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GLM Analyses of field and large laboratory experiments and their use to calibrate surface phosphorus load model for the watershed of Lake Balaton

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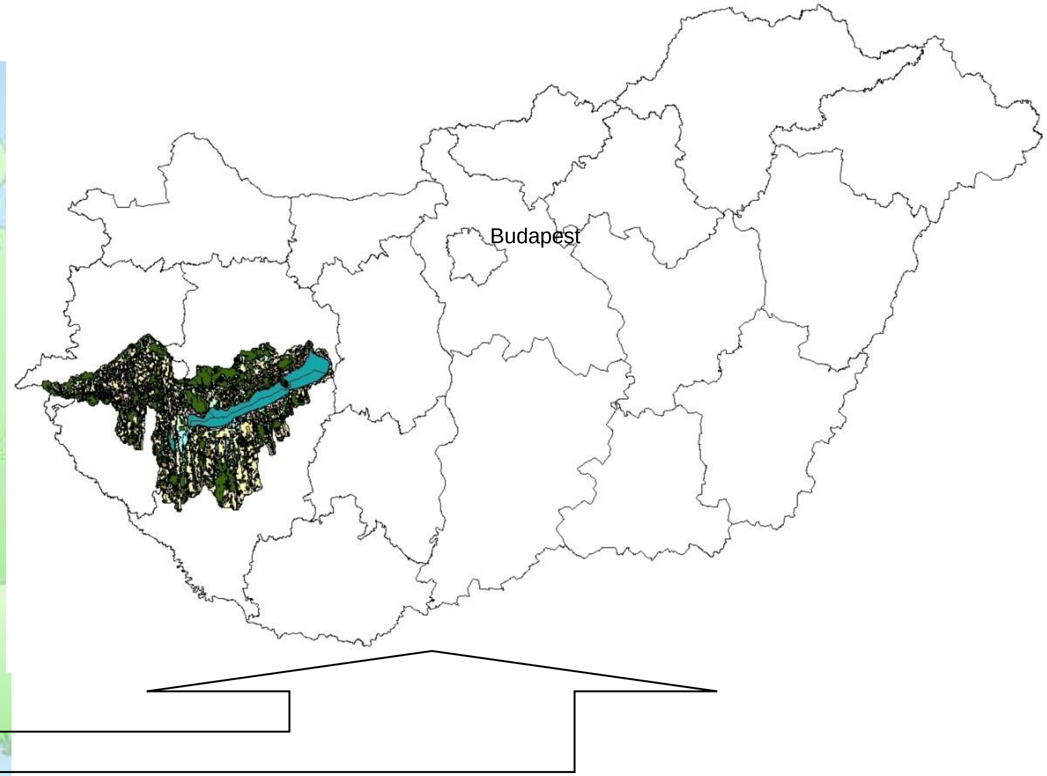
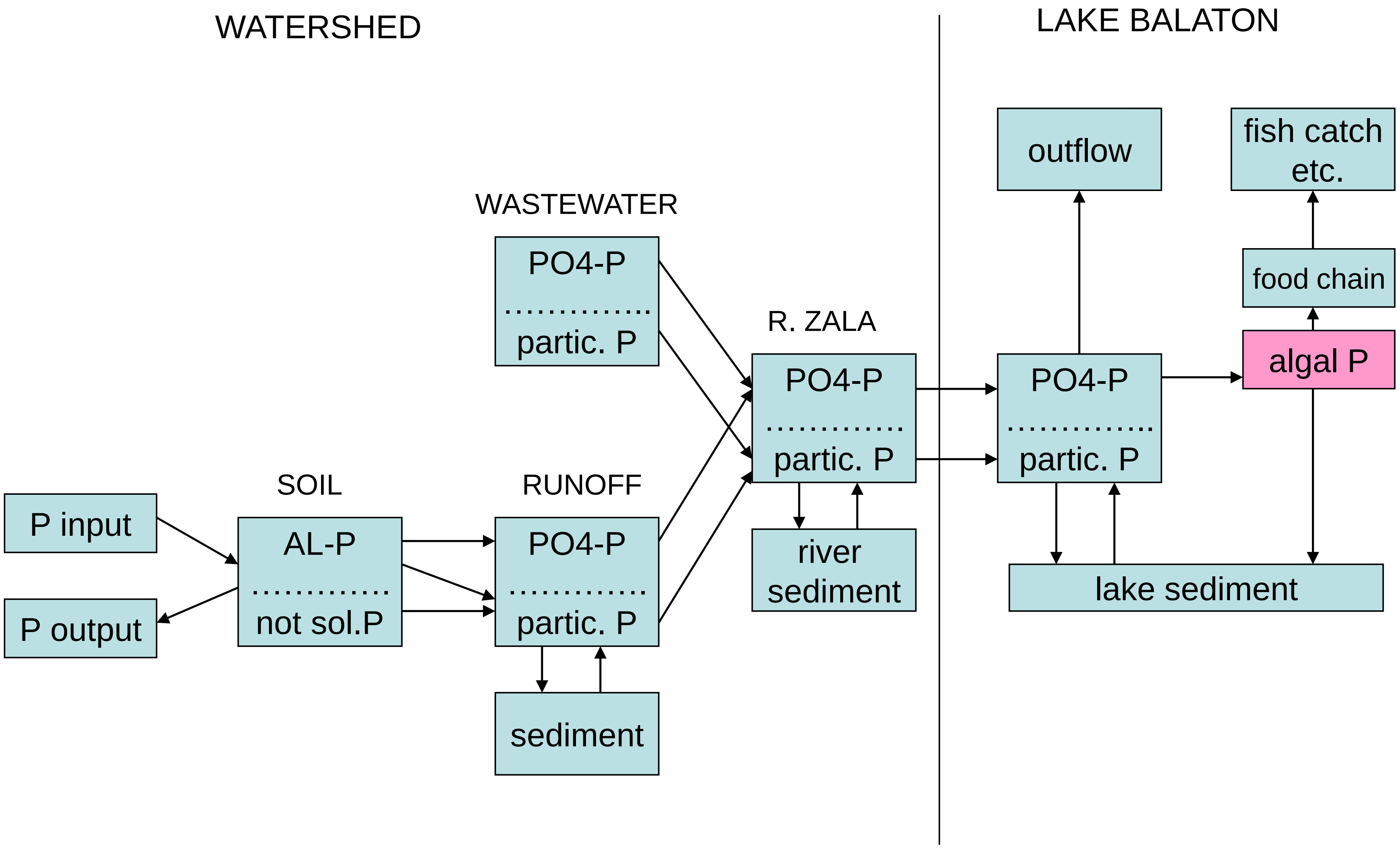
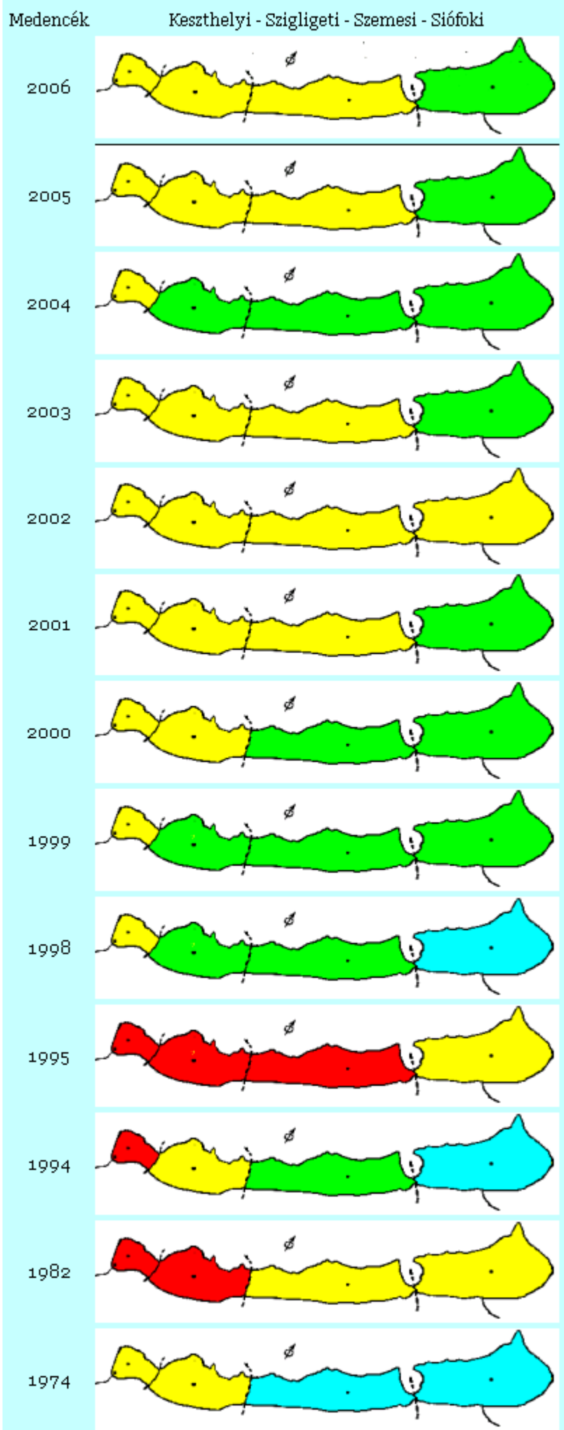
Location of Hungary within Europe and location of the watershed of Lake Balaton in Hungary



The only major watershed completely within the borders
The 2nd most important touristc area in Hungary

Problem statement





Deterioration of the water started in the late 1960's
Macrophyton eutrophication → algae blooms
Worst year: 1995

OECD szerinti minősítés

Oligotróf	<8 µg/l	Oligotrophic
Mezotróf	8-25 µg/l	Mesotrophic
Eutróf	25-75 µg/l	Eutrophic
Hipertróf	>75 µg/l	Hypertrophic

Az ábrasor összeállításánál a nyári időszakban a **nyílt vízen mért** klorofill-a értékeket vettük figyelembe.

