LAND DEGRADATION AND REHABILITATION IN MEDITERRANEAN ENVIRONMENTS

FIELD TRIP

Figueiras (Santiago de Compostela) wildfire

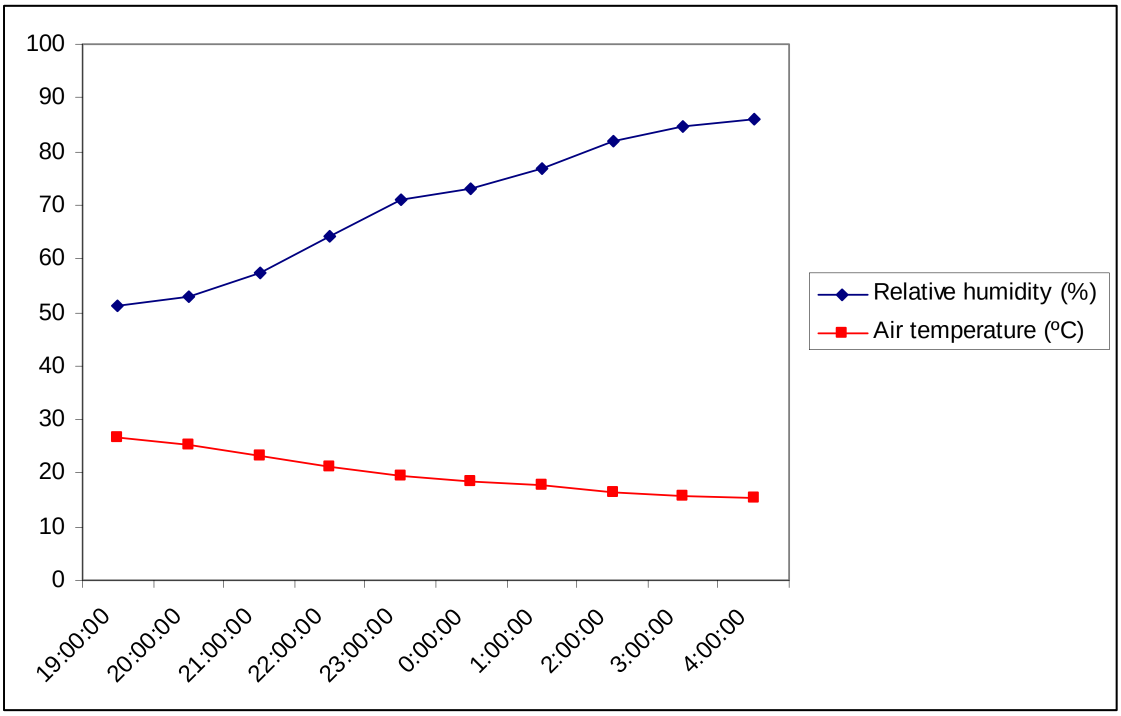
The fire started at 19:44 of August 9th and it was controlled on August 10th at 4:27. It was totally extinguished on August 10th at 17:30. Suppression activities took 8 hours and 43 minutes whereas mop up tasks to eliminate the smouldering phase lasted 13 hours and 3 minutes. That means an elevated probability to reach high levels of soil burn severity was present, as you can see on the site. In the suppression and mop up activities 1 incident commander, 4 forest rangers, 8 brigades, 10 water tank trucks, 2 bulldozer, 2 helicopters and 2 airplanes were involved.

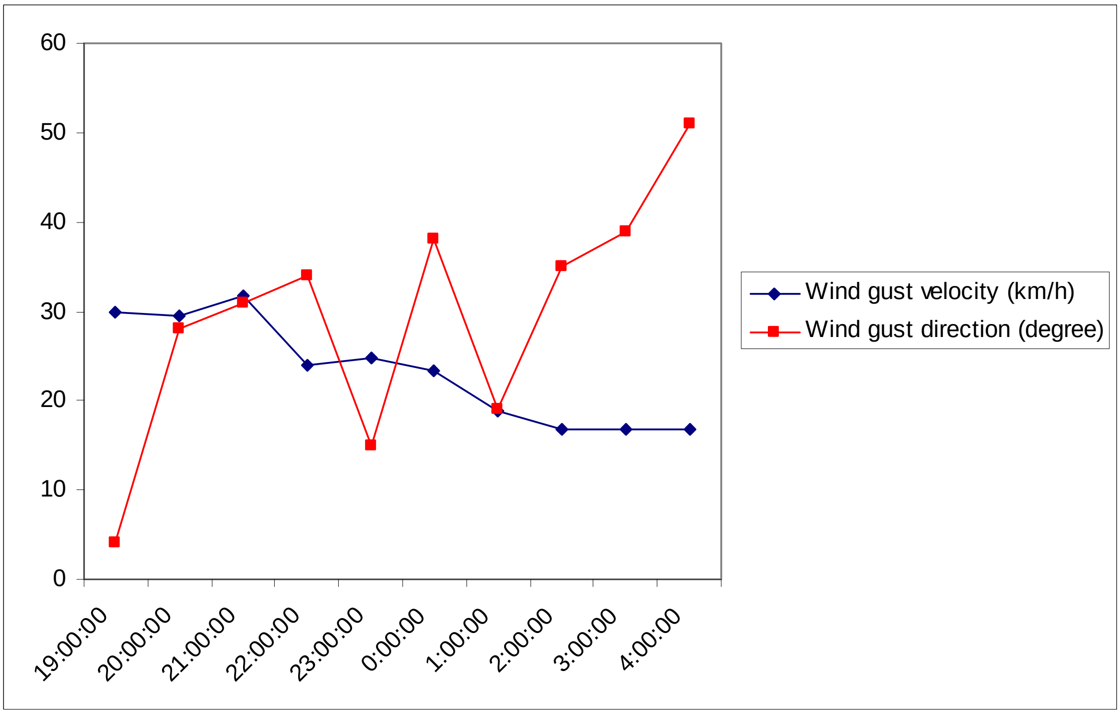
The total affected area was 28,47 hectares, 18 of them are mostly covered by a *Eucalyptus globulus* reforestation and small patches of deciduous trees closed to the creek. The rest are covered by shrub, dominated by gorse (*U. europaeus*).

Meteorological conditions before and during fire

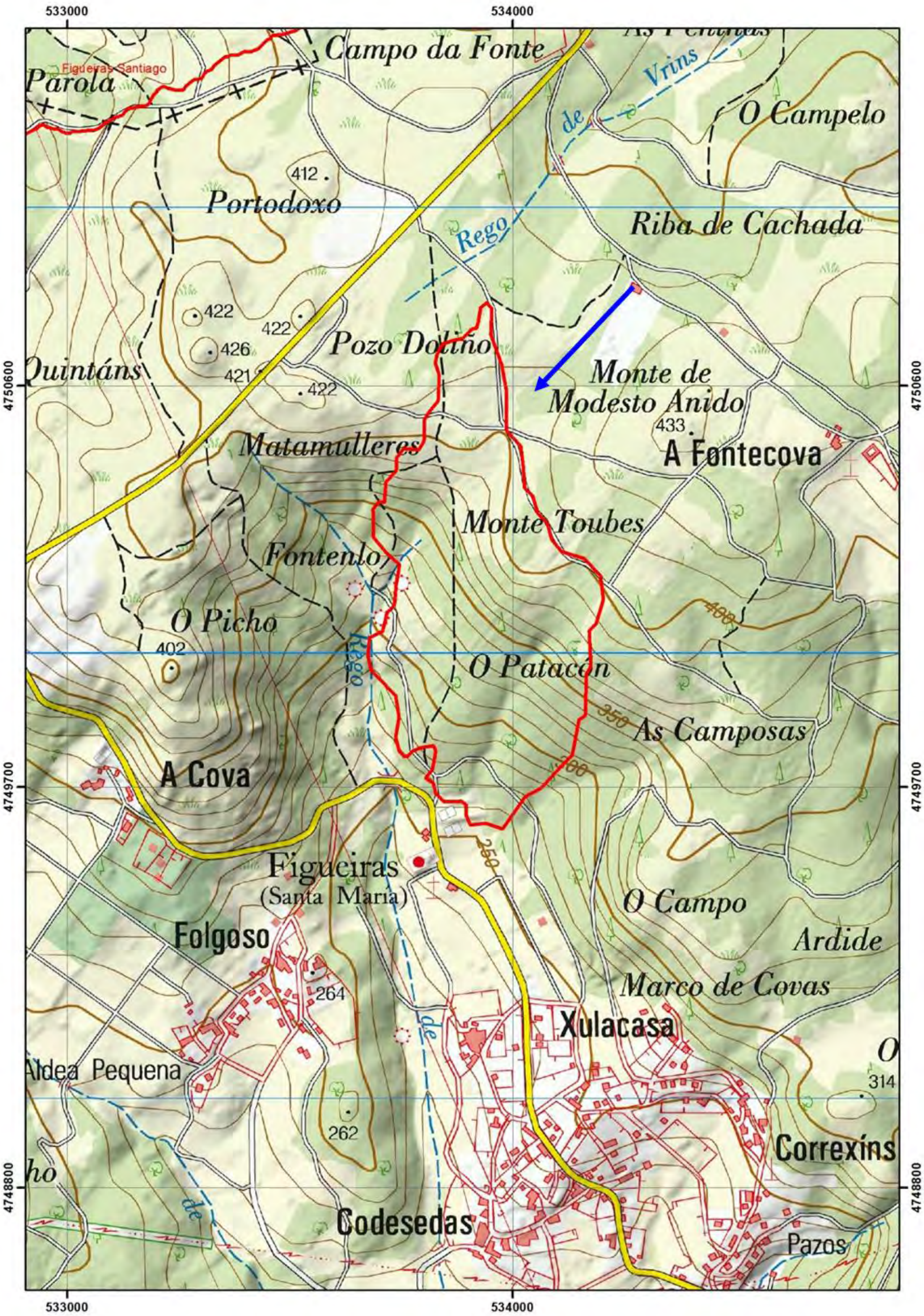
The last rainfall occurred 39 days before fire date. The mean of the maximum daily temperature during that period was 24ºC and the relative humidity was 56%. Mean of the wind gust velocity during those days was 37 km/h.

