REMOTE SENSING OF LAND USE CHANGES AND LANDSLIDING FROM 1955 TO 2006 IN ROCCHETTA S. ANTONIO, THE DAUNIA APENNINES

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Amedeo Magnotta (1966-2012) architect and local administrator

OBJECT:

Study of the landsliding trend in Daunia Subapennine from 1955 to 2006 in relation to the main predisposing and triggering factors

OUTLINE:

1) **Introduction**:

- **purpose of the research**
- **problem**
- **study area**

2) **Techniques of data acquisition:**

- **satellite images and aerial photographs processing**
- **data integration and processing in a GIS**

3) **Results and Analysis of predisposing and triggering factors of landslides:**

- **1955-1976-2006 landslide maps**
- **1955-1976-2006 land use maps**
- **land use change**
- **slope**
- **drainage network**
- **wet areas**

4) **Conclusions**

INTRODUCTION: problem and purpose of the research

- **Widespread and recurrent landsliding in the southern Daunia Apennines (Apulia region, southern Italy)**

- **Purpose of the research was the investigation of time evolution of landslide occurence and of its distribution with respect to land use changes, performed with data integration and analysis in a GIS**

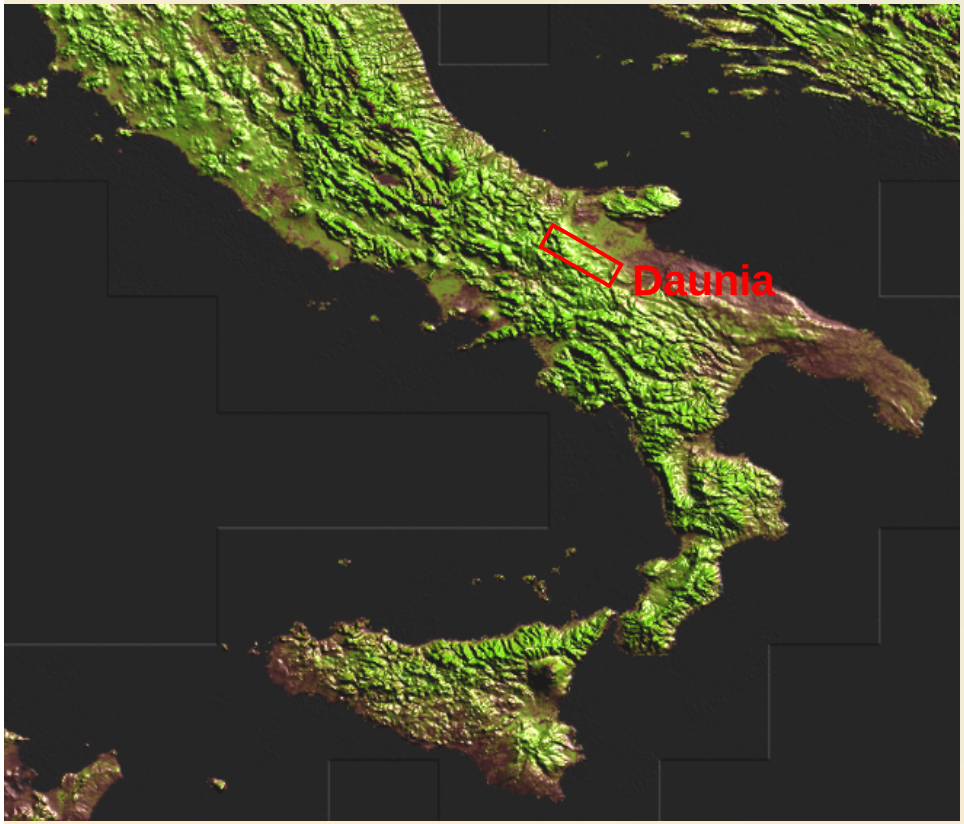
  Use of high resolution satellite images (IKONOS) for landslide mapping

  Use of satellite data for a supervised, semi-automatic classification of land use

  For a 16 km^2 area, defined as the catchment area including an 11-km portion of the SP99bis road (in the municipality of Rocchetta S. Antonio, FG), the study was extended backwards to 1955 using historical airphotos for landsliding and land use mapping

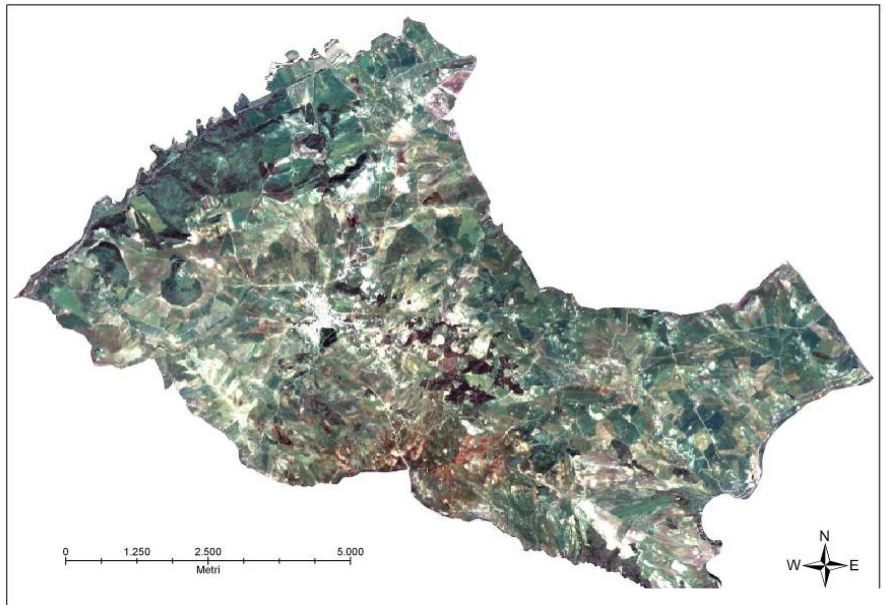
- **Applicability of high resolution imagery for detailed mapping and associated factors of instability (ponded water, wet areas, concentration of roadway runoff) also investigated**

Slope instability in the Daunia apennines



Damage to rural houses

Selection of the study area



Municipal territory of Rocchetta S. Antonio

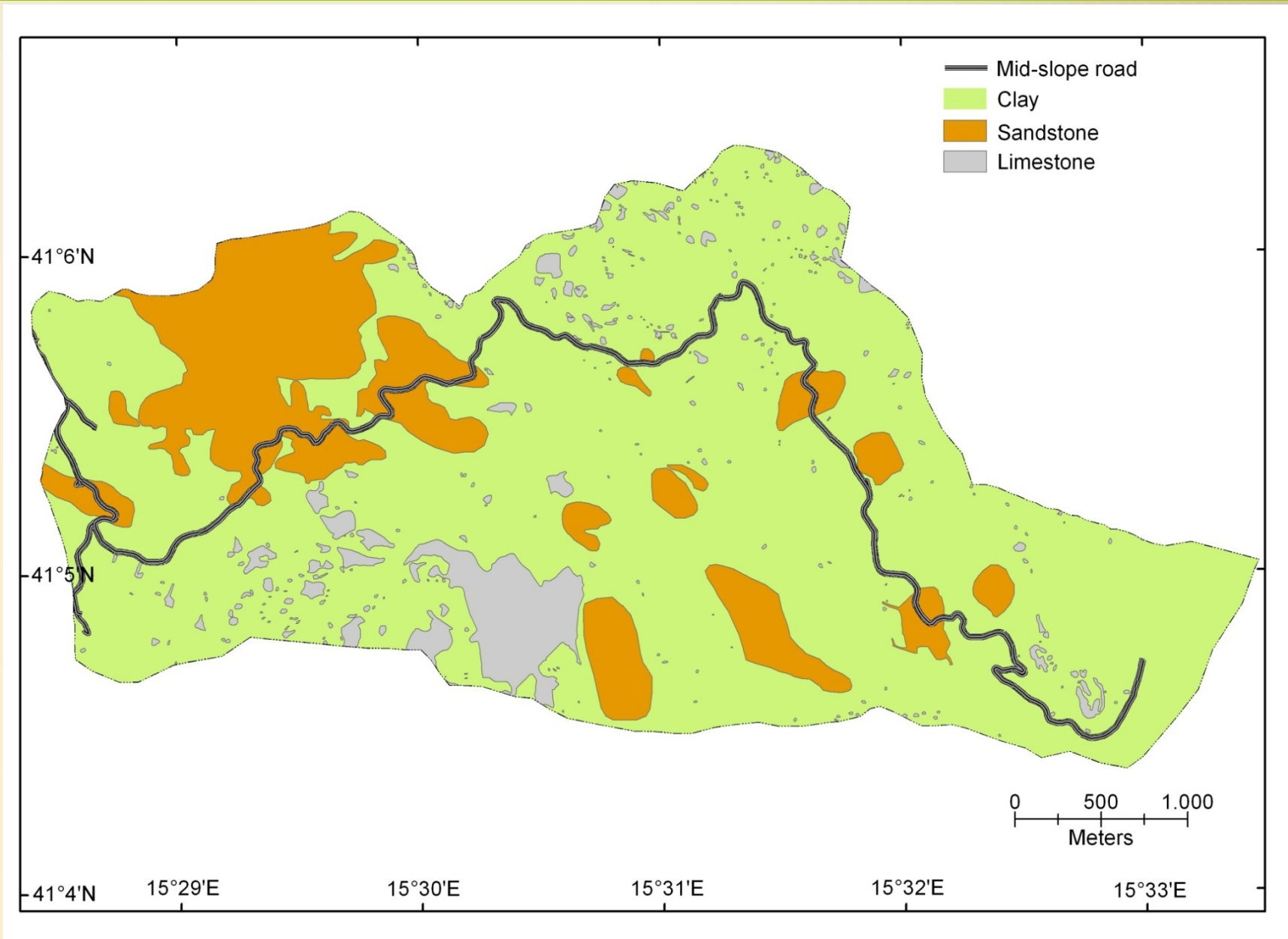
Municipal territory	No/ Km²	Area of municipal territory (km²)	Areal frequency (%)
Monteleone di Puglia (eastern area)	4,5	12,1	7,0
Accadia	1,3	30,5	1,7
Sant'Agata di Puglia	3,7	115,6	6,0
Rocchetta S. Antonio	6,2	71,8	11,1
Candela	0,9	95,9	1,4

