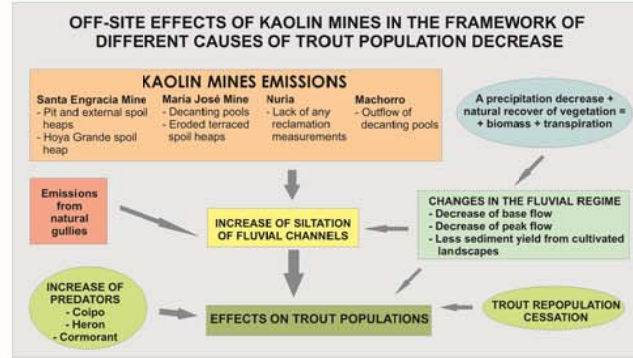
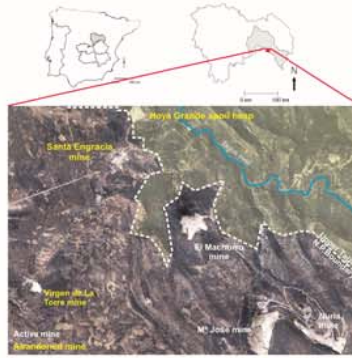


## INTRODUCTION

The Upper Tagus (Alto Tajo) Natural Park is one of the largest and most valuable protected natural areas in Spain (Guadalajara Province).

At the edge of the Natural Park, a series of kaolin mines, with operations preceding the declaration of the protected area (year 2000), have affected in the past to the wildlife aquatic habitats of the area, and constitute nowadays a very high risk of siltation of the nearby fluvial network (within the Park), being this the main environmental issue of the protected area, as it is stated by its managers.



	On-Site Effects	Off-Site Effects
Abandoned mines	<p><b>INTERNAL DEPOSITS</b> Due to gravitational and hydric activities. (left) Debris cones, (right) alluvial cones</p> <p><b>INTENSE WATER EROSION</b> Gully and rill erosion (left) external spoil heap in the early 90's, (right) same spoil heaps nowadays</p>	<p><b>SILTATION IN THE FLUVIAL NETWORK</b> Gully erosion on spoil heaps is connected to the fluvial network producing siltation in the nearby streams and Tagus river. Filling and breaking of check dams also occurs.</p> <p><b>FERTILE SOILS LOSS</b> Gully erosion on spoil heaps produces sedimentation on fertile soils</p>
Active mines	<p><b>INTENSE WATER EROSION</b> Gully and rill erosion</p> <p>Runoff within the active mines trigger rill and gully formation in spoil heaps and dirty roads, and extensive sedimentation in alluvial cones.</p>	<p><b>INTENSE WATER EROSION</b> Water concentration in the mines produces gully erosion and sedimentation on fertile soils downslope.</p> <p><b>STREAM SEDIMENTATION</b> <b>DIRECT EFFECTS:</b> increase water turbidity, suspended silt and clay particles difficult the fish and insects breathing. <b>INDIRECT EFFECTS:</b> sediment spoil the gravel beds which are spawning grounds for fishes and insects decreasing their populations affecting the food chain.</p>

## What are we studying in this framework ?

### ABANDONED MINES SEDIMENT SOURCES: IDENTIFICATION AND QUANTIFICATION

**Direct methods**  
Evaluation of sediment emissions from check - dams

$$V = \frac{B \times H}{3} = 6000 \text{ m}^3 \rightarrow 3200 \text{ Tm/yr}$$

V= volume of sediments (m<sup>3</sup>);  
B= dike surface;  
H= length of the sediments wedge that fills the dam (150 m)

Density = 1.6  
Time of siltation = 3 yr

**Indirect methods**  
RUSLE (Revised Universal Soil Loss Equation)

RUSLE 1.06 "Rusle for mined lands, constructed sites and reclaimed lands" (Toy & Foster, 1998)  
Developed from empirical data recorded from mining lands, constructed sites and reclaimed lands.

**RESULTS:**  
Maximum erosion between 150 and 200 Tm/ha/yr. Main erosion sources are abandoned mines and natural gullies

Eco-hydrological Units	Slope	Erosion (Tm/ha/yr)
Exploitation slope	> 25 °	202.54
Spoil heaps with rills	> 25 °	86.12
Natural gullies	> 25 °	197.93

### ACTIVE MINES RESTORATION MODEL REAL CASE: MACHORRO MINE

Since 1982, mining companies in Spain must reclaim their mining developments. In addition, for being located at the edge of a Natural Park, these active mines must adapt their reclamation plans to the Natural Park law requirements. Therefore, the El Machorro reclamation plan is being revised by us by request of the Upper Tagus Natural Park administration and by the environmental policy of the enterprise *itself*.

	Actual reclamation plan	Suggested reclamation
1- Landform designs	The typical 'terraced' landform design is not 'geomorphically' stable in the long term and it does not fit with the original ecosystems and landscapes	With the aim of reducing runoff and soil erosion, the building of composed concave slopes is proposed, whereas the highwalls' geomorphic activity has to be controlled with retention trenches, blending them into the landscape.
2- Terrain structure	The spread of external soils is considered to be unsuitable, due to it is expensive and it does not help to restore original ecosystems	A new architecture of topsoil and surficial deposits is recommended based on the original structure of the surficial geology of the silica sand slopes in which the mine is located.
3- Decanting pools	Actual decanting pools need maintenance works	The construction of systems of flow control and sediment storage (decanting pools, as small ecologically functional wetlands) is proposed at the basis of the concave slopes, gauged by the methodology of the IECA (International Erosion Control Association)