WG 1: « critical sources »

Magdeburg 7-9 sept. 2009

A plot tree structure to represent surface flow connectivity in rural catchments and facilitate landscape management and water protection

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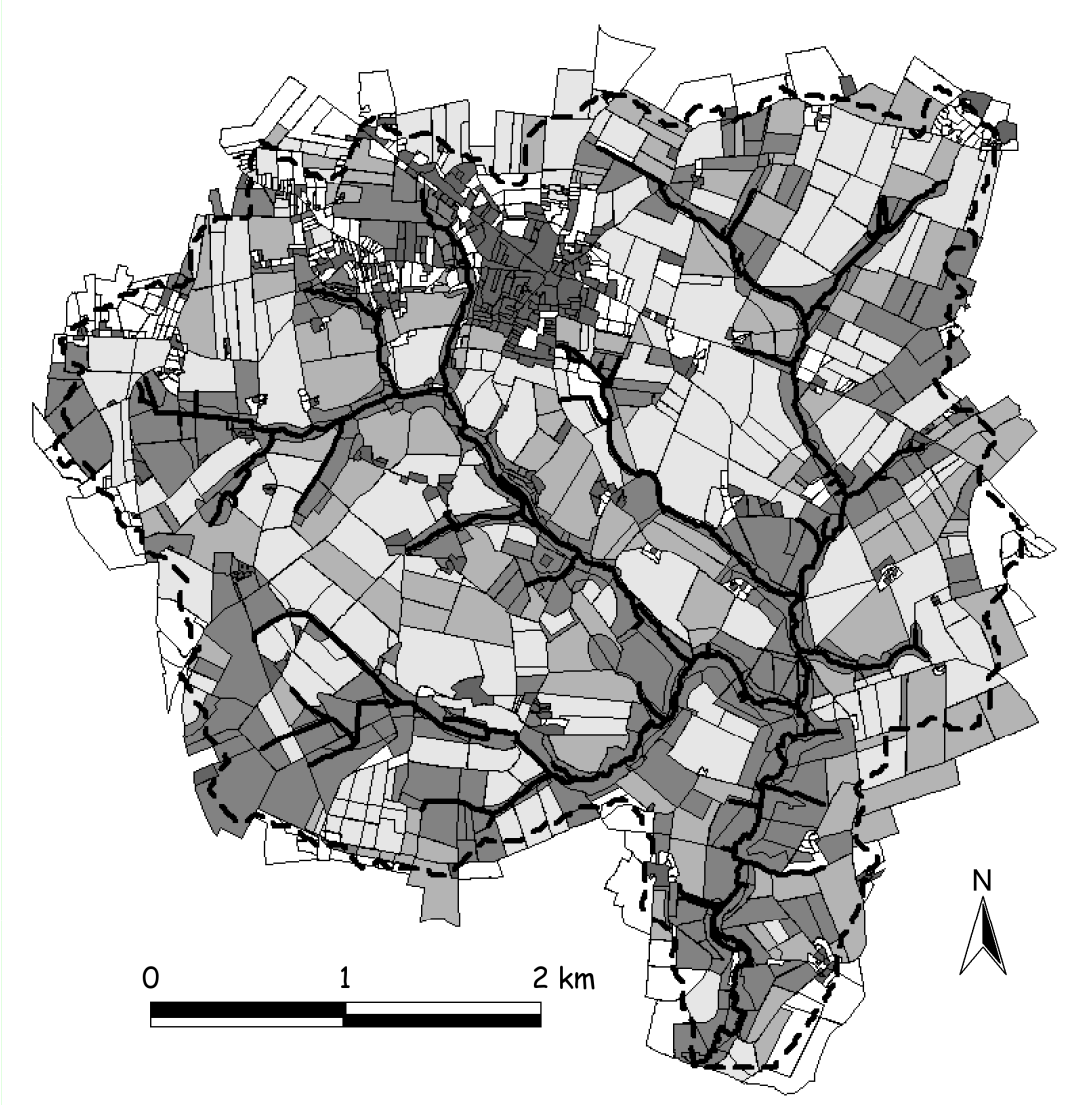
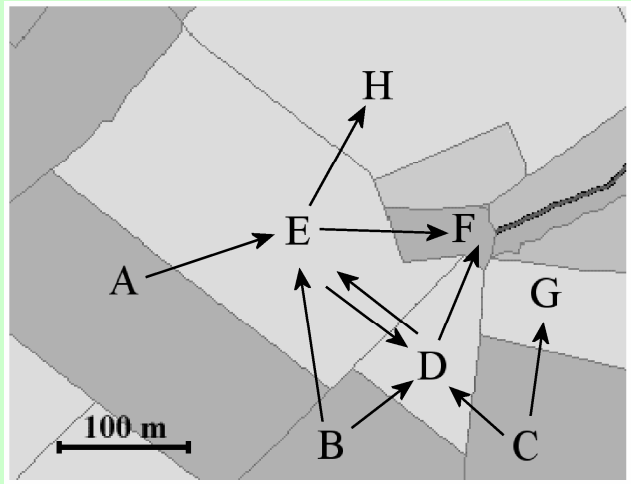
PÔLE D'ENSEIGNEMENT SUPÉRIEUR ET DE RECHERCHE AGRONOMIQUE DE RENNES

ALIMENTATION
AGRICULTURE
ENVIRONNEMENT

INRA

- Agricultural landscapes are structured
  - by a mosaic of farmers' fields whose land use change over time
  - by linear elements such as hedgerows, ditches and roads (boundaries, interface) which are more or less connected to each other and to the fields
- Such man-made features are now well known to have an effect on catchment hydrology, erosion and water quality, acting as sink or source
- In such agricultural landscapes, as necessary step for improving landscape design and water protection, it is crucial to have
  - an adequate representation of the flow pathways and
  - relevant indicators of surface flow connectivity over the catchment towards the stream





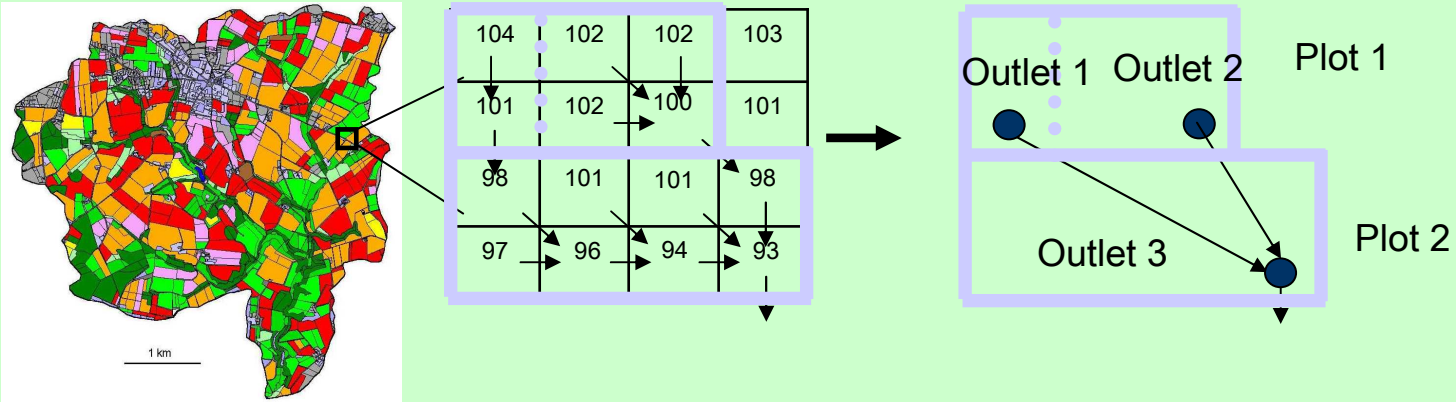
How to take into account the flow pathways and therefore identify critical source areas?