elevation
170-770 m a.s.l.

precipitation
600-750 mm

land use
cereals

Study area: 16 km^2 catchment around 11 km road



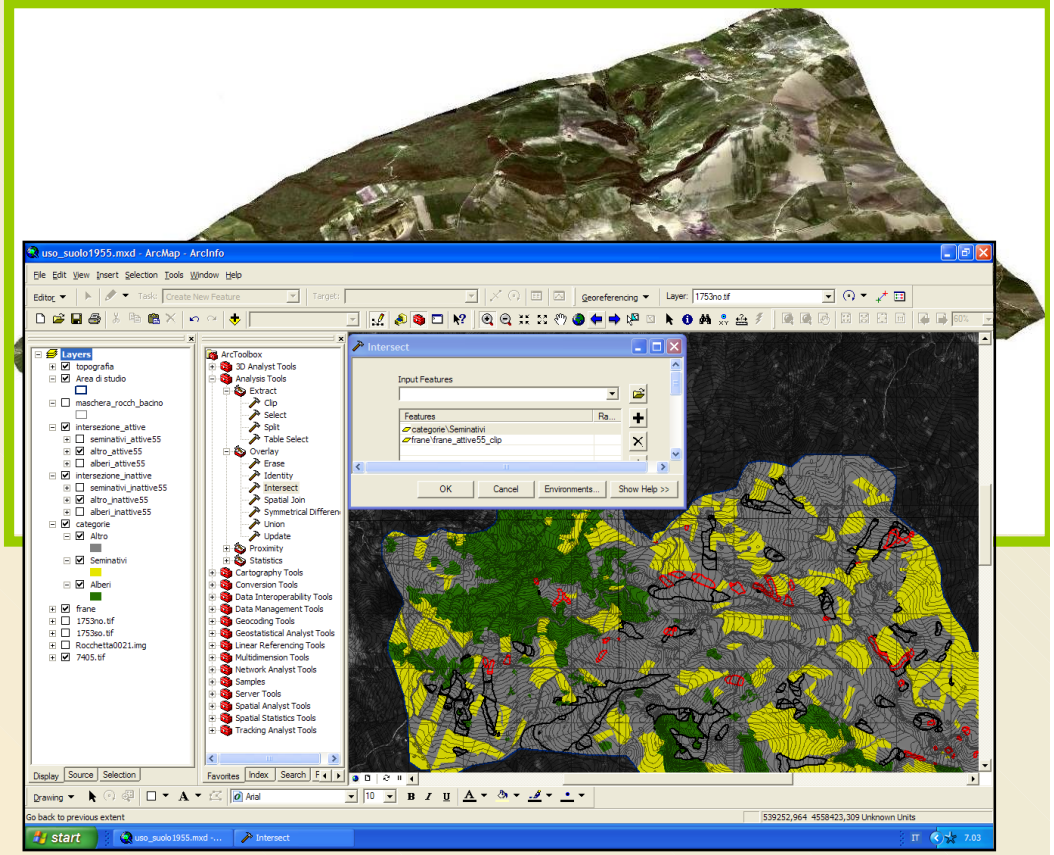
Data acquisition and analysis methodologies

- need to characterize the trend of landsliding and land use from 1955 to 2006

- stereoscopic analysis of aerial photographs

- 3D rendering and processing of high resolution optical satellite images

- field survey: feedback of the ground truth



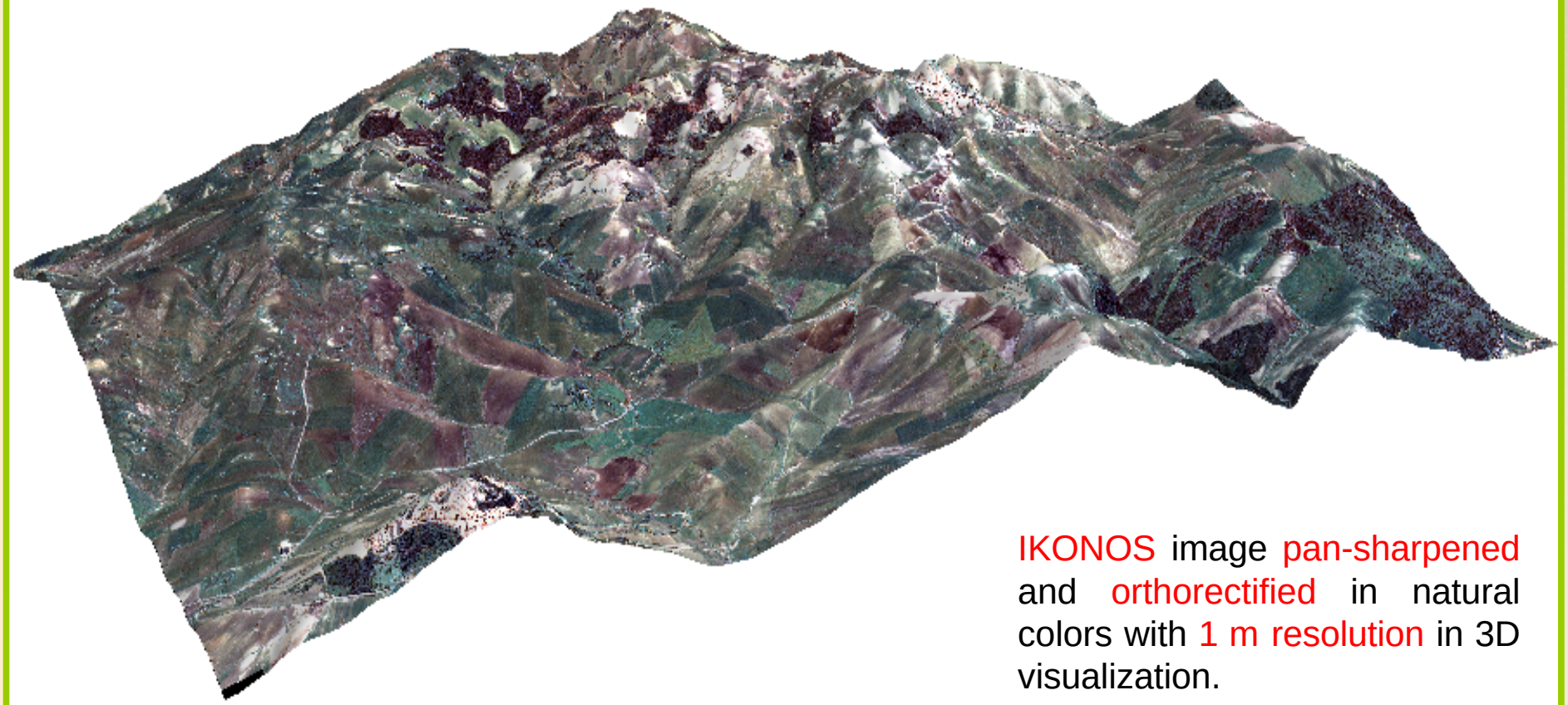
- GIS
  - georeferencing and 3D and 2D rendering of images and spatial data of different origin, scale and format;
  - cartographic layout;
  - statistical and spatial analysis

