Soil & Water Assessment Tool | SWAT

Sub-hourly Modeling of Sheet Erosion and Sediment Transport using the SWAT Model

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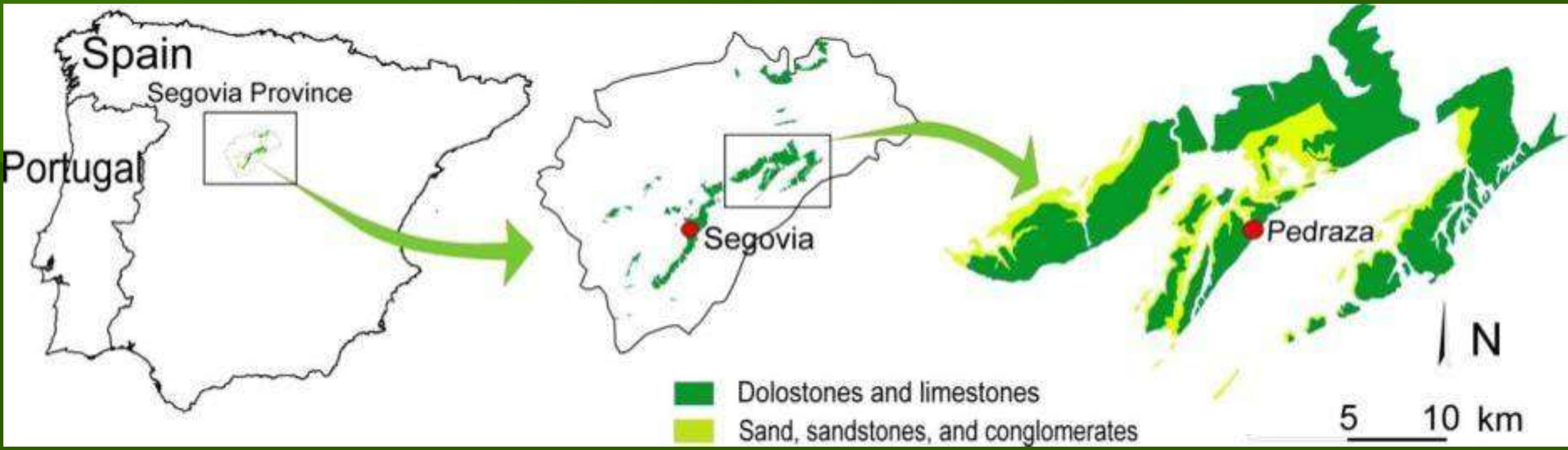
Why ?

- **Gullies developed on sands:**
  - Rare worldwide
  - Few studies on such gullies
- **Apparent high activity and hillslope-channel coupling**
- **No previous hydrogeomorphic studies in this area**

Objectives

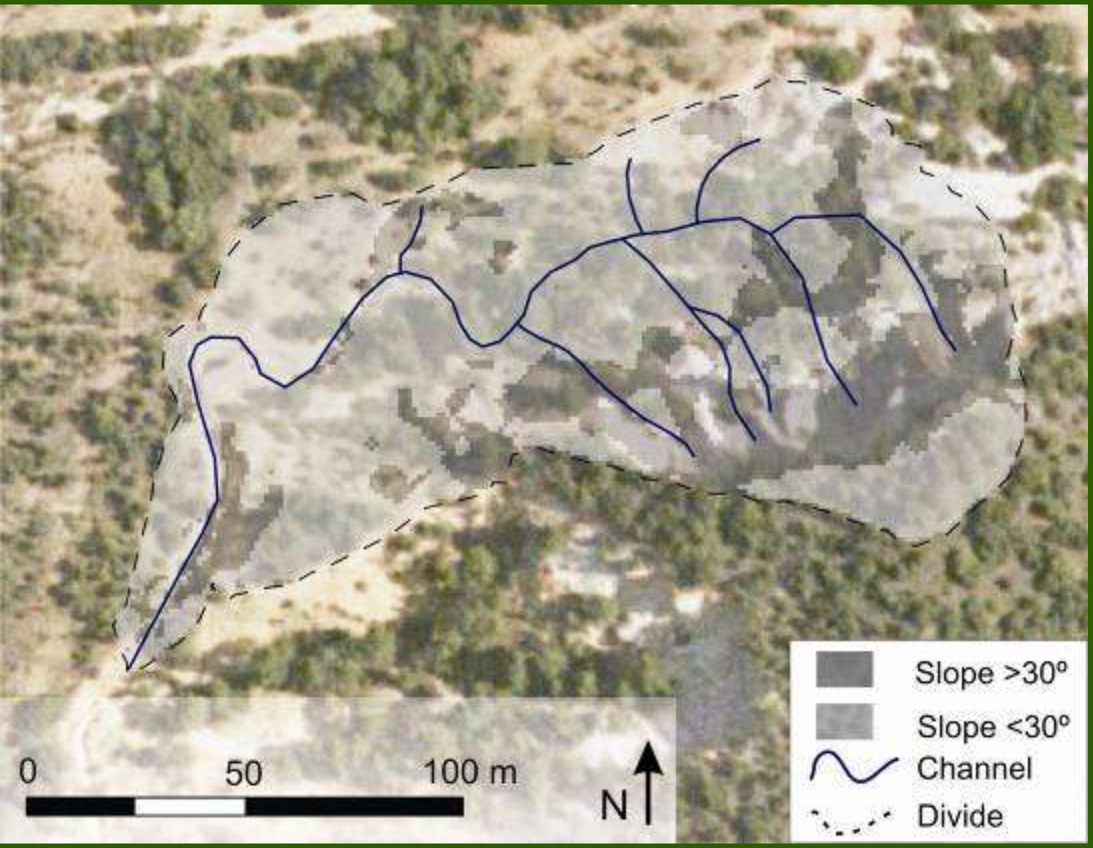
- Understand the geomorphic processes operating within these gullies.
- Demonstrate sheet erosion is the predominant erosive process
- Estimate sediment yield

