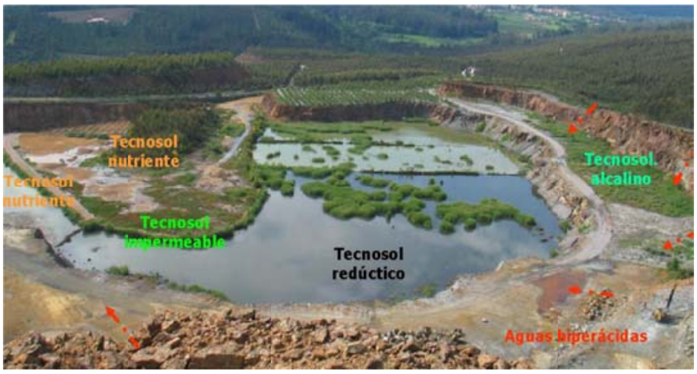
LANDCARE FOR THE FUTURE
SANTIAGO DE COMPOSTELA, JULY 16-18, 2018

Co-funded by the Erasmus+ Programme of the European Union

FIELD TRIP 1



RESTORATION OF THE TOURO MINE

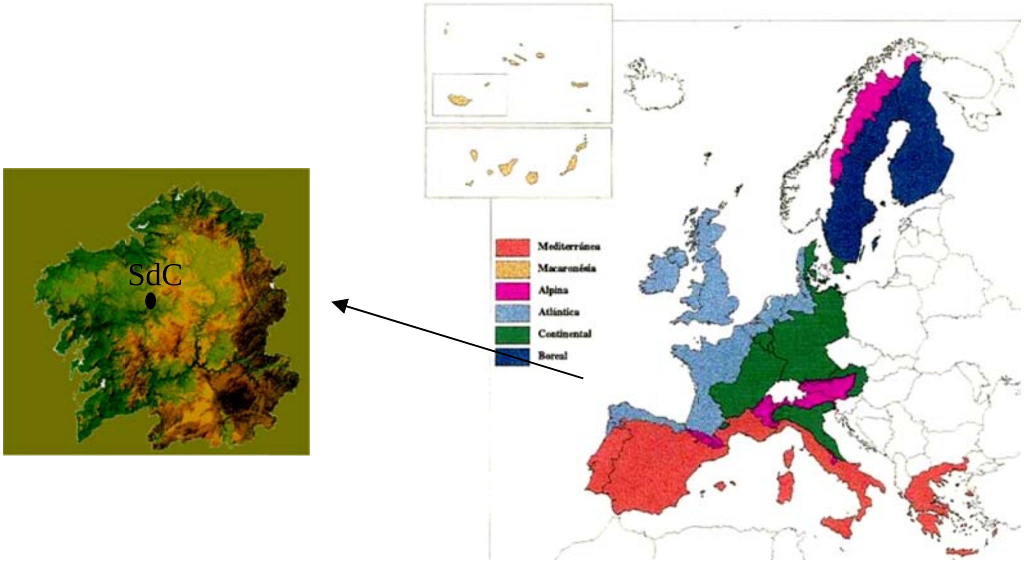
EMERGENCY STABILIZATION PLANNING AND TECHNIQUES IN BURNT AREAS

USC Universidade de Santiago de Compostela
Xunta de Galicia Consellería do Medio Rural
U Lisboa Universidade de Lisboa
EDIA Empresa de Desenvolvimento e Infra-estruturas do Alqueva, S.A.
Consiglio Nazionale delle Ricerche
WEST Systems
National and Kapodistrian University of Athens
Archipelagos Institute of Marine Conservation

GENERAL OVERVIEW

Galicia is an autonomous community in northwestern Spain comprising the provinces of A Coruña, Lugo, Ourense and Pontevedra. It is bordered by Portugal to the south. Galicia has approximately 2.78 million inhabitants (as of 2008), with the highest concentrations in two coastal areas (A Coruña and Vigo). The capital is Santiago de Compostela.

Galicia has its own historic language, Galician (*Galego*), which is related to Portuguese. Although essentially derived from Latin, Galician also has Celtic and Germanic influences.



