Connectivity

Erik Cammeraat

IBED

University of Amsterdam

Contents

- *Introduction*
- *Factors connectivity*
- *Flow generation*
- *Surface conditions*
- *Connectivity*
- *Hydrological response and change*
- *Conclusions*

Factors affecting Connectivity

- Climate
- Hillslope runoff potential
- Landscape position
- Delivery Pathways
- Lateral buffering

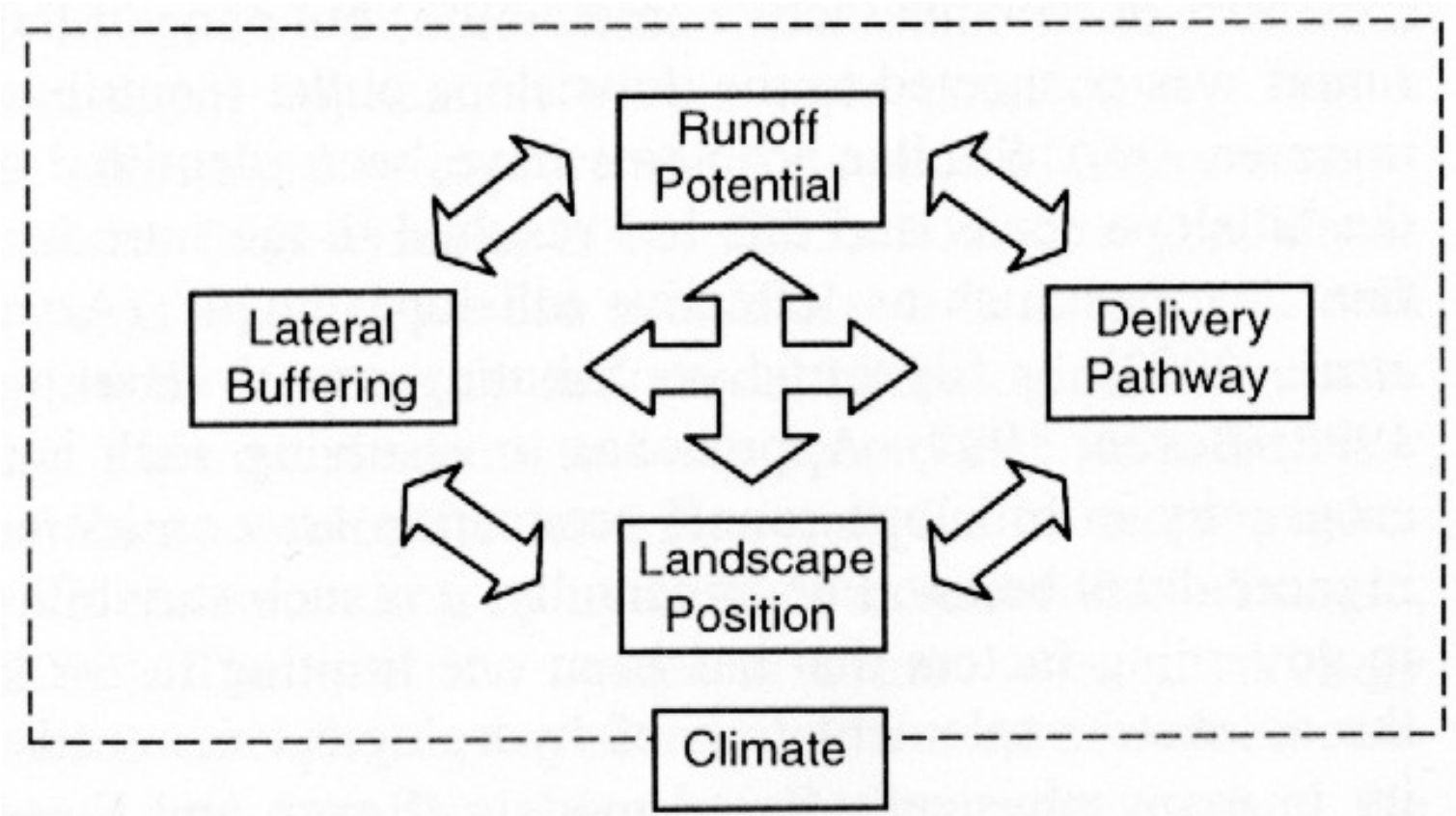
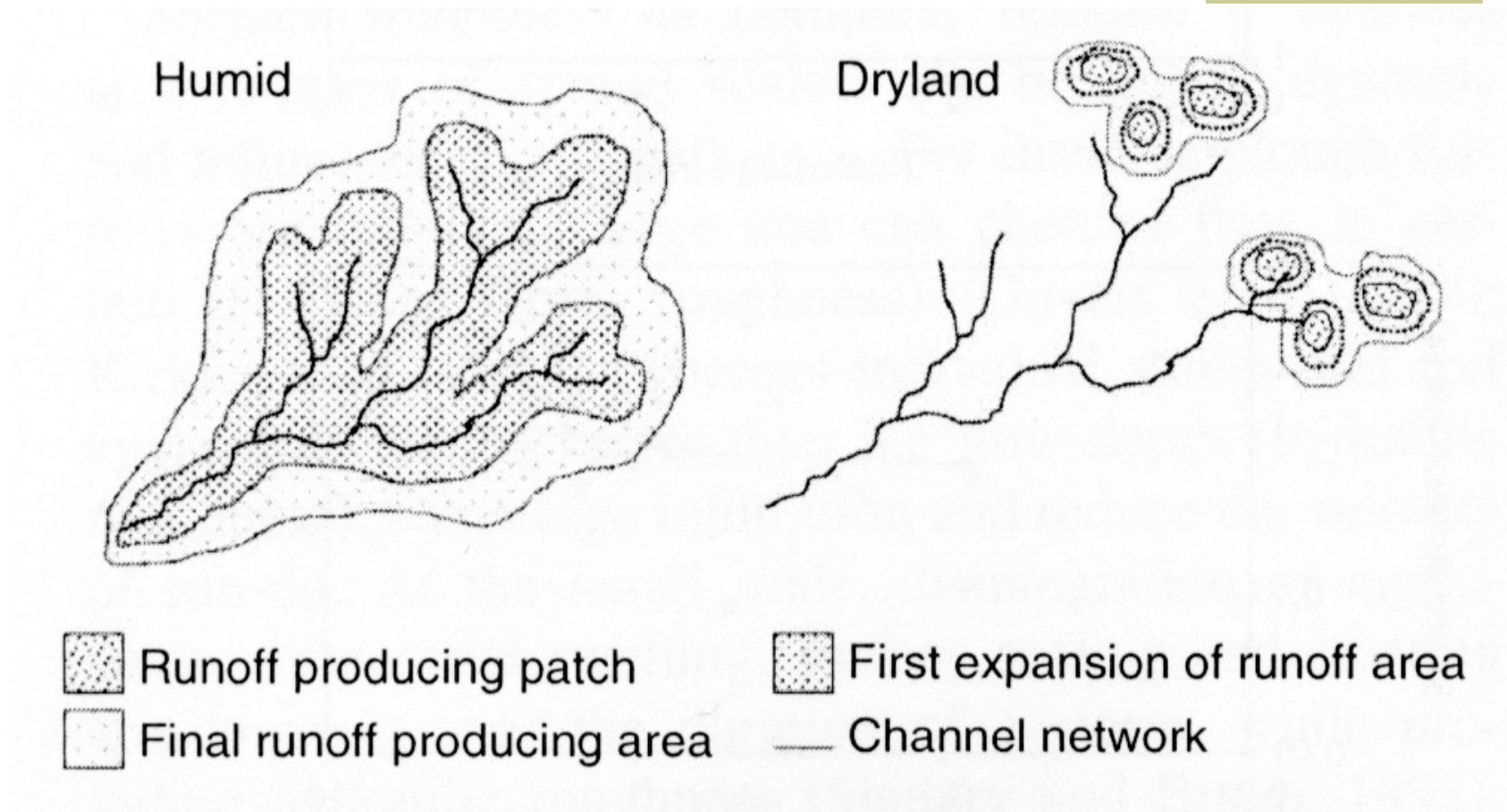
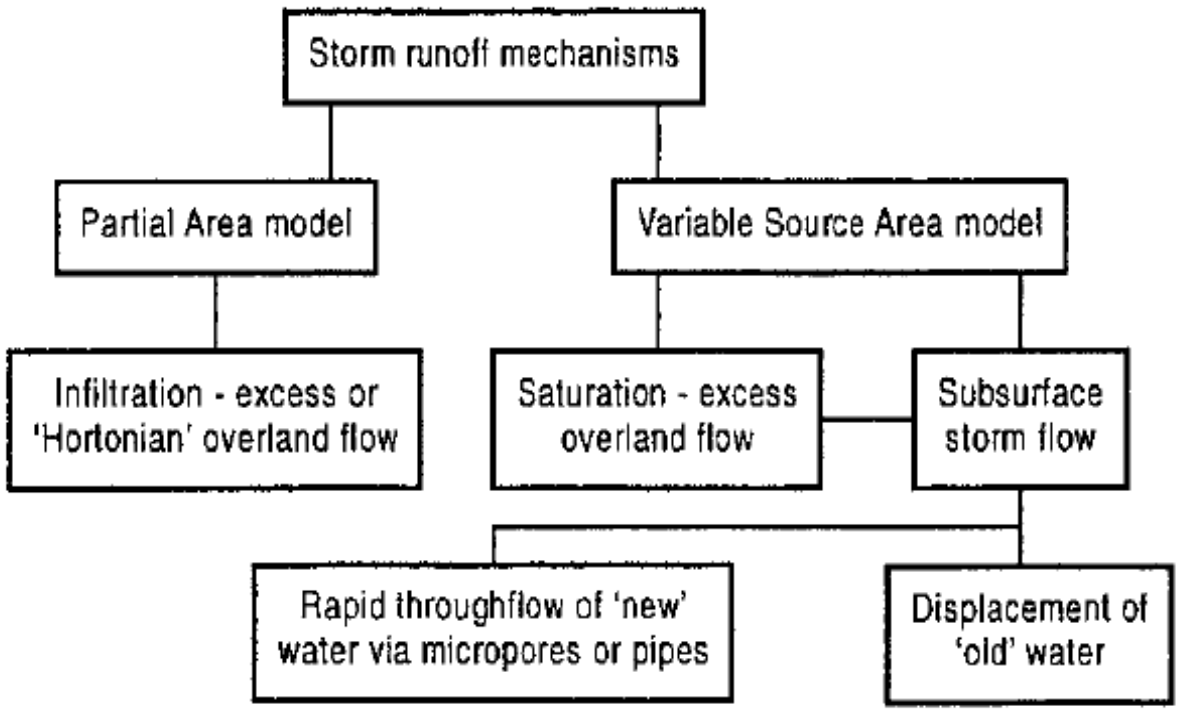


