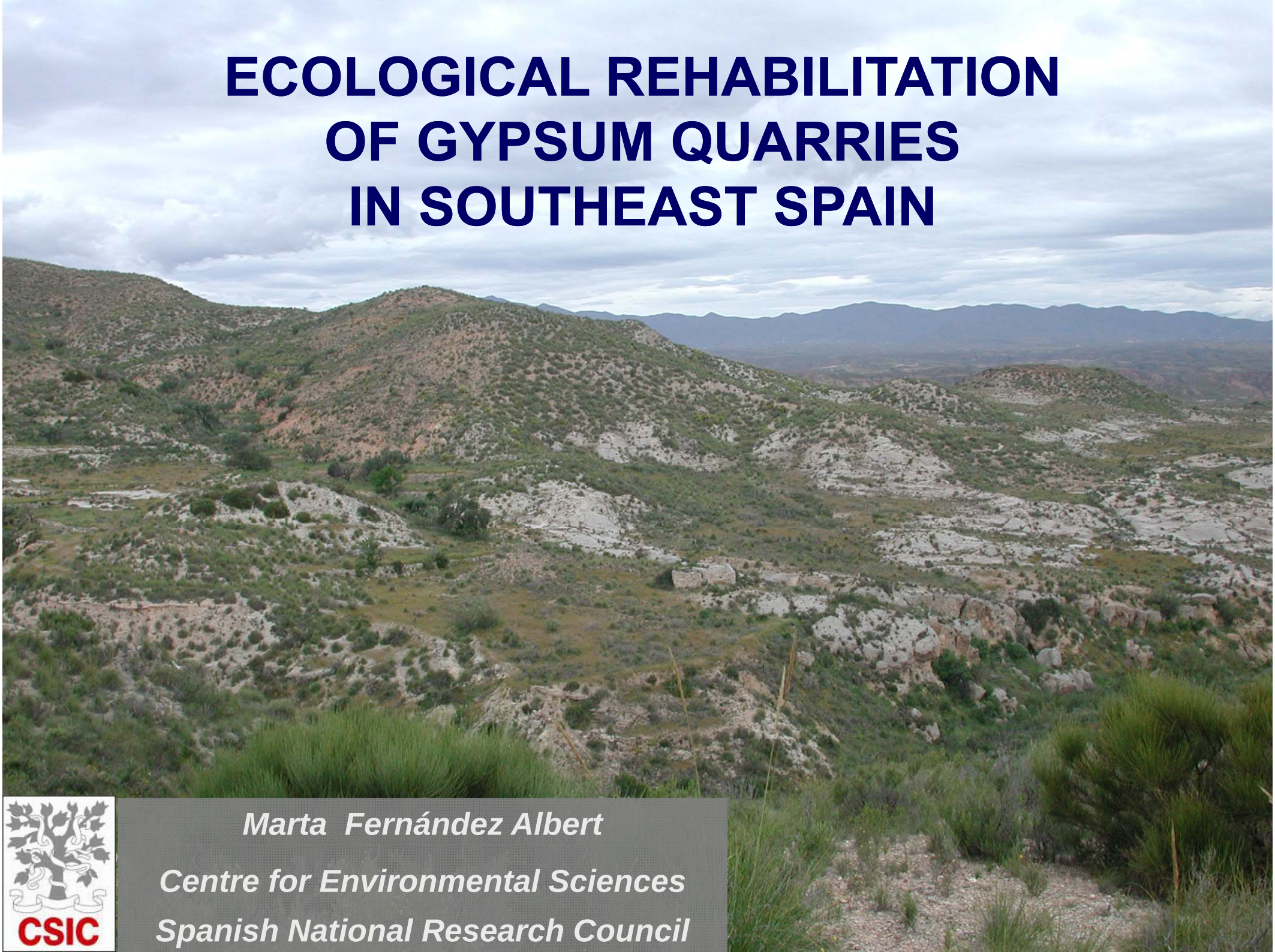
ECOLOGICAL REHABILITATION OF GYPSUM QUARRIES IN SOUTHEAST SPAIN



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INTRODUCTION

GYPSUM OUTCROPS:

- **Arid or semiarid climate**
- **EU Habitats Directive 92/43/CEE gives priority to their conservation**
- **Spain: The gypsum outcrops of Spain are the most outstanding for the conservation of gypsiferous flora.**

Helianthemum alypoides

GYPSUM PRODUCTION:

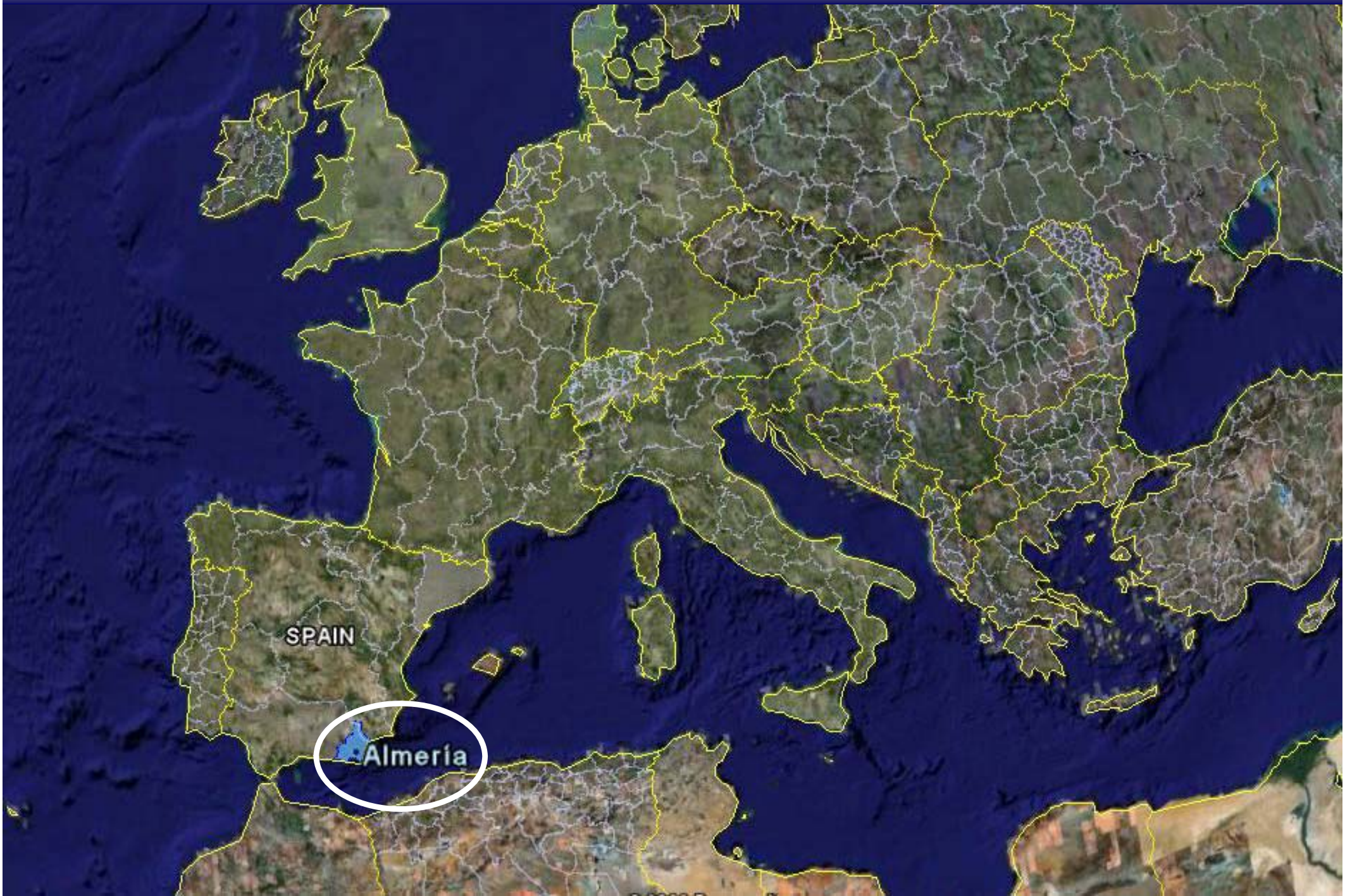
- **The big increase of gypsum extraction endangers the conservation of the plant communities**

Teucrium turredanum

REHABILITATION NEED:

