

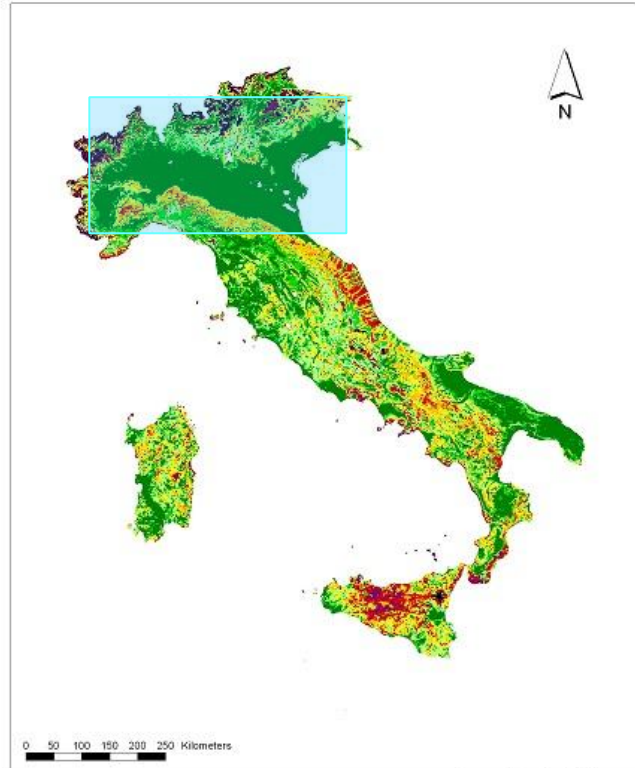
# SOIL EROSION FROM MODELLING TO MITIGATION: CAN CONSERVATION AGRICULTURE BE A SOLUTION?

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*Francesca Staffilani - Regione Emilia-Romagna D.G. Environment*



# SOIL EROSION RISK



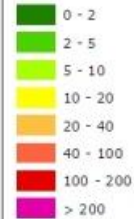
**Actual Soil Erosion Risk Italy  
by Rill and Inter-Rill Erosion**



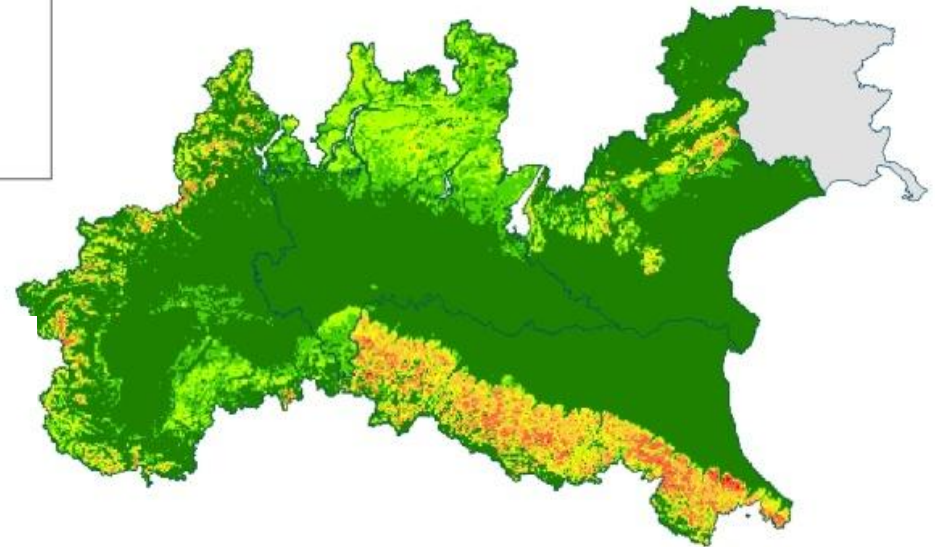
Approximate Soil Loss  
(t/ha/yr)



Erosione attuale (t/ha)