The climate of the area is sub-humid Mediterranean with a centro-European trend. The annual average rainfall in the area is 1000-1900 mm, and the temperature, 13-16 ºC. The wettest month is November and the driest August. The lowest mean monthly temperature (5.4 ºC) occurs in January.

A wide diversity of geological substrates are found in Galicia, but two materials occur in more than 90% of the area: granitic rocks, and rocks that have undergone a low degree of metamorphism (schists, phyllites, slates…). There are also basic and metabasic rocks (gabbros, amphibolites, granulites), ultrabasic rocks (dunites), small enclaves of limestones, quartzites and sandstones intercalated between the slates and phyllites, and a large number of sedimentary rocks.

The forest soils, mainly developed from granitic rocks, schist and shale, are classified as Humic or Distric Cambisols and Alumi-humic Umbrisol. They usually have a loam or sandy loam texture and are well drained. The clay fraction is dominated by minerals of low surface reactivity, such as kaolinite and oxides of Al and Fe. The A horizon is rich in organic matter, strongly acidic, with low CEC and low levels of available P, Ca, Mg and K. The soil humidity and temperature regimes are Udic (mean period with partial drought, 2 months) and Mesic (mean frost-free period, 10 months), respectively.

Land uses

Forests cover some 40 % of the land in the region, shrubland a further 30 %, and the rest of the land is classified as agricultural land. Three types of forest can be distinguished. The most important are the coniferous plantations, mainly pines and fir. Natural forests are made up of oak, chestnut and birch. The third type is eucalyptus plantations.

Galicia produces more than 50% of the national timber supply in Spain, although it comprises only 6% of the country's land base.

RESTORATION OF THE TOURO MINE: WATER CONSERVATION AND CARBON SEQUESTRATION

Felipe Macías-Vázquez, Felipe Macías-García, Juan Antelo and María L. Fernández Marcos, *University of Santiago de Compostela*

The Touro mine is located in a formation of amphibolites mineralized with metal sulphides, mainly pyrite and pyrrhotite. This open cast mine was originally exploited for copper (1974-1988) and more recently for building aggregate. After the mine was closed, the pit faces, spoil dumps, trituration and flotation installations, and the sludge pond were abandoned to the elements for several years. As part of the restoration work, which began in the late 1990s, some of the faces have been partially or totally covered with water and the sludge pond has been partially filled in with soils from the area, and revegetated.

The most important environmental problem at the mine is the acidity generated by sulphide oxidation. This may occur via inorganic mechanisms in which the initial stages are characteristic of environments that are not excessively acidified, and in which O_2 acts as the oxidizing agent, and by other more advanced mechanisms characteristic of strongly acidified environments, in which the main oxidizing agent is Fe^{3+} and in which the reactions are usually catalyzed by specialized bacteria.

$$2FeS_2 + 7O_2 + 2H_2O \leftrightarrows 2Fe^{2+} + 4SO_4^{=} + 4H^+$$
$$4\ Fe^{2+} + O_2 + 4\ H^+ \leftrightarrows 4\ Fe^{3+} + 2\ H_2O$$
$$Fe^{3+} + 3H_2O \leftrightarrows Fe(OH)_3 + 3H^+$$
$$FeS_2 + 14Fe^{3+} + 8H_2O \leftrightarrows 15Fe^{2+} + 2SO_4^{=} + 16H^+$$

RECOVERY OF THE SOILS AND WATER

The uncontrolled oxidation of sulphides generates hyperacidic (pH 2-3) and hyperoxidizing (> 500 mv) soils and waters, with high electrical conductivity and high concentrataions of sulphates, Fe, Al and Ca, in which only extremophilic and some acidophilic microorganisms can survive.