IKONOS satellite image (April 2006)

2005-2006 winter landslide map

It was performed a 3D visualization of IKONOS image requiring:

- orthorectification of the images
- pan-sharpening procedure

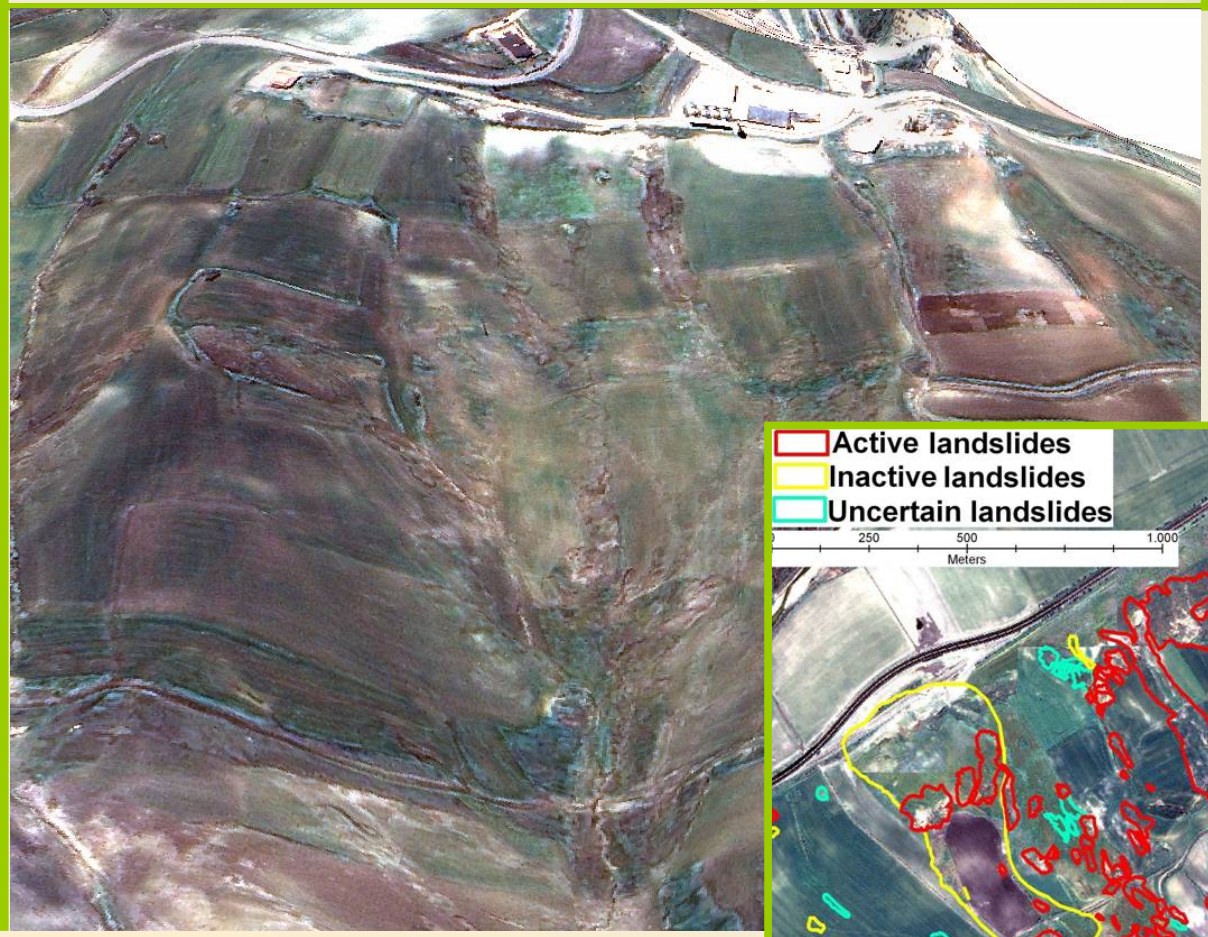


IKONOS image pan-sharpened and orthorectified in natural colors with 1 m resolution in 3D visualization.

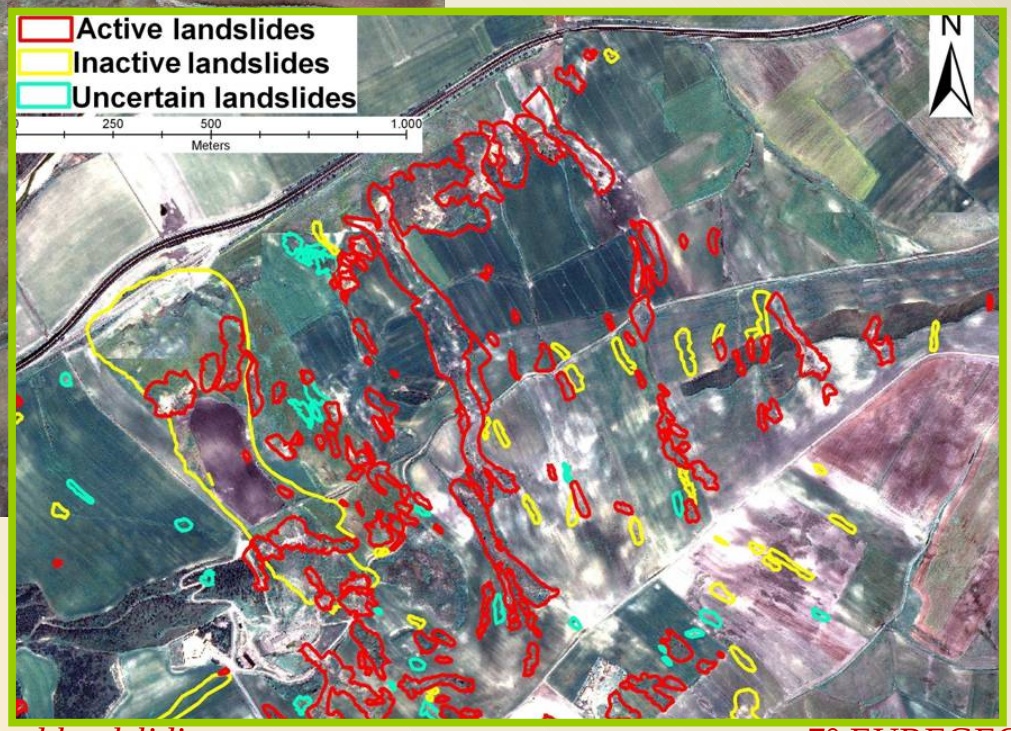
Landslide mapping from 2006 IKONOS image

3D rendering for mapping landslides

IKONOS satellite image (April 2006)