- **Mining causes the destruction of the original soil**

SITE DESCRIPTION



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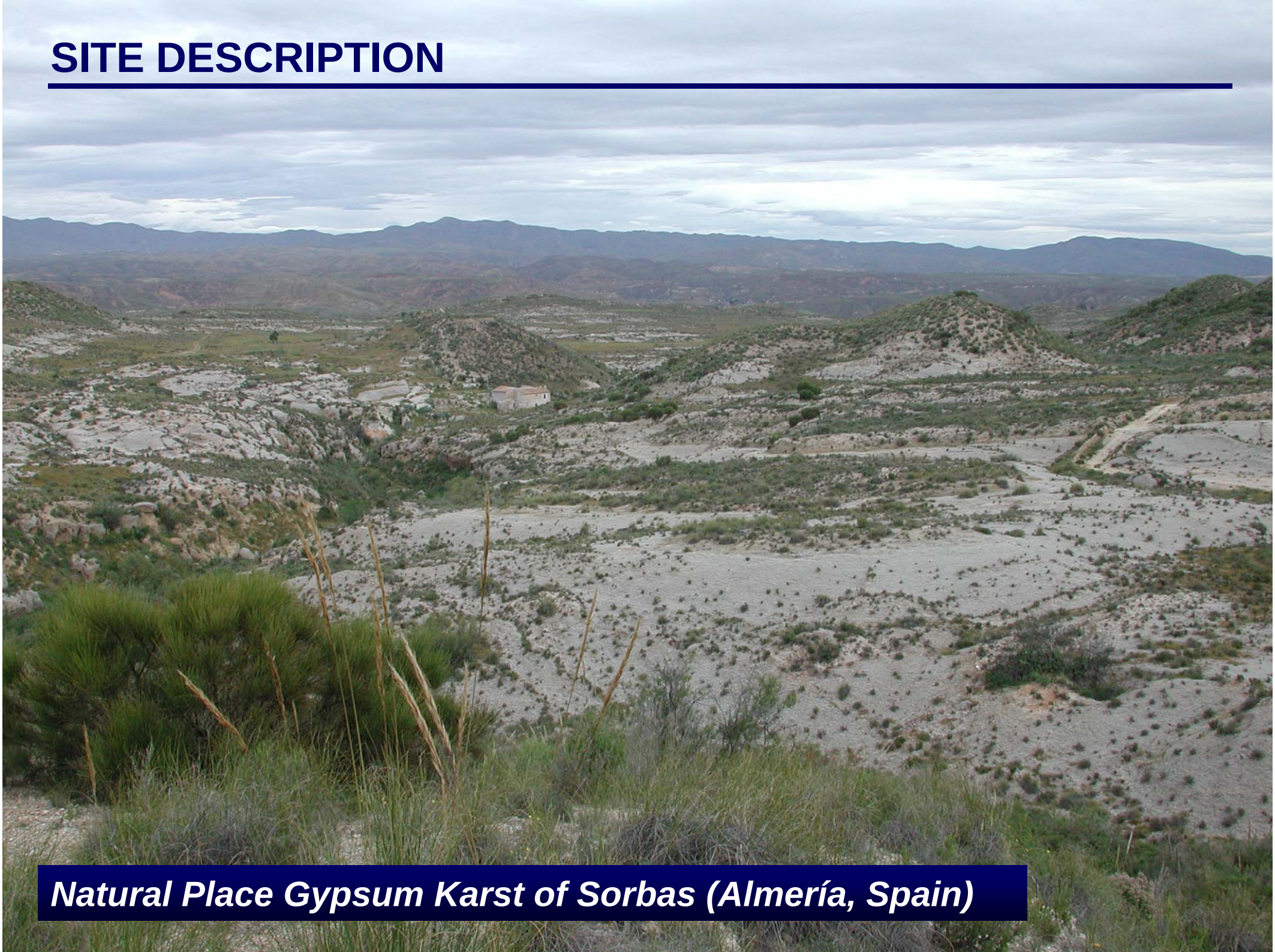


Natural Place Gypsum Karst of Sorbas (Almería, Spain)

REHABILITATION PROGRAM

1. Geomorphological reconstruction: surface remodelling with two different materials: gypsum fines and sterile materials.

↓

2. To evaluate the amendment necessity of the landfill soil with MSW compost

↓

3. Topsoiling: surface covered with topsoil

↓

4. Monitoring: soil development, plant growth, etc

↓

5. Control actions

↓

Ecological target

OBJECTIVE

GENERAL GOAL:

Determine the most suitable application rate for an organic amendment consisting of Municipal Solid Waste Compost intended for use in the rehabilitation of a gypsum quarry in semiarid environment of Southeastern Spain.