1. Method

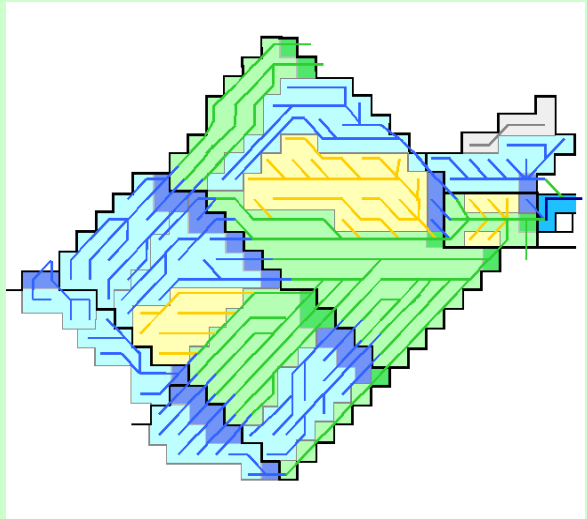
Aurousseau P., Gascuel-Odoux C., et al., 2009

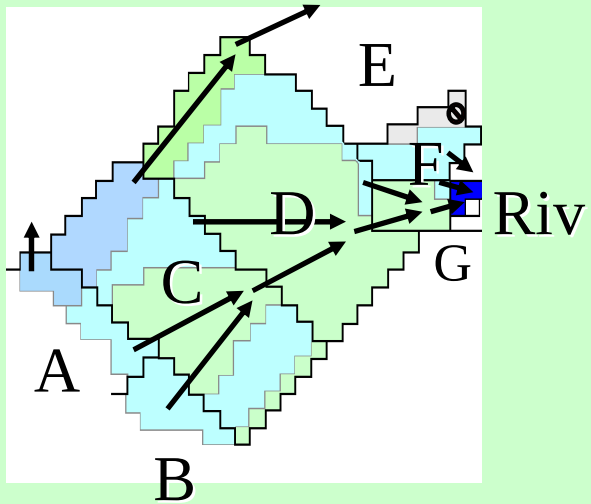
A plot drainage network as a conceptual tool for the spatialisation of surface flow pathways for agricultural catchments.

Computer and Geosciences, 35, 276-288.



Identifying the inlets and outlets on each field





Estimating the relative areas contributing to any outlet

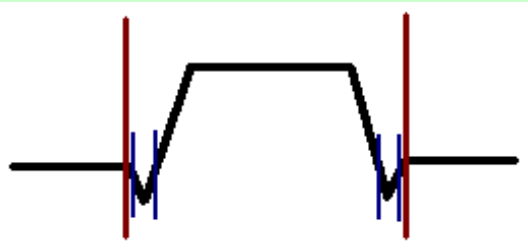
Deducing a drainage network composed of a set of elementary plot outlet trees labelled by attributes, particularly surface areas

Inside one plot, hydrological areas are delineated regarding its outlets

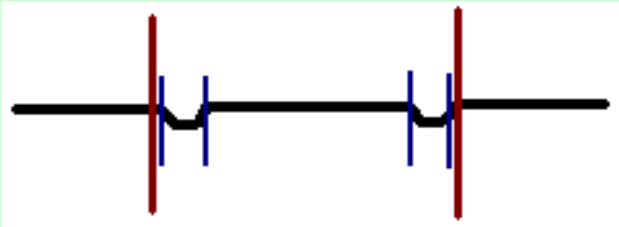
If present, linear networks such as roads, modify this tree structure, by adding functions

- Wall: redirect the flow pathways
- Walls crossing or Sink: can isolate a part of catchment area

