Estimate of sediment yield in small Alpine basins:

some issues on empirical versus physically based approach

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International Conference
Sediment Transport Modeling in Hydrological Watersheds and Rivers
Conférence Internationale
Modélisation du transport de sédiments dans les bassins-versants et dans les rivières

Matteo Forlani, Ùamiano Trevisi, Francesca Berteni, Stefano Barontini, Paolo Caronna, Matteo Balistrocchi

Empirical approach: the USLE

Guerna river basin (Bergamo, Regione Lombardia funding)
UNGAUGED

USLE- Universal Soil Loss Equation

Wischmeier e Smith (1978, USA)
RUSLE: Reinard et al., 1991

- Empirical
- Agricoltural management (USA)
- Multiplicative
- Erosion limited
- Universal
- Standard

- Uniform slope
- Slope 9%
- Length 22,13 m
- Bare soil
- soil work along maximum depth lines

Theory: empirical approach USLE-RUSLE

USLE- Universal Soil Loss Equation

Wischmeier e Smith (1978, USA)
RUSLE: Reinard et al., 1991

- Empirical
- Agricoltural management (USA)
- Multiplicative
- Erosion limited
- Universal
- Standard

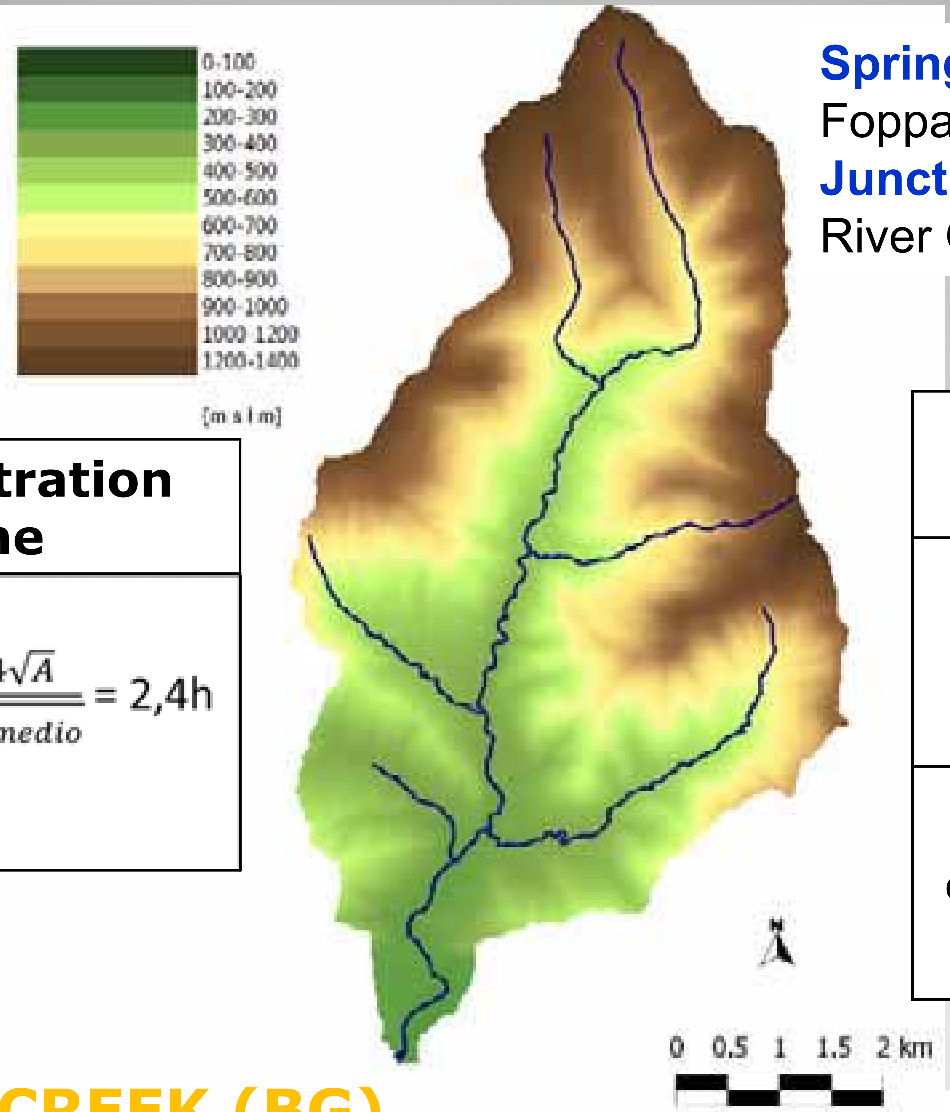
$$A = R \cdot K \cdot LS \cdot C \cdot P$$

A → soil erosion[t/ha·anno]
R → climatic factor
K → soil factor
LS → topographic factor (RUSLE)
C → vegetation factor
P → agricoltural practices

Theory: empirical approach USLE-RUSLE

GUERNA CREEK (BG) Morphology

Digital Elevation Model 20x20m

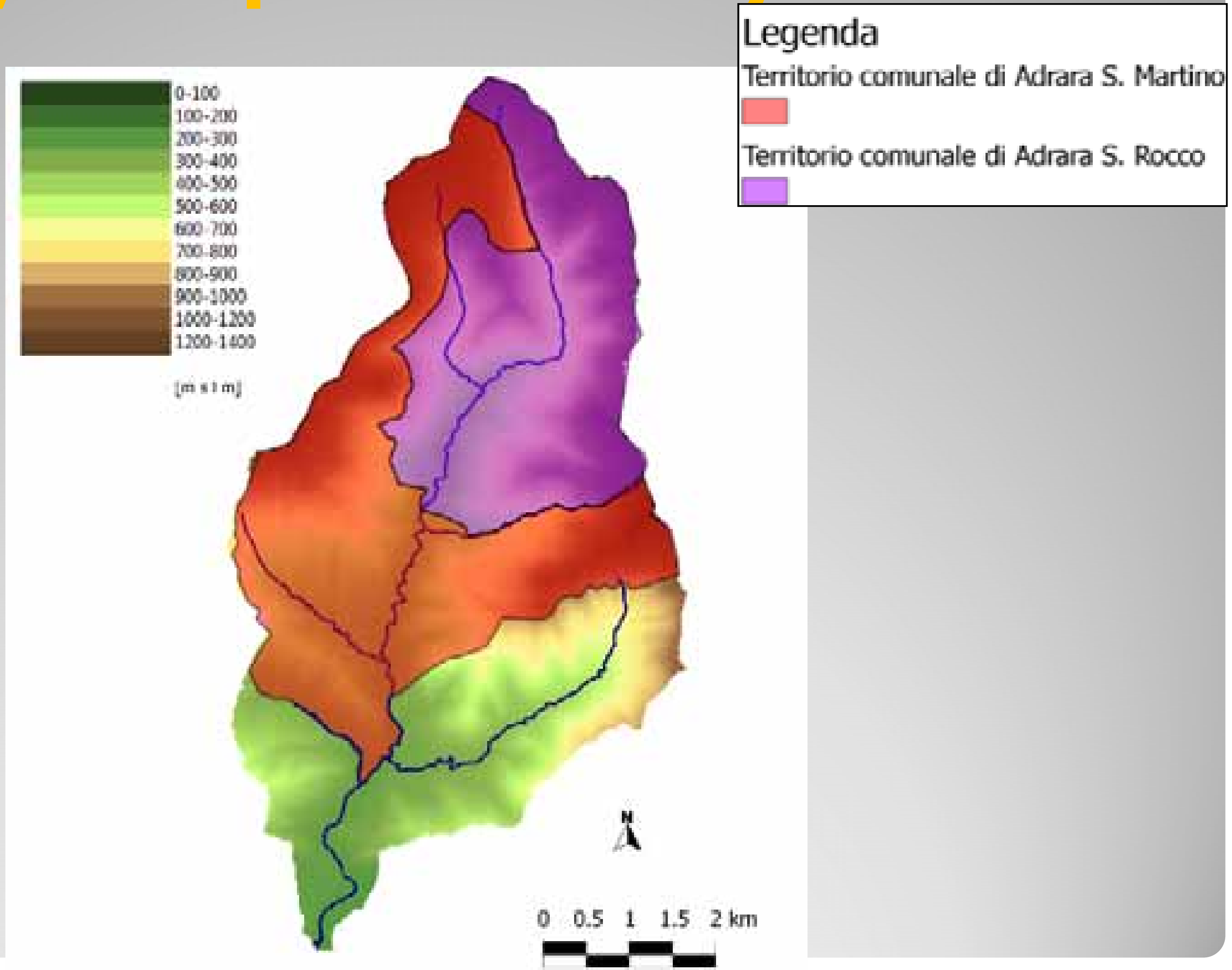


Springs:
Foppa peak1331 m a.s. l.
Junction:
River Oglio 195 m a.s.l.

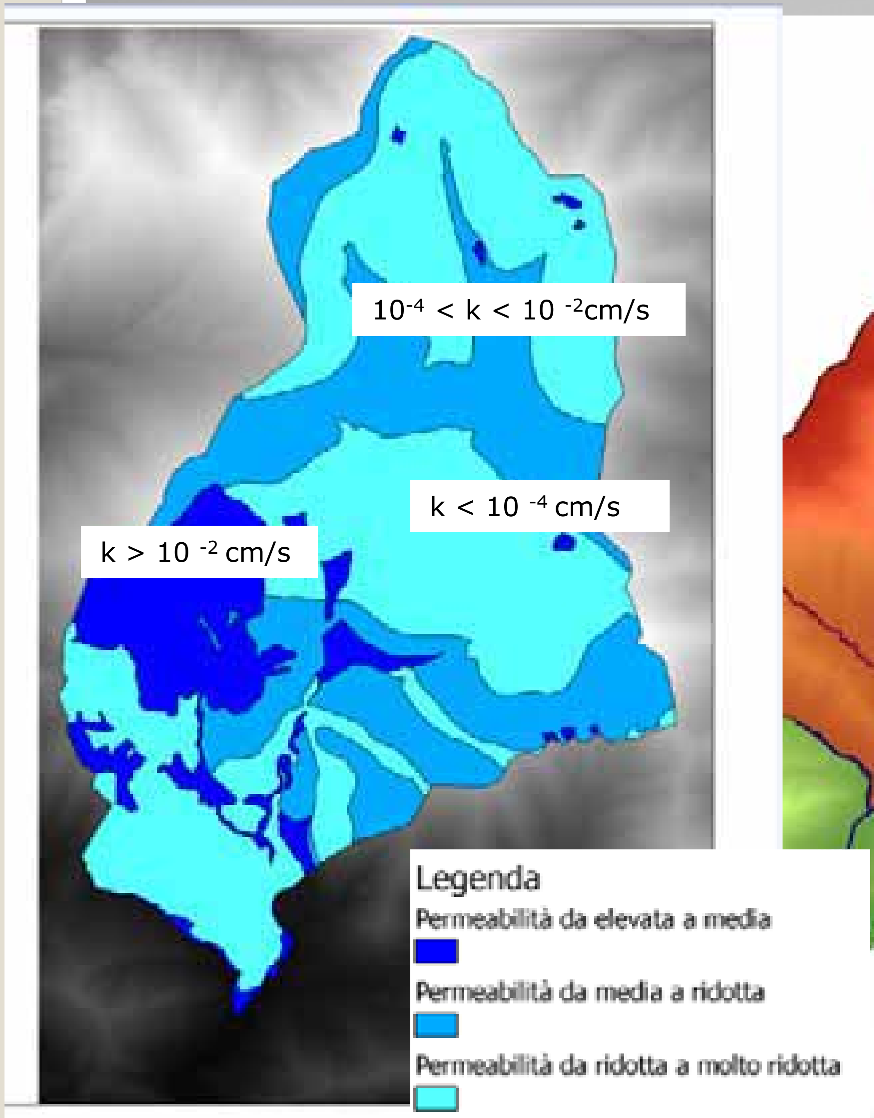
Concentration time
$T_C = \frac{1{,}5L+4\sqrt{A}}{0{,}8\sqrt{\Delta H_{medio}}} = 2{,}4h$

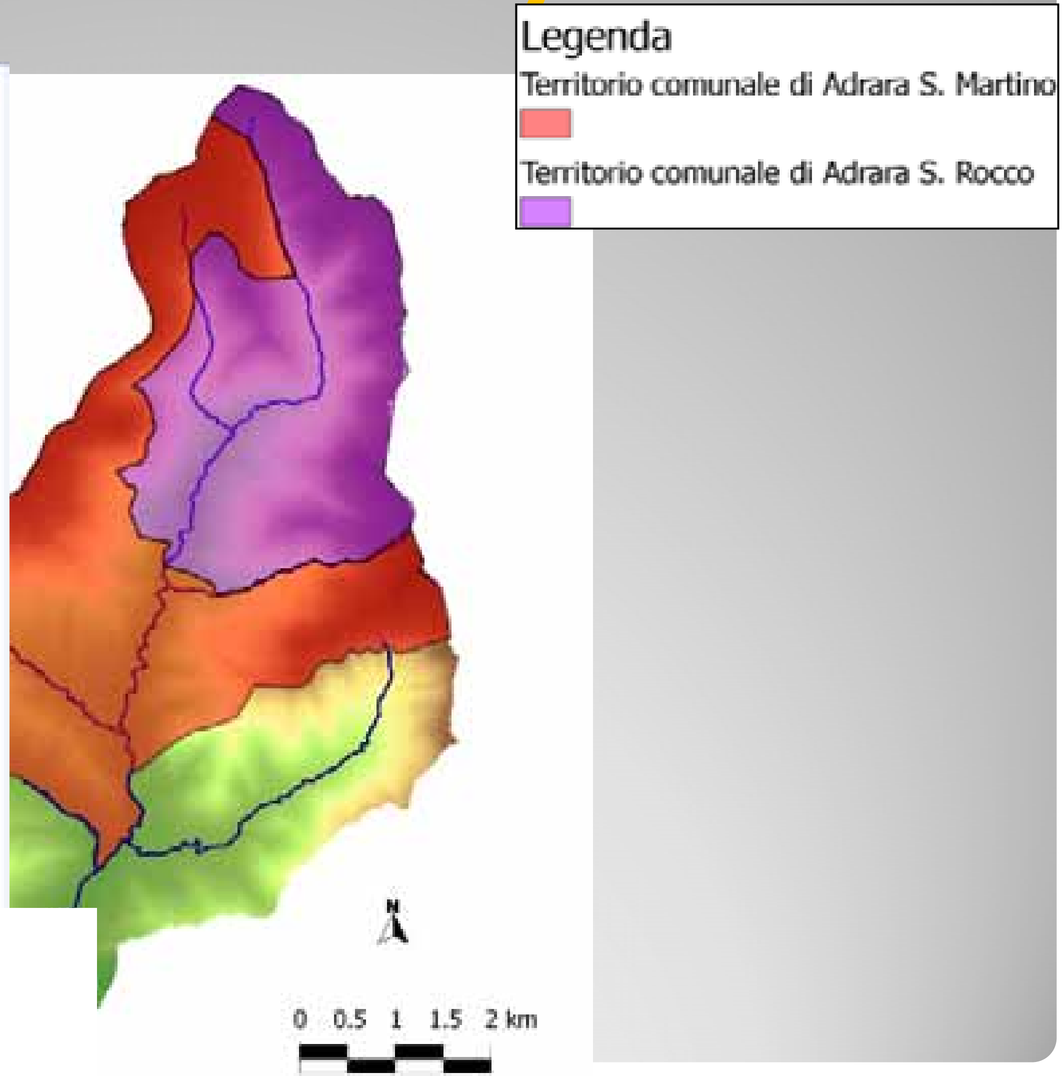
Area(A)	30,9 km^2
Main course length(L)	12,4 km
Average elevation (ΔH_{media})	451,9 m