The course of air temperature and relative humidity and wind gust velocity and direction are shown below.



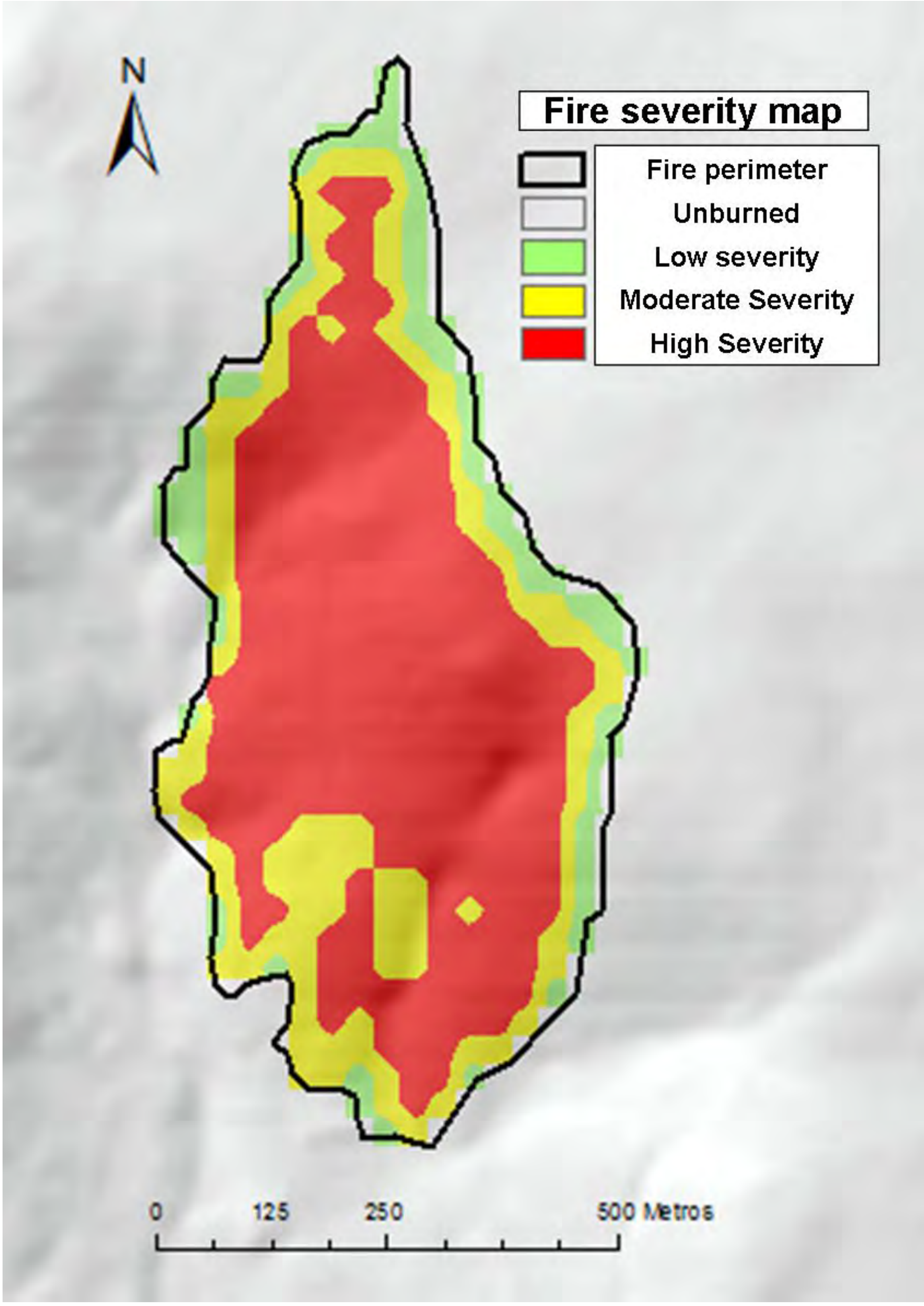


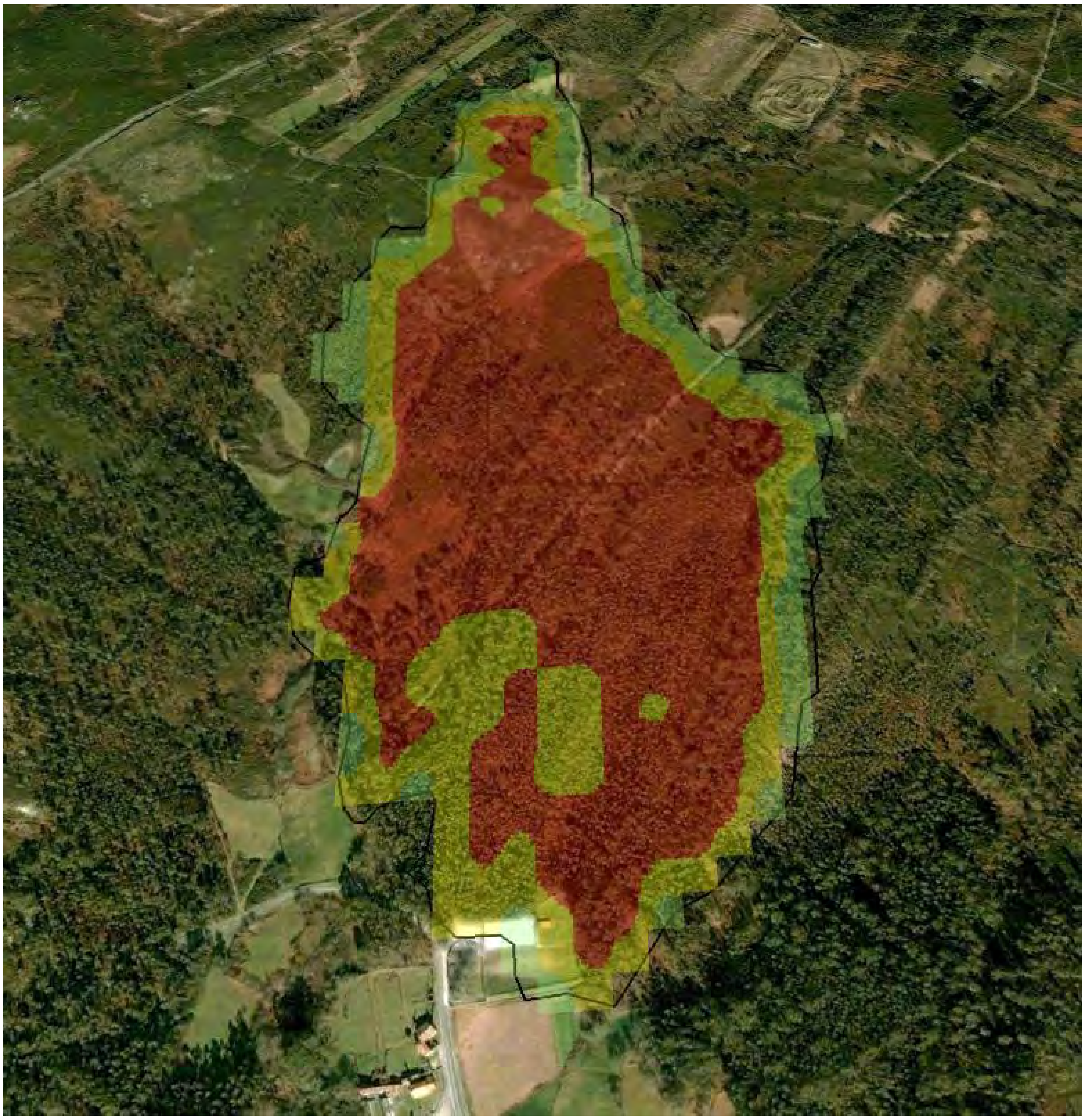
Topographic map showing fire perimeter and dominant wind direction during fire.