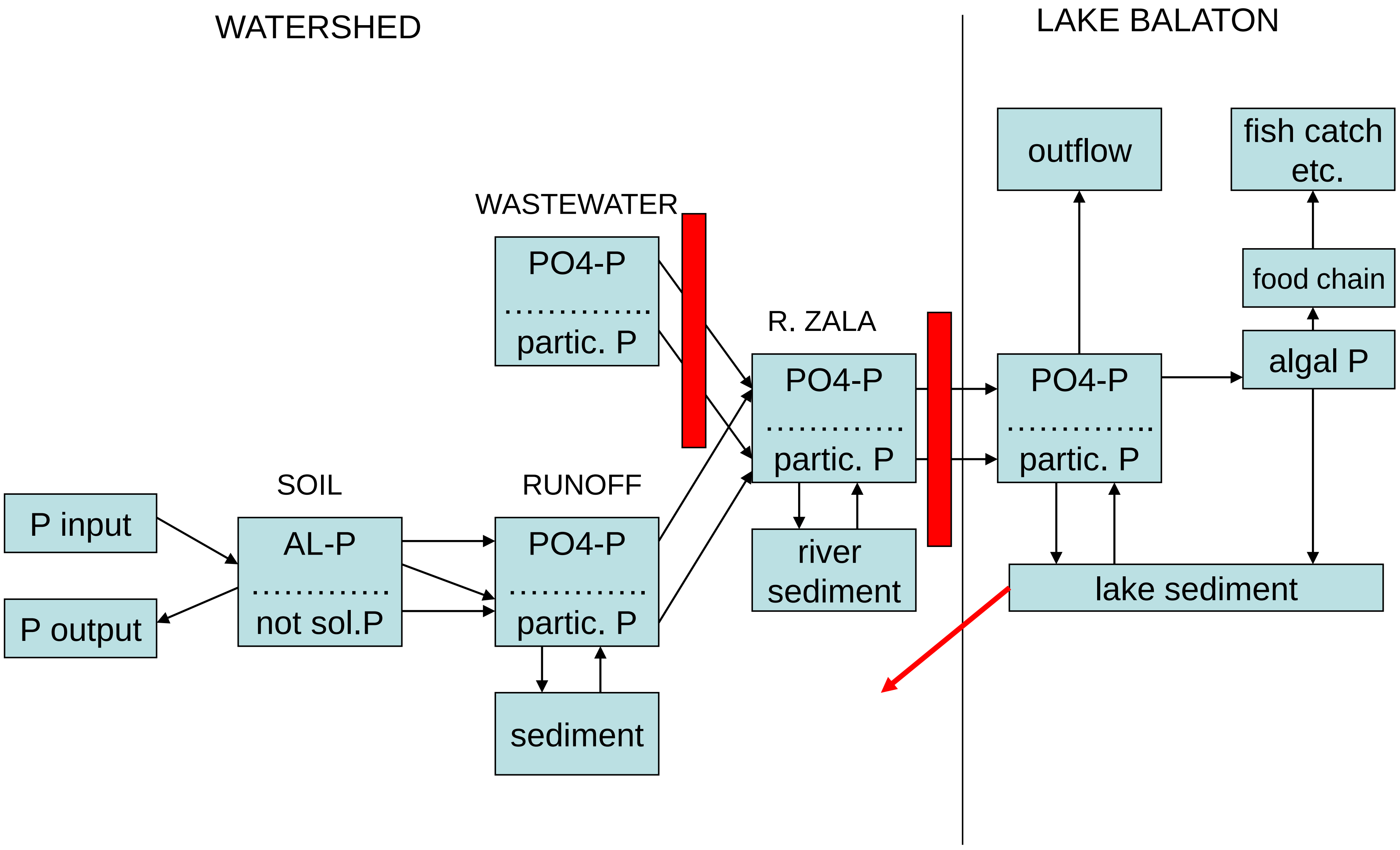
A tó vízminősége nyugatról keletre fokozatosan változik, a keleti medencében kedvezőbb minőségét mutatva. A vízminőség különbségét a medencénként eltérő - időnként előforduló - algásodás is jelzi.

A tó vízminőségét egyre csökkenő mértékben ugyan, de kedvezőtlenül befolyásolja, a Zala vízgyűjtőről érkező növényi tápanyag, amely a Kis-Balatonból távozva a tó összes terhelésének több, mint egyharmada.

Main reason: external phosphorus load
(point sources and non-point sources)

Main possibility of regulation: reducing external P load

Site description and prevention measures
There are still poblems remaining



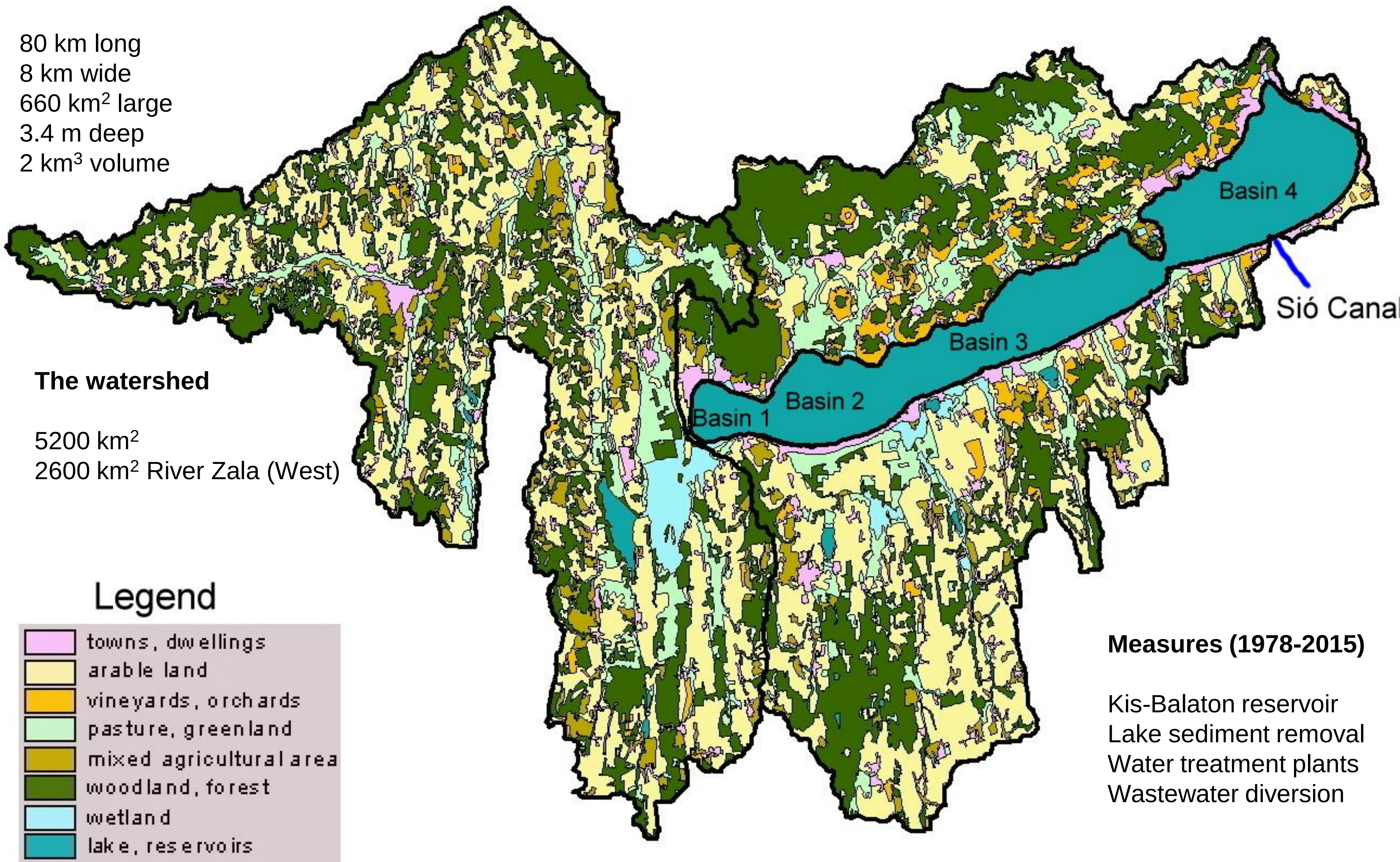
Land use in the watershed of Lake Balaton (Corine Landcover Database 2000)