At the Touro mine, natural processes and the posterior mining activities have brought different sulphide-rich materials to the surface. These materials may be susceptible to oxidation by the above-mentioned mechanisms. Three main groups of materials can be distinguished:

1.- Fresh or scarcely weathered rock containing sulphides
2.- Dumps or piles of excavated material
3.- Decantation sludges

In addition to the physical limitations of the Touro mine soils, their hyperacidic nature and high concentrations of dissolved Al, the soils are also deficient in nutrients such as P, K, and N, and as a result of the absence or scarcity of biomass, contain very little C. This prevents the soils from recovering by themselves, by natural means.

Waste products from industrial processes are often used in the recovery of degraded and or contaminated mine soils, as waste products may have properties that eliminate or mitigate the plant growth limiting properties of the mine soils.

Materials with one or more of the following properties are suitable for restoration purposes:

1.- Reducing nature: Substances capable of decreasing the redox potential below the stability field of Fe^{3+} by consuming oxygen are suitable, because they slow down sulphide oxidation, thus decreasing the production of acidity. The following materials are suitable: triturated pruning waste and forest clearing remains, sewage sludge, agrifood waste, elemental Fe, turf, good quality compost and any readily degradable material rich in labile organic matter.

2.- pH amending capacity: Maintaining the pH above 3.5 involves the elimination of Fe^{3+}, which would drastically reduce the generation of acidity. If the pH is maintained at pH > 5.5 in the output waters, this will allow the survival of aquatic life, including fish populations. Materials used to reduce the acidity include agricultural lime and other agro-industrial waste products, such as biomass ash, dregs, sewage sludge, mussel shells and demolition waste.

3.- Capacity for adsorption of sulphates: This occurs at pH< 6.0 in edaphic or sedimentary materials or industrial waste rich in oxides or hydroxides of Fe, Al, Mn and Ti etc., especially if they are amorphous or of a low degree of order. The waste products used include the red sludges derived from bauxite and Al hydroxides generated in aluminium smelters, etc.

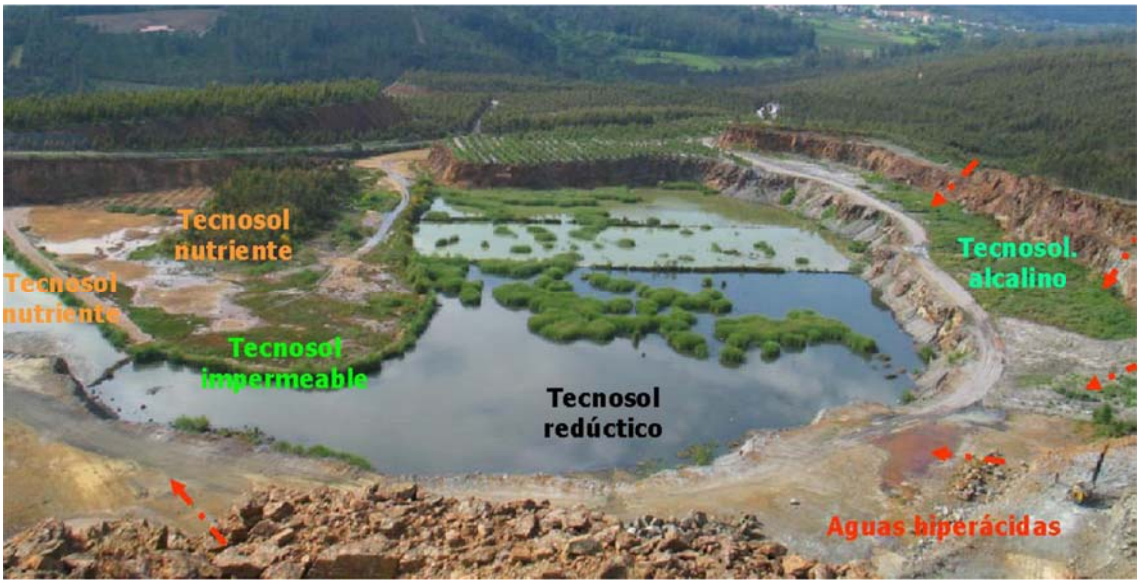
4.- Capacity for adsorption of heavy metals: As well as precipitation mechanisms based on increasing the pH, the retention of metals by surface adsorption is also suitable. The above-mentioned materials can fix metals, as can others such as turf, humiferous soils, waste from fungus production, etc.

