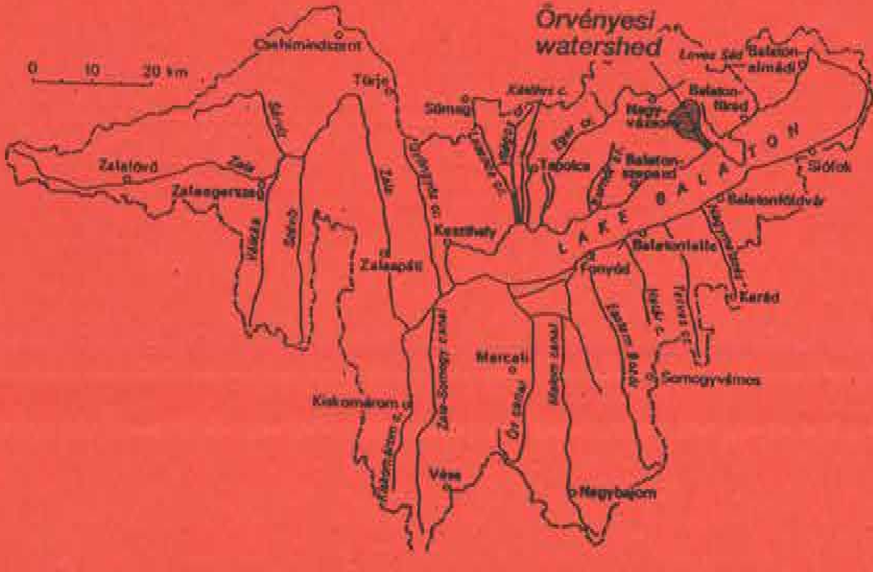
NEWSLETTER 2 + 3 / 1997

ESSC EUROPEAN SOCIETY for SOIL CONSERVATION



Catchment area of Lake Balaton

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THE BALATON PROJECT

Preface

In 1995 the Editor-in-Chief presented a newsletter, which contained nearly 30 pages, reporting on soil management in Norway. The feedback from our members showed a high rate of appreciation for such "directed" issues. The Executive Committee of our Society has, therefore, decided in 1996 to continue to produce occasional issues with "closed themes". We are pleased to offer a second issue of this kind.

This issue of the ESSC Newsletter is dedicated to the "Balaton-Project" carried out in 1990-1995 within the framework of an international project of the German Research Fund (Deutsche Forschungsgemeinschaft), the Hungarian Academy of Sciences and the Hungarian National Scientific Research Fund (OTKA) under cooperation of the Institute of Physical Geography, University of Trier, and the Geographical Research Institute of the Hungarian Academy of Sciences. The research also formed part of the MEDALUS II (Mediterranean Desertification and Land Use) collaborative research project under the Environment Programme of the European Community. The financial support from these institutions is gratefully acknowledged.

The German working group was: W. Braunschweig, B. Bernsdorf, S. Bernsdorf, R. Hansen, J.M. Hassel, B. Henzler, A. Schäfer, E. Tressel and H. Willger. Team leader: G. Richter and R.-G. Schmidt. About 100 students of the Applied Physical Geography section of the University of Trier supported the field work, especially the soil and landuse mapping and the rainfall simulations during their practical training.

The Hungarian working group was: T. Huszár, B. Kászap, D. Lóczy B. Márkus, E. Meszáros, G. Mezősi, E. Párkanyi, S. Papp, L. Szálai and G. Varga. Team leader: A. Kertész

The results of the research were first reported at the Balaton Symposium on 2nd and 3rd of May 1994 in Budapest. The contributions in this newsletter are shortened versions of those reports.

A. Kertész | G.Richter | R.-G. Schmidt

1. The study area

1.1 Introduction

A. Kertész and G. Richter

Lake Balaton is situated in the mid-western part of Hungary and has an area of 595 km^2. Its catchment of some 5774 km^2 comprises three subcatchments with different physical conditions (Fig. 1):

1. The largest part of the catchment belonging to the Zala river (2,622 km^2) is made up of hilly landscape and is under agricultural use.
2. Along the southern shore a series of elongated watersheds with low relative relief is typical.
3. Along the northern shore of the lake small catchments with high relief intensity, diverse geology and soils and a high variety of the landuse predominate. This area is 1128 km^2 in size.

The lake ecosystem is extremely vulnerable to sediment and nutrient input as:

- the lake has an average depth of only 3.2 m and a low water volume of only 1900 million m^3,
- some 57% of the average water input to the lake is lost by evaporation, and
- the outlet of the lake has to be closed most of the time in order to keep the water level as high as possible. The water exchange is, therefore, highly reduced, and pollutants and sediments stay in the basin for years.

The lake is exposed to environmental impacts caused by the chain of settlements along the shore, by tourists during the summer and by intensive agriculture in the catchment. The influx of sediment and solutes to the originates mainly from non-point pollution sources and contributes to its eutrophication and alkalization. Since the surroundings of the lake are the largest recreation area of the country and form an important contribution to the Hungarian economy, investigations on water conservation of the lake are of major significance.

The study area

One of the small catchments of the northern shore of the lake was selected for closer study. It was assumed that these small catchments with their high relief intensity and variety of the landuse are important sources of the non-point pollution of the lake. A comparison of the Zala and the Northern Catchment will help demonstrate their

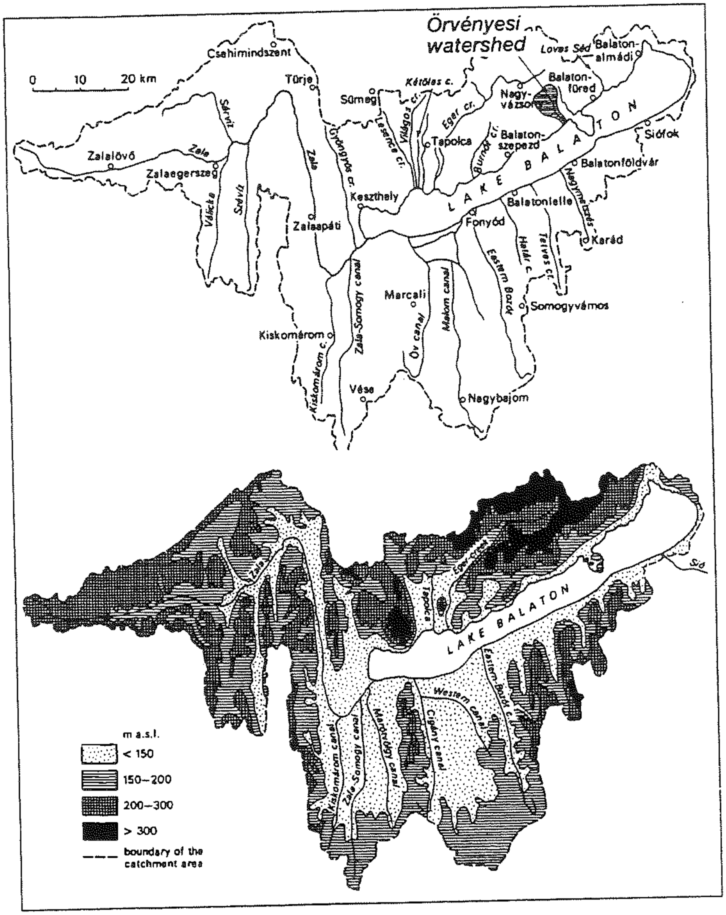

Figure 1: Catchment area of Lake Balaton

relative importance. A detailed analysis of the test area, the Örvényesi Catchment (24 km^2), forms the basis of extrapolation for the whole Northern Catchment (Fig. 1, upper part).

The detailed objectives of the investigations in the study area are:

1. The calculation of mean annual soil transport by soil erosion.
2. The measurement and calculation of the yearly transport of sediments and solutes from the test area into the lake.
3. Suggestions for erosion control and diminution of sediment transport and input of solutes into the lake.

Methods

The detailed analysis of the test area of Örvényesi Séd comprised first a detailed mapping of all the relevant parameters at the scale of 1 : 5000:

- slope categories, based on a digital elevation model,
- shape of the relief (convex and concave forms as respectively water divides and water collectors,
- the linear elements of the agricultural landscape (field roads, walls, terraces, ditches),
- soil texture classes,
- soil depth,
- humus content of the topsoil,
- stone content of the topsoil,
- landuse/vegetation, and
- the erotopes, the separate catchment areas of unconcentrated runoff.

The maps were digitized and stored in a GIS, organized by the computer programmes ARC-INFO and ARC VIEW.

For the assessment of the soil loss within the test area the Universal Soil Loss Equation (USLE) was applied. The main parameters R and K were calibrated by analysis of data from four pluviograph stations and by plot measurements under natural rainfall and rainfall simulation. Using the calibrated parameters, the potential soil loss was determined for each erotope of the test catchment. The potential annual soil loss of the catchment of Örvényesi Séd was then compared with the actual input of sediment into the lake at the gauging station at the catchment outlet. The amount of solutes leaving the test area and entering the lake was also measured. Based on these results and their extrapolation to the northern shore of the lake, proposals could be made to diminish the soil and nutrient input to the lake.

1.2 Relief, geology and soils

R.-G. Schmidt and W. Braunschweig

In the test area, the catchment of Örvényesi-Séd, the highest elevation is 416 m a.s.l. and the outlet is at 104 m altitude giving a relative relief of 312 m. The geology comprises mainly karstic Triassic limestones, dolomites and marls and their regolith (calcareous fragments embedded in clay matrix) as well as a mantle of unconsolidated deposits (loess, slope loess, colluvial sediments).

The catchment consists of three small basins, i.e. those of Pécsely, Klárapuszta and Vászoly (Fig. 2). They are characterized by a low relief with slope angles < 7°. The whole area is full of microforms of anthropogenic origin, like deep-cut tracks, graben and ditches.

The slope category map (see Fig. 2) shows the following distribution:

0 - 2°	17 %
>2 - 7°	43 %
>7 - 11°	21 %
> 11 - 15°	10 %
> 15 - 35°	7 %
> 35°	0.3 %

Gentle slopes are used as arable land (the 0-7° category makes up 60 % of the arable area) and steeper slopes as vineyards and orchards.

On loess and marl the soils are either rendzinas or medium to severely eroded brown forest soils. In lower lying areas meadow soils are typical. On hilltops the parent rock is often exposed. Soil texture depends largely on parent rocks (dolomite, limestone, marl and loess) resulting in most cases in a clayey, silty texture. Table 1 shows the names and the distribution of the texture classes. Silty clay is the dominant texture class. The skeleton content is in most cases not very significant (it is <10 % in 90 % of the analysed samples). The humus content is 2-4% in about 40 % of the soil samples and less than 2 % in 37% of the samples. Table 2 presents the frequency distribution of soil thickness classes.

Table 1: Soil texture classes and their frequency distribution

classes	code	% clay	% silt	% sand	frequency (%)
clay	T	65 - 100	0 - 35	0 - 35	0.8
weak silty clay	Tu2	45 - 65	30 - 55	0 - 25	20.3
medium silty clay	Tu3	35 - 45	40 - 65	0 - 25	27.3
strong silty clay strong clayey silt	Tu4/ Ut4	17 - 35	45 - 83	0 - 33	34.2
weak clayey silt medium clayey silt	Ut2/ Ut3	8 - 17	50 - 92	0 - 42	17.2
silt	U	0 - 8	80 - 100	0 - 20	0.2

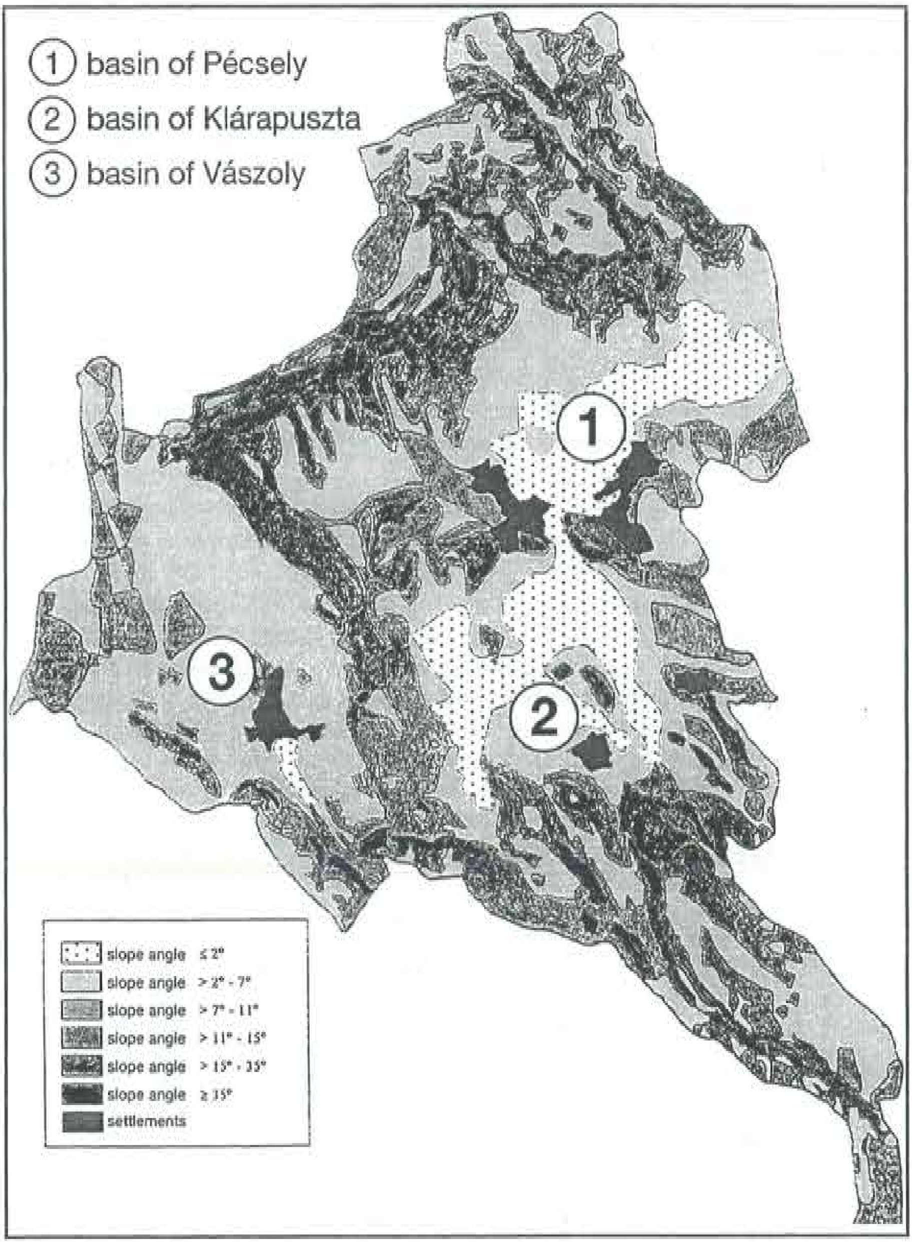

Figure 2: Slope category map of the Örvényesi watershed

Table 2: Frequency of the soil thickness classes

soil thickness (cm)	frequency (%)
0 - 30	21.4
> 30 - 60	39.7
> 60	38.9
total	100.0

1.3 Land use changes around Lake Balaton, Hungary

T. Huszár, A. Kertész and D. Lóczy

An attempt was made to reconstruct the history of land use changes over the Balaton Catchment using official statistics for municipalities merged into data series for the three major sub-catchments of the lake (Table 3). Our working hypothesis was that although land use changes have been primarily controlled by socio-economic processes, they are manifested to a variable extent in the three subcatchments with considerably different physical conditions. At the beginning of the 20th century, small-scale farming was typical in the area. After World War II fundamental changes took place. Small-plot farming was replaced by large-scale, mechanized farming. Land collectivisation, completed by 1961, involved the creation of fields of mechanizable size (tens or even hundreds of hectares). Marginal land or small plots were abandoned or allotted to members of the cooperative farms to be cultivated as household plots in order to produce for the market and obtain extra incomes.