The lake

80 km long
8 km wide
660 km^2 large
3.4 m deep
2 km^3 volume

The watershed

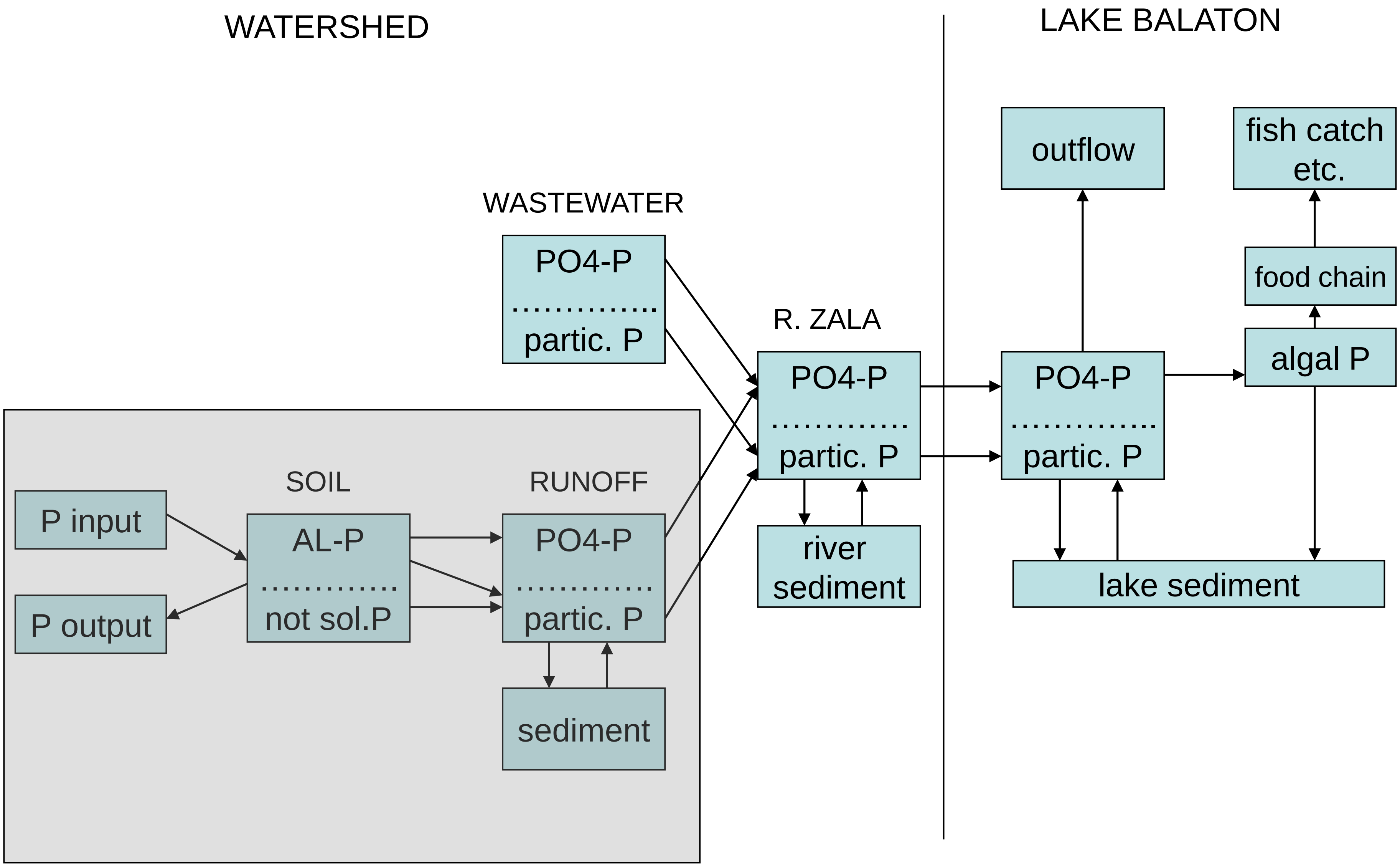
5200 km^2
2600 km^2 River Zala (West)



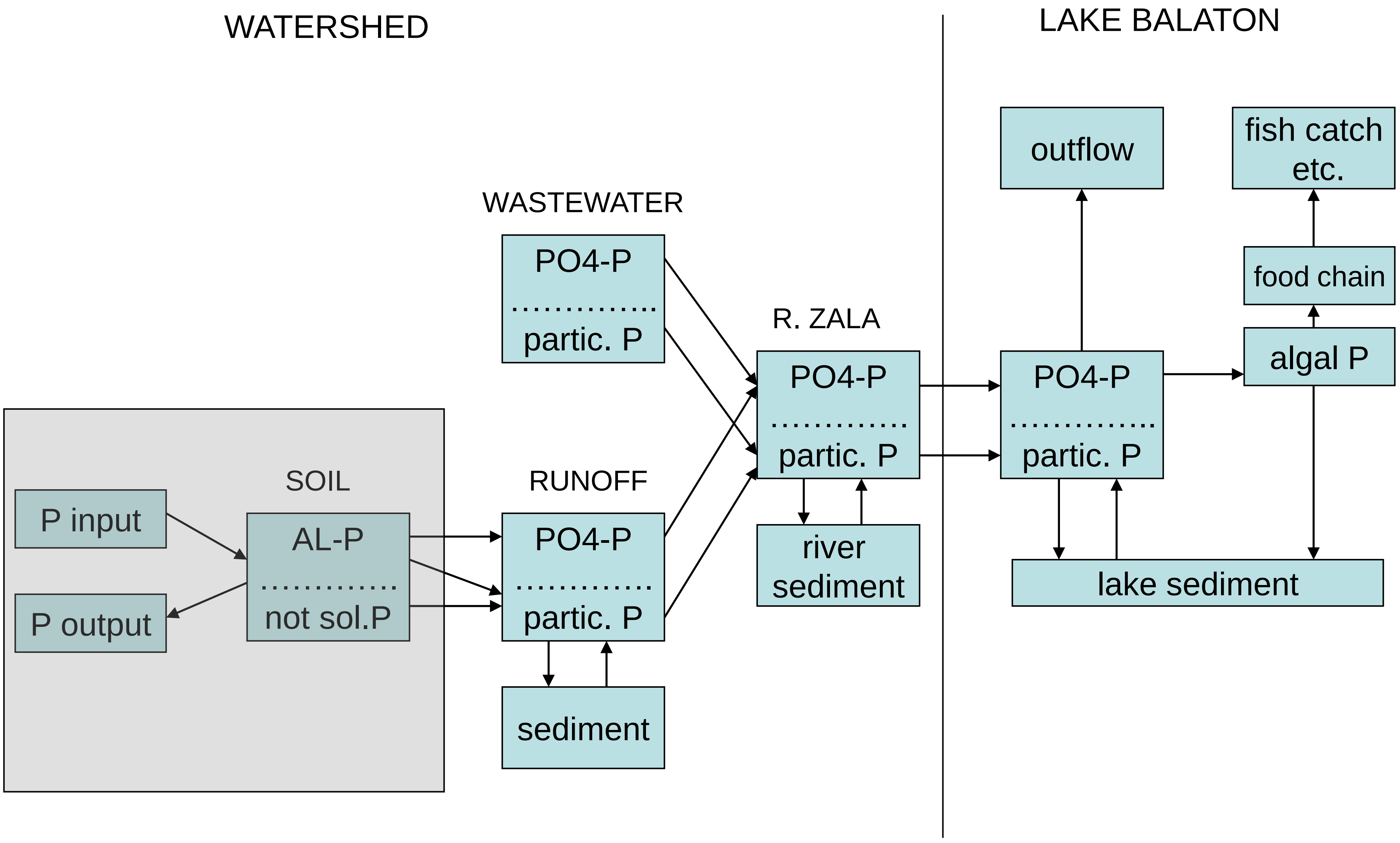
Measures (1978-2015)