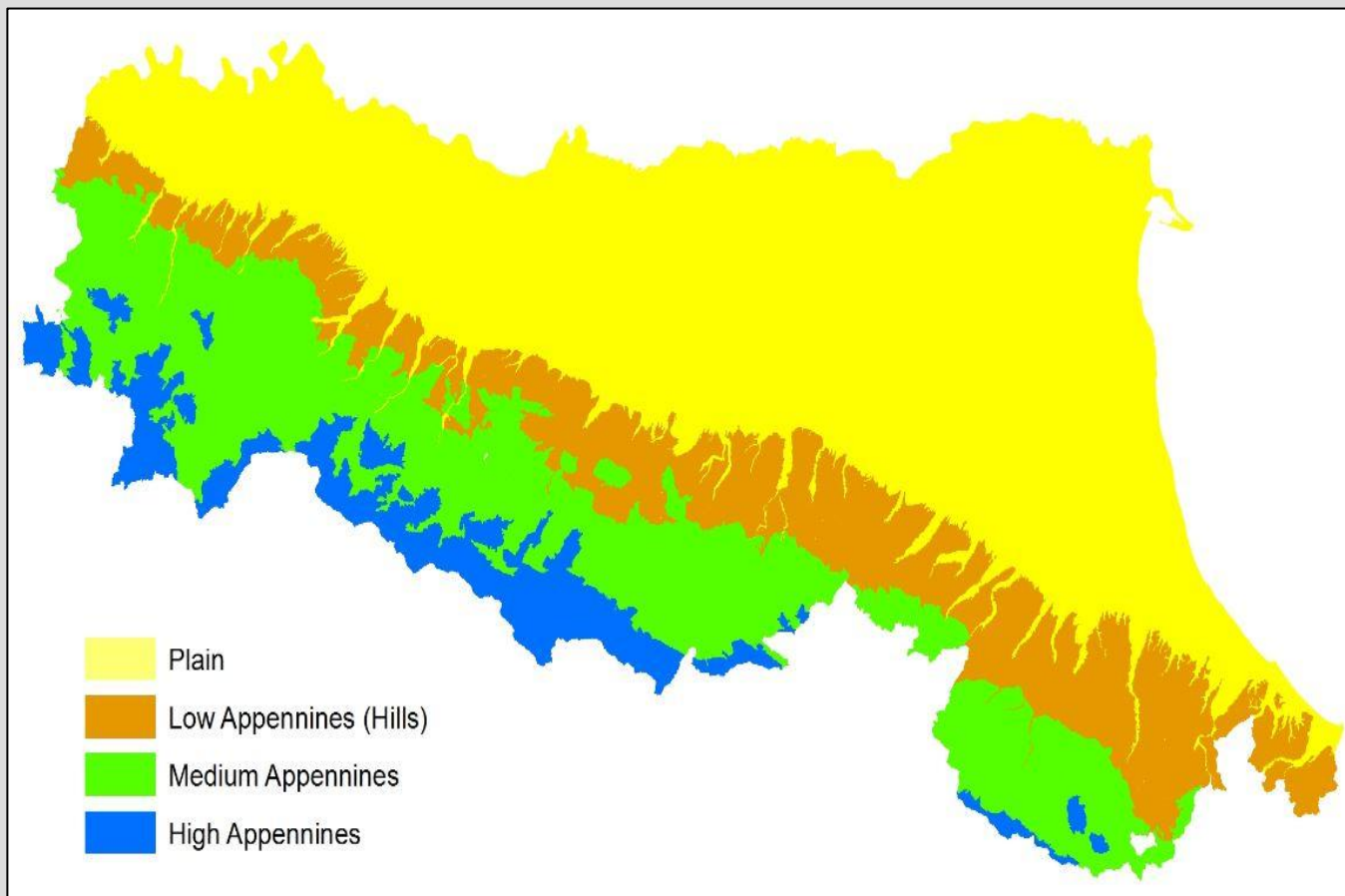
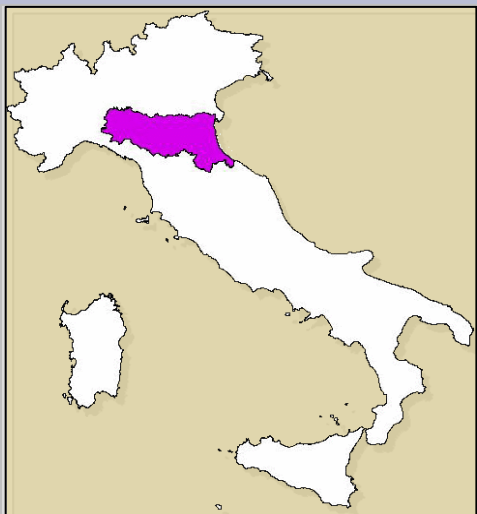
**Actual Soil erosion risk in the river Po Basin**



