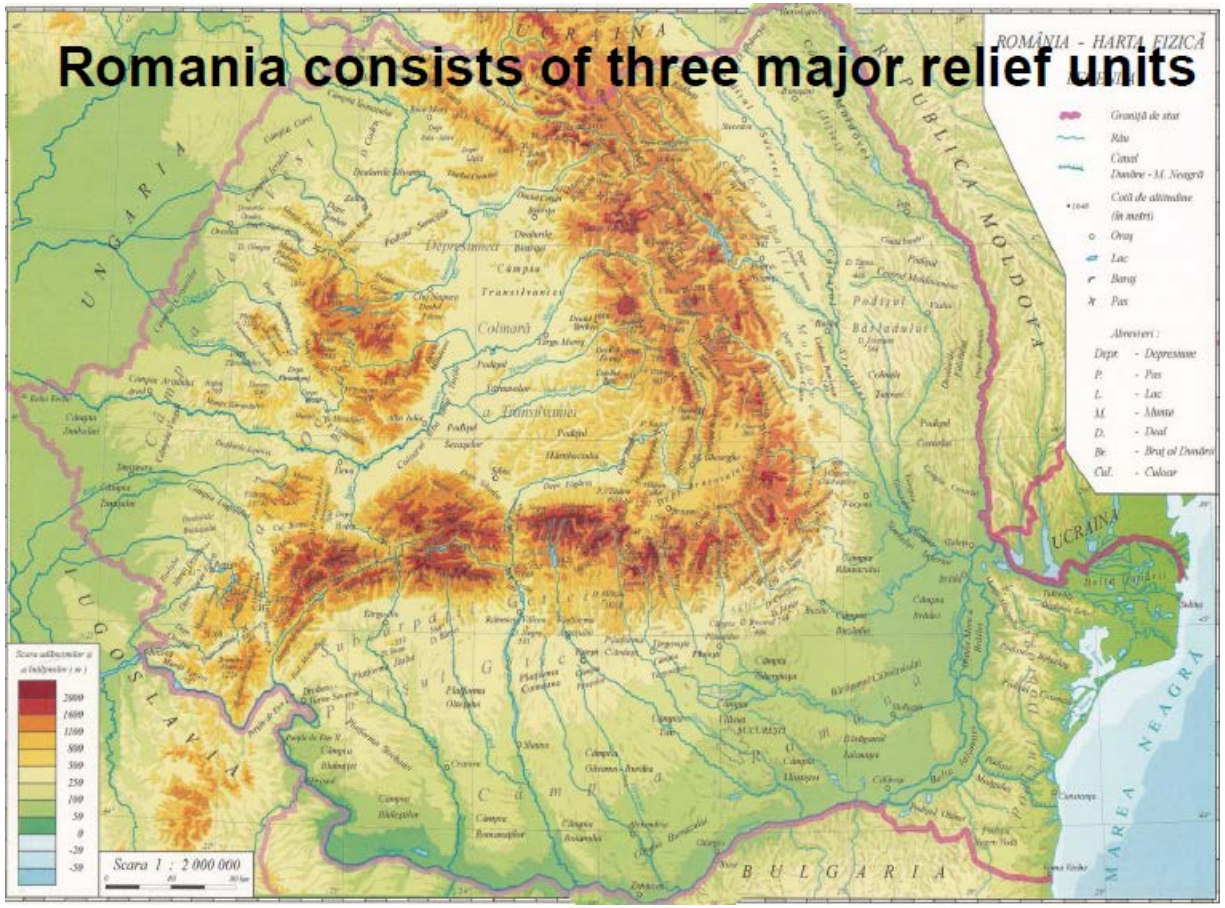
Based on information from:

Prof. dr. ION IONITA
"Alexandru Ioan Cuza" University of Iasi

EUROPEAN UNION
European Regional Development Fund

creating the future
Programm zur grenzüberschreitenden Kooperation ÖSTERREICH - UNGARN 2007-2013
AUSZTRIA - MAGYARORSZÁG Határon Átnyúló Együttműködési Program 2007-2013

Soil Erosion in Romania

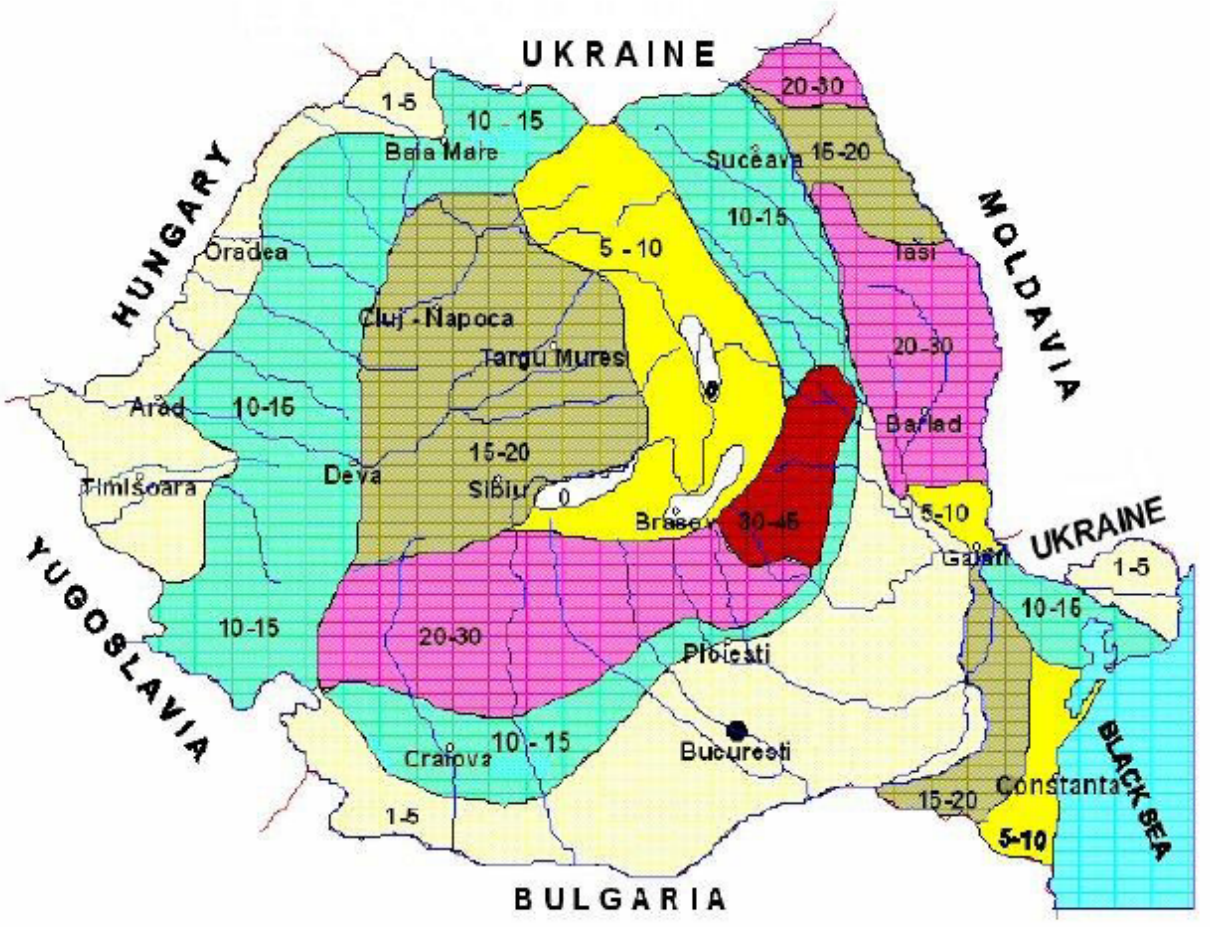


Soil Erosion in Romania

Total erosion by land-use in Romania (Motoc M., 1983)

No	Land-use	Total erosion			
		million t/yr	%		
1	Arable	28.0	26.2	24.7	22.3
2	Pasture	45.0	42.2	39.6	35.7
3	Vineyard	1.7	1.6	1.5	1.2
4	Orchard	2.1	2.0	1.8	1.7
5	Unproductive (Abandoned land as gullies)	29.8	28.0	26.4	23.6
	Agricultural land	106.6	100.0	-	-
	Woodland	6.7	-	6.0	5.3
	Total	113.3	-	100.0	-
	River bank and localities erosion	12.7	-	-	10.2
Total		126.0	-	-	100.0

Soil Erosion in Romania



Total erosion on agricultural land in Romania - tonnes / ha / year
(Motoc, M.,1983)

Soil Erosion in Romania

Total erosion by types of processes (*Motoc M., 1983*)

No	Process	Total erosion		
		million t/yr	%	
1	Soil erosion	61.8	54.5	49.0
2	Gully erosion	29.8	26.4	23.6
3	Landslides	15.0	13.1	11.9
4	Gully erosion and landslides in woodland	6.7	6.0	5.3
	Total	113.3	100.0	-
	River bank and localities erosion	12.7	-	10.2
Total		**126.0**	**-**	**100.0**

Soil Erosion in Romania

Environmental threats:

- **Soil erosion**
- **Gullying**
- **Landslides**
- **Sedimentation**

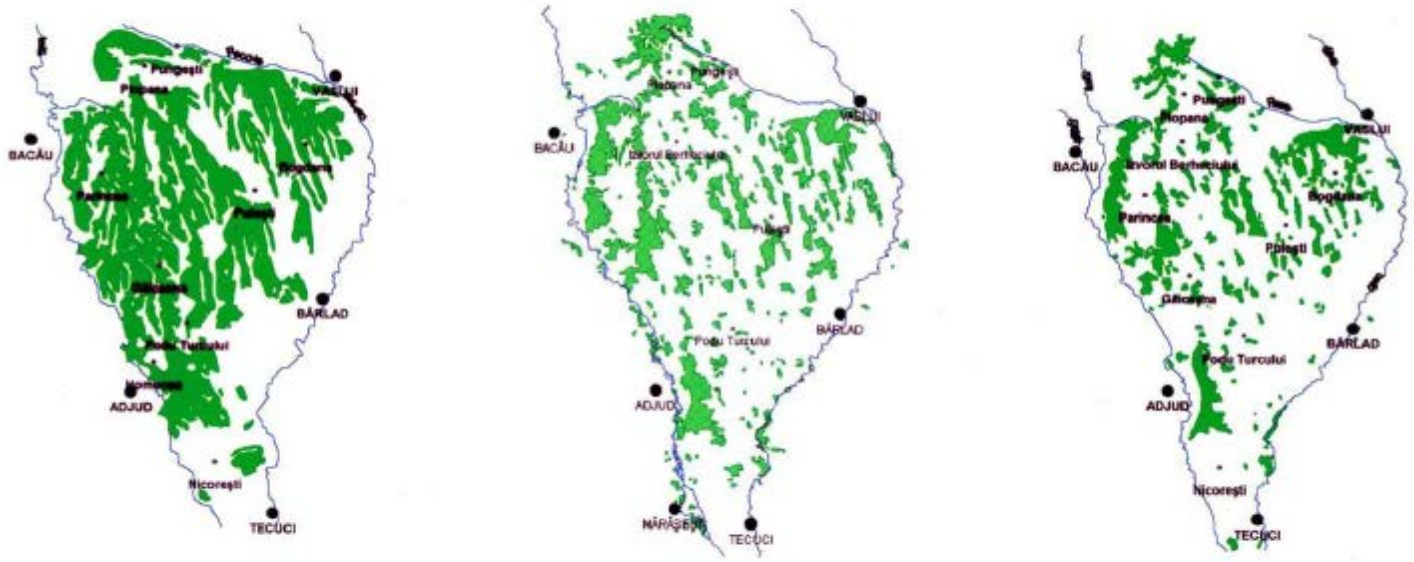
Soil Erosion in Romania

LAND DEGRADATION OVER THE LAST TWO CENTURIES IN THE MOLDAVIAN PLATEAU - ROMANIA

No.	Stage	Features
1.	Till 1829	• Forest was dominant + Grazing clearing mostly
2.	1829 = crossing year	Adrianopol Treaty
3.	1829 - 1899 A preparing stage for future land degradation	The most dynamic change in the Romanian landscape: - Sharp increase of the cultivated land in Moldavia: 6 % in 1829, 19 % in 1862 and 36 % in 1893 - Collapse of the forest since 1864 Land Reform
4.	1900 - 1920 A transitory stage	• Cultivated land in Romania = 48% • Extension of the up and down hill farming • First remarks on land degradation
5.	1921-1970 The climax stage of land degradation	• No significant change in land use • 1921 - Land Reform • Severe up and down hill farming under small plots • Improper road network • 1962 – Co-operativization Act • Land degradation peak during '60s
6.	1971 - 1990 Decreasing tendency of the land degradation	• Extention of the conservation practices and contour farming in huge agricol units • Land use stratification in Moldova: cropland 57%, pastures 16% and forest 15%
7.	1991 - 2010 Revival of land degradation	• Land Act No. 18 / 1991 • Up and down hill chopping and farming is on the screen again

Soil Erosion in Romania

Forest distribution in the Tutova Rolling Hills (*Poghirc, 1970*)



1832 **47.4%**

1893 **21.9%**

1970 **18.8%**

EUROPEAN UNION
European Regional Development Fund

BOKU

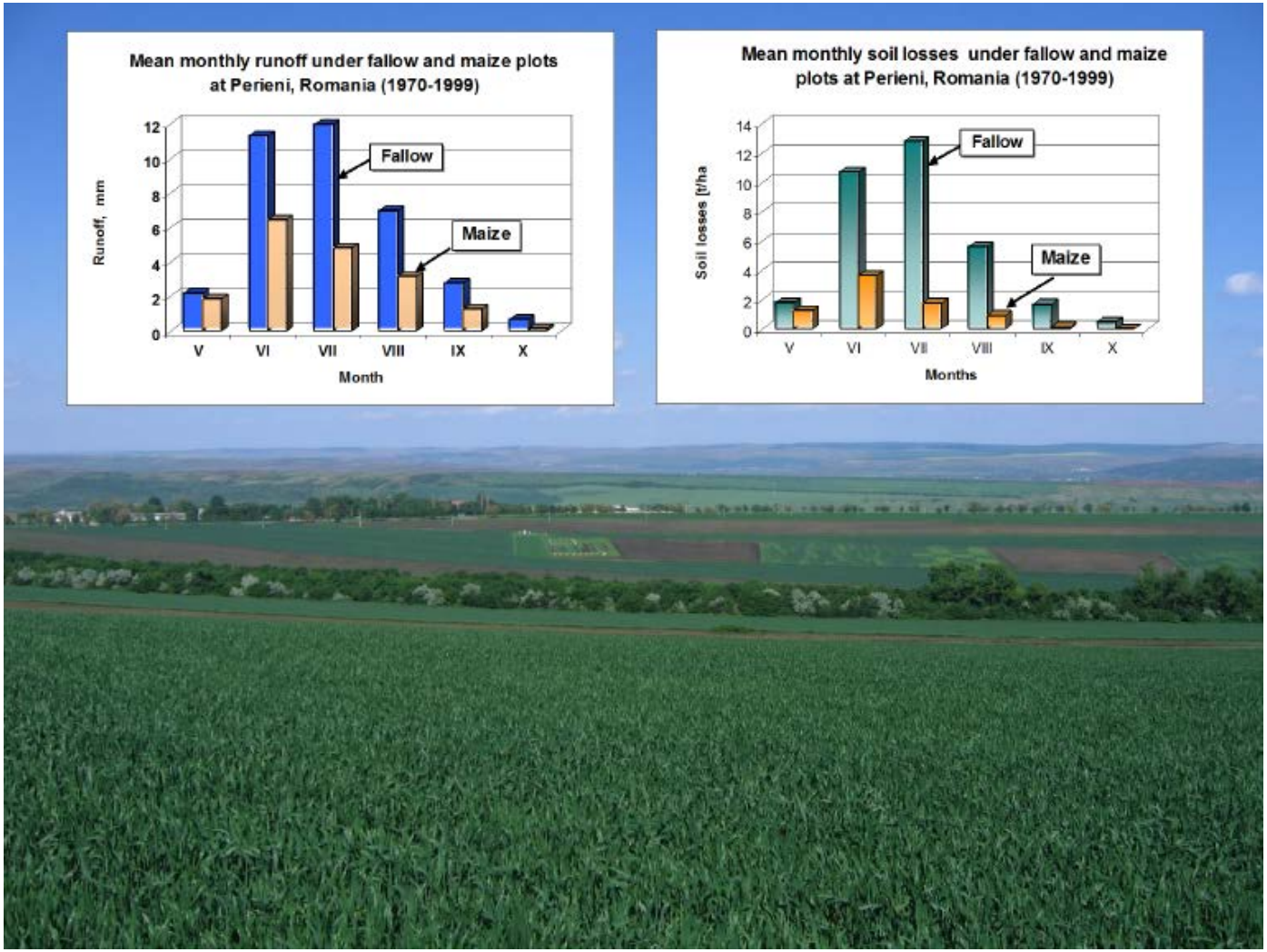
SONDAR
Soil Strategy Network in the Danube Region

creating the future
Programm zur grenzüberschreitenden Kooperation ÖSTERREICH - UNGARN 2007-2013
AUSZTRIA - MAGYARORSZÁG Határon Átnyúló Együttműködési Program 2007-2013