Study Area

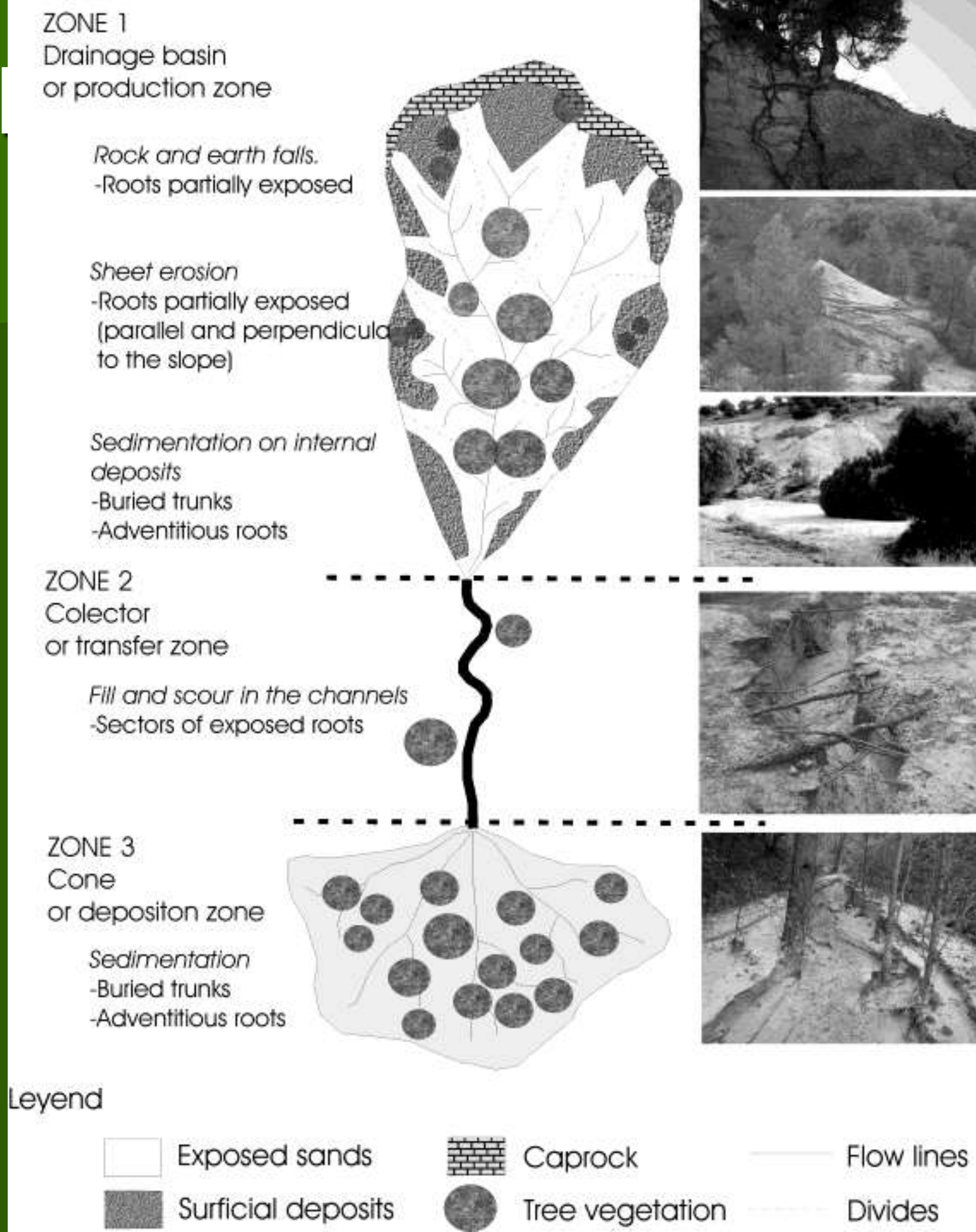


- Continental mediterranean climate
  - Precipitation 650 mm/year
- Cretaceous bedrock sediments
- Mesas and cuestas
- Sandy cambisols
- Holm oak and savin forests