0 50 100 200 Kilometers



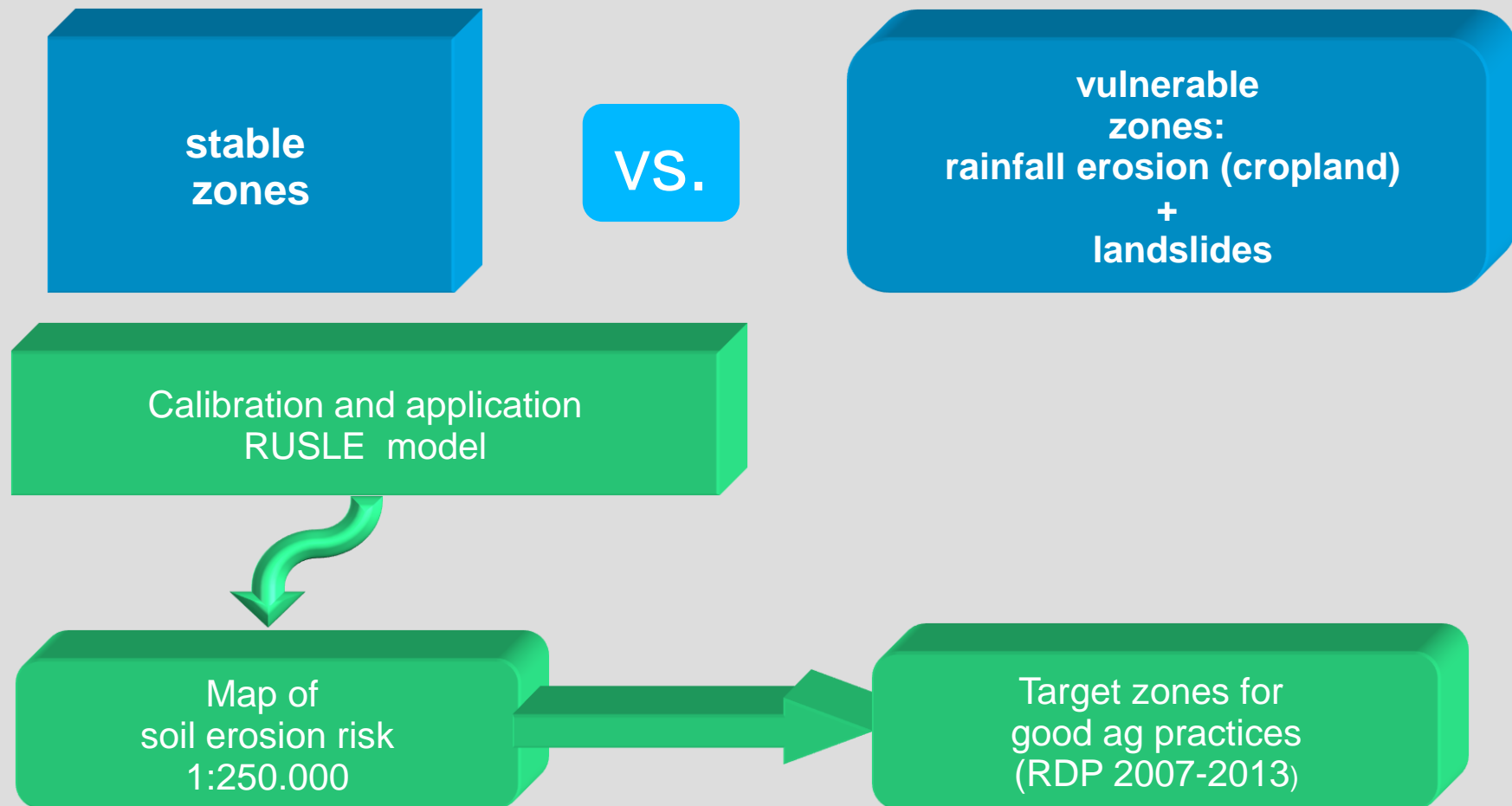
# MORPHOLOGY OF EMILIA-ROMAGNA



**The Apennine chain covers half the total Area of the region**

# LAND VULNERABILITY: KNOWLEDGE AND MANAGEMENT stage 1

Constitutional instability of the geological substrate of the Apennine:  
analysis of effects



# THE FACTORS OF RUSLE AT A REGIONAL SCALE

The RUSLE (Revised Universal Soil Loss Equation) model aims to evaluate soil erosion risk  
(*Wischmeier and Smith, 1978; rev. Renard et al., 1997*):

$$A = R * LS * K * C * P$$

**A** = Soil Loss ( $\text{Mg} \cdot \text{ha}^{-1} \cdot \text{y}^{-1}$ )

**R** = Rain Erosivity (function of rainfall intensity and duration)  
 $EI = 0.11 * P^{1.82}$ , (*CNR-IRPI 2003*)

**LS** = Slope Length (estimation of topography effect, as sediment transportation capacity by run off)  
 $(\text{FlowAccumul.} * \text{CellSize} / 22.13)^{0.4} * ((\sin(\text{Slope} * 0.001745) / 0.09)^{1.4}) * 1.4$ , (*Mitasova et al., 1996*)

**K** = Soil Erodibility (soil aptitude to be taken off by rain)  
 $K = 7.594 [0.0034 + 0.0405 \exp[-0.5((\log(Dg) + 1.659) / 0.7101)^2]]$ , (*Renard et al. 1997*)

**C** = Soil Cover Factor  
regional db, with crops, their distribution, timing of management (*RER, ARPA, CNR-IRPI, 2004*)