Soil Erosion in Romania

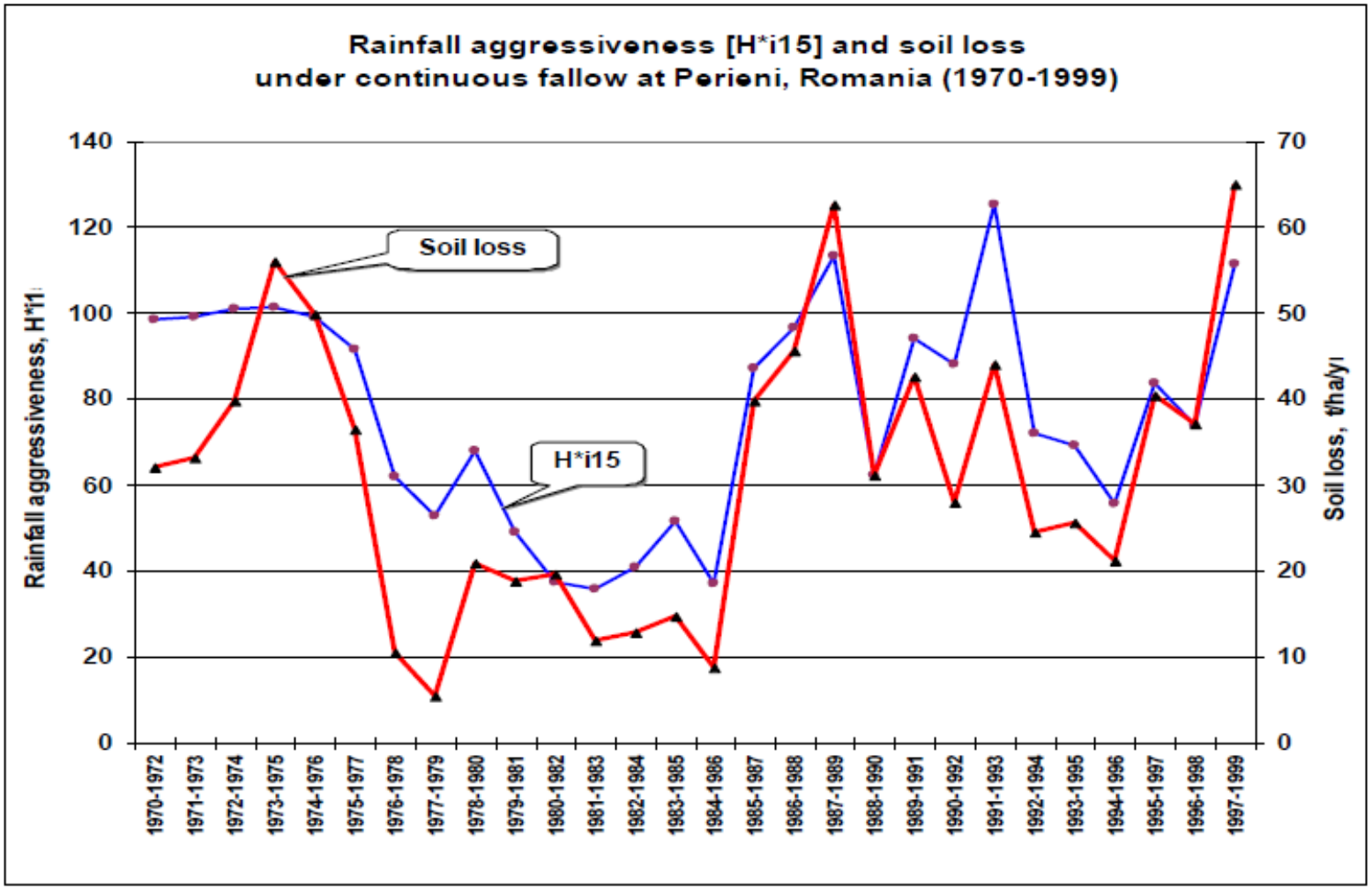
Soil Erosion in Romania

Soil Erosion in Romania

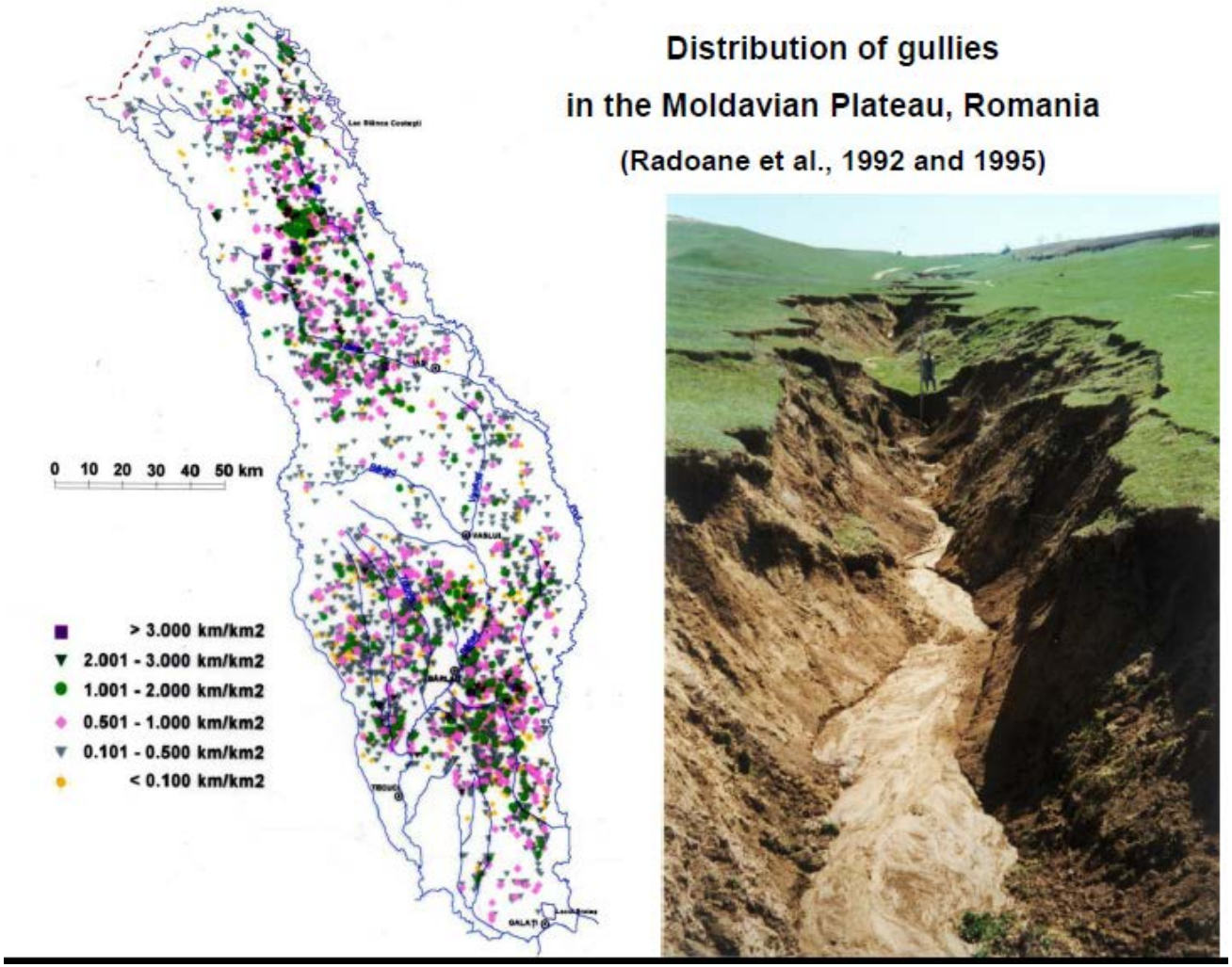


Soil Erosion in Romania

Soil Erosion in Romania

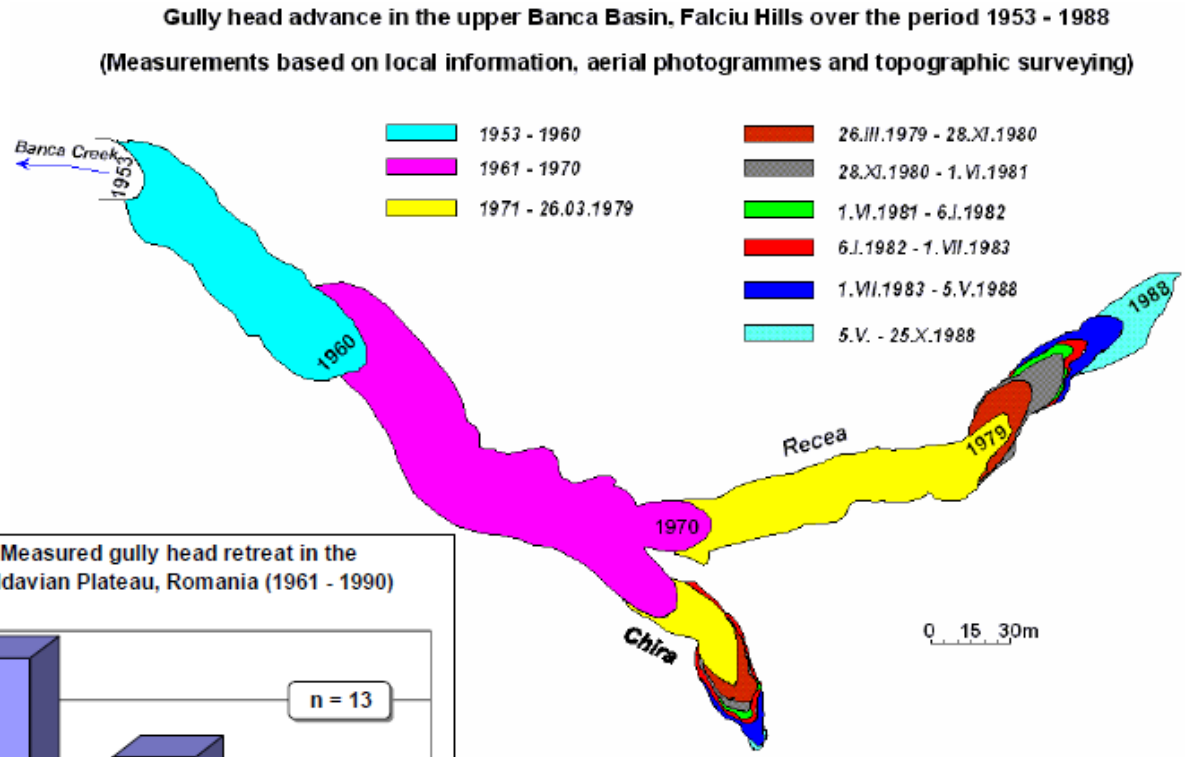


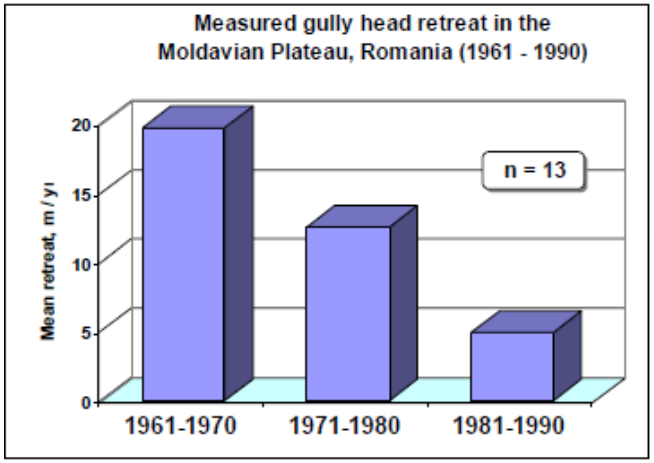
Soil Erosion in Romania



Soil Erosion in Romania

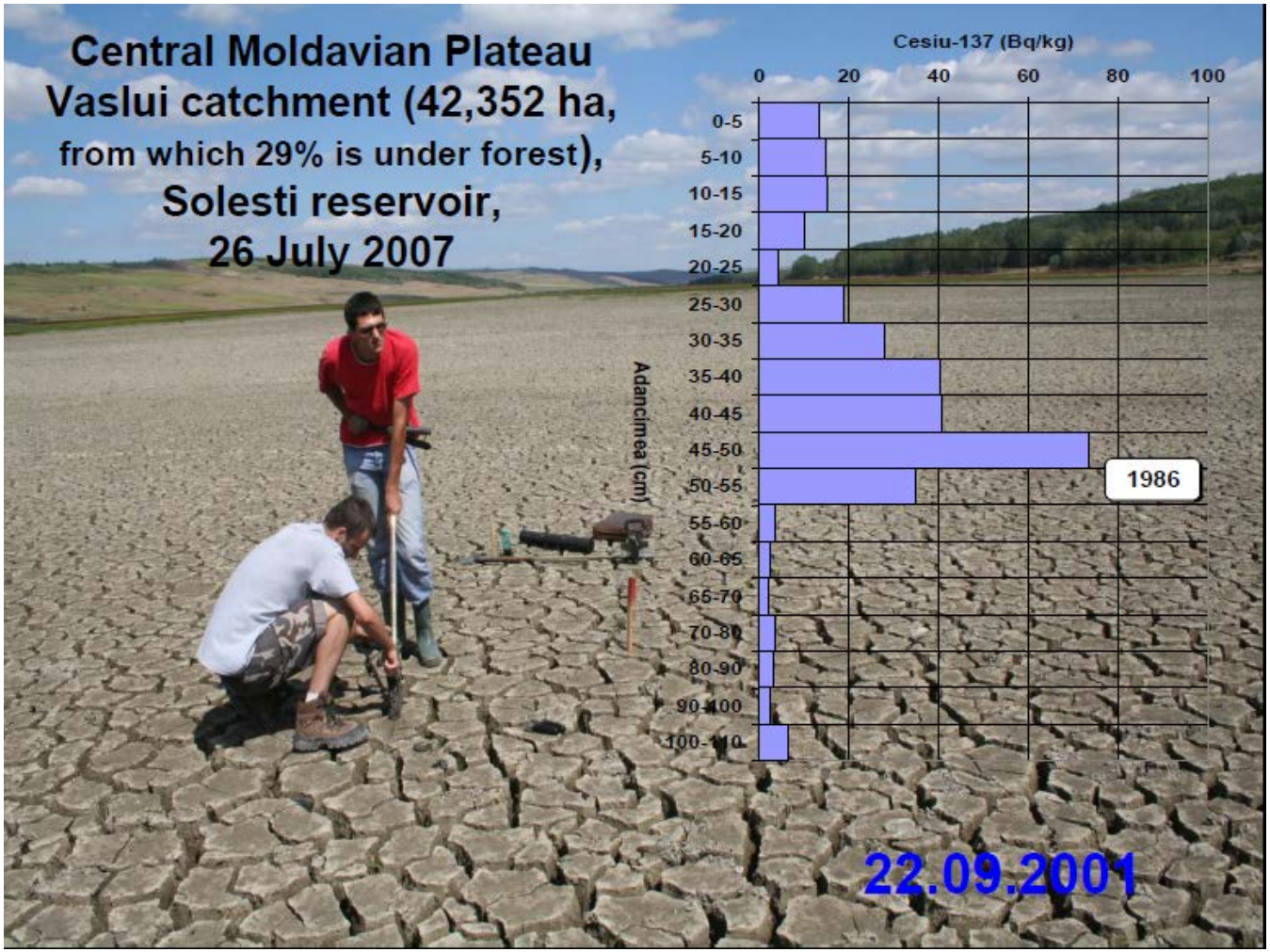
Soil Erosion in Romania





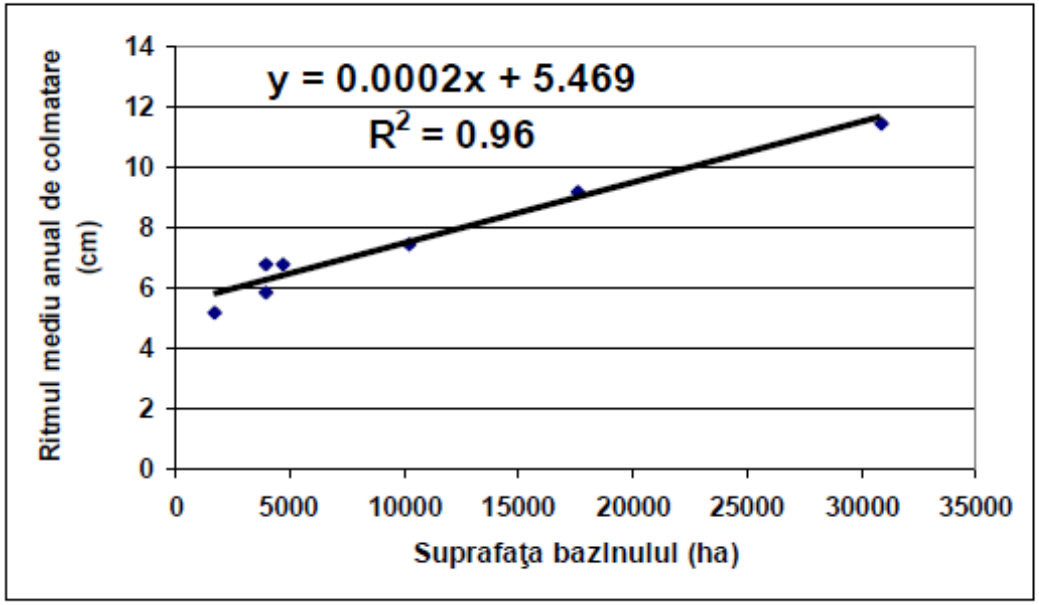
Soil Erosion in Romania