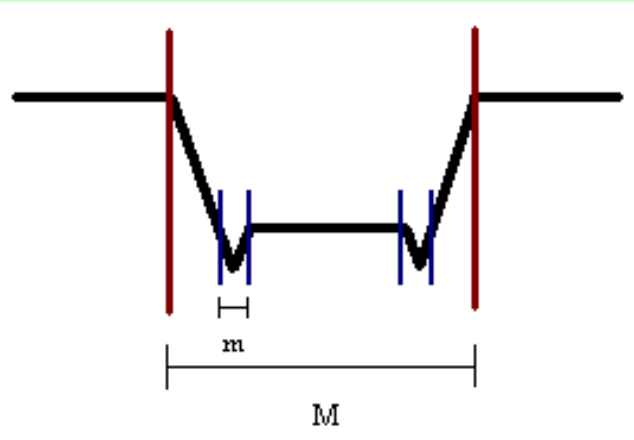
Applied for hedgerows and roads



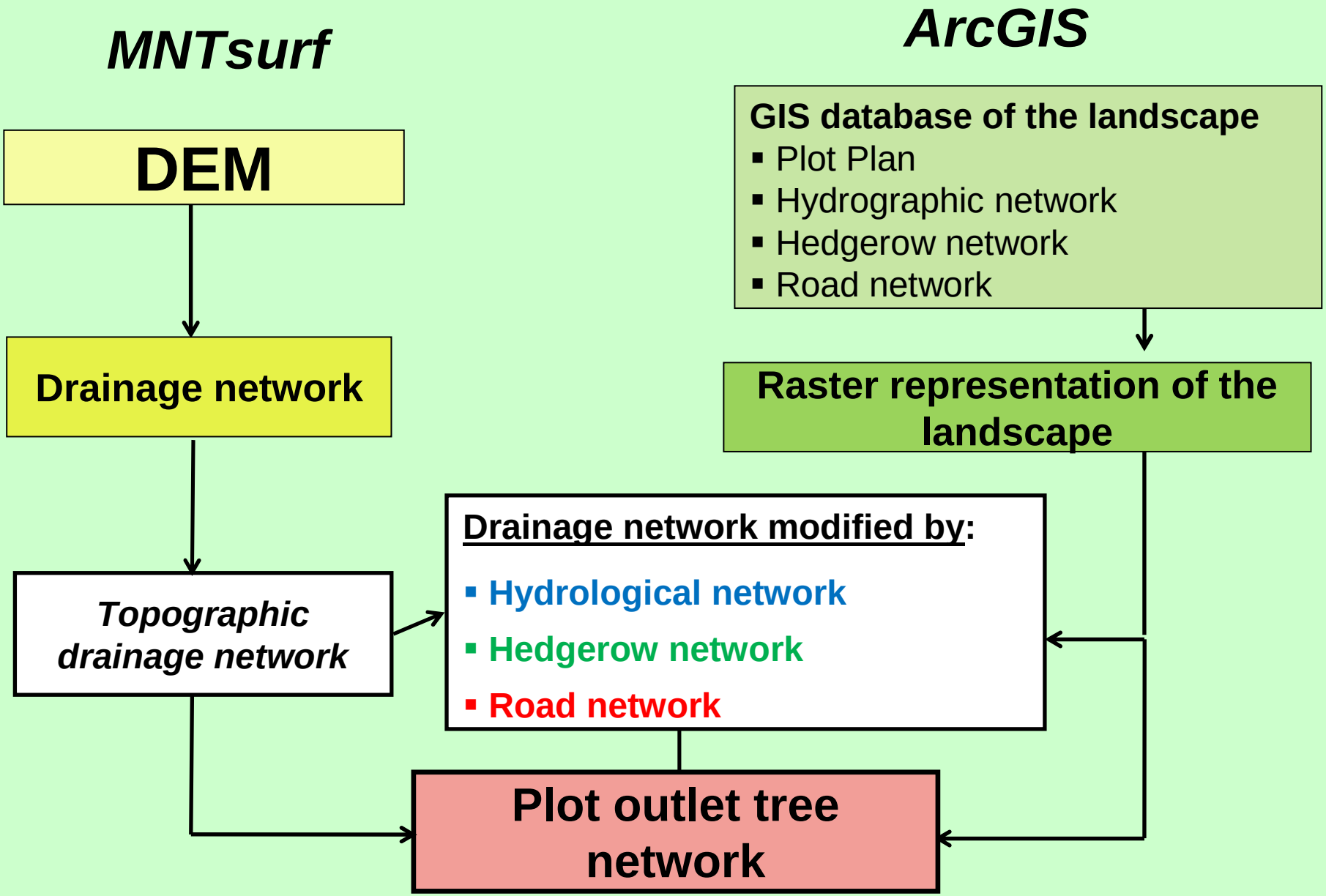
Road acts as a wall



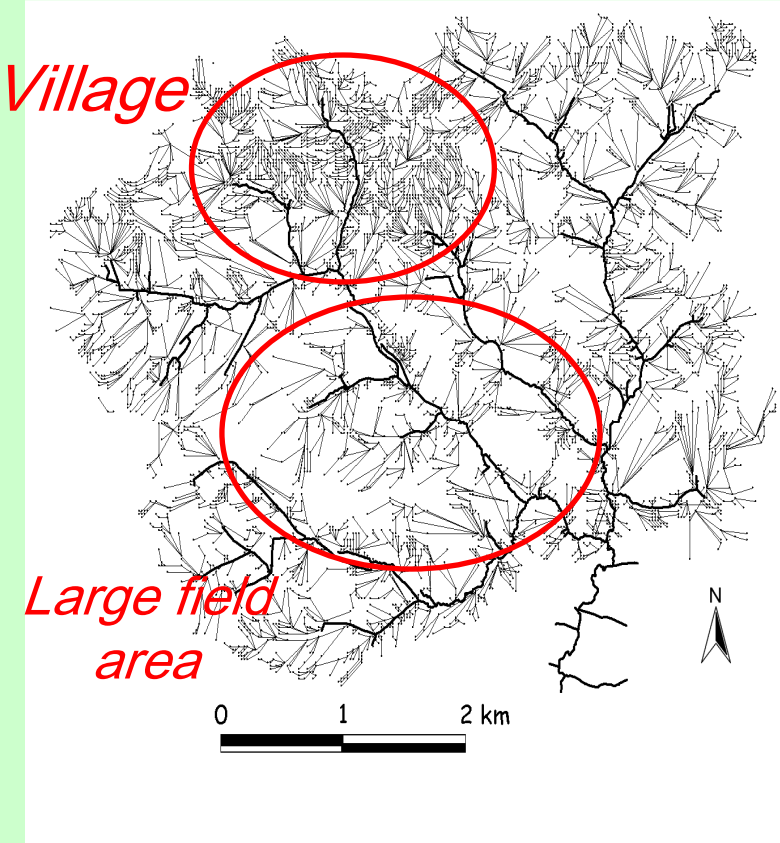
Neutral road

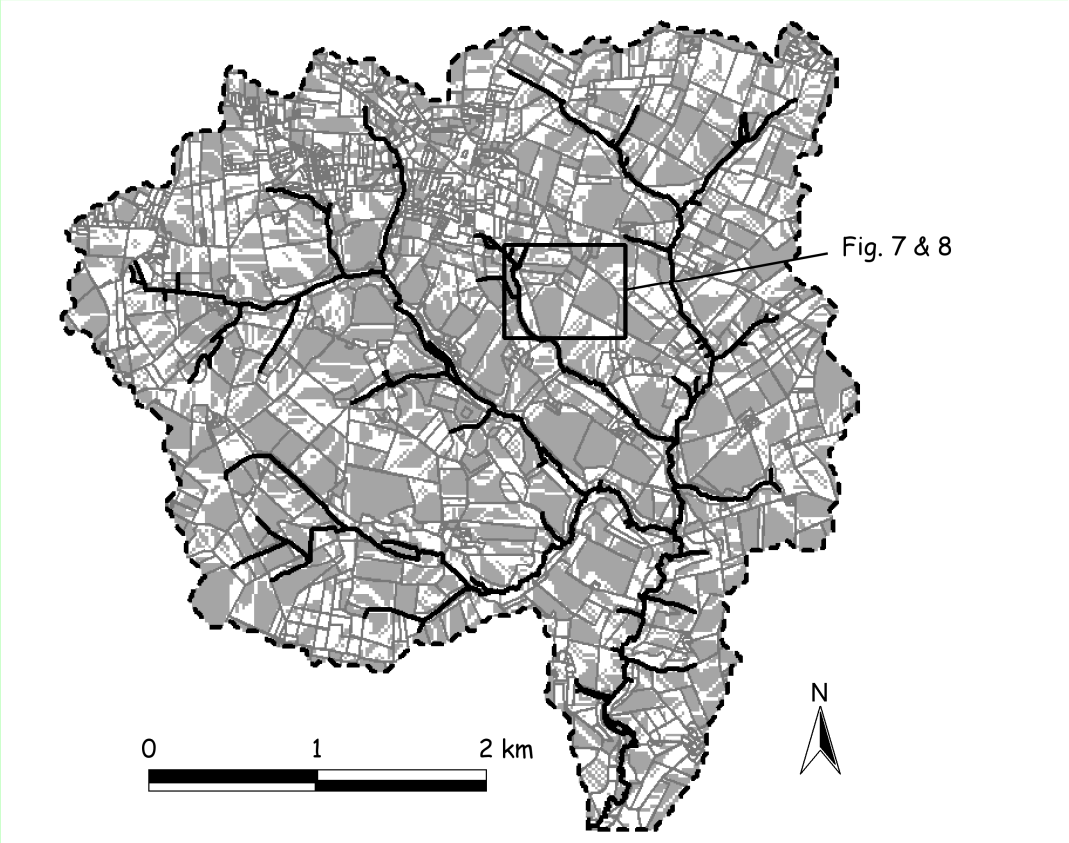


Road acts as a ditch



The global plot outlet tree represent a pattern of surface flow relationships and constitutes a *landscape drainage network*

