LANDCARE

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

FIELD TRIP GUIDE

TRAINING IN LAND DEGRADATION AND REHABILITATION FROM THE APPROACHES DEVELOPED IN LANDCARE PROJECT

Challenges for rehabilitation in the Setubal Peninsula region (Southern Lisbon)

INTERNATIONAL WORKSHOP:

TRAINING IN LAND DEGRADATION AND REHABILITATION:

CURRENT CHALLENGES AND NEW EDUCATIONAL RESOURCES

26-27 OCTOBER 2017, Lisbon, Portugal

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

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

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ACKNOWLEDGEMENTS:
Câmara Municipal de Sesimbra
Sociedade Portuguesa para o Estudo das Aves (SPEA)
Instituto de Conservação da Natureza (ICNF)
SECIL-Outão.
Society for Ecological Restoration

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1. INTRODUCTION: LANDCARE project

LANDCARE "Land Degradation and Rehabilitation in Mediterranean Environments" is an international project co-funded by the Erasmus+ Programme of the European Union (2015-2018). The overall objective of LANDCARE is to improve training capacities in relation to Land Degradation and Rehabilitation (LD&R) in Southern Europe. The partnership is composed by eight members, being one academic and one professional partner from each participant country (Spain, Portugal, Greece and Italy).

Academic partners:

1-University of Santiago de Compostela (USC, Spain), Project Coordinator.

2-University of Lisbon (ULisboa, Portugal)

3-National and Kapodistrian University of Athens (NKUA, Greece)

4-National Research Council (CNR, Italy)

Professional partners

5-Forest Research Centre of Lourizan (CIF Lourizán, Xunta de Galicia, Spain)

6-West Systems SRL (WS – Italy)

7- Empresa de Desenvolvimento e Infra-estruturas do Alqueva – EDIA (Portugal)

8- Archipelagos Institute of Marine Conservation – Archipelagos (Greece)

The project focuses in four topics reflecting the different partner's expertise: freshwater ecosystems, coastal areas, contaminated soils, and Wildfire areas, and two thematic strands transversal to all topics, namely Environmental education and Employability related with LD&R. LD&R is a field that requires training involving real study cases and hands-on experience. For this reason, the education path proposed in the project combines short-term international mobility through intensive courses with innovative online learning (PLEs, SPOCs) and international mobility to gain real-world experience through internships hosted by the professional partner participants. In parallel to the student's formation, an especial effort is dedicated to teaching staff training and to the exchange of best practices on land rehabilitation among participants.

More information about the project:

https://www.facebook.com/landcareproject/

http://landcare.es/

https://www.youtube.com/channel/UCprzqDSEKrGiYkyzTh7DZdQ/videos

2. WORKSHOP TRAINING IN LAND DEGRADATION AND REHABILITATION: CURRENT CHALLENGES AND NEW EDUCATIONAL RESOURCES

Improving training capacities in relation to Land Degradation an Rehabilitation (LD&R) in Southern Europe is an increasing need in order to fulfil the demands of an emerging labour market to contribute to the green economy, and finally to mitigate widespread land degradation. In this context, the International LANDCARE workshop, held in Lisbon, 26-27 October, 2017, will focus on "TRAINING IN LAND DEGRADATION AND REHABILITATION: CURRENT CHALLENGES AND NEW EDUCATIONAL RESOURCES". This workshop intends to address current needs and recent tools in high education formation to foster the advancement of land rehabilitation across Southern Europe.

In addition, this Workshop will host the Presentation of the first **Network for education, training and transfer: land restoration and development,** and the **International Conference for Educators and Students Rehabilitation of Degraded Lands: Challenges for Education, Training and Employability** (16-18 July 2018, Santiago de Compostela, Spain).

Table 1. Training in Land Degradation and Rehabilitation: Current Challenges and New Educational Resources Workshop Program on the 26 October 2017.

Thursday 26 OCTOBER 2017		
Time	**Topic**	**Speaker**
9:00-9:15	Opening and Welcome	Teresa Ferreira (Instituto Superior de Agronomia Univ Lisboa—ISA/ULisboa, Portugal)
9:15-9:30	LANDCARE Project: Land Degradation and Rehabilitation in Mediterranean Environments	Agustin Merino (Univ Santiago de Compostela —USC, Spain)
CHALLENGES IN LAND DEGRADATION AND REHABILITATION TRAINING		
9:30-9:50	Society of Ecological Restoration mission in Europe: Dissemination of Best practices	Jordi Cortina (Chair of Society for Ecological Restoration-Chapter Europe - SERE)
9:50-10:10	Iberian Centre for River Restoration (CIREF) Mission in Iberian Peninsula: Articulating Knowledge Exchange and Training of Best Practices	Evelyn Garcia Burgos (Catalan Water Agency & CIREF, Spain)
10:10-10:30	Ecological Rehabilitation in Portuguese continental waters: potential of demonstrative experiences for training	Rui Cortes (Tras-os-Montes University, Portugal)
10:30-11:00	Coffee break	
11:00-11:20	What to do after fire? Key messages for post-fire restoration	Francisco Moreira (CEABN-InBio, ISA/ULisboa & CIBIO-InBIO, Univ Porto, Portugal)
11:20-11:40	Rehabilitation of contaminated soils in Portugal and integration of study cases in educational projects	Manuela Abreu (Instituto Superior de Agronomia, University of Lisbon, ISA/ULisboa, Portugal)
11:40-12:00	Fluvial Rehabilitation in Spain: demonstration of case studies in large rivers as a tool for knowledge transfer	Fernando Magdaleno Mas (Centre for Studies and Experimentation on Public Works– CEDEX, Ministry of Agriculture, Food and Environment, Spain)
12:00-12:30	Debate - Chair by ULisboa & EDIA LANDCARE partners	
12:30-14:00	Lunch	

Thursday 26 OCTOBER 2017		
Time	**Topic**	**Speaker**
LANDCARE PROJECT OUTPUTS: TRAINING RESOURCES IN LAND DEGRADATION AND REHABILITATION		
14:00-14:20	A flexible Personal Learning Environment to foster learner-centred pedagogical approaches in Land Rehabilitation	Vasileios Kotinas Univ of Athens, Greece)
14:20-14:40	Online Learning Tools (SPOC & MOOC) encouraging interaction between learners, educators and the wider public	Grazia Masciandaro & Serena Doni (CNR, Univ of Pisa, Italy)
14:40-15:00	The role of enterprises in the formation of skilled professionals for an emerging labour market in land rehabilitation	Giorgio Virgili (West Systems, Italy)
15:00-15:20	Volunteering as a strategy to align youth formation with society and environment	Anastasia Miliou (Archipelagos, Greece)
IMPACT OF LANDCARE ON BEST PRACTICES FOR LAND REHABILITATION		
15:20-16:00	International cross-sectoral cooperation impact on education: students experience in LANDCARE	Joint presentation by students participating in Intensive courses and internships of LANDCARE
16:00-16:15	Network for education, training and transfer: land restoration and development	Jordi Cortina (SERE) & Agustin Merino (USC/Spain)
16:15-16:20	Rehabilitation of Degraded Lands: Challenges for Education, Training and Employability | International Conference for Educators and Students	Agustin Merino (USC/Spain)
16:20-16:30	Closure of International Workshop	
16:30-17:00	Break	
17:00-18:30	LANDCARE Project Annual Meeting	