Ortophoto of the wildfire area

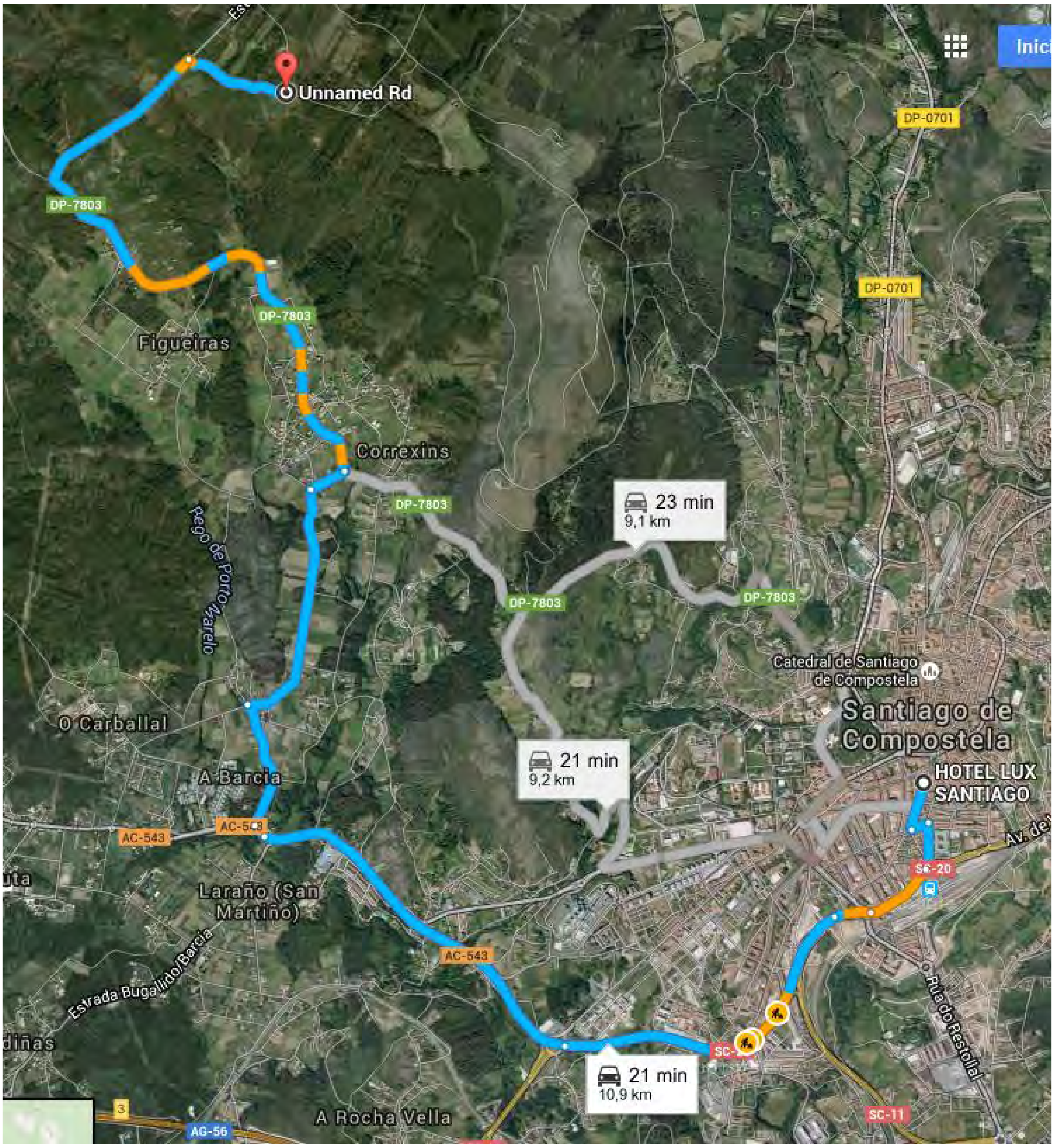
Fire severity map obtained from dNBR index in base of Lansdat 8 imagery





Proposed area to be rehabilitated

Itinerary to visit Figueiras wildfire



Topics.

1.-Soil erosion quantification. The use of sediment fences (following Robichaud and Brown, 2002 methodology).

2.- Soil stabilization treatments. Why to use mulch for post-fire soil erosion reduction?

3.- Examples of different mulch materials. Advantages and limitations.

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Restoration of Aquatic Ecosystems

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Objectives

In this seminar the strategies followed in recovering the ecological status of different inland aquatic ecosystems are shown. Basic research techniques in Hydrobiology research (sampling methodology and methods of biological characterization of water quality) are also found.

Justification

Lakes, wetlands and rivers and their banks have historically suffered many types of impacts: pollution, channelization, dredging, damming, diversion of funds, occupation crops, roads and housing estates, etc. Restoration is necessary to restore degraded ecosystems activity. Restoration methodologies depend on the type and extent of degradation.

The European Water Framework Directive requires conservation of the ecological status of waters and encourage the restoration of degraded systems. This implies a change of strategy in water management, emphasizing ecological values. Therefore, adequate scientific and technical training on these issues is needed.

Programe

Concepts:

- Restauration, rehabilitation and related concepts. Diagnosis systems and hábitat evaluation. Basic strategies for restauration of rives and river banks.

Field trip:

- Analysis of physical and chemical properties
- Ecology value assessment
- Degradation description
- Discussion of the rehabilitation measures carried out
- Proposal of rehabilitation strategies

Places to visit

Coca Park (X= 27662 m Y= 4731669 m) Datum ETRS89

The Coca Park is placed in Vilagarcía de Arousa, it's an urban park next to the channel of the Con river. An old fountain gives its name to the park.

- River channel restored some time ago, now showing problems of lateral erosion, mainly in river bends. Reinforced banks were eroded and are falling.
- Krainer wall on one side of a lateral building.
- River completely channelized from this park to the river mouth, placed 1.5 km away.
- Tipical channelization problems I this final section.

<u>Pontearnelas</u> X= 27647m, Y= 4725280 m)

A small dam was built in the Umia river to provide drinking water to the surrounding area. The current dam was made in a river just before a bend and the river bank faced to the dam was severely eroded. It was stabilized with some rocks for some years but in 2014 rocks were replaced using a wooden log-crib wall system (Krainer walls).

Two small Denil fishways allow migratory fishes to bypass the dam. This style of fishway uses a series of symmetrical close-spaced baffles in a channel to redirect the flow of water, allowing fish to swim upstream. There is also a fish counting device on one side.

Caldas de Reis (X= 36838m, Y= 4732157 m)

Bermaña river joins Umia river in Caldas de Reis. Both rivers were channelized in this section to regulate river flow. In the Umia river a hight stone wall was built in the right margin. Some channelization effects can be seen:

- shorter channel → flow increase → homogeneous substrate in the river bed → erosion increased downstream
- absence of riparian plants…
- low biological diversity (macroinvertebrates, fishes, plants…)

RECLAMATION OF THE AS PONTES MINE

1. Introduction

The origins of the exploitation of the mineral deposit of As Pontes (A Coruña) date back to the 40s with the aim of obtaining lubricants and liquid fuels from national raw materials. A 32 MW thermal power plant and a carbochemical complex were built at that time, whose fuel and raw materials were obtained from the lignite extracted from the mine.

Later, a greater thermal power plant of 1,400 MW was built in 1972. Additionally, the open-pit mine was provided with new equipment to extract 12 million tons of lignite per year, and thus supply fuel to the plant.

Between 1993 and 1996, the complex underwent new changes in order to meet the environmental demands and so it started to consume a mix of local lignite and imported coal of low sulphur content, notably reducing the emissions of SO_2 (the annual consumption of the mine is 6 million).

In 2008, it was agreed to only consume imported coal, ending up in this way the mining activity of As Pontes.

1.1. Mineral deposit characteristic

The brown coal deposit is a sedimentary series consisting of an alternation of brown coal and clays, with alternating sands of Tertiary age (about 40 million years). In total 19 layers of lignite, with great variability in clay layers alternate coal, with thicknesses between 1 and 28 meters counted.

The exploitation had an approximate length of 6.2 km, with maximum widths of 2.9 km on the edges and 1.5 km in the central area and a maximum depth of 288 m. With two large fields of exploitation (Field West and East) and an intermediate area called threshold.

In 1999 the exploitation of East field is completed and begins the development of a tip inside said hollow. The cuts geometry and unfavourable geotechnical conditions did not allow the construction of internal mine tip until this year. Therefore, most of sterile deposited on a external tip located on the southwester edge of the mine, outside the productive basin.

1.2. Restoration process of the dump

The restoration process was conducted in two phases, the first started on the external tip in 1985 and ended in 2007. The area occupied by this dump is 1,150 has the outside where 720 million m3 accumulated and has a height maximum of 160 m from the original ground. In the end, the order of 6,000 physical-chemical analyses of soil and water, were made and used more than 3 million m3 of vegetable or sterile selected land, built 67 km of roads and 56 km of canals. 40,000 m3 of organic fertilizers, chemical fertilizers 500,000, 120,000 kg of seeds are also provided, and 600,000 trees were planted.

At the bottom of each partial slope of the mine tip, runs a ditch for water harvesting. In parallel, runs a track that provides access to all levels. As in the mine, to protect the waste dump outside contour runoffs were built before work begins stacking, a set of channels along the perimeter. Its length is about 20 kilometres.

In the second phase of restoration which began in 2007 on the internal tip on an area of 93 ha where 80 million m3 accumulated. With respect to the original level internal waste dump it is at the same level or below. This implies that, in the process of restoration, part was submerged in the lake today.

The restoration of both mine dumps was designed trying to set irregular lines, softening the edges and varying the width of the platforms. With this aim, a set of different material profiles were used depending on the characteristics of restored area.

Here are some examples of the forementioned profiles:

Profile 1

Vegetal cover – 20 cm
White clays and/or ashes (low sulphur content) – 10 cm
Carbon clays (high sulphur content).

Profile 2

Vegetal cover - 20 cm
Clays or slates (low sulphur content) – 50 cm
Sterile mixture of clays, ashes and slates (variable proportion)

Profile 3

Artificial cover Mixture of materials with low content of sulphur and organic matter (manure) – 25 cm
Clays or slates (low sulphur content) – 50 cm
Sterile mixture under variable proportion

All these actions aim to ensure the stability of the slag heap, control water and prevent erosion, as well as facilitating the implementation of the restoration work.

During this process, the most serious limitations found in older sterile soils with high sulphur content, high acidity and toxicity, nutrient deficiency, seasonal flooding due to its impermeability, and compacting. Moreover, younger soils were constructed using sterile free sulphur as substitutes topsoil and had fewer limitations for the development of vegetation.