5.- Fertilizing capacity: the following are used in addition to synthetic fertilizers: organic fertilizers (manure, slurry, compost..), plant waste (especially leguminous waste) and agrifood waste.

The application of different types of waste has been tested at the Touro mine and it was found that waste products with one or more of the previously mentioned properties are suitable for restoration purposes (alkalizers, reducing agents, adsorbents or fertilizers).

This prompted the use of “Technosols”, which basically consist of mixtures of the above materials in different proportions. Different recipes are created as required, i.e. different substances that are suitable for correcting soils and waters are used depending on the properties required.

This has also led to the valorization of waste to produce “Technosols”, which comply with the soil functions defined by the European Strategy for Soil Protection. Many of these “Taylor-made Technosols” have already been successfully used, and their capacity to recover contaminated soils and waters, and their compliance with main soil functions (i.e. for carbon sequestration, production of food and fibres, and as a biological habitat) have been demonstrated.



Development of one of the zones where correction of acidic waters has been achieved by the use of Technosols and creation of a wetland environment.

WHAT ARE WE GOING TO LEARN?
The environmental problems associated with pyrite oxidation
The influence of geochemisty on the mobility of heavy metals
Techniques to restore contaminated areas
What is a technosol and how it can be used

WHAT ARE WE GOING TO DISCUSS?
Techniques to work with students in contaminated areas (learning by doing)
Education and awareness strategies to encourage the restoration of contaminated areas

EMERGENCY STABILIZATION PLANNING AND TECHNIQUES IN BURNT AREAS: THE WILDFIRE OF MONTE FARO, CHANTADA

Alberto Ledo[1], Miguel López[1], José Antonio Vega[2], María T. Fontúrbel[2], Vicente Otero[3], Noemí Santiago[3], Colleen Fugate[3], Otilia Reyes[3], Sheila F. Riveiro[3], Beatriz Omil[3] and Agustín Merino[3], Cristina Santín[4]

[1] VIII Forest District, Xunta de Galicia, Spain. [2] Forest Research Center of Lourizán, Xunta de Galicia, Spain. [3] Platando Cara ó Lume, University of Santiado de Compostela, Spain. [4] Swansea University, UK.

BEFORE THE VISIT

https://youtu.be/L-7wXlKPWfg

https://youtu.be/5y9WOzMRXyM

Characteristics of the wildfire

The fire occurred at Monte Faro, in the municipality of Chantada, between the 12th and the 17th of October 2017. The area burned was 318 ha. The fire occurred under conditions that favored the spread of fire.

The mild climate of that year allowed a large accumulation of dry biomass in the forest and scrubland. In addition, during those days, the wind speed was higher than 70 km/hr, relative humidity was less than 30% and temperature higher than 30 º C. In these conditions controlling the fire was difficult.

During the field trip we will explain how the extinction work was carried out and also the environmental impacts that resulted from the fire. The measures that were taken to prevent the degradation of soils and waters were also discussed.

During the extinction, in addition to the land brigades, which had to use heavy machinery, such as bulldozers, amphibious-type aerial vehicles and helicopters also collaborated.

Damage to vegetation and soils

The fire affected an area of natural value, included in the Natura 2000 Network.

The most affected vegetation were the dense bushes of *Ulex europaeus* (gorse) and *Pterospartum tridentatum*. Young repopulations of Scots pine (*Pinus sylvestris*) and maritime pine (*Pinus pinaster*) were also lost. In addition, some deciduous trees were also partially affected.

The assessment of the damage to the soil is important to evaluate the subsequent recovery of ecosystems. A system of soil burn severity based on visual observation of the forest floor and uppermost mineral soil layer was used. Five levels of soil burnt severities are distinguished. In most of the area the soil burnt severity was moderate. However, in approximately 8 ha, the soils were very affected by the very high temperatures reached during the fire. In these areas the risk of erosion is extremely high.