Geology and permeability

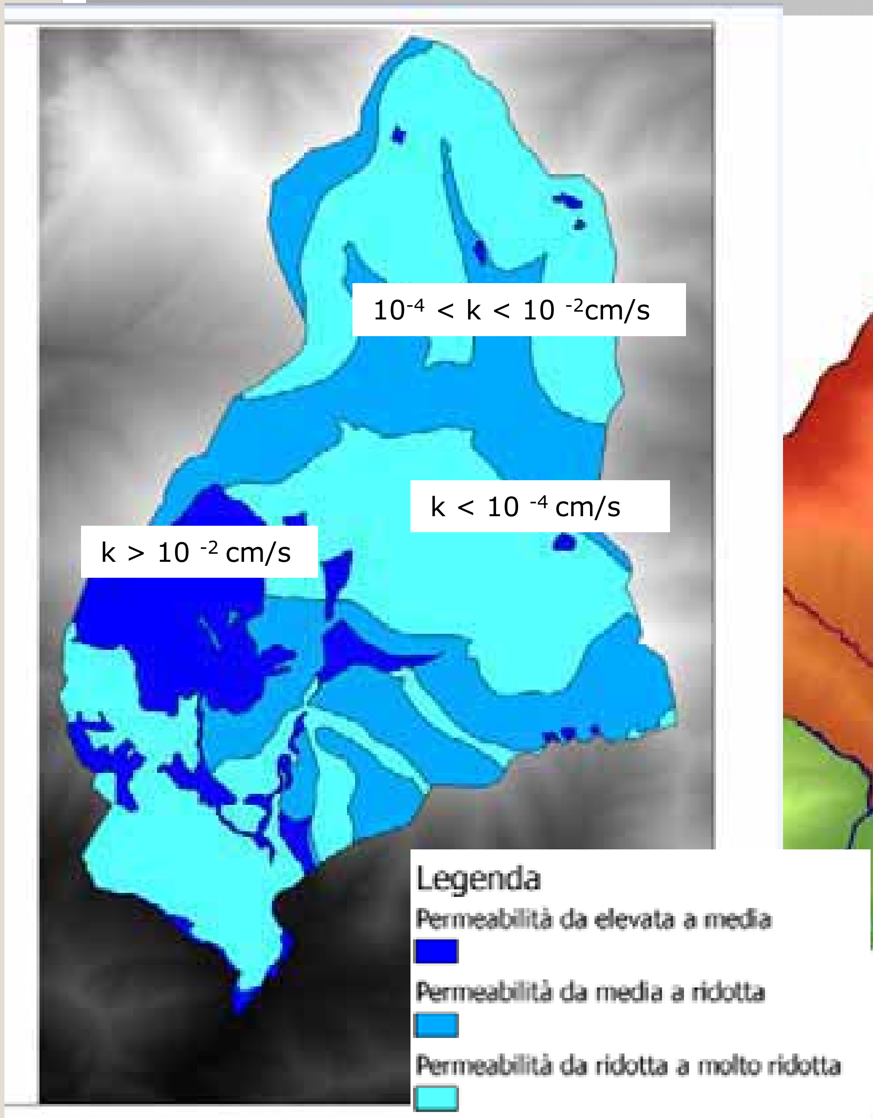


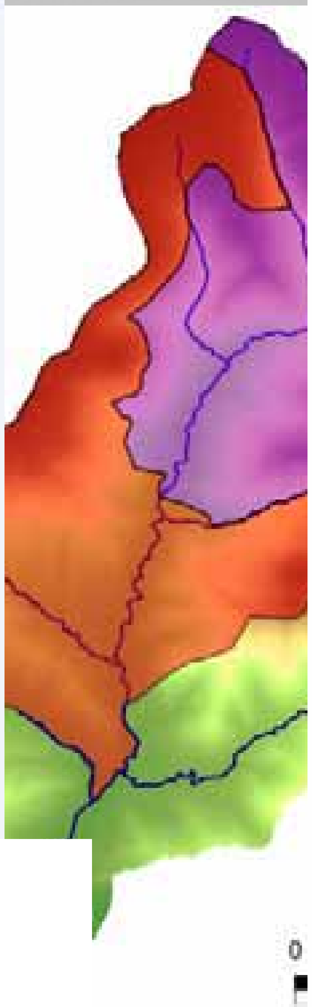
Geology and permeability

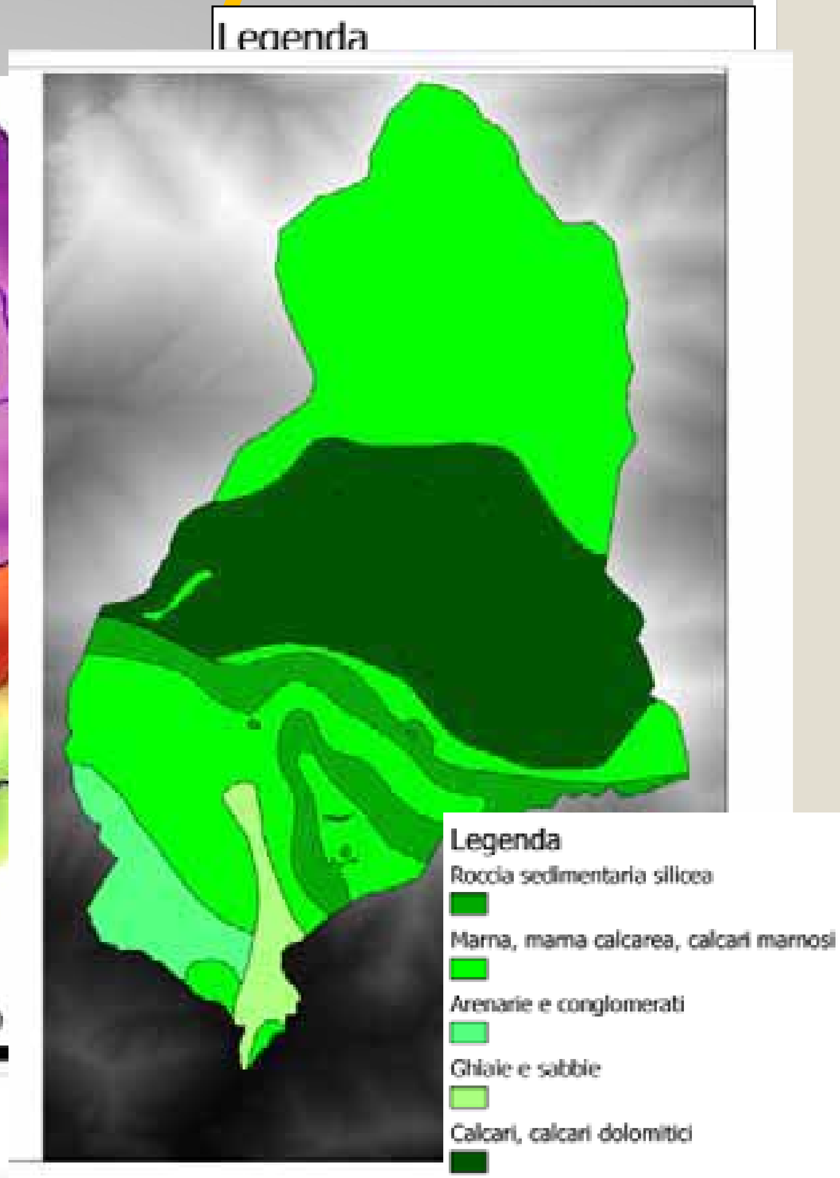




Geology and permeability







Slope map

Topographic factor LS map

Fattore LS:

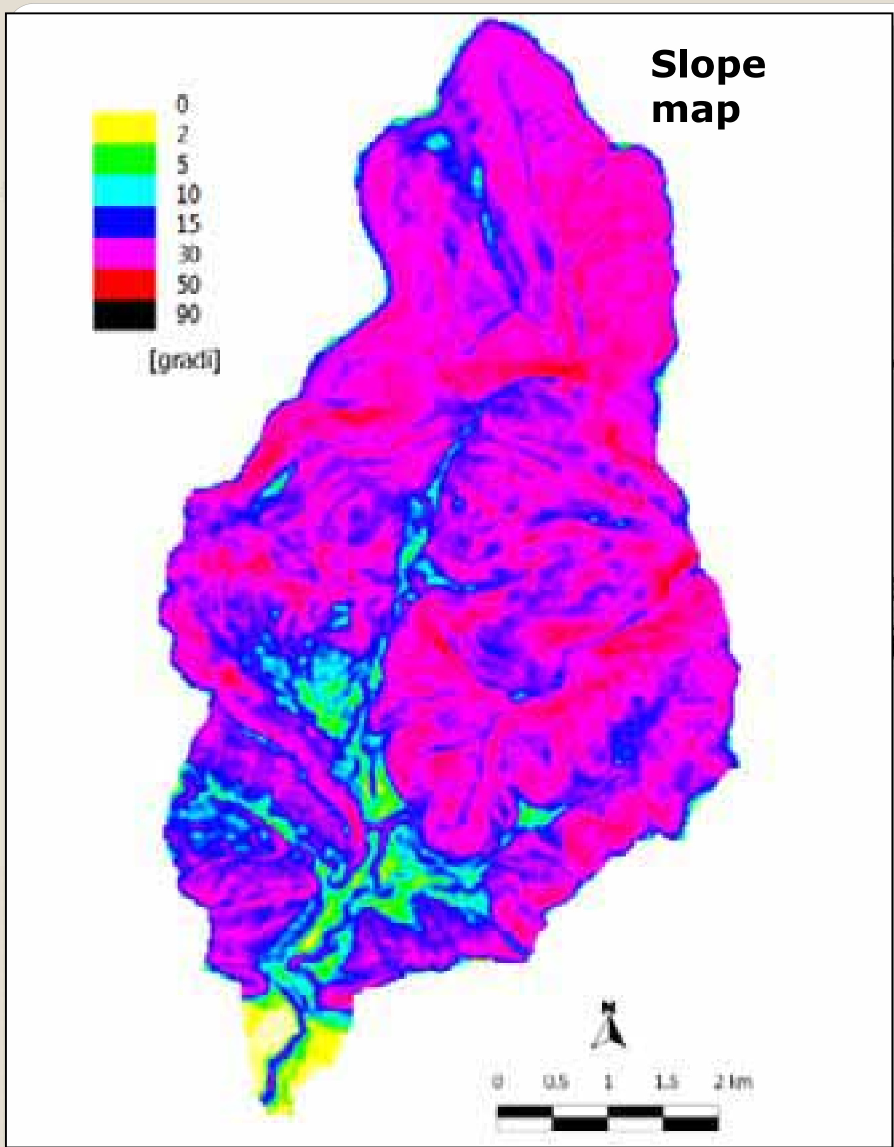
È stato calcolato puntualmente nel bacino partendo da un modello digitale del terreno con risoluzione 20m:

$$LS = \left(\frac{A_s}{22,1}\right)^{0,4} \cdot \left(\frac{sen\beta}{0,0896}\right)^{1,3}$$

[Moore e Burch (1986); da Bosco e Oliveri (2007)]

con A_S=*20m* (per ciascuna cella) è l'area della parcella per unità di larghezza della base della stessa e β la pendenza espressa in gradi ricavata dalla mappa delle pendenze.

Estimate of hillslope water erosion



Topographic factor LS map

rtendo da un modello digitale del terreno con

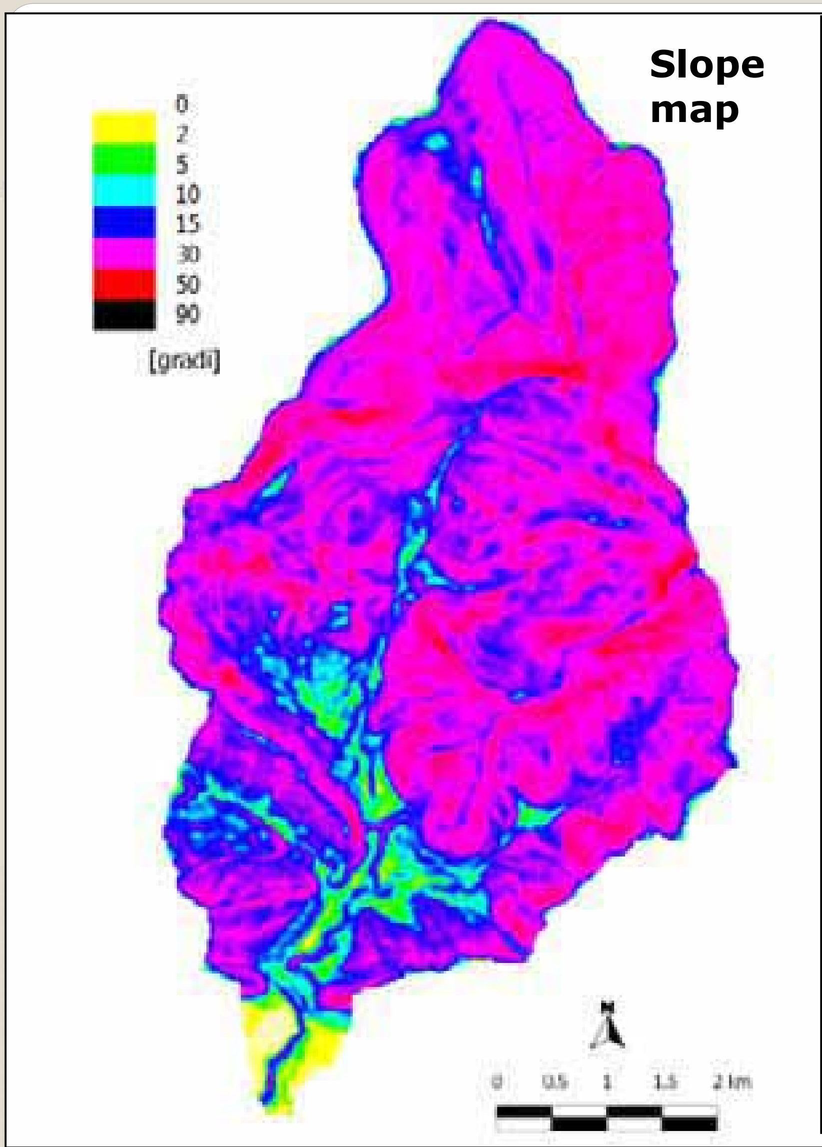
$$ ^{4} \cdot \left(\frac{sen\beta}{0,0896}\right)^{1,3} $$