Soil Erosion in Romania



Soil Erosion in Romania

Relationship between the mean annual sedimentation rate and drainage area within the Tutova Rolling Hills, Romania



Soil Erosion in Romania

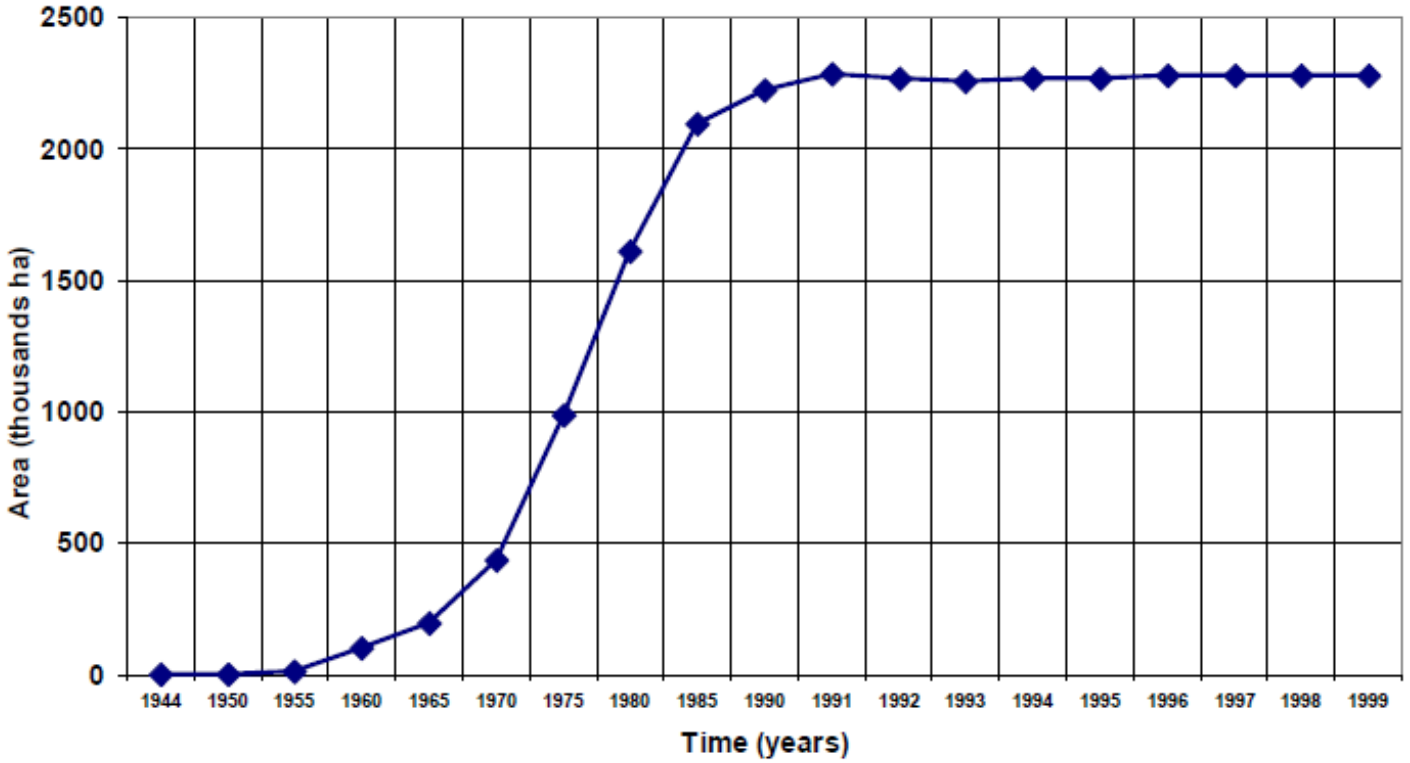
SOIL CONSERVATION

- **Agricultural land subjected to water erosion averages 6.4 mil ha (42.6%) of the total.**

- **By the end of 1989, as much as 2.2 mil ha, equating to 30% of agricultural land at risk of erosion, was adequately treated with conservation measures.**