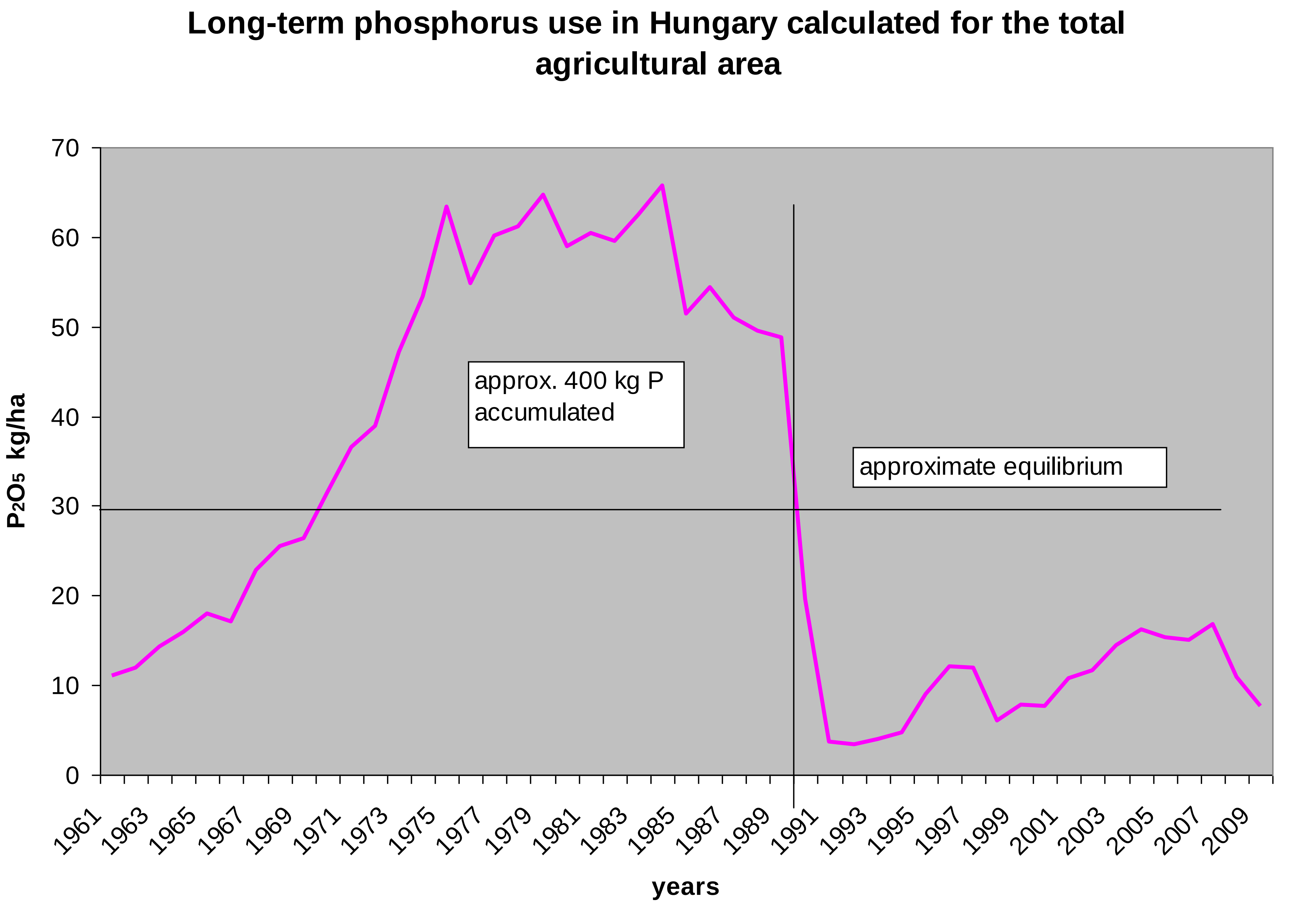
Kis-Balaton reservoir
Lake sediment removal
Water treatment plants
Wastewater diversion

The problem still exist: the western basins are hypertophic at lakeshore
Hypothesis: water quality cannot be further improved without agri-environmental measures

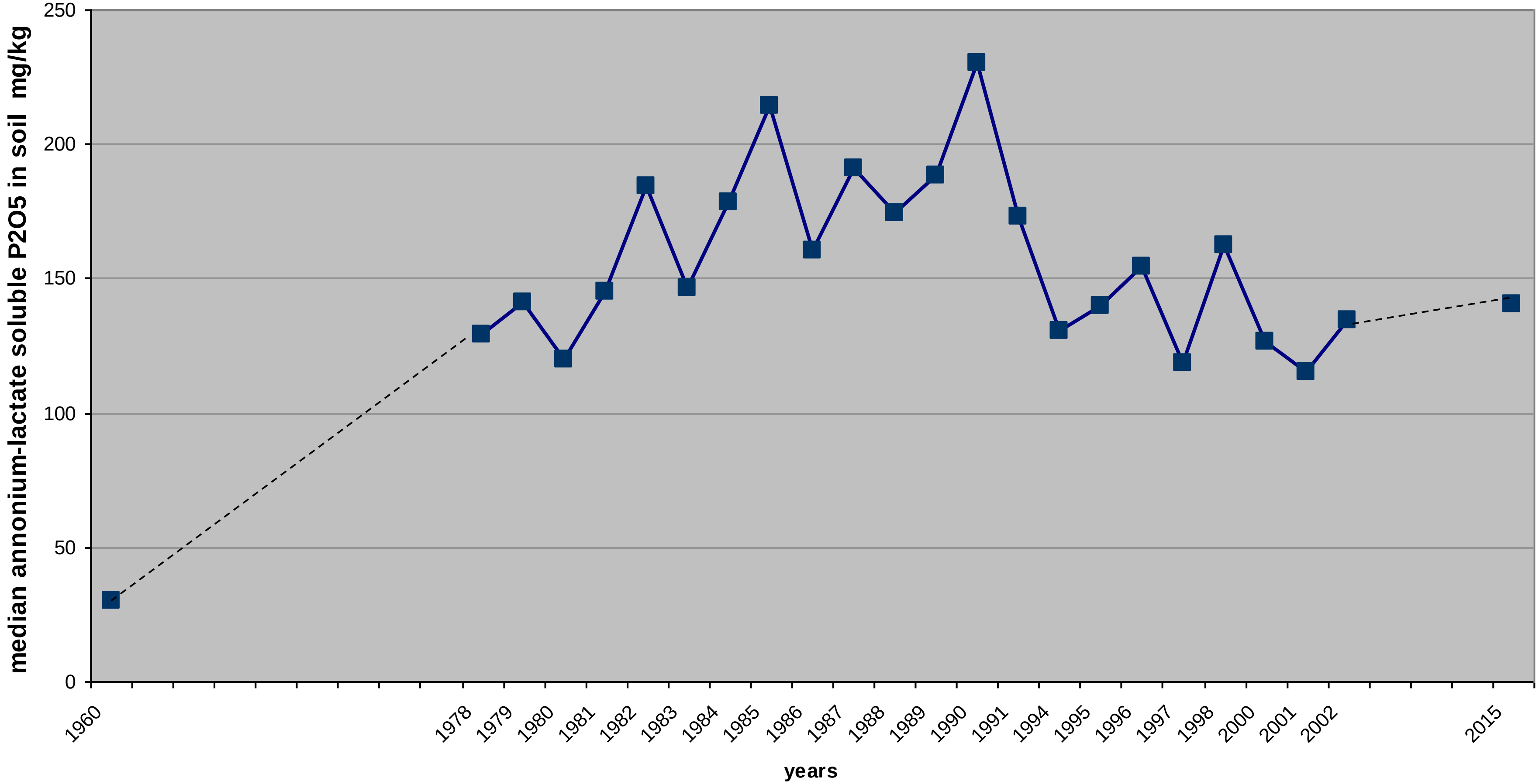


P balance and trend analysis approach

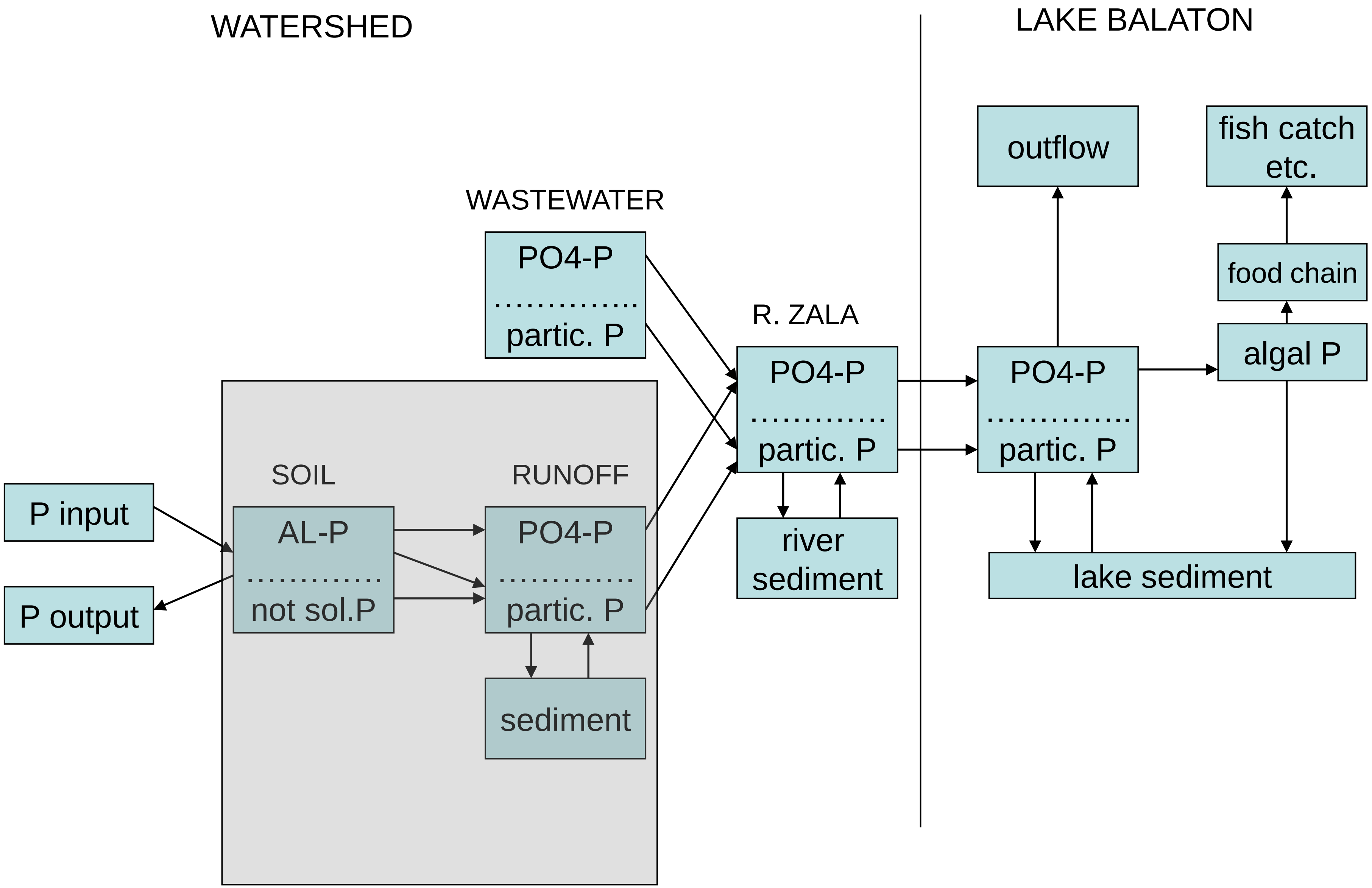



Long-term phosphorus use in Hungary calculated for the total agricultural area
P_2O_5 kg/ha
70
60
50
40
30
20
10
0
approx. 400 kg P accumulated
approximate equilibrium
1961
1963
1965
1967
1969
1971
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
years