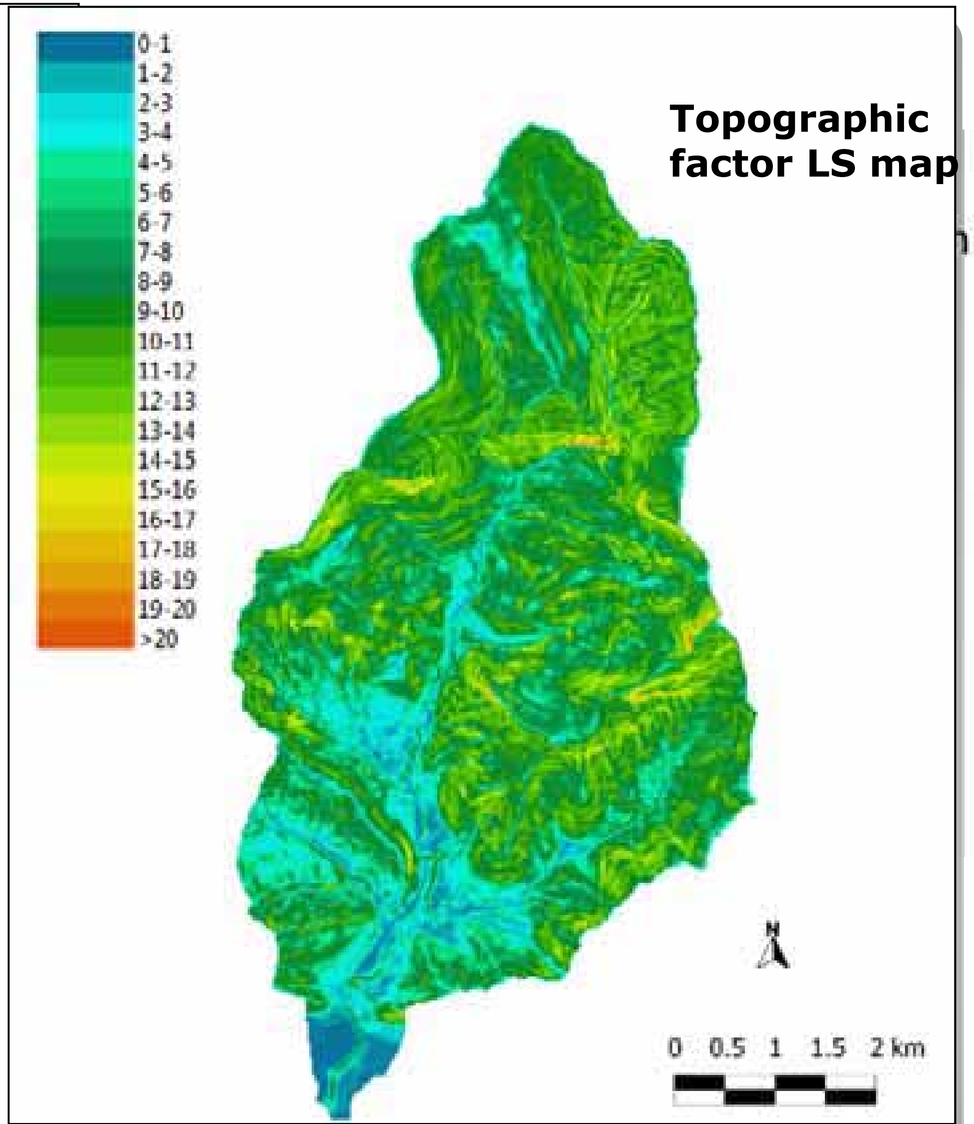
[Moore e Burch (1986);
da Bosco e Oliveri (2007)]

parcella per unità di larghezza della base

ricavata dalla mappa delle pendenze.

Estimate of hillslope water erosion





Estimate of hillslope water erosion

Results for the lumped approach

$R = 159{,}47$ t/ha/k units

$K = 0{,}10$

$LS = 20{,}70$

$P = 1$

$$C = \begin{cases} 0{,}030 \text{ (forest)} \\ 0{,}040 \text{ (meadow)} \\ 0{,}126 \text{ (vignard)} \end{cases}$$

$$A = R \cdot K \cdot LS \cdot C \cdot P$$

Summary

	R [unità erosive]	K [t/ha]	LS	C	P	A [t/ha*anno]
Area boscata	159,47	0,1	20,70	0,030	1	**9,90**
Prato e pascolo	159,47	0,1	20,70	0,040	1	**13,21**
Vigneto inerbito	159,47	0,1	20,70	0,126	1	**41,60**

High soil erosion (threshold value 12,5 t/ha · anno)

- Very high slopes in some cells
- USLE was derived for crop land (slope < 20 %)
- "vignard" on terrace slopes
- high rainfall effect even if *R* is underestimated

RUSLE: distributed approach

$$A = R \cdot K \cdot L \cdot S \cdot C \cdot P$$

Fattore R:

$$R = 38{,}46 + 3{,}48\bar{P}$$ [Lo et al. ; da Bosco e Oliveri (2007)]

con $\bar{P}$ precipitazione media annua pari a 1260mm. R vale per l'intera area *4423,3* $\frac{MJ \cdot mm}{ha \cdot h \cdot anno}$

Fattore K:

$$K = 0{,}0034 + 0{,}0405 \cdot exp\left[-0{,}5\left(\frac{logD_g + 1{,}659}{0{,}7101}\right)^2\right]$$

$$D_g = exp\left[\sum f_i \cdot ln\left(\frac{d_i + d_{i-1}}{2}\right)\right]$$ [Romkens et al. (1986); da Bosco e Oliveri (2007)]

con d_i diametro massimo, d_{i-1} diametro minimo e f_i frazione in massa di sabbia, limo e argilla determinati sperimentalmente. K vale per l'intera area *0,038* $\frac{t \cdot ha \cdot h}{ha \cdot MJ \cdot mm}$

RUSLE: distributed approach

$$A = R \cdot K \cdot L \cdot S \cdot C \cdot P$$

Fattore R:

…co e Oliveri (2007)]

con $\bar{P}$ precipitazio… …23,3 $\frac{MJ \cdot mm}{ha \cdot h \cdot anno}$

Fattore K:

… e Oliveri (2007)]

con d_i diametro n… …bia, limo e

argilla determinat…

RUSLE: distributed approach

$$A = R \cdot K \cdot L \cdot S \cdot C \cdot P$$

Fattore R:

e Oliveri (2007)]

con $\bar{P}$ precipitazio 3 $\frac{MJ \cdot mm}{ha \cdot h \cdot anno}$

Fattore K:

Oliveri (2007)]

con d_i diametro m a, limo e

argilla determinat

RUSLE: distributed approach

$$A = R \cdot K \cdot L \cdot S \cdot C \cdot P$$

Fattore R:

Oliveri (2007)]

con $\bar{P}$ precipitazio

$\frac{MJ \cdot mm}{ha \cdot h \cdot anno}$

Fattore K:

iveri (2007)]

con d_i diametro m … limo e

argilla determinat

RUSLE: distributed approach

$$A = R \cdot K \cdot L \cdot S \cdot C \cdot P$$

Fattore R:

…liveri (2007)]

con $\bar{P}$ precipitazio… $\frac{MJ \cdot mm}{…a \cdot h \cdot anno}$

Fattore K:

…eri (2007)]

con d_i diametro m… …mo e argilla determinat…

RUSLE: distributed approach

$$A = R \cdot K \cdot L \cdot S \cdot C \cdot P$$

Fattore R:

iveri (2007)]

con $\bar{P}$ precipitazic

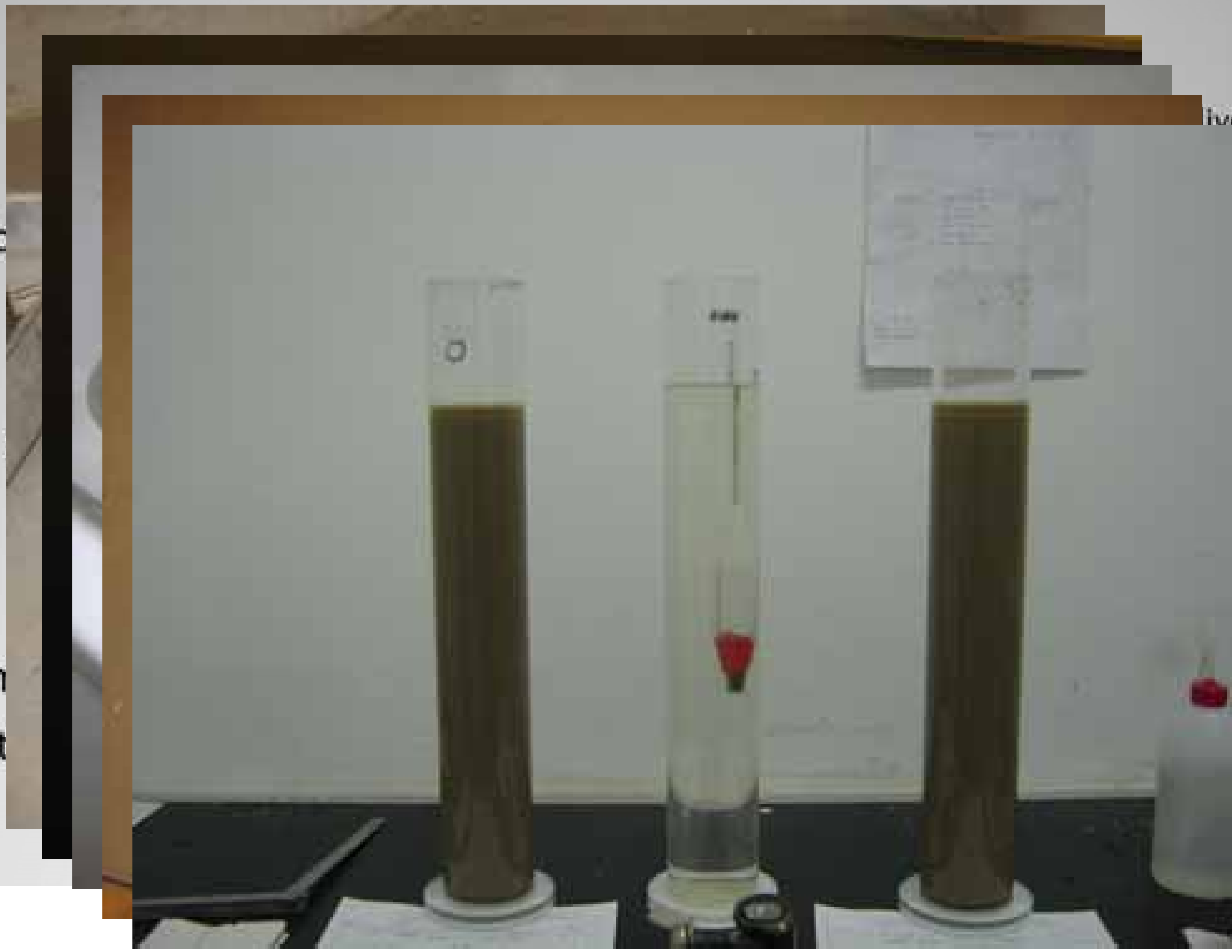
$\frac{J \cdot mm}{h \cdot anno}$

Fattore K:

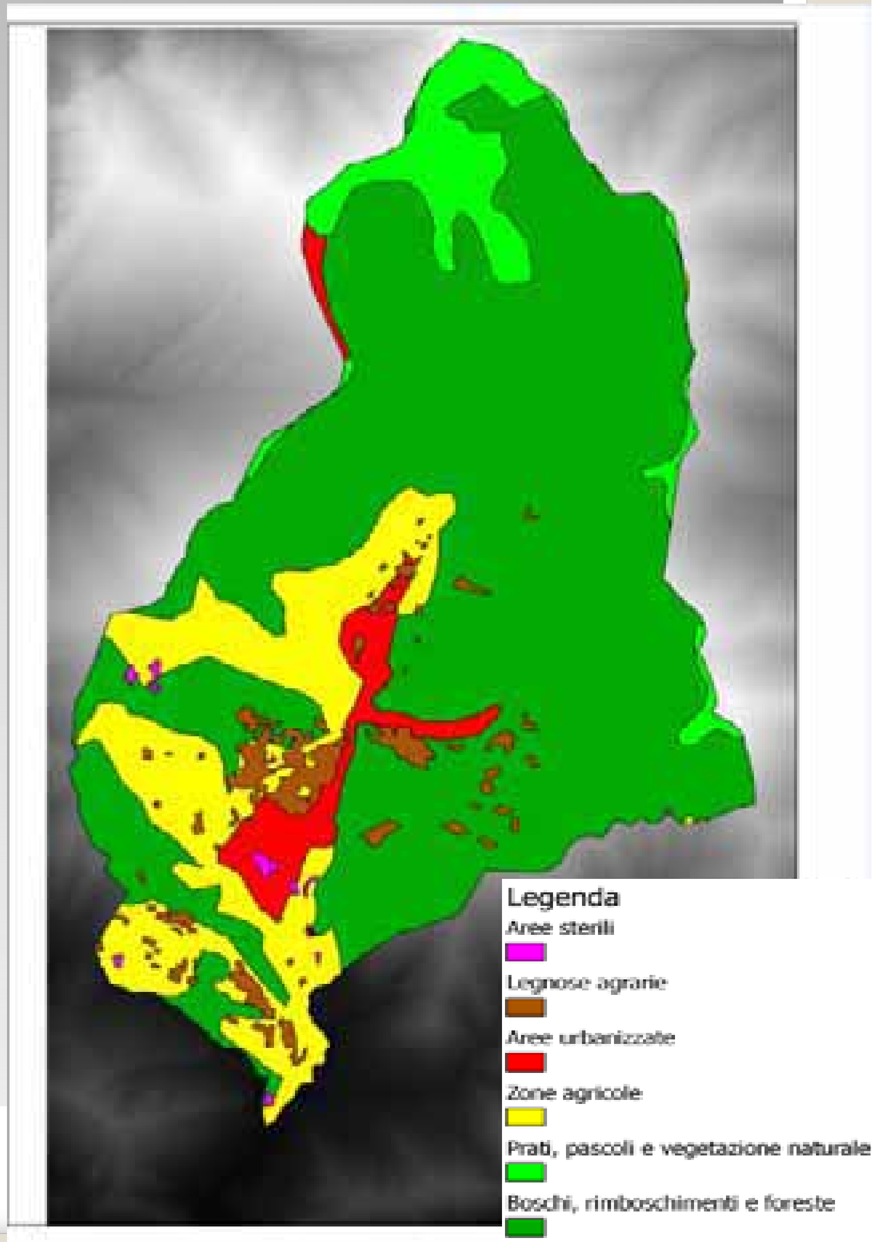
(2007)]

con d_i diametro m ... o e

argilla determinat

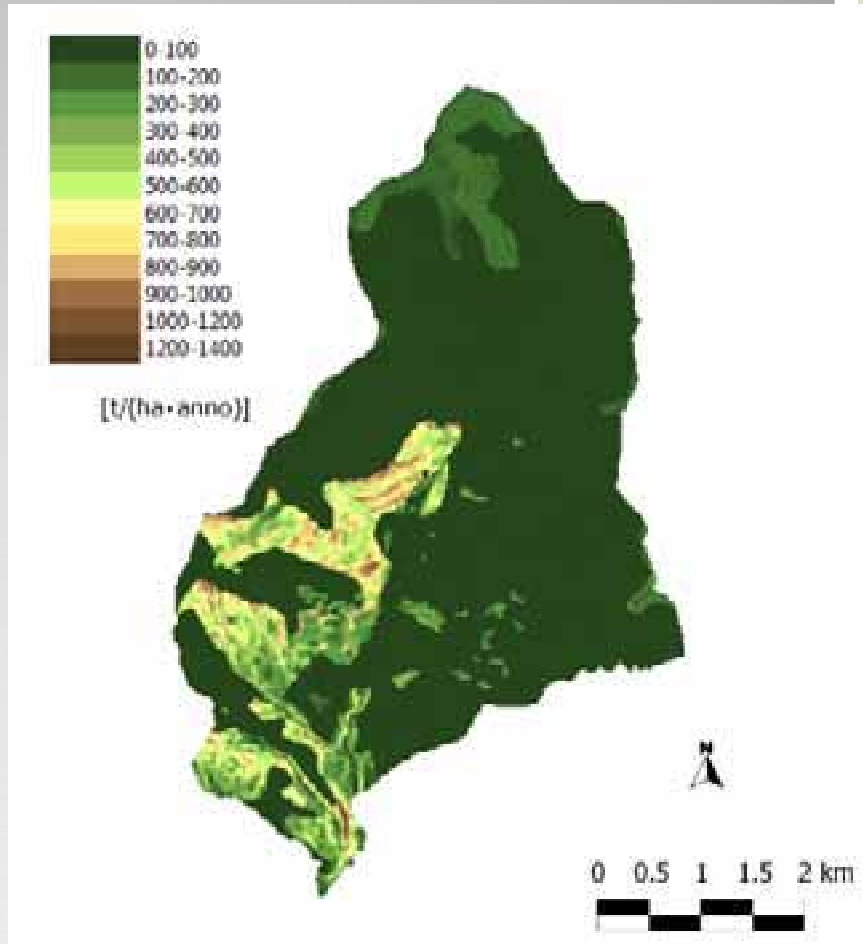


class	C [-]	P [-]
Bare areas	0,36	1
Crop trees	0,37	0,45
urban areas	0,003	1
Crop areas	0,45	1
Meadows and natural vegetation	0,07	1
forest	0,002	1