Figure 4. The components of catchment connectivity

- Flow generation
  - Infiltration
  - Saturation overland flow
  - Saturated through flow
  - Return flow
  - Pipe flow
- Antecedent moisture conditions


Humid
Dryland
Runoff producing patch
Final runoff producing area
First expansion of runoff area
Channel network


Storm runoff mechanisms
Partial Area model
Variable Source Area model
Infiltration - excess or 'Hortonian' overland flow
Saturation - excess overland flow
Subsurface storm flow
Rapid throughflow of 'new' water via micropores or pipes
Displacement of 'old' water

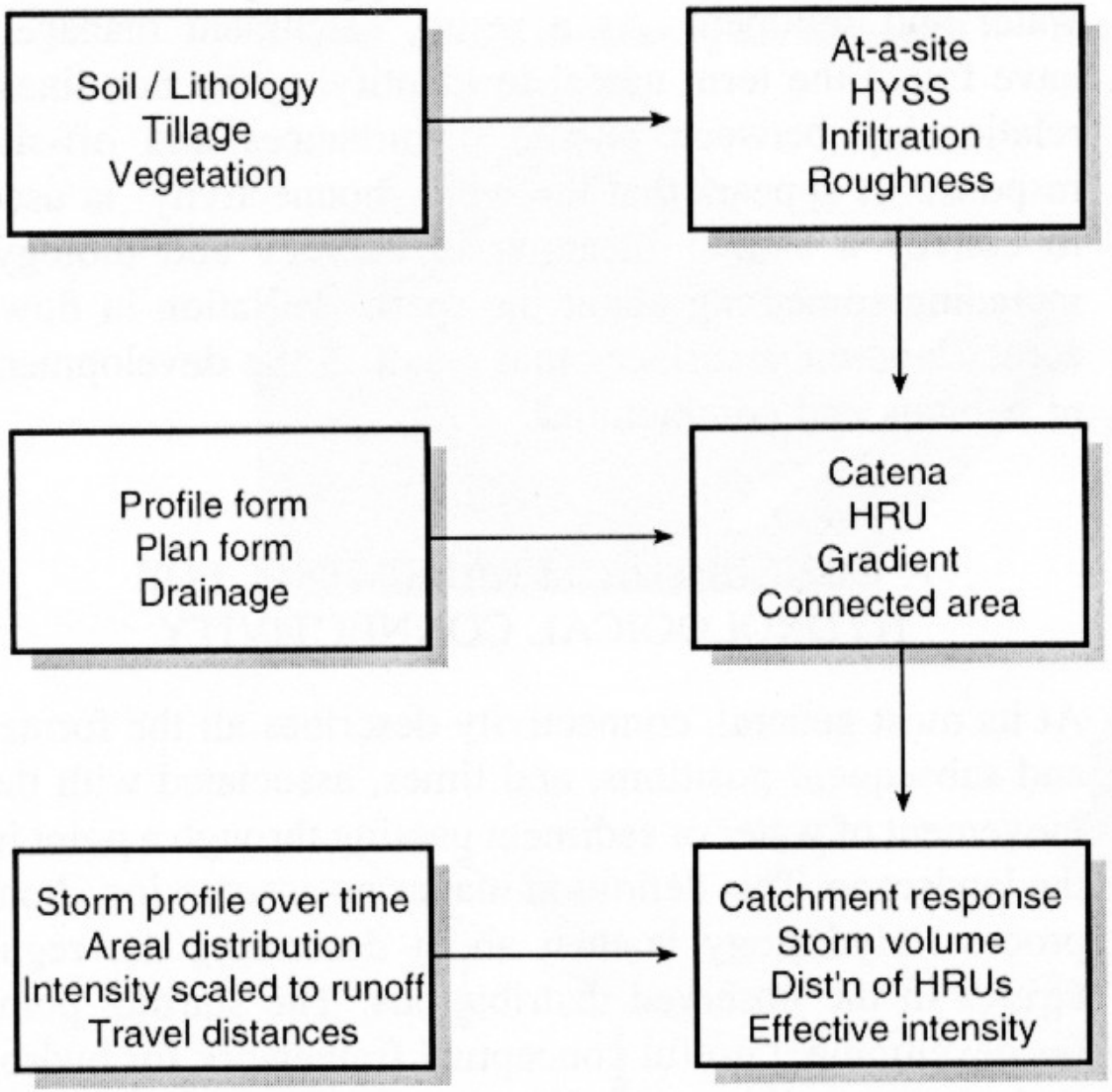
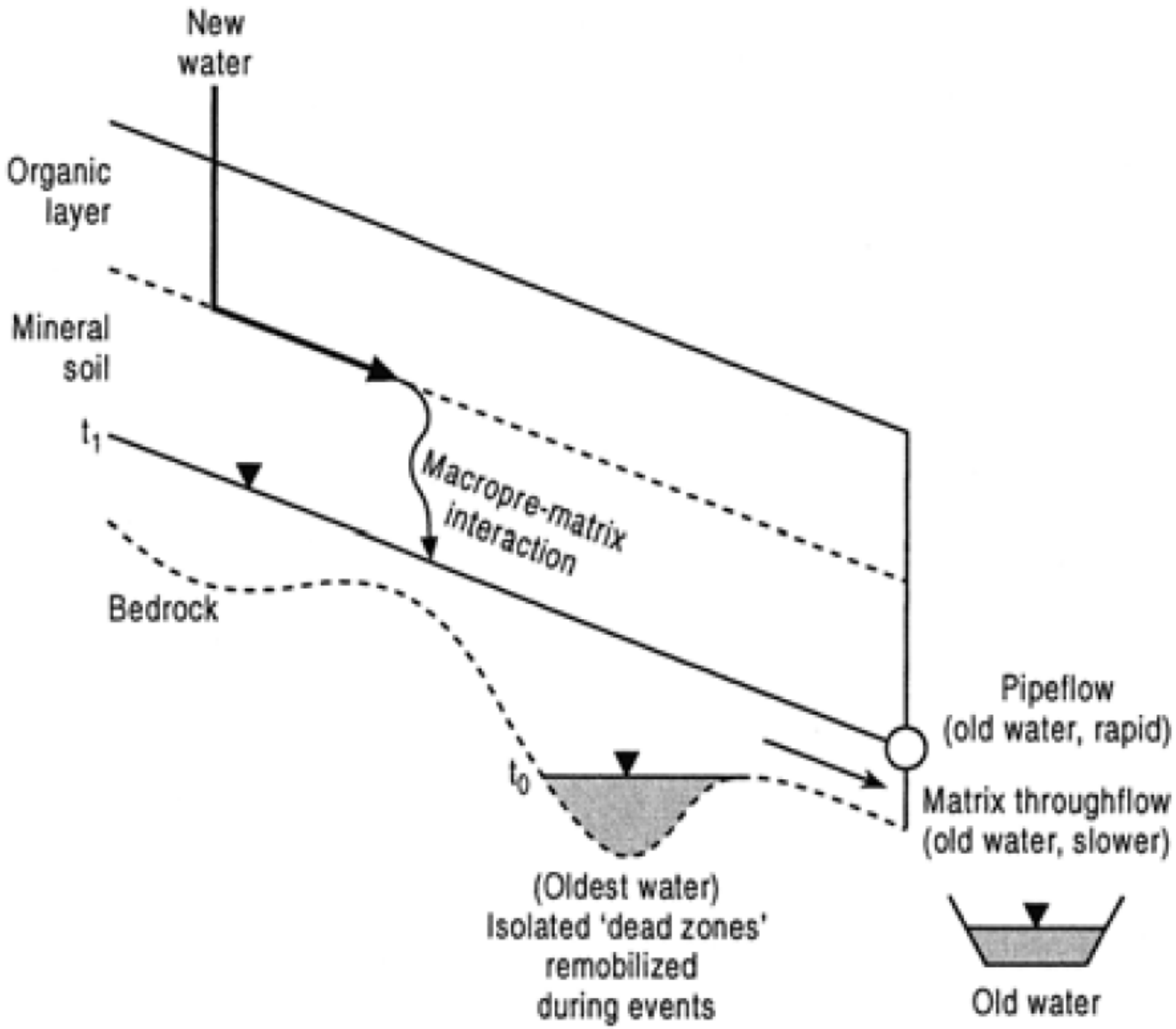
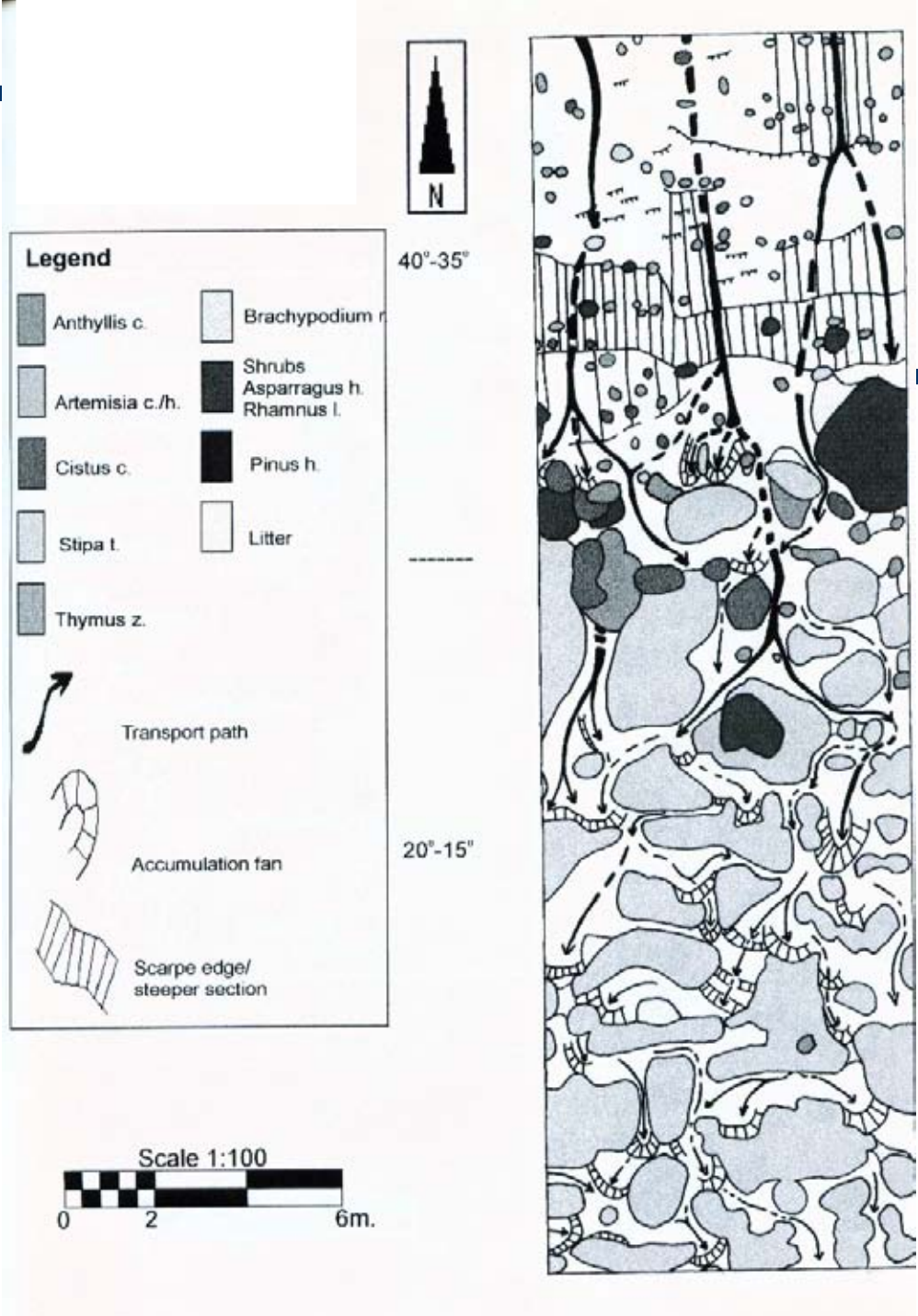