To ensure the recovery of ecosystems, a protocol of urgent soil protection techniques against erosion was implemented at Mount Faro. These techniques focused mainly on the areas of greater severity, especially those of more slope and close to the water courses. The most important protection technique was mulching with cereal straw. The application was made by helicopter.

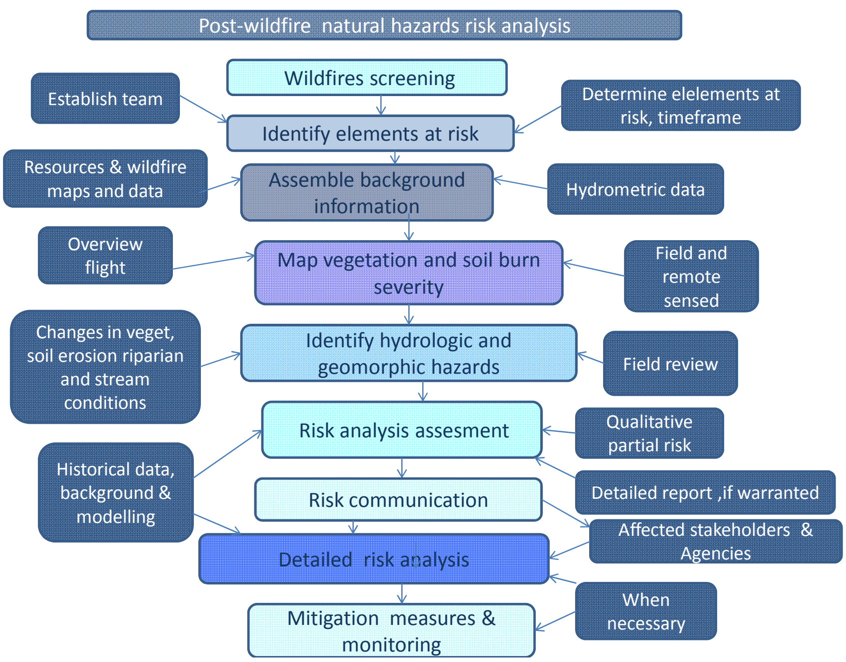
The application of straw mulching was very effective, as we will be able to observe by comparison between treated and untreated areas. In the latter, soil erosion is clearly visible.

In some areas, instead of straw, mulching was done using the remains of burnt vegetation and logging residues. However, with the burnt residues you cannot cover the soil as effectively as with the straw.

System of Soil burn severity (SBS) levels used in Galicia, through the immediate post-fire soil and duff visual characteristics

Soil burn severity (SBS) levels	Forest floor (Oi+Oe+Oa)	Mineral soil (Ah horizon)
0	No evidence of fire	No evidence of fire
1	Oa layer (lower duff) partially or totally intact	Undisturbed
2	Oa layer totally charred and covering mineral soil. There may be ash.	Undisturbed
3	Forest floor completely consumed (bare soil). There may be ash.	Undisturbed. Soil structure unaffected. SOM not consumed. Surface fine roots not burned
4	Forest floor completely consumed (bare soil). There is no charred residue. Thick layer of ash.	Soil structure affected. SOM consumed in the upper layer. Surface soil color altered (grey). Surface fine roots burned
5	Forest floor completely consumed (bare soil). There is no charred residue.	Soil structure affected. SOM consumed in the upper layer. Surface soil color altered (reddish). Surface fine roots burned

Post-wildfire emergency stabilization planning



Outline of the procedure for assessment of post-wildfire natural hazards used in Galicia (Forest Research Centre of Lourizán, Xunta de Galicia).

The protection measures also included strategies to reduce the sediment load in waters from post-fire soil erosion. For this, check dams were built. The check dams are barriers installed in the channels that slow the speed of the water and trap the sediments. These structures were made with branches of the burnt trees from the burnt area.

Performance of heli-mulching in Monte Faro

What we are going to learn?