In the southern subcatchment, comprising mostly loess-mantled hills, the proportion of the land under agriculture has fallen below 60 per cent recently, but arable fields still extend over two-thirds of the area in agricultural use. The peak was reached in the late 1960s (72 %), when production in agricultural cooperatives was profitable and large investments were made into the expansion of production both extensively and intensively. Since the 1970s, however, the trend has reversed and thousands of hectares are being converted into gardens and orchards. In contrast with the Northern Catchment, this land use group has almost no tradition here (it did not even cover 1 per cent of the agricultural land prior to World War I). The natural endowments are not favourable for grapevine, since the percentage of south-facing slopes is relatively small. Consequently, a recent decreasing trend is observable. With the drainage of broad valley floors, the area of meadows was reduced, but the transformation of stock-breeding, i.e. stable keeping on fodder instead of grazing, resulted in a lower demand for pastures.

The expansion of forests from 15 to 21 per cent (slightly above the national average, see Table 3) should be regarded a positive development. The origins of tourism date

Table 3: Land use changes in Lake Balaton Catchment (1895 -1984)

Zola catchment	**1895**	**1913**	**1935**	**1962**	**1966**	**1971**	**1984**
agriculture	70.2	74.2	74.3	69.5	67.5	69.4	61.8
forest	24.7	20.5	20.5	22.8	24.4	25.4	27.2
derelict	4.9	5.1	4.9	7.2	7.4	8.7	10.2
Northern catchment	**1895**	**1913**	**1935**	**1962**	**1966**	**1971**	**1984**
agriculture	50.9	51.1	52.5	45.5	43.9	44.0	40.4
forest	24.7	23.8	24.0	24.4	25.3	25.8	25.8
derelict	23.9	24.8	22.8	29.4	30.1	29.4	33.1
Southern catchment	**1895**	**1913**	**1935**	**1962**	**1966**	**1971**	**1984**
agriculture	64.7	68.2	67.8	62.8	59.8	60.9	57.2
forest	15.2	11.0	13.2	15.6	17.4	17.9	21.1
derelict	19.4	20.3	20.3	18.6	23.6	20.7	20.8

back to the middle of the last century. In the 1970s infrastructure developments and the widespread allotment of land for summer-house building led to a 3 per cent increase of derelict land between 1971 and 1984.

In the northern subcatchment the expansion of plantations (orchards and vineyards) was motivated by the rapid growth of lakeshore resorts form the 1960s. Every summer hundreds of thousands of visitors have to be supplied with fruits, vine and vegetables. Parallel with this process arable land shrank substantially in the post-war period. Meadows and pastures (treated as one category in the statistics from 1984) only show minor changes over the decades since they were, even in the first place, restricted to tracts of land hardly suitable for any other purpose. This also applies to forests and reed-beds; only partial successes can be mentioned in the afforestation and reed-bed restoration programmes. Some of the barren limestone and dolomite ridges were planted with pine (*Pinus nigra* and *P. silvestris*) in the 1950s. The conifers do not find optimal conditions on calcareous rocks and they are alien to the landscape. In the following decades stream channelisation and wetland drainage reduced the areal extension of wet meadows. Their heavy soils, however, were of little use for farming.

The westernmost portion of the Balaton region, the Zala Catchment is an area of rather low agricultural potential, where land use is closely adjusted to topographic conditions. It is typical that the peak of arable land extension was reached before World War II (63% in 1935) and no attempt was made to increase this area further in the 1960s. The recent decline conforms with the national trend. The cooler and wetter climate does not favour the plantation of fruit trees and grapevines, but vegetable gardening has almost trebled its areal extension over this hundred years time span. The valley floors (if they are not built up) remain to be used as meadows. The decline in stock-breeding, however, also manifests itself, since pastures cannot even maintain their 10 per cent share. The reed-beds of the one-time Little Balaton swamp (drained in the 1950s) are now being restored. Their role in the filtering of the Zala river water before entering the lake is crucial.

Like all Eastern Europe, Hungary experienced a change of political system in 1989-90. Under the christian democratic government a land privatisation programme was launched and those who lost their land in forced collectivisation or suffered any negative distinction under the communist rule could buy land at auctions for the so-called recompensation vouchers allotted to them by a state agency. The land areas of the former cooperative farms were in part distributed among private holders. By May 1994, 70 to 75 per cent of agricultural land was already privately owned. This, however, has not yet resulted in an explosion of the previous pattern of land use, since most of the elderly new owners do not undertake to cultivate their land themselves but lend it to the former cooperative farms, which are now reorganised as joint-stock companies. It is to be expected, however, that more and more smallholders will establish the conditions of private farming and the countryside will show a more varied picture in respect to land use. The gradual aging of the rural population is very difficult to reverse. Therefore, in many areas intensive cultures (orchards and vineyards) are affected by the danger of being abandoned or, together with their old buildings, are being transformed to serve tourist functions.

The land use map of Örvényesi watershed is presented in Figure 3 as a typical example of the Northern Catchment. In the central part of the catchment meadows and swamps prevail because of the high groundwater level. The footslopes with a low inclination are covered by large fields of 40-130 ha each. The typical rotation is winter wheat - rape or sunflower - maize - maize - barley. The steeper slope sections are used as vineyards, orchards or gardens and in some cases the land is abandoned and covered by shrubs. Since 1990 the large vineyards of the cooperative farm have been completely distributed among private holders. The majority of the arable land, however, is still cultivated by the cooperative, and the large size of the fields has not changed.

The land use categories of Örvényesi Catchment are as follows:

Arable land	18 %	Vineyard	12 %
Meadow	18 %	Garden	1 %
Abandoned land	9 %	Shrub	8 %
Forest	30 %	Swamp	2 %
Settlement	2 %		

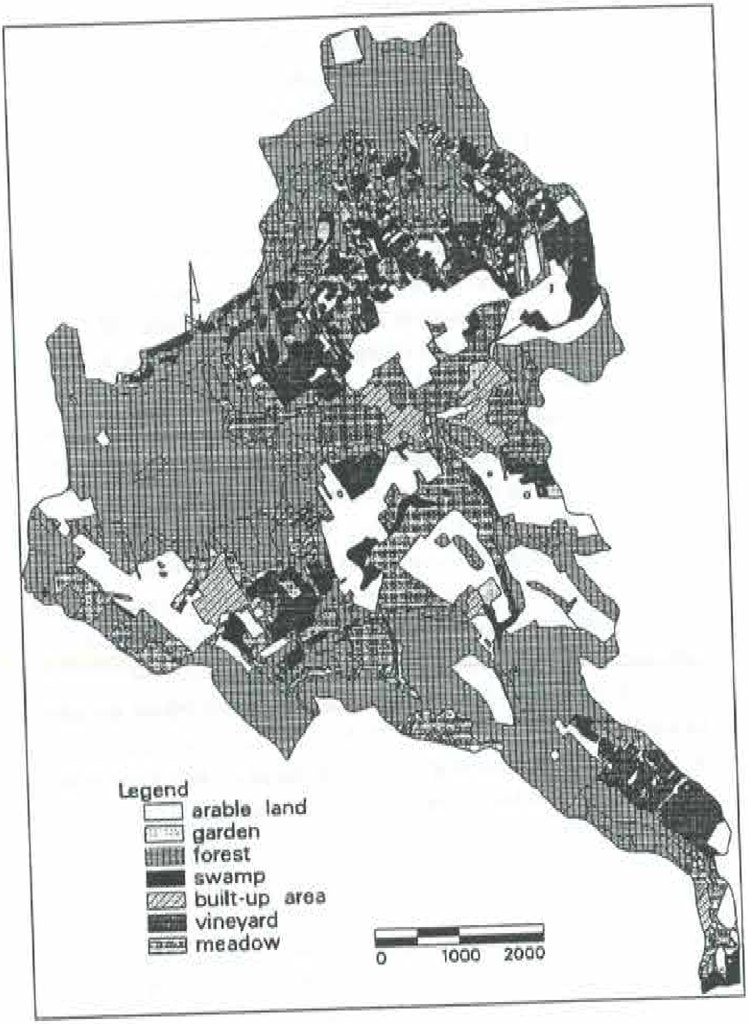

Figure 3: Landuse of the Örvényesi watershed

2. Field work, experiments and methods

2.1 Precipitation and rain energy

Birgitta Henzler

The climate of Hungary has a transitional character between continental, mediterranean and atlantic types. It belongs to the Cfb - climate according to Köppen, i.e. it is a moderate continental climate. The Northern Catchment belongs to the climatic region of western Transdanubia. The mean annual rainfall is 630 mm of which 260-350 mm fall in the growing season (summer half year). The precipitation maximum is in June.

For the identification of the rainfall energy, rain gauge data of three stations were used (Fig. 4), namely Pécsely (data between 1984-91) in the catchment and Balatonakali (1979-91) and Balatonszemes (1979-91) near but outside. Rainfall registrations cover the period between May and October in each case.

For the calculation of the R factor rainfall events >10 mm and >12.5 mm respectively were used (Table 4). The calculation followed the method of Wischmeier & Smith (1978) so that EI is given in kJ/m^2. In the original version of the USLE a period of 6 hours without rain was required to separate two rainfall events. According to the results of measurements at the station of Mertesdorf near Trier in Germany and at Csákvár in Hungary the six-hour separation value cannot be applied to Central Europe. Under the climatic conditions often occurring, small cyclonic showers, which do not produce runoff and soil loss, are considered by the model to be erosive,

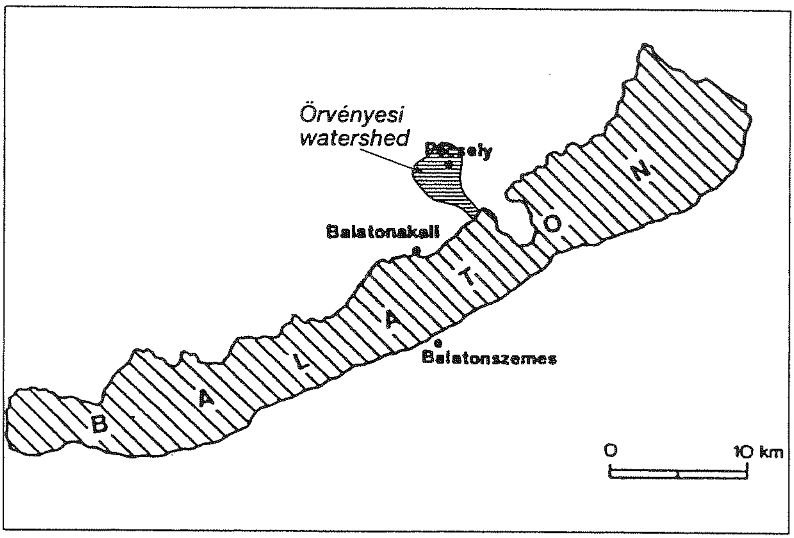

Figure 4: Pluviograph stations near the Örvényesi watershed

if the rainfall amount exceeds 10 mm per day. As a consequence of this, the value of the R factor is overestimated. It was, therefore, decided to separate two rainfalls by a timespan of only half an hour.

According to the results of plot measurements at Csákvár station between 1989 and 1995 the occurrence of erosive rainfall events during the winter half year is very rare and the amount of soil loss is also unimportant. Therefore limiting the calculation of the R factor to the measurement period May-October is justified.

The summer rainfall amount is about 300 mm for each of the three stations. The number of erosive rainfalls > 9.9 mm is only about 8 per cent of the total number of rainfall events. They represent, however, 41 per cent of the rainfall amount and 68 per cent of the rainfall energy of the summer season (Table 4). Applying a 30 minute separation interval, the value of the R-Factor is reduced from R = 50 to R < 40. The station of Balatonakali was chosen to be representative. Its R-factor value of 36 was, therefore, applied in modelling based on the USLE.