3. FIELD TRIP: CHALLENGES FOR REHABILITATION IN THE SETUBAL PENINSULA REGION (SOUTHERN LISBON)

3.1. Plan of the field trip 27 October 2017

Time	Activity
8:30	Departure from Tapada da Ajuda (Main Building Door, Instituto Superior de Agronomia)
09:30	Stop 1. Mata dos Medos and Fossil Cliff of Costa da Caparica
11:00	Stop 2. Sustainability of wetlands: Lagoa pequena (Lagoa de Albufeira)
12:45	Lunch (Azoia village)
15:30	Stop 3 – Arrábida Natural Park: Natural Values and Rehabilitation Challenges
19:00	Arrival at Tapada da Ajuda

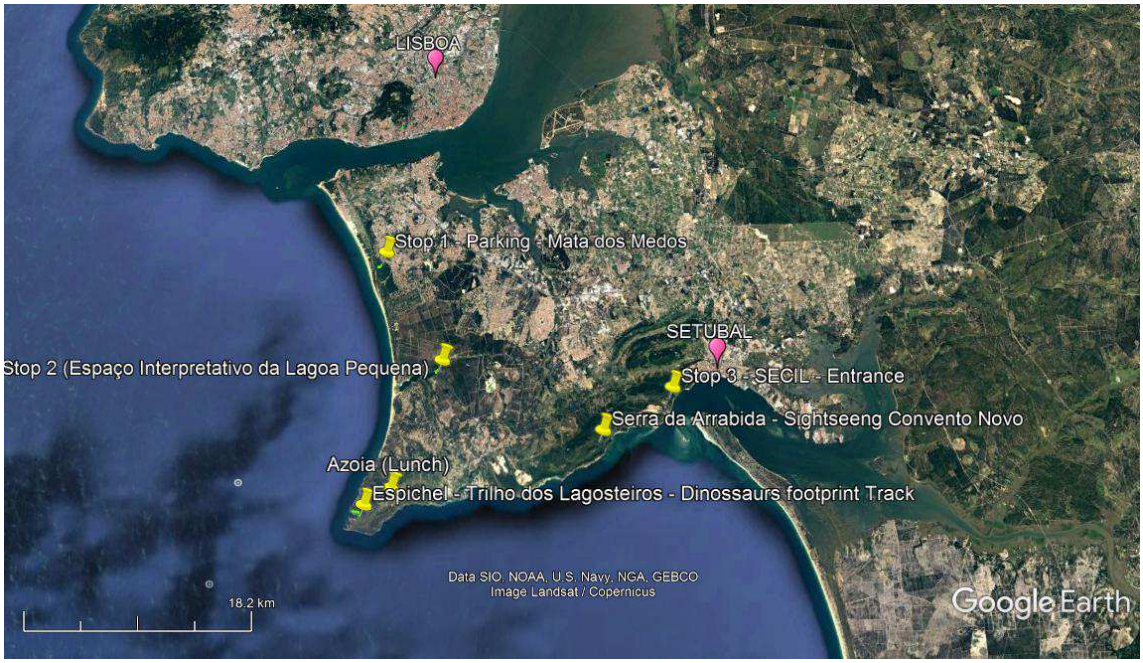

Figure 1. General view of the Setúbal Peninsula region and the field trip stops.

3.2. Biophysical context of the region

The Setubal Peninsula is included in the Mediterranean Biogeographical region. Annual rainfall ranges 600–900mm, while annual average temperature ranges 15–17ºC, with dominant winds N, NW and W, showing a climate that combines Mediterranean and Atlantic influences (Pais, 1992). The area is situated between two large estuaries, the Tagus River in the North and the Sado River in the South (Figure 1 and 2A). The coastal area shows a strong morphologic asymmetry due to the different maritime regimes to which it is exposed and due to the nature and structure of its rocky substrate. The occidental part, limited by Cabo Raso in the North and by Cabo Espichel in the South forms a curved littoral belt with smooth slope on detrital rocks, with large beaches. In contrast, the meridional part is characterized by the marked relief of Serra da Arrábida, essentially composed of calcareous rocks, and by few small beaches embedded within the rocky coast (Cruces et al., 2002). From a geological and geomorphological viewpoint, this Peninsula is formed by two fundamental units that influence the littoral morphology: the Albufeira Syncline and the Arrabida Massif. The axial region of Albufeira Syncline is located North of Lagoa de Albufeira, being formed by a detrital series and occasionally carbonated (sequence of sands, silts and clays, with layers of marls) deposited since the Miocene until present, inclined to South and cut by the Tagus Estuary (Figure 2B). In the southern part, older series emerge, from Cretaceous to present, forming a series essentially carbonated and detrital, inclined to North. Finally, at Massif of Arrabida, older rocks (Jurassic) are represented, predominating limestones and marl lithologies (Fig 2B). (Cruces et al., 2002a).

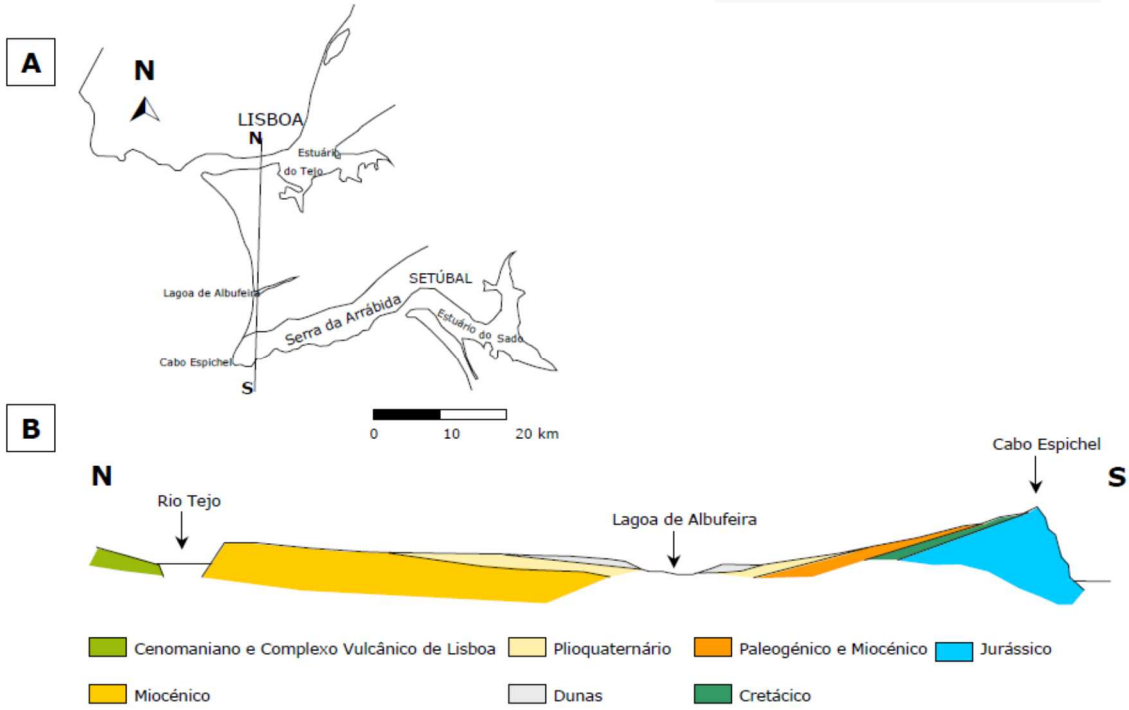

Figure 2. Setúbal Peninsula (A) and North-South Geology of the region (B). (from Cruces et al., 2002)