Experimental catchment: Barranca de los Pinos

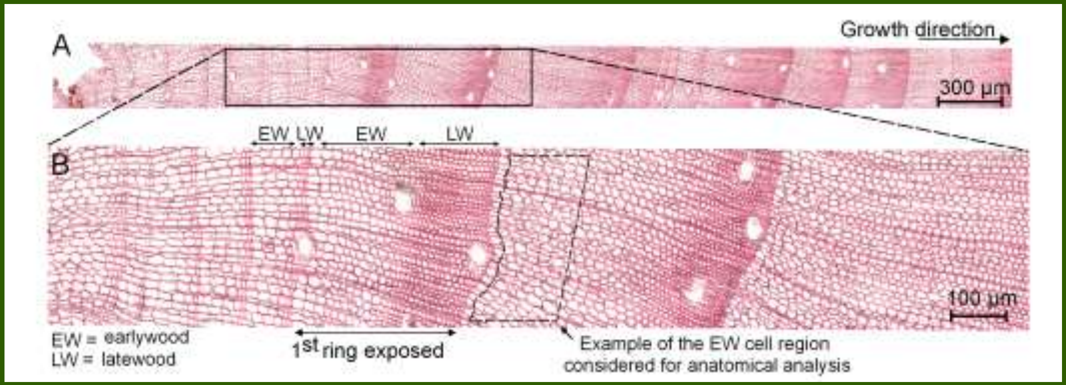


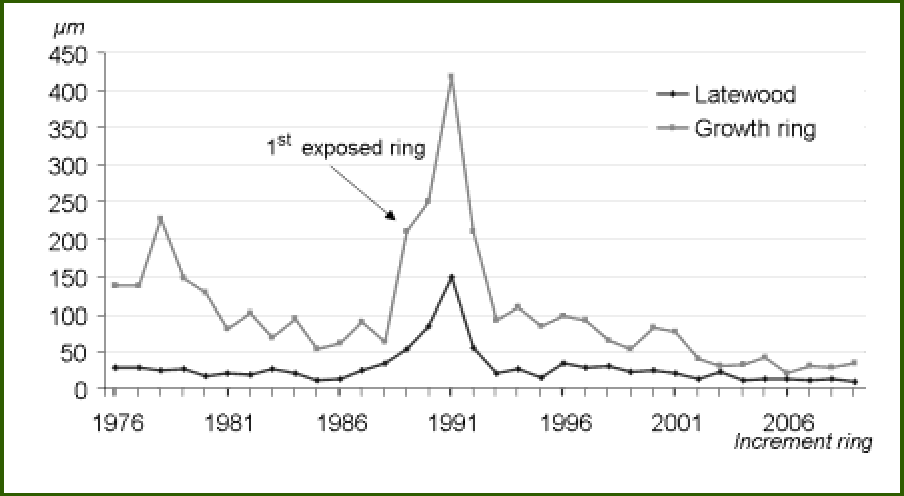
- Landform map
  - High gradient slopes
    Gravitational processes
  - Low gradient slopes
    Erosive processes due to overland flow and splash
  - Channels
    Fluvial processes

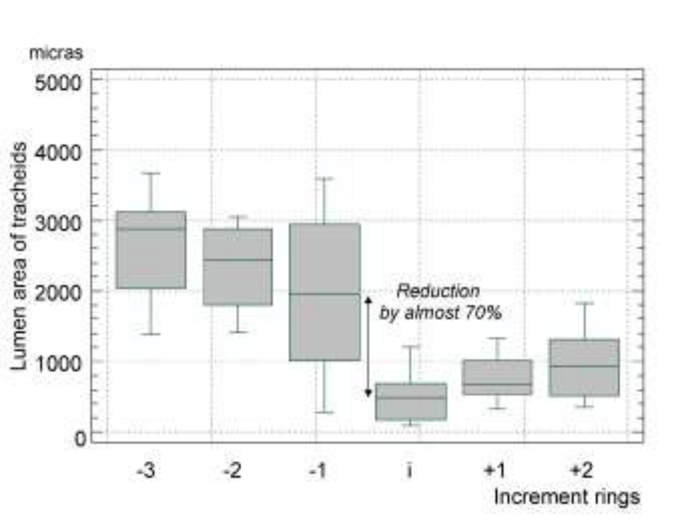

ZONE 1
Drainage basin
or production zone
Rock and earth falls.
-Roots partially exposed
Sheet erosion
-Roots partially exposed
(parallel and perpendicula
to the slope)
Sedimentation on internal
deposits
-Buried trunks
-Adventitious roots
ZONE 2
Colector
or transfer zone
Fill and scour in the channels
-Sectors of exposed roots
ZONE 3
Cone
or depositon zone
Sedimentation
-Buried trunks
-Adventitious roots
Leyend
Exposed sands
Surficial deposits
Caprock
Tree vegetation
Flow lines
Divides