The results show that the proper handling of sterile, and pay special attention to selective placement of materials containing sulphur, are the most important factors to provide a suitable environment for the growth of vegetation.

1.3. Lake construction

Environmental solution adopted to rehabilitate the mining hole was big flood of it and the consequent creation of an artificial lake. Geographical and geological exploitation As Pontes characteristics are presented as ideal for creating this artificial lake. The high rainfall and the situation of the farm in a low area next valley Eume river made it possible to capture a large volume of water, which came from three different basins: the runoff space itself, corresponding to the slag heap and the Eume river.

In addition, the low permeability of the materials that make up the glass of the farm borders the waters in the hollow itself and prevents infiltration into surrounding aquifers.

The first action aimed at defining the project to create the lake As Pontes was the realization of a Study of Environmental Impact Assessment (2004) based on chemical models where the preventive measures that are necessary to take to avoid possible impacts to the environment are established Natural and control of the waters of contribution to filling the lake.

The process took place in three phases called the Joint Environmental Monitoring Plan:

- **First phase:** to establish the "zero state". It was developed during the previous two years at the beginning of filling and stable reference values of surface and groundwater around the lake.
- **Second phase:** monitoring plan during filling of the lake. It was carried out during the period of the filling and all aspects related to the project were monitored: surface water and groundwater; the works to be performed and the progress of colonization of the flora and fauna of the areas rehabilitated. Special mention the lake, where regular monitoring was applied in surface and depth.
- **Third phase:** monitoring plan during operation of the lake. It began once the dimension reached lake overflow. As in previous phases of surface and groundwater are controlled, but also the overflow of the lake, the pH and flow monitored continuously.

This plan also involves achieving limit values of chemical parameters of the lake water, which must meet to be directed towards the Eume river.

The completion of the restoration work does not imply that the different habitats created stabilize, but continue to evolve rapidly. In this sense the dump is an ecosystem in permanent transformation that encompasses four specific ecosystems: grassland, shrubland, woodland and wetlands.

This diversity of habitats has been used by wildlife, which has colonized progressively and quickly the dump, so currently living temporarily or permanently 180 species of vertebrates, some especially important for their rarity or uniqueness within wildlife Galician or even Iberian. Of the 180 identified species, 9 correspond to amphibians, 6 reptiles, 131 birds and 34 mammals.

2. General Objective

The restoration of this open-pit mine aimed to simulate the ground shapes that would have been naturally developed by the materials (sustratum or sterile) and the climatic and physiographic context (relief, soil and vegetation) which characterize the area affected by the extractive activity. Once these shapes were identified, they were designed and constructed.

Ultimately, the goal was to reconstruct catchments, valleys and watersheds included. This means, a drainage network of water reaches, such as rivers, streams and channel beds separated by hillslopes and, in general, any kind of relief which may be appropriate to restore in the continental land surface, whose final appearance and operability will be similar to the surrounding landscape to that affected by the mine.

The forementioned objective was reached by applying the following measures:

- Use of the vegetal cover previously extracted from the mine.
- Thorough selection of the sterile.
- Geometric design to achieve a good drainage and control the erosive processes.
- Development of appropriate techniques to set and preserve the vegetation.
- Achievement of the ideal conditions to reintroduce the fauna.
- Land uses definition.

The implementation of all these measures was accomplished through a work methodology and a monitoring plan of the restored surfaces basically based on the soil, water, vegetation and fauna evolution.

Throughout this practice, it will be checked the current situation of soil, water and vegetation of the restored area. With this aim, diverse activities will be conducted to study the-state-of-art of those components of the ecosystem.

The goal of each activity (one per ecosystem) will be to assess through measurements, samples and in situ identification of herbaceous and arboreal species, the habitat sustainability where, as previously mentioned, live and coexist different types of animals and plants.

3. Partial Objectives

- Get to know the evolution of the dump restoration
- Set the nutritional, sanitary state and the stability of the forest located in the dump
- Floral diversity of herbaceous, woody and arboreal species
- Wood and grass production. Possible uses
- Soil evolution and its surroundings
- Water quality and its surroundings

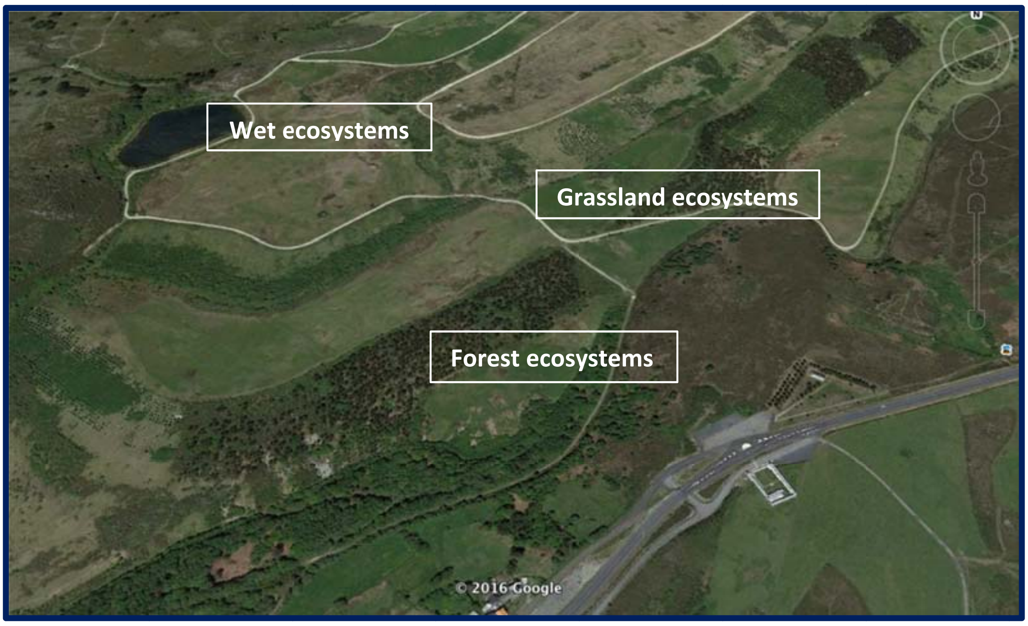

Figure 1. Course activities location

4. Forest ecosystem

In many areas of the dump, different species of trees were introduced with the purpose of enhancing the floristic diversity. Two types of planting were performed: monoculture in stands and mixed species in larger areas, always seeking to maintain a stable ecosystem and according with the environment.

These communities are formed by conifers such as *Pinus pinaster, Pinus pinea, Pinus radiata, Pinus sylvestris* or *Pseudotsuga menziesii*, demanding hardwoods (in terms of soil quality) like

Castanea sativa, Quercus robur, Quercus rubra, Acer pseudoplatanus, Sorbus aucuparia... or hardwood upgraders of soil such as *Alnus glutinosa, Alnus cordata* or *Betula alba* (see Figure 2).

Figure 2. Forest ecosystems

This practice field will be carried out on a specific monoculture where it will be evaluated its revitalizing capacity of evolutionary processes soil, its floristic diversity and its productivity. With this aim, the following tasks will be conducted:

1. **Visual identification of susceptible species of forestry use and biodiversity** (other species of scrub or underbrush)
2. **Determination of site productivity**: Site productivity is one of the many parameters that may be degraded in forest stands. Even though the chemical parameters of techno-soils may be within the admissible thresholds for the actual normative, the productivity of the site shows the suitability for tree cropping. In this lab, the productivity of a techno-soil afforested with *Pinus radiata* will be evaluated by means of the Site Index (IS) determination (Figure 3).

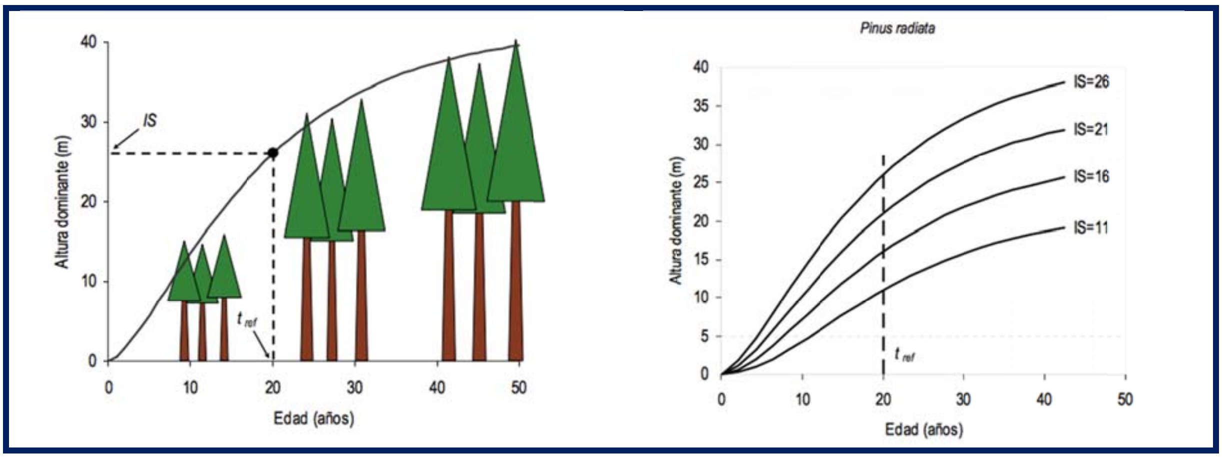

Figure 3. Site productivity

a. Establishment of a fixed-area sample plot of XXX m^2
b. Measurement of the tree height of the 100 tallest trees per hectare. How many?
c. Calculation of the mean height of the 100 tallest trees per hectare
d. Determination of the tree age. (Note that a forest planation is a seven-aged stand!)
e. Approximate determination of the site Index by using Figure 3