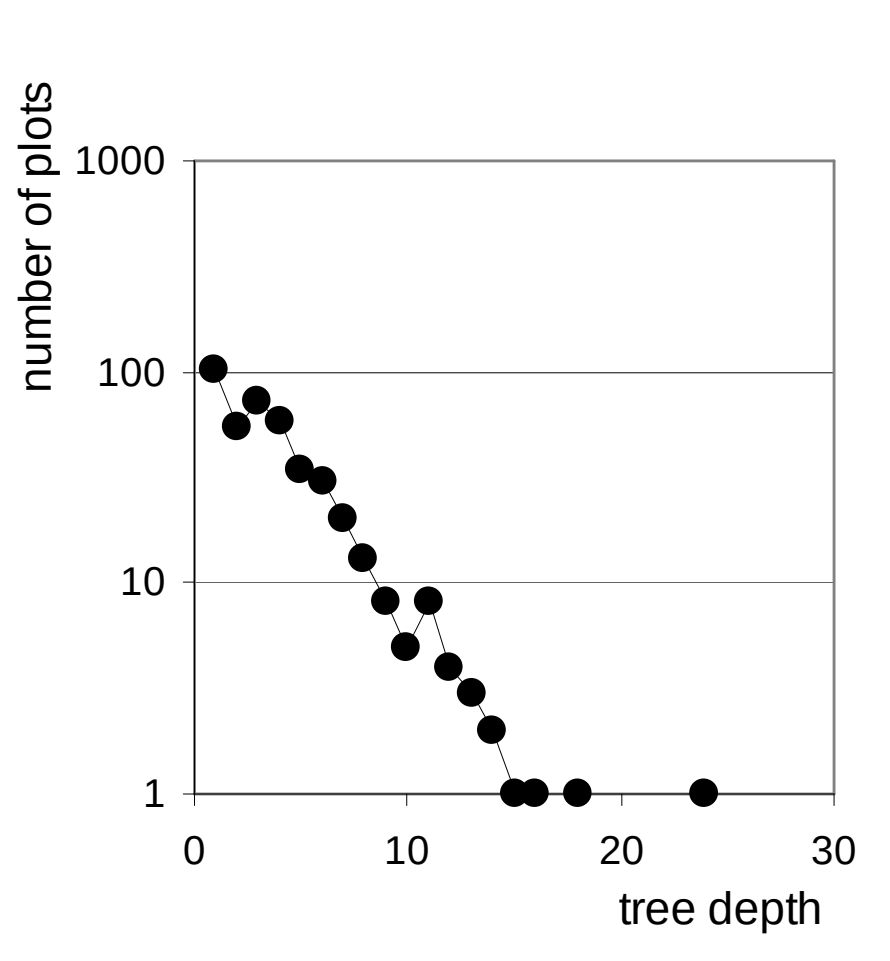


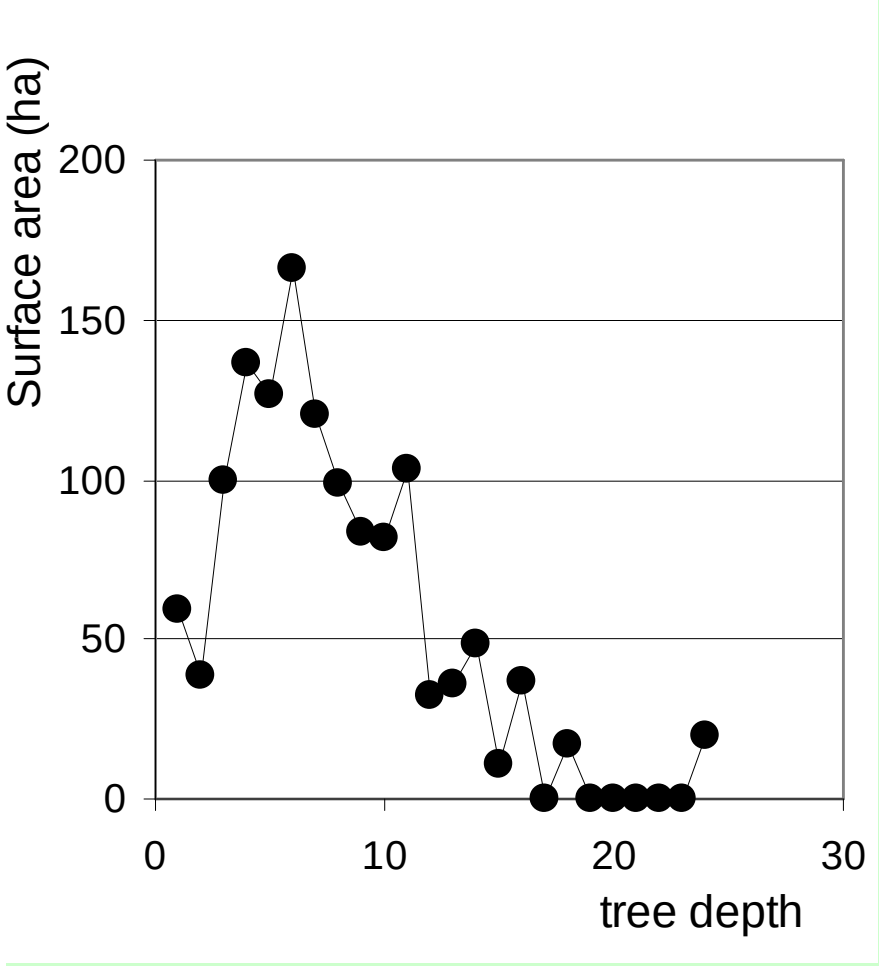


The global plot outlet tree represents the pattern of surface flow relationships over the catchment.

Therefore, only a part of the surface area of the catchment is effectively connected to the stream

Entire or part of plots are disconnected





Statistics on the plot connectivity

The small plot outlet trees are numerous

The great part of the surface area is composed of middle size plot outlet trees

This can be usefull to compare different catchments

- This landscape drainage network greatly reduces the number of objects in comparison with a drainage network made up of pixels or DEM cells.

- It provides a simple and appropriate way of representing the surface flow connectivity from plot to plot over the catchment, which leads to a functional display of data for decision support.

- It allows us to highlight the plots of potential risk regarding surface runoff

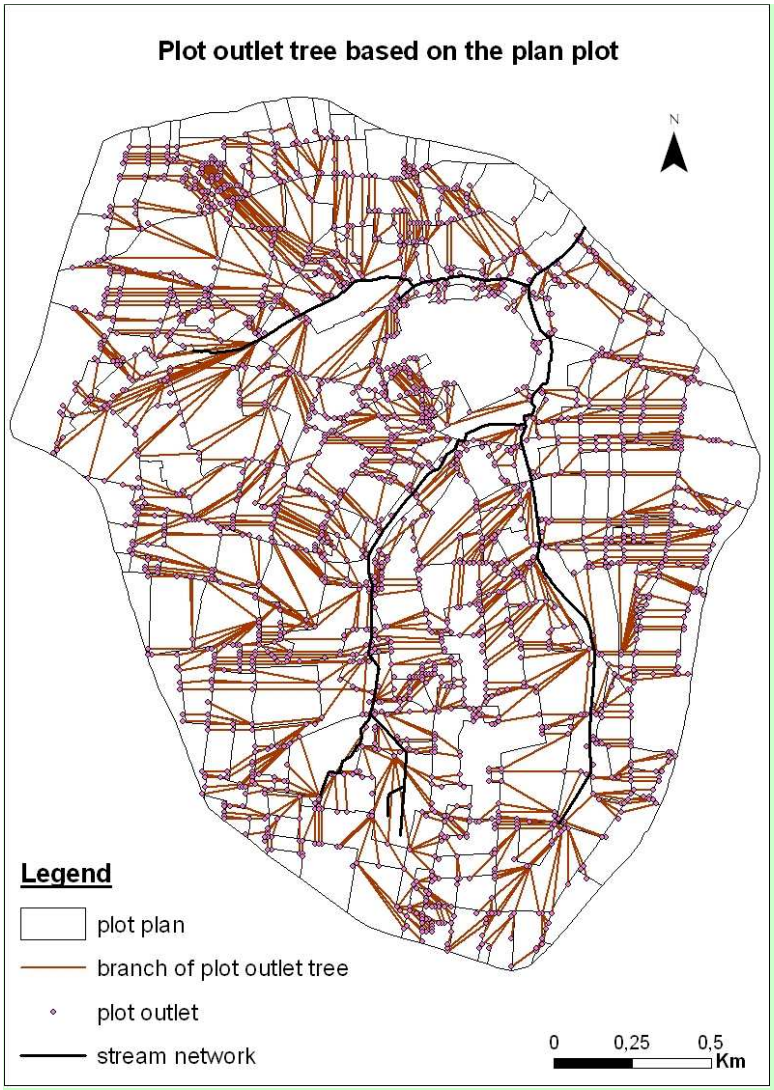
2. Applications to identify critical source areas for erosion