Methods

- **Estimate sheet erosion rates by using a dendrogeomorphic aproach**







Methods

- **Estimate sheet erosion rates by using a dendrogeomorphic aproach**

$$CES = 36A^{-0.2} - \frac{2}{\log P} + \log BR$$

CES: Sediment delivery ratio

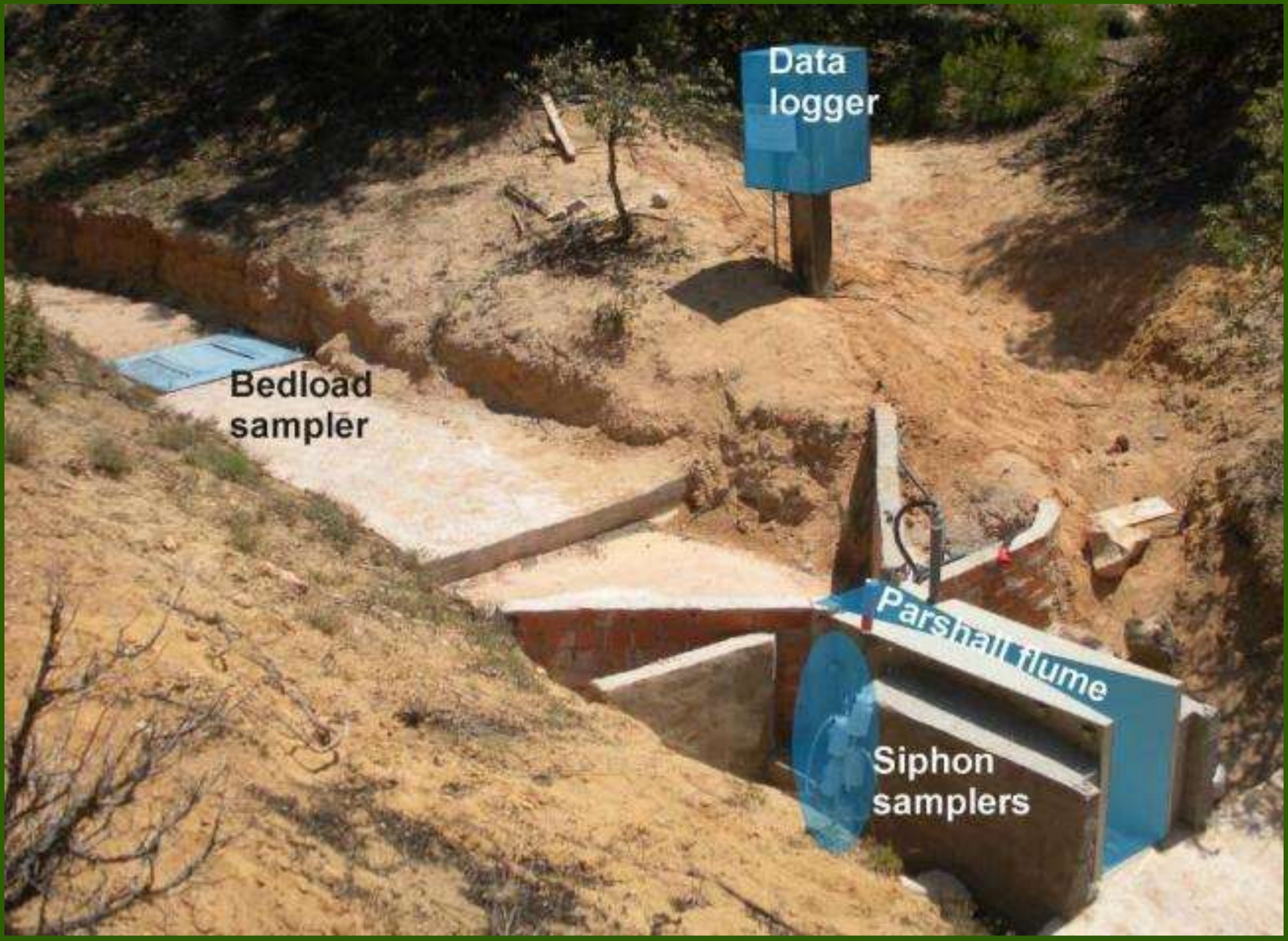
A: Catchment area

P: Main channel slope

BR: Bifurcation ratio (f – stream order)