3. **Scale** (calculation forest volumes):

a. Measurement of diameter in cross at chest height (dn= dn_1+dn_2/2)
b. Age estimation (see Figure 4)
c. Distance between trees

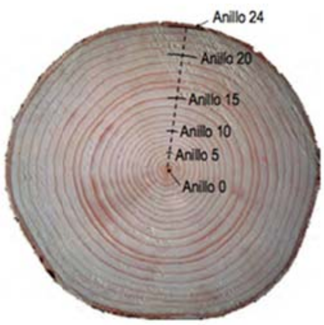


Figure 4. Age estimation

The parameters measured in each of the trees are introduced in the following table:

Table 1. Forest parameters

Plot sample:		**Date:**	
Starting time:		**Ending time:**	
Location:	As Pontes (A Coruña)		
Forest species:	*Pinus Radiata*	**Age (years):**	
Plantation stake (m):		**Area (ha):**	
Number of trees below the minimum diameter limit (dn < 7.5 cm):			
Observations:			

Plot	Tree	D1 (cm)	D2 (cm)	Dn (cm)	Ht (m)	Observation
	1					
	2					
	3					
	4					
	5					

Plot	Tree	D1 (cm)	D2 (cm)	Dn (cm)	Ht (m)	Observation
	6					
	7					
	8					
	9					
	10					
	11					
	12					
	13					
	14					
	15					
	16					

4. **Manure:**
    a. Estimate: This pine plantation has significant manure. In practice, the amount of manure is estimated by extracting a known layer and subsequently weighing the field surface.
5. **Material needed:**
    a. Vertex
    b. Calliper
    c. Pressler borer
    d. Measuring tape
    e. Survey
    f. Production Tables
    g. Balance
6. **Determinations:**
    a. Density of trees (Tree ha^{-1}) [approximate value]
    b. Dominant height (Ho) [height of a hundred feet per hectare thicker]
    c. Age (years)
    d. Single volume (m^3) and total volume ($m^3 \cdot ha^{-1}$) with bark

Questions:

- Do you consider this plantation as a stable ecosystem?
- How much wood production could you estimate to be obtained in this stand at the rotation age?
- Do you agree with the silvicultural operations perform on it? Otherwise, which do you think would be the right ones?

5. Grassland ecosystems

It is formed by numerous herbaceous, either grasses or legumes that have by objectives upholstering quickly the ground, avoid the commissioning the erosive processes, contribute to the improvement of the water runoff, start the association numerous surfaces of the mine dump and put in value a surface unproductive through the use of grass.

The first vegetal implantation was carried out with species with important capacity of adaptation and survival such as *Dactylis glomerata, Festuca arundinacea, Festuca trichophylla, Lolium perenne, Trifolium pratense* or *Trifolium repens*. These species are the most suitable for the soils of the mine dump, therefore, normally used on degraded land. Later, they began to appear representing spontaneous species of the area as *Holcus lanatus, Agrostis capillaris, Agrostis castellana, Agrostis truncatula, Plantago lanceolata, Bellis perennis,* or *Lotus corniculatus* forming the end permanent grassland which together constitute an ecosystem that stands out for its biological and landscap features (see Figure 5).

Figure 5. Grassland ecosystems

During the execution of this work it will be seek to establish the importance of these ecosystems from the pastoral point of view, the biodiversity and the concordance with the environment. This practice will hold the following activities:

1. **Visual identification of the species**, both those susceptible of grassland use and the ones which contribute to improve diversity
2. **Determination of production in wet pasture:**

To do this it will be necessary:

a. Select a plot of 1 m wide for 3 meters long for the identification of the different species
b. Determine the full cover
c. Visually identify the percentage of the land surface occupied by each specie
d. Take a sample of 1 m^2 of grass to weight its total volume and easily separate the vegetation species placed on it.

3. Material needed:

a. Cuttings (3)
b. String
c. Shearing
d. Square (0,25 m^2)
e. Balance
f. Paper bags
g. Measuring tape

4. Determinations:

a. Total and partial (by species) plant cover
b. Diversity: Number of species for plot

Both determinations will be accomplished by visual identification of the species present on a plot of 3 m^2 (see Table 2).

Table 2. Herbaceous species found in the selected plot

Location:	As Pontes (A Coruña)
Plot:	Pasture
Altitude (m):	470
Slope (%):	11_17
Aspect:	
Cover (%):	
Height vegetation (cm):	
Plot area (m^2):	3
Number of species:	

Herbaceous Specie	Family	Mark with an X
Agrostis truncatula Parl. Subsp. commista (Gramineae)	Gramineae	
Agrostis curtisii L.	Gramineae	
Agrostis capillaris L.	Gramineae	
Cirsium palustre (L.) Scop.	Gramineae	
Cytisus commutatus (Willk.) Briq.	Leguminosae	
Dactylis glomerata L.	Gramineae	

Herbaceous Specie	Family	Mark with an X
Digitalis purpurea L.	Scrophulariaceae	
Festuca trichophylla (DucrosexGaudin) K. Richter.	Compositae	
Hipochoeris radicata L.	Compositae	
Holcus lanatus L.	Gramineae	
Jasione montana L.	Campanulaceae	
Juncus bufonius L.	Juncaceae	
Juncus effusus L.	Juncaceae	
Lotus corniculatus	Leguminosae	
Lithodora prostrata (Loisel.) Griseb.	Boraginaceae	
Ornithopus perpusillus L.	Leguminosae	
Plantago laceolata L.	Plantaginaceae	
Rubus spp.	Rosaceae	
Trifolium repens L.	Leguminosae	
Ulex europaeus L.	Leguminosae	
Ulex gallii Planchon	Leguminosae	
Vicia tetrasperma (L.) Schreb.	Leguminosae	

Total	
Gramineae	
Compositae	
Leguminosae	

Once all the species are identified, the abundance index is calculated with the aid of the measuring tape (see Table 3).

Table 3. Abundance Index

Abundance index	Herbaceous coverage
r	low herbaceous or shrubby specie with one individual
+	cespitose herbaceous specie or a single individual shrub or tree
1	It covers less than 10% of the soil surface
2	It covers between 10 and 25% of the soil surface
3	It covers between 25 and 50% of the soil surface
4	It covers between 50 and 75% of the soil surface
5	It covers between 75 and 100 % of the soil surface

Furthermore, it is also important to estimate the average height of the total cover of herbaceous. This mean value will define the degree of restoration and stability of the mine dump.

Likewise, the density of species per ha is obtained as a result of the number of herbaceous species identified in the plot divided by its corresponding area:

$$Diversity = \frac{Nº\ plants\ \ (plot)}{3\ \ m^2}$$

c. Total and partial (by species) wet production

Production is estimated from short vegetation contained within a square of 0.25 m^2 and its subsequent weighing with a balance.

The square will be randomly launched four times; each sample is formed by the sum of four squares.

This operation is repeated up to three times and then the average is calculated:

Table 4. Total and partial wet production

	W1 (kg)	W2 (kg)	W3 (kg)	W4 (kg)	Total (kg)
Sample 1					
Sample 2					
Sample 3					
Average	---------*10= --------------- tons ha^{-1}				

Hight wet production: 15 tons ha^{-1}

Normal wet production: 12 tons ha^{-1}

Low wet production: 9 tons ha^{-1}

Questions:

- Which are the dominant species in this meadow?
- Is there any specie which may indicate some soil alteration?
- What is your opinion on the ecosystem restoration? Do you think that it has been achieved? What about the type of restoration? Has it been the most suitable to reach the initial goals?

6. Wet ecosystems

Throughout the restoration period, a large number of pools were constructed over the area of the old dump (see Figure 6). These artificial water bodies present a positive water balance, which means the water level does not undergo important oscillations. They are transitional areas between the aquatic and terrestrial systems where exist vegetal and animal communities of great diversity and complexity.

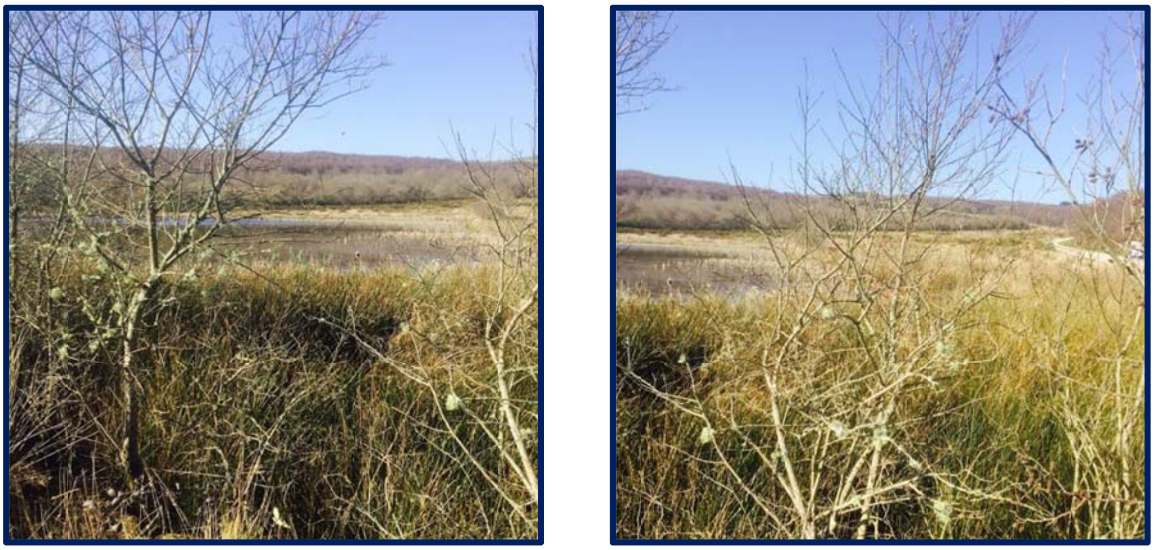

Figure 6. Wet ecosystems

The main goal in these pools was to achieve a suitable water quality, linked to the bed materials and the restoration level reached in the corresponding watershed. According to the chemical tests and the presence of animals and plants associated to this type of areas, the water quality is similar to that obtained for fresh water in the surrounding area (see Table 5).