SPECIFIC OBJECTIVES:

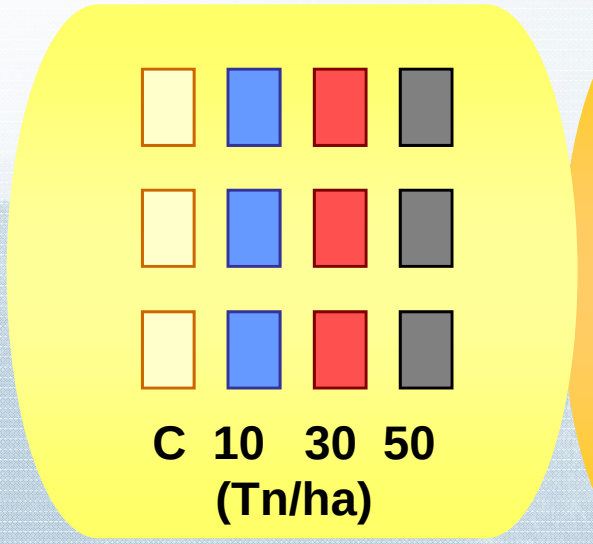
1. **Characterization of the two types of *Soil Forming Materials*: gypsum fines and sterile materials.**

2. **Influence of the two *Soil Forming Materials* on vegetation structure and their consequences for restoration.**

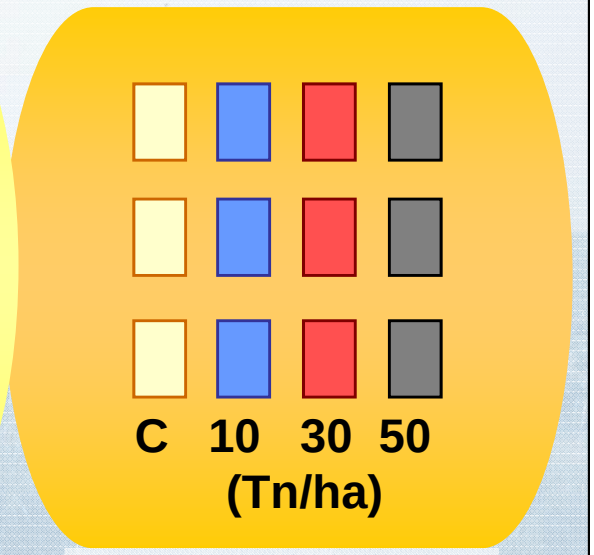
3. **Soil evolution of the two landfills (fines, sterile).**

4. **Comparative analysis with the main gypsicolous soils: Gypsic Regosol and Haplic Gypsisol**

MATERIALS AND METHODS



GYPSUM LANDFILL



STERILE LANDFILL

MATERIALS AND METHODS

1. **Initial characterization of the substrates: gypsum fines and sterile materials**
2. **Physical analysis**:
   - Granulometric analysis
   - Available water-holding capacity: difference between field capacity (FC) and permanent wilting point PWP)
   - Aggregate stability
3. **Physico-chemical analysis:**
   - pH factor
   - Electrical conductivity
4. **Chemical analysis:**
   - Total Organic Nitrogen
   - Total Organic Carbon
   - Assimilate Phosphorous
   - Assimilate macronutrients: Calcium, Potassium, Magnesium and Sodium
   - Sulphate ions
   - Carbonates
   - Micronutrients: Fe, Mn, Zn, Cu and B
   - Total elements: K, Ca, Na, Mg, Fe, Mn, Zn, Cu, Al, P, Ti, Ba, Sr, B, Pb, Ni, Cr, and Cd