Table 4: R-factor values for the gauging stations Balatonakali, Balatonszemes and Pécsely (top) and precipitation and rainfall energy for Pécsely based on 1984-1991 data

Station	R-factor value N > 12.7 mm	R-factor value N > 10 mm
Balatonakali	31	36
Balatonszemes	38	--
Pécsely	--	37

Precipitation classes (mm)	No. of events	%	cum. %	Precipitation (mm)	%	cum. %	R-factor (kJ.mm/m².h)	%	cum. %
0 - 10	625	92.3	92.3	166.46	58.9	58.9	12.00	32.4	32.4
> 10 - 12	12	1.8	94.1	16.43	5.8	64.7	1.98	5.4	37.8
> 12 - 14	6	0.9	95.0	9.90	3.5	68.2	1.34	3.6	41.4
> 14 - 16	8	1.2	96.2	15.19	5.4	73.6	3.74	10.2	51.6
> 16 - 18	8	1.2	97.3	16.93	6.0	79.6	3.80	10.3	61.9
> 18 - 20	6	0.9	98.2	14.11	5.0	84.6	2.41	6.6	68.5
> 20 - 22	4	0.6	98.8	10.45	3.7	88.3	2.96	8.0	76.5
> 22 - 24	3	0.4	99.3	8.79	3.1	91.4	2.66	7.2	83.7
> 24 - 26	0	0.0	99.3	0.00	0.0	91.4	0.00	0.0	83.7
> 26 - 28	0	0.0	99.3	0.00	0.0	91.4	0.00	0.0	83.7
> 28 - 30	2	0.3	99.6	7.35	2.6	94.0	2.38	6.5	90.2
> 30 - 32	0	0.0	99.6	0.00	0.0	94.0	0.00	0.0	90.2
> 32 - 34	0	0.0	99.6	0.00	0.0	94.0	0.00	0.0	90.2
> 34 - 36	1	0.1	99.7	4.36	1.5	95.5	0.87	2.4	92.6
> 36 - 38	0	0.0	99.7	0.00	0.0	95.5	0.00	0.0	92.6
> 38 - 40	0	0.0	99.7	0.00	0.0	95.5	0.00	0.0	92.6
> 40	2	0.3	100	12.35	4.5	100	2.67	7.4	100
Total	677	100		282.30	100		36.78	100	

2.2 Plot measurements under natural rainfall

A.Kertész and G. Richter

The Hungarian Academy of Science runs a field station at Csákvár between Budapest and Lake Balaton. Everything is available which is necessary for long-run plot measurements: a building with laboratory, power supply and accommodation for field workers, and a slope of 8° inclination in a fenced area under surveillance. In 1989, five topsoils of the Balaton region were transported to Csákvár and installed in ten plots of 8 m x 1 m in size. During the following years these plots were kept under seedbed conditions and K-measurements were made under both natural rainfall and rainfall simulations. Comparative rainfall simulations at Csákvár and on the original locations of two of these soils showed nearly identical results.

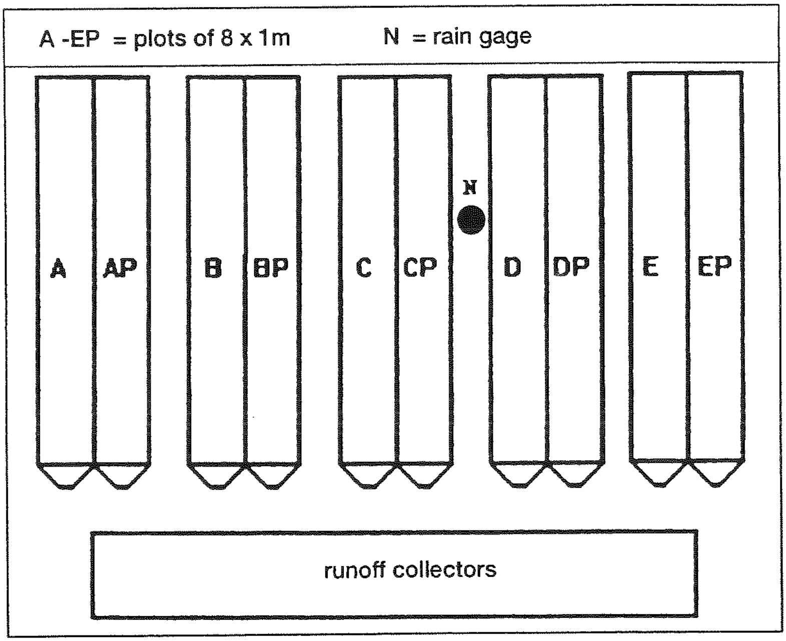

Figure 5: The field plots of the Csákvár measurement station

The following soils were installed (see Fig. 5):

- Plot A and AP: the original *in situ* soil, a stony and sandy loam on dolomite.
- Plot B and BP: an eroded brown forest soil on a loamy miocene sand from the Tapolca region, northern shore of lake Balaton.
- Plot C and CP: a silty clay on mesozoic limestones and marls near Pécsely in the test area.

- Plot D and DP: a silty clay of a rendzina from the Klárapuszta basin in the test area,
- Plot E and EP: a very silty clay of a colluvial brown forest soil near Pécsely in the test area.

Information on texture and stone content of all surveyed soils at the Csákvár station and in the test area is given in Table 8.

From April 1990 to October 1992, 19 erosive rainfall events > 9.9 mm were registered, their rainfall energy was recorded and the soil loss measured (Table 5). These natural rainfalls had a total rain energy of 71.1 kJ/m^2 and caused 3.5-9.5 t/ha soil loss (note that Plot D came into function later). Table 6 shows the calculation of the K-values, based on rainfalls of 10 mm and more. The K-values range from 0.05 to 0.11. Table 7 gives the same calculation for all rainfalls of 0.5 inches and more. The differences are unimportant. These K-values will now be compared with those obtained by rainfall simulations.

Table 5: Station Csákvár - plot measurements under natural rainfall 1990-92

date	precipitation	EI	soil loss (kg/ha)				
	(mm)	(kJ/m^2)	plot A	plot B	plot C	plot D	plot E
07.04.90	17.6	3.5	139	2	3	-	3
14.05.90	14.2	5.4	164	198	796	-	1452
10.06.90	10.8	1.5	194	518	63	-	980
37.06.90	13.6	7.8	1034	1346	1073	-	863
21.08.90	10.4	0.8	17	205	70	-	99
31.10.90	10.9	0.2	-	1	-	-	-
06.04.91	11.2	2.4	-	12	8	-	12
17.04.91	13.8	0.6	-	3	1	-	5
02.06.91	10.0	1.1	8	6	8	-	8
08.06.91	16.4	4.3	4	67	13	-	254
23.06.91	10.9	4.5	3	6	3	-	9
17.07.91	11.4	2.9	-	44	48	-	99
19-21.07.91	44.1	6.0	18	284	121	-	447
31.07-01.08.91	29.9	10.4	70	285	140	-	857
09.08.91	10.9	4.5	817	1034	1043	589	2743
25.03.92	17.1	0.6	-	-	-	-	4
06.06.92	25.6	4.1	674	805	625	602	930
29.07.92	13.4	9.3	400	931	154	391	749
17.10.92	10.6	1.2	2	23	3	-	4
> 10.0 mm	302.8	71.1	3556	5770	4172	1582	9518
> 12.7 mm	205.7	52.0	2512	3921	2926	993	5564

Table 6: K-values derived from plot measurements of all natural rainfalls > 9.9 mm for Station Csákvár, 1990-92

Plot	soil loss (t/ha)	LS-correction	skeleton correction	EI (kJ/m^2)	K-value
A	3.556	0.84	1.29	71.1	0.05
B	5.770	0.84	1.16	71.1	0.07
C	4.172	0.84	1.16	71.1	0.05
D	1.582	0.84	1.05	19.7	0.07
E	9.518	0.84	1.05	71.1	0.11

Table 7: K-values derived from plot measurements of all natural rainfalls > 12,7 mm for Station Csákvár, 1990-92

Plot	soil loss (t/ha)	LS-correction	skeleton correction	EI (kJ/m^2)	K-value
A	2.512	0.84	1.29	52.0	0.05
B	3.912	0.84	1.16	52.0	0.07
C	2.926	0.84	1.16	52.0	0.05
D	0.993	0.84	1.05	13.4	0.06
E	5.564	0.84	1.05	52.0	0.09

2.3 Rainfall simulation experiments and the erodibility factor (K)

A.Schäfer

In addition to the measurements of soil loss on plots under the influence of natural rainfall a rainfall simulation programme was executed between 1990 and 1992 for the more exact determination of the K factor. The rainfall simulator used for the experiments was developed in 1981 at the University of Trier by G. Pahl and H. Willger. The simulator is based on the laboratory simulator of J. de Ploey (Fig. 6). Coarse drops fall down from two parallel tubes on to a net with a mesh size of 2 mm. This creates the raindrop spectrum which is shown in Fig. 7. The starting height of raindrops is 5-8 m resulting in a rain energy value almost identical with those given by Wischmeier. The calculation of the kinetic energy of the Trier rainfall simulator, however, is based on the drop size spectrum and velocity of the drops related to different fall heights of the rainulator bridge. At the height of 7 m a value of 27.7 J/m^2 per mm of rain is reached (Hassel and Richter, 1992). The equipment rains over an area of 2 x 10 m.

The rainfall simulation programme included both experiments on the plots of Csákvár Research Station and 6 sites in Örvényesi-Séd Catchment. Table 8 shows the physical

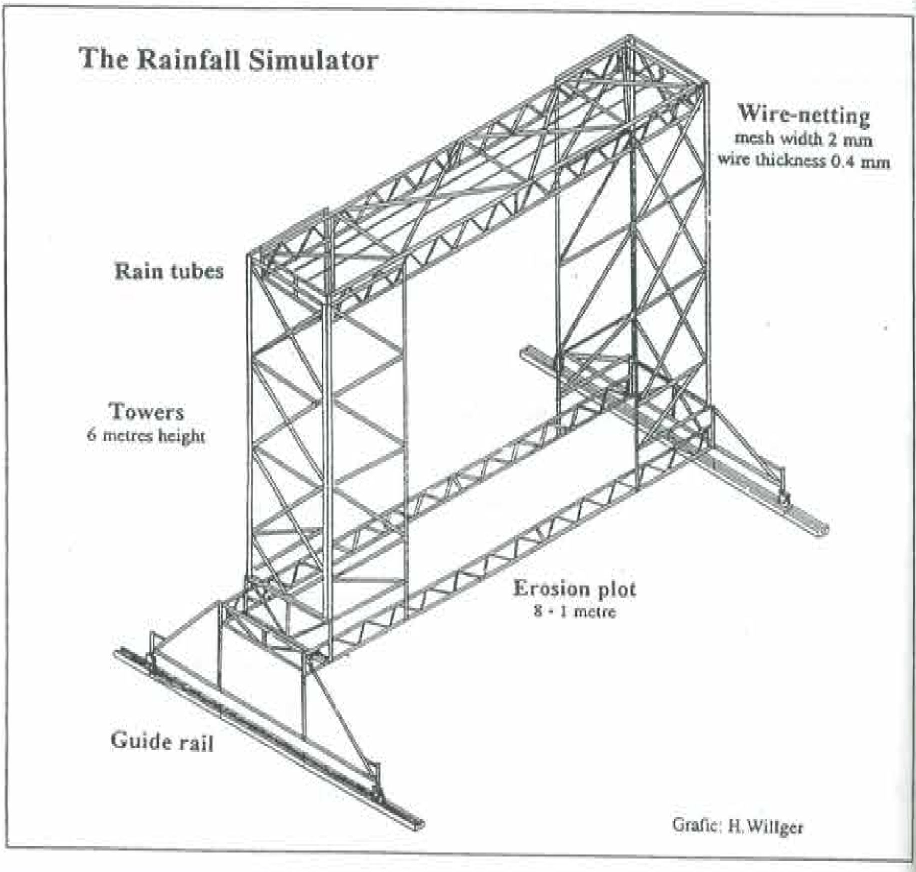

Figure 6: The Trier rainfall simulator

properties of the soils included in the rainfall simulation programme. Rainfall simulation experiments were carried out in two or three cycles, each cycle consisting of three experiments, i.e. under dry, damp and wet conditions as described by Martin (1988) and Schäfer (1995):

• experiment under dry conditions	60 minutes
• break	12-24 hours
• experiment under damp conditions	30 minutes
• break	15 minutes
• experiment under wet conditions	15 minutes

The 28 rainfall simulation experiments represent altogether 168 simulations including repetitions.

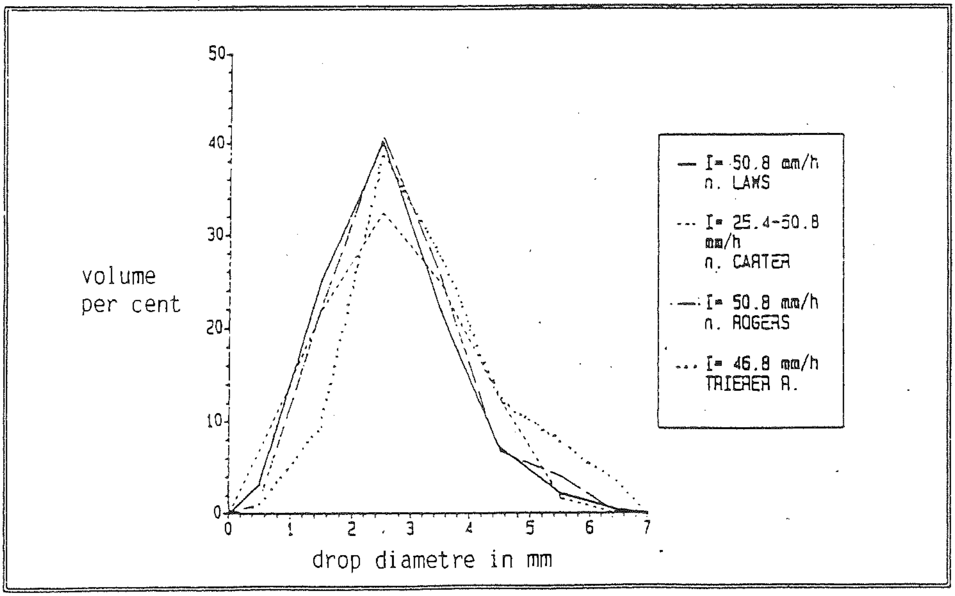

Figure 7: The raindrop spectrum of the simulator Trier (Hassel and Richter 1988)

If the maximum runoff was reached and it did not change any more the experiments could be finished before the given time. The rainfall intensity value was between 50 and 80 mm/h. Each litre of runoff is registered from the beginning of the raining time. Soil loss is then determined from litre samples taken from the 3rd, 5th, 7th, 10th, 15th and 20th litre and then from every 10th litre. The samples are filtered afterwards. Besides rainfall and runoff amounts, soil moisture, skeletal content and surface roughness were measured before and after the experiments.