**P** = Support Practice Factor  
estimation of effect of soil cover by crops and residues + agricultural practices

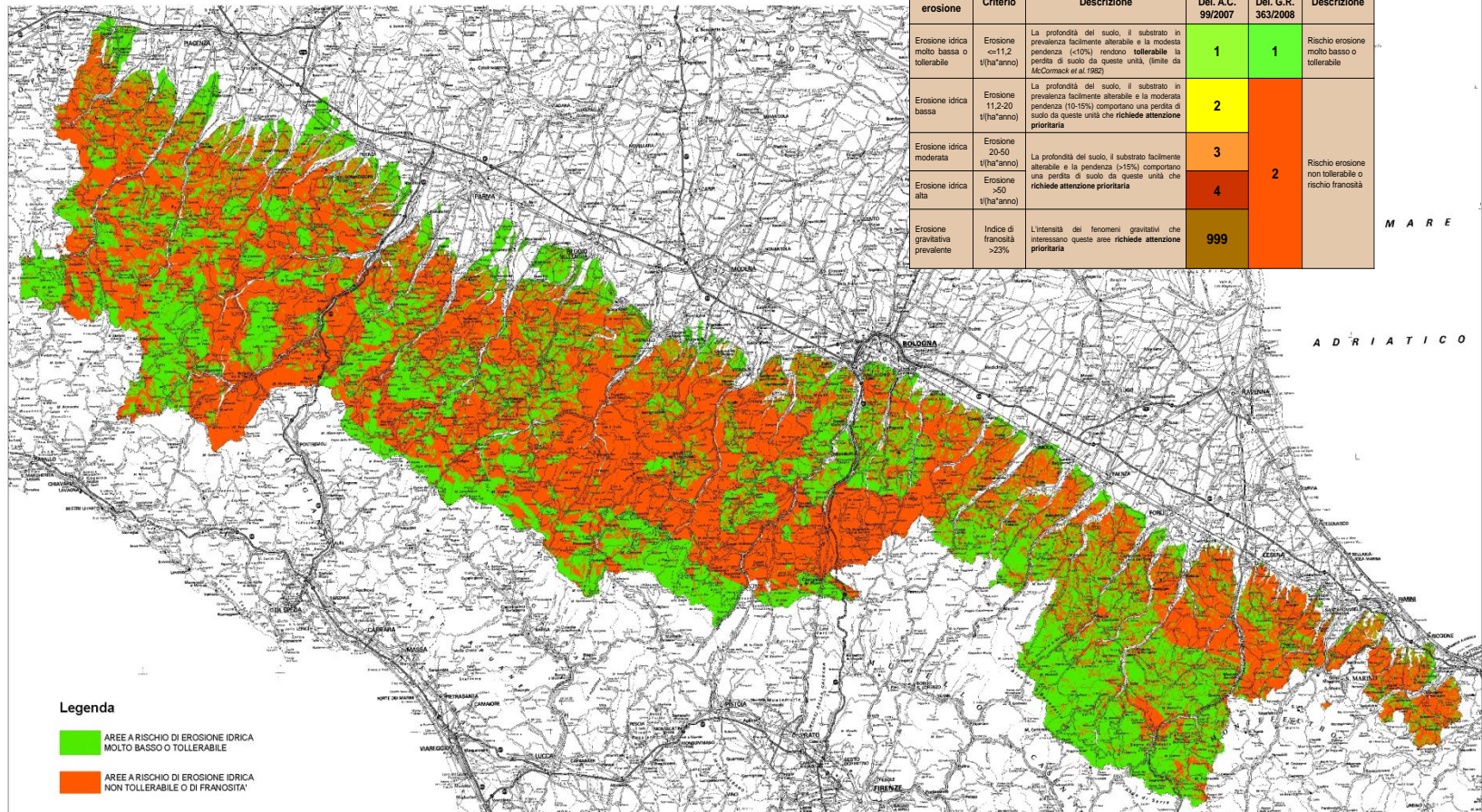
# LAND VULNERABILITY: KNOWLEDGE AND MANAGEMENT



## ACTUAL SOIL EROSION RISK (RAINFALL+ LANDSLIDES)



Secondo stralcio Programma Operativo dell'Asse 2 del PRSR 2007-2013



Classe di erosione	Criterio	Descrizione	CLASSI Del. A.C. 99/2007	CLASSI Del. G.R. 363/2008	Descrizione
Erosione idrica molto bassa o tollerabile	Erosione $\leq 11.2$ t/(ha*anno)	La profondità del suolo, il substrato in prevalenza facilmente alterabile e la modesta pendenza ( $<10\%$ ) rendono tollerabile la perdita di suolo da queste unità, (fonte da McCormack et al. 1982)	1	1	Rischio erosione molto basso o tollerabile
Erosione idrica bassa	Erosione 11.2-20 t/(ha*anno)	La profondità del suolo, il substrato in prevalenza facilmente alterabile e la moderata pendenza (10-15%) comportano una perdita di suolo da queste unità che richiede attenzione prioritaria	2	2	Rischio erosione non tollerabile o rischio franosità
Erosione idrica moderata	Erosione 20-50 t/(ha*anno)	La profondità del suolo, il substrato facilmente alterabile e la pendenza ( $>15\%$ ) comportano una perdita di suolo da queste unità che richiede attenzione prioritaria	3		
Erosione idrica alta	Erosione $>50$ t/(ha*anno)		4		
Erosione gravitativa prevalente	Indice di franosità $>23\%$	L'intensità dei fenomeni gravitativi che interessano queste aree richiede attenzione prioritaria	999		

### Legenda

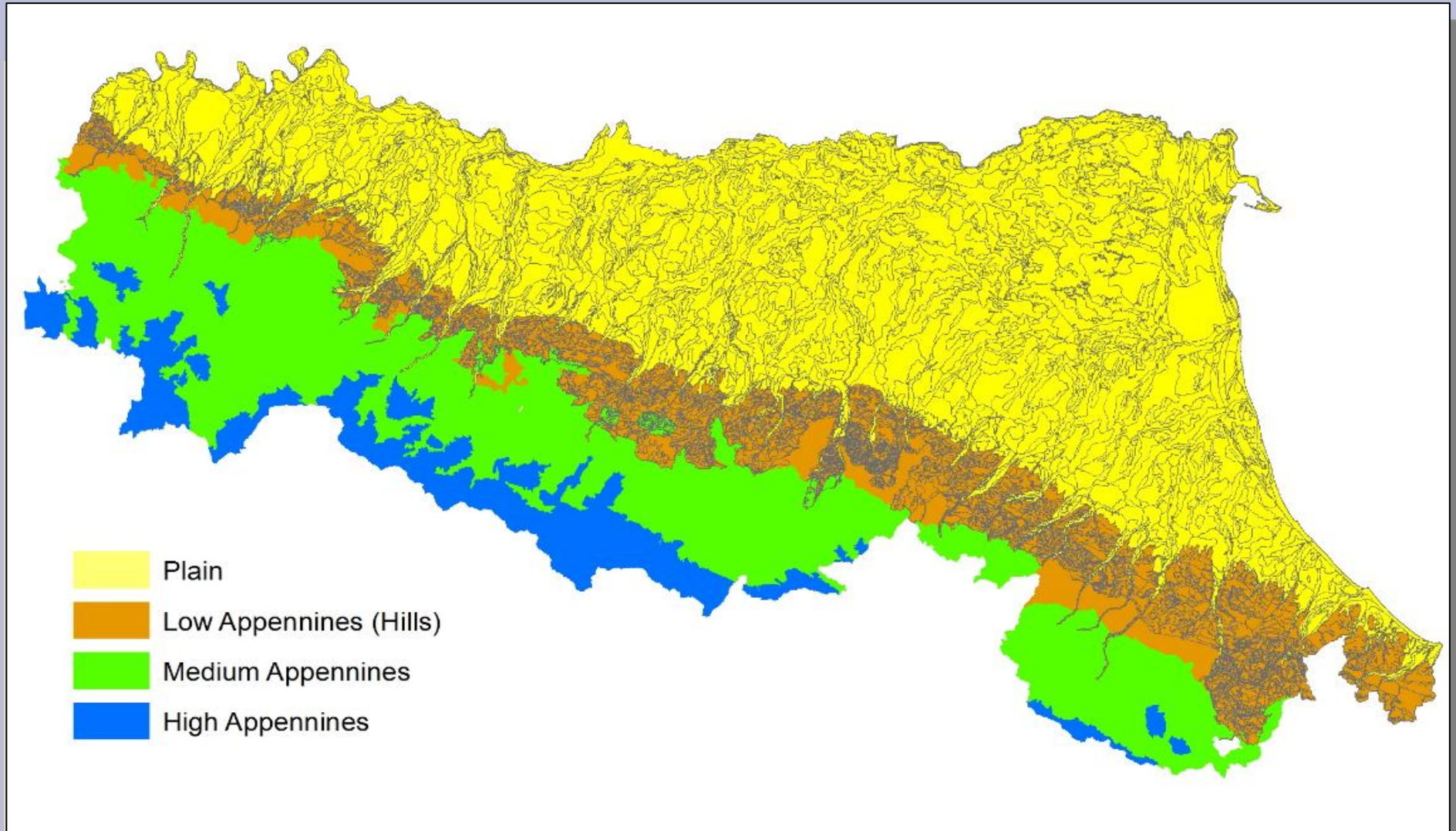
- AREE A RISCHIO DI EROSIONE IDRICA MOLTO BASSO O TOLLERABILE
- AREE A RISCHIO DI EROSIONE IDRICA NON TOLLERABILE O DI FRANOSITA'