- The behavior of the fire and firefighting strategy
- Some causes of the wildfire in the region: fuel load, forest management, others.
- The damages of the fire on the vegetation and capacity of plants to regenerate
- To distinguished different soil burnt severities which can will be useful to design the emergency stabilization planning and techniques
- The plant revegetation: species and its relation with the soil burn severities

What are we going to discuss?

- Techniques to work with students in burnt areas (learning by doing)
- Education and awareness strategies to prevent wildfires and encourage the restoration of burnt areas (social engagement)

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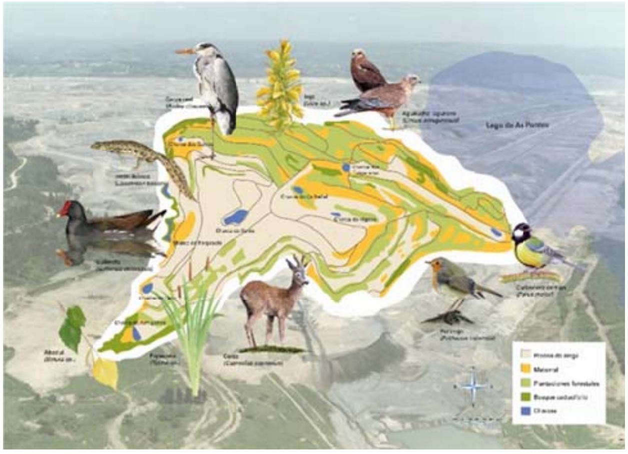
SANTIAGO DE COMPOSTELA, JULY 16-18, 2018

FIELD TRIP 2



THE RESTORED MINE OF AS PONTES

DONIÑOS 'S DUNE SYSTEM AND WETLANDS

USC UNIVERSIDADE DE SANTIAGO DE COMPOSTELA

XUNTA DE GALICIA CONSELLERÍA DO MEDIO RURAL

U LISBOA UNIVERSIDADE DE LISBOA

EDIA Empresa de Desenvolvimento e Infra-estruturas do Alqueva, S.A.

Consiglio Nazionale delle Ricerche

WEST Systems

National and Kapodistrian UNIVERSITY OF ATHENS

ARCHIPELAGOS INSTITUTE OF MARINE CONSERVATION

THE RESTORED MINE OF AS PONTES (SPAIN): THE EDUCATIONAL POSIBILITIES OF THE NEW ENVIRONMENTS GENERATED

Agustín Merino[1], Ramón Valle[2], José Antonio Méndez Lolo[2], Patricia M. Rodríguez-González[3], Xoan Carlos Rodríguez[4], Juana Pardo[5], Álvaro Díaz de Freijo[6]; Eva Hernández-Bruguera[6]

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BEFORE THE VISIT

Video:
https://www.youtube.com/watch?v=G1TxRiCMRl4

Guide for visitors, including information about the new different environmental ecosystems and practical exercises to carried out during the visit:
https://www.dropbox.com/s/jzeodyw6dmxtndd/GUIA%20AS%20PONTES_VERSION%205JUL2018.pdf?dl=0

The restoration of the mine of As Pontes (Spain)

The restoration of the mine of As Pontes (Spain) was one of the first (1981-2012) and greatest environmental rehabilitation challenges worldwide. The restored area (24 km^2) is made up by a lake (15 km^2 area and 400 m depth), which coincides with the hole of the lignite exploitation, and a big dump (11.5 km^2 area and 200 m height), currently re-vegetated, generated by the storage of mining tailings. The most important limitations of the tailings for natural revegetation were high acidity and lower porosity. Reclamation was based on the application of organic agricultural and urban residues over the surface dump. Nowadays, the former dump is covered by a great variety of different ecosystems (grasslands, shrub lands, tree systems and wetlands). Due to the great challenge of this restoration, this new landscape deserves to be visited by students, environmental educators and scholars.