Methods

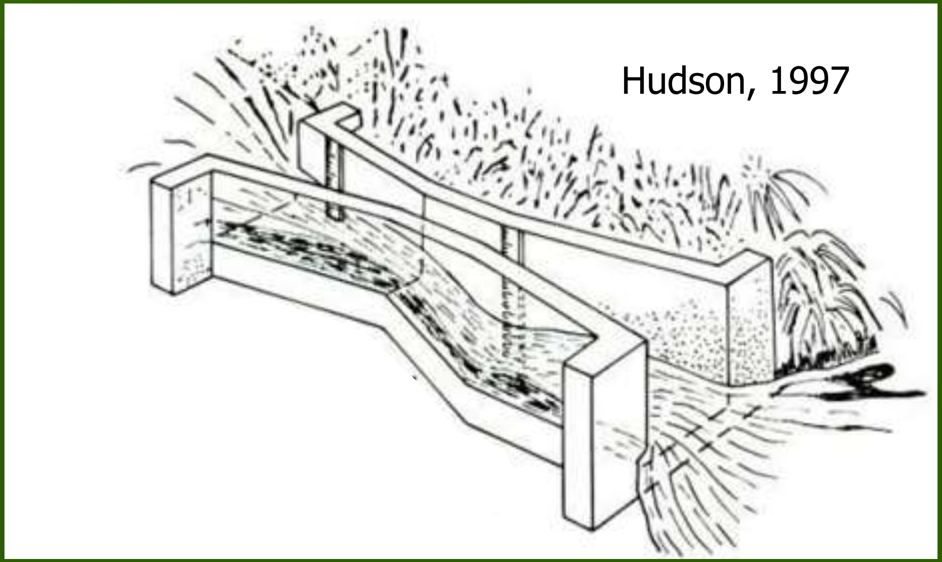
- **Field measurement of total soil erosion and runoff**