Gascuel-Odoux C., et al., in review
Hydrological Processes

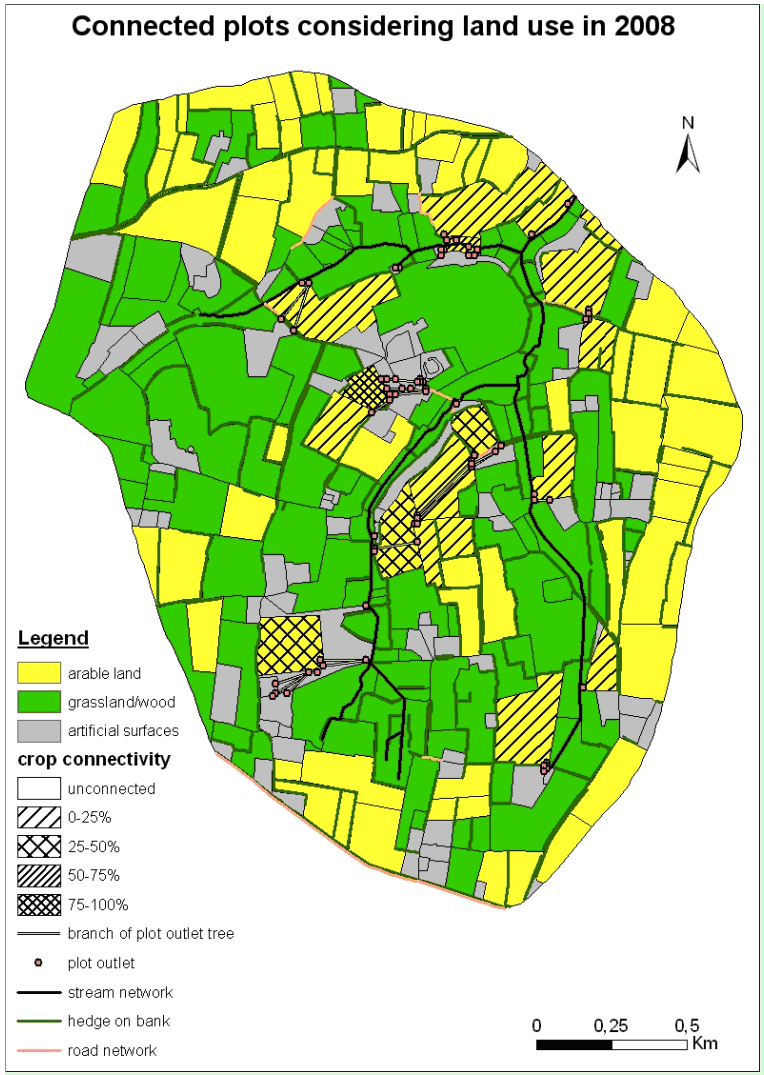
A catchment presenting
- High baseflow erosion (40%)
- High density of hedgerows
- Grassland

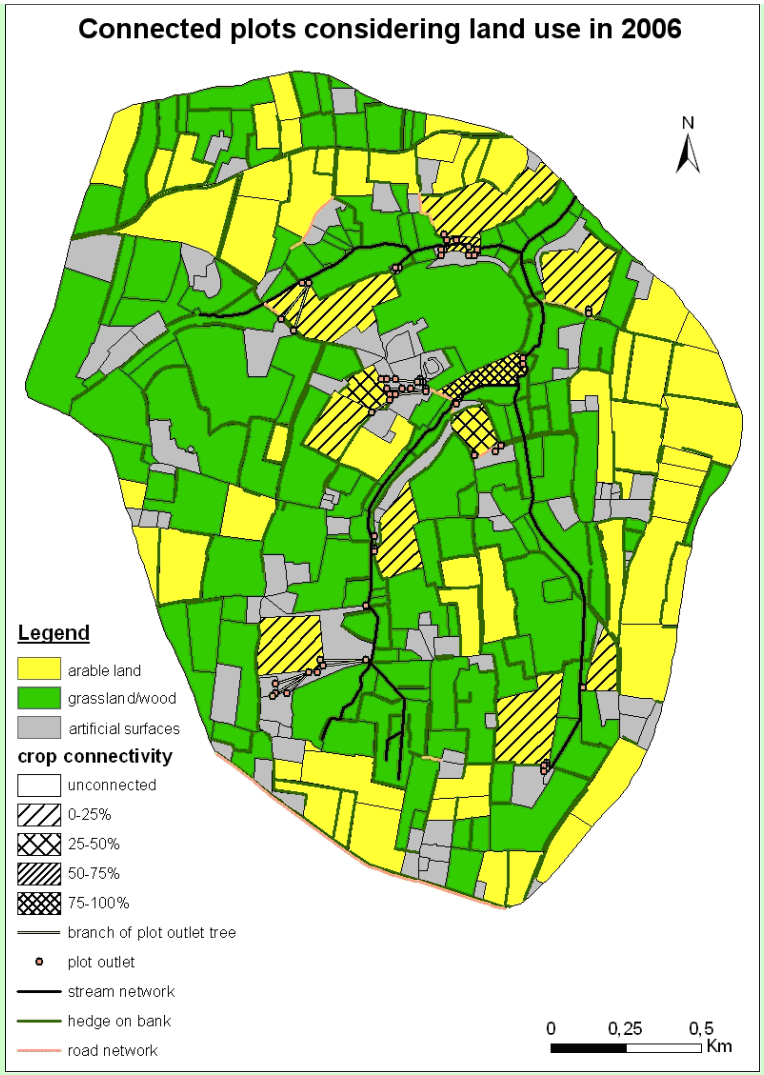
Assumption : riparian erosion ?

Lefrançois J, Grimaldi C et al, 2007.
Hydrological Processes.



The hedgerow and road networks are highly developed, and therefore, reduce the effective contributing area to the stream





When considering the land use

- Sink: on grassland and forested areas

Taking into account land use improve the identification of critical areas

Attributes of tree structures	Based on the plan plot	Plus hedge and road network	Plus land use in 2006	Plus land use in 2008
Number of connected pixels	43955	23601	1960	2147
Number of connected plots	312	247	30	35
Mean number of plot outlets per plot	6,61	3,84	2	2
Mean height of trees	3.82	2.72	1.53	1.65
Mean drainage area of trees (m^2)	25174	14424	6125	5803

Cultivated areas *(results in percent of the cultivated areas)*		**2008**
		1.73km²
Effect of hedge and road network	Partially or totally connected plots	79.5%
	Connected surface areas (pixels)	18.3%
Effect of land use, hedge and road network	Partially or totally connected plots	27.9%
	Connected surface areas (pixels)	7.2%

The connected areas are low extended (7% of the surface area) and close to the stream, indicating that the suspended sediment comes from riparian areas in this catchment

Some upslope plots are connected to the stream by the way of artificial areas which can play a major role in connecting upslope arable areas

We can easily identify the hot points of source of erosion : they are not numerous

3. Modelling surface runoff and pollutant fluxes

Gascuel-Odoux C, Cordier MO, et al., 2009

A decision-oriented model to evaluate the effect of land use and management on herbicide contamination in stream water.