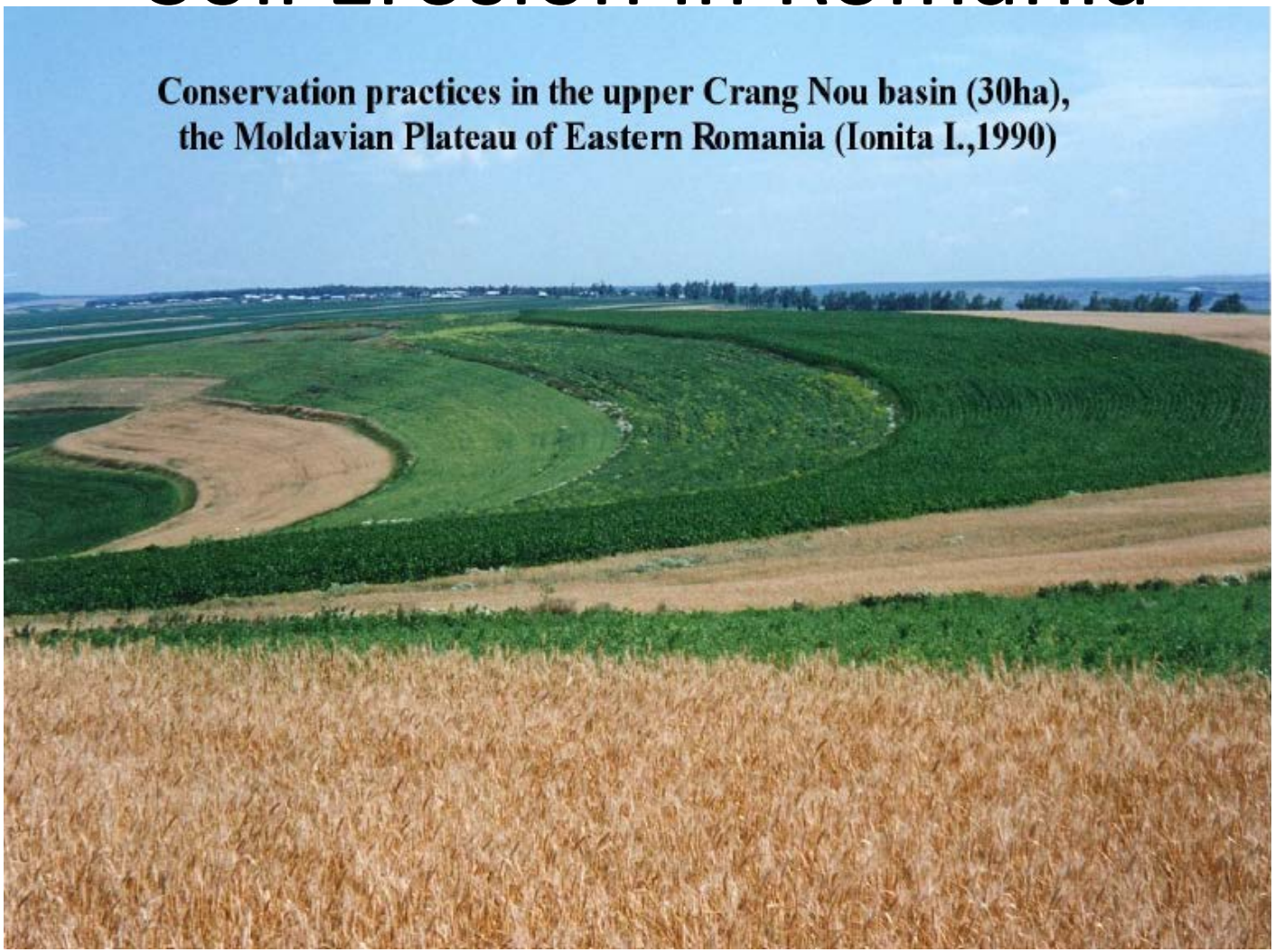
Soil Erosion in Romania

Development of the Conservation Practices in Romania (1944 – 2000)