Methods

- **Field measurement of total soil erosion and runoff**

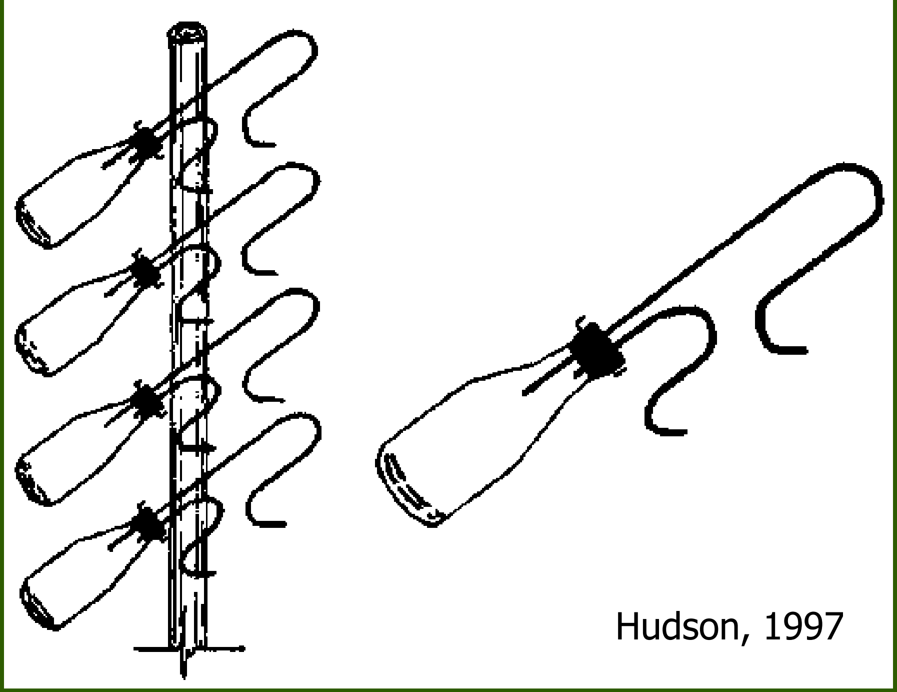
- Parshall flume → water discharge



Methods

- **Field measurement of total soil erosion and runoff**

- Siphon samplers → suspended sediments and solutes



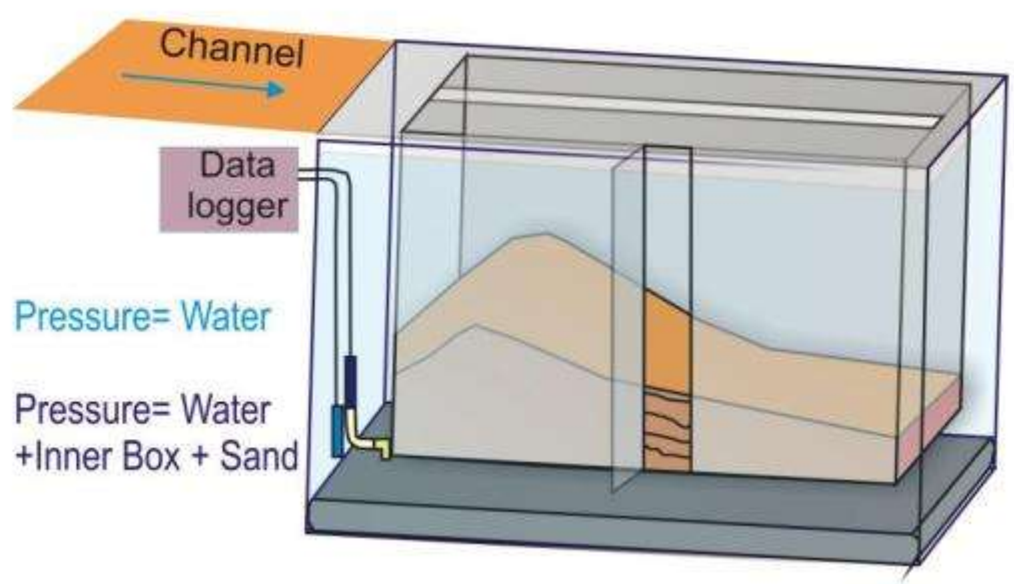
Hudson, 1997

- 6 ½-liter bottles

Methods

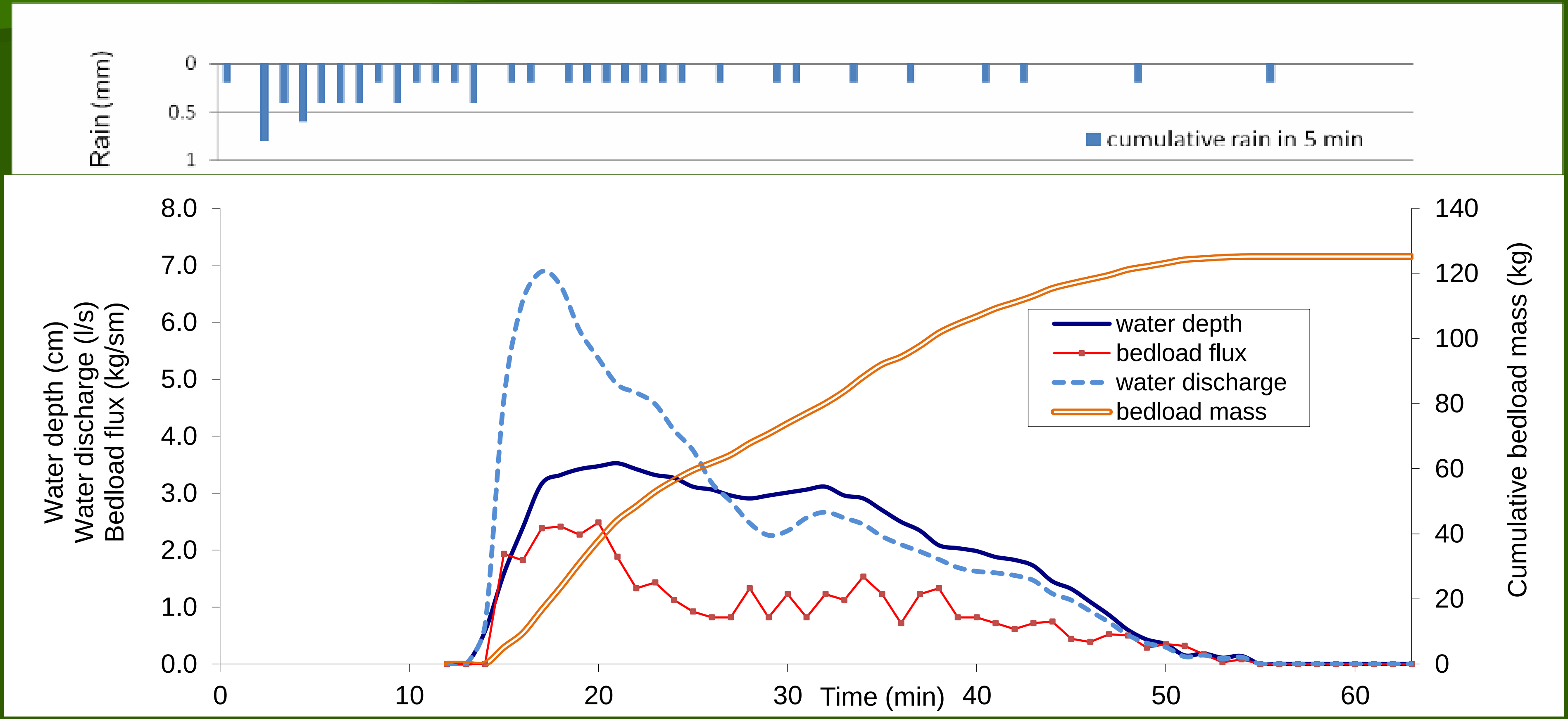
- **Field measurement of total soil erosion and runoff**