Environmental modelling and software,

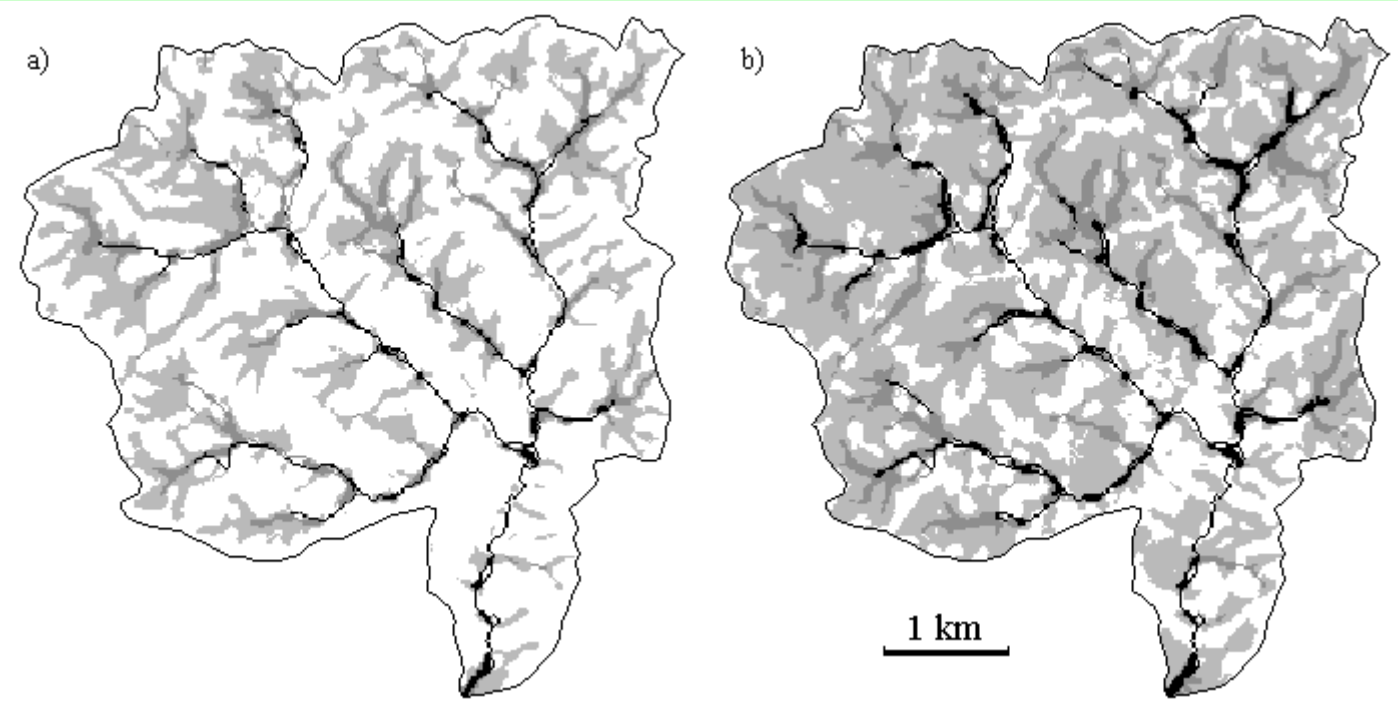
Modelling surface and subsurface flow

Stream Model (Plot outlet tree + soil surface conditions)

Topmodel (DEM + hydrological assumptions)

Coupling water and pollutant (here pesticides), crop growth model

Simple bio-physical models or expert rules



- Map of the surface areas where the water table depth < threshold (1 m) at two dates

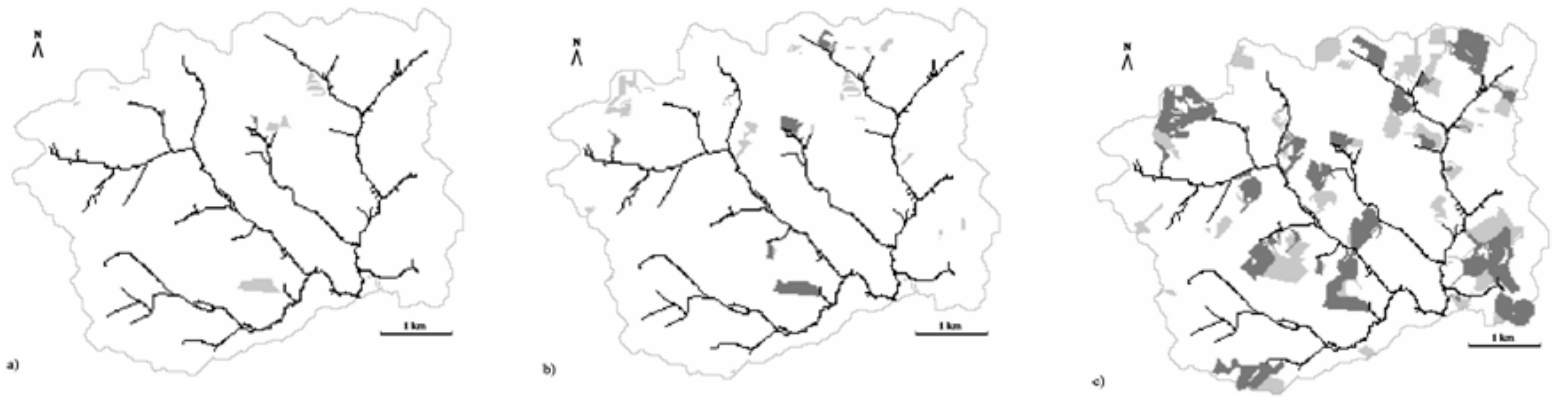
= Contributing areas by subsurface flow
(preferential recharge to the shallow groundwater)

Map of surface areas with soil sealing

(soil surface conditions changing in time)