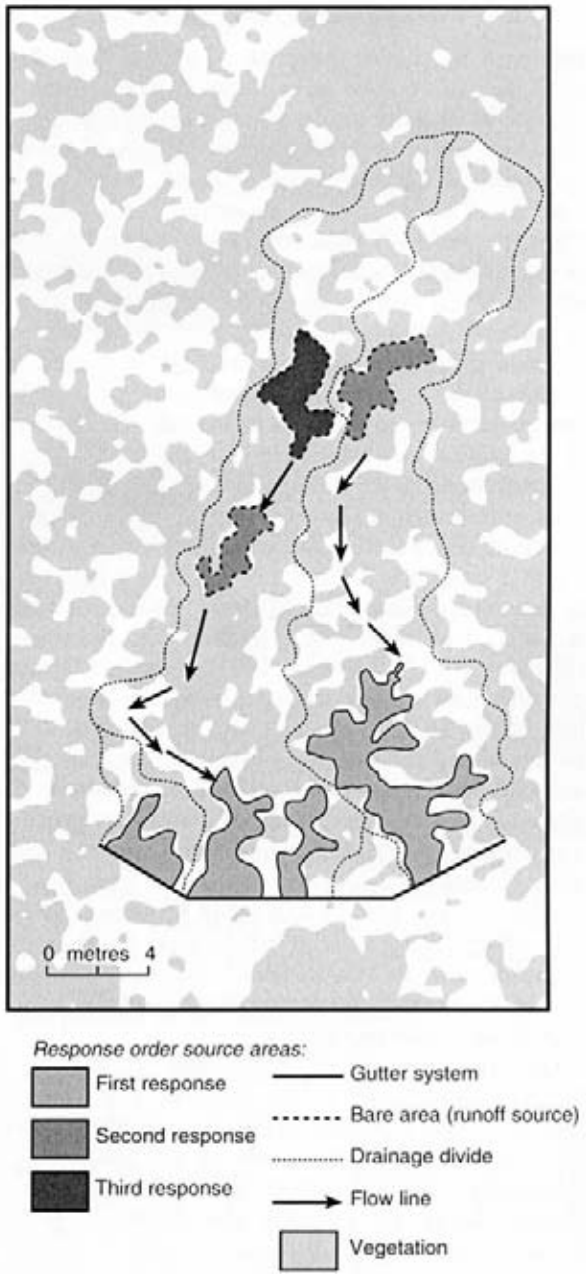
Figure 2. The nesting of factors influencing hydrological connectivity at different spatial scales


New water
Organic layer
Mineral soil
t_1
Macropre-matrix interaction
Bedrock
Pipeflow (old water, rapid)
t_0
Matrix throughflow (old water, slower)
(Oldest water) Isolated 'dead zones' remobilized during events
Old water

Surface conditions

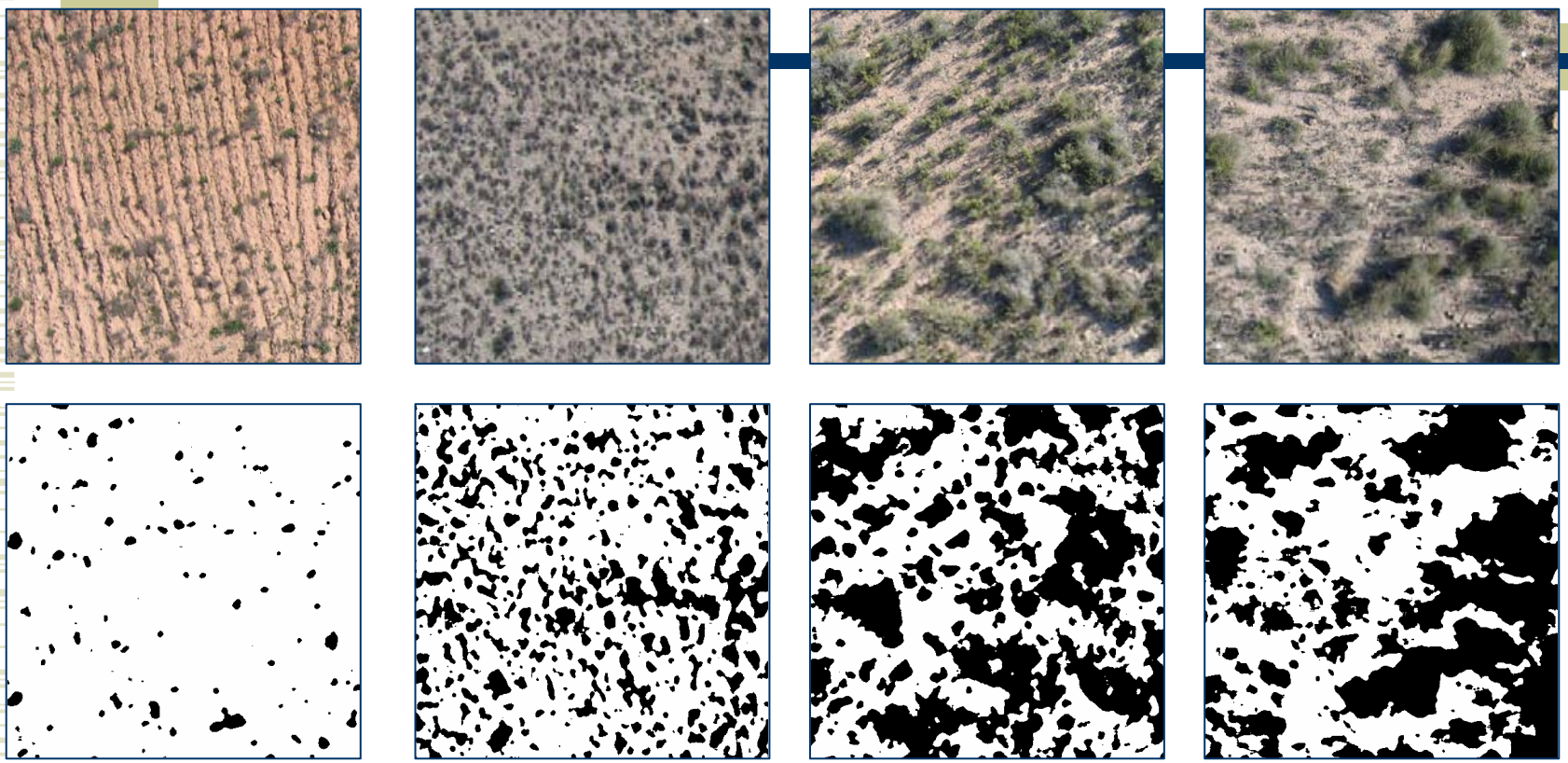
- Topography
  - Flow accumulating/diverting zones
  - Roughness
  - Subsurface topography
  - Lateral continuity of horizons
- Land use
  - Tillage
  - Vegetation type


N
Legend
Anthyllis c.
Brachypodium r.
Artemisia c./h.
Shrubs
Asparragus h.
Rhamnus l.
Cistus c.
Pinus h.
Stipa t.
Litter
Thymus z.
Transport path
Accumulation fan
Scarpe edge/
steeper section
40°-35°
20°-15°
Scale 1:100
0
2
6m.