Change of soil test-P (ammonium-lactate soluble P) in arable soils in the watershed of Lake Balaton

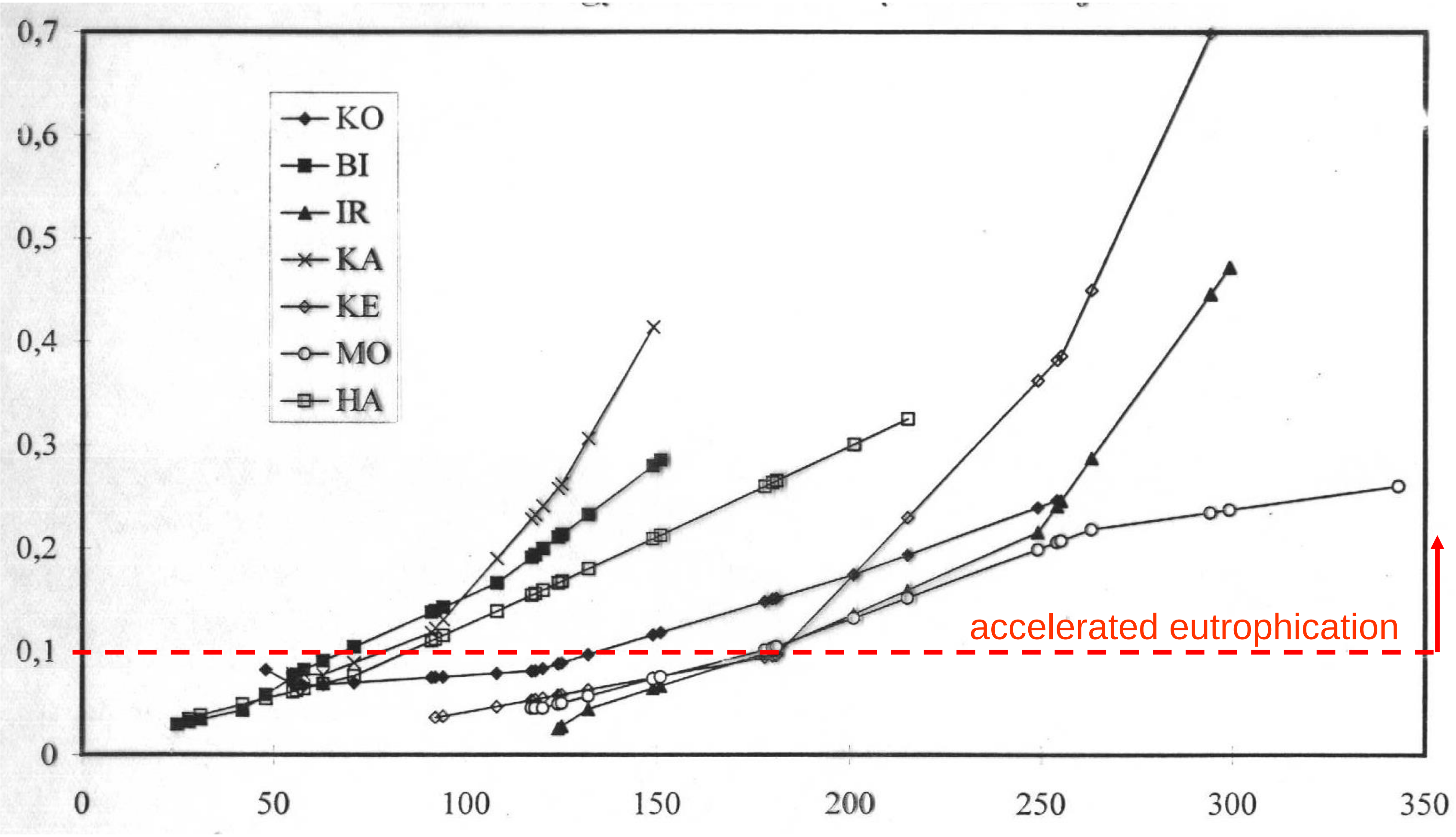


Model experiment approach



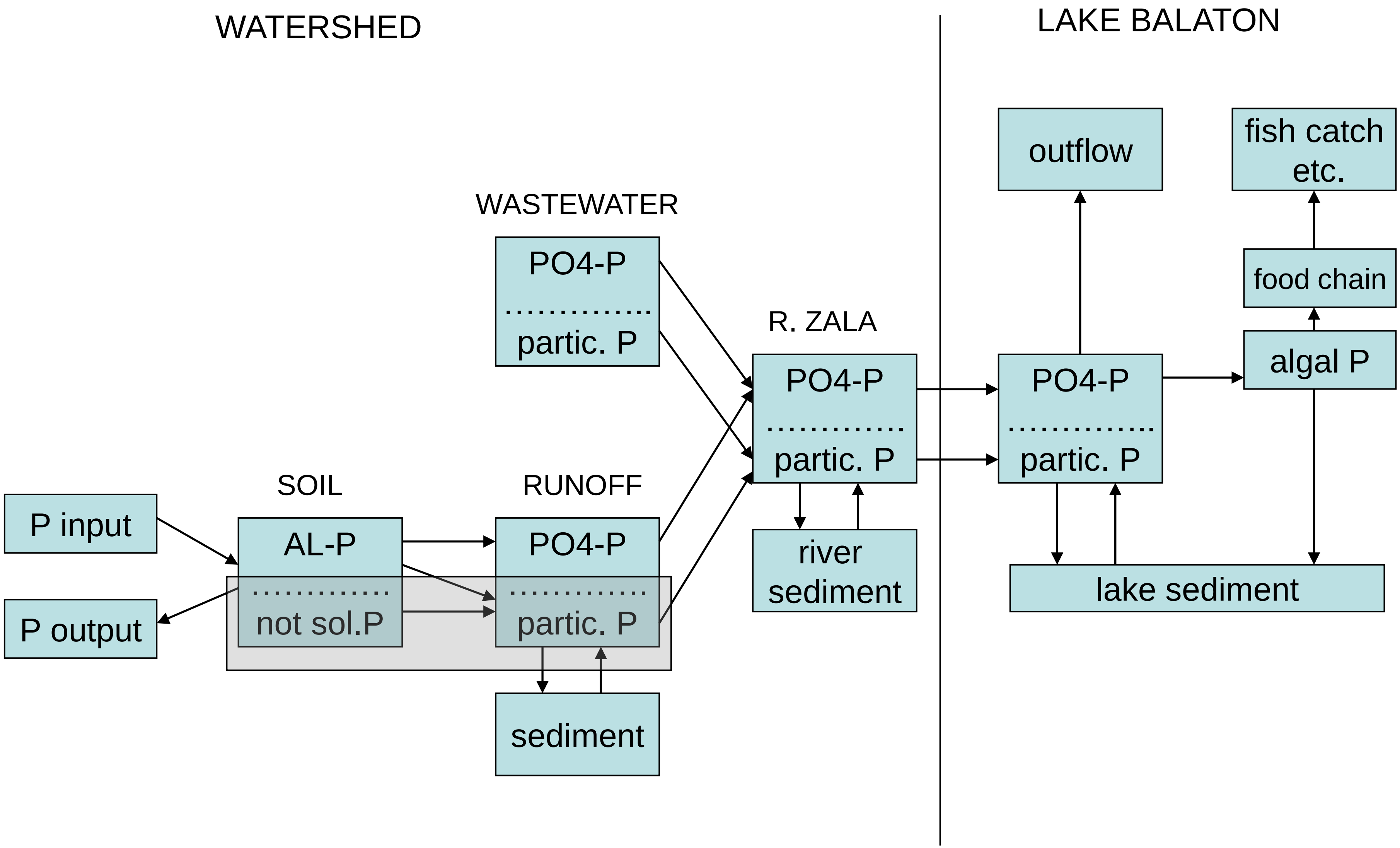
PO4-P content in suspensions prepared from differently treated soils (0-150 kg/ha/yr P2O5)
(average of several soil to solution ratios and deposition times) at 7 sites