RUSLE: distributed approach results

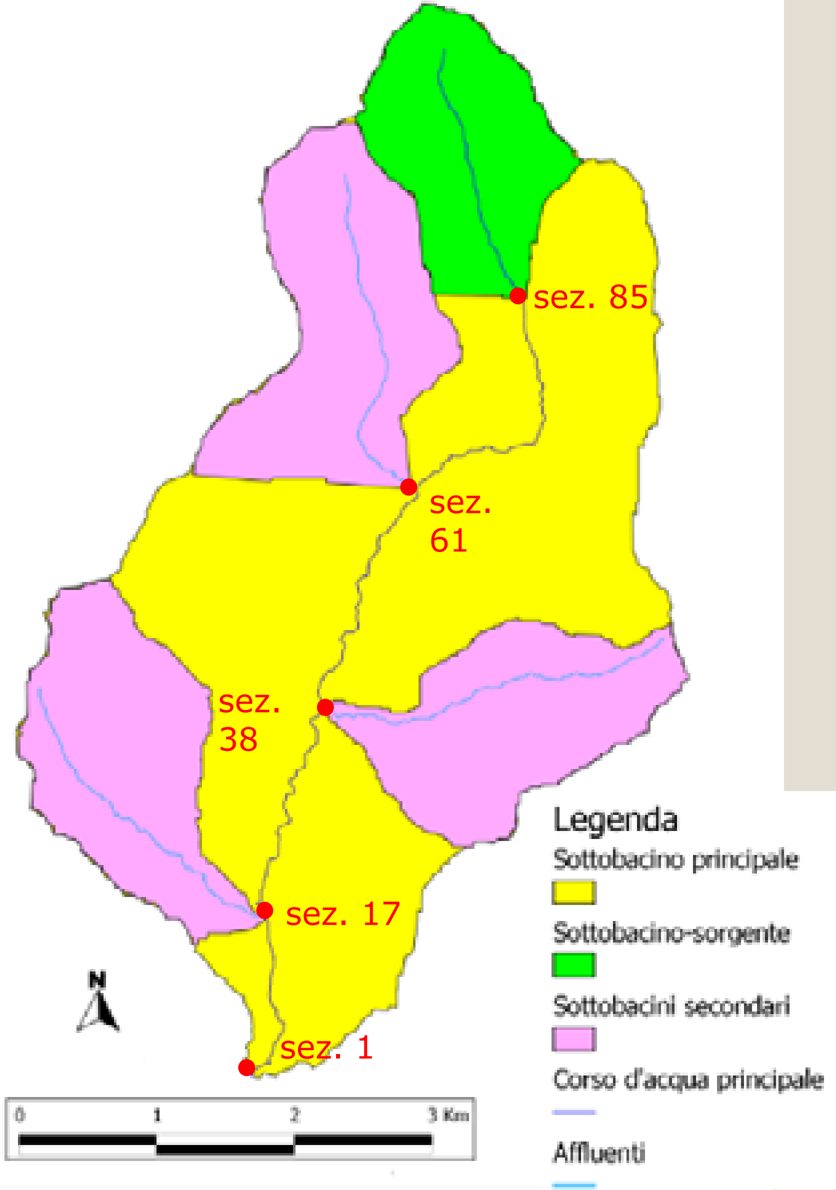
- Yearly average specific sediment yield: 94,35 t/(ha·year)
- Yearly average sediment yield: 206881,35 t/year



Regional estimate of peak discharge for unmonitored basins

section	A [Km²]	T_c [h]	$Q_{c,100}$ [m³/s]
85	2,1	0,58	15,4
61	2,9	0,62	19,4
38	2,3	0,62	16,6
17	2,5	0,76	17,4
1	21,1	1,85	82,7

$$Q_1 - (Q_{85} + Q_{61} + Q_{38} + Q_{17}) = 13{,}9\ m^3/s$$



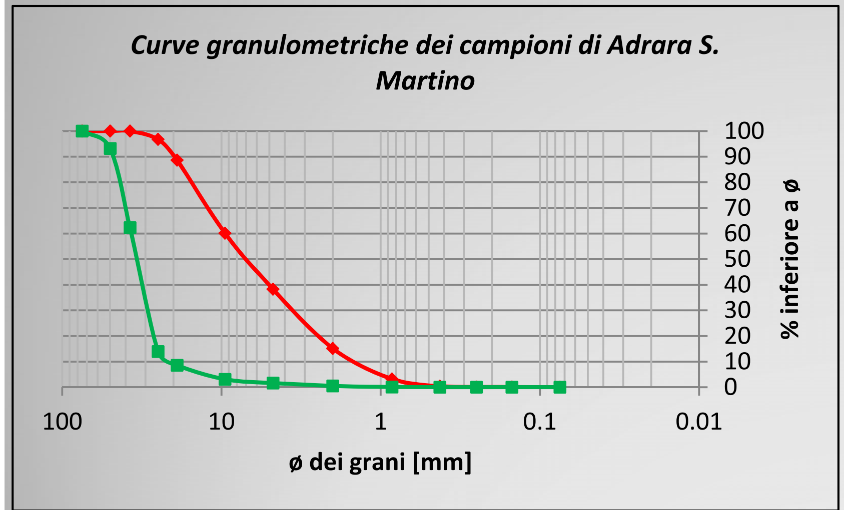
HEC-RAS hydraulic model

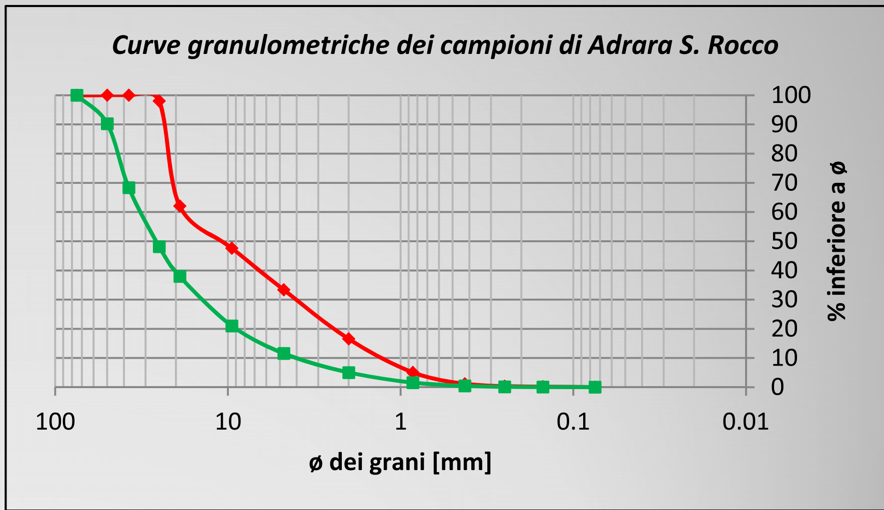
HEC-RAS hydraulic model

Laboratory analysis (0,075÷75mm):4 particle size distributions i:

1st simulation: subsurface layer (finer size)

2nd simulation: surface layer(coarser size)





downstream reach **upstream reach**

HEC-RAS hydraulic model

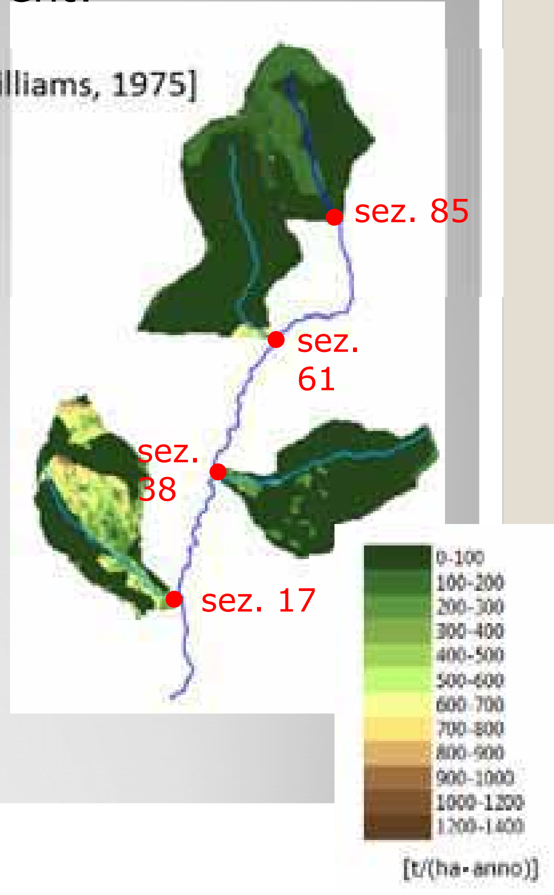
- Hp: sediment yield by the hillslopes enters the river

- *RUSLE* → Yearly average soil erosion
- *MUSLE* → 100- year return period event:

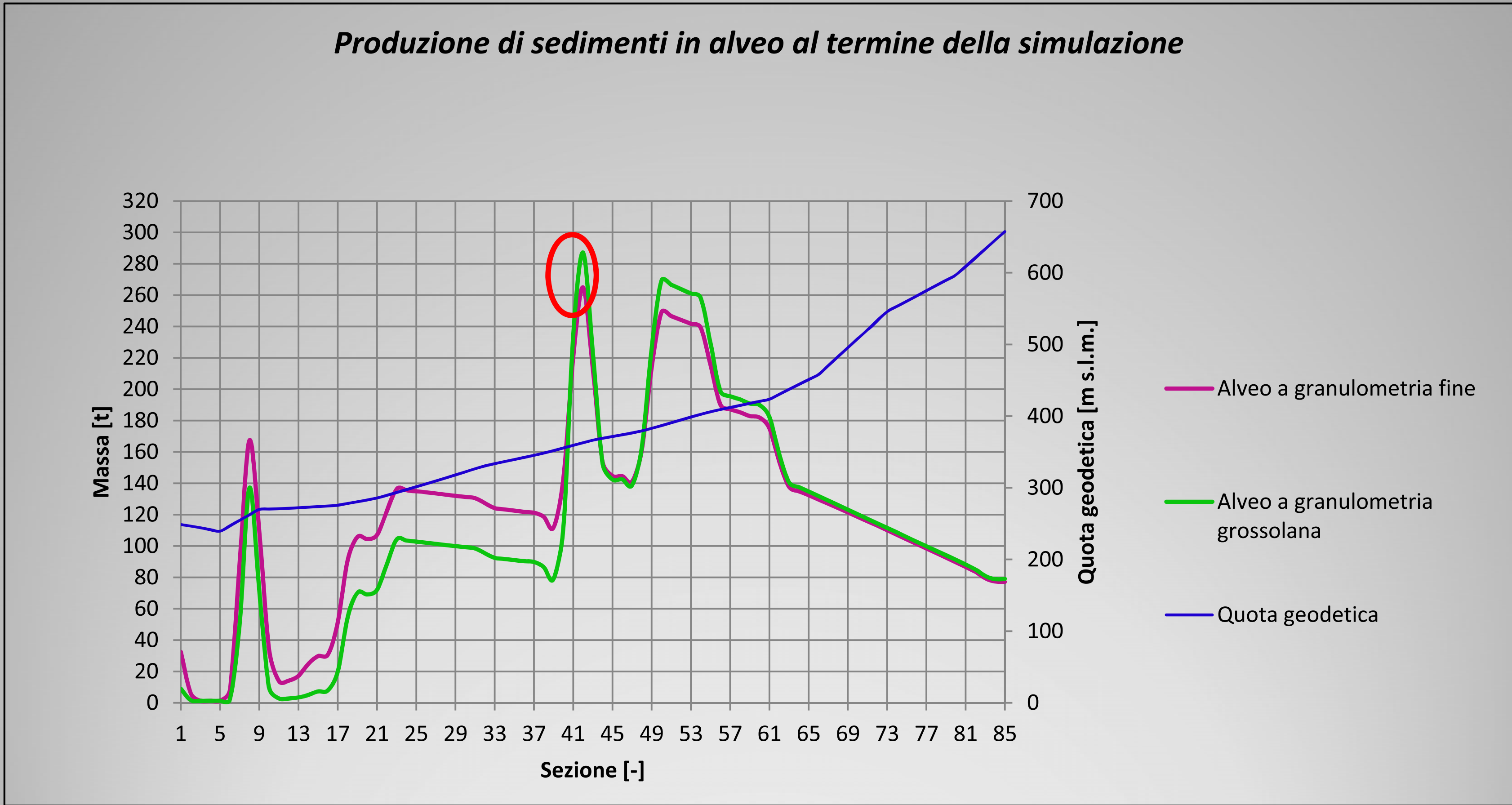
$$R_{100} = 0.8776(Q_{100} \cdot v_{100})^{0.56} \quad \text{[Williams, 1975]}$$

$$A_{100} = \frac{A}{R} \cdot R_{100}$$

85	A=9684,3t/y	A_{100}=8,1t/day
61	A=6334,7t/y	A_{100}=7,2t/day
38	A=4269,7t/y	A_{100}=4,1t/day
17	A=55962,3t/y	A_{100}=62,7t/day
Area tot	A=206881,4t/y	A_{100}=2186,4t/day



Results: sediment yield at the end of the event



The highest sediment yield is at section 42: 265t with fine bed, 287,2t with coarse bed

