

## **CASCADE STUDY AREA 1: Caramulo Mountains, Portugal**

Responsible partner: UAVR

### **1. General information**

Following work in the late 1980s and early 1990s, fire-related research by the UAVR team was “rekindled” by the summer fires in 2003 and the subsequent submission and funding (by the national Foundation for Science and Technology – FCT) of the research projects EROSFIRE-I and PHOENIX, addressing post-fire erosion and vegetation recovery, respectively. Subsequent research projects and associated post-doctoral and PhD grants made it possible to intensify this work and widen its scope, namely by addressing: (i) social-economic and land-use planning aspects; (ii) land degradation in general, i.e. not just losses of soil particles but also of soil organic matter and nutrients; (iii) effectiveness of emergency soil conservation measures; (iv) off-site effects on downstream aquatic habitats and flood zones, including with respect to eco-toxicological effects of ash-loaded runoff; (v) comparison with eco-hydrological processes in long-unburned forests as well as agricultural lands. The overall research approach involves a close link between measurements and modelling, ultimately aiming at the assessment of scenarios of post-fire land management as well as of climate and land-use changes.



**Figure 1. Typical landscape in the area.**

### **2. Geographical description**

The study region is located in north-central Portugal, and is part of the Vouga River Basin which drains into the Ria de Aveiro coastal lagoon area. According to Köppen’s climate classification system, the climate can be classified as Csb, i.e. as humid meso-thermal with a prolonged dry and warm summer - when the majority of wildfires occur. Annual rainfall ranges from 1200 to over 2000 mm/year at the highest elevations. This relatively high rainfall for Mediterranean regions is worth stressing as it enhances vegetation growth and,

thus, the accumulation of fuel load, on the one hand, and, on the other, increases rainfall erosivity and, thus, post-fire erosion risk.

The area belongs to the major physiographic unit of the Hesperic Massif, which is dominated by pre-Ordovician schists and greywackes and Hercynian granites. The terrain has a pronounced relief with steep slopes that are typically around 20-25° but steeper in places. The soils are mapped (scale of 1:1.000.000) as a complex of Humic Cambisols and, to a lesser extent, Dystric Litosols. Soils are typically shallow (<40 cm deep), and therefore particularly susceptible to degradation by soil erosion processes.

### **3. Main ecosystem(s) in the study areas, and functions/services they provide**

The study area is predominantly covered by forests (CORINE2006: approximately 60%). The principal tree species are Maritime Pine (*Pinus pinaster* Ait.) and eucalypt (*Eucalyptus globulus* Labill.). They have been planted on a large scale, starting at the end of the 19<sup>th</sup> century and with the autochthonous Maritime Pines increasingly being replaced by the allochthonous eucalypts in the past decades. Since both species are highly flammable, their widespread planting is commonly regarded a key factor in the present-day wildfire regime. Important differences between the two types of forest plantations are that: (i) the rotation cycle is much shorter for eucalypt than for Maritime Pine (10-15 vs. 40 years); (ii) following fire, mechanical ground operations like ploughing and, in recent times, especially terracing are frequent in eucalypt stands but hardly ever occur in pine stands (where natural regeneration prevails). Such mechanical ground operations can markedly enhance soil erosion rates and greatly reduce vegetation recovery.

Important ecosystem services provided by the two predominant types of forest plantations are: (i) wood production, with eucalypt plantations assuming special relevance for the paper industry (a paper pulp plant exists in the Aveiro municipality); (ii) production of forest residues for biomass electricity centrals; (iii) protection against floods, which is particularly important in the case of the city centre of Águeda due to its location in a floodplain; (iv) attenuation of rainfall-runoff response, which will be fundamental for the dam complex that is currently being built in the lower Vouga river (Ribeiradio-Ermida) for generation of hydric electricity; (v) provision of good water quality, both for healthy aquatic ecosystems and the capture of surface water for irrigation and drinking water purposes as is the case of the Carvoeiro station in the lower Vouga river; (vi) preservation of natural values, especially in the Maritime Pine stands and perhaps also the less-intensively managed eucalypt stands.; (vii) tourism and recreation.

### **4. Ecosystem dynamics**

Besides logging, (re-)planting and regular management operations such as stand thinning and treatments of the undergrowth, wildfires are the main ecological factor affecting the forests in the study region. Between 1975 and 2010, wildfires affected over 35.000 ha of rural lands within the region, amounting to almost 40 % of its total area. Recurrence of wildfires was far from exceptional, since roughly 20 % of the 1975-2010 burnt area was affected by wildfires twice and roughly 10 % was affected even more often.