Soil Erosion in Romania

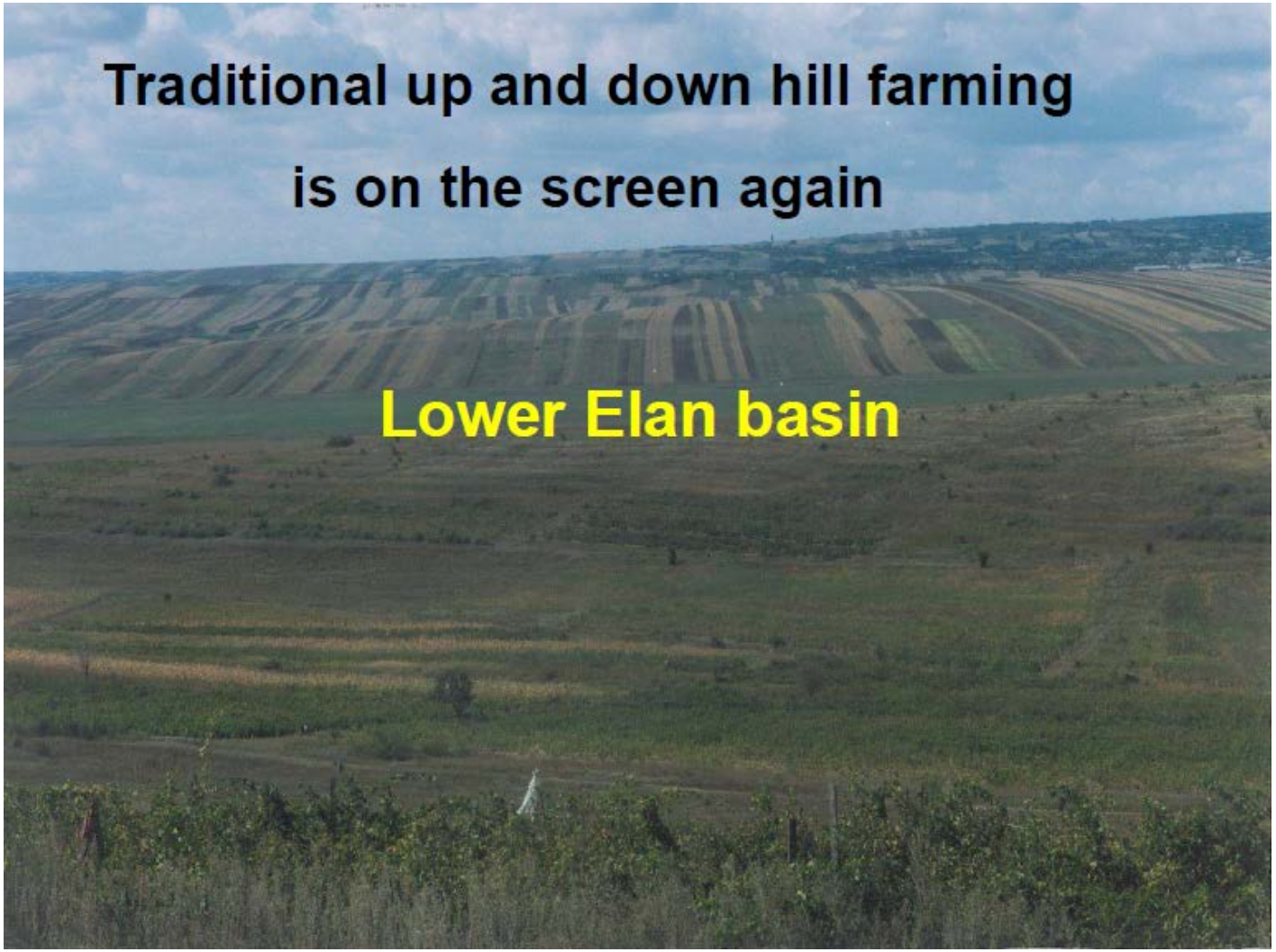
Soil Erosion in Romania



Soil Erosion in Romania

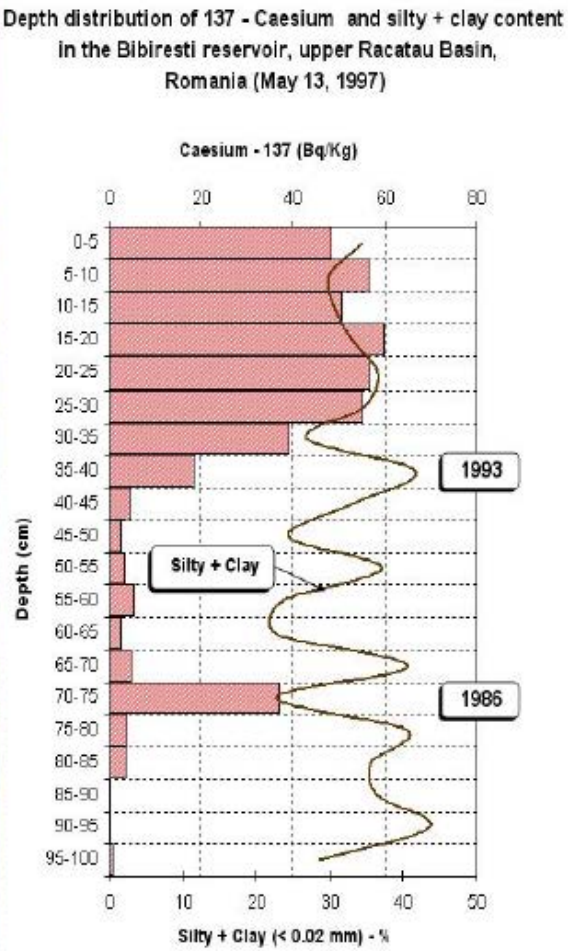
Soil Erosion in Romania

Soil Erosion in Romania



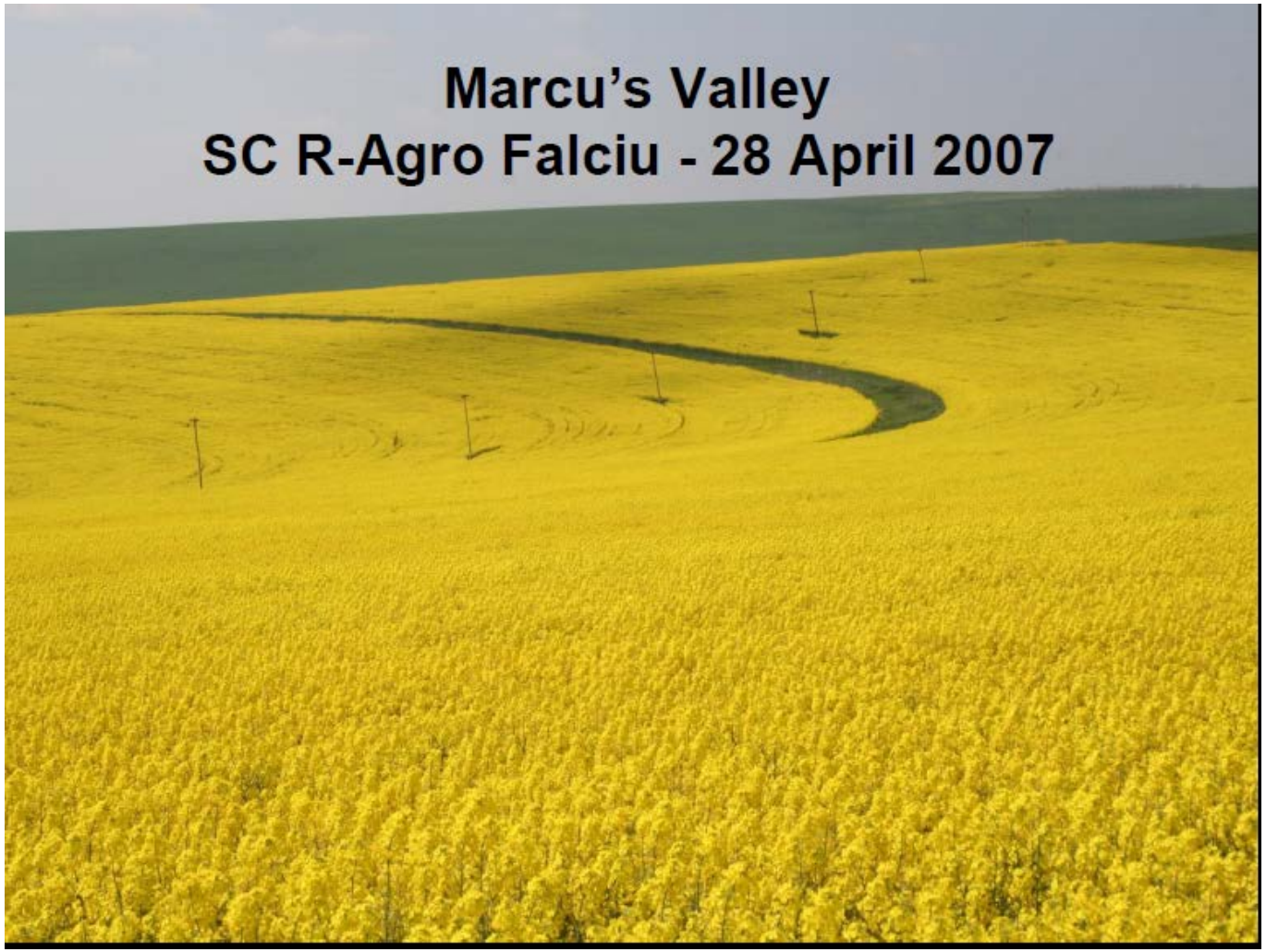
Soil Erosion in Romania

Soil Erosion in Romania



Soil Erosion in Romania

Soil Erosion in Romania



Soil Erosion in Serbia

Soil Erosion in Serbia

The EU Thematic Strategy on Soil Protection

The major treats to soil identified so far

→ Soil erosion

→ Decline in soil organic matter

→ Soil contamination

→ Salinization

→ Physical degradation (compaction)

→ Soil sealing

→ Floods and landslides

Soil Erosion in Serbia

The national strategy for preserving national resources and goods (Serbia, 2010)

The major treats to soil identified so far – in order by intensity of a treat

→ Soil sealing

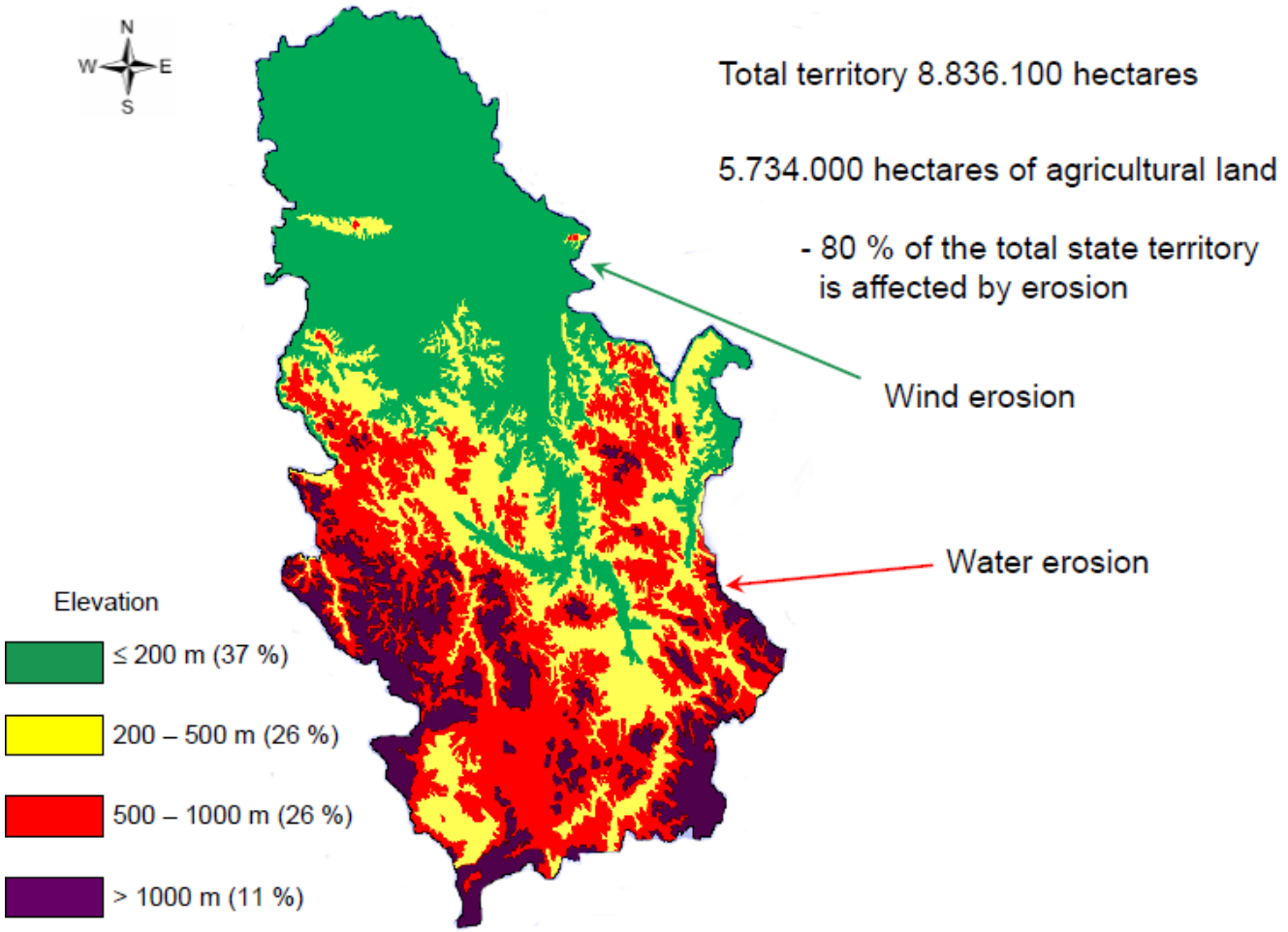
→ Decline in soil organic matter

→ Soil acidification

→ Soil contamination

→ **Soil erosion**

Soil Erosion in Serbia



Soil Erosion in Serbia

Methods for annual soil erosion risk estimation implementing in Serbia:

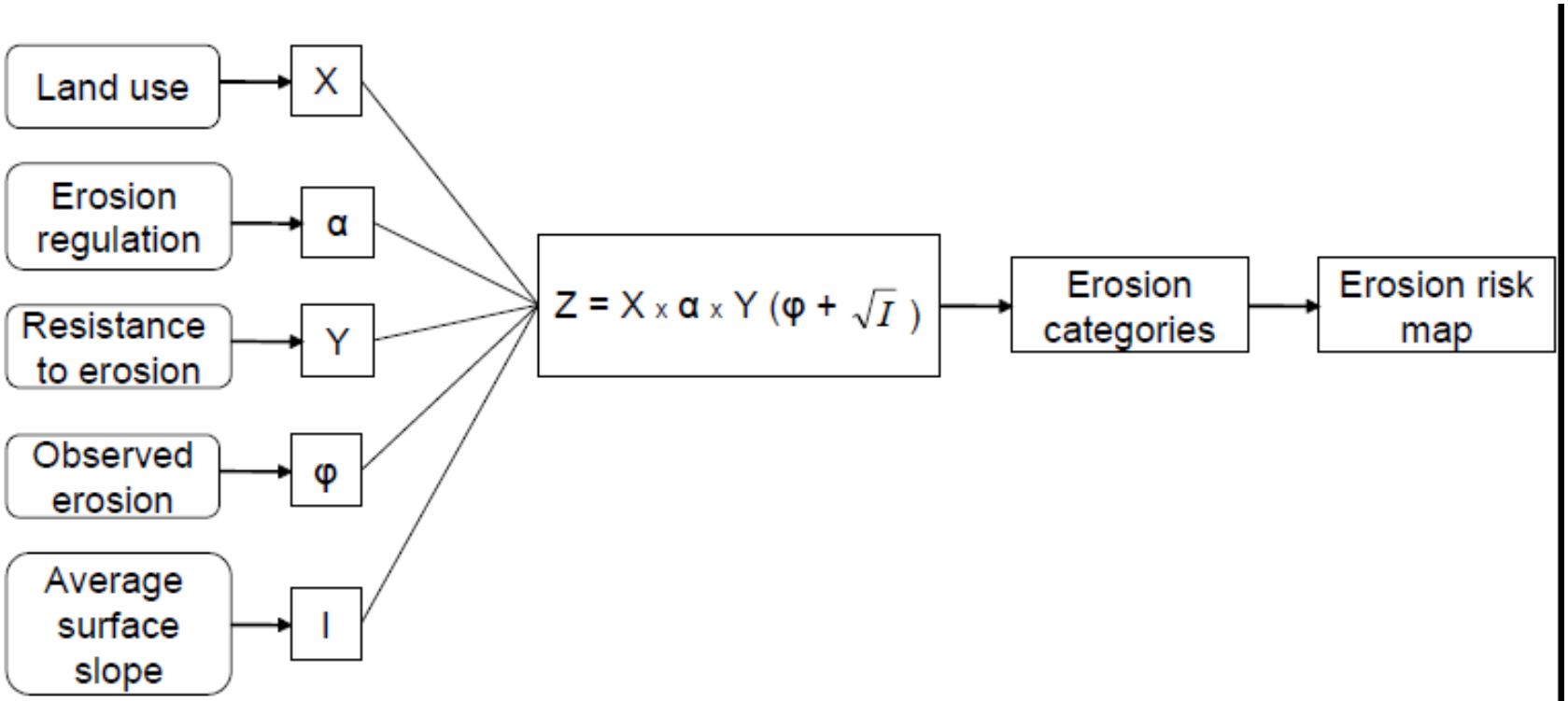
→ Universal Soil Loss Equation (USLE) (Wischmeier & Smith, 1978)