Summary

- Empirical approach (RUSLE) to estimate the average yearly soil erosion (20681,4t/y).
- Empirical approach (MUSLE) for the analysis of the 100-year return period flood event (2186,4t/day).
- HEC-RAS hydraulic model to estimate flow transport capacity (maximum 4167,6t/day) and sediment yield along the river network(maximum value at the end of the event 287,2t)

FUTURE task:

- Find the meteorological event for which the coarse size surface layer could be removed

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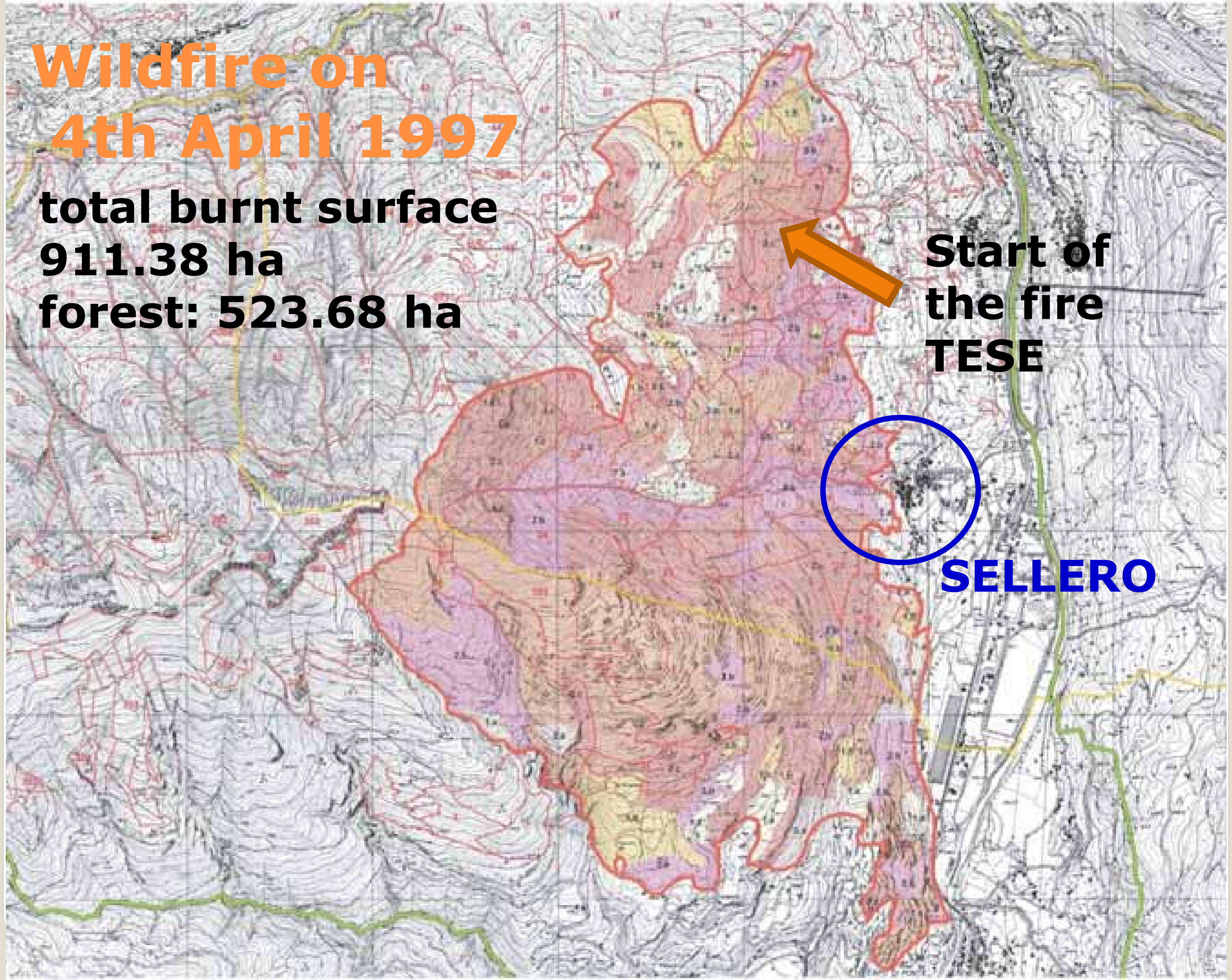
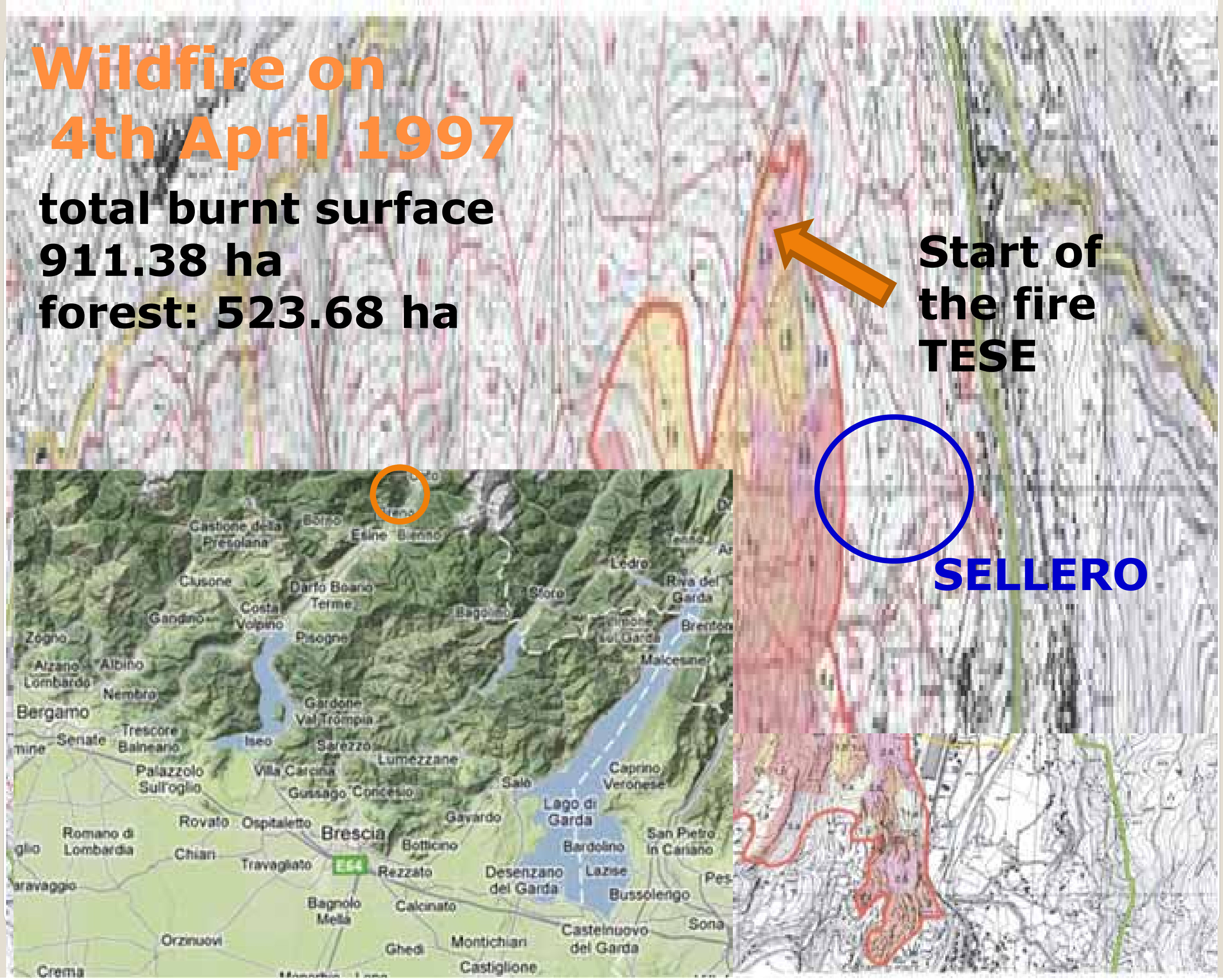
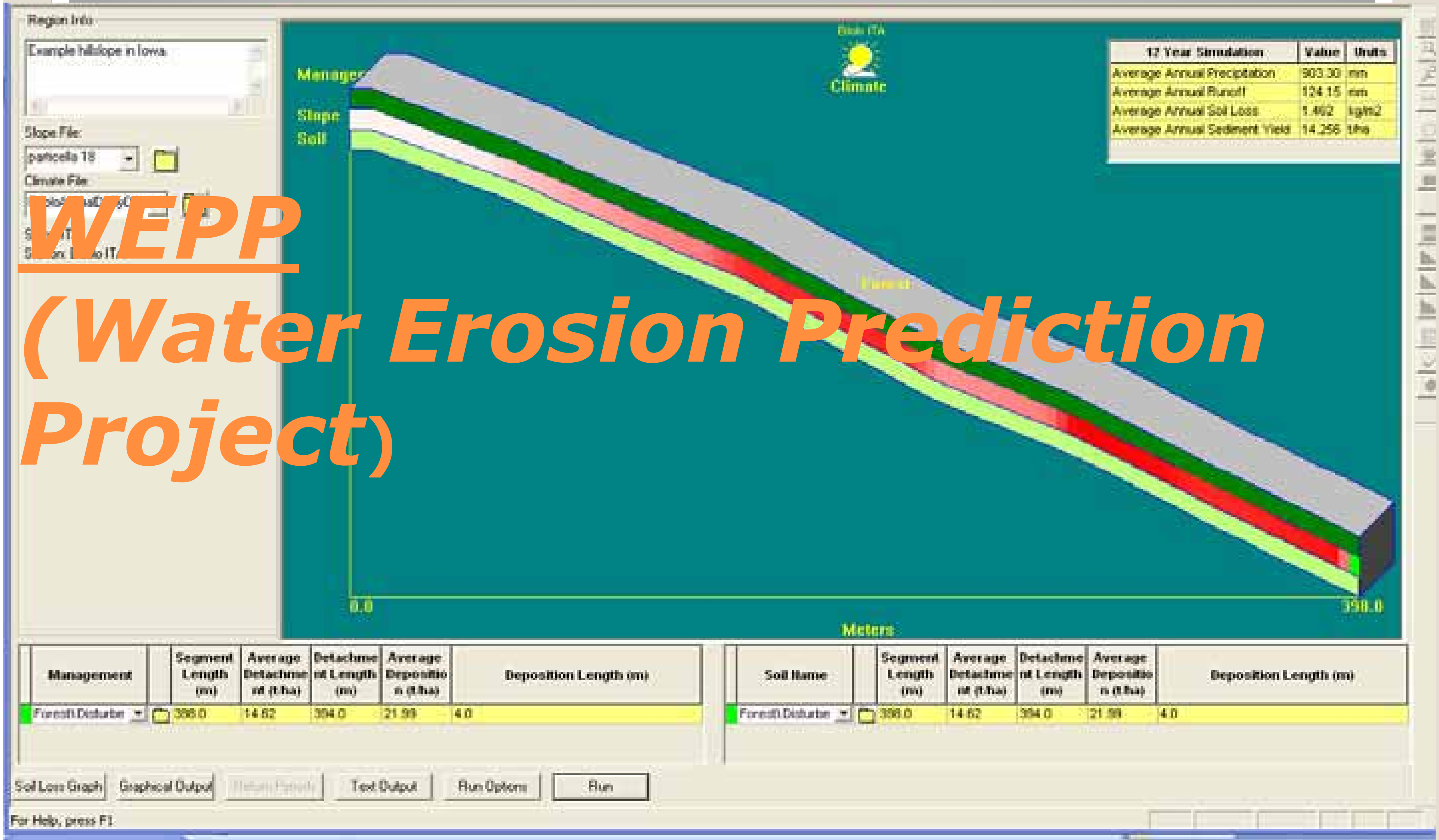
Physically based approach: WEPP

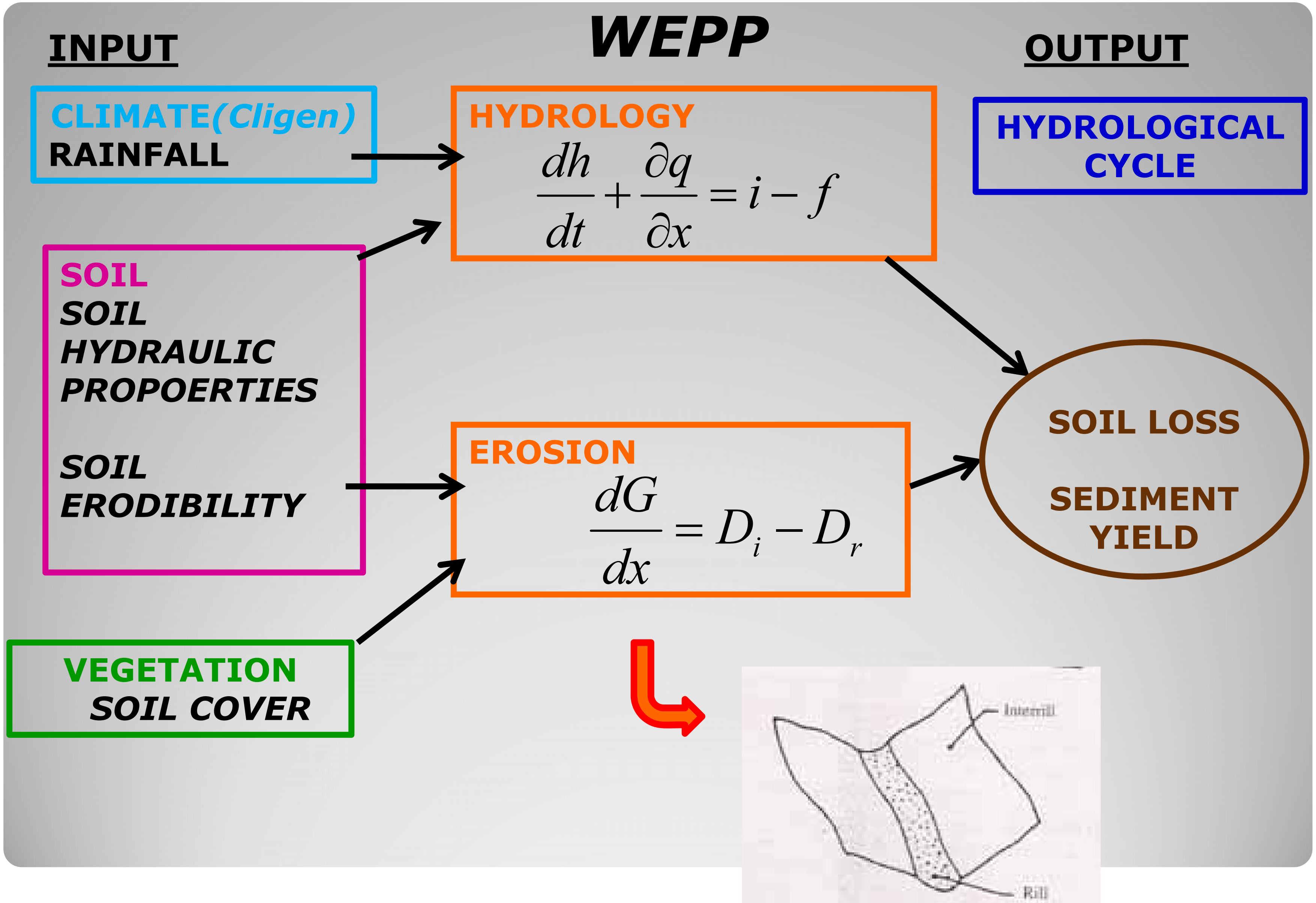
Sellero case study


Wildfire on
4th April 1997
total burnt surface
911.38 ha
forest: 523.68 ha
Start of
the fire
TESE
SELLERO