Table 5. Water quality assessment parameters

WATER QUALITY

PARAMETERS	UNITS	AVERAGE VALUE	LIMIT VALUE AGUAS DE GALICIA
Tª	ºC	8,5-23,0	-
pH	**Units pH**	**6,8-7,4**	**5,7-9**
Conductivity at 25ºC	µS cm^{-1}	250-300	500
Oxygen (saturation)	%	95	30
Al	mg l^{-1}	<0,05	1,00
Fe	mg l^{-1}	<0,10	0,30
Mn	mg l^{-1}	<0,10	2,00
SO_4^{2-}	mg l^{-1}	85-105	250
PO_4^{3-}	mg l^{-1}	<0,20	0,20
NO_3^-	**mg l^{-1}**	**2**	**25**
NO_2^-	mg l^{-1}	<0,01	0,01
Cl^-	mg l^{-1}	10	200

WATER QUALITY

PARAMETERS	UNITS	AVERAGE VALUE	LIMIT VALUE AGUAS DE GALICIA
S^{2-}	mg l^{-1}	<1	1
NH_4^+	**mg l^{-1}**	**<0,05**	**1,00**
As	mg l^{-1}	<0,001	0,01
Cd	mg l^{-1}	<0,01	0,01
Ni	mg l^{-1}	<0,05	0,10
Hg	mg l^{-1}	<0,00002	0,001
Pb	mg l^{-1}	<0,0005	0,01
N Total	mg l^{-1}	<1	10
Suspended solids	mg l^{-1}	<2	25
Toxicity Ec50	Equitox/m^3	<1	1
DBO_5	mg l^{-1}	<3	3
CO_3^{2-}	mg l^{-1}	<0,10	-
HCO_3^-	mg l^{-1}	<10	-
Na	mg l^{-1}	8,04	-
K	mg l^{-1}	1,30	-
Ca	mg l^{-1}	29,40	-
Mg	mg l^{-1}	5,90	-
Transparency	m	6	-

In most cases, the banks of the pools are full of herbaceous species such as *Carum verticilatum, Eleocharis palustris, Juncus bulbosus, Juncus heteriphyllus, Oenanthe croata* or *Typha latifolia*. Furthermore, other typical species of calm, shallow waters grow up over the water surface, such as *Callitriche stagnalis, Ceratophyllum demersum, Potamogeton pectinatus* or *Potamogeton natans*. These plants feed important aquatic birds and fresh water fishes such as the carp.

This practice aims to verify the water quality of the wet ecosystem by assessing the water state, and the vegetal diversity of the banks. This purpose will be achieved through the following steps:

1. **Visual identification of bank species**

Table 6. Bank species

Location:	As Pontes (A Coruña)
Plot:	Wet ecosystem
Altitude (m):	470
Slope (%):	11_17
Aspect:	
Cover (%):	
Height vegetation (cm):	
Plot area (m^2):	
Number of species:	

Aquatic Herbaceous	Mark with an X
Callitriche stagnalis	
Carum verticillatum	
Ceratophyllum cf. demersum	

Eleocharis palustris	
Glyceria declinata	
Glyceria fluitans	
Hydrocotyle vulgaris	
Juncus bulbosus	
Juncus heterophyllus	
Oenanthe crocata	
Potamogeton natans	
Potamogeton pectinatus	
Ranunculus ololeucos	
Typha latifolia	

2. **Ecological characterization of the pool**
   - Plants identification
   - Water sampling
3. **Required material:**
   - Measuring tape
   - Paper bags
   - Markers
   - pH test strips
   - NO_3^- y NH_4^+ test strips
   - Water jar
4. **Parameters to determine:**
   - Vegetal diversity

Table 7. Vegetal diversity of the wet ecosystem

Number of species	Type	Development status

- pH of water

The pH of water is measured **semiquantitatively** by visual comparison of the reaction zone of a test strip with the fields of a colour scale (see Figure 7).

NOTE:
If the water sample is weakly buffered, leave the test strip into it until the colour no longer changes.

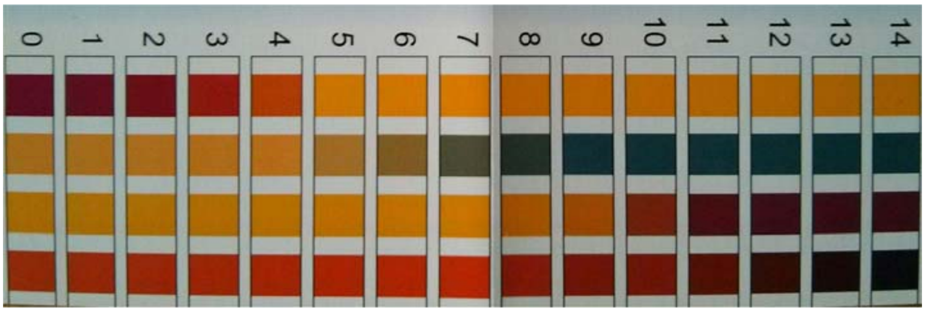

Figure 7. pH colour scale

Procedure:

Immerse **all reaction zones** of the test strip in the pretreated sample (**15 – 25 °C**) **for 3 sec**.

Shake off excess liquid from the strip and **after 1 min** determine with which colour field on the label the colour of the pH reaction zone coincides most exactly.

Read off the corresponding result of pH.

- NO_3^-

As happened to pH, the nitrate concentration is measured **semiquantitatively** by visual comparison of the reaction zone of a test strip with the fields of a colour scale (see Figure 8).

Each strip also features a second reaction zone (**alert zone**), the colour of which changes in the presence of nitrite ions.

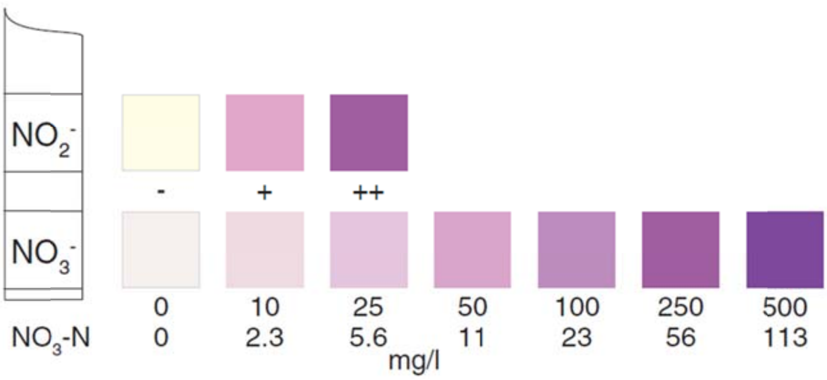

Figure 8. Nitrates colour scale

NOTE:

Reclose the tube containing the test strips immediately after use

Warning: The pH must be within the range 1-12!

Procedure:

Immerse **both reaction zones** of the test strip in the pretreated sample (**15 – 25 °C**) **for 1 sec**.

Shake off excess liquid from the strip and **after 1 min** determine with which colour field on the label the colour of the NO_3^- reaction zone coincides most exactly.

Read off the corresponding result of nitrate in mg/l.

Levels of nitrate can be expressed in either of two ways: "nitrate as nitrogen" (symbol: NO_3-N) or simply as nitrate (NO_3^-). The units' conversion is included in table 8.

Table 8. Nitrate units conversion

Units required	=	units given	x	conversion factor
mg/l NO_3-N		mg/l NO_3^-		0.226
mg/l NO_3^-		mg/l NO_3-N		4.43

- NH_4^+

Once again, the concentration of ammonium is measured **semiquantitatively** by visual comparison of the reaction zone of a test strip with the fields of a colour scale (see Figure 9). However, a reagent (NH_4-1) is also needed in this case.

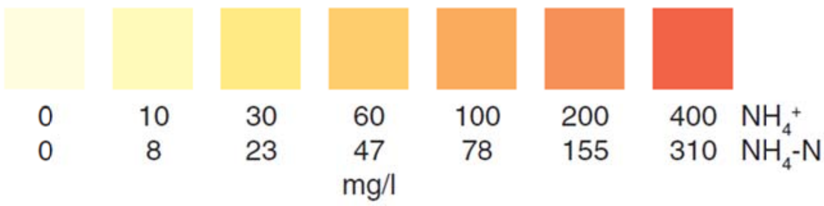

Figure 9. Ammonium color scale

NOTES:

Reclose the reagent bottle and the tube containing the test strips immediately after use

Rinse the test vessel with distilled water only

Warning: Samples containing more than 400 mg/l NH_4^+ must be diluted with distilled water.

Procedure:

Rinse the test vessel several times with the pretreated sample.

Pretreated sample (**15 - 25 °C**)	5 ml	Fill the test vessel to the 5-ml mark.
Reagent NH_4-1	10 drops	Add and swirl

*** Hold the bottle vertically while adding the reagent!**

Immerse the reaction zone of the test strip in the measurement sample **for 3 sec**.