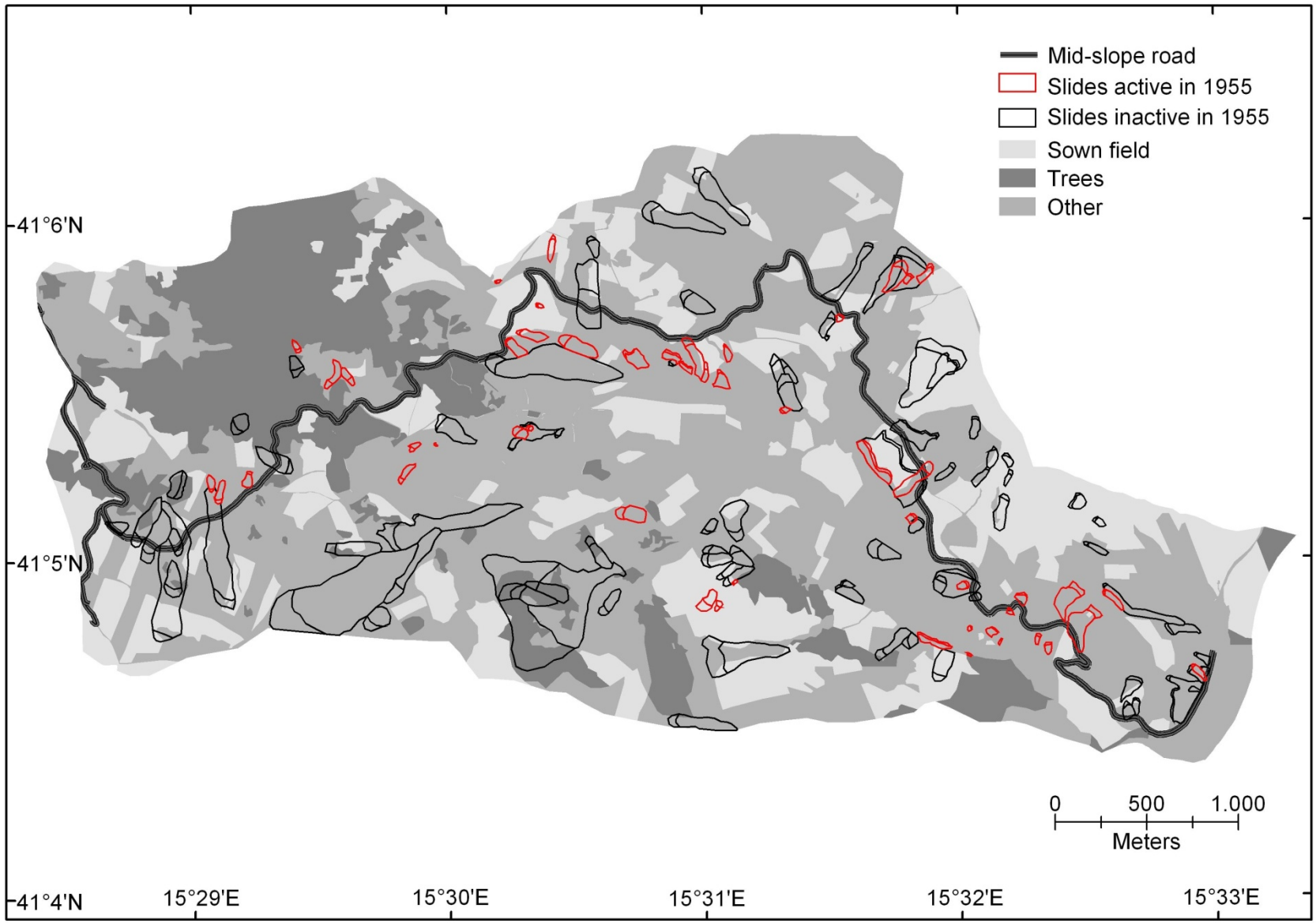


Zoom of pan-sharpened and orthorectified IKONOS image in true color, draped over DEM (3x vertical exaggeration). Active and inactive landslides were mapped on screen.

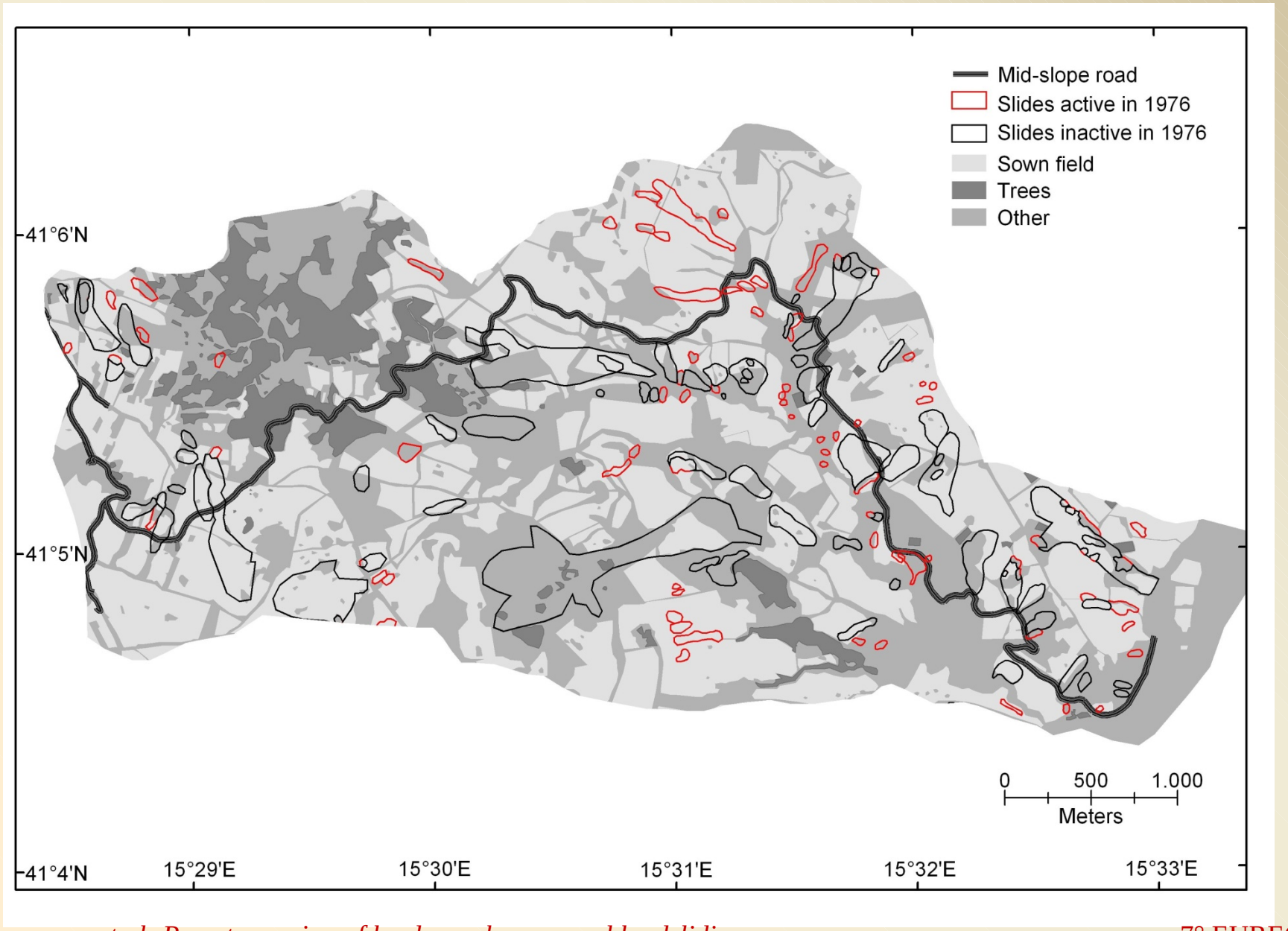


Example of active, inactive and uncertain landslides, in 2D visualization.

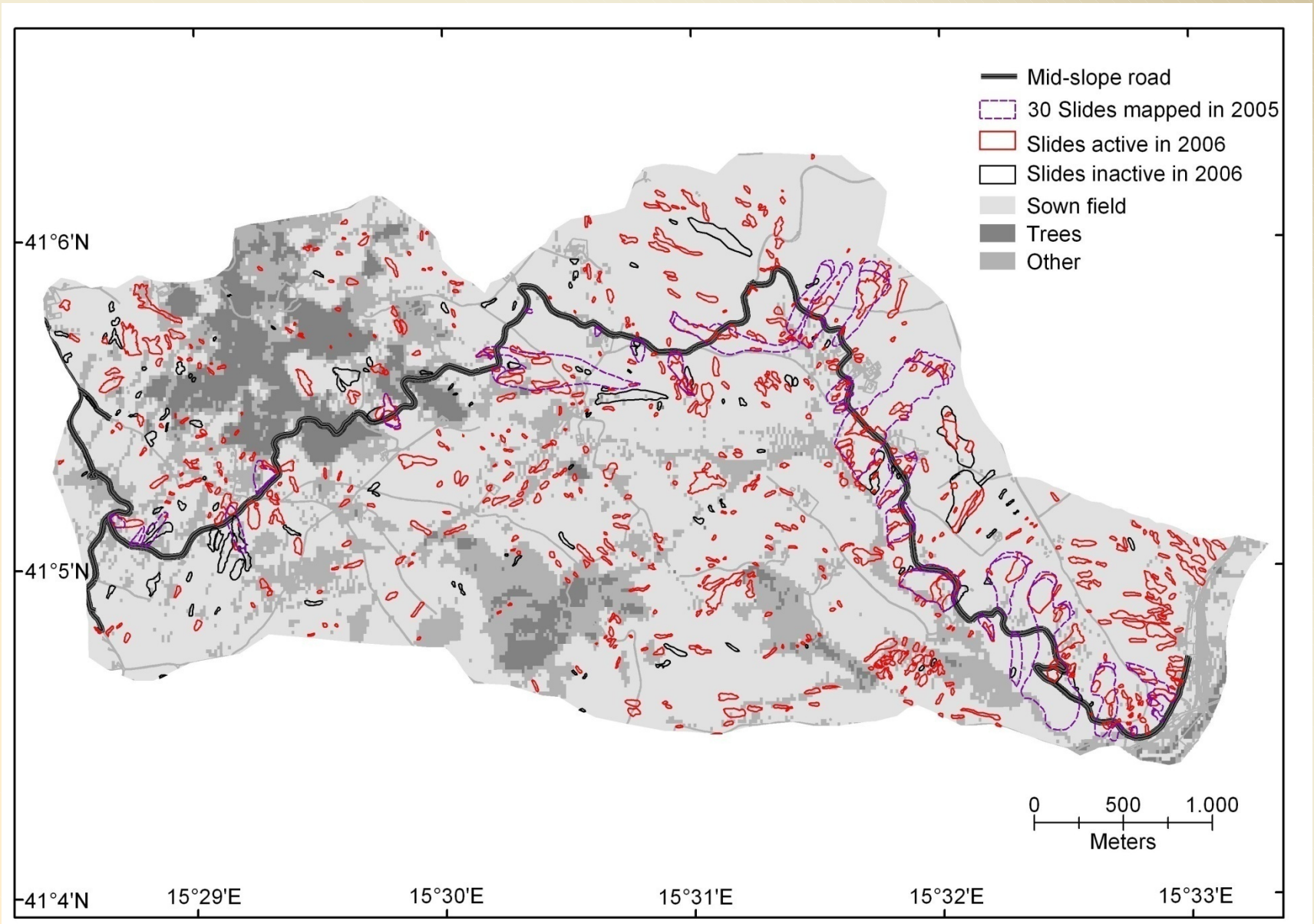
Landslides and land use map (1955)