Realizzazione 2008  
a cura di:  
Servizio Pianificazione di Bacino e della Costa - RER  
Servizio Geologico, Sismico e dei Suoli - RER  
Autorità di Bacino Fiume Reno  
Autorità di Bacino dei Fiumi Romagna  
Autorità di Bacino Conca Marecchia

scala 1:250.000



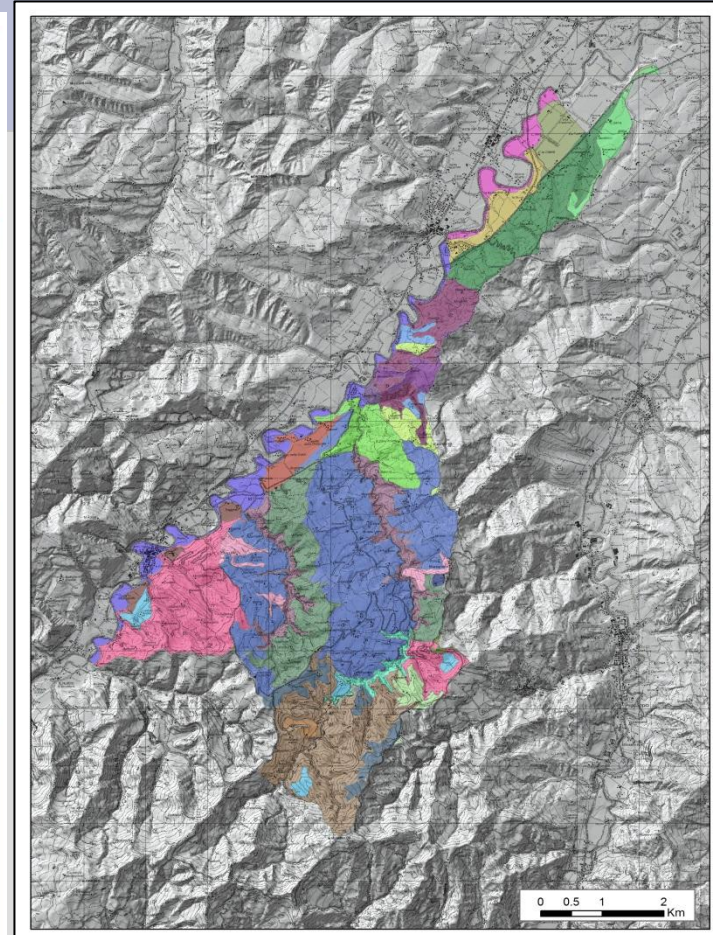
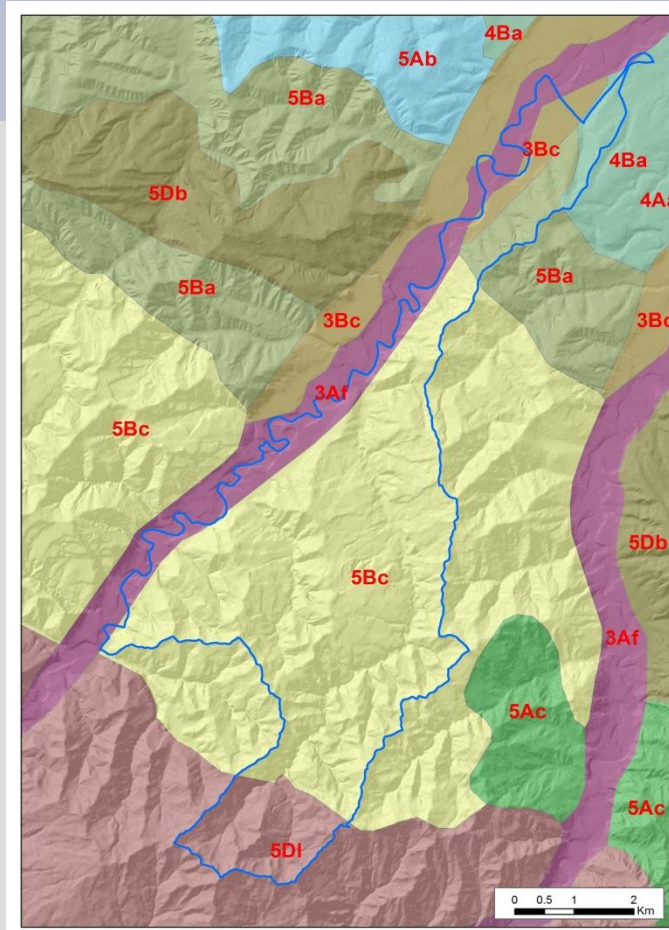
# LAND VULNERABILITY: KNOWLEDGE AND MANAGEMENT stage 2



Soil map at scale 1:50.000 enlarged to most of regional hilly area (82%)

# LAND VULNERABILITY: KNOWLEDGE AND MANAGEMENT stage 2

- Soil map at scale 1:50k enlarged to most of regional hilly area (82%)
- New application of RUSLE model: basin modelling.