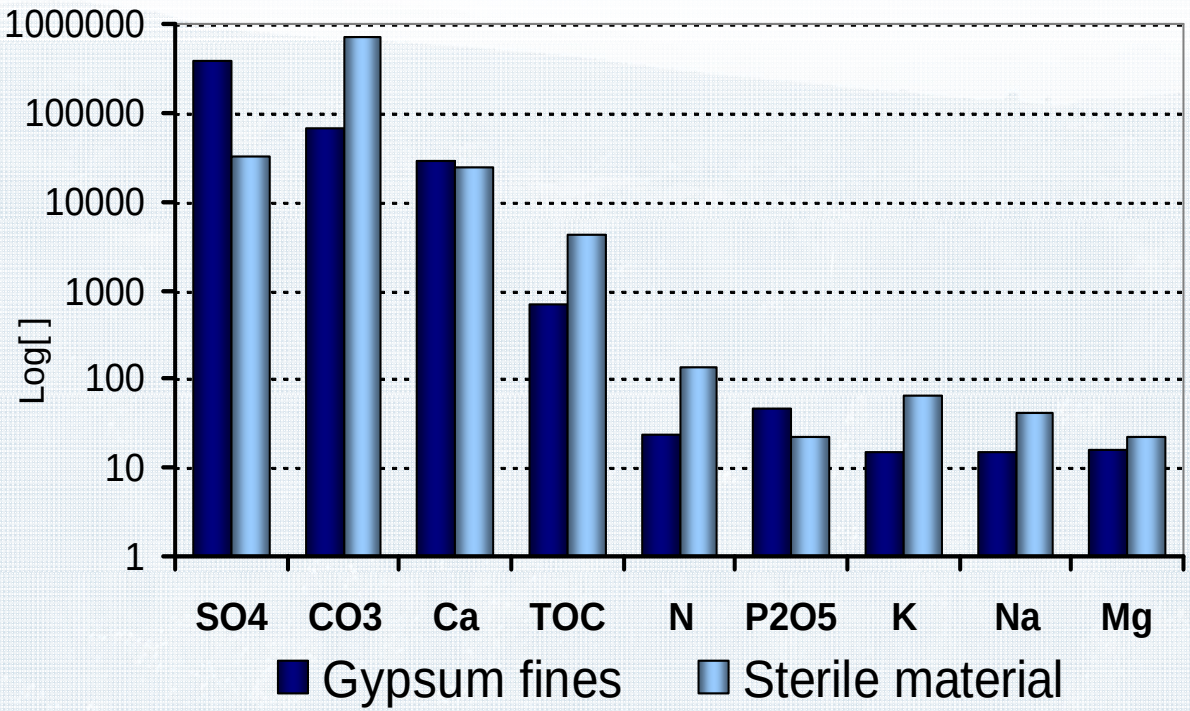
MATERIALS AND METHODS

5. **Analysis of organic matter**
    - Extraction and purification of humic acids
    - Characterization of humic acids: spectroscopy…
6. **Vegetation monitoring**:
    - Canopy cover for woody perennials and herbaceous annuals.

      Compared with meteorological factors:
        - Average maximum-minimum temperature
        - Annual rainfall
7. **Natural Place Study:**
    - Autochthonous Soils: Gypsic Regosol and Haplic Gypsisol
    - Native plant communities
8. **Statistical analysis:**
    - Analysis of variance ANOVA
    - Multivariate analysis:
        - Discriminant analysis, comparing soil samples with autochthonous gypsum soil profiles

RESULTS

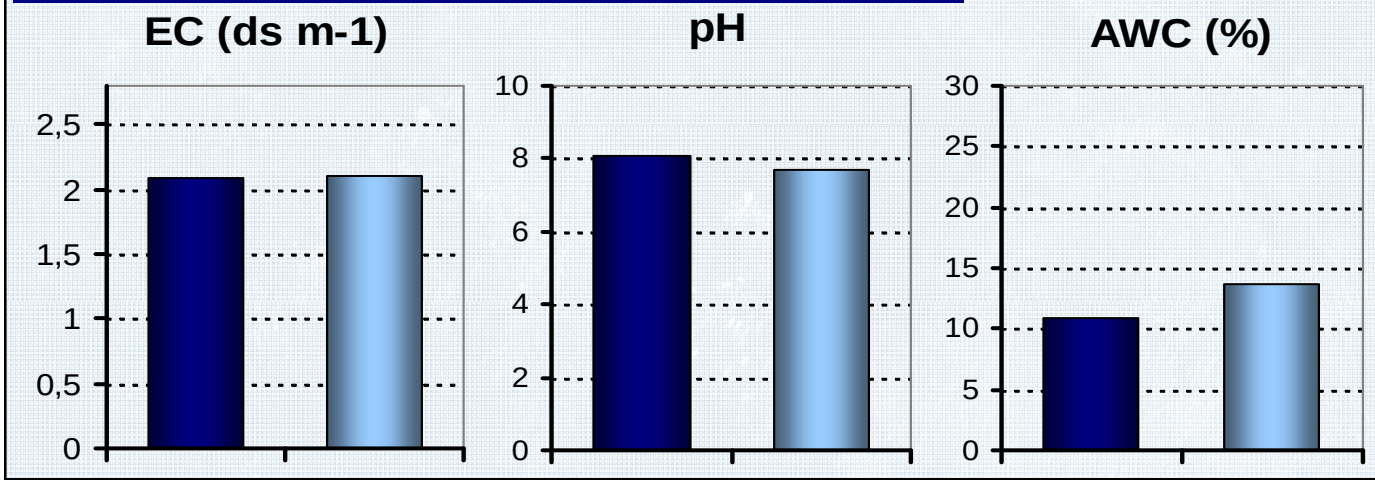
Chemical composition (lognormal scale)