- Reid slot sampler → automatic and continuous bedload sampling



Methods

- **Channel: Basin outlet**



Effective rain: 9.2 mm
Runoff coefficient 5.4 %

Total sediment yield : 3.3 Mg

Methods

Subhourly SWAT model -Motivation

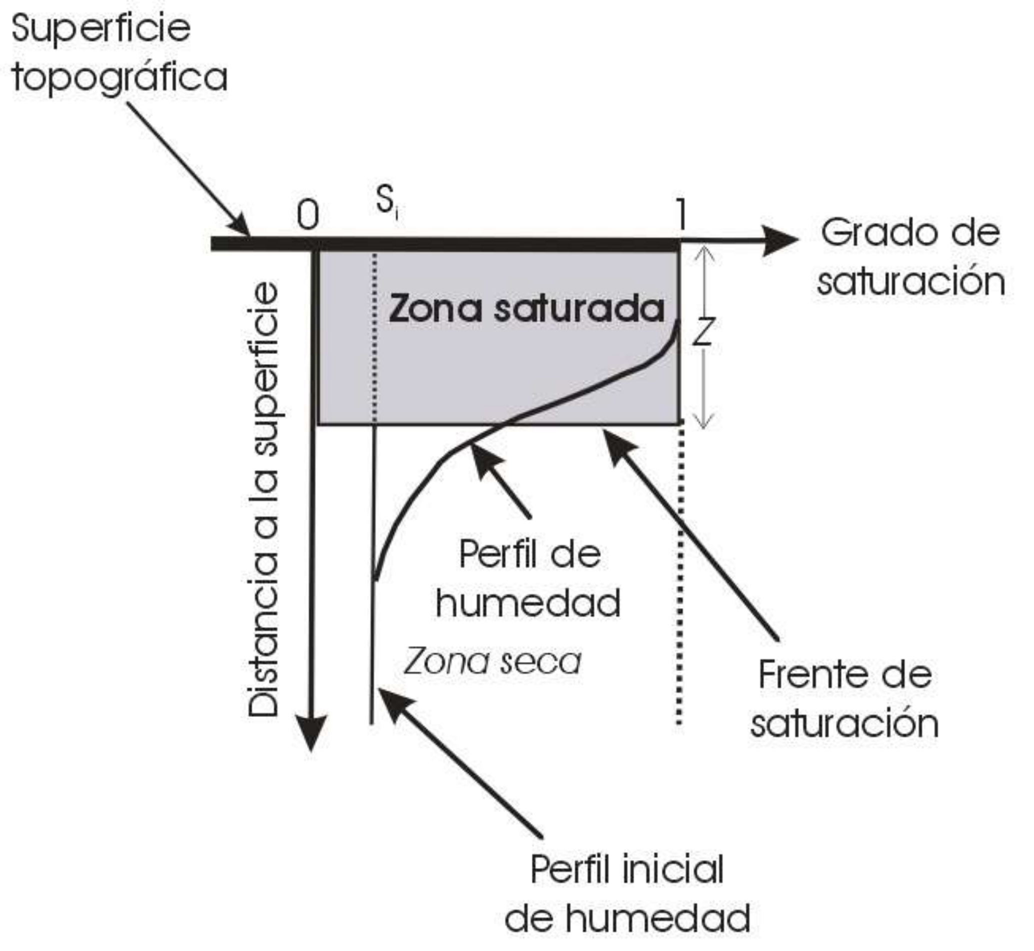
Jeong et al., 2010

- ❑ The Universal Soil Loss Equation (MUSLE) in SWAT 2005/2009 is intended for daily upland erosion and sediment transport modelling in overland flow
- ❑The MUSLE is an empirical model developed for predicting long term average soil loss and is NOT adequate for subdaily continous simulation
- ❑ Subdaily erosion and sediment transport is not available in SWAT 2005/2009

Methods

Subhourly SWAT model -Motivation

✓ *Estimation of infiltration and excess rainfall*



$$f(t) = K\left(\frac{\Psi \Delta \theta}{F(t)} + 1\right)$$

Where K is the hydraulic conductivity, ψ is the wetting front suction head, $\Delta\theta$ is the change in moisture content and F(t) is the cumulative infiltration depth.