Table 9 shows the results of the rainfall simulation experiments, expressed as average K-values under dry, damp and wet conditions. These three values had now to be connected to a single K-value. This was done on the basis of the rainfall recordings of station Pécsely for 1984-91. During this period, some 65 per cent of the erosive rainfall (>10 mm) fell on dry soil with less than 5 mm rain being registered during the previous two days. Some 25 per cent of the rainfalls occurred in damp conditions, defined by 5 mm or more of rain falling during the previous two days, and 10 per cent occurred in wet conditions, defined by 10 mm or more rain falling since the day before.

In this way the three K-values were weighted by the factors 0.65, 0.25 and 0.10 respectively. The average K-values of the rainfall simulations are shown in Table 9 and compared with the K-values obtained by plot measurements under natural rainfall and those calculated by the USLE.

Table 8: Texture of the soils used in the rainfall simulation experiments

Site	No.	clay	silt				sand				skeleton
			fine	medium	coarse	total silt	fine	medium	coarse	total sand	
Csákvár A	1	22.6	6.2	10.6	23.5	40.3	25.4	9.2	2.5	37.1	11%
Csákvár B	2	15.8	2.8	3.9	6.9	13.6	44.6	25.1	0.9	70.6	7%
Csákvár C	3	29.5	12.8	16.6	21.0	50.4	12.1	3.9	4.1	20.1	7%
Csákvár D	4	43.9	13.4	15.9	15.7	45.0	7.8	2.0	1.3	11.1	3%
Csákvár E	5	32.3	12.2	17.1	26.3	55.6	8.4	1.9	1.8	12.1	3%
Pécsely vineyard, upper slope section	6	29.9	12.4	18.0	20.4	50.8	11.3	4.0	4.0	19.3	21%
Pécsely vineyard, lower slope section	7	37.4	10.7	15.6	28.0	54.3	6.5	1.0	0.8	8.3	4%
Pécsely cropland	8	24.6	8.1	16.6	40.9	65.5	8.7	0.4	0.7	9.8	-
Pécsely vineyard, loess	9	19.5	6.7	15.4	44.6	66.7	12.4	0.6	0.8	13.8	-
Pécsely maize I, loess	10	19.7	6.4	13.2	48.3	67.9	11.3	0.6	0.5	12.4	-
Pécsely maize II, clay	11	57.1	15.0	14.3	9.4	38.7	2.7	1.0	0.5	4.2	-

Table 9: Average K-values based on rainfall experiments, plot measurements and calculation by the USLE

Site	No.	K-factor under given conditions			K-factor according to		
		dry	damp	wet	rainfall simulation	natural rainfall	USLE
Csákvár A	1	0.06	0.12	0.13	0.08	0.05	0.36
Csákvár B	2	0.24	0.41	0.36	0.29	0.07	0.20
Csákvár C	3	0.10	0.14	0.11	0.11	0.05	0.33
Csákvár D	4	0.12	0.19	0.20	0.14	0.07	0.21
Csákvár E	5	0.18	0.25	0.26	0.21	0.11	0.30
Pécsely vineyard, upper slope section	6	0.13	0.13	0.13	0.13	-	0.47
Pécsely vineyard, lower slope section	7	0.20	0.23	0.25	0.21	-	0.45
Pécsely cropland	8	0.11	0.18	0.24	0.14	-	0.61
Pécsely vineyard, loess	9	0.19	0.40	0.37	0.26	-	0.64
Pécsely maize I, loess	10	0.17	0.24	0.28	0.20	-	0.63
Pécsely maize II, clay	11	0.01	0.09	0.15	0.04	-	0.25

The comparison of results obtained by the three different methods shows a mediocre correspondence between soil loss values calculated on the basis of natural and simulated rainfall respectively. The K-factor values calculated on the basis of USLE/ ABAG shows, however, much higher values than those obtained from natural and simulated rainfall. This is due to an overestimation in the application of the

Wischmeier model to Central Europe as is already known. Under these circumstances the application of measurement-based K-factor values is very important for a calibration of the USLE / ABAG.

The next step was to find average K-values of the texture classes in order to calibrate the USLE. Table 10 relates the available data to the texture classes of the region and calculates the K-values, which were afterwards used for the calculation of soil losses in the Örvényesi watershed.

Table 10: The average K-values of the texture classes
M = measurement under natural rainfall, S = rainfall simulation experiment

Texture class	code	rainfall simulation S or plot measurement M	K-value	average K-value
clay	T	-	-	0.03
weak silty clay	Tu_2	Pécsely maize II clay (S)	0.04	0.04
weak sandy loam	Ls_2	Csákvár plot A (M) Csákvár plot A (S)	0.05	0.05
strong silty clay, strong clayey silt	Tu_4, Ut_4	Csákvár plot C (S) Csákvár plot C (M) Csákvár plot E (S) Csákvár plot E (M) Pécsely vineyard upslope (S) Pécsely cropland (S)	0.11	0.13
medium silty clay	Tu_3	Csákvár plot D (S) Csákvár plot D (M) Pécsely vineyard downslope (S)	0.14	0.14
strong loamy sand	Sl_4	Csákvár plot B (S) Csákvár plot B (M)	0.29	0.18
weak or medium clayey silt	Ut_2, Ut_3	Pécsely vineyard loess (S) Pécsely maize I loess (S)	0.26	0.23
silt	U	-	-	0.30

2.4 The landuse factor C

A. Kertész and G. Richter

The definition of the C factor could not be based on measurements because the Csákvár plots were maintained under seedbed conditions. These plots are also much too small to reflect field conditions. Therefore C factor values had to be taken from the literature (Schwertmann, 1982) and applied to the area.

The C values for each land use type except forest were fixed as follows:

fallow with grass and bushes	C = 0.03
meadow, pasture	C = 0.05
cereals	C = 0.10

fodder crop or forage crop	C = 0.10
gardens and orchards	C = 0.20
sugar beet	C = 0.30
maize	C = 0.40
rape	C = 0.50
vineyards	C = 0.60

The normal rotation is wheat-rape-maize-maize-barley for which C = 0.26

Since the fields are well protected by plant cover during the rainfall maximum (Jun in 3 years of the 5-year rotation, the C value for this rotation was fixed to C = 0.2 instead of C = 0.30. The farming calendar is as follows:

culture	**sowing**	**harvesting**
wheat	October	July
rape	September	July
maize	April	October
maize	April	October
barley	March	July

2.5 Erotope mapping as a basis for the application of the USLE on watershed scale

G. Richter, B. Márkus and A. Kertész

In the absence of a relatively simple and reliable soil erosion model with easy measurable input data for investigations similar to those carried out here, many users prefer to continue working with the USLE. It is, however, important to calibrate the main parameters of this model for adaptation to the regional conditions. This has been described in the previous chapters.

Originally the USLE was a field-scale model. Later the calculation of slope segments and irregular slopes with differing soil textures and landuse opened the opportunity to calculate soil loss from whole slopes. Normally the unconcentrated runoff, which is modelled by the USLE, begins and ends at convex and concave archings of the relief, and at linear elements of the agricultural landscape like field roads, terraces, ditches, walls and similar obstacles. It is, therefore, necessary, if larger areas are examined by use of the USLE, to define exactly the area for which the soil loss is calculated. We called these areas "erotopes" and defined them as "inclined parts of the relief with an unconcentrated runoff of more or less the same direction". They are bordered by the mini-watersheds of the curvature of the land and by linear structures of the agricultura landscape such as ditches, brooks, roads, field roads, terraces and walls. Forested areas, villages and flat valley bottoms < 2° are not taken into consideration.

Fig. 8 shows how such an erotope map is constructed on the basis of the GIS which contains the following information levels:

- digital relief model
- landuse map
- soil maps (texture, humus content, skeleton content, depth of the soil profile)
- linear elements of the agricultural landscape
- roads and settlements
- hydrographic map

The construction of the erotope boundaries takes place directly on the screen, and each erotope receives a number.

The following operation with ARC VIEW prepares the data collection. Beginning upslope the operator draws a catena with the cursor to the downslope boundary of the erotope following the runoff direction. Always after a certain distance a retrieval of the data base is carried out. In the case of a change in the combination of parameters compared with the point before, this is announced. A map of the changing parameter appears. Six points are examined on the way from the upslope to the downslope boundary of the erotope. Now the decision is made if a segmentation of the erotope takes place and how many segments are necessary (maximum 5). In addition the length of the erotope in the direction (L) is measured. This procedure of the catena-check is repeated two times in different parts of the erotope. If there exist differences in the combination of parameters between two catenas, the erotope can be divided into segments (along the contour) or catena strips (downslope) and the parts calculated separately.

Now the operator overlays the erotope map on the screen step-by-step with the other information levels and fills in a list of parameter combinations by using code numbers (Table 11). The numbers represent the predominant parameter class in this catena strip or segment. It would be too difficult to fix the criteria for this procedure in a computer programme. Therefore this part of the method is a computer-aided one.

Now the list is stored in the computer. A computer programme calculates the soil loss by replacing the code numbers by values, by multiplication of these values of L, S, K and C with the weighting factor of the segment (W) or by addition of the results of the catena strips, and lastly by multiplication of LSKCW times the R-value of the region.

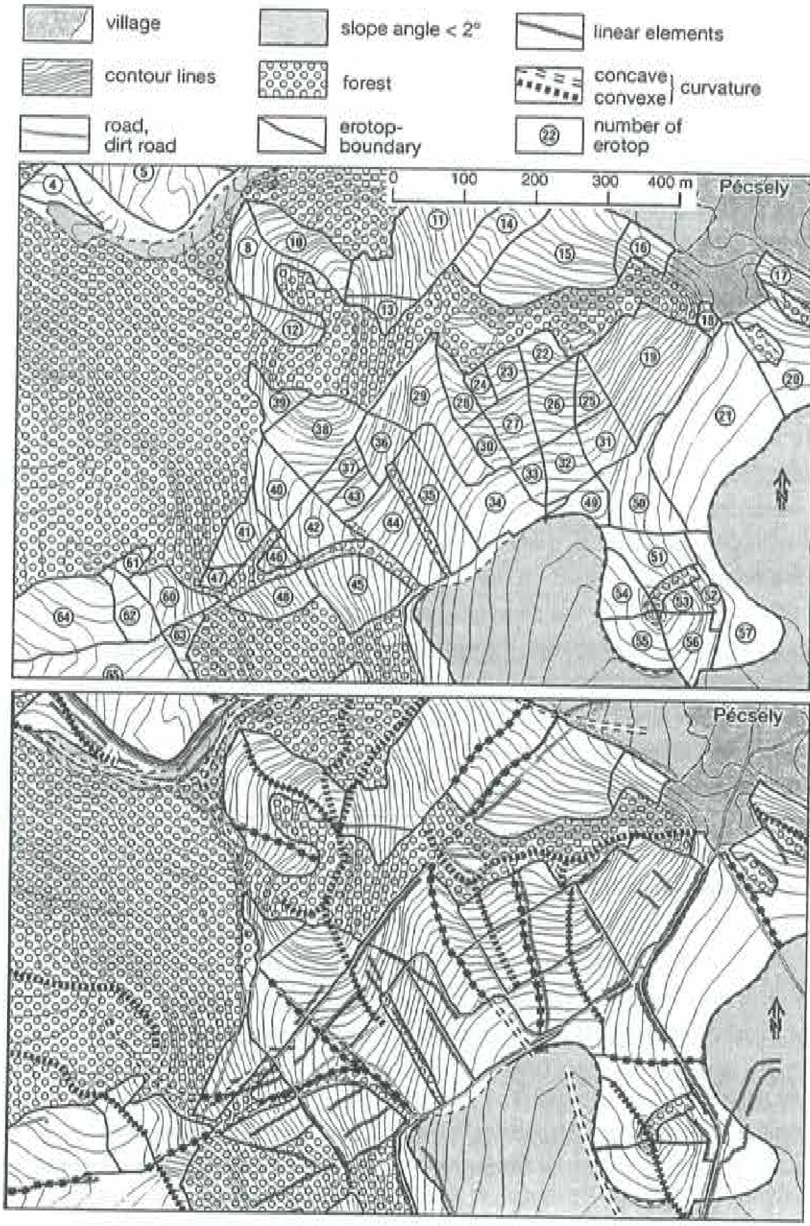

Figure 8: Build-up of the erotopes on the screen

Table 11: Parameter combination list of two erotopes, an example

erotope no.	catena	no. of segments	S	T	H	Sk	Ag	Per	G	V
15 L = 270 m	1 2 3	- - -	3 3 2	1 1 2	2 2 2	1 1 1	3 3 2	3 3 3	2 2 3	4 1 1
16 L= 220 m	- - - - -	1 2 3 4 5	3 3 3 3 2	3 3 3 3 3	2 2 2 2 2	1 1 1 1 1	3 3 3 3 3	3 3 3 3 3	2 2 2 3 3	6 4 4 1 1

Notes: In erotope 15, separate calculations are made for three strips along the three catenas (=3 lines). In erotope 16, separate calculations are made for five segments (=5 lines).