0 metres 4
Response order source areas:
First response
Second response
Third response
Gutter system
Bare area (runoff source)
Drainage divide
Flow line
Vegetation

Upscaling Connectivity

Fallow | Short abandoned | Long abandoned | Semi-natural



4% | 27% | 46% | 46%

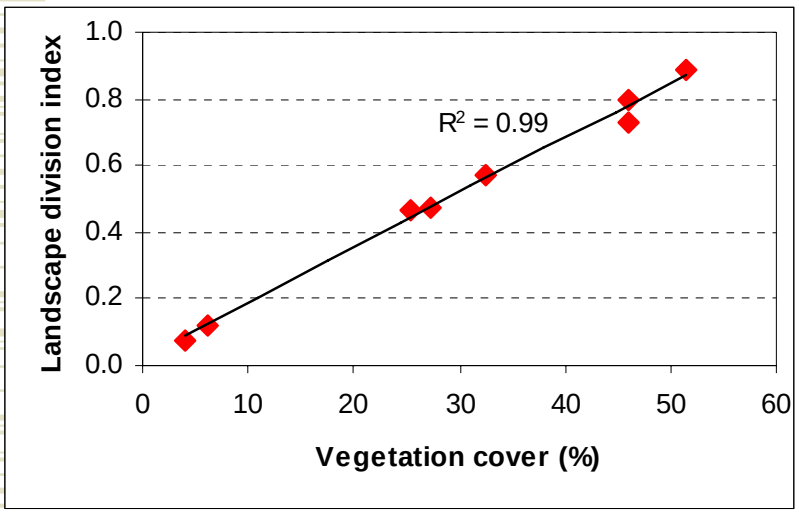
Classified with the supervised maximum likelihood method in ENVI

Upscaling Connectivity

Spatial metrics with FRAGSTATS

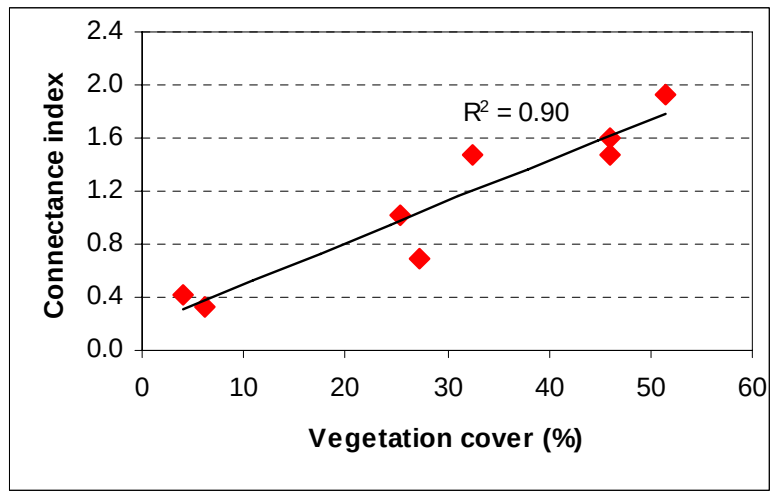
Landscape division index

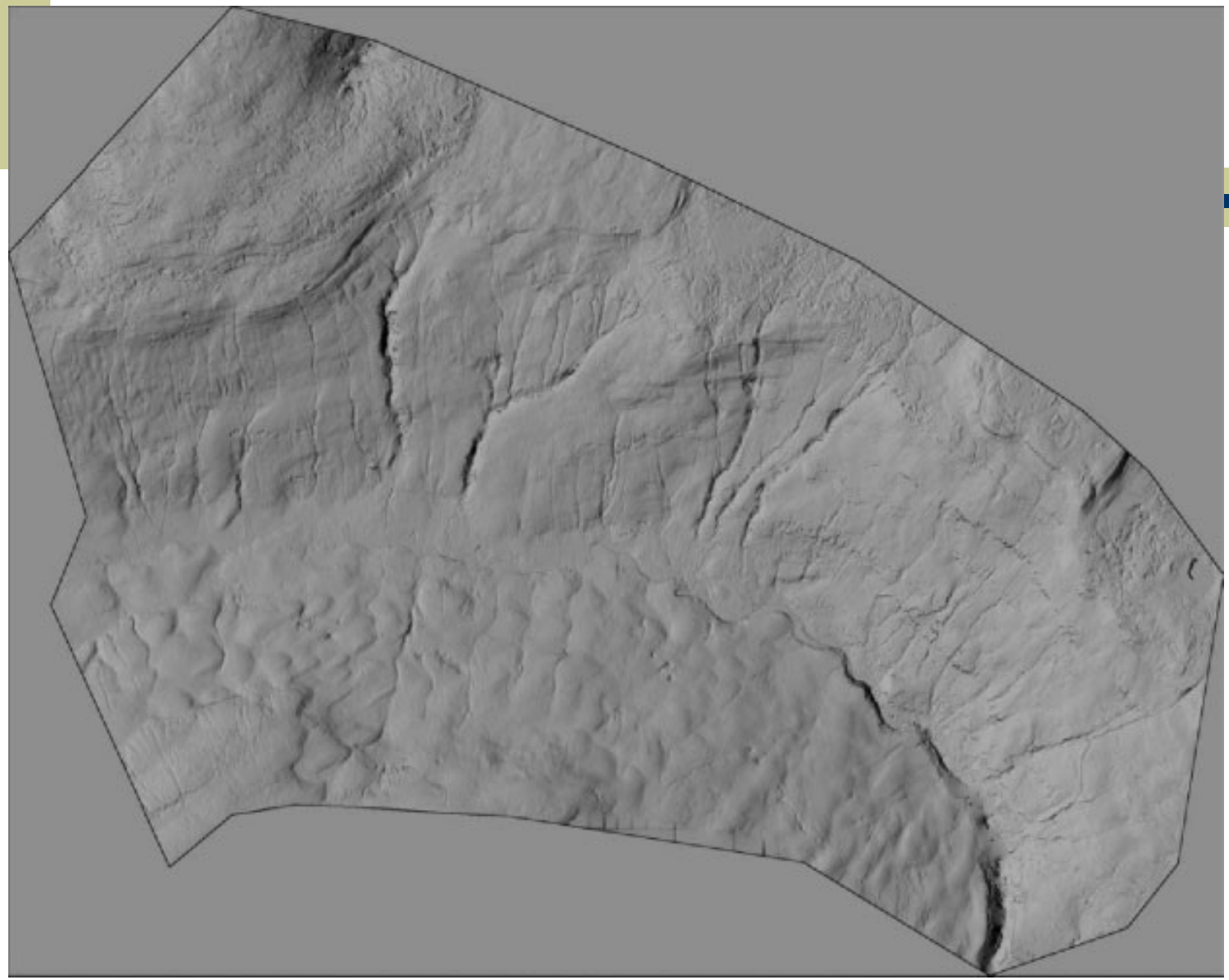
$$LDI = 1 - \left(\sum_{i=1}^{n} \left(\frac{a_i}{A} \right)^2 \right)$$