Wildfires and post-fire land management can markedly increase soil erosion and soil fertility losses, resulting in degradation of soil conditions and the associated ecosystem functions to possibly irreversible levels (at least in the human time frame). Past and on-going research in the study region has found post-fire erosion rates to be low compared to Australia and the USA but similar to other parts of the Iberian Peninsula. These comparatively low rates result from an erosion process that is essentially sediment-limited. This, in turn, is taken to reflect the long and intense land-use history in the study region, similar to the rest of Mediterranean Europe. In more recent times, important land-use changes have been the widespread planting of Maritime Pine by the national forest services during the first half of the 20<sup>th</sup> century and their subsequent conversion to the more intensively managed eucalypt plantations.

Prior studies have brought to the forefront that many soils in the study region are fragile and susceptible to further degradation. Soils are often shallow and covered by extensive stones at the surface. Limitations in root development and plant water and nutrient availability could explain why post-fire recovery of the undergrowth vegetation is commonly slow and contracted. Nonetheless, it is yet to be clarified whether (recurrent) wildfires, possibly combined with adverse post-fire environmental conditions (e.g. due to poor management practices or drought) have produced or will produce irreversible changes in the forest ecosystems of the study area

## **5. Proposed experiments**

The presence and nature of wildfire-induced tipping-points will be studied for Maritime Pine plantations, following the same overall approach as at the other CASCADE study areas. To this end, pine stands that burned zero, one and four times between 1975 and 2012 (the period for which burned-area maps are available) were selected to compare vegetation-water-soil interactions under reference, semi-degraded and degraded conditions. The (semi-) degraded study sites were burnt by a wildfire during early September 2012 that affected a total area of approximately 3.000 ha; the reference sites are located in the immediate surroundings of this burnt area.

## **6. Relevant end-users of knowledge in the region / country**

Besides the local land owners in the area of the field experiments (see 5.), relevant end-users of knowledge include:

- local authorities, in particular “juntas de freguesia” and boards of common grounds;
- associations of forest land owners such as the Baixo Vouga Forestry Association;
- municipal Technical Forestry Offices (GTF) and town halls;
- Institute for Nature and Forest Conservation (ICNF), including its regional delegations;
- Commission of Coordination and Regional Development of the Centre Region (CCDRC);
- Environmental protection organisations such as Quercus or “Liga para a Protecção da Natureza” (LPN);
- Portuguese Environmental Agency (APA);

- RAIZ - Research Institute for Forestry and Paper;
- Paper and pulp producing companies such as “grupo Portucel Soporcel”;
- Water provision organisations such as the Association of Carvoeiro Municipalities (Carvoeiro water capture station);
- Hydric energy companies such as Greenvouga (Ribeiradio-Ermida dam complex);
- State and private tourism organisations.

## 7. Anticipated activities and workshops with stakeholders

The activities with stakeholders will centre on the study site locations (see 5.). A start is being made with an inventory of the key actors that, besides the actual land owners, are directly or indirectly involved in the management of the selected study sites and their immediate surroundings. An initial stakeholder workshop is foreseen for early 2013, and is to be followed up by a systematic survey of the stakeholders and a preliminary questionnaire of selected stakeholders before the summer of 2013.

## 8. Past and on-going projects on ecosystem functioning, thresholds, and related aspects

- EROSFIRE (2005-2008) - erosion risk assessment & modelling following wildfire, see <http://www2.dao.ua.pt/RECNAATUR/EROSFIRE/files/Scriptio%20Internship%20Erosfire.pdf>
- PHOENIX (2005-2009) - vegetation recovery with time after fire
- RECOVER (2007-2010) - effectiveness of emergency soil conservation measures
- EROSFIRE-II (2007-2010) - on- & off-site wildfire effects on runoff and erosion, see <http://www.cesam.ua.pt/index.php?menu=82&tabela=projectosdetail&projectid=260&language=eng>
- DESIRE (2007-2011) - stakeholder-based land conservation strategies against desertification, see <http://www.desire-project.eu/>
- HIDRIA (2009-2012) - rainfall-runoff modelling of long-unburnt forest catchments, see <http://www.cesam.ua.pt/index.php?menu=82&language=pt&tabela=projectosdetail&projectid=261>
- FORESTAKE (2010-2013) - role of stakeholders in forest policy success in fire-prone areas, see <http://www.cesam.ua.pt/index.php?menu=82&language=eng&tabela=projectosdetail&projectid=272>
- FIREREG (2010-2013) - mid-term post-fire regeneration in eucalypt & pine forest, see <http://www.cesam.ua.pt/index.php?menu=82&language=eng&tabela=projectosdetail&projectid=270>
- FIRECNUTS (2010-2013) - on- & off-site wildfire effects on runoff and soil, organic matter, carbon and nutrient losses, see <http://www.cesam.ua.pt/index.php?menu=82&language=eng&tabela=projectosdetail&projectid=262>

## 9. Key references about ecosystem dynamics in the study area or wider spatial setting.



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