3.3. Stop 1 – Mata dos Medos and Fossil Cliff of Costa de Caparica

The first stop will be in Mata dos Medos at the Interpretative Panels of the Protected Landscape of Arriba Fossil da Costa de Caparica (Paisagem Protegida da Arriba Fóssil da Costa da Caparica). We will start with an introductory explanation of the subsequent itinerary that intends to focus discussion on historical and current management of Coastal areas and Forests in the Setubal Peninsula.

3.3.1. Forest Management at Mata dos Medos

3.3.1.1. History of management

Mata Nacional dos Medos (also known as Pinhal do Rei) is a 338ha Public Forest thought to have been originally planted on the orders of King João V (XVIII century). The intention appears to have been to hold back the sand which was blowing into the farmed areas inland. It was classified as Botanical Reserve in 1971 due to its high plant diversity (Fonseca, 1998). The tree cover is mainly dominated by stone pine (*Pinus pinea*), with other pine species present including *Pinus pinaster* and *Pinus halepensis*. Several Mediterranean trees and shrubs naturally colonized the understory after the forest plantations, such as *Juniperus turbinata, Quercus coccifera, Olea europaea* var. *sylvestris, Pistacia lentiscus, Rhamnus alaternus, Myrtus communis, Phyllirea angustifolia, Rhamnus lycioides* subsp. *oleoides, Corema album, Lavandula luisieri, Cistus salvifolius* and *Cistus crispus* , accompanied by a few climbers, such as *Smilax aspera* var. *altissima*, *Rubia peregrina* var. *longifolia*, *Tamus communis*, *Bryonia dioica* and several *Lonicera* species.

The Mata dos Medos forest was subjected to a wildfire shortly after the 25th April, 1974 Revolution (also referred to as "*Revolução dos Cravos*", meaning "The Carnation Revolution"). The area was later re-planted by the Forest Services with *Pinus pinea* and managed with soil fertilization and silvicultural treatments.

Following a 20–25 minutes walking itinerary (Figure 3) is possible to cross sectors of the plantation which were subjected to different management treatments through time.

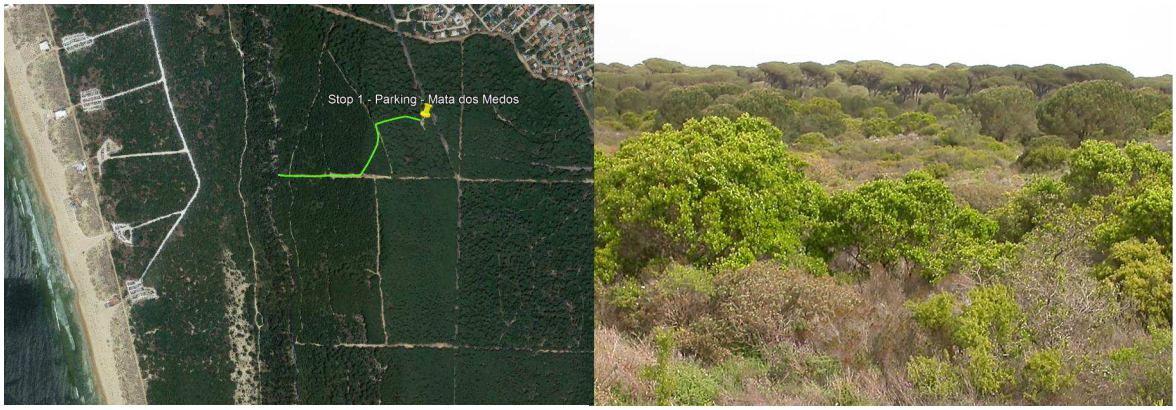

Figure 3. Walking itinerary (left) to sightseeing point of the Fossil Cliff and dunes of Caparica and interior appearance of Mata dos Medos (right) (Photo PA).

Figure 4. Illegal construction on the Cliff Ridge (Photo PA).

3.3.1.2. Current challenges for rehabilitation

Currently the main challenge in this area is being able to reconcile its recreational use with the need to ensure protection from wildfires and, simultaneously, promote its biological diversity. Its proximity to the urban beaches of Metropolitan South Lisbon (Costa de Caparica) and its relaxing and shady environment during summertime make it a very appealing area for tourists, which come in large numbers every summer. Touristic urban development is also a threat, although its location within a nationally protected area has proven to be efficient in preventing widespread urban expansion. Nevertheless some remains of illegal construction, often too close to the Cliff ridge, can still be found in the area (Figure 4).

3.3.2. Coastal Erosion and Urban pressure in Fossil Cliff of Costa de Caparica

3.3.2.1.Land use history

After the walking path through Mata dos Medos, we arrive to a Sightseeing site where the Fossil Cliff of Costa de Caparica can be observed. The Protected Landscape (Paisagem Protegida) of the Fossil Cliff of Costa da Caparica occupies an area of 1570 ha between Costa de Caparica village and the northern limit of Lagoa de Albufeira. The Protected area was created in 1984 in order to preserve the geomorphic and geologic features and the natural communities. It constitutes one of the best geologic spots to observe Miocene (represented since the Serravallian –15 to 9 million years) deposits, the main substrate of the Fossil Cliff, and to find different fossils. The oldest unit Argilas azuis de Xabregas (Xabregas Blue clays, Serravalian age), owes its name to the colors of minuscule pyrite spheres. This feature indicates deposition with water circulation and deficient oxygenation. Phenomena of collective death lead to groups of organisms that fossilized in-situ with well-preserved shells (Mollusca) but also vertebrates (marine mammals and fish) (Pais, 1992). More recent strata include the Pliocene and Pleistocene layers that also exhibit different fossils.

The Fossil Cliff has an abrupt relief, with altitude ranging from 80m in the North and 40–50m in the Southern part of Fonte da Telha. All the scarp is subject to erosion that originates block falls and permanent sand slide. Wind and rain expose the more resistant strata and confer the Fossil Cliff its characteristic shape. Anthropogenic activity has also contributed to its instability, increasing the erosion rate.