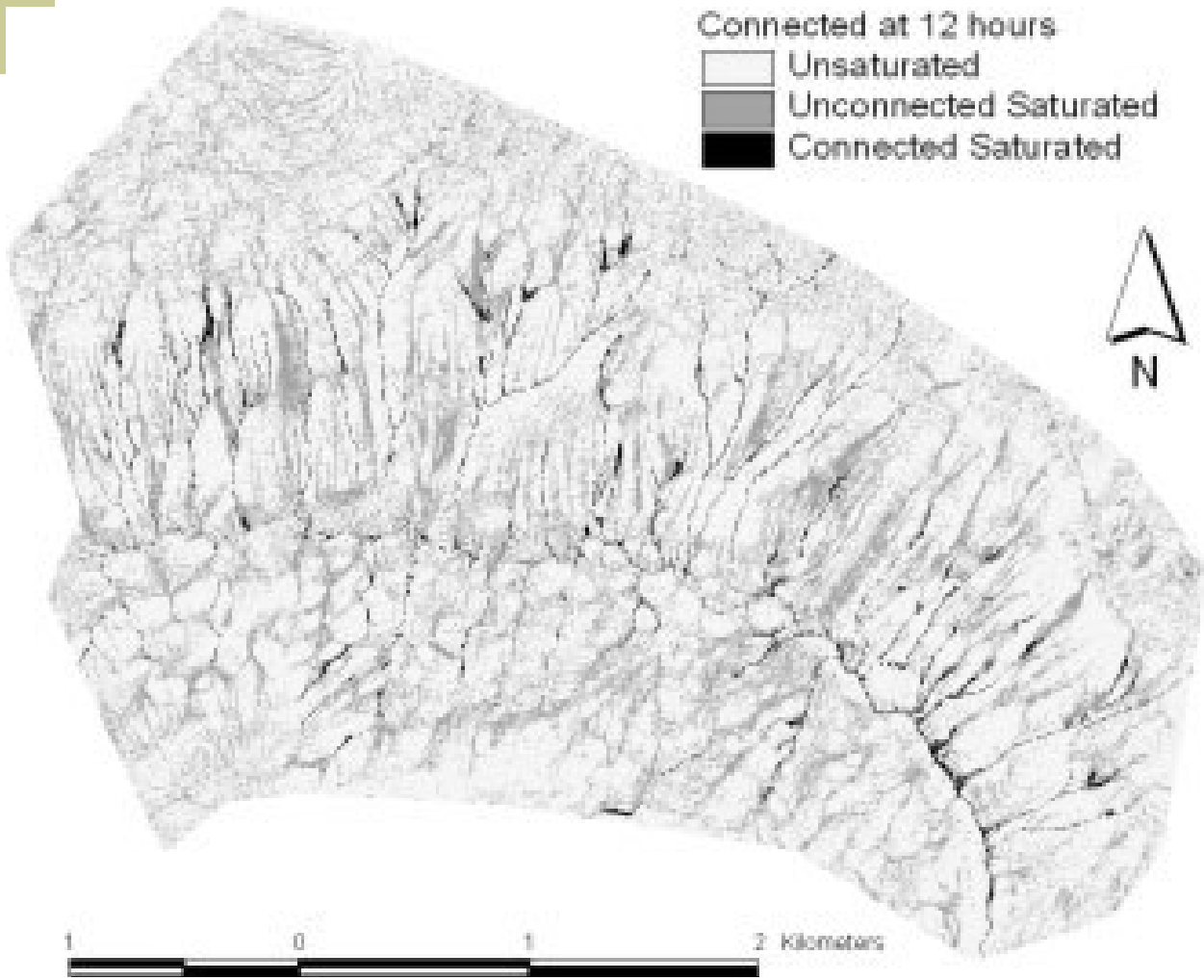


Connectance index

$$CI = \left(\frac{\sum_{j \neq k}^{n} c_{ij}}{\frac{n(n-1)}{2}} \right) * 100$$



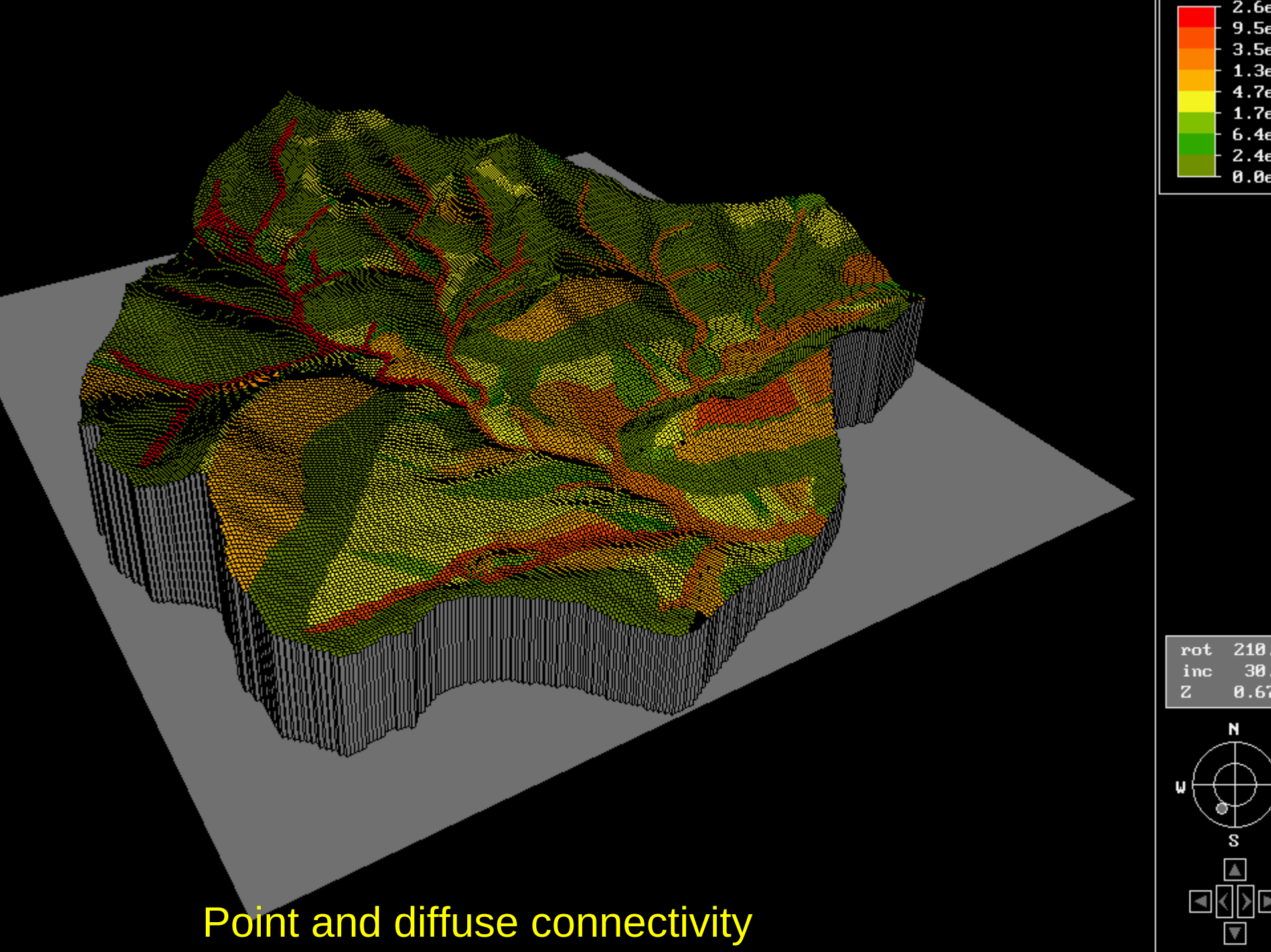



Connected at 12 hours
Unsaturated
Unconnected Saturated
Connected Saturated
N
1
0
1
2 Kilometers