L = length in m
S = slope angle class
T = texture class
H = humus content class
Sk = stone content class
Ag = aggregate class
Per = permeability class
G = depth class of the soil profile
V = vegetation or land use class

The result is a computed list of the USLE calculation for all erotopes. It contains a line for each segment or catena strip, in which the main input data L, S, K and C are listed and multiplied by the weighting factor. LSKCW forms the last column. In the last line of the erotope calculation the LSKCW values of all segments are added up and multiplied by R. The programme compares this result with the tolerable soil loss, which depends on the depth of the soil profile, and prints a star to those erotopes for which the calculated soil loss is higher than the tolerable one (Table 12).

The programme also prints another list in which the erotopes are listed according to their predominant landuse. This list informs on erotope number, area in hectares, soil loss per hectare and year, and the average and total amount of soil loss from this type of landuse. Both computer lists contain the basic information for a map of soil loss in tons per hectare and year for the whole of the Örvényesi watershed which can be used for conservation planning.

Table 12: The computer list of soil loss calculations by use of the USLE per erotope

erotope	L	S	K	C	W	LSKCW
	Σ LSKCW		R Σ LSKCW	Cvor		ntol (*)
101	2.10	0.82	0.21	0.26	0.19	0.02
101	2.10	0.82	0.21	0.26	0.35	0.03
101	2.10	2.37	0.13	0.26	0.46	0.07
101	0.12		4.49	0.26		
102	1.78	0.82	0.26	0.26	0.50	0.05
102	1.78	0.82	0.17	0.26	0.50	0.03
102	0.08		2.97	0.26		
103	2.13	4.40	0.26	0.40	0.35	0.34
103	2.13	0.82	0.26	0.26	0.65	0.08
103	0.42		15.08	0.40		*
104	2.13	4.40	0.26	0.40	1.00	0.98
104	0.98		35.20	0.40		*
105	1.78	2.37	0.19	0.40	0.35	0.11
105	1.78	4.40	0.19	0.40	0.65	0.39
105	0.50		17.88	0.40		*
106	1.74	2.37	0.16	0.03	1.00	0.02
106	0.02		0.72	0.03		
107	2.33	2.37	0.19	0.40	0.19	0.08
107	2.33	0.82	0.19	0.26	0.35	0.03
107	2.33	0.82	0.19	0.26	0.46	0.04
107	0.16		5.59	0.26		*
108	2.77	2.37	0.19	0.40	0.35	0.17
108	2.77	0.82	0.19	0.40	0.65	0.11
108	0.29		10.27	0.40		*
109	2.26	0.82	0.17	0.40	0.19	0.02
109	2.26	0.16	0.17	0.40	0.35	0.01
109	2.26	0.16	0.17	0.40	0.46	0.01
109	0.04		1.59	0.40		
110	1.35	0.82	0.14	0.40	0.50	0.03
110	1.35	0.82	0.23	0.40	0.50	0.05
110	0.08		2.93	0.40		

R, L, S, K, C = factors of the USLE

W = weighting factor of the slope segment

Cvor = predominant land use factor C

ntol (*) = soil loss higher than tolerance

2.6 The soil loss tolerance

G. Richter

This is an unsolved question. What is the tolerable soil loss? It has to be taken into consideration that the European soils have been in agricultural use for hundreds or even thousands of years. Therefore, the percentage of eroded soils with shallow profiles is here relatively high, and this question should therefore be handled more strictly than in the United States. Schwertmann, Vogl and Kainz (1987) have proposed values of the soil tolerance, depending on the profile depth of the soil, which range from 1 to 10 tonnes per hectare and year (Table 13). These values were used in Table 12. Recommendations for soil conservation measures should be connected with soil loss and profile depth, as proposed in Table 14.

Table 13: Soil loss tolerances (after Schwertmann, Vogl and Kainz, 1987)

G-value (soil depth)	code	soil profile	soil loss tolerance (t/ha.a)
< 30 cm	1	shallow	1
30 - 60 cm	2	medium	3
60 - 100 cm	3	deep	7
> 100 cm	4	very deep	10

Table 14: Soil depth, soil loss ratio and recommendation for conservation measures (after Richter)

G-code	soil loss (t/ha.a)				
	< 1	1-3	3-7	7-10	> 10
1	tolerable risk	considerable risk	high risk	no permanent cultivation	no cultivation
2	no risk	tolerable risk	considerable risk	high risk	no permanent cultivation
3	no risk	no risk	tolerable risk	considerable risk	high risk
4	no risk	no risk	no risk	tolerable risk	considerable risk

Notes:

no risk:	soil loss is much lower than the soil loss tolerance; no protection measures
tolerable risk:	soil loss is in the range of the soil loss tolerance; protection measures are, however, useful
considerable risk:	soil loss exceeds the soil loss tolerance; protection measures are strongly recommended
high risk:	soil loss is much higher than the soil loss tolerance; protection measures or landuse changes are required urgently
no permanent cultivation:	the high soil loss does not allow a permanent cultivation without destruction of the soil
no cultivation:	the high soil loss does not allow any cultivation without rapid destruction of the soil

3. Results

3.1 Soil loss in the Örvényesi watershed

A. Kertész and G. Richter

Following the method described in section 2.5, 416 erotopes were mapped in the Örvényesi watershed. Their boundaries were stored as one level in the GIS together with the other necessary levels of information. Data on the area of each erotope wer given by ARC-INFO. The calculations using the calibrated USLE were also carried out by the GIS programme.

The 416 erotopes cover an area of 1219 ha, about 50 per cent of the watershed. Forested areas, settlements and valley bottoms with an inclination less than 2° remained outside the calculation and form the remaining 50 per cent of the 2400 ha watershed. For one part of the watershed (606 ha) two calculations were carried ou one with the original K-values of the USLE (calculated by the K-formula), the othe with the calibrated K-values, based on plot measurements and rainfall simulation. T two different K-values are compared in Table 9. The results of both calculations are presented in Table 15. The overestimation of soil loss by use of the original USLE i evident. The calibrated values predict a soil loss of only 30-45 per cent of these values, and one third on average.

Table 15: Örvényesi watershed. Comparison of the results of the soil loss calculation by use of the original and the calibrated version of the USLE in one part of the watershed.

land use type	area (ha)	soil loss (t)		
		K_o (K original)	K_c (K calibrated)	% (K_c/K_o)
abandoned land	103.72	339.82	151.23	37.8
meadows	116.28	247.57	111.46	45.0
fields	260.27	2608.65	1065.47	40.8
vineyards	125.75	3978.32	1188.34	29.9
total	606.02	7234.36	2516.50	34.8

Table 16: Örvényesi watershed. Calculation of the annual soil loss from different land us types by use of the calibrated version of the USLE

land use type	area (ha)	total soil loss (t)	average soil loss (t/ha)	soil loss > tolerance level	
				area (ha)	% of total area
abandoned land	180.65	332.20	1.78	41.31	22.9
meadows	210.05	222.73	1.11	5.52	2.8
fields	449.73	1734.58	3.86	118.05	26.3
vineyards	387.55	4119.76	10.63	284.87	73.5
total	1218.98	6399.27	5.25	449.75	36.9

Table 16 presents the results of the calculation of annual soil losses from different landuse types of the Örvényesi watershed by use of the calibrated version of the USLE, the erotope mapping and the GIS of ARC-INFO (Table 16). The range is 1.1 to 10.6 t/ha.a, the average for 1219 ha is 5.25 t/ha.a. The soil loss is higher than the tolerable value (ntol) on 26 per cent of the area devoted to fields and on 74 per cent of the vineyards. A comparison of Fig. 2 (slope categories), Fig. 3 (landuse) and Fig. 9 (soil loss map) shows this clearly. The flat areas in the three basins, covered by meadows, have no problems. Large field areas around these central depressions have inclinations of 2-7°, but the size of the fields is still too large to prevent high erosion rates. Most of the vineyards cover the steep slopes and suffer erosion. They urgently need conservation measures. The abandoned land is generally found in the steepest parts of the slope. It should be revegetated as soon as possible.

3.2 Water balance, sediment and solute yield in the Northern Catchment

A. Kertész and G. Varga

Calculation method

Measurements of sediment, solutes and discharge at three water courses, i.e. Örvényesi-Séd, Eger-viz and Burnót-patak, of the Northern Catchment have been carried out by the local water authorities for the last two decades. Yearly average values of sediment load and solutes for these three water courses were determined first. Since measurement data are only available for these three tributaries the calculation for the Northern Catchment was based on the extrapolation of their summarized water output. It must be underlined that the results of these calculations should only be considered as an assessment because of possible errors. One source of error is the linear extrapolation of data for a larger area proportional with runoff. Another may be caused by the fact that the original measurement data have a frequency of one or two weeks. This implies that important floods causing a considerable part of material transport may be left out of the measurements.

Water balance calculations

A detailed analysis of the test area, the Örvényesi-Séd catchment, was carried out. The water transport of Örvényesi-Séd depends mainly on its supply by the karst water system. This is indicated by the water balance of the stream (see Table 17), with the average values for the period 1975-1990 of 589 mm for precipitation, 523 mm for evaporation and 177 mm for runoff. Therefore it can be assumed that the catchment of the subsurface karst water system is not identical with that of the stream on the surface.

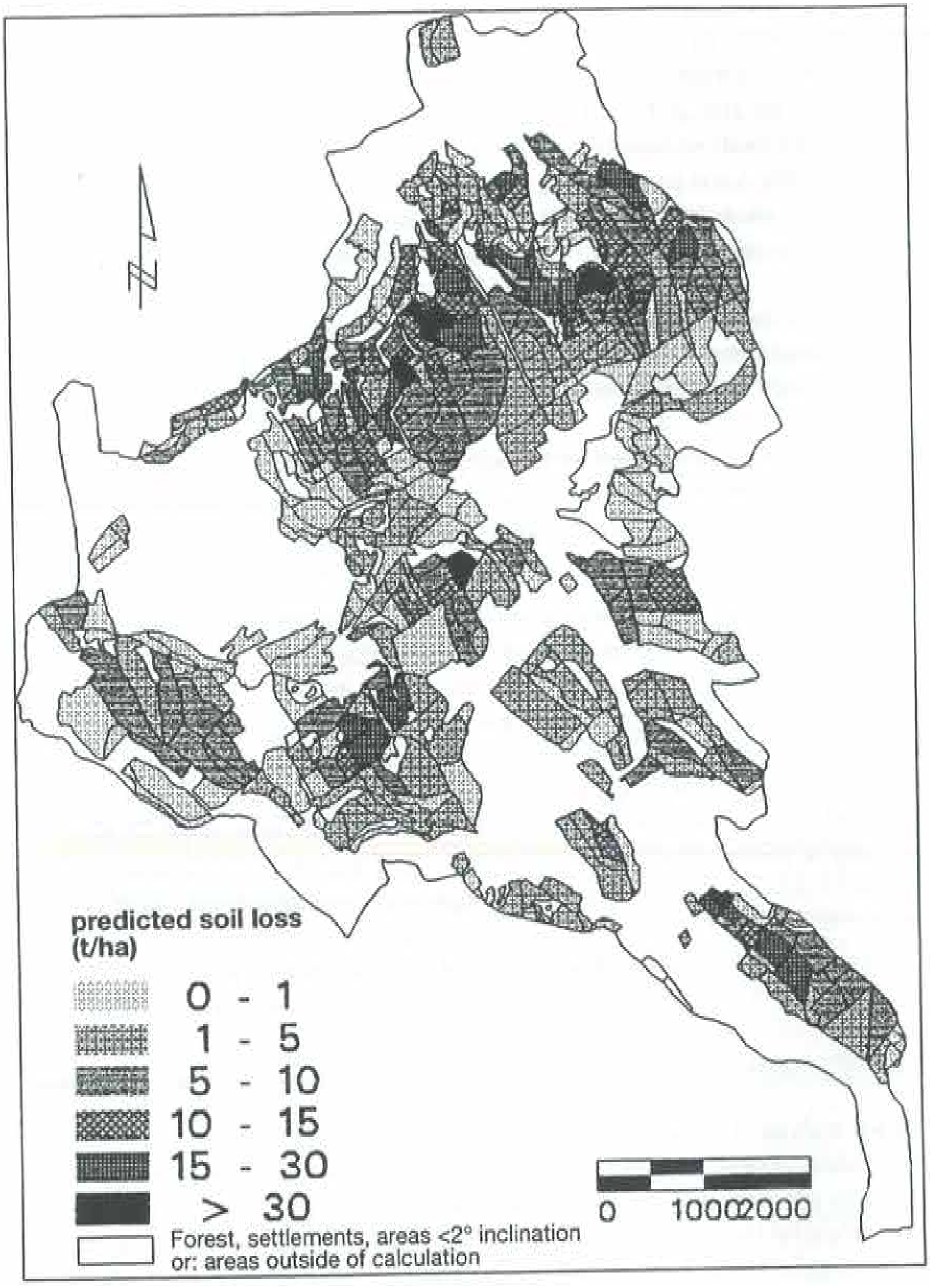

Figure 9: Soil loss map of Örvényesi watershed

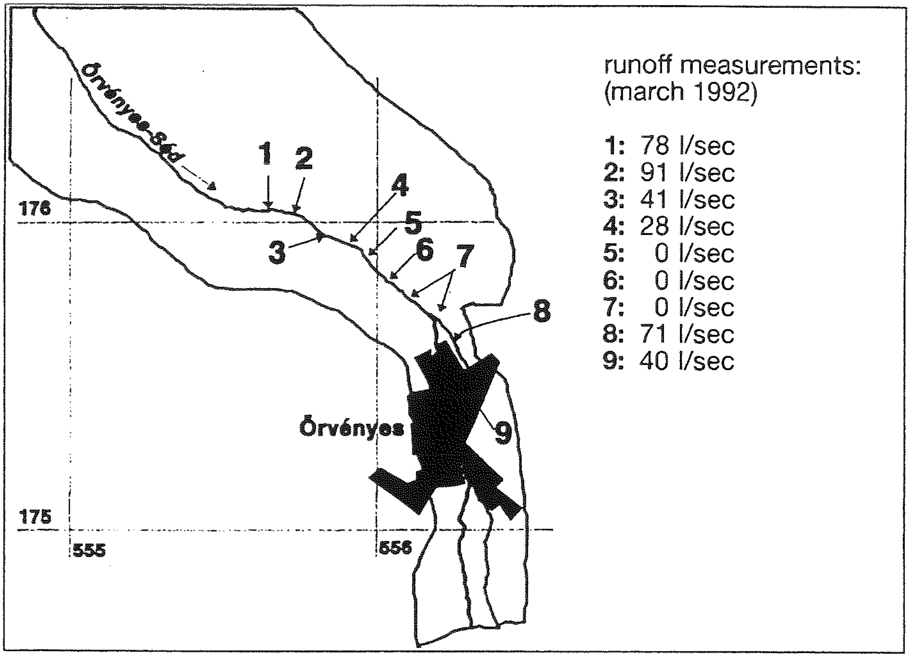

Figure 10: The karst seeping area of Örvényesi creek

The Örvényesi stream is also a karst stream. Two main karst springs form the origin of the stream. Before reaching Lake Balaton near the village Örvényes, the stream has to cross a ridge of limestones and dolomites in a deeply incised V-shaped valley. This is a zone of karst seepage, as is proven by runoff measurements in March 1992 (Fig. 10).