	Gypsum fines	Sterile material
SO_4 (g kg^{-1})	384.52 ± 128.94	31.70 ± 6.46 *
CO_3 (g kg^{-1})	68.50 ± 15.02	726.75 ± 28.36 *
Ca (g kg^{-1})	28.63 ± 0.22	24.78 ± 1.51 *
COT (mg kg^{-1})	677.5 ± 316.2	4312.5 ± 478.2 *
N (mg kg^{-1})	23 ± 0	135 ± 6.12 *
P_2O_5 (mg kg^{-1})	45 ± 2.89	22.5 ± 1.44 *
K (mg kg^{-1})	15 ± 2.89	65 ± 6.77 *
Mg (mg kg^{-1})	16.25 ± 2.39	41.25 ± 1.25
Na (mg kg^{-1})	15 + 0	22.5 + 2.5 *

*Tukey´s test (*p<0.05)*

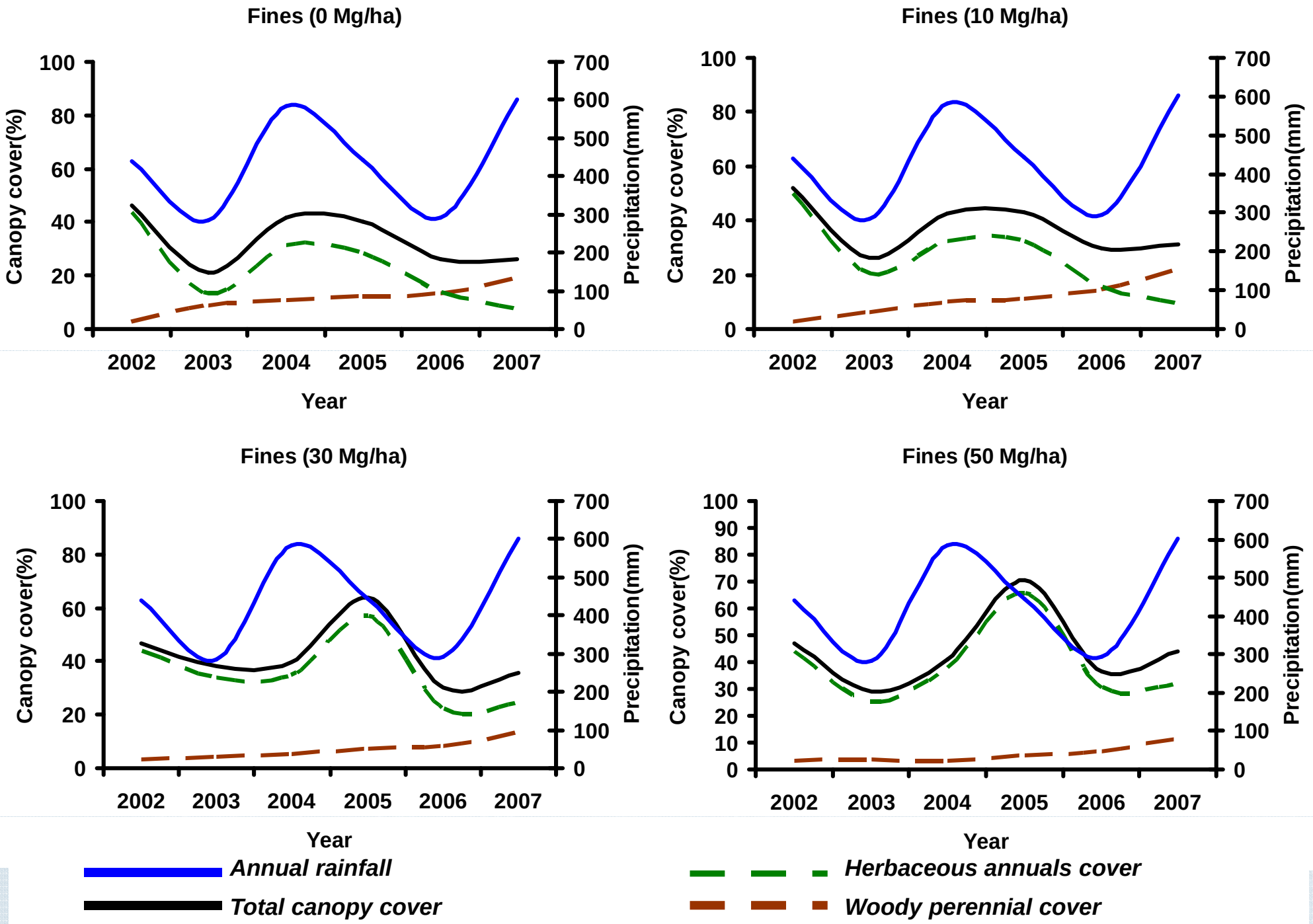
Physico-chemical properties



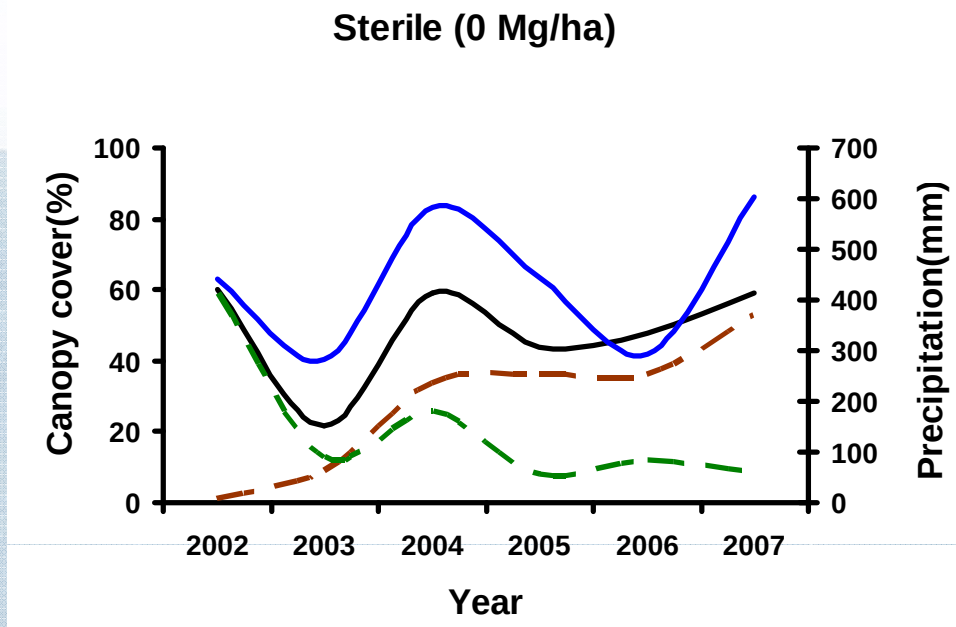
	Gypsum fines	Sterile material
EC (dS m^{-1})	2.09 ± 0.08	2.10 ± 0.06
pH	8.07 + 0.10	7.70 + 0.11
AWC (%)	10.9	13.7 *

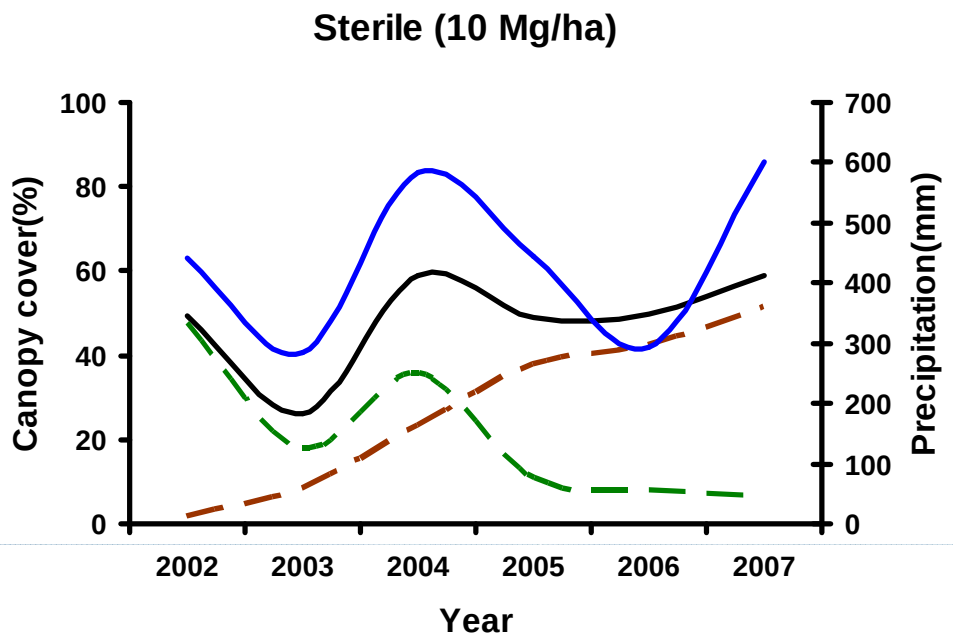
Tukey´s test (p<0.05)