**Brasina creek Basin**

**1:250k > 6 Map Units, 12 Soil Units**

**1: 50k >19 Map Units, 50 Soil Units**



# RUSLE modelling the Basin of Brasina creek

Description	
River basin	Brasina creek
Total area	3,408 hectares
Municipalities	Predappio, Dovadola, Castrocaro
altitude	50-700 m a.s.l.
ave. annual rain	800-1,500 mm
Geology	“Marnoso-arenacea”
Soils	Fine to coarse loamy family
Erosion evidence	Laminar flow - rills



# RUSLE modelling the Basin of Brasina creek

“K” factor modelling improved by consideration of SOM content (Torri, 1997)

Simulations by means of the RUSLE model, applied at basin scale, identified:

- 32% of total basin area affected by erosion risk at high rate ( $>50 \text{ Mg} \cdot \text{ha}^{-1} \cdot \text{y}^{-1}$ );
- 8% at a moderate level ( $20\text{-}50 \text{ Mg} \cdot \text{ha}^{-1} \cdot \text{y}^{-1}$ ).



# Further improvements: “C” AND “P” FACTORS

## LAND USE IN THE BASIN OF BRASINA CREEK

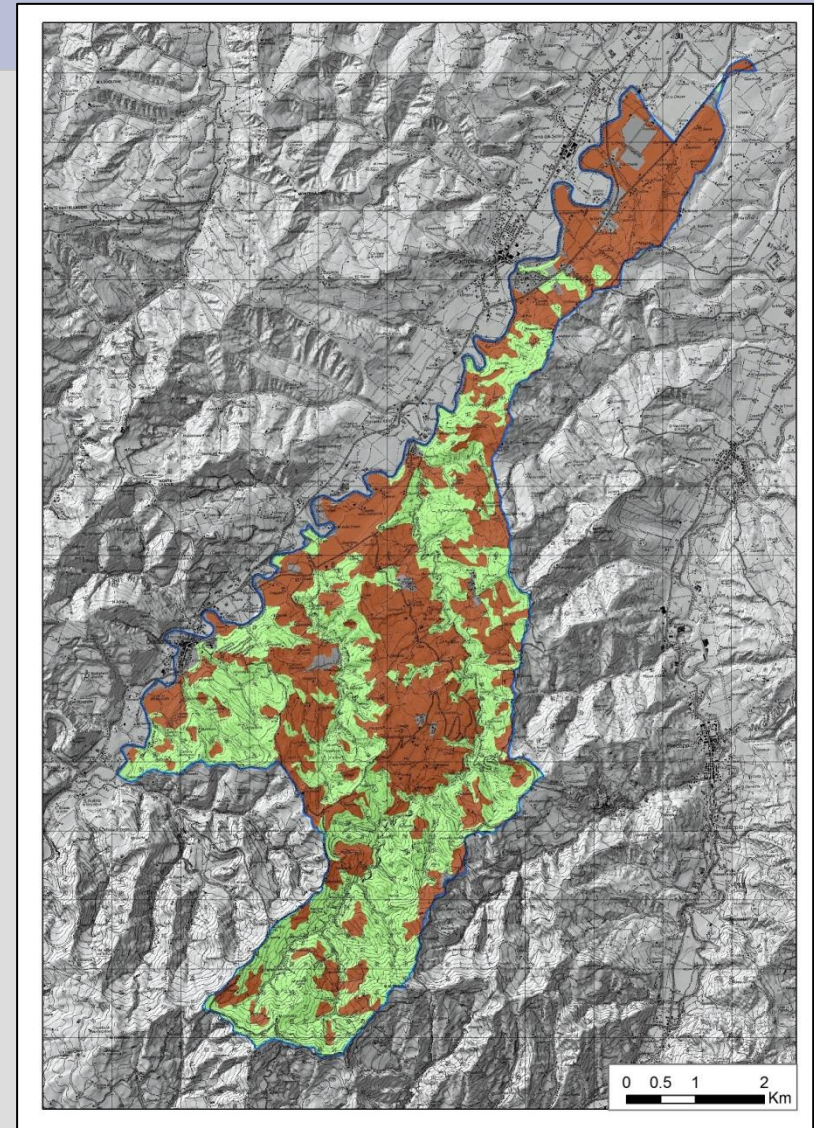
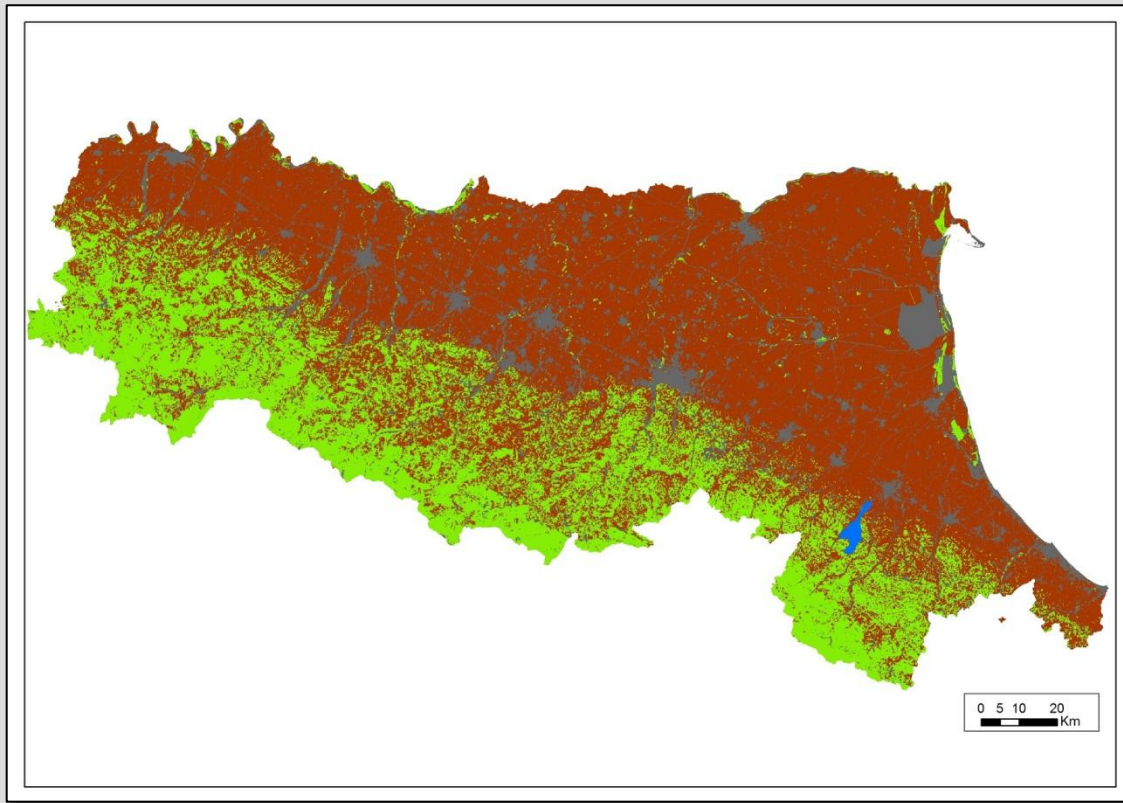
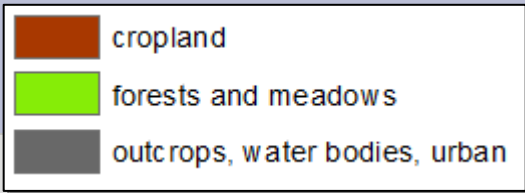
arable and horticultural crops with 44% represent the most relevant agricultural land use, followed by forest and meadows (representing 42% of the area).