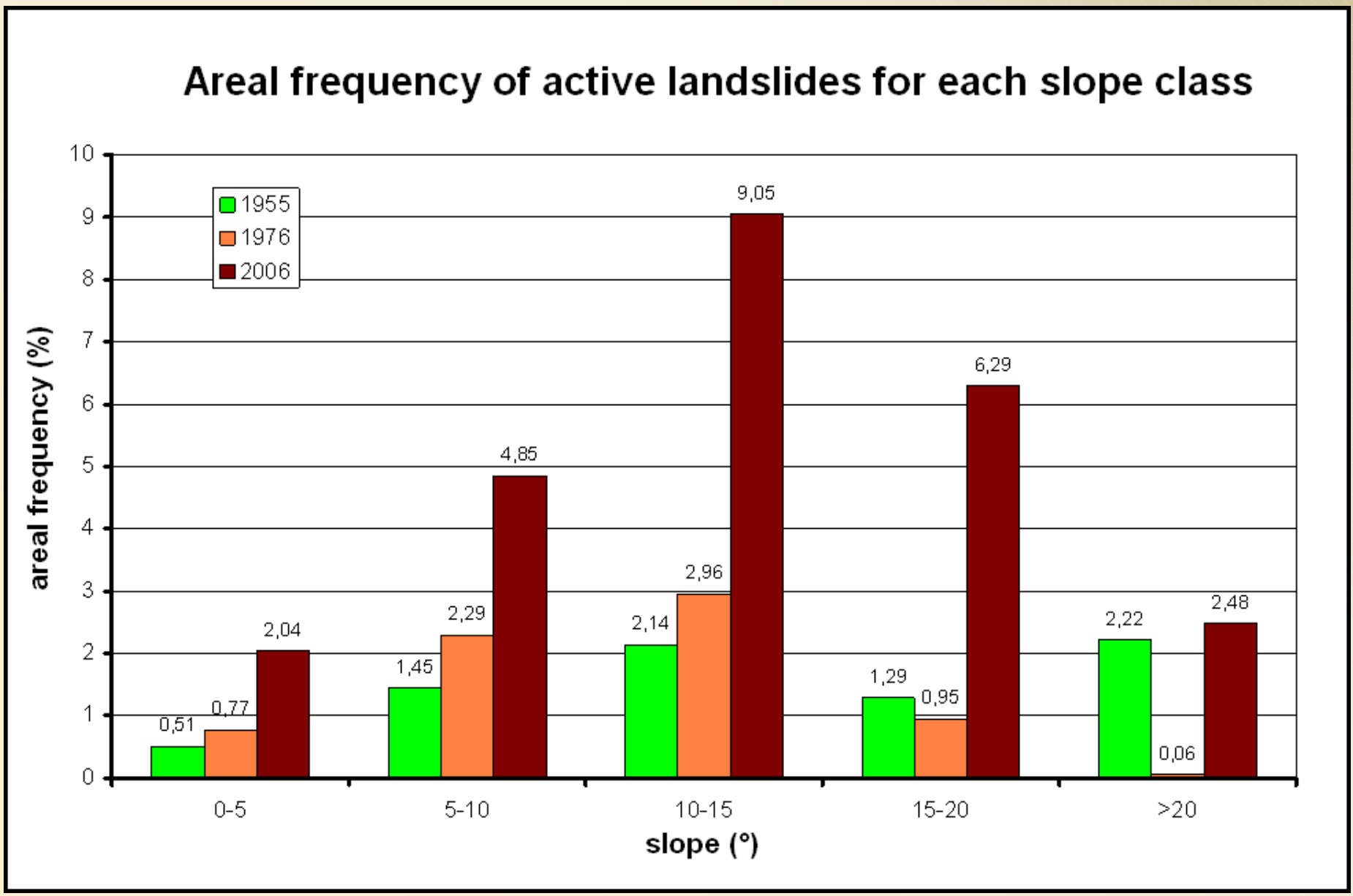
Landslides and land use map (1976)



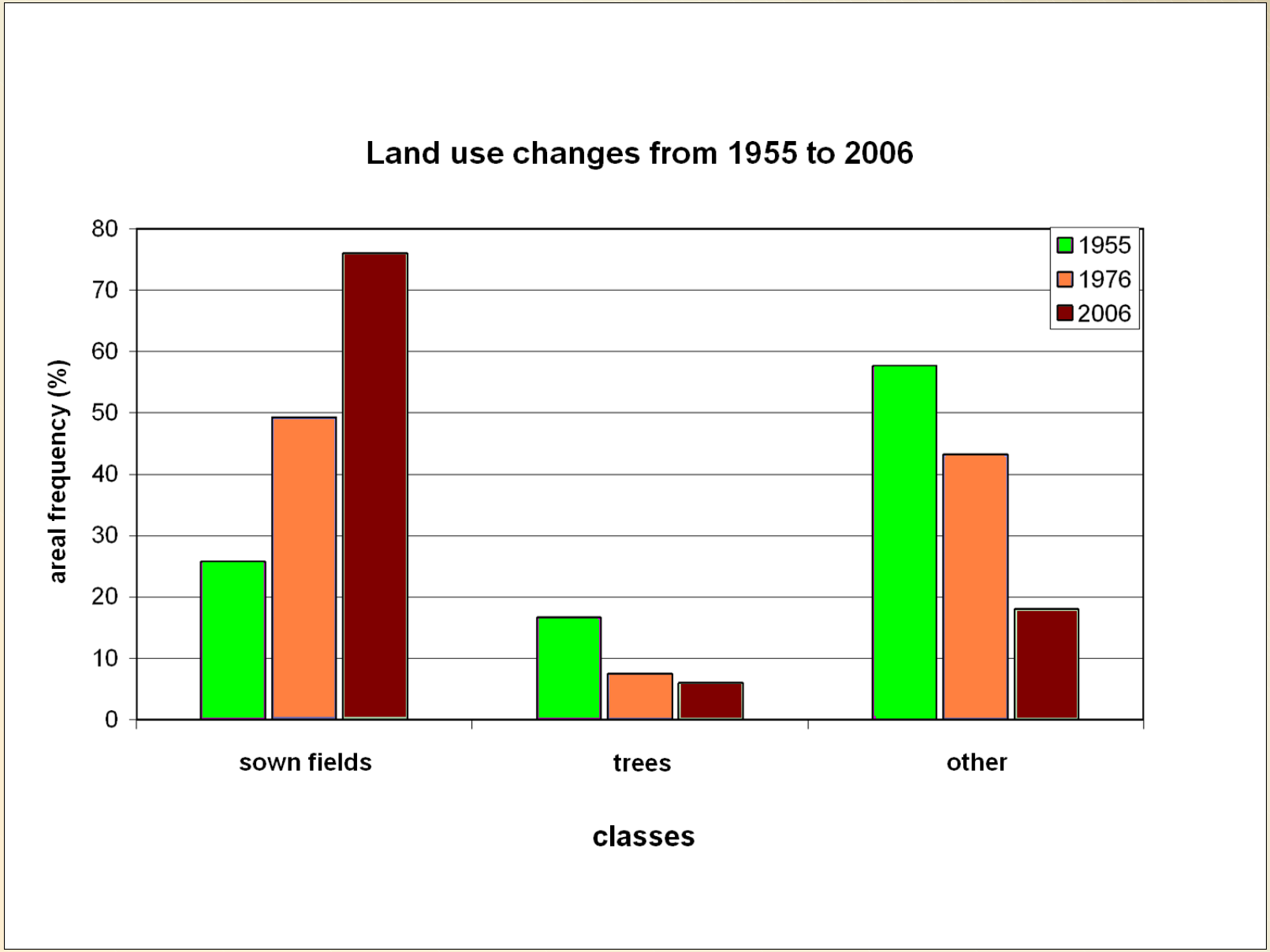
Landslides and land use map (2006)