PO4-P
mg/L

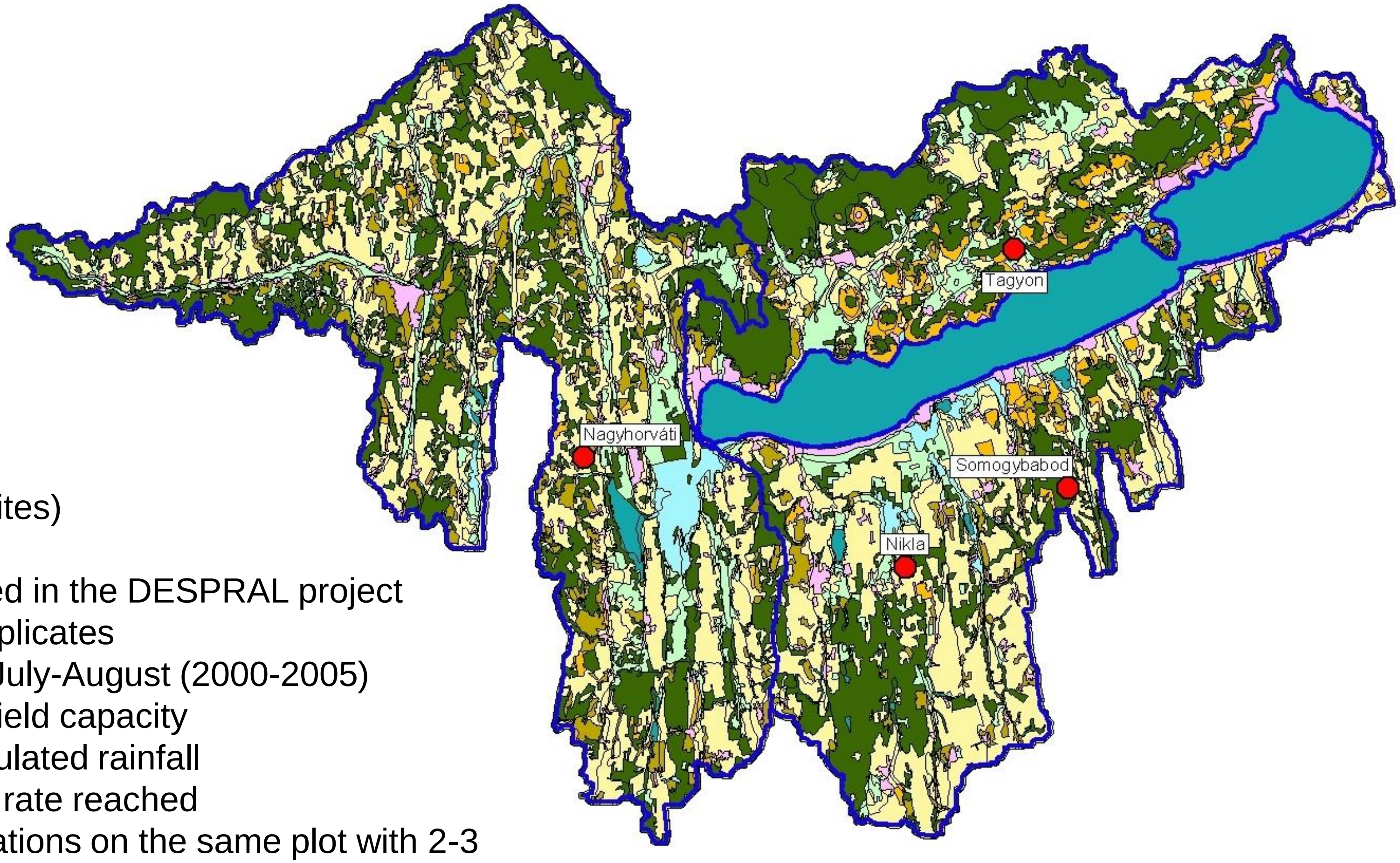


AL-P in soils (function of fertilizer treatment) mg/kg P2O5

Plot scale erosion experiments in the lab and on the field



Four experimental sites (representative for the watershed)



Field experiments (4 sites)

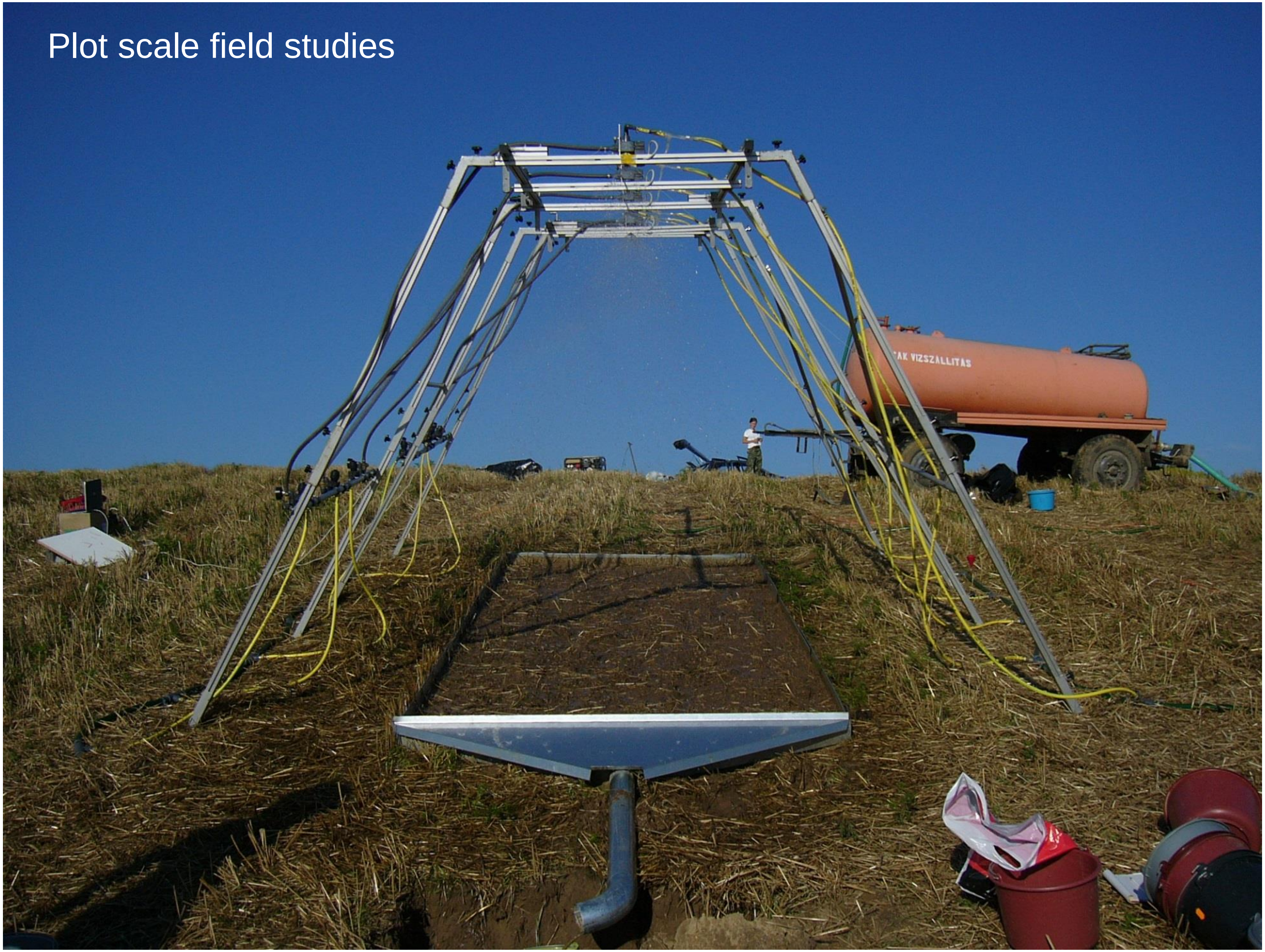
Methodology developed in the DESPRAL project
2x5 m plot size, 3-4 replicates
Seedbed condition in July-August (2000-2005)
Gentle pre-wetting to field capacity
60 (90-120) mm/h simulated rainfall
until equilibrium runoff rate reached
3-4 consecutive simulations on the same plot with 2-3 day return time

Laboratory experiments (3 sites)

1x3x0.5 m big boxes, 2 replicates (2006)
Fild-equivalent slope + 13 %
…other conditions are the same

Sites	pH_{dw}	pH_{CaCl2}	OM %	CaCO3 %	sand %	silt %	clay %
Nagyhorváti(1)	7.3	6.8	1.71	0.4	35.6	41.6	22.8
Somogybabod(2)	8.3	7.7	1.52	22	31.4	51.7	16.9
Tagyon(3)	7.6	7.2	1.81	4.3	41.3	29.5	29.2
Nikla(4)	5.8	5.4	1.20	0	82.1	13.7	4.2