Some authors (Pais, 1992), based on the analysis of old cartography, argue that the origin of the current configuration of the Fossil Cliff is related with the Lisbon earthquake in 1755. Apparently, before 1755 the Cliffs would be in direct contact with the beach, limiting the coastline. The earthquake would have fossilized the Cliff, taking it to the current position farther from the sea.

Figure 5. Left: Costa de Caparica coastline retreat and urban area evolution (from Veloso et al., 2009); Right: Current view of the Costa de Caparica urban area (Imagery 2016).

The large sand beaches in the bottom and parallel to the Fossil Cliff comprise sand deposits extended along Costa de Caparica. Up to 1870 this stretch was protected by a sand spit 3 km in length, connected to the Bugio lighthouse. Since 1870 important physiographic transformations have occurred on Costa de Caparica (Figure 5). Evidence of such transformations is, for instance, coastline retreat – the noticeable sand spit retreat of about 3 km – which caused an irreversible loss of beach width and dunes. Construction of dams in Tagus River substantially reduced the sediment transport in the river channel and resulted in sediment shortage at the downstream river section, aggravating this problem. To minimize losses and stabilize the coastline some groins and a seawall were constructed. As a result, the coastline has remained more or less stable for almost 30 years (1972–2000), although with a continuous loss of sand. From 2000 on erosion events increased, with massive sediment removal from the beach and dunes. Several alternative options to minimize coastline retreat and infrastructure destruction were considered, from which emerged one that basically consisted of reshaping the existent groins and seawall with a 3 million m^3 sand nourishment (Veloso et al., 2009).

As illustrated in Figure 5, the urban area increased considerably in Costa de Caparica between 1972 and 1996. (Veloso et al., 2009). The littoral plain, which has been initially occupied by fishermen communities, originally from Ílhavo (Northern Portugal), still showed a reduced population in 1959 (Pais 1992). During wintertime, whenever sea conditions where rough, and fishing impossible, people would also practice some horticulture, thus creating an horticultural landscape known as "*Terras da Costa*", nowadays located at the inner (or inland) edge of the village (Figure 6). This activity was made possible by the incorporation of organic matter of marine origin (e.g. small fish and crab, algae) into the soil (Blanes, 2003), a traditional practice at the population's place of origin, Ílhavo. Furthermore, the absence of frost and fresh water availability (shallow aquifers), are highly favorable conditions for intensive agriculture, allowing 2-3 crops/year.

Figure 6. "*Terras da Costa*" agricultural fields, located between the Fossil Cliff and the village of Costa de Caparica (Photo PA).

The proximity with the large Lisbon Metropolitan Area lead to an increasing growt of the peripheral urban agglomerates such as Caparica and Fonte da Telha. The illegal urbanization with expansion of clandestine houses lead to population density increase and communication infrastructures expansion. In addition to the pressure imposed by urban and agricultural activities in the area, the tourism pressures cause extra difficulty for coastal zone management (Figure 7).

Figure 7. Urban expansion in Caparica (Photo PA).

Since the end of s.XIX and until the 60's of the s.XX, the dune system in the littoral plain at the bottom of the Fossil Cliff was occupied by extensive plantations of exotic species (*Acacia longifolia, A. cyanophila, A. retinodes, A. pycnantha).* This was a former approach of Forestry Services to limit mobilization of dunes and promote their fixation, an intervention firstly discussed by José Bonifácio de Andrada e Silva in his 1815 book "*About the need to plant new woodlands in Portugal…*" (Rego, 2001) but only implemented at the turn of the XXth century (Lourenço, 2009).

3.3.2.2. Current challenges for rehabilitation

The Caparica Littoral is an excellent example of a coastal area under pressure of the Lisbon Metropolitan Area, of which it is an integrated component. The concentration of the population, with more than 2,8 million inhabitants by 2011, and the exponential growth of the urban areas is by itself a complex territorial phenomenon. The result has been obvious, translating into serious environmental problems in an area with rich natural values, with direct implications on lessening of the citizen's quality of life. This has special relevance given to the occupation and loss of areas with geologic, geomorphologic, fauna, flora or landscape interest, due to their direct and indirect impact (Ferreira et al., 2006). Alien invaders – especially Acacia spp. – pose several challenges whenever ecological restoration of disturbed areas is equated, particularly in the low sandy platform below the Fossil Cliff.

3.4. Stop 2 –Lagoa pequena (Lagoa de Albufeira)

3.4.1.Lagoa de Albufeira natural values

In this stop we will carry out a visit to the Lagoa pequena, guided by the managers of the protected area, Dr.ª Marta Franco, Arq.ª Catarina Carvalho (Gabinete Municipal de Ambiente e Sustentabilidade, CM-Sesimbra) and Paula Lopes (SPEA).

The Albufeira lagoon is located 20km south of Lisbon, in the coastal arc of Trafaria–Espichel (Figure 8) and is formed by two main bodies – Lagoa Grande and Lagoa Pequena (Figure 8 and 9). Its major axis is oblique to the coast (trending NE-SW), having a surface flooded area of 1.3 km^2, a maximum depth of 13 m below mean sea level and extends perpendicularly to the coast over 3.6 km. The upstream part of the lagoon, the "Lagoa Pequena", is shallow, with maximum 2m depth, and has about 350m x 900m size (Freitas, 1995).