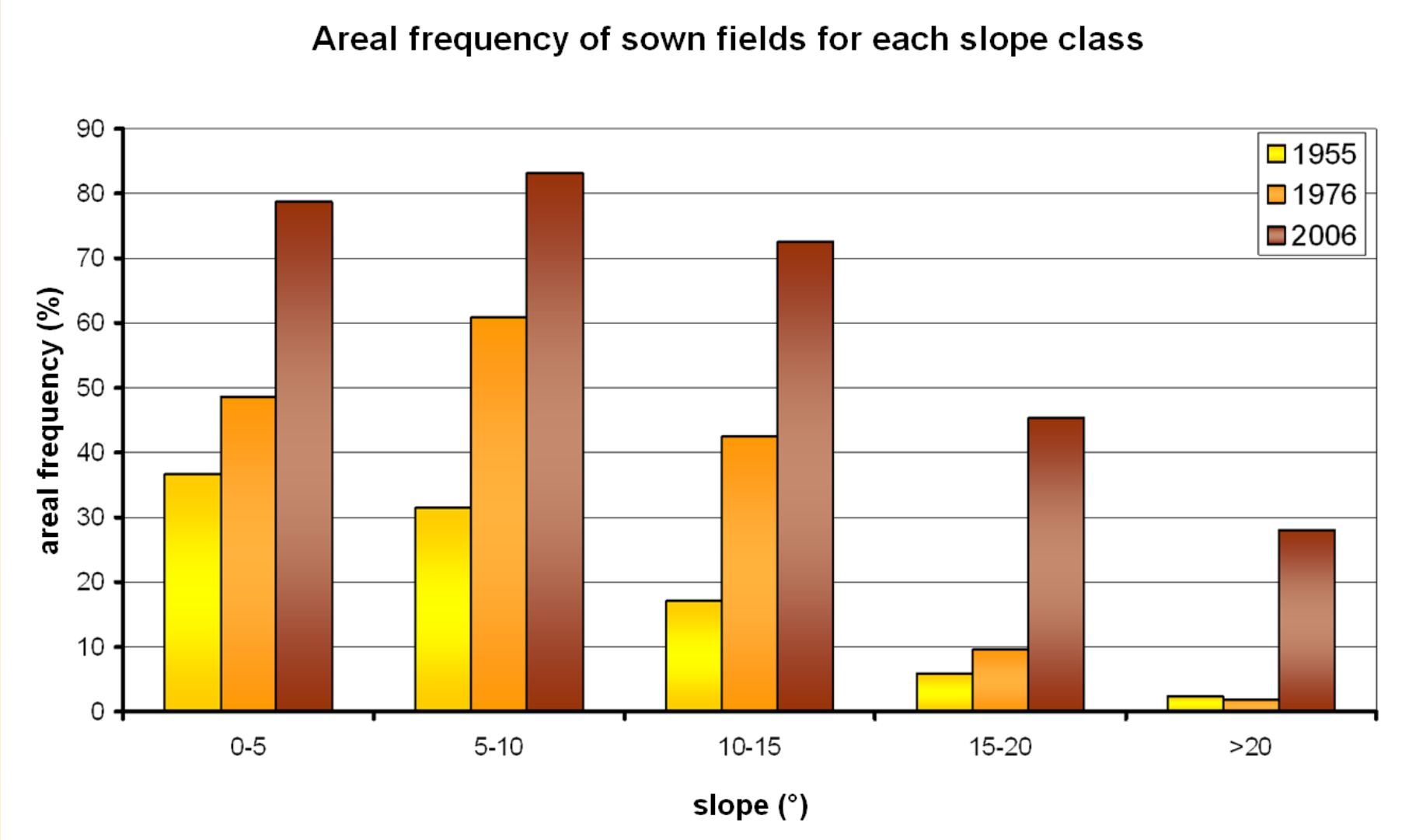
Landsliding statistics and slope distribution