The connection between precipitation and runoff was analysed by regression analysis for each of the four seasons. The correlation coefficients (0.15 for spring, 0.11 for summer, 0.28 for autumn and 0.37 for winter) prove that there is no correlation between precipitation and runoff as a consequence of the effect of karst springs. The subsurface drainage basin is different from the surface drainage basin and the extent of the subsurface system is unknown. The two other water courses under assessment, the Burnót Patak (82 km^2) and the Eger-viz (350 km^2) show the same runoff characteristics of a karst system. The extrapolation of the data from the 456 km^2 of these three watersheds to the 1128 km^2 of the whole Northern Catchment led to the result of an average runoff of 86 million m^3 or 4 litres per second and km^2.

The Zala river basin is much larger than the Northern Catchment. Its water input into the lake from an area of 2622 km^2 is 262 million m^3 or 3-3.5 litres per second and

Table 17: Water balance of Örvényesi-Séd

water year	precipitation (mm)	evaporation (mm)	runoff (mm)
1975/76	521	490	142
1976/77	674	661	220
1977/78	609	630	101
1978/79	550	557	88
1979/80	643	584	94
1980/81	525	493	92
1981/82	687	553	84
1982/83	566	421	144
1983/84	704	566	94
1984/85	616	540	150
1985/86	664	519	219
1986/87	594	547	126
1987/88	486	344	117
1988/89	487	455	48
1989/90	513	482	32
average	589	523	117

km^2. The Zala Catchment is much more important for the water supply of lake Balaton as shown from the following data:

average water input per year	946 million m^3	
minus precipitation on the lake surface	380 million m^3	
runoff from the whole watershed	566 million m^3	
runoff from the Zala watershed	262 million m^3	= 46 %
runoff from the Southern watershed	218 million m^3	= 39 %
runoff from the Northern watershed	86 million m^3	= 15 %

Calculation of sediment and solutes yield

In Table 18 the calculation of sediment and solute yield for the Örvényes watershed and the whole northern watershed are compared. Since the latter are extrapolated from measurements on three watersheds, the data cannot be identical, but they have more or less the same range. The solutes are separated in two groups: the predominant geogenetic solutes of the karst system such as Ca, Mg and SO_4 and those of anthropogenic sources such as nitrates and phosphates. The geogenetic group make up 58 per cent of the solutes and the anthropogenic group 42 %. This reduces to a great extent the possibility of human influence on a reduction of the solute transport into the lake, and the alkalization of the lake can be considered as a natural process.

Table 18: Comparison of annual sediment and solutes yield of the test area and the Northern Catchment

inputs	from Örvényesi watershed		from Balaton Northern Catchment	
water	2.1 million m³	875 m³/ha	86.3 million m³	765 m³/ha
sediment	118.3 t	49.2 kg/ha	3118 t	27.6 kg/ha
Ca	245.1 t	102.1 kg/ha	12211 t	108.3 kg/ha
Mg	143.8 t	59.9 kg/ha	6172 t	54.7 kg/ha
SO_4	166.1 t	69.2 kg/ha	18054 t	160.1 kg/ha
Na	28.6 t	11.9 kg/ha	2065 t	18.3 kg/ha
Cl	50.7 t	21.1 kg/ha	3259 t	28.9 kg/ha
K	14.7 t	6.1 kg/ha	1002 t	8.9 kg/ha
NH_4	0.9 t	0.3 kg/ha	42 t	0.4 kg/ha
NO_3	78.0 t	12.5 kg/ha	2088 t	18.5 kg/ha
PO_4	0.4 t	0.2 kg/ha	24 t	0.2 kg/ha

Table 19: Comparison of annual sediment and solutes transport from the Northern Catchment and from the Zala Catchment into Lake Balaton

inputs	Balaton - Northern Catchment		Zala Region	
water	86 million m³		262 million m³	
	t/a	t/km².a	t/a	t/km².a
sediment	3118	2.80	6518	2.50
Ca	12211	11.10	19126	7.30
Mg	6172	5.60	7914	3.00
SO_4	18054	16.40	14705	5.60
Na	2065	1.90	6036	2.30
Cl	3259	3.00	6523	2.50
K	1002	0.90	1432	0.50
NH_4	42	0.03	137	0.05
NO_3	2088	1.90	993	0.40
PO_4	24	0.02	93	0.03

Table 19 compares the sediment and solute yields from the Northern Catchment and the Zala river. Detailed investigations of the latter have been carried out during the last two decades. Due to its larger extent the Zala River transports much more sediment and solutes into the lake. The yields per km^2, however, are higher in the Northern Catchment, especially those of Ca, Mg, SO_4 and nitrates.

The average values of both catchments, however, which are based on measurements during different periods, have to be discussed more in detail. The data of the Zala river before 1984 show an average sediment yield of 10339 t/year, those since 1984 only 5672 t/year. The reason is that in that year the canal, in which the Zala river crosses the Kisbalaton swamp, was closed. Since this change the swamp acts again as a natural filter and reduces the sediment input.

Table 20: Northern Catchment, output of water, sediment and solutes in per cent of their average values 1984-1994

	percentage of the average 1984-94 value										
inputs	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**
water	143	152	212	170	139	86	58	36	28	27	49
sediment	374	123	211	88	54	28	39	22	18	24	27
geogenetic solutes	133	119	205	101	110	70	51	43	40	38	59
anthropogenic solutes	167	126	259	114	85	46	32	29	27	26	38

In the Northern Catchment the change came in 1989-90 with a couple of years with reduced rainfall and runoff (Table 20). Its influence reduced the transport of geogenetic solutes to about 40-50 per cent of the average 1984-94 value. The influence on sediment transport and anthropogenic solutes was higher; a reduction to 20-30 per cent of the average was registered. Partially this is due to the reduced nutrification in the agriculture. After the change of the regime and after starting reprivatization, hardly any fertilizers were applied in the region.

The main conclusions can be summarized as follows. Investigations of the test area revealed relationships which allow the extrapolation to the whole area of the Northern Catchment. The calculations point to the decisive role of karstic waters in the water balance. A large amount of precipitation infiltrates and will be stored in the karstic rock. Subsurface drainage basins are different from the surface ones. As a consequence, no correlation between precipitation and runoff could be verified. The same is true for solutes, i.e. there is no correlation between solutes and discharge. The high solute values of Ca and Mg are connected with the karstic process of bedrock solution.

Comparisons of solute measurements do not always allow the same general conclusion as in case of the sediments. It is, however, evident that the high amount of some anthropogenic solutes is connected to non-point agricultural pollutants and soil erosion, so that a different agricultural management including possible land use changes should be considered in the near future.

3.3 Summary and conclusions

A. Kertész and G. Richter

An extended geoecological mapping operation of a watershed of 24 km^2 of the Northern Balaton Catchment, plot measurements under natural rainfall and 168 rainfall simulations on 11 soils brought together a large amount of detailed information. The data were stored in a GIS and evaluated for model calculation and map production using ARC-INFO and a calibrated USLE. The method of erotope mapping allowed a calculation of the predicted soil losses for the whole watershed. These values were compared with the measurements of sediment yield at the outlet of the watershed into the Lake. Sediment and solute yields were extrapolated from three small watersheds, which together cover 456 km^2, to the whole Northern Catchment of 1128 km^2 and the results were compared with data for the Zala river catchment, the largest part of the Balaton Catchment (2622 km^2). The main results are the following:

1. It is necessary to calibrate the USLE parameters by measurement and experiment before application to conditions of Central Europe. Otherwise an overestimation of the soil loss prediction may be expected.

2. If the input data for the use of the USLE are available in a GIS, erotope mapping can be easily carried out by use of ARC-INFO and ARC VIEW.

3. This mapping operation allows the application of the USLE for calculation of soil loss on slope scale and watershed scale.

4. Soil erosion in the 24 km^2 test area causes an average soil loss of about 6400 t/year from 1220 ha of land under agricultural use or abandoned fields. This is an average of 5.25 t/ha. Some 4100 t are eroded from vineyards and 1700 t from fields.

5. On 26 per cent of the fields and 74 per cent of the vineyards the predicted soil loss is higher than the soil loss tolerance.

6. Only 100-700 t of the eroded soil leave the catchment through the outlet into the lake, that is about 0.1 t/ha.a or less than 2 per cent of the predicted erosion rate. This is due to following facts. The streams cross the catchment in wide flat basins with a high groundwater table. The overland flow has, therefore, to cross at least 20-50 m of flushing meadows before it reaches the stream. Secondly the hydrographic system is ruled by a karst water regime, and most of the runoff disappears in the subsurface before returning to the headwater regime.

7. The solute yield from the test area is 11 times higher than the sediment yield. The major part of it belongs to the geogenetic solutes of the karst area, but the output of nitrates and phosphates is also considerable.

8. A comparison of the sediment and solute yields from the Northern Catchment

and the Zala region show that the Zala transports higher quantities of both into the lake, due to its larger extent. The rate of geogenetic solutes per km^2 and that of nitrates, however, is higher in the karst area of the Northern Catchment.

9. The aim of reducing sediment input and eutrophication of the Lake can be achieved mainly by conservation measures in the Zala Catchment. The conservation of the soil itself seems to be more urgent in the Northern Catchment, where large areas of vineyards and fields suffer under an erosion rate beyond the soil loss tolerance

10. Simple and cheap conservation measures for the vineyards are weeding or mulching. The field sites could be better protected by dividing the very large fields (up to 130 ha) into smaller units, bordered by grass strips, and by installation of some grassed waterways along the concavities of the relief.

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ABOUT THE BURNING PROCESS OF SOME PEAT SOILS IN ALBANIA

There are about 38,000 hectares of peat soils in Albania. Burning has occurred on some of them since 1990. The process is prevalent on almost all the peat soils in Korcë, a district in the southeast of the country. There are different opinions about the process in the agricultural literature; some view it as harmful and others as useful. An investigation was made into the extent of burning and its consequences.

The depth of burned peat was assessed from profiles located randomly at different points over an area of 2,095 hectares. The surface area of burning was determined for the period 1990-1996. The quantity of burnt peat was determined from its bulk density. Chemical analyses were conducted to assess differences between burnt and unburnt peat.

For 1990-1996, some 1,500 hectares of the study area were burned with 8 per cent of this being burned twice. The depth of burned peat was 52 cm and the thickness of the burned layer was 10.5 cm. The following statistical relationship was established between the depth of the burned peat (X; cm) and the thickness of the material that results from burning (Y; cm) (Figure 1):

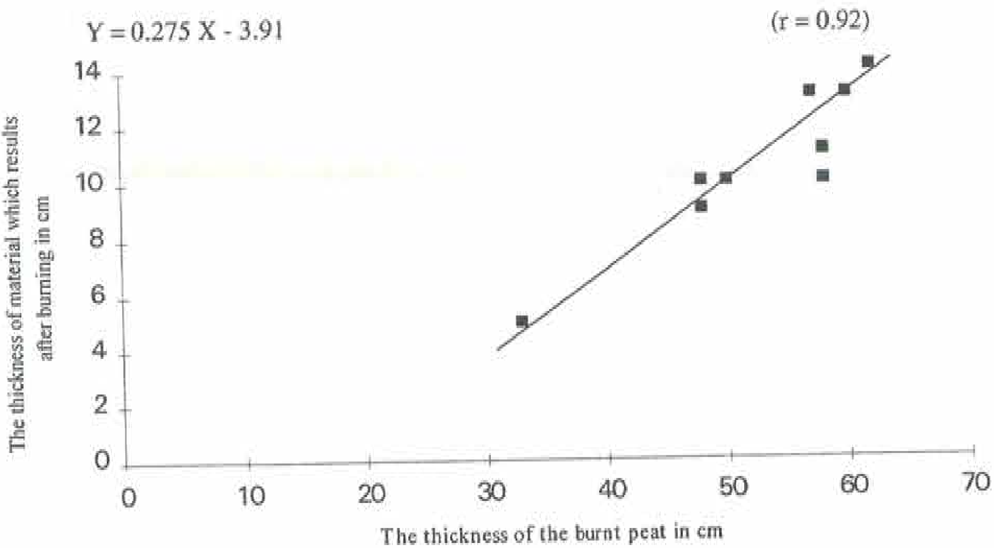

Figure 1. Relationship between depth of burned peat and thickness of material resulting from burning

The effect of the burning process varies spatially with differences in the depth of burning from 10 to 60 cm. This variability impedes agricultural activities involved in crop production. Based on 1,500 hectares of burning, a depth of burning of 52 cm, a bulk density of the surface layer (0-35 cm) of 0.41 Mg/m^3 and a bulk density of 0.18 Mg/m^3 for the layer below the surface, the quantity of burned peat is 2,500,000 tonnes which is equivalent to 1,500,000 tonnes of coal.