2003

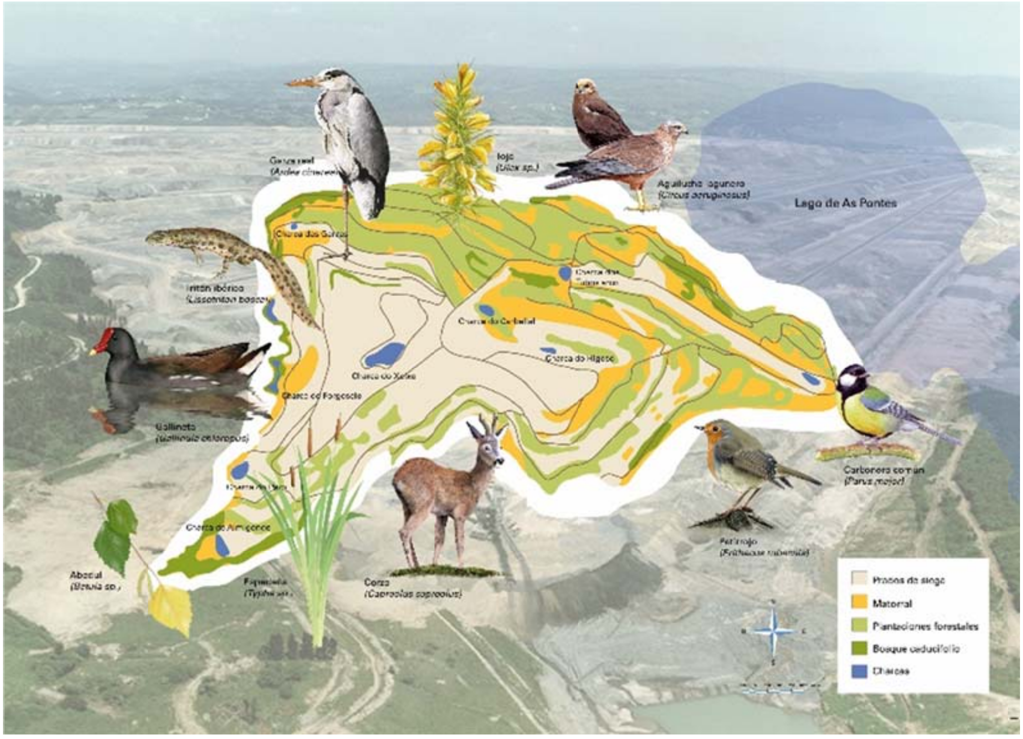
2017

Evolution of the Seixo pond from its preparation to the present

The EDUCA AS PONTES project

The objective of EDUCA AS PONTES Project (http://restauraspontes.es) was to develop innovative educational resources to demonstrate the restoration process, to study the biodiversity trajectories and the ecosystem services arising from the new environments, in order to promote society awareness on land degradation. The educational resources were developed through an interactive participatory approach, testing and discussing the materials and activities during dedicated workshops with teachers from secondary schools and vocational studies.

As educational materials, a guide for educators, a field notebook for students and different explanatory panels, were developed. These activities are developed throughout an “educational tour” of 20 km length, which runs through the different environments. The tour is made up by different short footpaths and visits to specific points in which the visitors learn about the limitations of the dump for the vegetation establishment, the restoration techniques that were employed and the characteristics of the current ecosystems. The visitors participate actively in debates (soil formation, biodiversity, trophic chains, climate change), explorations (short walks), experimentations (simple analysis of water, aquatic species identification) and educational games.



Distribution of the different biotopes (light pink: grasslands; yellow: shrubs; green: forest formations; blue: wetlands) in the restored mining area of As Pontes (12 km^2)

Examples of practical activities in the restored mining area of As Pontes

DURING THE VISIT

WHAT WE ARE GOING TO LEARN?

The environmental problems associated with pyrite oxidation in mine reclamation
Techniques to restore large mine areas
Landform design in mine rehabilitation

WHAT WE ARE GOING TO DISCUSS?