Wildfire on
4th April 1997
total burnt surface
911.38 ha
forest: 523.68 ha
Start of
the fire
TESE
SELLERO
Castione della
Presolana
Esine
Clusone
Darfo Boario
Terme
Costa
Volpino
Gandino
Pisogne
Zogno
Alzano
Lombardo
Albino
Nembro
Bergamo
Trescore
Balneario
Iseo
Gardone
Val Trompia
Sarezzo
Lumezzane
Palazzolo
Sull'oglio
Villa Carcina
Gussago
Concesio
Rovato
Ospitaletto
Brescia
Botticino
Gavardo
Salò
Romano di
Lombardia
Chiari
Travagliato
E64
Rezzato
Bagnolo
Mella
Calcinato
Ghedi
Montichiari
Castiglione
Orzinuovi
Crema
Desenzano
del Garda
Lago di
Garda
Bardolino
Lazise
Bussolengo
Castelnuovo
del Garda
Sona
Caprino
Veronese
San Pietro
in Cariano
Malcesine
Riva del
Garda
Ledro
Storo
Bagolino
Brentonico

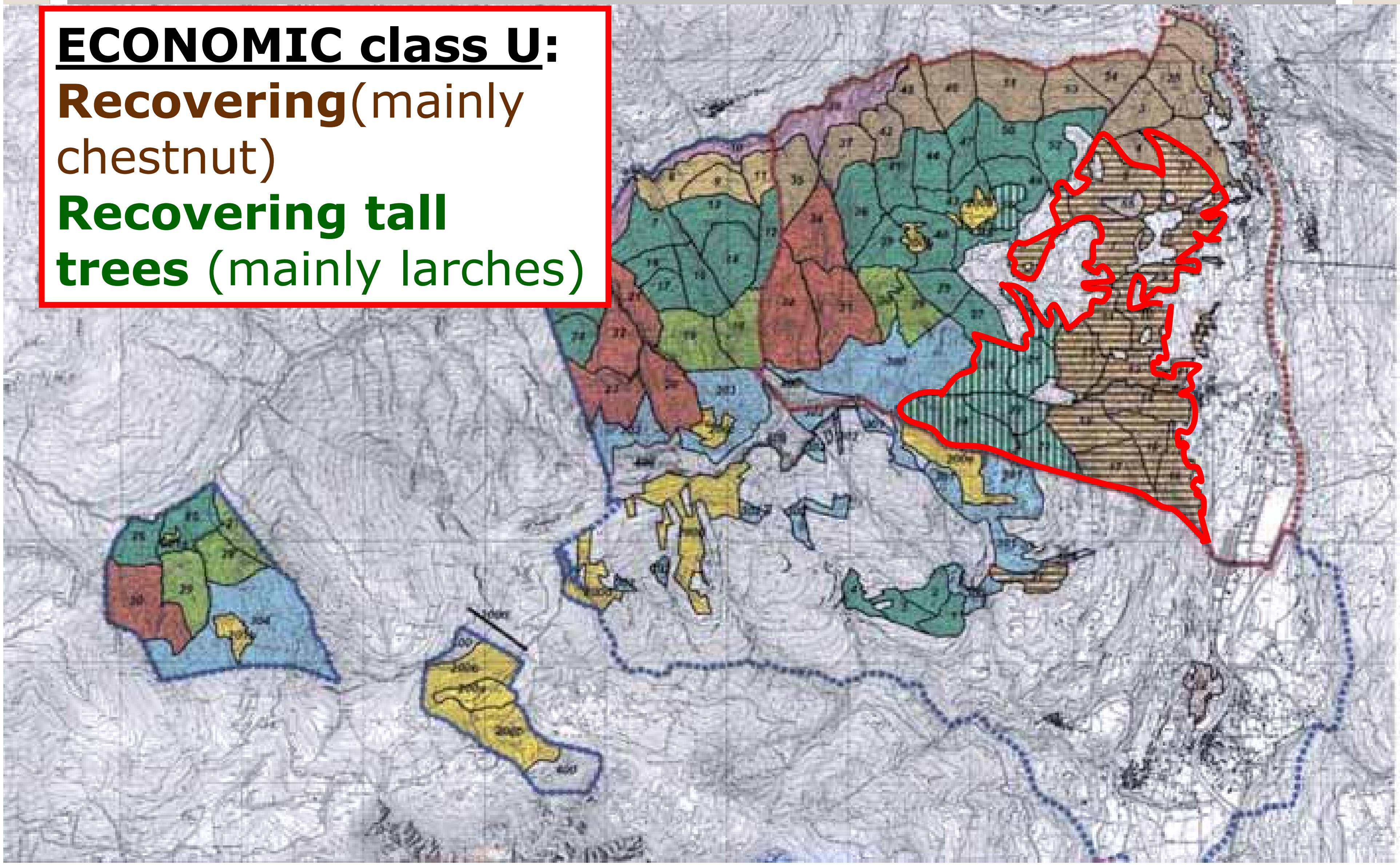
WEPP (Water Erosion Prediction Project)




WEPP
INPUT
OUTPUT
CLIMATE(Cligen)
RAINFALL
HYDROLOGY
$\frac{dh}{dt} + \frac{\partial q}{\partial x} = i - f$
HYDROLOGICAL CYCLE
SOIL
SOIL HYDRAULIC PROPOERTIES
SOIL ERODIBILITY
EROSION
$\frac{dG}{dx} = D_i - D_r$
SOIL LOSS
SEDIMENT YIELD
VEGETATION
SOIL COVER
Interrill
Rill

Forest management plan: vegetation economic classes

<u>ECONOMIC class U</u>:
Recovering(mainly chestnut)
Recovering tall trees (mainly larches)



chestnut

larches

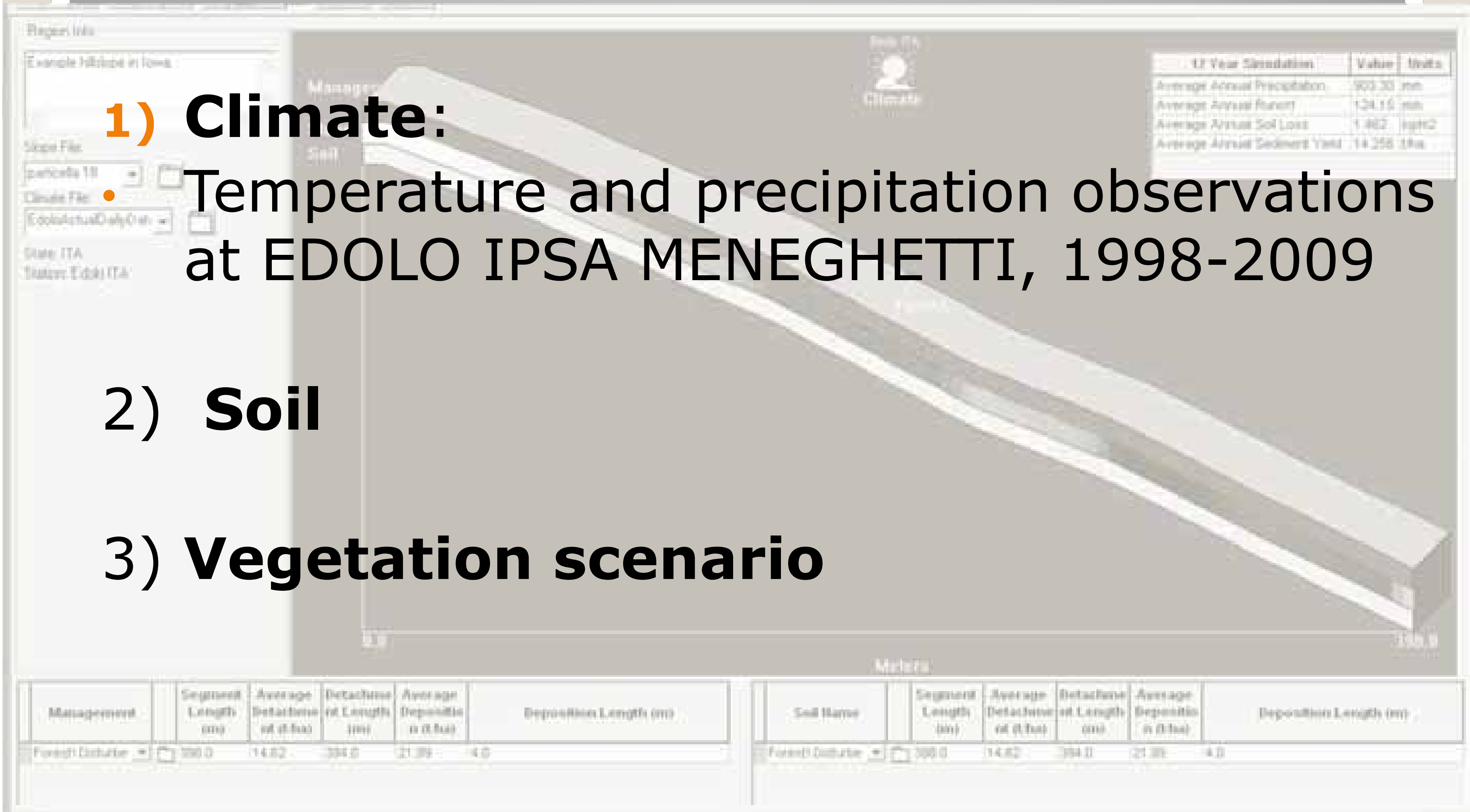
Valle Allione forest service has performed some restoring operations

1) **Climate**:

- Temperature and precipitation observations at EDOLO IPSA MENEGHETTI, 1998-2009

2) **Soil**

3) **Vegetation scenario**

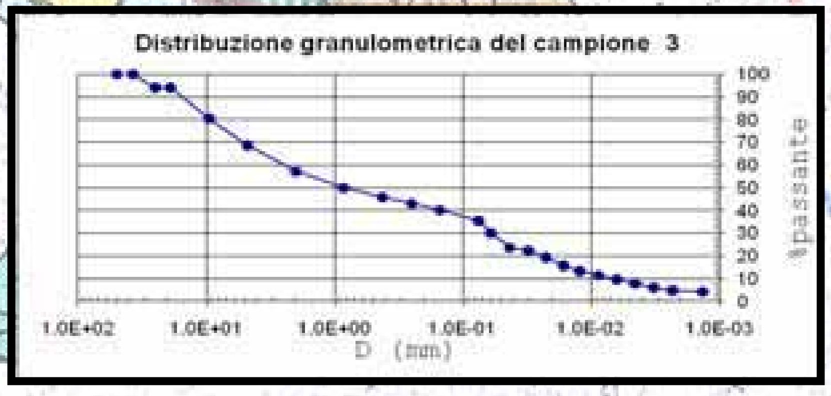


Soil: particle size distribution

Sample 1

Sample 2

Sample 3



SOIL

	USDA classes			name	gravel	humus
	SAND (%)	SILT (%)	CLAY (%)			
sample1	63.77	28.71	7.53	sandy-loam	55.52	5.04
sample 2	59.93	34.62	5.45	sandy-loam	27.17	16.33
sample 3	54.15	37.71	8.13	sandy-loam	42.79	2.20
average	59.28	33.68	7.04	sandy-loam	41.83	7.86

Forest mangement plan:

- **Depth: 200 mm (shallow)**
- **Geology:**

➢ **shale (chestnut)**
➢ **sandstone (larch)**

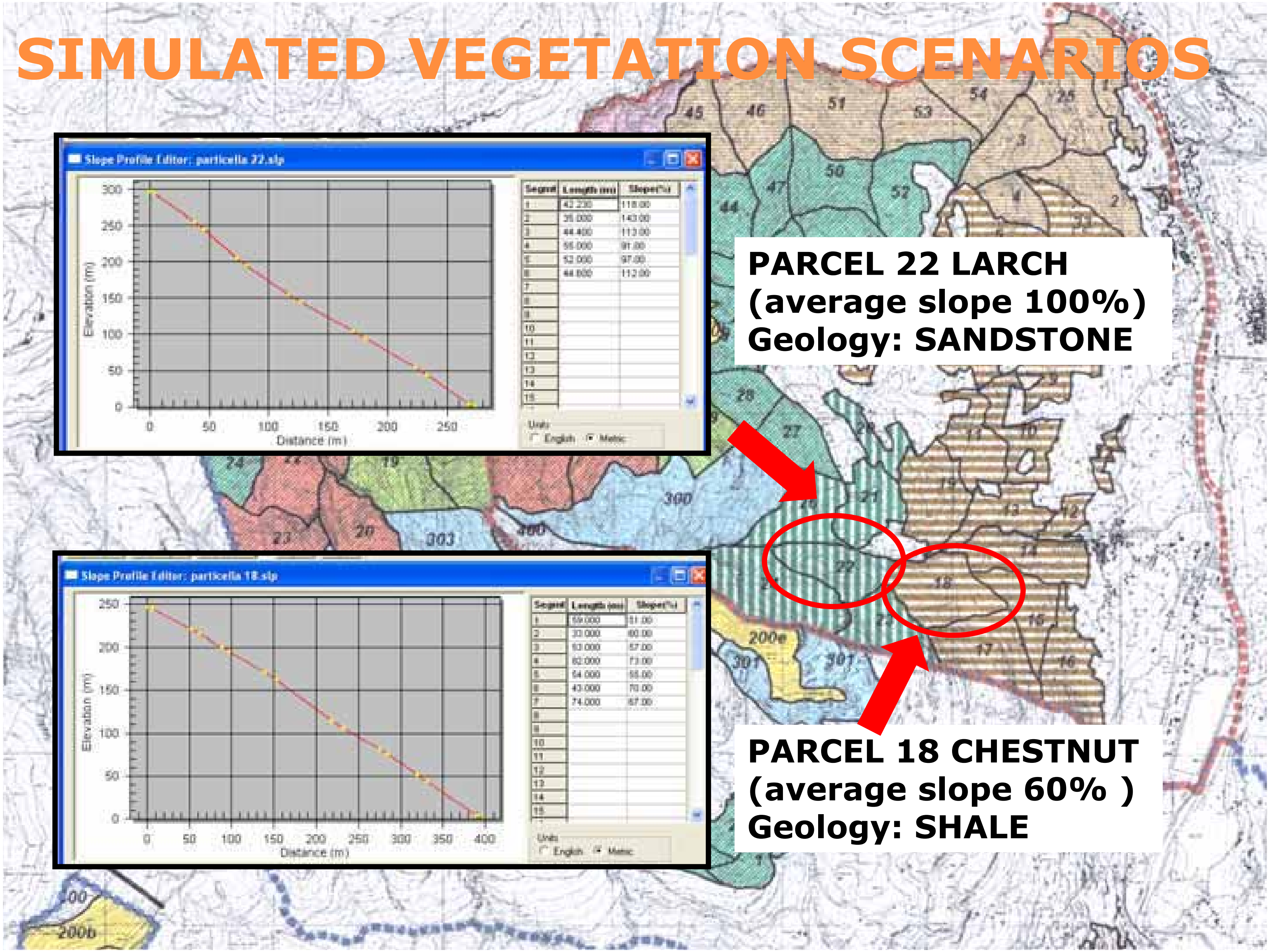
Previous field analysis:

- **hydraulic conductivity: 10 mm/h**

Empirical laws (WEPP):

- **Rill Erodibility**
- **Interril Erodibility**
- **Critical Shear**
- **ecc.**

SIMULATED VEGETATION SCENARIOS



Segment	Length (m)	Slope(%)
1	42.230	118.00
2	35.000	140.00
3	44.400	113.00
4	55.000	91.00
5	52.000	97.00
6	44.800	112.00

PARCEL 22 LARCH
(average slope 100%)
Geology: SANDSTONE

Segment	Length (m)	Slope(%)
1	59.000	51.00
2	33.000	60.00
3	63.000	57.00
4	62.000	73.00
5	54.000	55.00
6	43.000	70.00
7	74.000	67.00

PARCEL 18 CHESTNUT
(average slope 60%)
Geology: SHALE

SIMULATED VEGETATION SCENARIOS

FOREST DISTURBED WEPP

YEARS AFTER THE WILDFIRE	VEGETATION SCENARIOS
0(1998)	High severity fire
1 (1999)	Low severity fire
2(2000)	Short grass
3(2001)	Tall grass
4(2002)	Shrub
5 -15 years (2003-2009)	Five years old forest
>15 years	Twenty years old forest

SELLERO

- HIGH INTENSITY WILDFIRE (1998):
  - a) parcel 18 (chestnut)
  - b) parcel 22 (larch)
- YOUNG FOREST (2003-2009): parcel 18 (chestnut)
- OLD FOREST (1998-2009):
  - a) parcel 18 chestnut)
  - b) parcel 22 (larch)

Post-fire vegetation: pioneer species **shrubs** (betulla, pioppo tremulo, salicone, etc.)