The organic matter content is decreased from 40.92 per cent in unburned peat to 0.52-0.60 per cent in burned material; the nitrogen content is 1.76 per cent in unburned peat and 0.05-0.06 per cent in the burned material. The quantity of nitrogen released to the atmosphere is 46,500 tonnes.

During the burning process some toxic components are added to the atmosphere above the area of burning and the surrounding environment is polluted. The study area is very near north Greece and Macedonia and close to Lake Ohri, an important tourist centre. Wind erosion is enhanced and local villagers say that "during winter it is snowing over our houses, in summer the particles of peat are falling on them".

By natural decomposition, the level of the peat soils falls rapidly at first and later more slowly. Where burning occurs, the lowering in depth is immediate and has caused groundwater levels to come so close to the surface that, during heavy rains, a marsh is formed, damaging winter crops and impeding the cultivation of spring and summer crops. The quantity of available N, P, K and Ca is increased in the soil after burning but these are largely leached out from the top soil; in the first year, however, crop production is increased.

Overall, the burning process appears harmful to the soils. It is usually caused by the shepherds who make fires in the summer and autumn and by farmers burning the crop residue after harvest. The nature of land ownership has not been clear during 1990-1996 so that the users of these soils have not been motivated to deal with the problem and do not have the possibility of fighting the fires. The determination of land ownership and the introduction of irrigation and drainage would be ways of protecting the soil from burning and reducing its environmental impacts over the area.

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AGRICULTURAL SYSTEM PROBLEMS IN ARID AND SEMI-ARID REGIONS (ASAR): A MEMORANDUM

Water availability is generally the major factor limiting crop development in arid and semi-arid regions (ASAR). In many of these areas, seasonal precipitation may suffice to ensure adequate crop development. However, a large part of the rainfall is lost to surface runoff and evaporation. Runoff is caused primarily by the impact of raindrops on the bare soil with resultant sealing of the surface, reduction of the infiltration capacity and, subsequently, soil erosion. Hence, rain water is lost while erosion carries away part of the fertile upper soil layer.

Soil mulching with crop residues is a common and very effective method for controlling runoff, erosion and evaporation. It is evident that mulching the soil surface can effectively reduce evaporation of soil water. It is well-established that mulching with crop residues can considerably increase rainwater availability for crop development and prevent soil degradation due to erosion.

Unfortunately, in ASAR, crop residues constitute a vital resource for the farmers and consequently they remove the residues from the field for use as livestock fodder, as a source of energy and for building purposes. From personal experience, it is difficult, even impossible, to convince local farmers to leave the residues in the field. Hence crop yields are low (assuming that manure or mineral fertilizers are not applied and that other improved cropping practices are not used owing to the farmer's lack of working capital), and water and soil are lost. These factors have a considerable impact on rural societies and are a prime cause of the prevalent low living standards and of famine, poverty, migration to urban areas, crime and collapse of the social structure.

The conventional solution to improving water availability is the implementation of major water resource development projects, i.e. construction of dams, impounding reservoirs and irrigation works. These projects are often unsuccessful (even without considering their environmental impact) due, on the one hand, to poor management and maintenance of the engineering facilities and lack of agricultural support systems; and, on the other hand, to the failure to consider the social and psychological aspects of rural development. Contributions of food and other valuable products by donor countries, though they may be a temporary palliative, do not go to the root of the problem and, moreover, detract from the farmer's motivation to produce for his own needs and for sale to the market, and to take steps to improve his lot.

One other solution - that of donor nation supplies of grains and fodder - may assist in ensuring that the crop residues are left in the field, but this solution - also only temporary - generally fails since only a small part of the grains and fodder reaches the farmers; they, in their turn, view this source of supply as a means of increasing their livestock numbers and therefore they continue to denude the soil of crop residues. Use of residues for energy and building material continues likewise.

It may be concluded from the above that a substitute for crop residues is needed which can be used as a soil mulch and which does not have alternative and more attractive uses. Materials such as residues from the food (e.g. sugar cane, sugar beet, oil cake) and wood industries, domestic sewage sludge and composted domestic solid organic wastes could all be used for improving the soil and increasing soil-water availability. These materials are available in the developed countries, where they constitute an environmental hazard, and their treatment and disposal involves considerable financial costs. These materials could be transported to agricultural areas in developing countries where they would be spread as a mulch over the soil surface before the wet season and would have the effect of controlling rainwater runoff, reducing soil moisture evaporation and minimizing soil erosion. In addition, they would enrich the organic content of the soil and, in the case of certain minerals, would improve nutrient content. In the long run, they would reduce land degradation and contribute to the welfare of the rural community.

This memorandum does not enter into the economic and logistic consequences of the proposal. In this context, it should be noted that the developed countries and international organizations are investing considerable amounts of money to assist the developed countries in ASAR, while the benefits are not commensurate with the investments.

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Editor's Note: Correspondence on this memorandum would be welcome.

INTERCULTURES ET GESTION SPECIFIQUE DU RUISSELLEMENT ET DE L'EROSION DIFFUSE SUR LES PLATEAUX LIMONEUX DU NORD-OUEST DE L'EUROPE

L'interculture (période comprise entre la récolte du précédent cultural et l'implantation de la culture suivante) est une période privilégiée de lutte contre les phénomènes érosifs compte tenu de la facilité avec laquelle les agriculteurs peuvent intervenir sur leurs parcelles pour fragmenter la croûte de battance et restaurer la rugosité de surface. Des enquêtes en exploitation agricoles réalisées dans le Pays de Caux (France) ont montré une grande diversité de pratiques agricoles en interculture. Pour orienter le conseil nous avons testé cinq itinéraires techniques sur trois états à la récolte différents. Les 15 traitements expérimentaux ainsi obtenus sont conduits sous pluies naturelles sur des surfaces de 20 m^2. Le sol est un limon moyen sableux avec une pente homogène de 2%. L'essai a été conduit du 14/09/1993 au 8/02/1994.

Les états à la récolte (début d'interculture) sont les suivants:

- BB : blé paille broyée sur place (100% de couverture du sol par les résidus végétaux).
- BE : blé paille exportée (50% de couverture du sol par les résidus végétaux).
- POIS93 : pois protéagineux de printemps fanes exportées (30% de couverture du sol par les résidus).

Les 5 itinéraires techniques retenus sont :

- SOC : déchaumage fin août à l'aide d'une déchaumeuse à socs (petite charrue) qui donne une surface très rugueuse mais enfouit tout résidu végétal.
- MOUT : implantation fin août d'une culture intermédiaire de moutarde. Labour + semis sur BB et BE; semis direct sur POIS93.
- Néopré : déchaumage fin août à l'aide d'un néodéchaumeur. Outils à dents qui confère à la surface un modelé très billonné et n'enfouit que partiellement les résidus végétaux.
- Néotar : déchaumage début octobre à l'aide d'un néodéchaumeur. En octobre les conditions sont plus humides qu'en août on s'attend début octobre à une dégradation plus rapide de la surface.
- O : aucune intervention pendant toute l'interculture.

Les résultats obtenus en fin d'interculture sont repris sur la figure 1. Cette figure donne la position des 5 itinéraires techniques selon le ruissellement et les départs de terre en moyenne pour les trois états à la récolte. Les traits horizontaux et verticaux délimitent des groupes statistiquement homogènes (test de Newmans-Keuls à 95%) respectivement pour les départs de terre et le ruissellement.

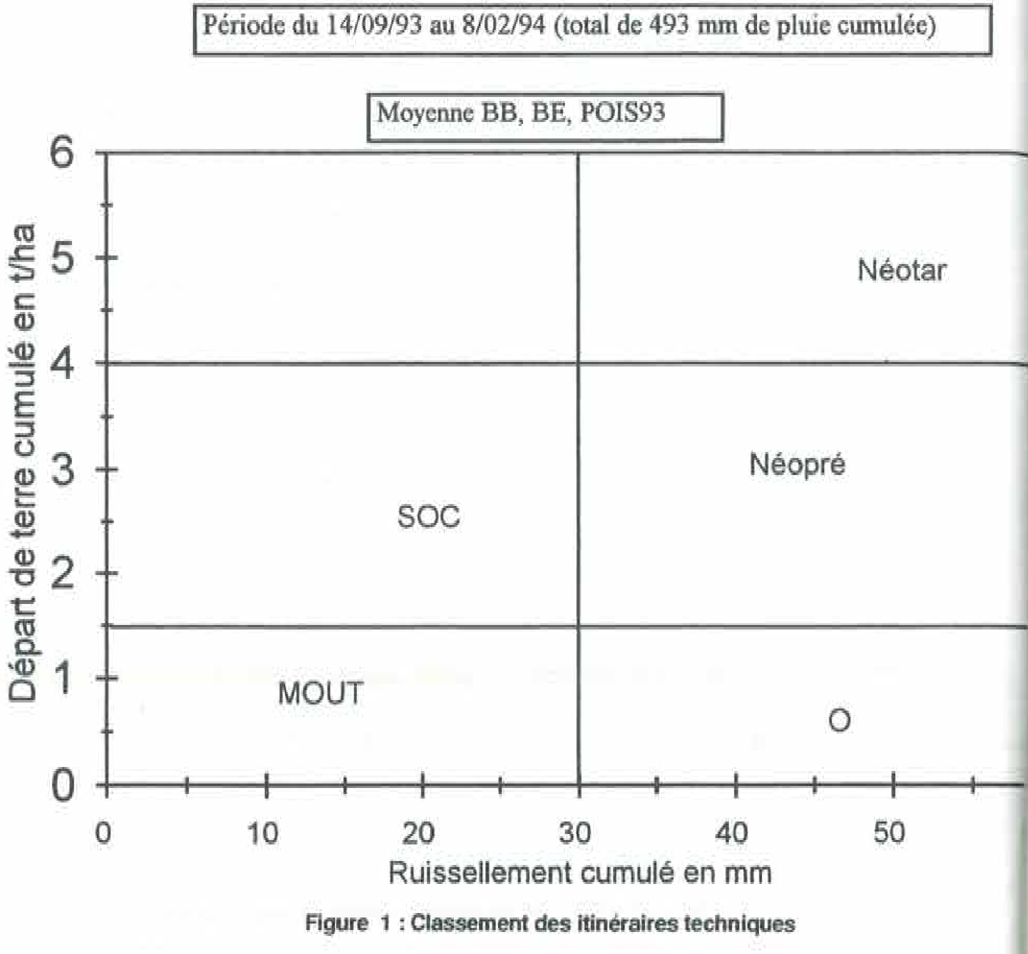

Figure 1 : Classement des itinéraires techniques

On note des différences significatives entre itinéraires techniques. Néotar ruisselle 4 fois plus que MOUT et conduit à des départs de terre 9 fois plus importants qu'avec O. Certaines interventions en interculture permettent de réduire significativement le ruissellement par rapport à des surfaces non traitées (SOC et MOUT par rapport à O). Par contre toute intervention culturale conduit à des départs de terre supérieurs ou égaux à ce que l'on constate sur les surfaces non traitées.

De façon plus générale, cette figure montre clairement que le ruissellement et l'érosion diffuse ne sont pas systématiquement corrélés; la corrélation semble dépendre des états de surface créés sur les parcelles. Il découle de ce constat que le choix d'un itinéraire technique en interculture pourra dépendre du risque que l'on souhaite réduire en priorité: soit le ruissellement soit le départ de terre. L'itinéraire SOC permet de réduire le ruissellement mais conduit à un accroissement des départs de terre. Seul MOUT conduit à une réduction du ruissellement sans accroissement des départs de terre. Toutefois cet itinéraire est plus coûteux en temps et en argent (semences à acheter, couvert à détruire avant l'implantation de la culture suivante) et ne peut donc pas être appliqué aussi facilement.

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Cet article reprend certains résultats de la thèse de docteur en Agronomie de l'INA-PG soutenue par l'auteur le 24/02/1997. Références: *Martin P., 1997. Pratiques culturales ruissellement et érosion diffuse sur les plateaux limoneux du Nord-Ouest de l'Europe. Application aux intercultures du Pays de Caux. Thèse de docteur de l'INA-PG. 184 p + annexes.*

II CONGRESS OF THE SOIL SCIENTISTS SOCIETY, RUSSIAN ACADEMY OF SCIENCES, ON THE 150TH BIRTH ANNIVERSARY OF V.V.DOKUCHAEV

The 150th Birth Anniversary of Professor V.V.Dokuchaev occurred on 1 March 1996. Dokuchaev was the outstanding Russian natural scientist who founded genetic pedology. He created the theory of soil as a special body of nature that linked 'live' and 'dead' (mineral) material. The basis of soil science, propounded by Dokuchaev, received wide recognition not only in Russia but throughout the world.

To mark the anniversary, the publishing house of Moscow University brought out a collection of selected works of Dokuchaev under the title, *Russian chernozem is more expensive than gold*, edited by academician G.V.Dobrovolskiy. An article about Dokuchaev, *A trance for centuries*, was published in the *Bulletin of the Russian Academy of Sciences* (No. 2, 1996). Articles on the development and modern state of Dokuchaev's pedology were published in the second and third numbers of *Pochvovodenie* for 1996. Special numbers of the Bulletins of Moscow and St Petersburg Universities were devoted to the anniversary. An envelope with Dokuchaev's portrait was also produced.

The Second Congress of the Soil Scientists Society of the Russian Academy of Sciences completed the celebrations. It took place on 27-30 June 1996 at St Petersburg State University. More than 400 Russian specialists and 26 leading foreign scientists attended. Among the foreign participants were the President, Professor A.Ruellan (France), and the General Secretary, Professor W.Blum (Austria), of the International Society of Soil Science, the Presidents of the Soil Science Societies in Belarus, Germany, Hungary, Ukraine and Yugoslavia, and representatives from China, Israel, Lithuania, Moldova, Slovakia, Tajikistan and USA.