Approaches to work with students in restored mine areas (learning by doing)
Education and awareness strategies to encourage the restoration of contaminated areas

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Educational posters:

Four posters have been designed showing the functioning of the different ecosystems and the ecological benefits of the restoration

DONIÑOS 'S DUNE SYSTEM AND WETLANDS: FACING UP THE GLOBAL CHANGE AND THE TOURISM CHALLENGES

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The Doniños wetlands and coastal dunes are located in the north-western Iberian Peninsula, close to the Ria de Ferrol (A Coruña province, Galicia, Spain) occupying a 800 m wide valley over the Ferrol Massif which is made up of Hercinic granitoids (Bellido Mulas et al.,1987). The whole back-barrier system has an approximate extension of 150 Ha. Of these, a coastal lagoon extends in a surface area of about 32 Ha. The mean annual precipitation in the area is around 970 mm per year and the mean temperature for January and July are 9.3°C and 17.8°C respectively (Carballeira et al., 1983).

Figure 1. Location of Doniños coastal wetlands and dune system.

The Doniños wetlands and coastal dunes are integrated in the Costa Ártabra Natura 2000 Site of Community Importance (SCI ES1110002) since 2004, and was declared Special Area of Conservation in 2014, occupying an area of 7.546 ha. The SCI includes several natural habitats including 13 priority habitats of the Directive 43/92/CEE.

Among the dune habitats that will be visited during the field trip, it is remarkable the presence of the particularly fragile 2130* priority habitat "*Fixed coastal dunes with herbaceous vegetation (grey dunes)*", and 2150* priority habitat "*Atlantic decalcified fixed dunes (Calluno-Ulicetea)*". The Doniños dune system also exhibits a good representation of 2120 "*shifting dunes along the shoreline with Ammophila arenaria (white dunes)*" and of 2110 "*Embryonic shifting dunes*", 2230 "*Malcolmietalia dune grasslands*" *and 2260* "*Cisto-Lavenduletalia dune sclerophyllous scrubs*". In addition, where the underlying water table reaches the surface, the system is diversified by the presence of 2190 "*humid dune slacks*", the wetland component of dune systems.

Figure 2. Images of the dune system in Doniños (1/12/2015)

The species present in these dune systems are especially vulnerable to the habitat transformation derived from increasing anthropogenic pressures such as tourism. For example the plant *Antirrhinum majus* subsp. *linkianum* included as Endangered (EN) in the IUCN Red List of Threatened Plants, presents only five populations with reduced number of individuals in the Costa Ártabra SIC, across whole Spain. These typical dune taxa suffer especially from the construction and access ways related with touristic pressure. An additional consequence of these human activities are the creation of pathways for invasive exotic species.

The Doniños coastal lagoon represents another priority habitat (1150*). The Doniños coastal lagoon is almost permanently closed by a 1.7 km long sand barrier which extends in a S-N direction and occupies 85,700 Ha (Guitian Rivera, 1987). A small 2.8 km long river feeds the basin from the east. The average depth of the lagoon is about 11-12 m being reduced when occasional breaching of the barrier occurs during heavy winter storms. Besides this, freshwater can be evacuated to the sea through a narrow point in the northern part of the barrier during episodes of maximum infilling coincident with large rainfall events. However, water exchange with the open sea is generally small. The aquatic plants living in the Doniños Lagoon are characteristic of the *Scirpo-Phragmitetum* association with *Najas marina* and *Utricularia* sp. *Alnus glutinosa* and *Salix atrocinerea* constitute the residual forest with *Quercus robur* as accompanying taxon (Guitian Rivera, 1987). Planted Pinus-Eucalyptus forest occupies the slopes of the adjacent mountains. Although the Holocene vegetation history in the nearby region is unknown, there is some evidence from marine sediments in the Ria de Ferrol that a mixed deciduous forest was the dominant formation at 3,000 years BP (Santos et al., 2001).

What we are going to learn?

-Development / evolution of coastal dunes
-The dynamics of coastal ecosystems as a basis for their sustainable management
-Erosion, preservation of coastal dunes within a context of climate change
-The environmental problems of dune systems associated with tourism
-Strategies to preserve dune systems

What we are going to discuss?

-Understanding how dunes are developed / increasing awareness on fragile systems
-Techniques to work with students/population in dune systems (learning by doing)
-Education and awareness strategies to preserve and restore dune areas

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