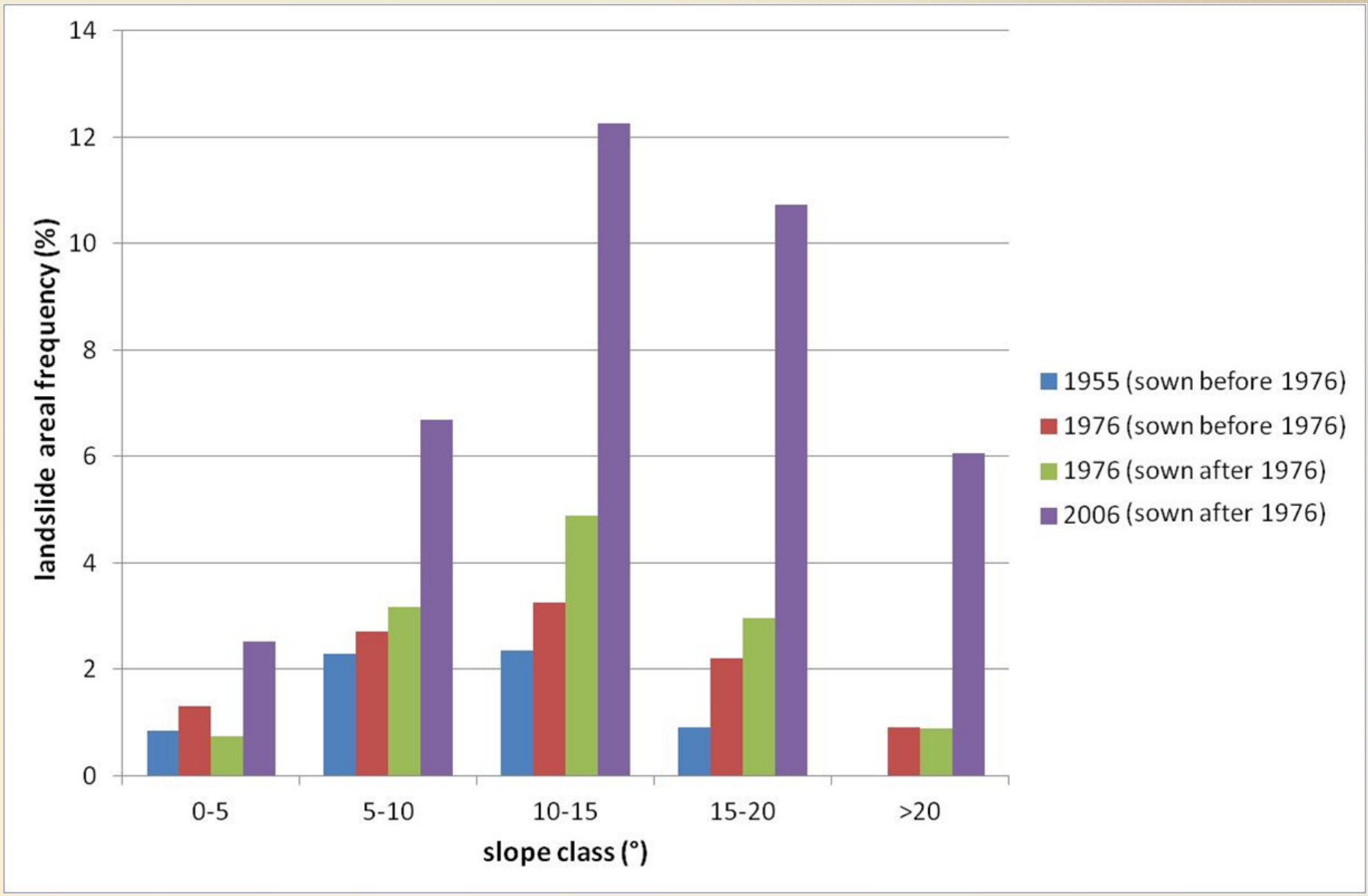
Land use statistics



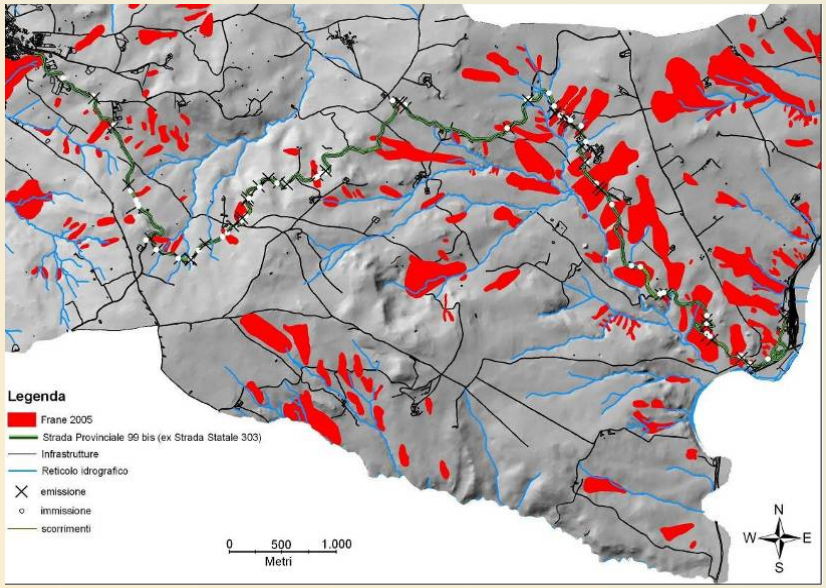
Land use statistics



Landslides and land use change statistics



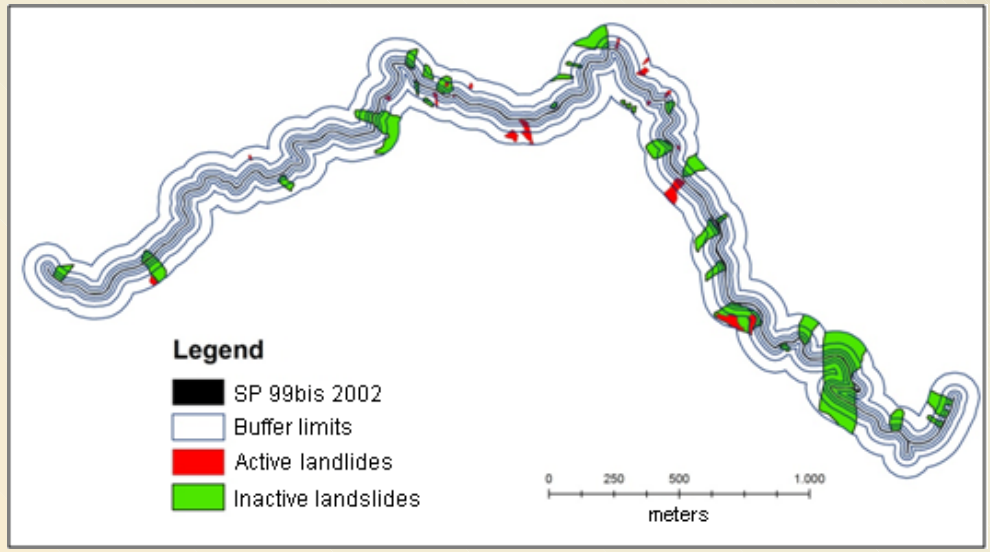
Landsliding along the SP99bis road



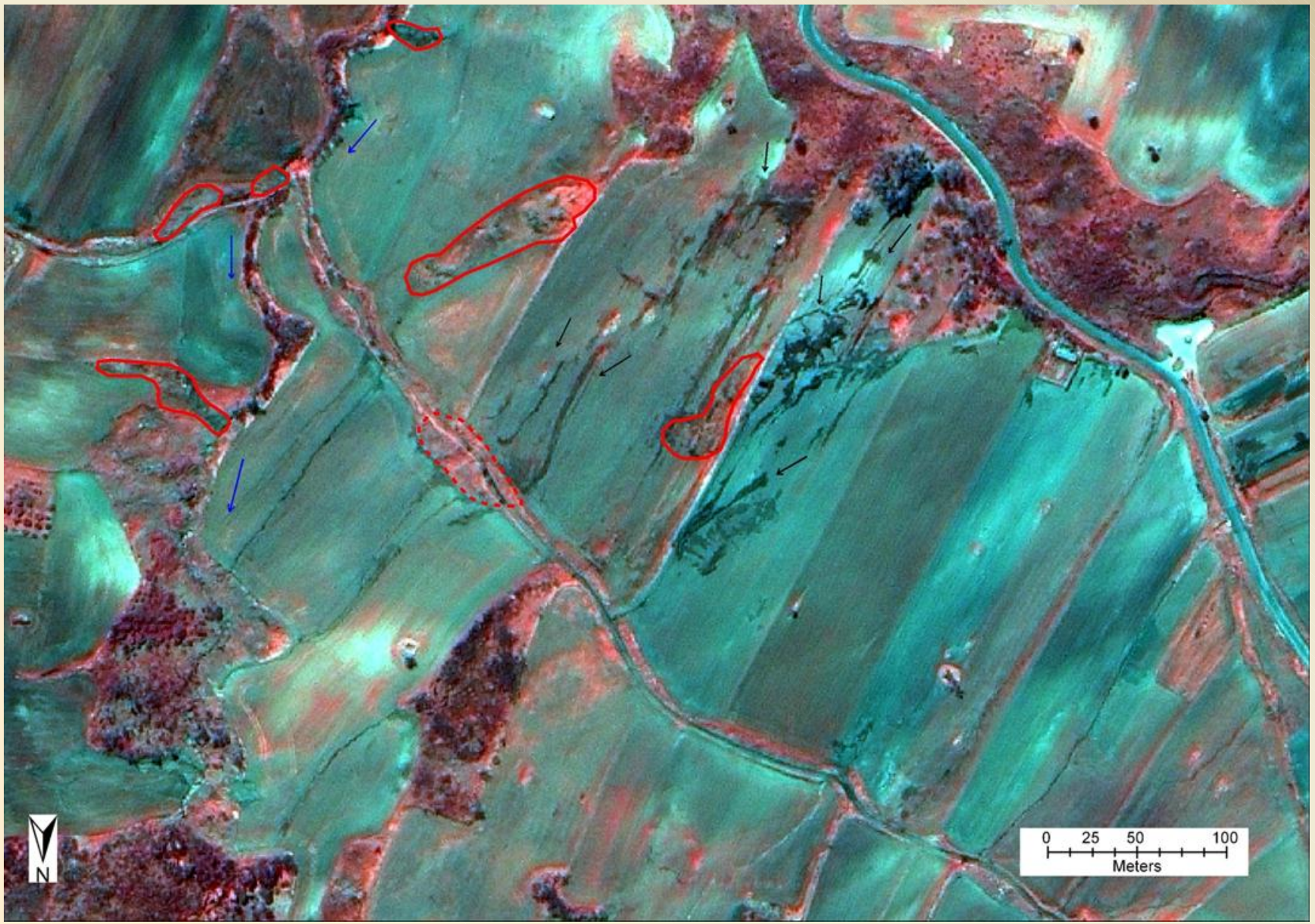
Rocchetta S.Antonio-Rocchetta Scalo (15 km)

30 landslides interesting the road :