But arable crops and horticulture can be considered to be less effective in reducing the erosion risk.

For these land use classes the vulnerability to erosion mainly depends on management practices:

- soil cover rate during rainy seasons,
- intercropping or grass cover for permanent crops,
- soil disturbance reduction (sod seeding)

# LAND USE MAP: overview / focus



# Agriculture in Apennine Hills

Hills of Emilia-Romagna (100<altitude<600 m a.s.l.) show very contrasting farming systems:

- arable crops rotation,
- orchards and vineyards on permanent grass cover,
- livestock farming based on cereals-alfalfa cropping systems.

These two latter can obtain a high level protection of topsoil against rain erosion, whilst arable rotations can result in huge soil losses ( $> 20 \text{ Mg} \cdot \text{ha}^{-1} \cdot \text{y}^{-1}$ ).

Conservation Agriculture: a new operation to reduce erosion risk in hilly cropland (RDP 2014-2020).

## Improving soil quality - strengthening the adaptation to climate change through SUSTAINABLE TECHNIQUES OF CONSERVATION AGRICULTURE

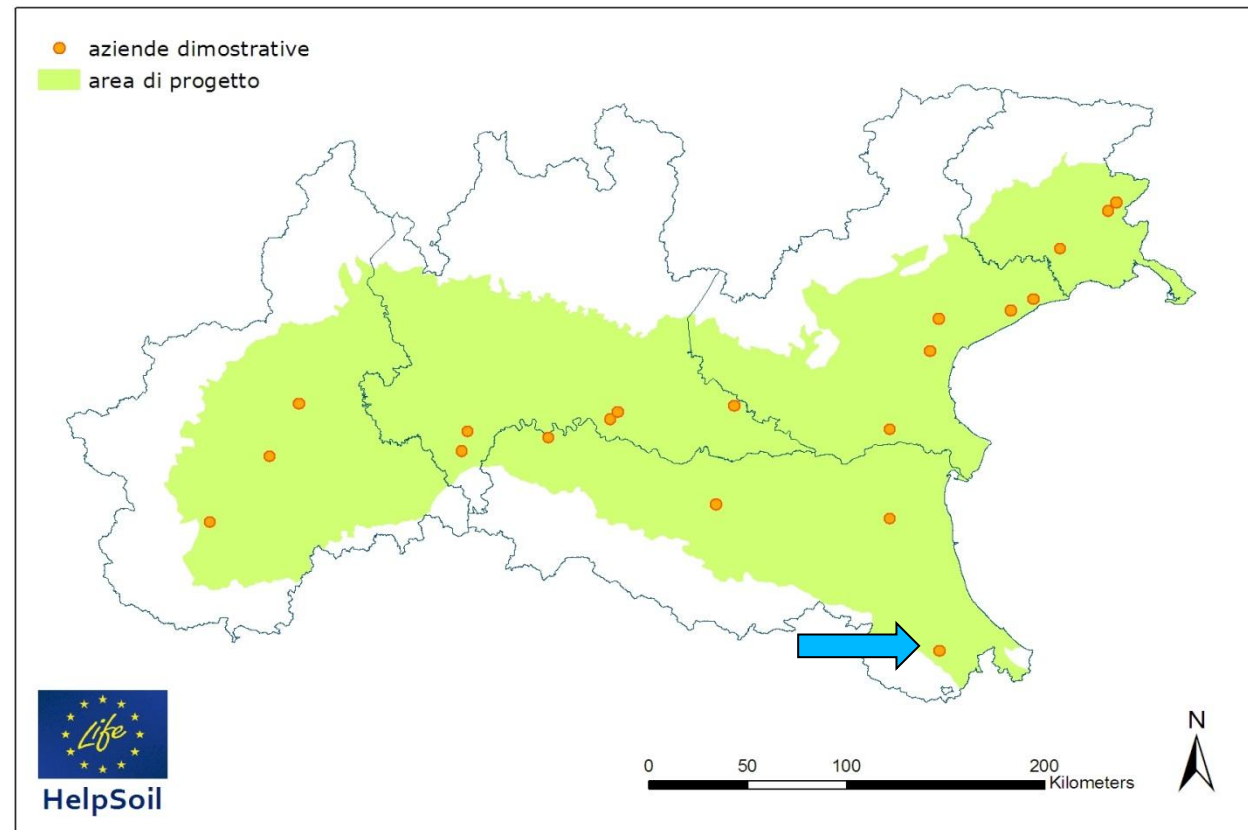
Conservation Agriculture (CA) is a production system based on a combination of 3 major principles:

- no inversion tillage and an overall reduction of soil disturbance, with preference for no-tillage;
- permanent maintenance of soil cover with crop residues or cover crops;
- plant species diversity or diversified crop rotations.