= the **potential** contributing area related to surface runoff

These surface areas increase in time



Map of surface areas connected and disconnected to the stream

Surface runoff can infiltrate on a part of the previous identified plots

= the **effective** contributing areas related to surface runoff

4. Deduce expert rules and spatial patterns explaining pollutant fluxes

Trepos R., phD

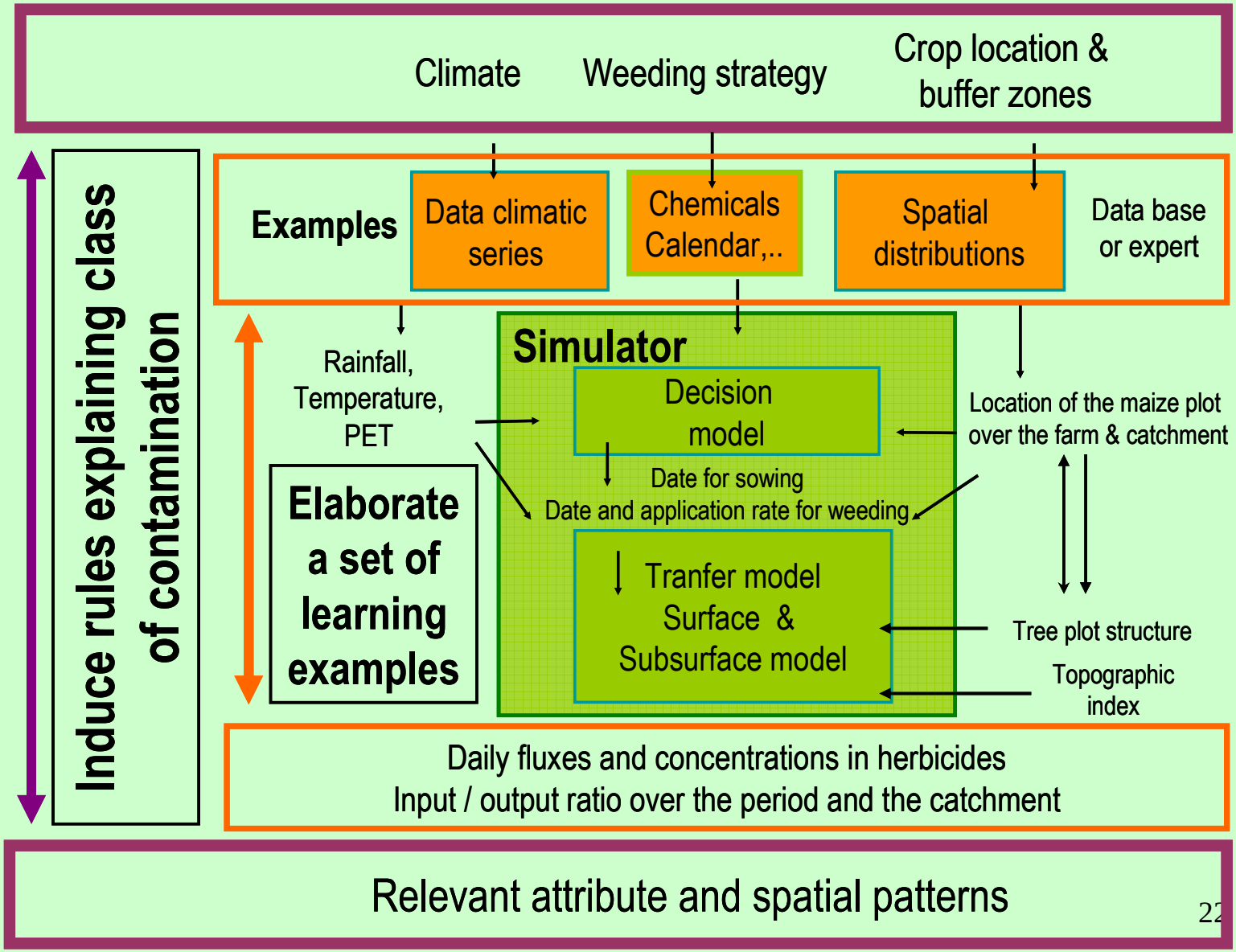
Trepos R, Salleb A et al., 2005.

A distance approach for action recommandation.

In : Machine Learning : ECML 2005 - Proceedings. Gama, J.;Camacho, R;Brazdil, P.;Jorge, A.;Torgo, L.(Eds). 16th European Conference on Machine Learning. 3-7 Oct. 2005, Porto, PT. Vol. 3720 p.425-436

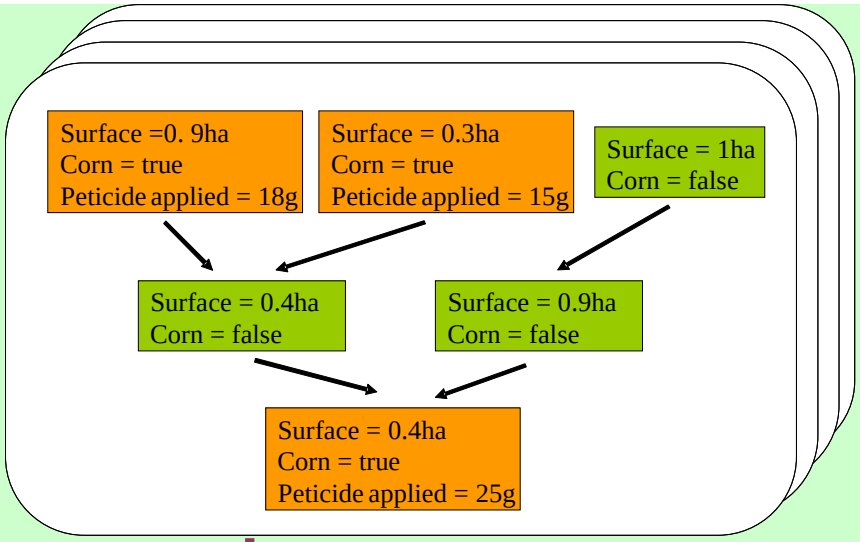
http://dx.doi.org/10.1007/11564096_41

Elaborate a large set of examples (simulations)
Induce rules (attributes or spatial patterns)



Two automatic learning methods have been tested

Large set of simulation results on plot outlet trees are used for induction processes



Automatic learning

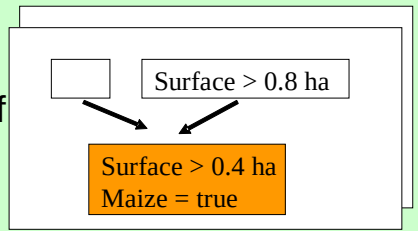
Method 1: tree patterns are generated, based on inductive logic programming

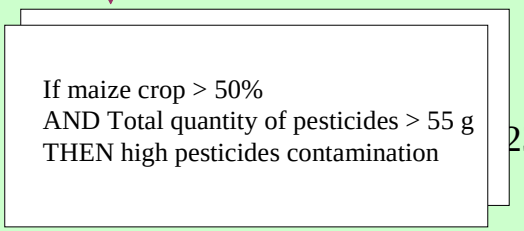
Method 2: the information contained in the trees are synthesized and attribute-value rules identified.

7 attributes per plot
Total amount of pesticides per plot
Contributing area of the outlet
Maize crop (true or false)
Buffer zone (true or false)
Slope of the plot
Topographic index (soil wetness)
Post or pre-emergence application

11 global attributes per tree
Total amount of pesticides
% of 2 types of chemical (Koc and half time)
% of pre-emergence applications
Total surface area of the tree
% of maize crop
Surface of the largest maize plot
% of buffer zone
Tree-structure depth
Elevation range of the tree structure
Pattern of the tree structure (long / width)