→**Erosion coefficient - Z** (Lazarević, 1985)

- Proposed by engineers from the Institute for Development of Water Resources "Jaroslav Černi", Belgrade

- Official quantitative indicator of erosion risk, according to Regulation for program of systematic soil quality monitoring, indicators for evaluation of soil degradation risk and methodology for remediation programs development (Sl. glasnik RS 88/2010)

Soil Erosion in Serbia



Flowchart for creating erosion risk map based on erosion coefficient (Z)

Soil Erosion in Serbia

Erosion categories based in the erosion coefficient Z

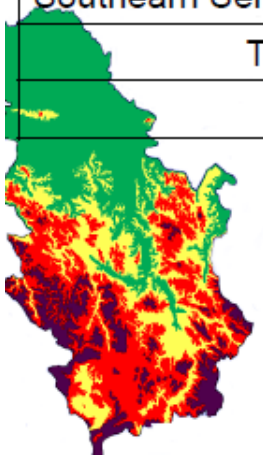
Erosion category		Z (Erosion coefficient) interval	Wp* [t ha^{-1} y^{-1}]
I	Extreme erosion	Z > 1.0	> 45
II	Strong erosion	0.71 < Z < 1.0	37.5
III	Medium erosion	0.41 < Z < 0.7	15
IV	Light erosion	0.2 < Z < 0.4	7.5
V	Very light erosion	Z < 0.2	1.5

*Wp – Predicted sediment yield = Soil loss

Soil Erosion in Serbia

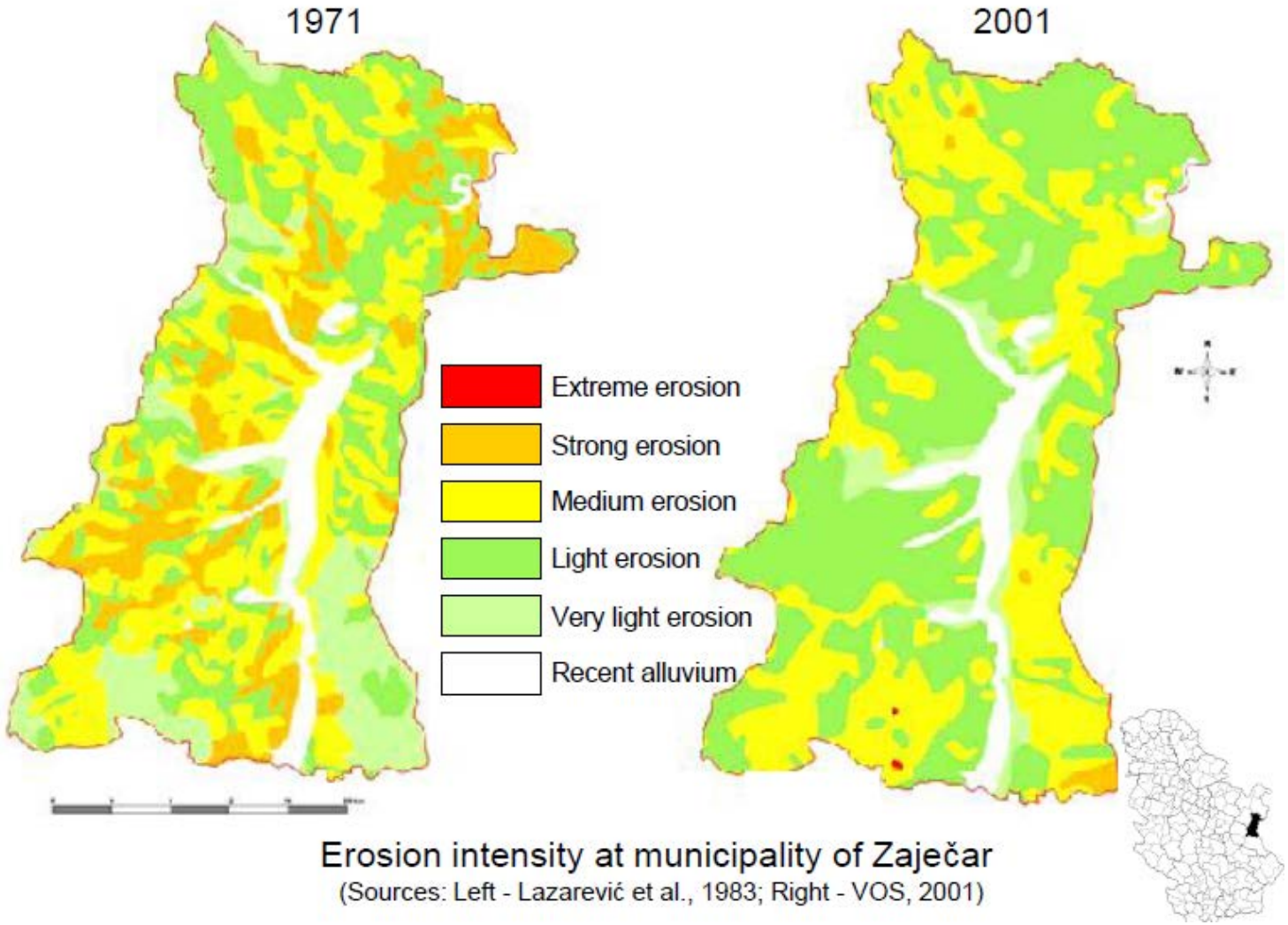
Estimated distribution of water erosion in Serbia (based on erosion categories)

Region	Area [hx1000]	Water erosion category				
		Extreme (>45 $tha^{-1}y^{-1}$)	Strong (37.5 $tha^{-1}y^{-1}$)	Medium (15 $tha^{-1}y^{-1}$)	Light (7.5 $tha^{-1}y^{-1}$)	Very light (<1.5 $tha^{-1}y^{-1}$)
		[hx1000]				
Northern Serbia	2150.6	4.8	33.6	94.7	1519.3	498.2
Westearn Serbia	1490.2	57.8	214.9	487.0	539.4	191.1
Central Serbia	1118.0	11.0	140.7	293.5	450.4	222.4
Eastearn Serbia	1500.9	62.9	178.9	444.8	684.0	130.3
Southearn Serbia	1487.7	105.0	206.0	313.2	740.3	123.2
Total	7747.4	241.5	774.1	1633.2	3933.4	1165.2
%	100	3.12	9.99	21.08	50.77	15.04



Estimated soil loss is below EU set target of 10 t h^{-1} annually at approximately 65 - 70 % of the territory

Soil Erosion in Serbia



Erosion intensity at municipality of Zaječar
(Sources: Left - Lazarević et al., 1983; Right - VOS, 2001)

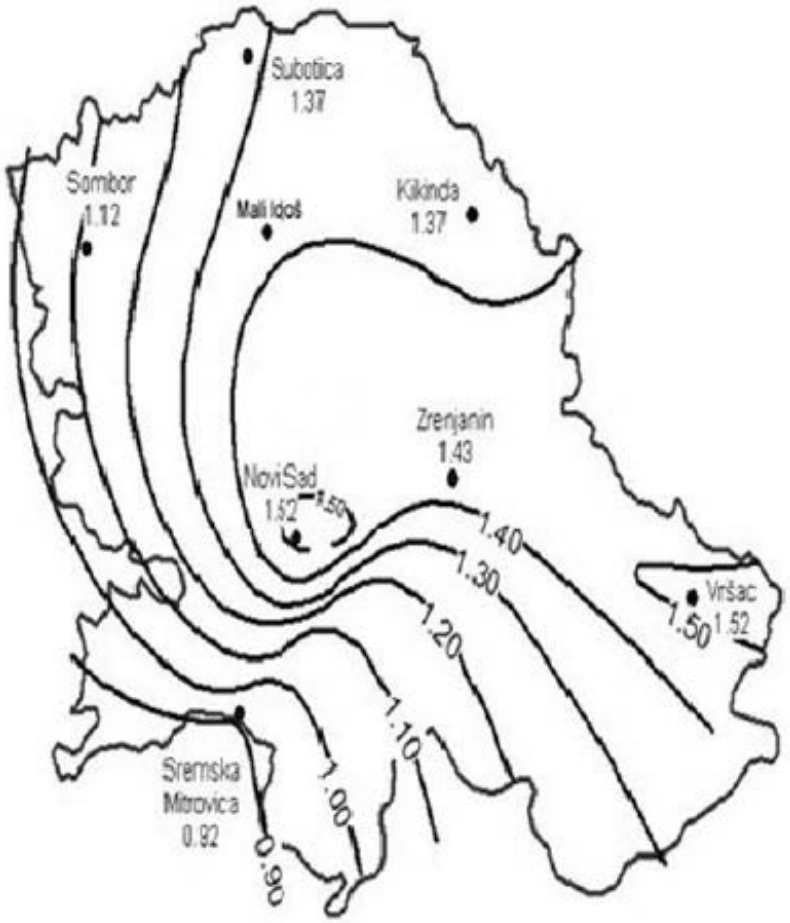
Soil Erosion in Serbia

Wind erosion in Serbia

Affects approximately 25 % of the state territory

- 18 % in province of Vojvodina

Soil Erosion in Serbia



Intensity of wind erosion (t h^{-1} y^{-1}) in autonomous province of Vojvodina

Soil Erosion in Serbia

Legislative frame for soil protection against erosion

Low on agricultural soil
(Sl. Glasnik 62/2006)

Low on water
(Sl. Glasnik 30-10/2010)

Regulation for program of systematic soil quality monitoring, indicators for evaluation of soil degradation risk and methodology for remediation programs development
(Sl. glasnik RS 88/2010)

National strategy for preserving national resources and goods (2010)

Elements for identification of erosion area

- Soil type
- Soil texture
- Soil water/temperature properties
- Topography
- Soil cover density
- Soil use
- Climate
- Hydrological conditions
- Erosion causing factors
- Coefficient of erosion Z