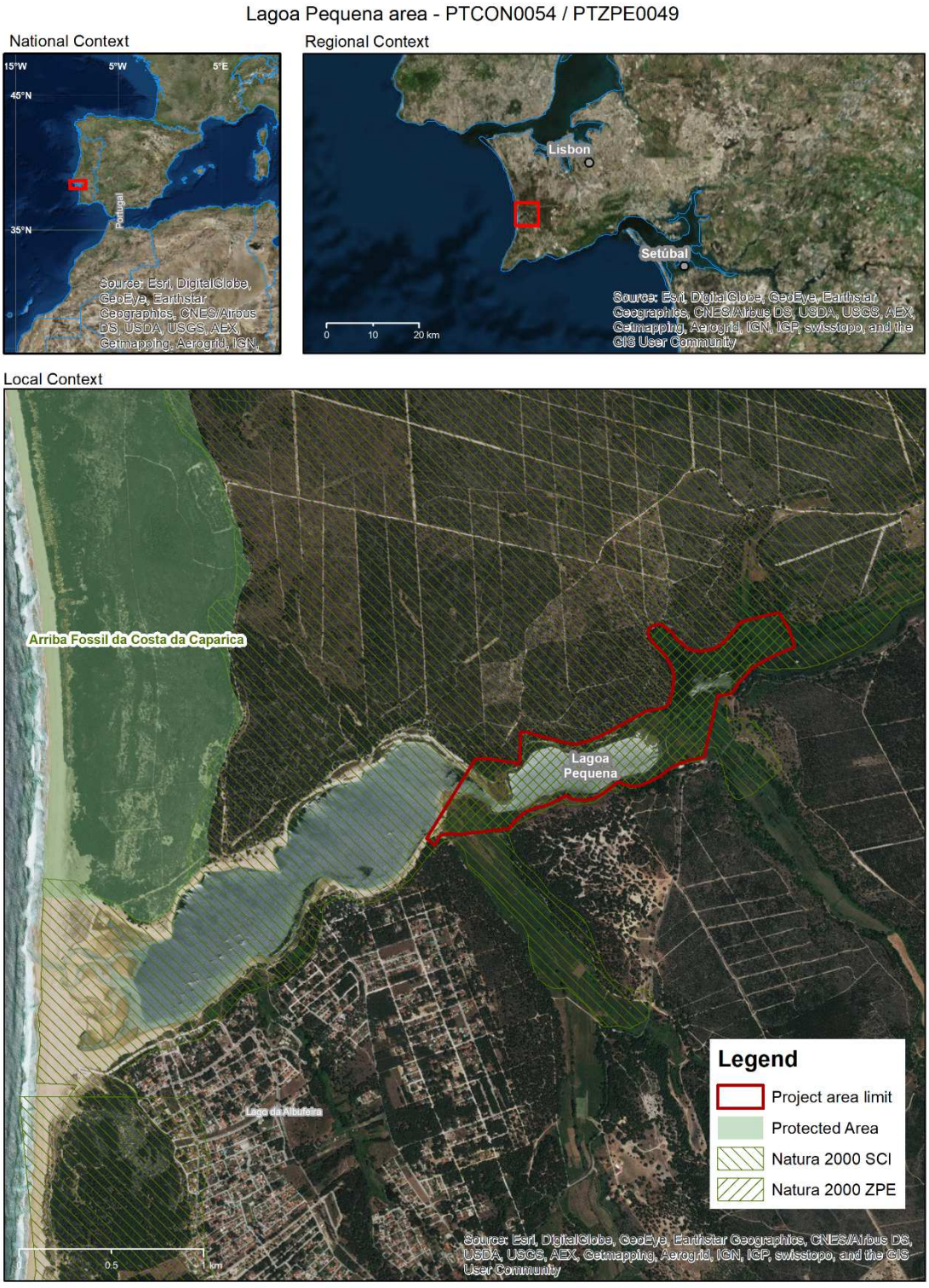

Figure 8- Regional Context and Limit of Protected Areas in Lagoa de Albufeira (source: authors)

In front of the lagoon, tides are semi-diurnal and the tidal range varies between 0.55 and 3.86m. The Albufeira lagoon inlet is inserted into a 24km long beach, between the mouth of the Tagus estuary and the Espichel Cape. The lagoon is separated from the Atlantic Ocean by a littoral

barrier and a mixture of highly mobile shallow channels and sand banks. It is usually isolated from the ocean where a tidal inlet is artificially opened once a year, allowing the renewal of the lagoonal water. In consequence, the lagoonal water becomes homogeneous and similar to marine water. The inlet, artificially opened every spring, closes naturally in weeks to months, usually in the winter. When the inlet is closed, the lagoon essentially collects freshwater from the tributaries leading to stratification of the water column (Fortunato et al., 2014). While these human interventions have occurred since the 15th century, it was suggested that their growing frequency causes the siltation of the lagoon. Most of the time, the inlet exhibits a wave-dominated morphology, with a shallow channel, a small ebb delta and a large flood delta (Freitas, 1995).

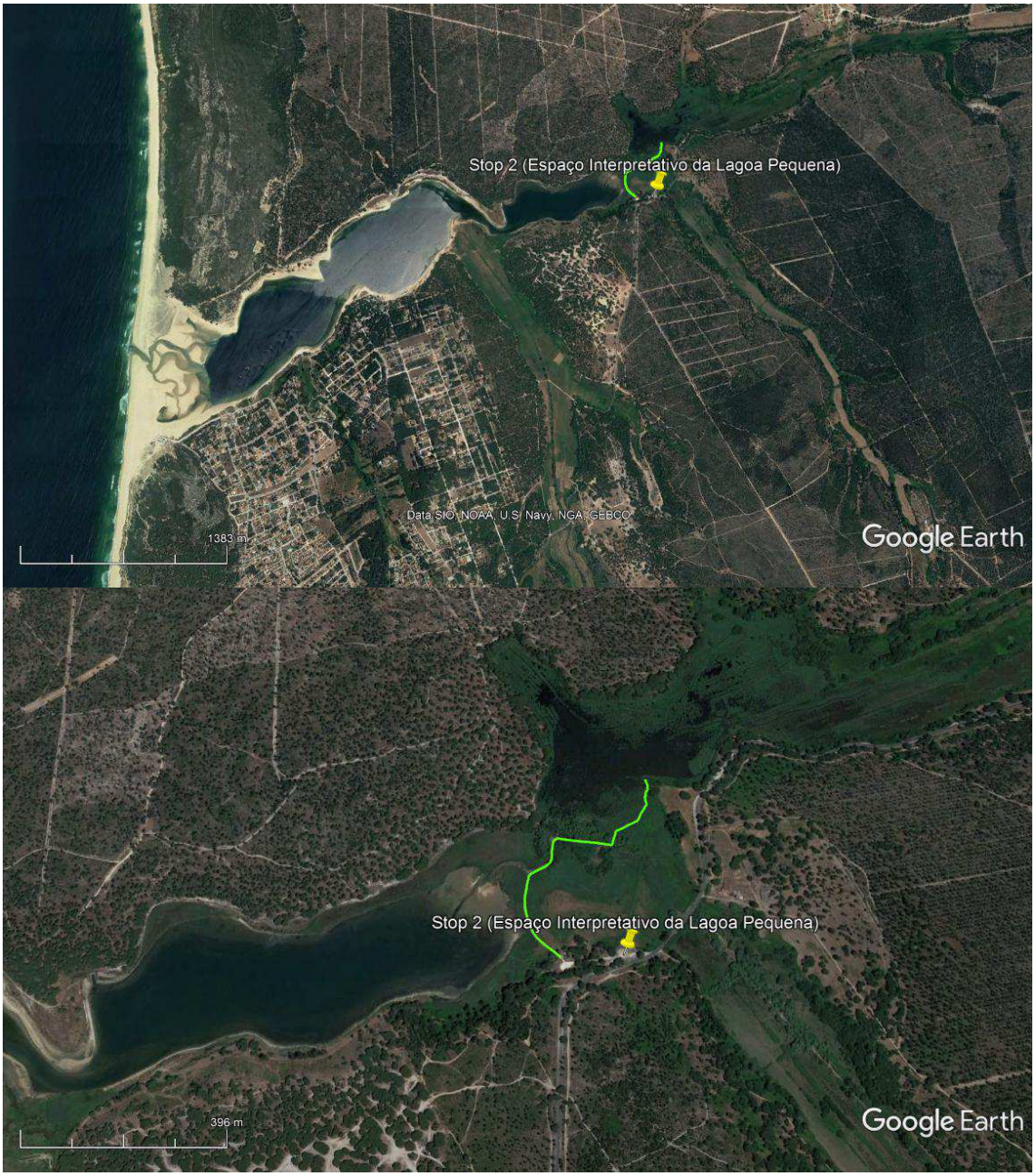

Figure 9 – Lagoa de Albufeira (top) and Lagoa Pequena (bottom) showing the proposed itinerary