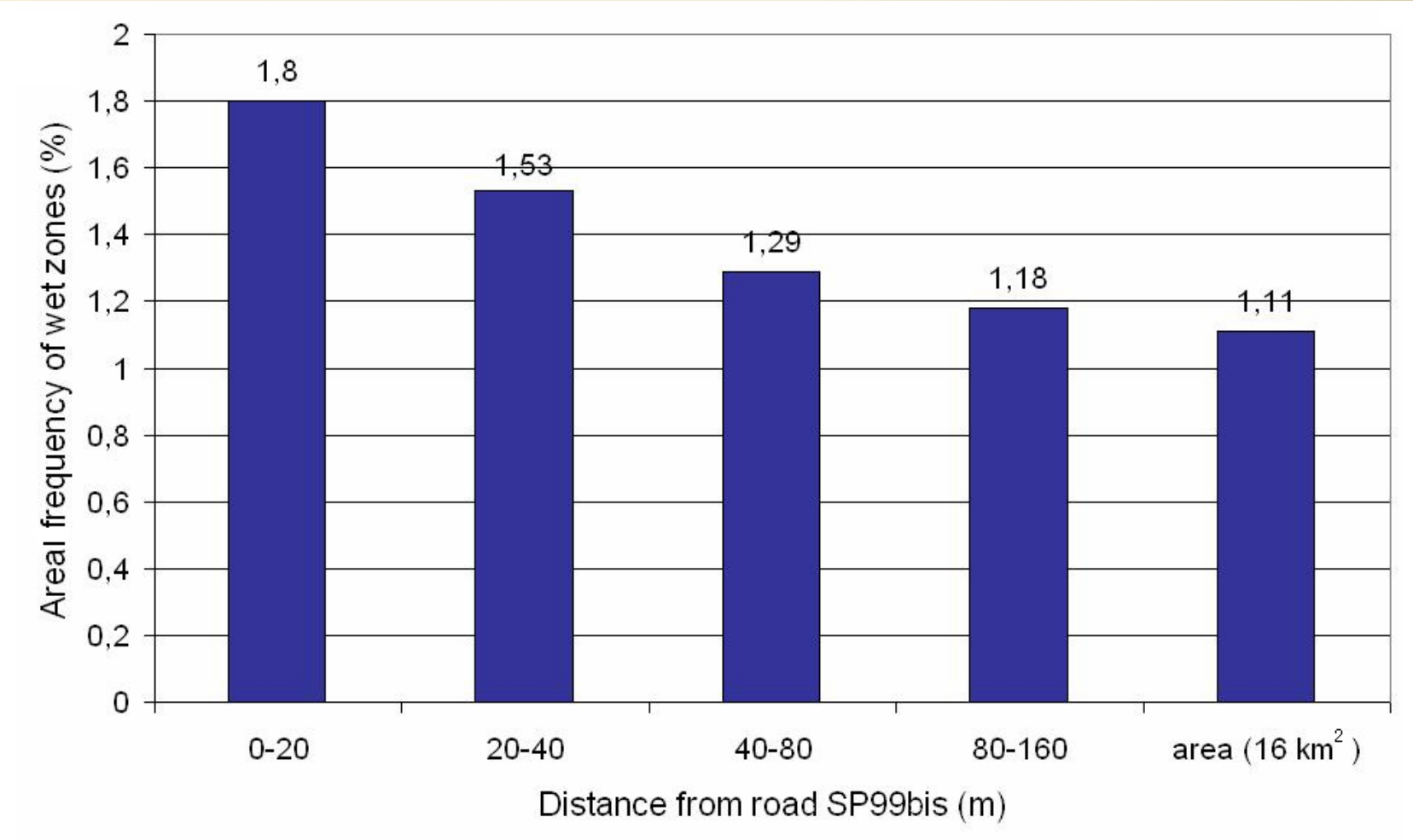
- Intensive crops on the slopes adjacent to the road
- Lesions to the continuity of the original surface of the side
- Changing the natural hydrological regime: 99 water inflow and outflow points were mapped along the road after an intense rainfall event
- Variation of stress on the slope



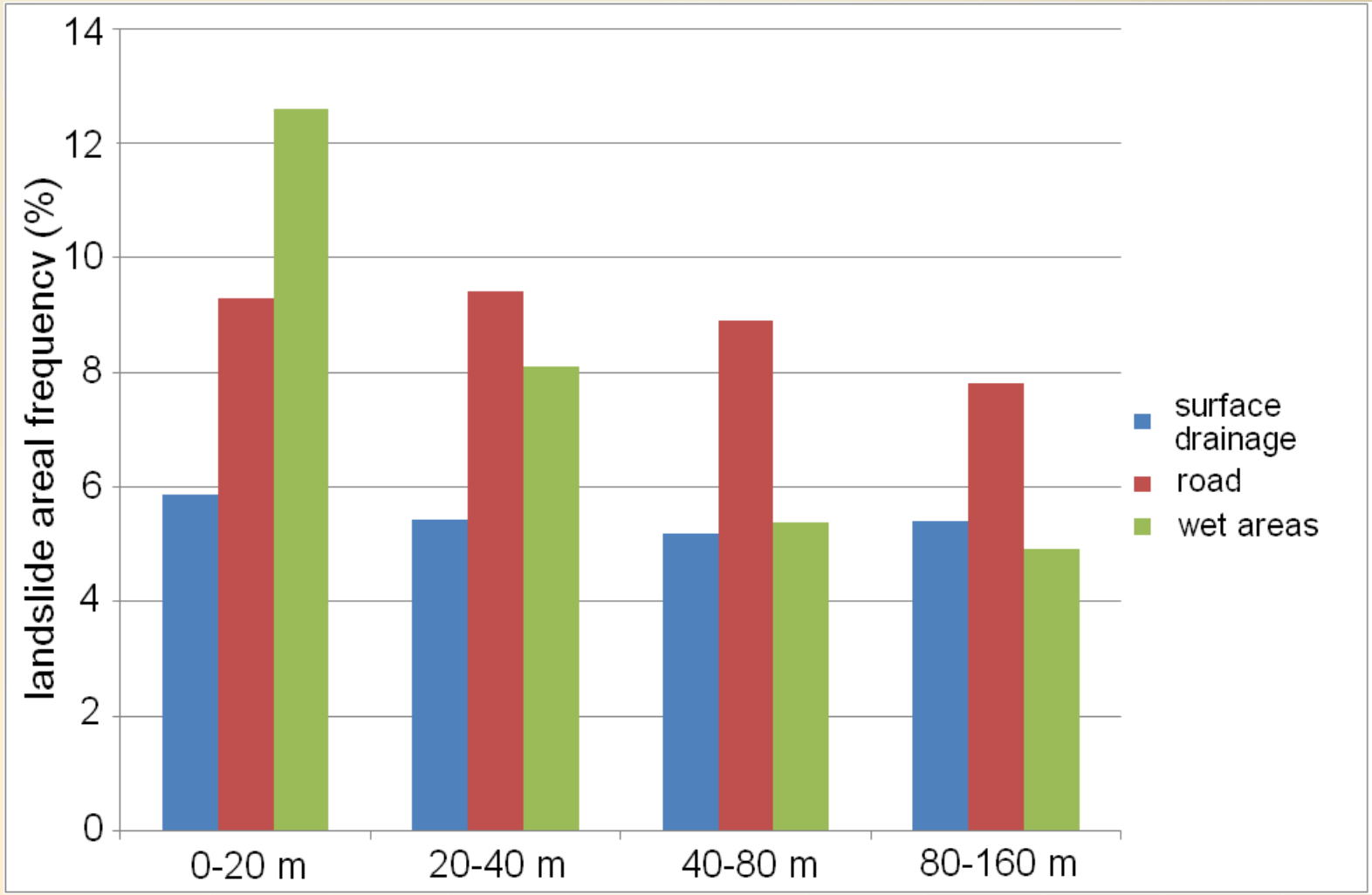
Wet areas detection with IKONOS imagery



Statistics of ponded water and wet areas



Landslide statistics in selected buffers



CONCLUSIONS (methodology)

- **HR optical satellite imagery can be exploited in detailed landslide and unstable slope investigations à high quality active landslide inventory maps from imagery draped over a few m grid DEMs**
- **The main advantages of the use of satellite images are:**
  - **a single image covering large areas eliminating the need to create mosaics of adjacent photos and reducing the volume of data to carry out the process for orthorectification;**
  - **satellite imagery acquired with a revisiting time period shorter than that required to repeat an aerophotogrammetric campaign.**
- **The non-application of the stereoscopic mode for the IKONOS images (still very expensive) in this work represented a limitation in the interpretation of the old inactive landslides.**
- **The aerial photographs, available from a long time, although not always with adequate spatial resolution, are an essential source of data for an analysis of historical trends of landslides.**
- **Possibility of detecting and mapping in detail also features indicative of the drainage conditions deleterious for the local slope (and the road) stability.**
- **HR remote sensing won't substitute *in situ* controls, but can guide and optimize field efforts by providing focus on specific local factors that influence susceptibility of hillslopes to landsliding.**

CONCLUSIONS (causes of instability)

ØThe comparison between 1955, 1976 and 2006 data shows a marked increase in landslide activity. Also considering the different mapping techniques, the increment is real and significant.

ØCultivations on steep slopes, marginal at first, extended over significant portions of the territory. The active landslide areal frequency and its increment reach their maximum values where cultivations extended on steeper and already unstable slopes.

ØRainfall triggering role can occur through the action on the slopes already "weakened" by other causes. Among the predisposing factors, significant changes in land use (farming and road infrastructure that alter the drainage capacity) seem to be particularly relevant.

ØWet areas, observed on the IKONOS image, can be indicative of local, seasonally persistent high groundwater levels within landslide-prone slopes and can be viewed as a signal indicative of the increased susceptibility to landsliding

Wet areas, rainfall and piezometric levels