Methods

- **Subhourly SWAT model -Motivation**

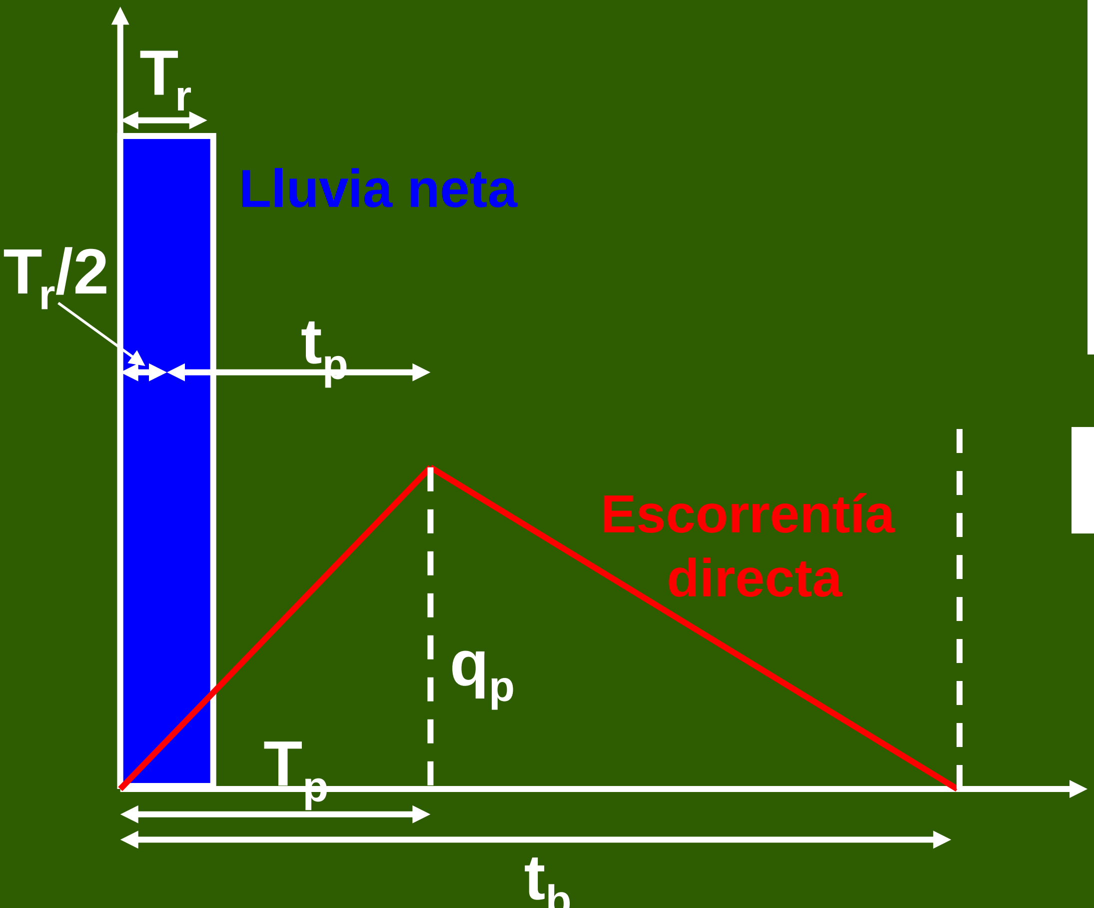
✓ *Surface runoff lag*

$$Q_{surf,i} = \left(Q'_{surf,i} + Q_{stor,i-1}\right)\left(1 - \exp\left[\frac{-surlag}{t_c/\Delta t}\right]\right)$$

Methods

- **Subhourly SWAT model -Motivation**

✓ *Unit hydrograph*



$$q_{uh} = t/t_p \ \text{if} \ t \leq t_p$$

$$q_{uh} = \frac{t_b - t}{t_b - t_p} \ \text{if} \ t > t_p$$

$$t_b = 0.5 + 0.6 t_c + tb\_adj$$

$$t_p = 0.375\, t_b$$

Methods

- **Subhourly SWAT model -Motivation**

✓ *Channel impoundment routing*

$$S_{\text{Prism}} = KQ$$

$$S_{\text{Wedge}} = KX(I - Q)$$

Advancing Flood Wave
$I > Q$

K = travel time of peak through the reach
X = weight on inflow versus outflow ($0 \leq X \leq 0.5$)
X = 0 ➔ Reservoir, storage depends on outflow, no wedge
X = 0.0 - 0.3 ➔ Natural stream

$$S = KQ + KX(I - Q)$$

$$S = K[XI + (1 - X)Q]$$

Receding Flood Wave
$Q > I$