Plot scale field studies

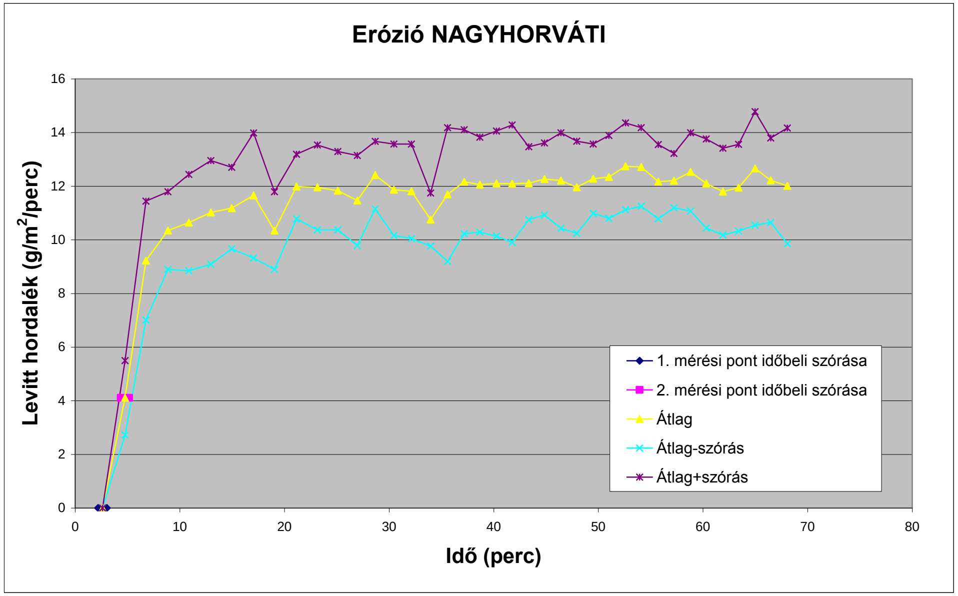


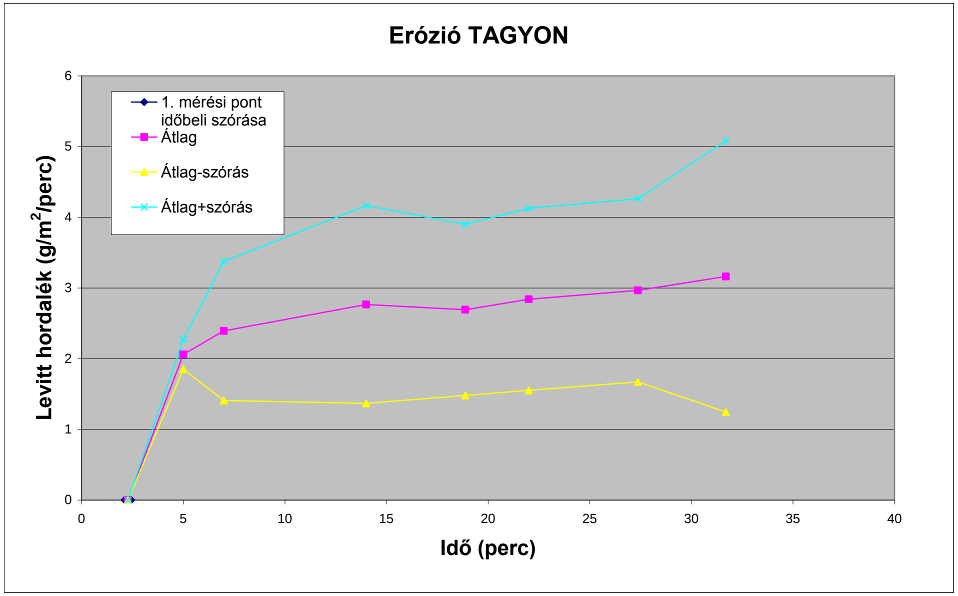
Small plot (2*5 m) measurements on the field; 60(-120) mm/h until stady-state runoff

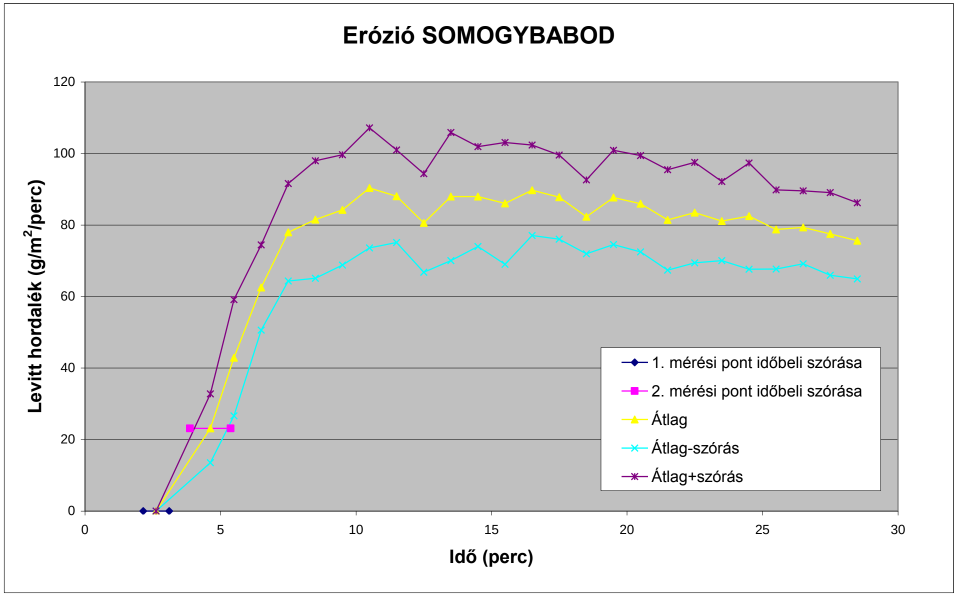
Large laboratory studies

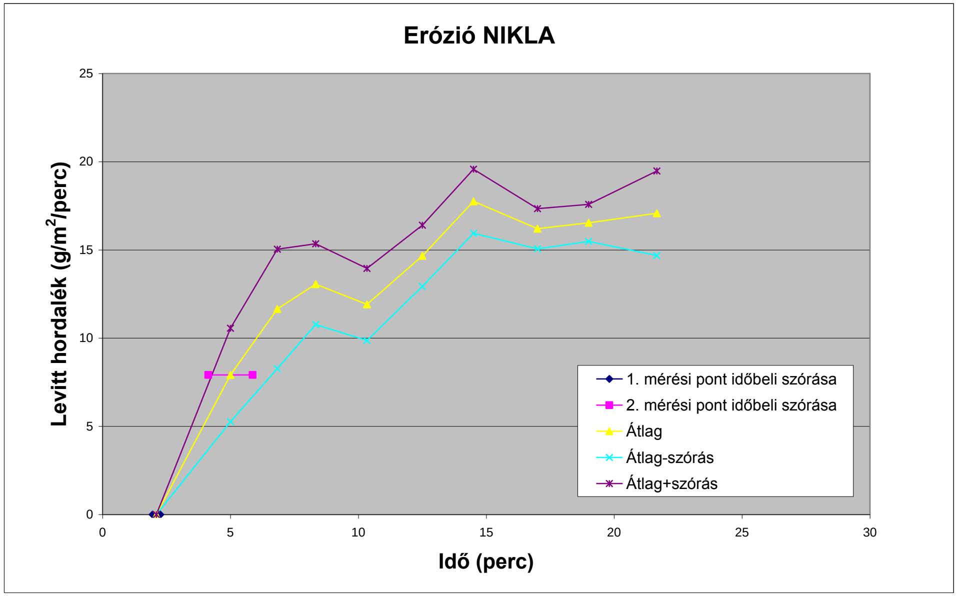
1*3*0.5 m;   25 cm arable soil + 25 cm sand (subsoil)

Erosion rates with the variability at the four sites interpolated to round minutes