Allow excess liquid to run off via the long edge of the strip onto an absorbent paper towel and **after 10 sec** determine with which color field on the label the color of the reaction zone coincides most exactly.

Read off the corresponding result of ammonium in mg/l.

Levels of ammonium can be expressed in either of two ways: "ammonium as nitrogen" (symbol: NH_4-N) or simply as ammonium (NH_4^+). The units' conversion is included in table 9.

Table 9. Ammonium units' conversion

Units required	=	units given	x	conversion factor
mg/l NH_4-N		mg/l NH_4^+		0.776
mg/l NH_4^+		mg/l NH_4-N		1.29

Questions:

- Among all the aquatic species founded in the ecosystem, which of them are more abundant?
- According to the measured parameters, would the wet ecosystem fulfill the demands of the Spanish legislation?
- What is your opinion with regard to the mine restoration from the ecological and landscape point of view?

7. Conclusion

Field Trip Wetland Restoration and Dynamics

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During this field trip we will visit several inland freshwater wetlands in the upper basin of the Miño River. More precisely, the trip is focused in two wetlands located in the Natura 2000 site Parga-Ladra-Támoga (see figure 1): The Cospeito Lake and an area including alluvial forests and an artificial pond in the St. Roque island (Ínsua de San Roque, a piece of land surrounded by two arms of the Miño river).

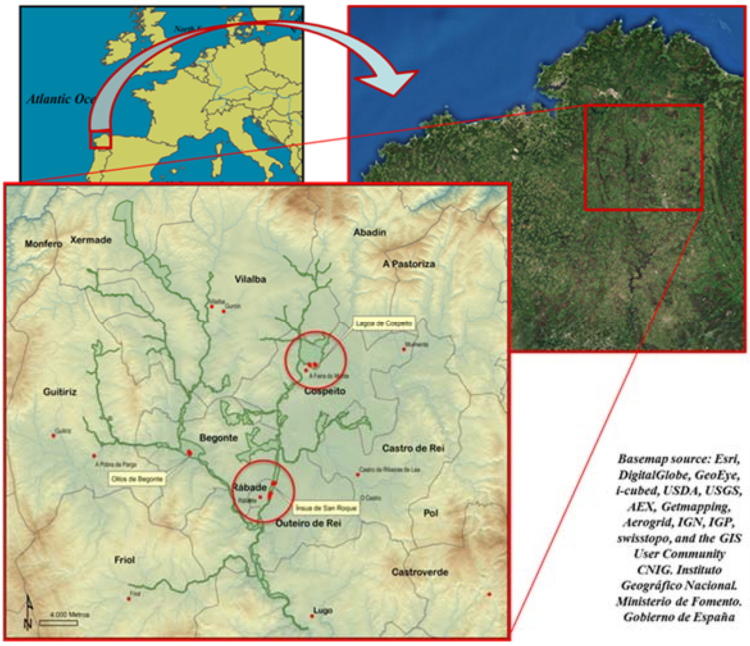

Figure 1. Overall location of the study areas

The interest of this areas is due to the different stage of recovery/evolution after ecosystem restoration actions. Indeed, the main water body of the Cospeito Lagoon was restored at the beginning of the 2000 decade, being a good example of medium-long term stage of habitat recovery (figure 2). In turn, there are several examples of early stages of ecosystem recovery both around the Cospeito lagoon (figure 3) and the St. Roque island (figure 4). These latter restoration actions were executed in the framework of the EU funded LIFE+ project Tremedal.

Figure 2. Cospeito lake during (left) and after(right) restoration. Image source: Ramil Rego et al., 2006; Díaz Varela

Figure 3. Early stages of vegetation recovery in the ponds excavated in the surrounds of the Cospeito lake. Image source: Life Tremedal; Rubinos Román

The Tremedal LIFE project aimed specifically at the restoration of different Habitats of Interest/priority for the EU, namely certain types of sphagnum acid bogs (HCI 7140, 7130, 7150), calcareous fens (HCI 7210, 7230) and wet meadows and peat lands (HCI 6410, 6510). Among the species of flora of Community Interest which are covered by the project, *Eryngium viviparum, Narcissus pseudonarcissus* subsp. *nobilis* and *Spiranthes aestivalis* are emphasized.

Figure 4. Pond excavated in the St. Roque island. Image source: Life Tremedal; Rubinos Román

Field Trip Coastal Habitats Restoration and Dynamics

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During this field trip we will visit a coastal area protected by several figures (Natura 2000 Special Area of Conservation and birds Special Protection Area, Natural Park and Ramsar Wetland of International Importance): The Natural Park of Corrubedo dunes and the Carregal and Vixán Lagoons (figure 1).

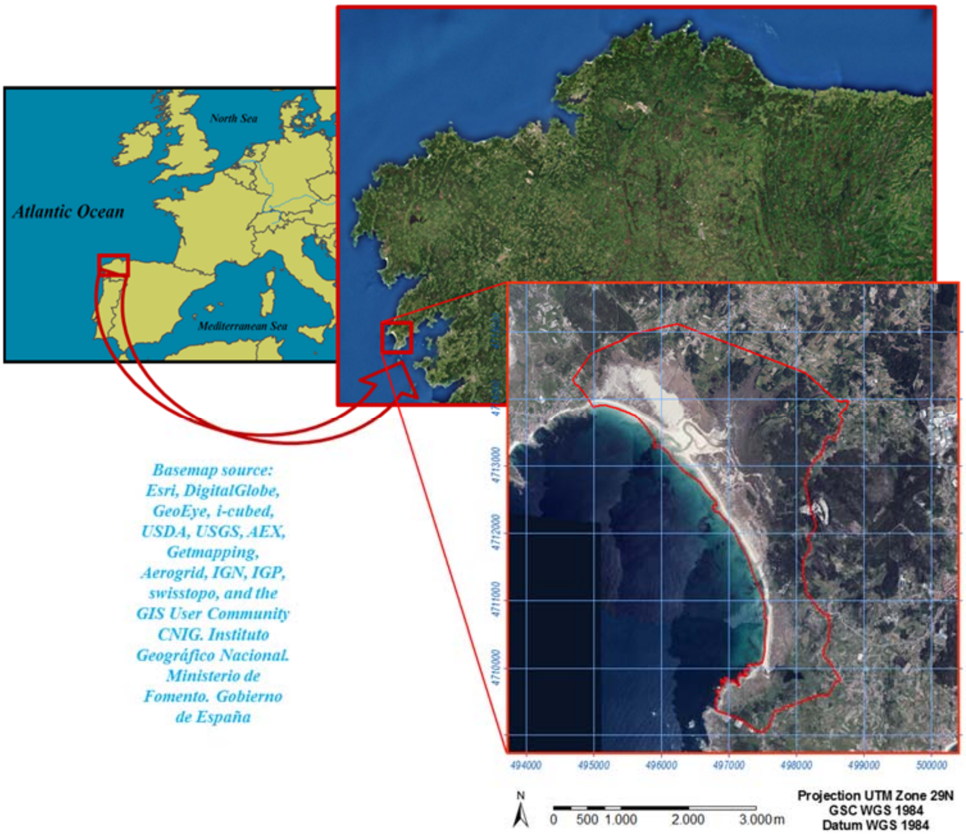

Figure 1. Overall location of the study area

Among the most interesting habitats of the area figure different coastal wetlands (salt marshes, coastal lagoons) along with a complex dune system with both shifting and fixed dunes.

One of the most significant challenges for biodiversity conservation of the area is the conservation of the sand dune system. This system is threated by local perturbation due to the touristic affluence in the area, causing the fragmentation of dune habitats and the perturbation of endangered bird species due to informal tracks and circulation across the dunes (see figure 2).

Some measures of tourist affluence control and regulation has been adopted, including the design, construction and signposting of routes (including footbridges in the places most prone to trampling erosion) and also the designation and control of parking lots. Also the access to the shifting dune system has been restricted and regulated.

The dune system is also threatened by global factors like climate change and sea level raising. In fact, there are some evidences pointing towards a retreat of the first front of the dune systems due to sea erosion during extreme storm events. This fact can be worsening by the touristic use of the beaches, as the areas eroded of the sand dunes are frequently trampled by summer visitors and require a careful sign and fencing to allow the dune recovery or at least stop the dune degradation.

Figure 2. Examples of dune habitat fragmentation due to informal paths and trampling. On the left a 3D block with indication of one of these paths. On the right a map indicating the extend of the paths in a sector of the dunes in the Natural Park. Taken from Diaz Varela et al., 2008. Image source CNIG-IGN, Ministerio de Fomento.

Doniños coastal lagoon-sand dune barrier system. Overall description and some discussion points on its conservation

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The Atlantic coast of Galicia includes up to 14 natural coastal lagoons (Ramil-Rego & Izco, 2003) corresponding with a general scheme of systems comprising a barrier of sand dunes that isolates a standing waterbody from the sea.

From a genetic view point, these systems were originated during the Holocene sea transgression, where massive amounts of sand sediments were laid along the coastal fringes creating sand beaches and dune systems. In some cases such systems blocked and isolated bays from the open sea, giving place to coastal lagoons. Such waterbodies were isolated from the erosive action of the sea, yet maintain certain connection with the sea by means of water inlets or channels of different nature and dimensions (Cillero, 2013; European Commission, 2013; Ramil-Rego & Crecente Maseda, 2012).