### LIFE HelpSoil project

Objective: feasibility of CA, in association with some novel techniques, to achieve best soil management.

Focus: to strengthen the ecological functions of soils (carbon sequestration, increase of fertility and edaphic biodiversity, protection against erosion, water retention).



- 5 regions of the river Po plain (northern Italy)
- 20 pilot farms
- 4 pilot farms in Emilia-Romagna, 1 located on steep land

## CONSERVATION AGRICULTURE IN HILLY CROPLAND

**“Gli Ulivi” pilot farm, represents the typical agriculture of Apennine Hills.**

**Total area: 300 hectares**

**Cropland area: 140 hectares**

**Cropping system: cereals, livestock feed and vineyards.**

**Basin: Brasina creek where RUSLE erosion model, as above described, has been testing.**

**Altitude: 295 - 420 m a.s.l.**

**Morphology: long, wavy, 10-40% slopes with predominant East orientation**

**Soils' parent material: pelithic-arenaceous rock-bed at 90-100 cm depth.**

**Soils: medium-textured, calcareous, with frequent Ca-carbonates concentrations, from moderately deep to deep.**





## CONVENTIONAL vs. CONSERVATION AGRICULTURE

**ARABLE CROP  
RAINFED  
ROTATION**

**Alfalfa (4 years) –  
Winter Wheat –  
W. Barley**

**CONVENTIONAL  
MANAGEMENT**  
plowing (30-40 cm depth)  
rotary harrow (1+ passages)  
sowing machine  
cereal straw harvested

**vs.**

**CONSERVATION  
MANAGEMENT**  
sod seeding  
crop residues mulch  
weed control / living mulch








# CONVENTIONAL vs. CONSERVATION AGRICULTURE (SURVEY of EFFECTS)

FIELD GUIDE

VISUAL SOIL ASSESSMENT

Annual Crops




BioAgriNomics  

## VISUAL ASSESSMENT

- soil cover
- soil erosion + regional soil survey manual
- photo shots
- GPS-referenced plots

VINEYARDS | OLIVE ORCHARDS | ORCHARDS | WHEAT | MAIZE | ANNUAL CROPS | PASTURE

PLATE 12 How to score surface crusting and surface cover



**GOOD CONDITION VS = 2**  
Little or no surface crusting is present; or surface cover is ≥70%.

**MODERATE CONDITION VS = 1**  
Surface crusting is 2–3 mm thick and is broken by significant cracking; or surface cover is >30% and <70%.

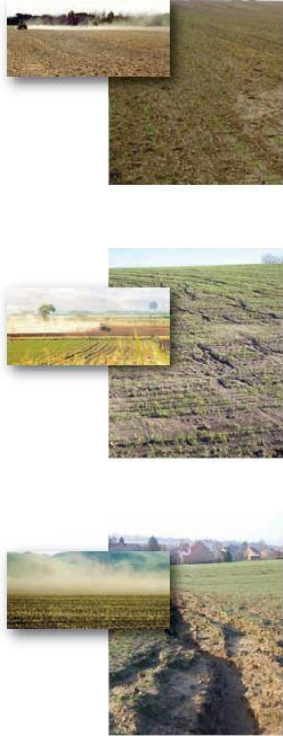
**POOR CONDITION VS = 0**  
Surface crusting is >5 mm thick and is virtually continuous with little cracking; or surface cover is ≤30%.

Surface cover photos: courtesy of A. Leys

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VINEYARDS | OLIVE ORCHARDS | ORCHARDS | WHEAT | MAIZE | ANNUAL CROPS | PASTURE

PLATE 13 How to score soil erosion



**GOOD CONDITION VS = 2**  
Little or no water erosion. Topsoil depths in the footslope areas are <150 mm deeper than on the crest.  
Wind erosion is not a concern; only small dust plumes emanate from the cultivator on a windy day. Most wind-eroded material is contained in the field.

**MODERATE CONDITION VS = 1**  
Water erosion is a moderate concern with a significant amount of rilling and sheet erosion. Topsoil depths in the footslope areas are 150–300 mm greater than on crests, and sediment input into drains/streams may be significant.  
Wind erosion is of moderate concern where significant dust plumes can emanate from the cultivator on windy days. A considerable amount of material is blown off the field but is contained within the farm.

**POOR CONDITION VS = 0**  
Water erosion is a major concern with severe gully, rilling and sheet erosion occurring. Topsoils in footslope areas are more than 300 mm deeper than on the crests, and sediment input into drains/streams may be high.  
Wind erosion is a major concern. Large dust clouds can occur when cultivating on windy days. A substantial amount of topsoil can be lost from the field and deposited elsewhere in the district.

Water erosion photos: courtesy of J. Quinton and A. Leys

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# VISUAL SOIL ASSESSMENT



**conventional**



**conservation**

# VISUAL SOIL ASSESSMENT



**conventional: 40% soil cover  
low sheet erosion**



**conservation: 60% soil cover  
no erosion**