FOREST DISTURBED WEPP

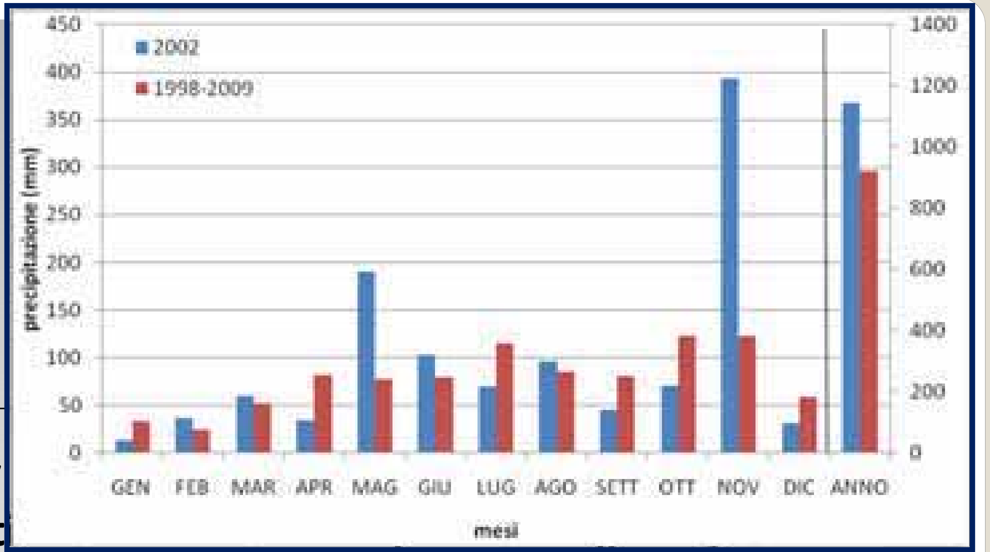
- Parcel 18

VEGETATION SCENARIOS	year	Yearly precipitation (mm)	Yearly runoff (mm)	Yearly average soil erosion (kg/m^2)	Yearly average sediment yield (t/ha)
High intensity wildfire	1998	890.4	222.37	149.92	1389.34
Low intensity wildfire	1999	951.6	219.36	51.53	484.98
Short grass	2000	1547.6	648.12	62.90	563.47
Tall grass	2001	930.3	145.89	24.06	183.58
shrub	2002	1143.2	276.26	6.94	63.71
Young forest	2003-2009	773.61	52.30	1.69	16.48
Old forest	1998-2009	903.3	121.66	1.38	13.51

RUNOFF

EROSION

Vegetation scenario testing: 2002



VEGETATION SCENARIOS	year	Yearly precipitat (mm)	(mm)	erosion (kg/m^2)	sediment yield (t/ha)
High intensity wildfire	2002	1143.2	412.02	291.449	2612.098
Low intensity wildfire	2002	1143.2	388.39	99.87	848.566
Short grass	2002	1143.2	353	42.837	384.424
Tall grass	2002	1143.2	319.22	17.596	164.094
shrub	2002	1143.2	276.26	6.936	63.713
Young forest	2002	1143.2	270.21	3.007	30.074
Old forest	2002	1143.2	267.64	1.596	15.964

RUNOFF

EROSION

High severity fire

	CHESTNUT (parcel 18)	LARCH (parcel 22)
Slope (%)	60	100
length (m)	390	270
geology	*SHALE*	*SANDSTONE*

parcel	year	Yearly precipitation (mm)	Yearly runoff (mm)	Yearly average soil erosion (kg/m^2)	Yearly average sediment yield (t/ha)
chestnut (18)	1998	890.4	222.37	149.921	1389.342
larch (22)	1998	890.4	125.13	86.636	831.038

Sellero case study summary

After the wild fire the sediment yield increased but the effect is smoothing in time.

- **WEPP simulations allowed an estimate of the time needed by the vegetation to recovery**
- **Soil erosion in influenced both by vegetation recovery and spatial and temporal rainfall distribution**

Limits:

- ✓ **Management operations are not easy to account for**
- ✓ **Too many parameters**
- ✓ **Rainfall partitioning not reliable with steep slopes**

- USLE approach can help in estimating the order of magnitude of the sediment yield
- WEPP can deal with landuse change and support recovery evaluation
- In both cases the parameters’ setting has to be tested through field and laboratory analysis
- The effect of steep slopes both on rainfall partitioning and sediment yield has to be taken into account in more detail

Conclusions

- Evaluation of sediment yield
- Clues on sediment yield change and runoff production change after wildfire
- Analysis of vegetation recovery
- Physical approach
- Empirical approach

Purposes

Detachment and transport of soil particles

Energy factors (rainfall, runoff)

Resistence factors (soil characteristics)

Man-induced factors (landuse, agricoltural practices)

Theory: hillslope water erosion

Detachment and transport of soil particles

Energy factors (rainfall, runoff)

Resistence factors (soil characteristics)

Man-induced factors (landuse, agricoltural practices)

- INTERILL EROSION (rainfall and overland flow)

Theory: hillslope water erosion

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Detachment and transport of soil particles

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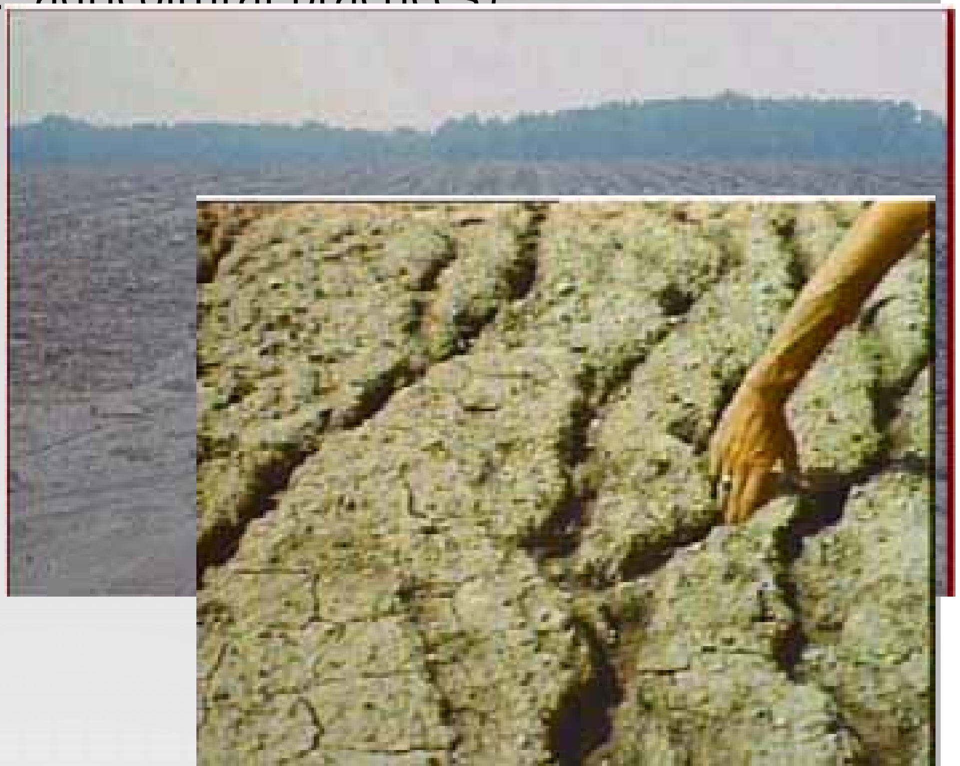


Detachment and transport of soil particles

Energy factors (rainfall, runoff)

Resistence factors (soil characteristics)

Man-induced factors (landuse, agricoltural practices)

- INTERILL EROSION (rainfall and overland flow)
- RILL EROSION(overland flow)
- GULLY EROSION (deepening of rills)

Theory: hillslope water erosion

R - Guerna watershed

Sarnico (2004 – 2010)

Zanchi and Torri

$$E' = 9{,}81 + 11{,}25 \cdot \log_{10}(I_p)$$

30 ~~minutes maximum~~ rainfall intensity

↓

Hourly maximum intensity

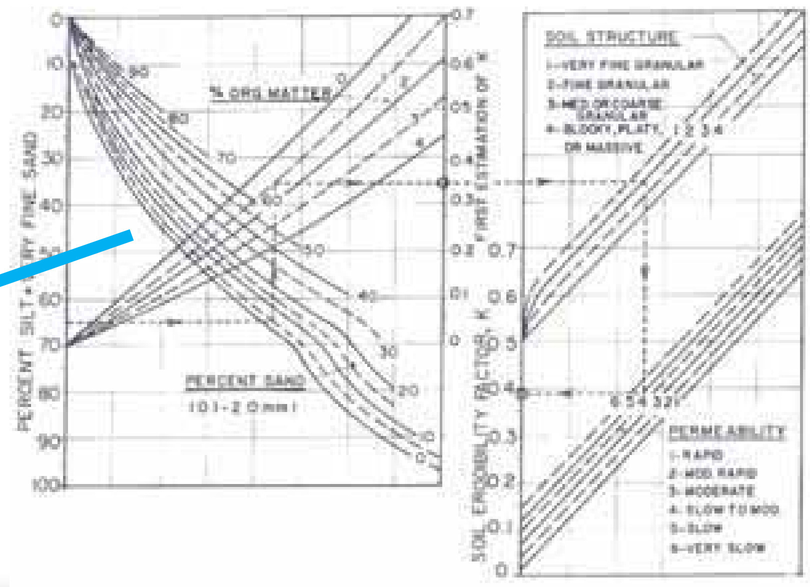
Sarnico	
Anno	**R**
2004	174,61
2005	150,69
2006	88,74
2007	148,35
2008	155,24
2009	177,18
2010	221,49
Complessivo	**159,47**

K – Soil factor

Is a measure of the soil erodibility

- fine particles (0,002 – 0,1 mm) → **10 %**
- coarse particles (0,1 – 2 mm) → **10 %**
- humus
- Structure
- Permeability

K = 0,1



Topographic factor *LS*

Hillslope length and slope

$$S = \frac{0.43 + 0.30 \cdot s + 0.043 \cdot s^2}{6.613}$$

$$L = \left(\frac{\lambda}{22.13}\right)^m$$

s = slope[%]

- $s < 1\%$ → $m = 0,2$
- $1 < s < 3\%$ → $m = 0,3$
- $3 < s < 5\%$ → $m = 0,4$
- $s > 5\%$ → $m = 0,5$

C – vegetation factor

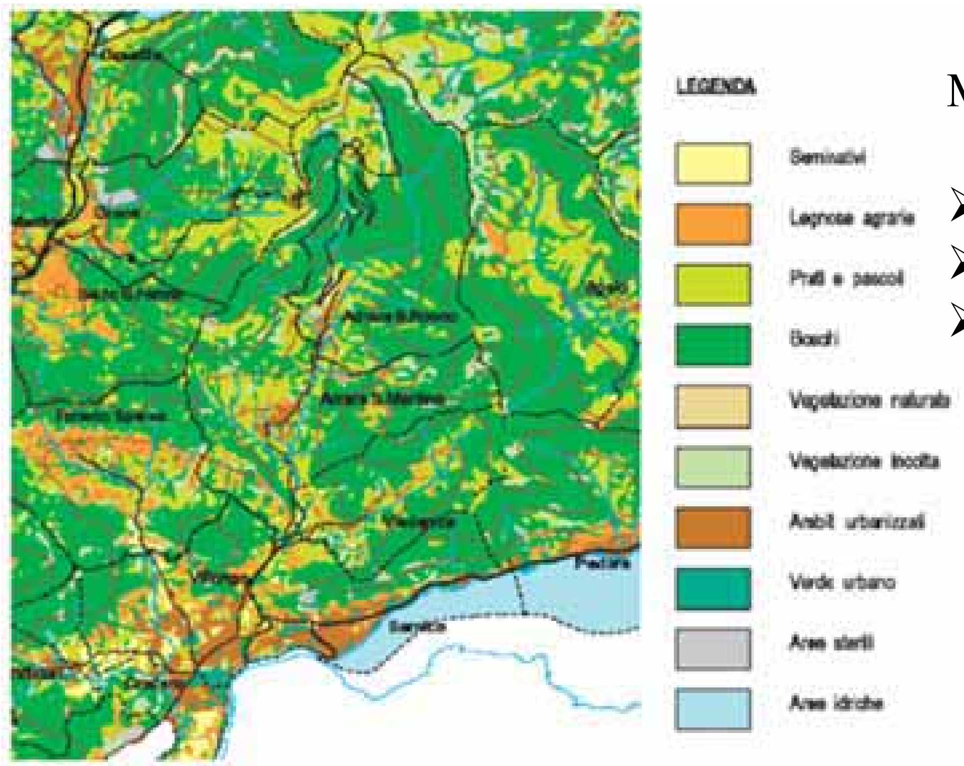
- crop type
- crop cycle
- growing time
- crop practices

Non agricoltural areas:

- tree height
- vegetation cover
- recovery from previous land use

Tipo e altezza della copertura vegetale[b]	Copertura[c] [%]	Tipo[d]	Percentuale di copertura del terreno					
			0	20	40	60	80	95-100
Assenza di chioma apprezzabile		G	0,45	0,20	0,10	0,042	0,013	0,003
		W	0,45	0,24	0,15	0,090	0,043	0,011
Copertura di erbe alte o macchia bassa (altezza di caduta 0,5 m)	25	G	0,36	0,17	0,09	0,038	0,012	0,003
		W	0,36	0,20	0,13	0,082	0,041	0,011
	50	G	0,26	0,13	0,07	0,035	0,012	0,003
		W	0,26	0,16	0,11	0,075	0,039	0,011
	75	G	0,17	0,10	0,06	0,031	0,011	0,003
		W	0,17	0,12	0,09	0,067	0,038	0,011
Macchia apprezzabile o arbusti (altezza di caduta 2 m)	25	G	0,40	0,18	0,09	0,040	0,013	0,003
		W	0,40	0,22	0,14	0,085	0,042	0,011
	50	G	0,34	0,16	0,09	0,038	0,012	0,003
		W	0,34	0,19	0,13	0,081	0,041	0,011
	75	G	0,28	0,14	0,08	0,036	0,012	0,003
		W	0,28	0,17	0,12	0,077	0,040	0,011
Alberi con assenza di sottobosco (altezza di caduta 4 m)	25	G	0,42	0,19	0,10	0,041	0,013	0,003
		W	0,42	0,23	0,14	0,087	0,042	0,011
	50	G	0,39	0,18	0,09	0,040	0,013	0,003
		W	0,39	0,21	0,14	0,085	0,042	0,011
	75	G	0,36	0,17	0,09	0,039	0,012	0,003
		W	0,36	0,20	0,13	0,083	0,041	0,011

C – vegetation factor



Main landuses:

- forest
- lawn
- vignard

	C
Area boscata	0,030
Prato e pascolo	0,040
Vigneto inerbito	0,126

P – agricoltural practices

Influence of agricoltural practices on soil erosion

Pratica (aratura, lavorazione)	Pendenza [%]	P
Nessuna	qualunque	1,00
Secondo le curve di livello	1÷6	0,50
"	7÷12	0,60
"	13÷16	0,70
"	17÷20	0,80
"	>20	0,90
A strisce (colture sarchiate - cereali)	1÷2	0,60
"	3÷8	0,50
"	9÷12	0,60
"	13÷16	0,70
"	17÷20	0,80
"	>20	0,90
A terrazzi (*)		Lavorazioni in traverso / Coltivazioni a strisce
"	1÷2	0,40 / 0,20
"	3÷8	0,50 / 0,25
"	9÷12	0,60 / 0,30
"	13÷16	0,70 / 0,35
"	17÷20	0,80 / 0,40
"	> 20	0,90 / 0,45
A rittochino	qualunque	1,00

Values depend on slope and practice

If no measure was taken

$P = \mathbf{1}$

LS factor

GIS (*Geographical Information System)*

- 76˙488 cells (20 x 20 m)
- 12 slope classes
- slopes higher than100% removed

LS factor

GIS (*Geographical Information System)*

Intervallo pendenza [%]		Pendenza media (100%=45°) [%]	Pendenza media [rad]	Pendenza media [°]	Num. Parcelle	Percentuale area [%]	S	L
0	19	9,5	0,0947	5,43	6390	8,35	1,08	0,95
19	39	29	0,2823	16,17	13864	18,13	6,85	0,95
39	58	48,5	0,4516	25,87	25314	33,10	17,56	0,95
58	77	67,5	0,5937	34,02	25564	33,42	32,75	0,95
77	96	86,5	0,7131	40,86	5356	7,00	52,64	0,95
Totale		50,72	0,46	26,18	76488	100,00	21,78	0,95
							20,70	

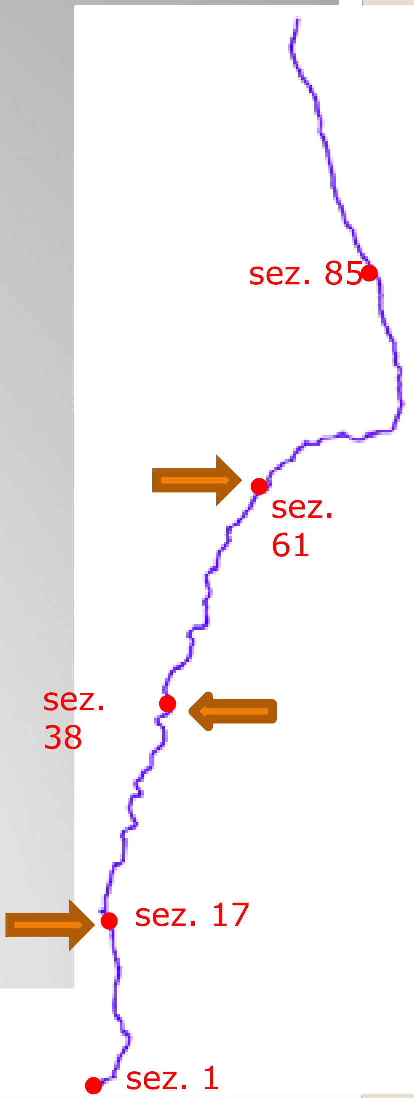
HEC-RAS hydraulic model

- Main course length: *9,6 Km*

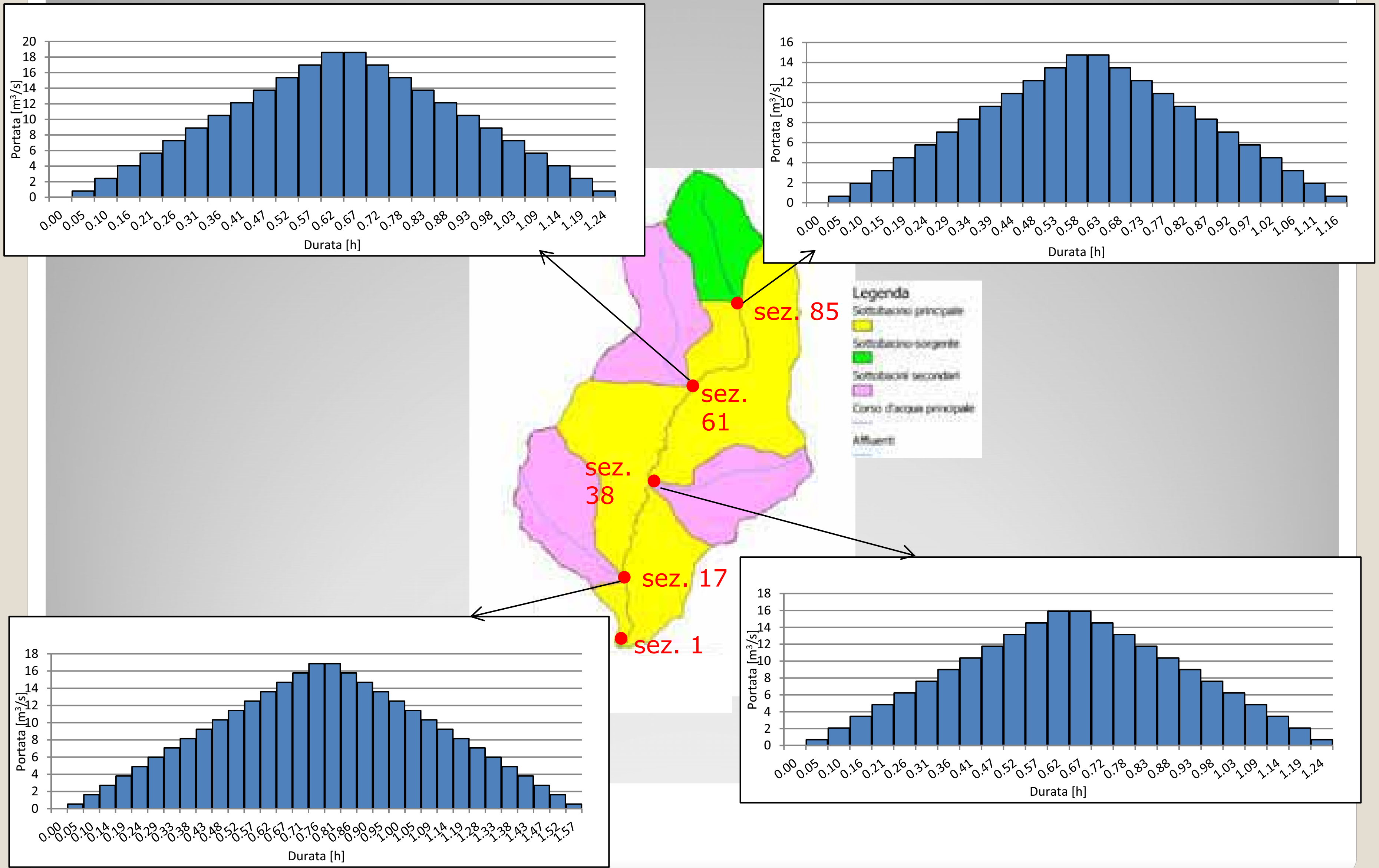
- Roughness n=0,07-0,05 s/m$^{1/3}$

- Solid discharge, *Meyer-Peter Muller* :

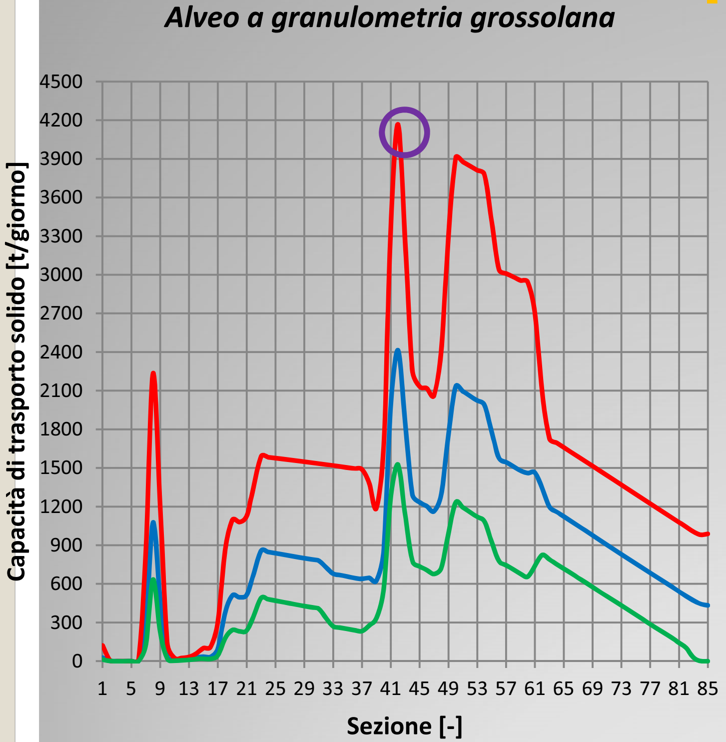
$$\left(\frac{k_r}{k'_r}\right)^{3/2} \gamma RS = 0{,}047(\gamma_s - \gamma)d_m + 0{,}25\left(\frac{\gamma}{g}\right)^{1/3}\left(\frac{\gamma_s - \gamma}{\gamma_s}\right)^{2/3} g_s^{2/3}$$



HEC-RAS hydraulic model



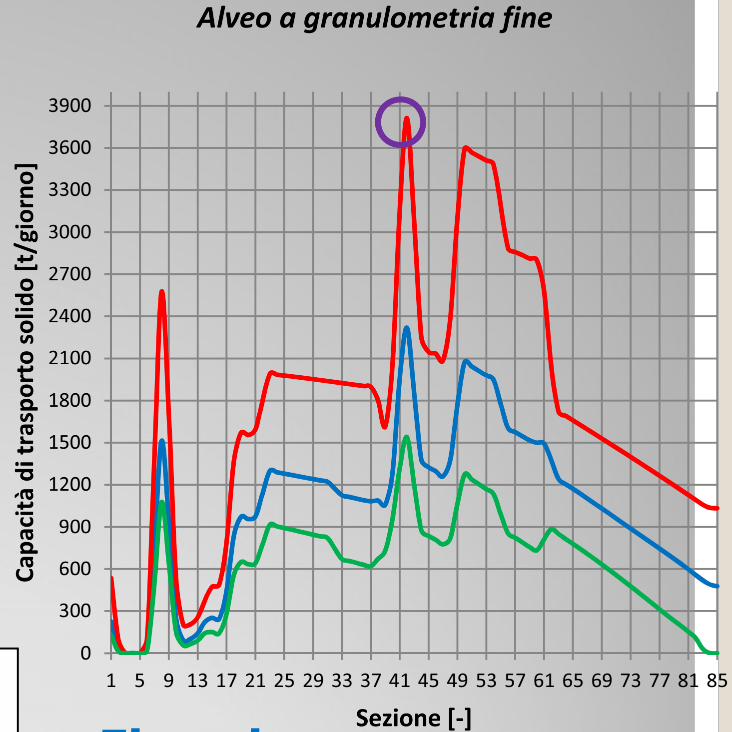
Results: flow transport capacity



Coarse size

The highest transport capacity at section 42: 4167,6t/day

4,55 minuti dall'inizio della simulazione
58,48 minuti dall'inizio della simulazione
117,44 minuti dall'inizio della simulazione



Fine size

The highest transport capacity at section 42: 3812,3t/day

RESIDUE

Initial Conditions Database

Initial: Tree-20 yr forest

Description: Initial conditions for 20-year old forest

Data Source: (null)

Comment: J. Laflen, 10/2002

Num	Parameter - 'Read Only'	Value	Units
1	Initial Plant	Tree-20 yr fo	
2	Bulk density after last tillage	1.1	(g/cub. cm)
3	Initial canopy cover (0-100%)	90	%
4	Days since last tillage	1000	days
5	Days since last harvest	100	days
6	Initial frost depth	0	cm
7	Initial interrill cover (0-100%)	100	%
8	Initial residue cropping system	Perennial	
9	Cumulative rainfall since last tillage	1000	mm
10	Initial ridge height after last tillage	10	cm
11	Initial rill cover (0-100%)	100	%
12	Initial roughness after last tillage	10	cm
13	Rill spacing	0	cm
14	Rill width type	Temporary	
15	Initial snow depth	0	cm
16	Initial depth of thaw	0	cm
17	Depth of secondary tillage layer	10	cm
18	Depth of primary tillage layer	20	cm
19	Initial rill width	0	cm
20	Initial total dead root mass	0.5	kg/sq.m
21	Initial total submerged residue mass	0.5	kg/sq.m

% surface covered by residue (leaves, etc)

	SELLERO	
	initial rill cover	*initial interrill cover*
	%	*%*
High intensity wildfire	45	45
Young forest	100	100
Old forest	100	100

RESIDUE

PARCEL 18	% COVER	years	Yearly precipitation (mm)	Yearly runoff (mm)	Yearly average soil erosion (kg/m^2)	Yearly average sediment yield (t/ha)
High intensity wildfire WEPP	25	(1998)	890.4	222.37	149.92	1389.342
High intensity wildfire Sellero	45	(1998)	890.4	218.91	114.93	1050.08

PARCEL 18	% COVER	years	Yearly precipitation (mm)	Yearly runoff (mm)	Yearly average soil erosion (kg/m^2)	Yearly average sediment yield (t/ha)
Young forest WEPP	20	7 003-2009)	773.61	56.34	1.967	19.156
Young forest Sellero	100	7 003-2009)	773.61	45.97	1.152	11.243