Limited set of patterns and rules

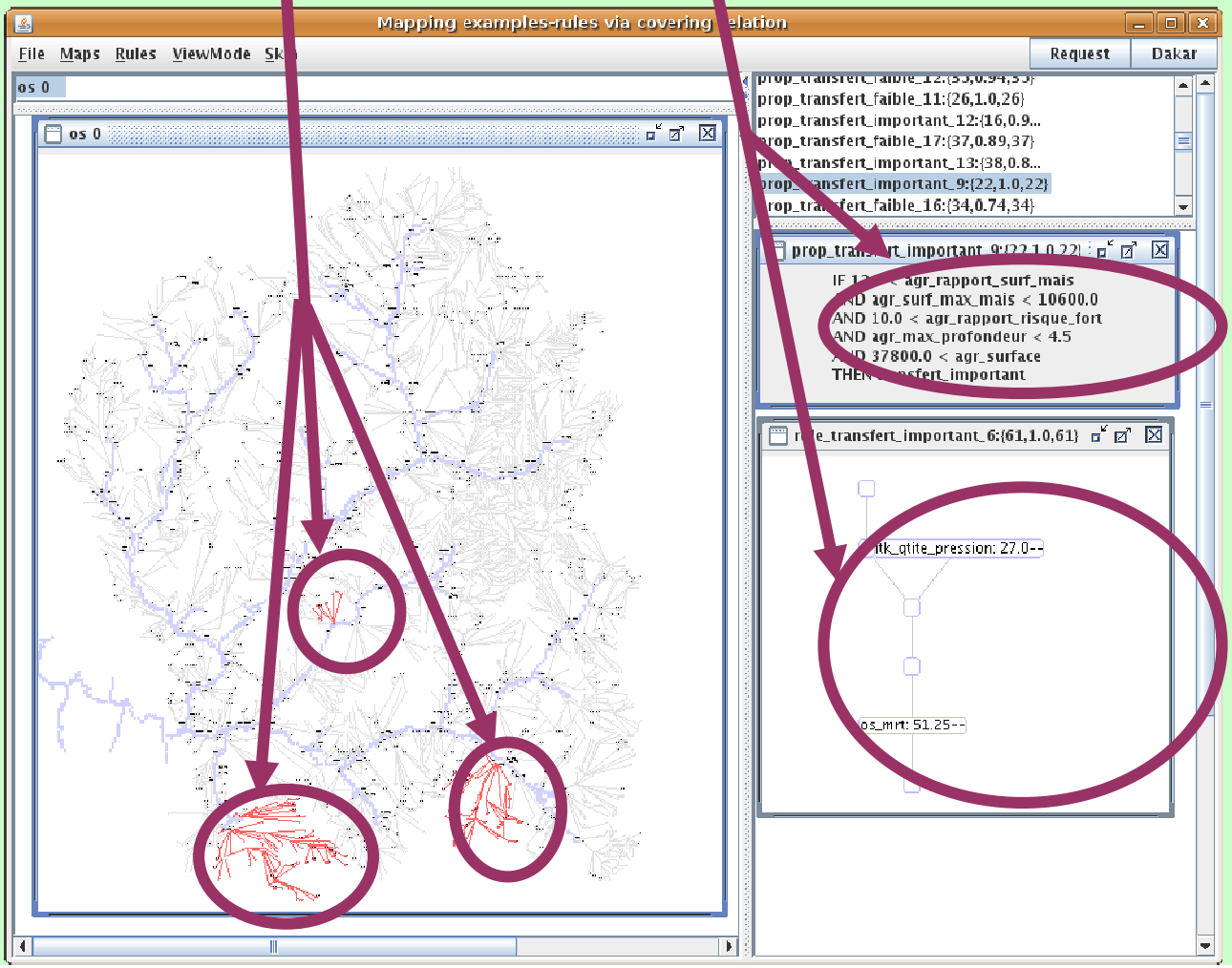


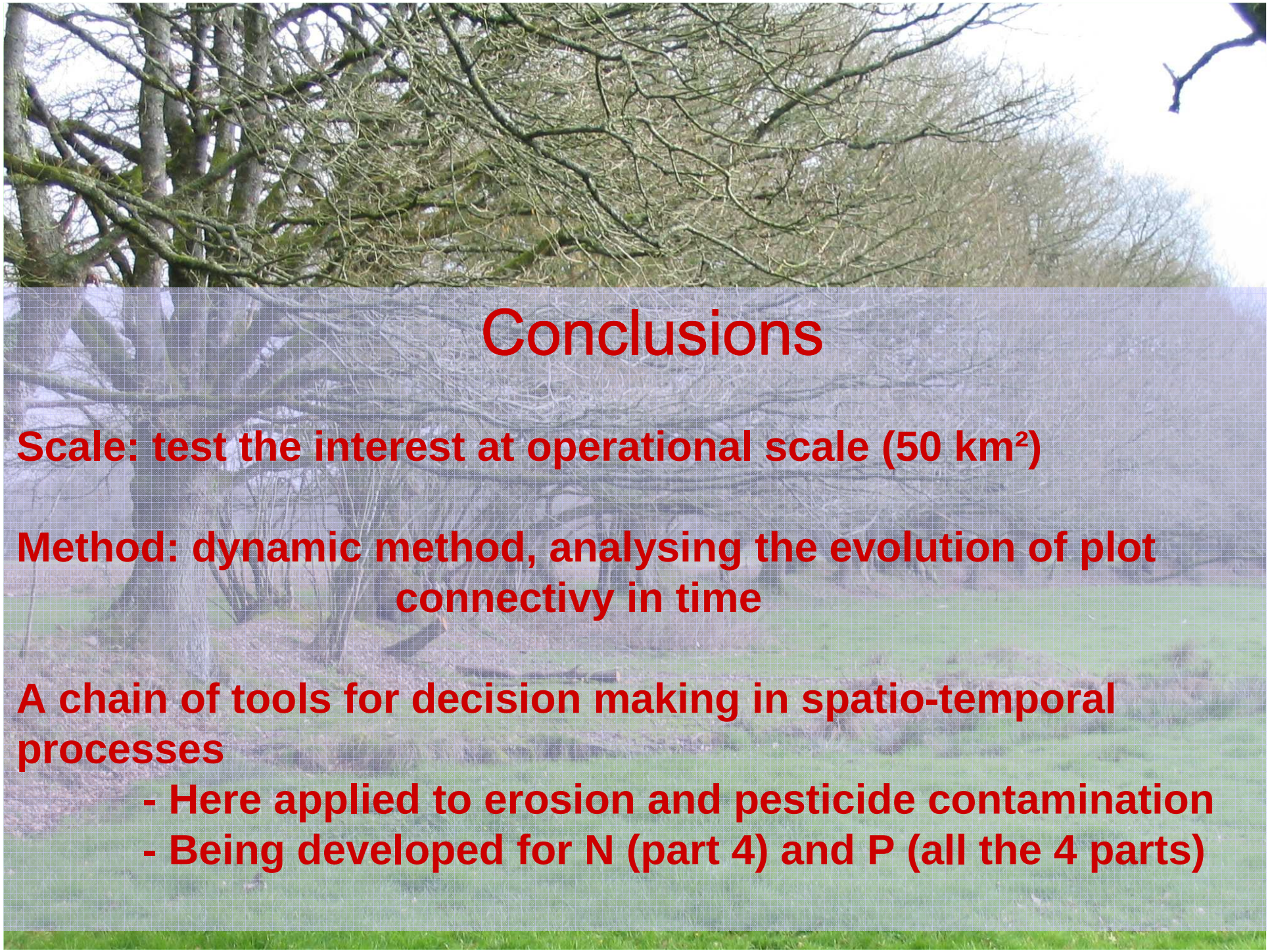


To help the decision making process, the learning methods are incorporated in a visualization tool.

Plot outlet trees are explained by selected patterns and rules on a catchment view

Interactive selection of patterns and rules





Conclusions

Scale: test the interest at operational scale (50 km²)

Method: dynamic method, analysing the evolution of plot connectivy in time

A chain of tools for decision making in spatio-temporal processes

- **Here applied to erosion and pesticide contamination**
- **Being developed for N (part 4) and P (all the 4 parts)**