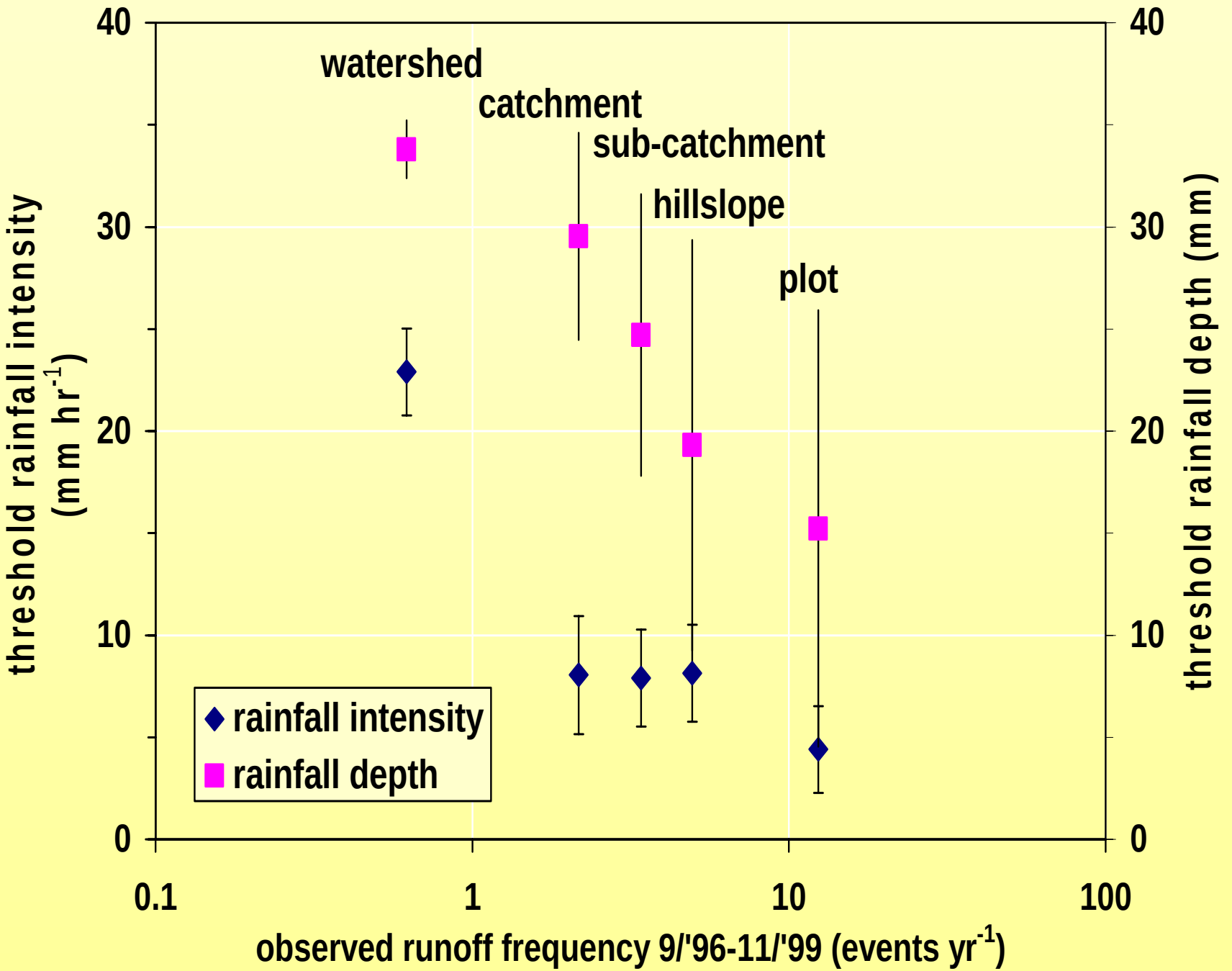
Connectivity

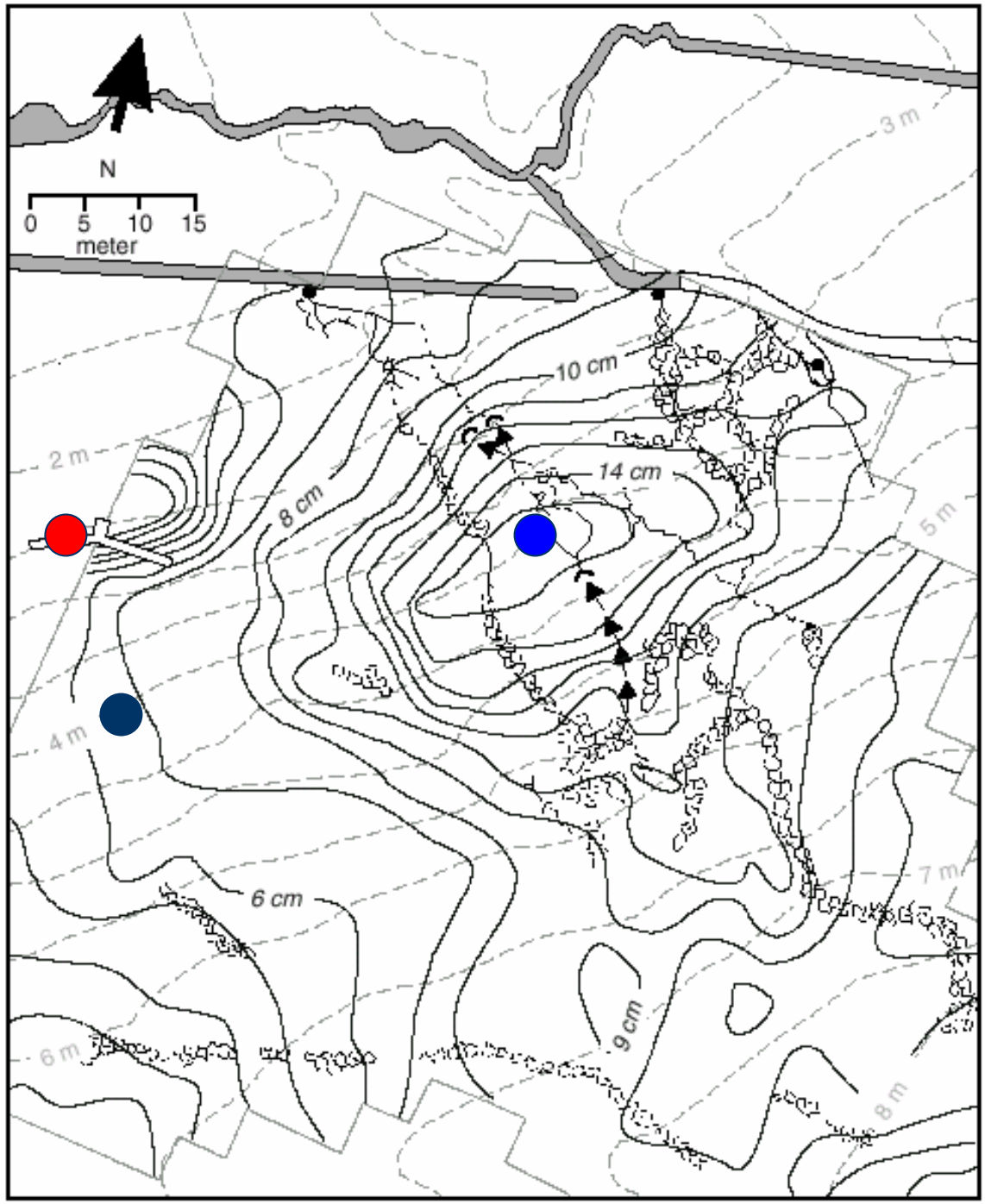
- Connecting zones
  - Overland flow/Saturated zones
  - Pipes
  - Diffuse flow
- Channel flow