Erosion areas identification, monitoring, mapping, protection and repairing are obligatory provided by districts – regional centers of authority (29) and municipalities

Soil Erosion in Serbia

Measures to prevent erosion (Low on Agricultural soil, 2006)
1) Temporarily or permanent prohibition of pastures and meadows (and other terrains) plowing for establishment of annual crops
2) Crop rotation
3) Tillage systems
4) Planting shelterbelts
5) Planting perennial trees
6) Ban on grazing livestock for a limited time, or limiting number of grazing animals on a certain surfaces
7) Infrastructure constructions
8) Ban on felling of forests and forest plantations above the affected parcels
9) Other measured

→ Control of the implementation of the erosion measures is provided by competent body of the local community

→ The Low on Agricultural soil obligate that biological measures should be implementing each year to at least 4% of new areas of total area affected, susceptible or endangered by erosion

Soil Erosion in Serbia

Problems to be solved
1) Creation of erosion risk map for the entire state territory, rather then for separate districts
2) Harmonization of the risk assessment method on two levels (national and EU)
3) The low should obligate standardized procedure for erosion risk assessment, instead of different (new) projects for each district
4) The low should consolidate the current terms “erosion zone” (terrain affected by erosion at different intensity) and “erosion area” (terrain susceptible to erosion, but without visible signs of erosion)
5) The low should oblige the land users to implement the measures to prevent erosion or allow implementation of repair project, if necessary (financed by state or local governments)

Soil Erosion in Serbia

Work currently in progress....

1) Formation of digital erosion map for the entire state territory

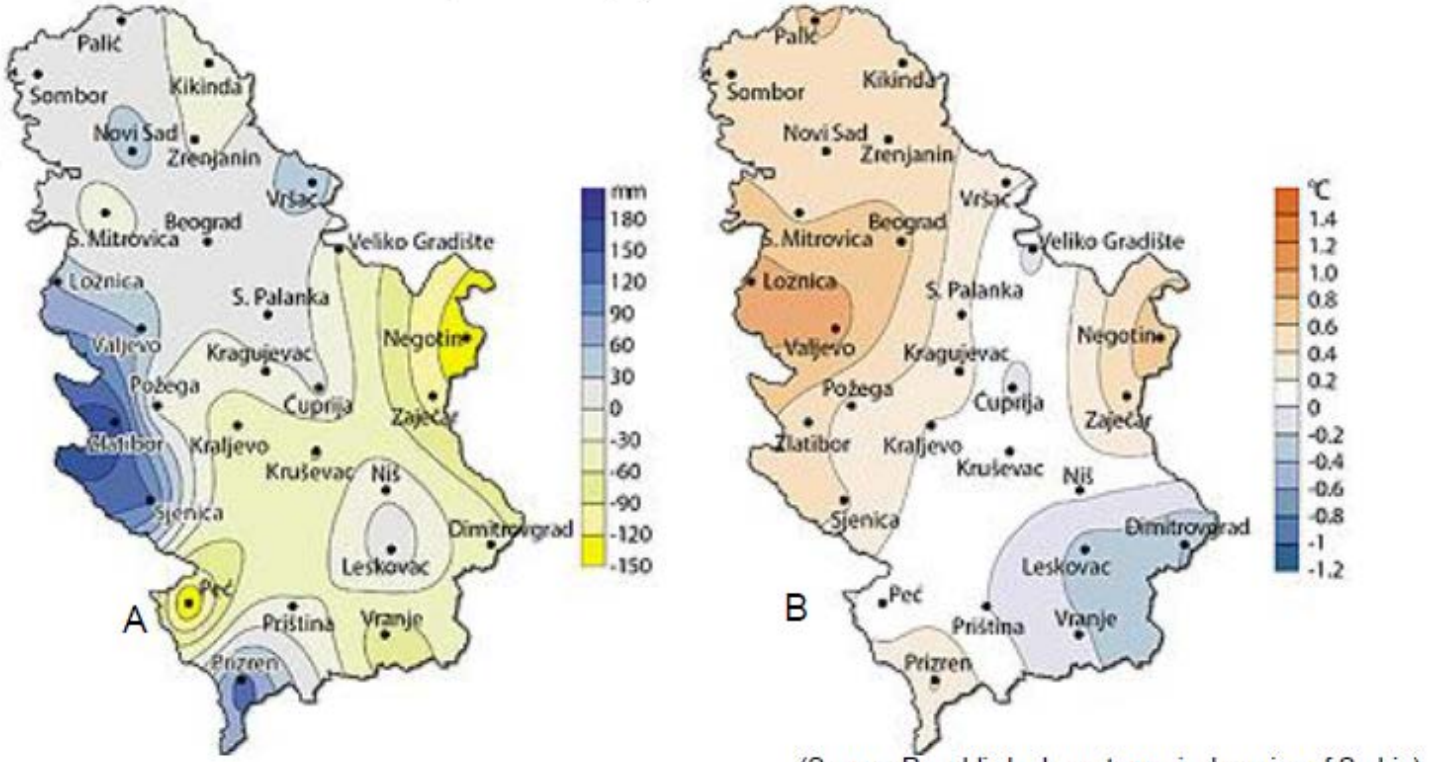
2) Constitution of *Serbia's Water Information System - VIS* (geo-informative system for monitoring the status of the torrent flows, the changes in erosion, and the facilities for protection against erosion)

3) State Project for planned planting of shelterbelts in the province of Vojvodina

4) Projects for torrent flows regulation at the most endangered areas

Soil Erosion in Serbia

Trends in the average annual precipitation (A) and temperature (B) from 1954 to 2004



(Source: Republic hydrometeorogical service of Serbia)

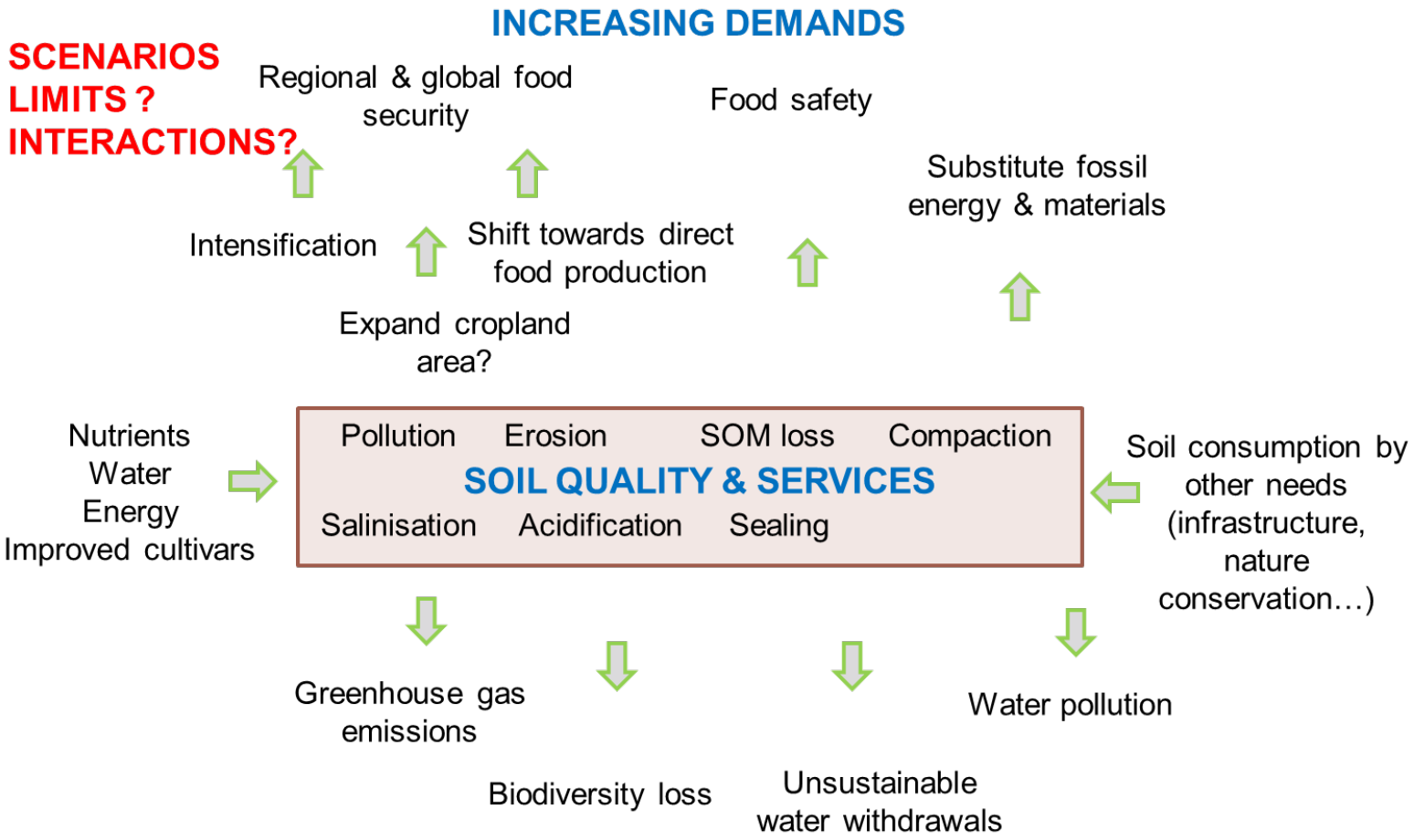
Possible effects of climate change on soil erosion?

Soil Erosion in Serbia

Soil Erosion in Serbia

Soil Erosion in Serbia

Summary


INCREASING DEMANDS
SCENARIOS
LIMITS ?
INTERACTIONS?
Regional & global food security
Food safety
Substitute fossil energy & materials
Intensification
Shift towards direct food production
Expand cropland area?
Nutrients
Water
Energy
Improved cultivars
Pollution
Erosion
SOM loss
Compaction
SOIL QUALITY & SERVICES
Salinisation
Acidification
Sealing
Soil consumption by other needs (infrastructure, nature conservation…)
Greenhouse gas emissions
Biodiversity loss
Unsustainable water withdrawals
Water pollution
ENVIRONMENTAL QUALITY