Nagyhorváti
Somogybabod
Tagyon

Re-analysis of the data

Technical objectives

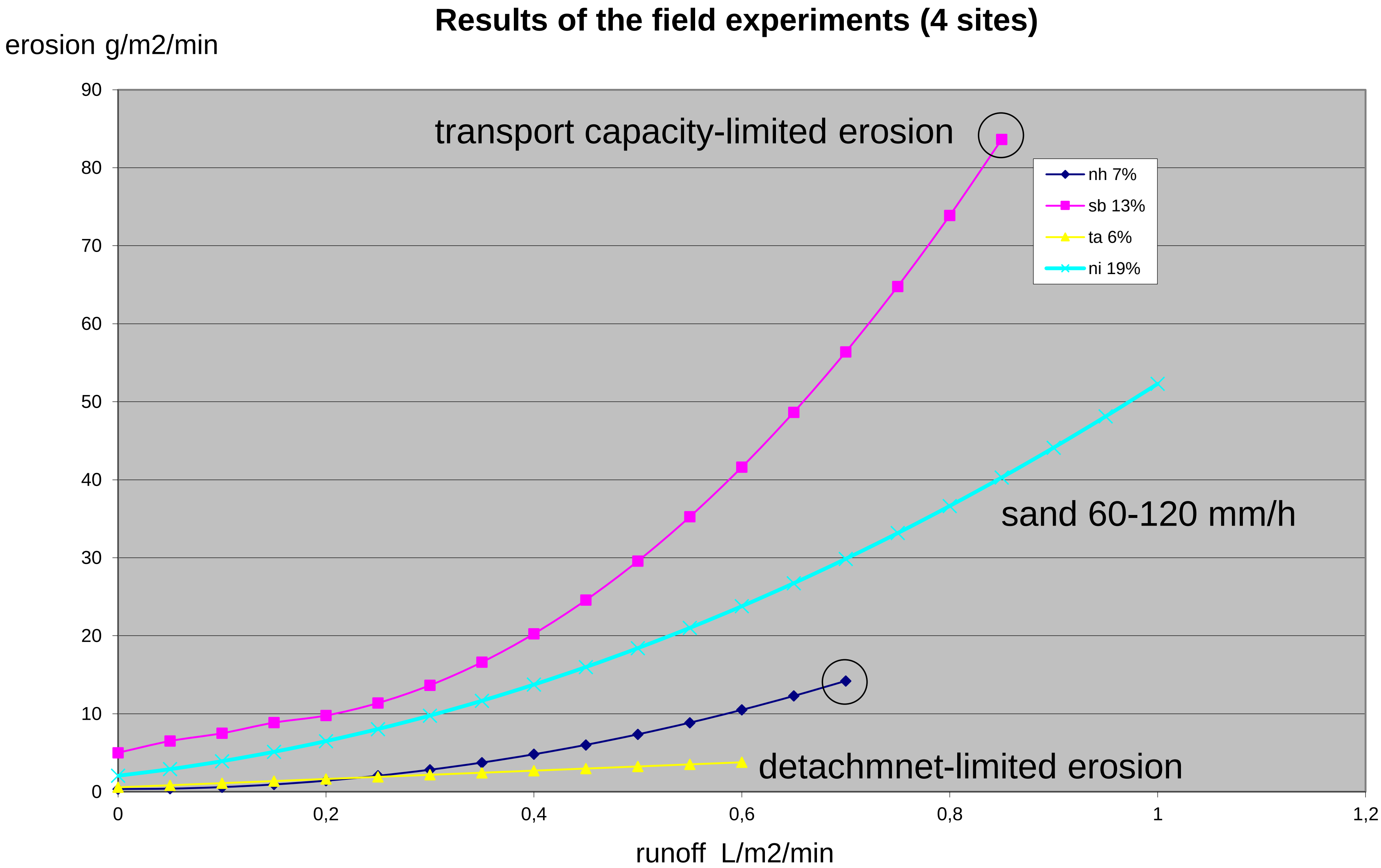
1.) What is the gain from using physically based model instead of empirical (USLE)

2.) How can ve use the experimental results to parameterize models

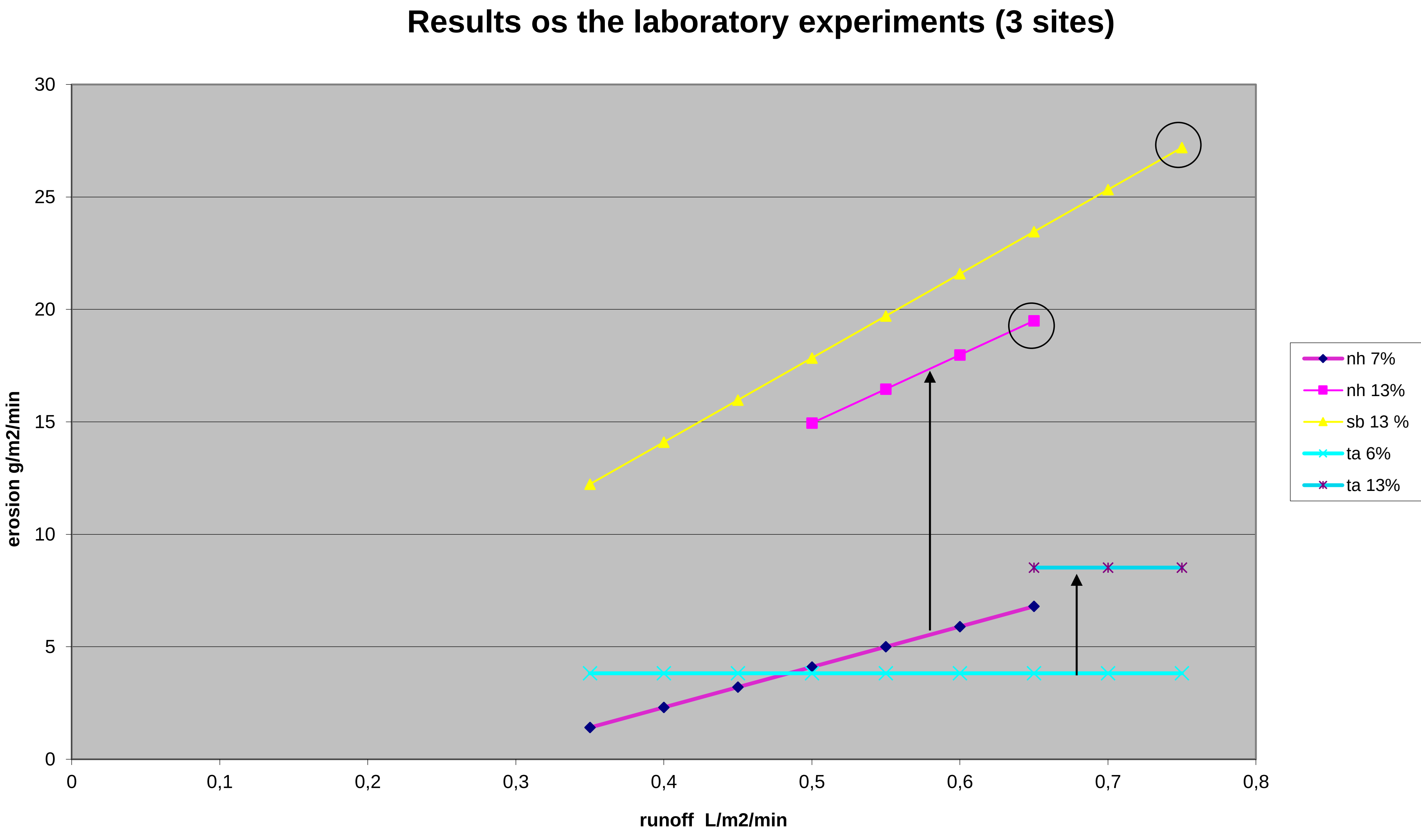
3.) How far can we extend capabilities of empirical models by the results

4.) What is the key variable that should be monitored to improve erosion prediction

Re-analysed data



Re-analysed data



Re-analysed data

plot No	Site	experiment	slope %	n	LN_runoff	LN_erosion	slope of the	r2_of the
					mean	mean	linear equation	linear equation
11	Nagyhorváti(1)	field	7	122	-0.884	1.636	1.466	0.931
12	Nagyhorváti(1)	field	7	103	-0.881	1.920	1.716	0.943
13	Nagyhorváti(1)	field	7	146	-0.900	1.734	1.568	0.974
14	Nagyhorváti(1)	field	7	125	-0.855	1.410	1.684	0.828
15	Nagyhorváti(1)	laboratory	7	29	-0.625	1.517	3.022	0.895
16	Nagyhorváti(1)	laboratory	13	22	-0.592	2.664	1.006	0.178
21	Somogybabod(2)	field	13	85	-0.309	3.950	1.703	0.885
22	Somogybabod(2)	field	13	82	-0.357	4.140	1.436	0.803
23	Somogybabod(2)	field	13	85	-0.288	4.279	1.643	0.776
24	Somogybabod(2)	field	13	82	-0.273	4.170	1.799	0.539
25	Somogybabod(2)	laboratory	13	29	-0.554	2.998	1.130	0.532
31	Tagyon(3)	field	6	85	-0.918	0.888	0.941	0.817
32	Tagyon(3)	field	6	90	-0.868	1.316	**0.255**	**0.170**
33	Tagyon(3)	field	6	76	-0.818	0.775	1.017	0.695
35	Tagyon(3)	laboratory	6	31	-0.567	1.328	**-0.019**	**0.000**
36	Tagyon(3)	laboratory	13	36	-0.331	2.135	1.562	0.320
41	Nikla(4)	field	19	40	-0.551	3.341	1.678	0.829
42	Nikla(4)	field	19	37	-0.737	3.067	1.539	0.774
43	Nikla(4)	field	19	29	-0.482	2.892	1.793	0.560

		R^2
Linear regression	ln(runoff) → ln(erosion) :	0.62
ANOVA	everything else than runoff (main effects)	0.80
ANOVA	(nested designs)	0.84
GLM	(main effects + runoff as covariance factor)	0.96

Conclusions

1.) What is the gain from using physically based model instead of empirical (USLE)
Realtively small

2.) How can ve use the experimental results to parameterize models
They cover the whole range of soil variability within this watershed

3.) How far can we extend capabilities of empirical models by the results
Empirical runoff dependence functions of erosion can be added

4.) What is the key variable that should be monitored to improve erosion prediction
Subsoil permability

Hot spots: loess derived arable soils

These areas produce more than 2/3 of the primary particulate P loss (erosion)
Reduction of erosion rate (subsoil loosening, mulching) may have dramatic decrease in diffuse phosphorus load to Lake Balaton