The site harbours important conservation values. Lagoa de Albufeira was designated a Ramsar Site (Wetland of International Importance, 7PT006) in 1996 because of meeting four criteria (rare type of wetland within the biogeographic region, important plant and animal populations to maintain regional biodiversity, supporting plant and animal species in a critical stage of their biological cycle and sustaining important native fish, contributing to local biological diversity). Albufeira lagoon is also included in the Habitats Directive Site of Fernão Ferro/ Lagoa de Albufeira (SIC Fernão Ferro/Lagoa de Albufeira, PTCON0054), since 1998 due to the presence of priority species (*Armeria rouyana, Jonopsidium acaule*) and habitats at the European Level. Priority habitats present include: Coastal lagoon habitat (1150*), Atlantic decalcified fixed dunes (Calluno-Ulicetea) (2150*), Coastal dunes with *Juniperus* spp. (2250*), Wooded dunes with *Pinus pinea and/or Pinus pinaster* (2270*), Mediterranean temporary ponds (3170*), Temperate Atlantic wet heaths with *Erica ciliaris* and *Erica tetralix* (4020*), and Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*Alno-Padion, Alnion incanae, Salicion albae*) (91E0*) (Mendes, 2003, ICN 2012).

Lagoa Pequena is a Birds Directive Site (ZPE Lagoa Pequena, PTZPE0049) since 1999 and it was classified by SPEA/BirdLife International as Important Bird Area (IBA, PT040) (Mendes, 2003). The *Phragmites australis* communities surrounding the Lagoa de Albufeira are specially important aquatic birds nesting in the site such as *Ardea purpurea, Ixobrychus minutos*, and *Porphyrio porphyrio*), but also to a great number of passerine species during their autumn migration (Costa et al., 2003).

The proposed itinerary (Figure 9) will cross the area of the Lagoa Pequena and Lagoa da Estacada located upstream, which receives most of the tributaries of the Lagoa de Albufeira drainage basin. In terms of vegetation, terrestrial communities adapted to sandy soils inhabit the surroundings of the lagoon, while a diversity of aquatic and hygrophyllous plant communities distribute across ecological gradients of hydroperiod and salinity across the wetland. Terrestrial communities include forest systems (dominated by *Pinus pinea*, *Pinus pinaster* or both; *Eucalyptus* plantations), shrubland areas, herbaceous patches and dune vegetation (with protected species such as *Armeria rouyana*, endemic to Portugal, Figure 10). Hygrophyllous woodland communities include *Salix atrocinerea* wetland forests (Figure 11) and *Tamarix africana* thickets. Herbaceous plant communities include the highly representative *Phragmites australis* community (Figure 11), *Juncus* sp community, and halophytes herbaceous communities (Silva et al., 2013)


Figure 10. *Armeria ruoyana* endemic to Portugal and priority species for conservation at European level, Habitats Directive Annex II (Photo Left PRG, Right PA)

3.4.2.Current challenges for sustainable management

One critical factor influencing management in Lagoa de Albufeira is the ecological succession experienced by these type of coastal wetlands, with cycles of open water to forested wetlands, and finally terrestrial forests that, at a landscape scale would be compensated by the natural formation of new coastal lagoons. Yet, human pressures have disturbed the natural dynamics of the ecological succession, and the formation of new coastal lagoons is extremely conditioned by extensive human occupation of coastal areas. Thus, maintaining these type of wetland is one of the reasons why the littoral barrier is artificially opened once a year. The isolation from the ocean had led to changes in the physico-chemical characteristics of water, alteration of the relation N/P, eutrophication and stratification of water masses due to different salinity levels and to the lack of hydrodynamics which implies a deficient water mixture (Mendes, 2003).

Sediment dynamics is another issue of critical importance on wetlands ecological functioning. The sedimentation occurring in Lagoa Pequena, has been attributed to increased sediment inputs from Ribeira da Ferraria, its main tributary. The agriculture practices in its valley have eliminated vegetation cover in the drainage basin, causing increased erosion, lagoon aggradation and shallowing. In the late 70's an intensive raft culture of mussel (*Mytilus edulis*) was introduced at Albufeira lagoon. The intensive culture of filtering organism in low-energy environments may raise particular sustainability problems, such as changes in sedimentation (Ferraz et al., 2005).

Agriculture and grazing together with the presence of the Sewage Treatment Plant of Lagoa/Meco (ETAR de Lagoa/Meco) impose pollution pressures. In addition, increased tourism activities and urban development in the surroundings of the wetland threaten ecosystems and species (Mendes, 2003).

Recent pressures over vegetation include the expansion of exotic species such as *Acacia cyanophylla, Carpobrotus edulis, Arundo donax,* and *Acacia longifolia* (Silva et al., 2013).

Figure 11. *Phragmites australis* community (Left) and *Salix atrocinerea* dominated wetland forests (Photo Left PRG, Right PA)

3.5. Stop 3 – Arrábida Natural Park

3.5.1. Serra da Arrábida

Serra da Arrábida is a national protected area, classified under the status of 'Natural Park'. It integrates the national NATURA 2000 site list both as a special area of conservation (Habitats Directive, Sitio Arrábida/Espichel, PTCON0010), and as a special protection area (Birds Directive, ZPE Cabo Espichel, PTZPE0050).

A short stop in the N379 from Azóia in direction to Setubal allows to enjoy the view of the magnificent Coastal area of Serra da Arrábida, including the Convento Novo, an ancient Franciscan Order Convent (sXVI) (Figure 12 and 13). This sea-facing small mountain (501 meters above m.s.m.) is an anticline composed of limestones, mostly of Jurassic origin. Its dominant soils "Terra Rossa" were developed from hard calcium carbonate rocks, some with dolomitic (calcium magnesium carbonate) character.

Figure 12 – View of Serra da Arrábida and Convento Novo (Photo PA).

The Serra da Arrábida natural vegetation, generally well preserved, has a high natural value due to the fact that the majority of the taxa share a paleomediterranean and/or paleotropical origin. This factor, together with a relatively high annual precipitation rate, no frost, and soils originated from dolomitic limestone, determine a vegetation of great richness and originality. More than 1300 plant species were identified in this area, which constitutes the 40% of total Continental Portuguese phytodiversity (Espirito Santo et al., 2011).

According to the phytosociological approach (Costa et al., 2005), two distinct vegetation series that can be found in this territory, both headed by cork oak (*Quercus suber*) woodlands: *Asparago aphylly-Querco suberis sigmetum*, on sandstone derived solis, and *Oleo sylvestris-Querco suberis sigmetum* on slightly hydromorphic sandy soils. Many of these forests were thinned and transformed into "montados" (cork oak savannas) or into pinewoods of *Pinus pinea* or *Pinus pinaster*.