Among the coastal lagoons of Galicia, Doniños, located in the Atlantic Coast of Galicia (Figure 1), is one of the most isolated from the sea effect as the connection with the open sea relies on a narrow and intricate channel crossing a well-developed sand dune barrier (Figure 2). This fact makes the water chemistry characteristics somehow closer to freshwater waterbodies and more dependent of the water input of the basin, even though strong influences can take place depending on the effects of seawater from storms, temporary flooding of the sea in winter or extreme tidal regimes (Cillero, 2013; Ramil-Rego & Crecente Maseda, 2012).

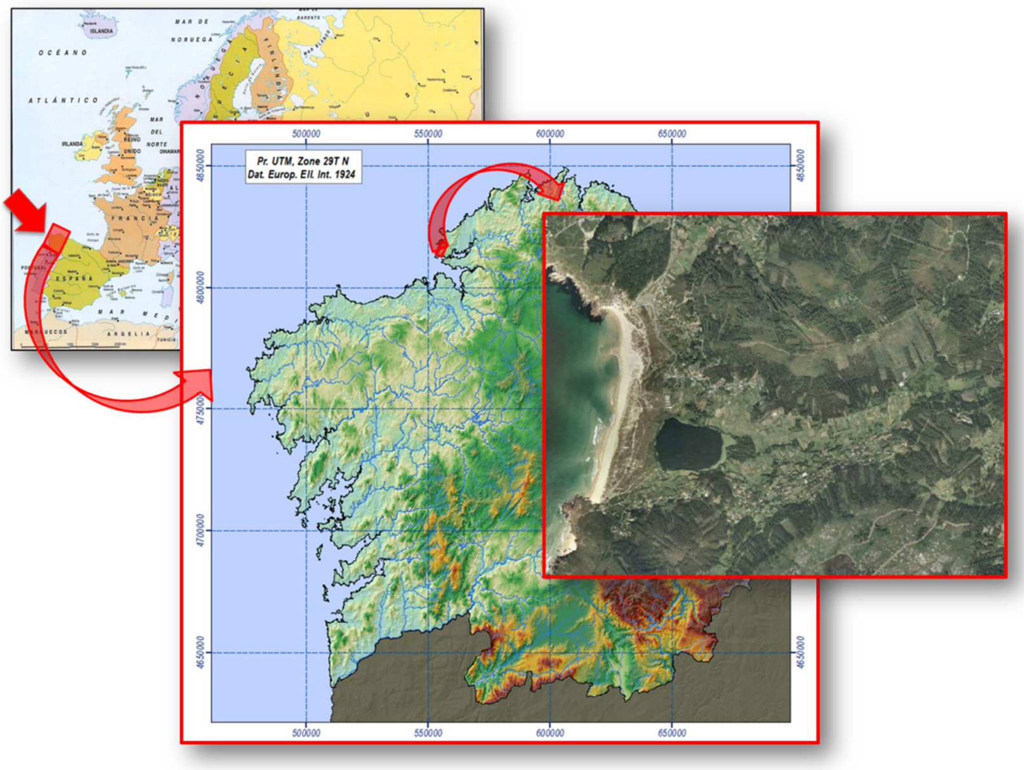

Figure 1. Location of the Doniños coastal lagoon-sand dune barrier system in the European and

Galician context. (Geographical data from PNOA © Instituto Geográfico Nacional de España).

The environmental and biodiversity importance of the Doniños lagoon and dune complex was acknowledged by its inclusion under different nature protection figures in the Natura 2000 network, namely Special Area of Conservation (SAC) Costa Ártabra (ES1110002) and birds Special Protection Areas (SPA) Ferrolterra-Valdoviño (ES0000258), being also declared by the Galician Environmental Administration as ZEPVN (Special Area of Natural Values Protection).

Figure 2. 3D Block representing the water body of the Doniños Lagoon and the approximate path of the channel to the sea crossing the sand dune barrier. (Geographical data from PNOA © Instituto Geográfico Nacional de España).

From the biodiversity viewpoint this complex hosts several habitats and species of high interest for conservation, underpinned by the EU Habitats Directive (EEC/92/43) and Birds Directive (2009/147/EC). Such habitats and species correspond mainly with coastal aquatic and hygrophilous and sand dune environments. (Ramil-Rego et al., 2008a; 2008b; Ramil-Rego & Crecente Maseda, 2012). Among the wet habitats it is worth pointing out the presence of the 25 ha wide coastal lagoon (1150* Nat 2000 priority habitat) along with other habitats like alluvial forests (91E0* Nat 2000 priority habitat) or calcareus fens with *Cladium mariscus* (7210* Nat 2000 priority habitat). The beach and dune barrier also hosts habitats like white shifting dunes (2120 Nat 2000 interest habitat), grey dunes (2130* Nat 2000 priority habitat) or humid dune slacks (2190 Nat 2000 interest habitat). See table 1 for a more detailed list of Natura 2000 habitats in the area.

The conservation status of the habitats and their species depends on the incidence of perturbations and the balance between the impact severity of the perturbation and their resilience. Such perturbations might affect both habitat extent and structure (that could be evaluated by physiognomic assessment of the habitat) and also the maintenance of their functionality, whose assessment requires a thorough understanding of their ecological traits like cycles of matter and energy. Apart from other drivers, acting at a global scale like climate changes, sea level raising, etc., the most perceptible threats and impacts on this area are related to land cover/land use changes, leading habitat destruction and fragmentation. Hence, the reclamation of dune habitats for building leisure facilities, and its fragmentation by poorly planned or informal paths for the access to the seaside, along with the spread of invasive species (frequently eased by the former processes), meant significant impacts in the area (Figure 3). Besides, the water quality of the lagoon and other related habitats is highly dependent on the quality of the inputs in the proximity of the water body and more precisely to urban or agricultural pollutants, due to the relatively small water catchment area and also to the relatively high confinement of the lagoon (Cillero, 2013; Diaz-Varela et al., 2008; Ramil-Rego et al., 2007; 2008a; 2008b; Ramil-Rego & Crecente Maseda, 2012).

Nat2000 code	Name of the habitat type
1110	Sandbanks which are slightly covered by sea water all the time
1130	Estuaries
1150*	Coastal lagoons
1170	Reefs
1210	Annual vegetation of drift lines
2120	Shifting dunes along the shoreline with *Ammophila arenaria* (white dunes)
2130*	Fixed coastal dunes with herbaceous vegetation (grey dunes)
2190	Humid dune slacks
2230	*Malcolmietalia* dune grasslands
3150	Natural eutrophic lakes with Magnopotamion or *Hydrocharition* - type vegetation
3260	Water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation
6410	*Molinia* meadows on calcareous, peaty or clayey-siltladen soils (*Molinion caeruleae*)
6420	Mediterranean tall humid herb grasslands of the *Molinio-Holoschoenion*
6430	Hydrophilous tall herb fringe communities of plains and of the montane to alpine levels
6510	Lowland hay meadows (*Alopecurus pratensis, Sanguisorba officinalis*)
7210*	Calcareous fens with *Cladium mariscus* and species of the *Caricion davallianae*
91E0*	Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*Alno-Padion, Alnion incanae, Salicion albae*)

Table 1. List of the main interest habitats of the Nature 2000 network (Annex I of the EU Habitats Directive EEC/92/43) occurring in the area. An asterisk (*) indicates a priority habitat. Source: Ramil-Rego et al., 2008a; 2008b; Ramil-Rego & Crecente Maseda, 2012.

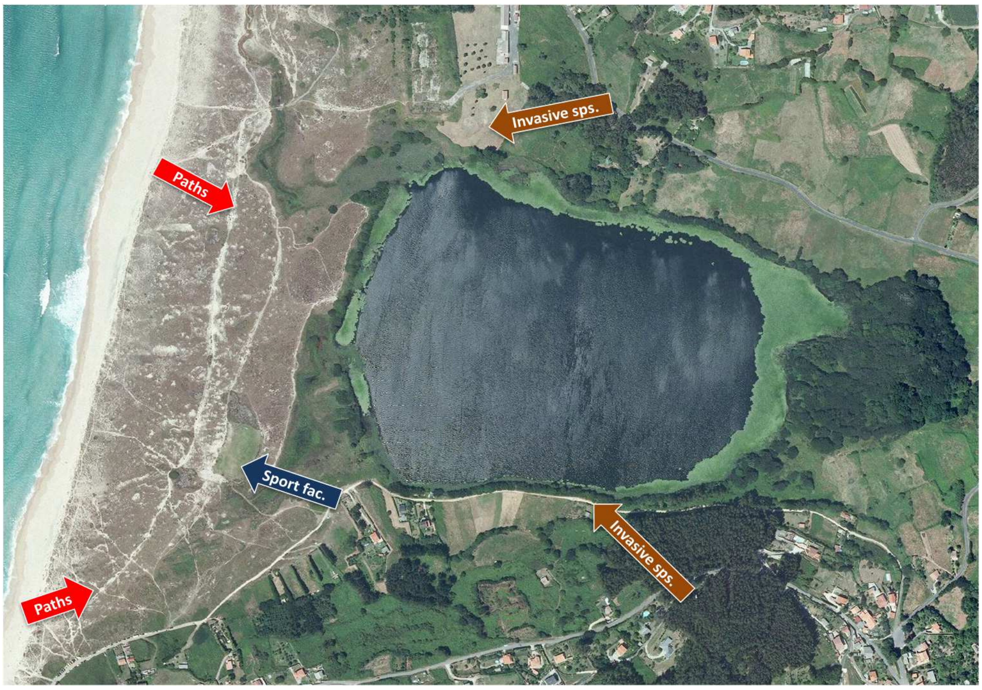

Figure 3. Aerial image and location of some of the environmental impacts in the Doniños coastal lagoon-sand dune barrier system. (Geographical data from PNOA © Instituto Geográfico Nacional de España).

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