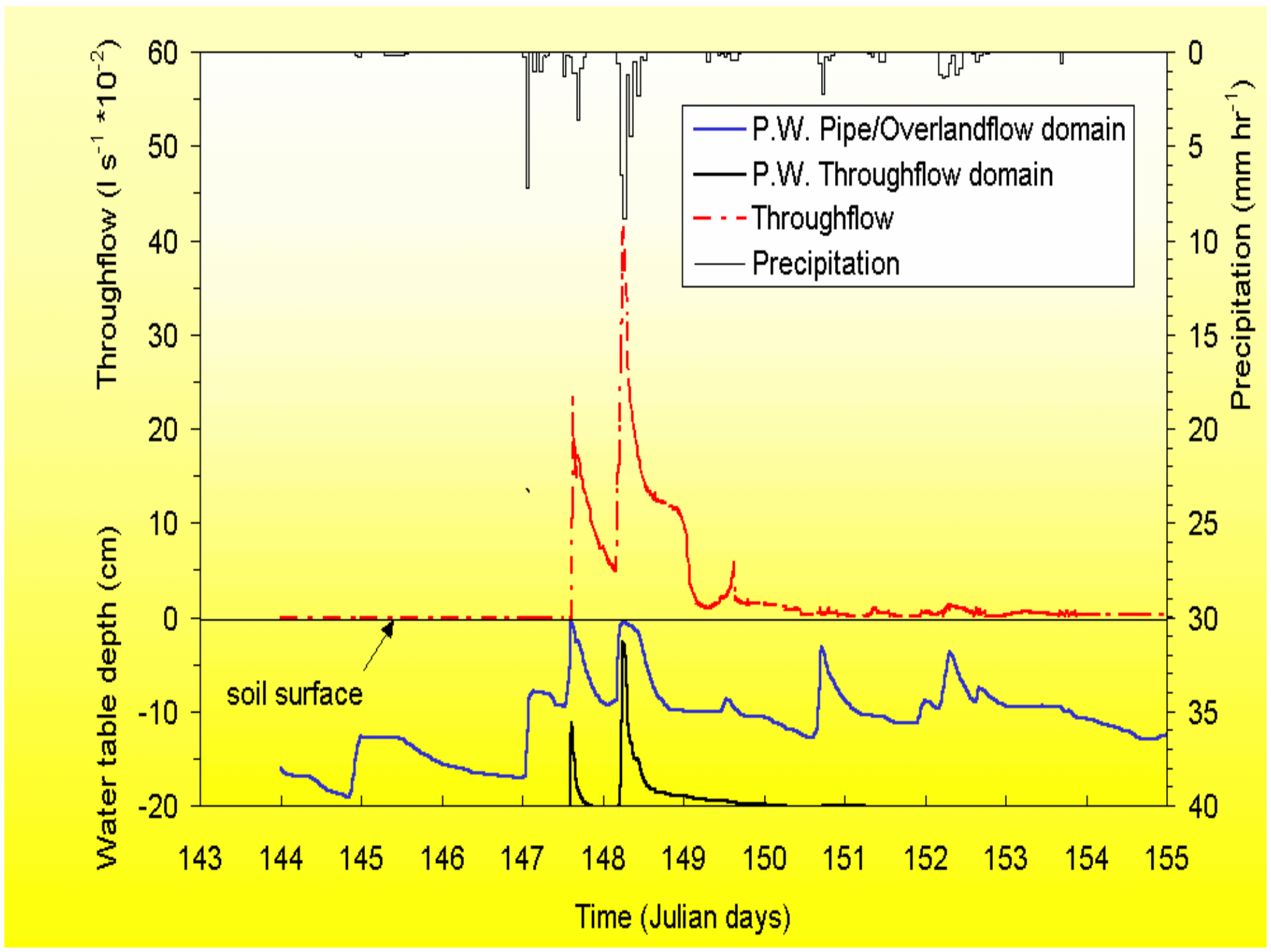

Connectivity mapping



Point and diffuse connectivity


watershed
catchment
sub-catchment
hillslope
plot
rainfall intensity
rainfall depth
threshold rainfall intensity (mm hr-1)
threshold rainfall depth (mm)
observed runoff frequency 9/'96-11/'99 (events yr-1)
0
10
20
30
40
0.1
1
10
100

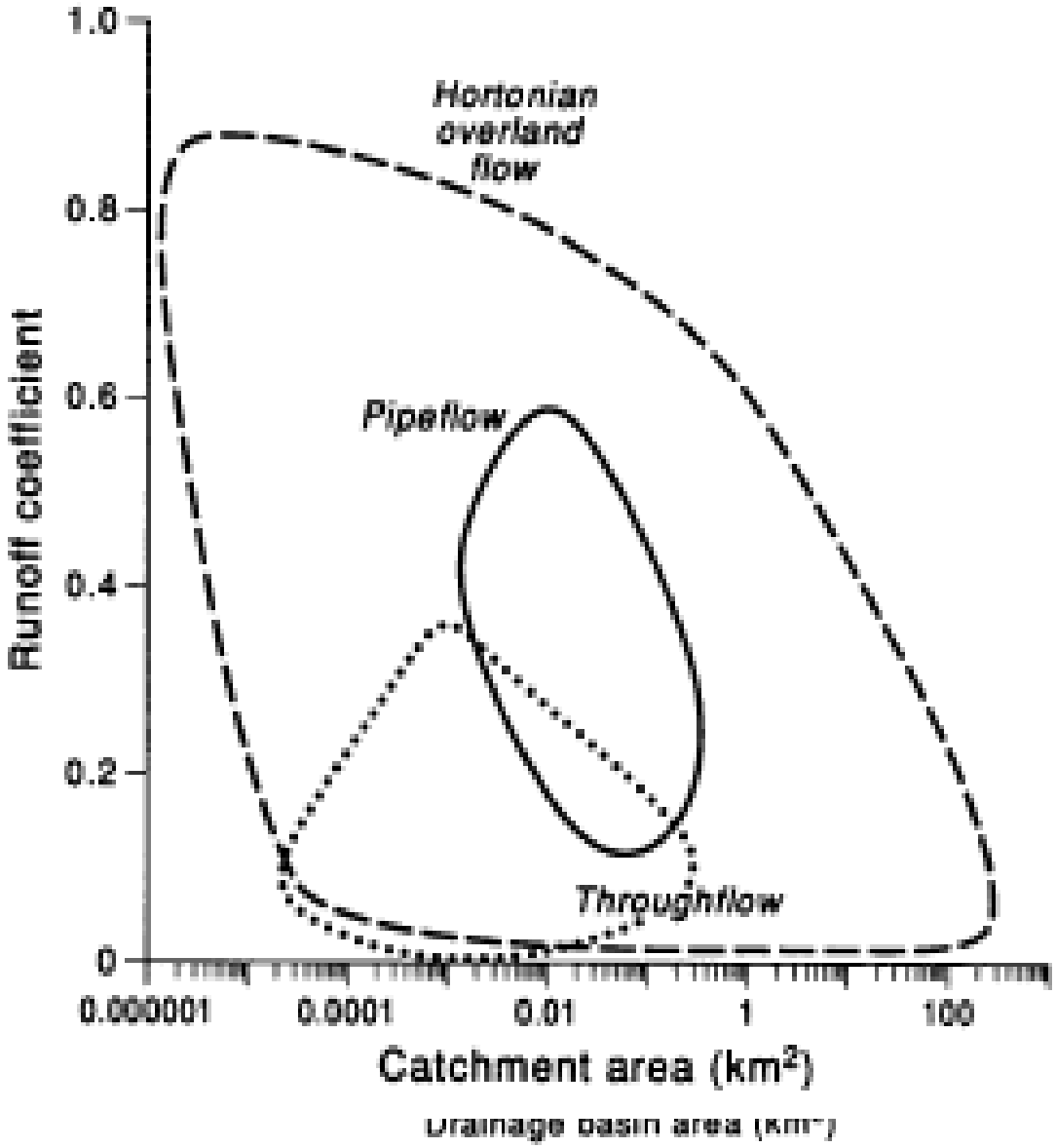

N
0 5 10 15
meter
3 m
10 cm
2 m
14 cm
8 cm
5 m
4 m
6 cm
7 m
9 cm
6 m
8 m


Throughflow (l s-1 *10-2)
Precipitation (mm hr-1)
Water table depth (cm)
Time (Julian days)
P.W. Pipe/Overlandflow domain
P.W. Throughflow domain
Throughflow
Precipitation
soil surface
60
50
40
30
20
10
0
-10
-20
0
5
10
15
20
25
30
35
40
143
144
145
146
147
148
149
150
151
152
153
154
155

Hydrological Response

- **Hillslope patterns and hydrological response**
  - Density and spatial organization of topographical, soil and vegetation patterns determine erosion and runoff response
  - Different runoff generation thresholds occur at different scales

- **Effects of Changes**
  - Land use change→ water budget, soil quality
  - High C contents: → vulnerable to irreversible desication → increase of connectivity and preferential flow, reduction in water storage capacity
  - Hydrological response will change (fast response endangering water yield in dryer periods
  - Runoff coefficients will increase
  - Space for time substitution studies ?


1.0
0.8
0.6
0.4
0.2
0
Runoff coefficient
Hortonian overland flow
Pipeflow
Throughflow
0.000001
0.0001
0.01
1
100
Catchment area (km²)
Drainage basin area (km²)

Conclusions

- Connectivity
  - Expansion of humid areas
    - Surface parameters
    - Subsurface parameters
  - Influence of man
    - Increased drainage and connectivity
    - Reduction in soil water retention