In the opening speech, the President of the Society, academician G.V.Dobrovolsky said that soil scientists were at St Petersburg to pay tribute to the founder of soil science, a large part of whose creative work was connected with St Petersburg University where he progressed from student to professor and Head of the Department of Mineralogy. G.V.Dobrovolsky emphasized that many of the papers at the Congress reflect the modern condition of soil science. The main problems of pedology as a 'natural-historical' discipline were reflected symbolically in the motto of the Congress, *Soil - Life - Prosperity*. It signified the importance of soil conservation for the preservation of life and its diversity in the biosphere and the reasonable use of soil fertility to increase the prosperity of people.

Seven plenary lectures were given:

- G.V.Dobrovolsky - *V.V.Dokuchaev and modern natural sciences*
- A.N.Kashtanov - *V.V.Dokuchaev and modern agriculture*
- A.Ruellan (France) - *The scientific bases of pedology*
- W.Blum (Austria) - *The concept of soil stability*
- A.P.Shcherbakov et al. - *Century dynamics, ecological problems and perspective of Russian chernozem*
- I.Szabolcs (Hungary) - *The role of Russian and Soviet soil scientists in development of world science*
- R.Arnold (USA) - *Thank you, Dokuchaev*

The second day of the Congress was devoted to three parallel symposia:

- *Soil - a mirror of landscape; landscape agriculture* - under V.I.Kirushin
- *Soil and ecology* - under L.O.Karpachevsky
- *The theoretical problems of pedology as a fundamental science: problems of the 21st century* - under V.O.Targulian.

On the third day, fifteen sessions covered the main directions of pedology, including problems of soil erosion and conservation, soil amelioration technology and protection of soil against pollution.

A new exposition, named after V.V.Dokuchaev was held during the Congress at the Central Museum of Pedology. This is a unique museum covering world soils and ecology. The natural and economic potential of the soil resources of Russia are shown together with the problems associated with the crisis condition of soil resources on our planet. A documentary film, *V.V.Dokuchaev - to 150 years from the date of birth*, was shown to the Congress participants. It was prepared in the film studio of St Petersburg University and produced by O.S.Podolskaya. An English version is available.

Academician G.V.Dobrovolsky was again elected as President of the Soil Scientists Society. The Congress marked the strengthening of theoretical research as the base of further development of pedology and emphasized the need for activating an ecological direction to the science. There are difficulties, however, connected with inadequate funding. The Congress accepted the proposal to name the Soil Scientists Society of the Russian Academy of Sciences after Dokuchaev.

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REPORT ON THE CONFERENCE ON THE EUROPEAN COMMUNITY'S FIFTH FRAMEWORK PROGRAMME, 28 FEBRUARY AND 1 MARCH 1997

As a representative of the ESSC, I took part in the above conference. On the second day of the conference our secretary, Dr. Jean Poesen was also present. The aim of the conference was to discuss the Fifth Framework Programme with representatives of European organisations.

The basis for the discussion was the Commission Working Paper of some 37 pages, entitled *Towards the 5th Framework Programme: scientific and technological objectives* and a 40-page paper on *Data relating to the socio-economic context of the 5th framework programme*. The Working Paper included the content and objectives of the programme.

The opening plenary session was chaired by Professor J. Routti, Director-General for Science, Research and Development of the European Commission. The welcoming messages were given by Mrs. W. Cresson, Member of the European Commission, responsible for Science, Research and Development and Professor U. Scapagnini, Chairman of the Committee for Research, Technological Development and Energy (CERT) of the European Parliament. It was interesting to follow comparisons with the USA and Japan concerning research and development. The importance of the European added-value was emphasised. The welcoming messages were followed by communications of general interest given by J. Routti, C. Desama, A. Syrota and H. Tent.

The afternoon was devoted to the following parallel working sessions:

(1) Unlocking the resources of the living world and the ecosystem
(2) Creating a user-friendly Information Society
(3) Promoting competitive and sustainable growth
(4) Confirming the international role of European research
(5) Innovation and participation of SMEs
(6) Improving human potential.

I took part in working session 1.

The second day started with reports by the Chairmen of the parallel working sessions. Then the views of the representatives of CERT, CREST, Economic and Social Committee, Committee of the Regions, ESTA and IRDAC followed. Professor J. Routti closed the conference at noon.

As the Commission Working Paper says there are two inseparably linked objectives to the EU's research and technological development policy, i.e:

- to maintain and enhance, in the context of a genuine "European research area", the research potential of European laboratories, universities and companies and their ability to produce knowledge of the highest level and high-quality technologies;

- to help ensure that European research serves the Union's economic and social objectives, in other words European research at the service of the citizen and European competitiveness in a global framework.

The six programmes of the 5th Framework are the same as the titles of the above-mentioned afternoon working sessions. The first three programmes are thematic; the remaining three can be described as horizontal programmes.

During the working session about the resources of the living world and the ecosystem it turned out that many important issues were not mentioned explicitly in the Working Paper. There was no statement about the importance of the soil and or about soil conservation. Of course, it is not possible to mention everything but, taking the problems of European agriculture into account, the soil should have been mentioned explicitly. The representatives of other societies mentioned their fields of interest too. Within the structure of Framework V, Section IV: management and quality of water is probably the most appropriate for research on soil. Section VI: new rural and coastal areas could also be of some interest since, in this section, sustainable development and the use of the land are mentioned.

Our report from the ESSC to the EU makes a case for the explicit mention of soil within the Framework. We hope that this suggestion will be considered favourably.

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Hungary

EUROPEAN TOPIC CENTRE ON SOIL

The European Topic Centre on Soil (ETC/S) belongs to the European Environment Agency's network of thematic centres that covers key European environmental problems. The Centre was created in September 1996 as a contract between the Consejo Superior de Investigaciones Científicas (CSIC) in Spain and the European Environment Agency (EEA). The aim of the Centre is to provide expertise on soils and soil-related problems, supplying the EEA and the European Environment Information and Observation Network (EIONET) with objective, reliable and comparable information for bodies responsible for developing European environmental policy.

The ETC/S is a consortium of seven national organizations and one international organization, all with recognized experience in the field of soil science.

The ETC/S is located at the headquarters of the lead organization:

- Centro de Investigaciones sobre Desertificación (CIDE), CSIC, Universitat de València, Generalitat Valenciana, Camí de la Marjal, s/n. Apartado Oficial, 46470. Albal, Valencia, Spain.

The joint leader organization is:

- Agriculture and Food Development Authority, TEAGASC, Johnstown Castle Research Centre, Wexford, Ireland.

The other organizations in the consortium are:

- Ministry of Environment and Energy, Geological Survey of Denmark and Greenland, Copenhagen NV, Denmark.

- Soil Survey and Land Research Centre, Cranfield University, School of Agriculture Food and Environment, Silsoe Campus, Silsoe, Bedford, U.K.

- Federal Environment Agency, Umweltbundesamt, Wien, Austria.

- Institut National de la Recherches Agronomique, Département de Science du Sol, Centre de Recherche d'Orléans, Ardon, Olivet, France.

- Bundesanstalt für Geowissenschaften und Rohstoffe, Hannover, Germany.

- Joint Research Centre (JRC), Ispra, Italy.

Sub-contracted organization:

- Institute for Soil Mapping and Classification, National Agricultural Research Foundation, Larissa, Greece.

The Centre issues a regular Newsletter.

For further information, contact: Dr J.L.Rubio at the address of the lead organization (telephone: + 34 - 6 - 1260126; fax + 34 - 6 - 1263908) or visit their Web site: http://homepage.tinet.i.e/~jcastle/etcs/index/htm

NEW BOOKS

Renard, K.G., Foster, G.R., Weesies, G.A., McCool, D.K. and Yoder, D.C., coordinators, 1997. *Predicting soil erosion by water: a guide to conservation planning with the revised Universal Soil Loss Equation (RUSLE).* United States Department of Agriculture Handbook No. 703, 404 pp.

Whilst stocks last, single copies may be obtained at no cost from USDA-ARS, Southwest Watershed Research Center, 2000 East Allen Road, Tucson, AZ 85719, U.S.A.

NEW PhD THESIS

Soil - vegetation interactions and water erosion processes in the micro-environment of three Mediterranean matorral species

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PhD Thesis. Katholieke Universiteit te Leuven (Belgium).
Directors: J.Poesen & J.L. Rubio.

This work was carried out at two European institutions: the Katholieke Universiteit te Leuven (Belgium) and the Centro de Investigaciones sobre Desertificación (Valencia, Spain). The experimental work was undertaken in the Municipality of Cofrentes (Valencia, Spain). Financial support was given by the Commission of the European Communities (EPOCH and ENVIRONMENT Program Grants).

In the Mediterranean region of East Spain (Valencia), where water erosion is the major process of desertification, vegetation plays a fundamental role in runoff generation and in sediment transport on slopes. In this study, the spatial and temporal variability of water erosion has been studied at the "individual plant" scale (microscale), under three representative species of the Mediterranean matorral that have different morphologies (*Rosmarinus officinalis*, *Stipa tenacissima*, *Anthyllis cytisoides*). The relative influence of individual plants of these three species on water erosion processes has been determined both in the short and long term. In the short term, splash, runoff and sediment transport rates have been quantified under and outside the plant canopy, under natural rainfall over an approximately two-year period. Splash cups, erosion pins and erosion microplots were used to quantify the different water erosion sub-processes.

In the long term (since the establishment of plants in the experimental site), the degree of modification of soil physical and chemical properties, erosion and sedimentation rates have been evaluated in the micro-environment of plants of the three species. An exhaustive soil sampling was achieved around plants and an index reflecting the influence of plants on erosion and sedimentation processes was defined and measured.

The results show that vegetation reduces significantly splash, runoff and sediment transport with reference to bare soil surfaces. General mean rates of reduction under plant canopy are 74% for splash erosion, 45% for runoff and 71% for sediment transport after 21 rainfall events (in a 27 month period). However, the three species are not equally efficient in controlling water erosion. Reduction of soil detachment is 90% under *Rosmarinus*, 83% under *Stipa* and 49% under *Anthyllis*, in respect of bare soil surfaces. Reduction of runoff is 66% under *Rosmarinus*, 51% under *Stipa* and 18% (not statistically significant) under *Anthyllis*; and concerning sediment transport, reduction rates are 94%, 88%, and 30% for the three species respectively. Therefore, *Rosmarinus officinalis* and *Stipa tenacissima* are much more efficient in reducing erosion in the short term under their respective canopies than *Anthyllis cytisoides* shrubs. These results show that plant efficiency in controlling water erosion is strongly influenced by plant morphology and structural components. The dense canopy of *Stipa tenacissima* tussocks and the dense canopy and litter covers of *Rosmarinus officinalis* shrubs are responsible for the higher efficiency of these two species in reducing splash and interrill erosion on the short term.

In the long term, differences in litter and canopy cover between species explain the higher magnitude of modification of soil properties under *Rosmarinus* and *Stipa* in relation to *Anthyllis* shrubs. Moreover, the very high roughness, which characterizes *Stipa tenacissima* tussocks, is responsible for the significantly higher sedimentation in the micro-environment of *Stipa* compared to the other two species, particularly *Anthyllis cytisoides*.

The results illustrate the complexity of interactions that take place between plants and soil erosion and sedimentation processes at the microscale in a patchy matorral community. Some important soil aspects are closely linked to plants by a series of interactions that influence water and sediment fluxes on slopes and affect slope microtopography. These interactions give rise to peculiar landscapes similar to mosaics of isolated plants and large areas of unvegetated soil. Real "fertility islands" develop under the canopy of plants, characterized by reduced rates of water erosion (splash and interrill erosion), improved soil physical and chemical properties (better structure and infiltration capacity), and higher rates of sediment retention. Moreover, these complex interactions give rise to microtopographic structures in association with plants, such as mounds or terraces, that optimize water and nutrient supply to plants, and that condition water erosion processes that take place at other spatial scales (slope scale, for example).

Given the very high efficiency of *Rosmarinus officinalis* shrubs and above all *Stipa tenacissima* tussocks in controlling water erosion processes at the microscale, these two autochtone species - well adapted to Mediterranean adverse conditions - could represent an alternative solution to classical afforestation methods, based on low growing tree species, in order to combat desertification and to further soil conservation in semi-arid marginal areas.

FORTHCOMING MEETINGS

• **22-24 October 1997 - Principle écologiques de gestion des paysages agraires.**
Saint-Cloud, Paris, France.
Quatre sessions: (1) Relations environnement/agriculture, exemples pris dans les différents pays représentés au colloque; (2) Transfert des polluants sur les terres de grande culture et leurs effets sur les chaînes alimentaires et la santé; (3) Evolution des pratiques culturales en agriculture - impact sur la biodiversité; (4) Relations sylvosystèmes/agrosystèmes/hydrosystèmes. Une journée de travail sur le terrain en terres de grande culture - Bassin Parisien (Vexin/Mantois).
Inscription colloque: 400 FF. *Excursion:* 200 FF.
Organisation: Centre de Biogéographie-Écologie, UMR 180 CNRS / ENS Fontenay-Saint-Cloud, Grille d'Honneur, Le Parc, 92211 Saint-Cloud, France.
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• **23-28 May 1999 - ISCO '99: 10th International Soil Conservation Organization Conference - Sustaining the global farm (local action for land stewardship).**
Purdue University, West Lafayette, Indiana, U.S.A.
The scope of the conference may encompass, but is not limited to: Science and technology for conservation planning and assessment; Soil survey and natural resource assessment for environment protection; Socioeconomic elements of land and water conservation; Conservation policy: a basis for action; and Conservation action: sustaining our land and water. Post-conference tours: (1) US Soil Survey Centennial, Lincoln, Nebraska to West Lafayette, Indiana; (2) Mexico City to Monterey, Mexico and Weslaco, Texas; (3) Southeastern United States and Atlanta, Georgia; (4) Northeastern United States, University Park, Pennsylvania to West Lafayette, Indiana; (5) Southwestern United States, Phoenix and Tucson, Arizona; (6) Pacific Northwest Region of the United States.
Registration: US$ 200 (includes reception, mid-conference tour, banquet, abstracts and proceedings).
Organisers: ISCO99, Purdue University, 1196 SOIL Building, West Lafayette, Indiana 47907-1196, U.S.A.
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Note: The ESSC is a cooperating partner at this meeting.