The potential and seral stages of the *Asparago aphylli-Querco suberis sigmetum* are: *Asparago aphylli-Quercetum suberis* (mature forest), *Buplero fruticosae-Arbutetum unedonis* (thicket or mantle high-shrub hedge), *Erico-Quercetum lusitanicae ulicetosum welwitschianii* (low-shrub community), *Avenulo sulcatae-Stipetum giganteae* (perennial grassland) and *Erico umbellatae-Ulicetum welwitschiani* (heath scrubland). In turn, the *Oleo sylvestris-Querco suberis sigmetum* is made up by the following potential and seral stages: *Oleo sylvestris-Quercetum suberis* (mature forest), *Junipero navicularis-Quercetum lusitanicae* (shrubby community) or *Asparago aphylli-Myrtetum communis* (shrubby community in edaphohigrophilous situation), *Stipa gigantea* community (perennial grasslands), *Thymo capitellati-Stauracanthetum genistoides* (gorse scrubland on deep paleodune sand), *Erico umbellatae-Ulicetum welwitschiani* (heath scrubland on compact substrata) and *Corynephoro macranthero-Arenarietum algarbiense* (annual community).

Figure 13 – Serra da Arrábida and Setúbal region, with Troia Peninsula (below, right)

Over the Serra's summit, an edaphoxerophilous permanent high-scrub juniper community is interpreted as the climax: *Querco cocciferae-Juniperetum turbinatae*. The strongly xeric character of this vegetation is testified by the co-dominance of *Olea europeae* var. *sylvestris*, *Asparagus albus* and ecologically similar taxa in some of these biotopes. Normally, primary positions of the *Querco-Juniperetum turbinatae* have a perennial grass community as a substitution stage: *Iberido microcarpae-Stipetum offneri.* This community, which can be observed in the steepest and more eroded slopes, is well adapted to fire. The second stage is either *Salvio sclareoidis-Ulicetum densi thymetosum sylvestris* or *Phlomido purpureae-Cistetum albidi*, dominated by *Cistus albidus*. Similarly, at Serra da Arrábida the *Quercus rotundifolia* is always a scrub (2–3 m) never reaching a tree size and thus never establishing as tall woodland. The putative explanation for this fact lies also in the high calcium/magnesium soil rate, becoming toxic to the holm oak.

The community *Phlomido lychnitidis-Brachypodietum phoenicoidis* (dominated by the perennial tall grass *Brachypodium phoenicoides*), an important Orchidaceae habitat, is rather ubiquitous on the Serra's foothills. Often seen on deeper soils, it also frequently appears in mosaic with the community *Salvio sclareoidis-Ulicetum densi thymetosum sylvestris* (dominated by *Ulex densus* and *Thymus zygis subsp. sylvestris*), which occupies the rockier and most eroded positions.

Other equally interesting communities occupy some smaller patches of this landscape: *The Sileno longiciliae-Antirrhinetum linkiani* is a dwarf perennial chasmo-comophyte community found on limestone walls and on rock crevices of Serra da Arrábida. On those locations it can also be found the chasmofitic community *Narciso calcicolae-Asplenietum rutae-murariae*. The succulent plants Sedum sediforme and Sedum album var. micranthum are common on flat rocks and form the *Sedetum micrantho-sediformis* community.

Finally, a reference to the community *Helianthemo stoechadifoliae-Limonietum virgatae*, that takes place on sea cliffs splashed by marine salt spray.

Cabo Espichel Dinosaur Tracks and footprints

If we travel from the Azóia village to Cabo Espichel we will cross along areas with alternating layers of calcareous and sandstone sediment, inducing sharp changes in plant communities: while communities over the former, basophyllous substrate, are colonized by plants like *Ulex densus, Cistus albidus*, *Klasea baetica* subsp. *lusitanica, Ferula communis* subsp. *catalaunica*, *Jasminum fruticans* and *Thymus* zygis subsp. *sylvestris*, the latter, acidophyllous substrate, is mostly occupied by heaths like *Calluna vulgaris*, *Erica umbelatta*, *Erica scoparia* and also *Thymus villosus*.

The littoral in this area is formed by Cretaceous and Jurassic carbonated rocks (limestones and marls), which constitute an erosive littoral, where processes are more dependent on tectonics and hydric erosion rather than on direct sea action. Yet, occasionally, some small bays favour the sediment accumulation originating small beaches such as Praia dos Lagosteiros and Praia do Cavalo (Figure 14), characterized by coarse deposits indicating the high hydrodynamism of the zone and the lack of sand in the surroundings. In Lagosteiros beach is possible to observe the contact between the Cretaceous and the Jurassic formations. Between this beach and the Cabo Espichel we can observe evidence of dinosaur's presence (Figure 14) (Cruces et al., 2002b). Although their footprints are located today in rocky layers, inclined, it should be noted that they were impressed when those where soft sediments deposited in shallow lagoons or brackish pools located in the Cretaceous and Jurassic littoral. After their deposition and burial by younger sediments, the so-formed layers and initially deposited in horizontal levels, experienced litification processes that transformed them in the limestones and marls observable today.

This is an area with quite a number of natural and cultural heritage features (*e.g.* the arrabidensean endemics *Euphorbia pedroi* and *Convolvulus fernandesii*, the Espichel Santuary among others). One of the current challenges for the area is to ensure good visitation conditions, providing secure environments, improving the signaling and information system.

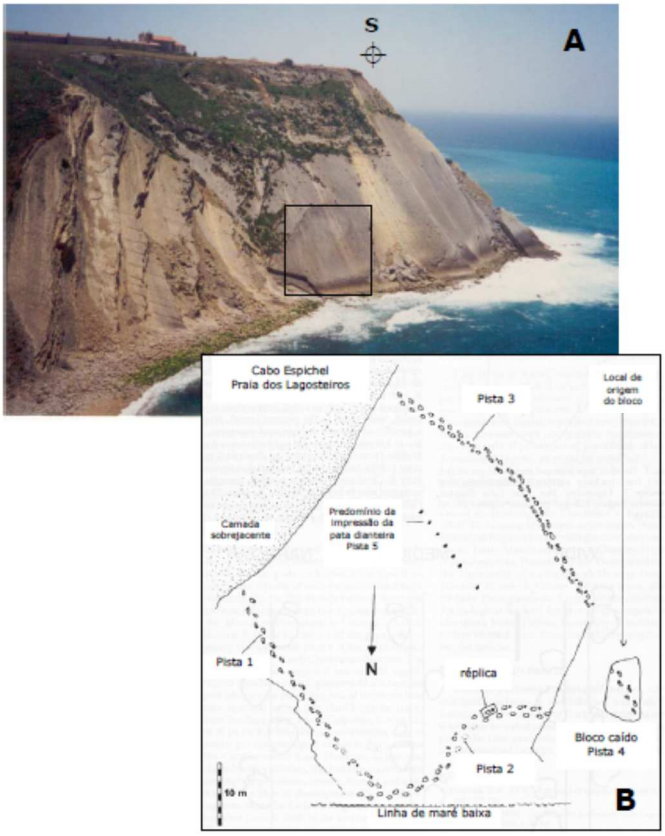

Figure 14. Lagosteiros beach and dinosaur footprint schematic representation (Cruces et al., 2002b).