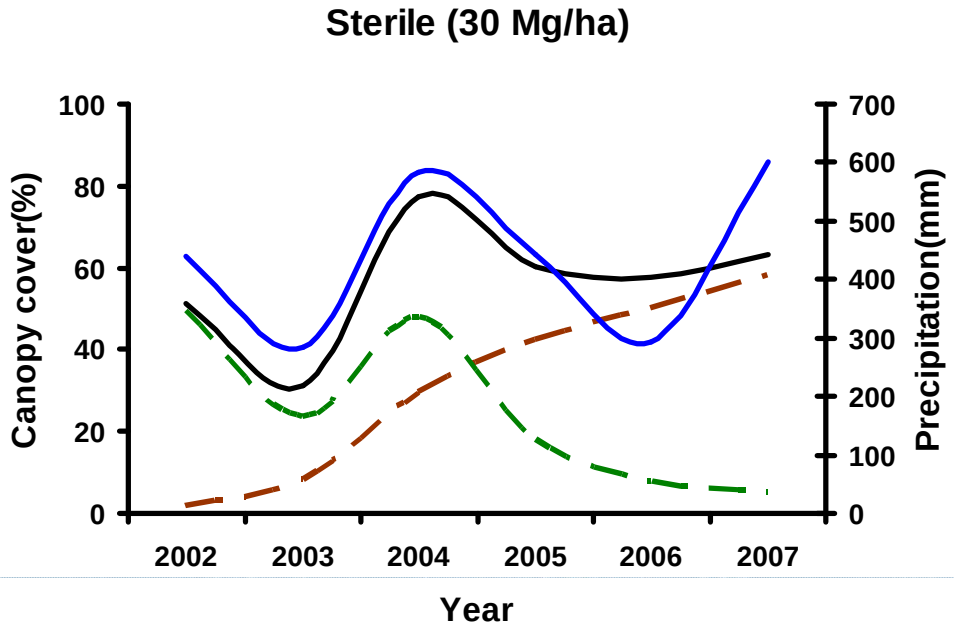
RESULTS

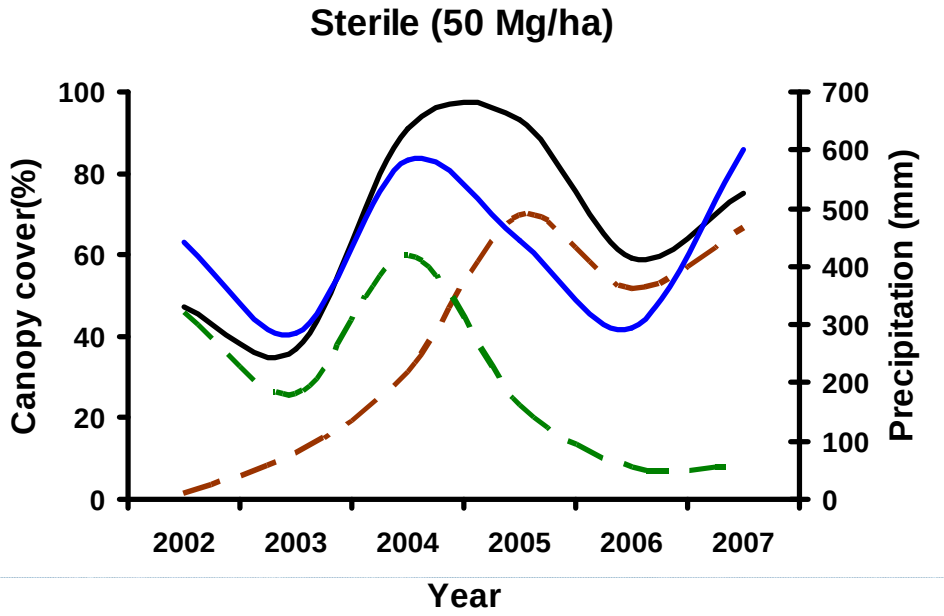

Fines (0 Mg/ha)
Fines (10 Mg/ha)
Fines (30 Mg/ha)
Fines (50 Mg/ha)
Canopy cover(%)
Precipitation(mm)
Year
2002
2003
2004
2005
2006
2007
Annual rainfall
Total canopy cover
Herbaceous annuals cover
Woody perennial cover

RESULTS









Annual rainfall

Total canopy cover

Herbaceous annuals cover

Woody perennial cover

RESULTS

GYPSUM LANDFILLS:

Higher content of Sulphates & Calcium

Lower water content
(high compactability)

Herbaceous predominance

STERILE LANDFILLS:

Higher content of Carbonates & general nutrients

Higher Water contain
(heterogeneous texture)

Perennial/shrubs predominance

PRELIMINARY CONCLUSIONS

1. **It has been demonstrated that landfill materials generated from this gypsum quarry (gypsum fines and sterile substrates) present significant different properties.**

2. **These differences extremely affect the development of plant communities. In this specific case *Sterile* material favors shrubland communities while *Gypsum Fines* favors herbaceous communities.**