3.5.2. Rehabilitation within a Protected Area: Visit to the Outão Quarries

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INTRODUCTION

Outão cement plant is located within the limits of the natural park (Natural Park of Arrábida) and the Natura 2000 site (Sitio Arrábida/Espichel, PTCON0010), south west of Portugal. The exploitation area covers about 100 ha, of which 42% have already been subjected to rehabilitation actions. Revegetation began in 1982 and aimed to recreate the natural habitats surrounding the quarries, using different techniques: reintroduction of soil; introduction of herbaceous and shrubs vegetation by hydroseeding; and plantation of native species produced in the plant´s own nursery (Figure 15). Therefore, recovered areas exhibit different stages of vegetation succession according to the period of restoration. The implementation of these actions has been followed by an extensive team of researchers from the Faculty of Sciences of the University of Lisbon since 1997. The team's studies focus not only on vegetation, but also on the reintroduction of soil as this affects plant development.

In 2007, SECIL integrated the fauna component in the project, with the support of a team of researchers from the University of Évora. The study began with the survey of vertebrate and invertebrate terrestrial fauna considering rehabilitated and natural areas. This baseline data was used to define an Action Plan that aims to promote conditions to increase the natural colonisation by fauna in the recovered areas. The strategy of the Action Plan relies on an adaptive management program, with periodic monitoring of fauna and continuous evaluation of actions' effectiveness. Recently, several short-term studies have been developed within this partnership regarding the potentially limiting topography of quarry in non-flying fauna movements, and spatial effects of quarry exploitation on fauna communities in the Natural Park of Arrábida.

Figure 15. Top: Visit to the nursery plant (production of native species used in the rehabilitation process); Bottom: Visit of the quarries and rehabilitated areas[1]

[1] The visit and access to the quarries depends on atmospheric conditions (heavy rain).

4. References

Blanes, R. D. L. 2003. Caracterização Sócio-cultural dos Agricultores das Terras da Costa. Relatório de Estágio na Paisagem Protegida da Arriba Fóssil da Costa da Caparica. ICN, 20pp.

Costa, J.C., Capelo, J., Arsénio, P. & Monteiro-Henrique, T. 2005 - The landscape and plant communities of Serra da Arrabida. Quercetea 7: 7-25. https://www.researchgate.net/publication/233919456_The_Landscape_and_Plant_Communities_of_Serra_da_Arrabida.

Costa. L.T., Nunes M., Geraldes, P., & Costa, H. 2003. Zonas Importantes para as aves em Portugal. Sociedade Portuguesa para o Estudo das Aves, Lisboa.

Cruces, A., Freitas, M.C., Andrade, C. 2002a. Geologia no Verão 2002 – Guia de Excursão, A Geologia no Litoral – Parte I: Do Tejo à Lagoa de Albufeira.

Cruces, A., Freitas, M.C., Andrade, C. 2002b. Geologia no Verão 2002 – Guia de Excursão, A Geologia no Litoral – Parte II: Da Lagoa de Albufeira a Setúbal.

Espírito-Santo, MD Tiago Monteiro-Henriques, T; Silva, V., Rodrigues, J.P. & Costa, J.C. 2011, Estudo da flora, vegetação e paisagem vegetal da Serra da Arrábida, Lisboa, 275pp. https://www.researchgate.net/publication/257366206_ESTUDO_DA_FLORA_VEGETACAO_E_PAISAGEM_VEGETAL_DA_SERRA_DA_ARRABIDA_-_Relatorio_para_a_candidatura_a_Patrimonio_Misto_da_UNESCO

Ferraz, M., Silva, E., Cruces, A., Freitas, M.C., Cachão, M., Andrade, C. Araújo, F. 2005. - Environmental characterization of the Albufeira lagoon (Portugal) at micro timescale using a multidisciplinary approach [talk]. In: Iberian Coastal Holocene Paleoenvironmental Evolution : Coastal Hope 2005 Conference Proceedings, Lisbon, Portugal, 24-29 July 2005. Editors Maria da Conceição Freitas, Teresa Drago. Lisboa, p. 54-57.

Fortunato, A.B., Nahon, A., Dodet, G., Rita Pires, A., Conceição Freitas, M., Bruneau, N., Azevedo, A., Bertin, X., Benevides, P., Andrade, C., & Oliveira, A. 2014. Morphological evolution of an ephemeral tidal inlet from opening to closure: The Albufeira inlet, Portugal. Continental Shelf Research, 73, 49-63

Ferreira, J.C. 2006. Coastal Zone Vulnerability and Risk Evaluation: ATool for Decision-Making (An Example in the Caparica Littoral - Portugal). Journal of Coastal Research SI 39 1590 - 1593 ICS 2004 (Proceedings).

Fonseca, P. 1998. Paisagem Protegida da Arriba Fóssil da Costa da Caparica. ICN, 18pp.

Freitas, M.C. 1995. A laguna de Albufeira, Península de Setúbal: sedimentologia, morfologia e morfodinâmica. Doctoral dissertation, Universidade de Lisboa. 337p.

Instituto de Conservação da Natureza e Biodiversidade. 2012. «Plano Sectorial da Rede Natura 2000 Sítios de Interesse Comunitário». http://www.icnf.pt/portal/naturaclas/rn2000/resource/docs/sic-cont/fernao-ferro-lagoa-de-albufeira.

Lourenço, D.C.G.R. 2009. Avaliação de áreas invadidas por espécies de Acacia na Paisagem Protegida da Arriba Fóssil da Costa de Caparica (Doctoral dissertation, Faculdade de Ciências e Tecnologia FCT/UNL). https://run.unl.pt/bitstream/10362/6123/1/Lourenco_2009.pdf .

Mendes, A. 2003. Lagoa de Albufeira. Uma contribuição para a sua gestão. Lisboa: ICN.

Pais, J.P. 1992. Paisagem Protegida da Arriba Fóssil da Costa da Caparica. Liberne, nº 42, 5-9.

Rego, F. 2001. Florestas Públicas, Ministério da Agricultura e Direcção Geral das Florestas, Lisboa, 105pp. ISBN: 972-95702-6-4.

Silva, J., Correia, O., Branquinho, C., Antunes, C., Cruz de Carvalho, R., Mexia, T., Tápia, S. 2013. «Relatório com o estado da flora e da vegetação na Lagoa de Albufeira e zona envolvente». Estudo da Lagoa de Albufeira. Faculdade de Ciências da Universidade de Lisboa. http://www.apambiente.pt/_zdata/Politicas/Agua/Ordenamento/SistemaMonitorizacaoLitoral/E_3.2.2.3_Estado%20da%20flora%20e%20vegetaao.pdf

Veloso Gomes, F., Costa, J., Rodrigues, A., Taveira-Pinto, F., Pais-Barbosa, J., das Neves, L. 2009. Costa da Caparica Artificial Sand nourishment and Coastal Dynamics, Journal of Coastal Research SI56, ICS2009 Proceedings.

Lagoa da Estacada Panoramic view (Photo PA)