CASCADE STUDY SITE 3: Valencia Mountain Ranges, Spain

Responsible partner: CEAM

1. General information

Many of the present-day forests and shrublands in eastern Spain have been developed on abandoned agricultural lands, where resprouting tree and shrub species have been historically eliminated, reducing ecosystem resilience to wildfires. Thus, post-fire landscapes in the area are commonly dominated by seeder shrub species. Moreover, as a consequence of increasing fire incidence and abandonment of agricultural practices, these shrubland communities have significantly spread in the Mediterranean coastal strip of Spain, further increasing fire risk due to their high flammability, which has established a positive feedback between fire risk and land degradation. Under these conditions, and the projections of increasing fire incidence under climate change, vegetation management strategies to enhance ecosystem resistance and resilience to wildfires are a priority in vast areas of the Mediterranean Basin.

2. Geographical description

The study area covers a series of mountain ranges (Ayora and Mariola) located in the Central to South part of the Valencia Region, SE Spain. The climate is dry Mediterranean, with mean annual rainfall and temperature varying between 350-700 mm and 13-18ºC, respectively. The dominant soils in the area are *Regosols* developed over marls and limestone colluviums, but shallow *Leptosols* and *Luvisols* developed over limestones are also found. The topography is characterised by moderate to steep slopes. Many of these slopes are covered by agricultural terraces that are currently abandoned and degraded.

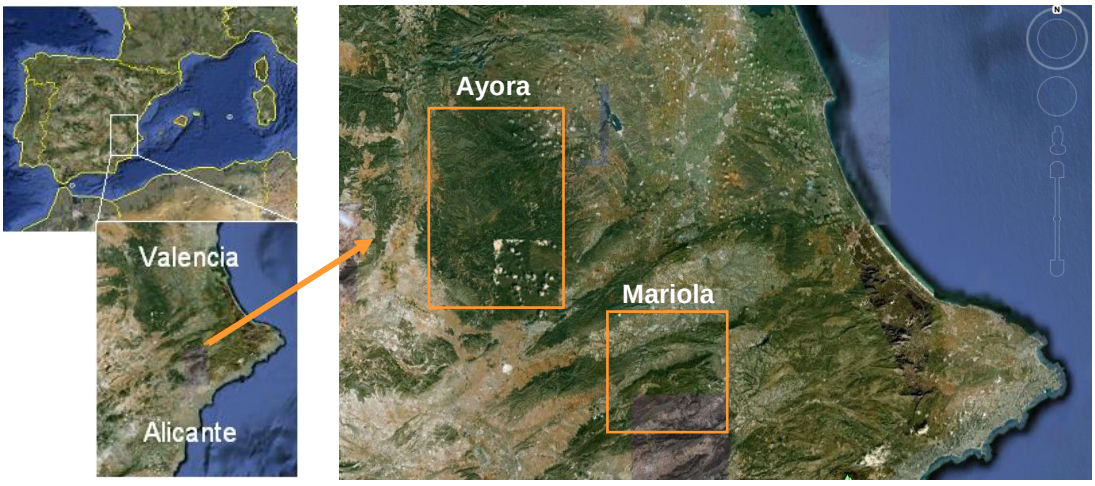

Figure 1: Location of the Ayora and Mariola mountain ranges.

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

The landscape in the area is a mosaic of agricultural land and abandoned fields covered by post-fire regenerating pine woodlands and shrublands, with a variety of dominant plant species and successional stages. Main goods and services provided by these ecosystems

include regulating and supporting services such as soil and water conservation, cultural services such as tourism and recreation areas, and various timber and non-timber forest products, including forage, aromatic plants, mushrooms, honey.

4. Ecosystem dynamics

The recent increase in fire incidence in the area, combined with the loss of ecosystem resilience due to past agricultural use and grazing, has driven a shift in the composition of vegetation communities, from woodlands and shrublands dominated by resprouting species to shrublands dominated by seeding species. When these shrublands are burned, further changes in plant species composition may occur, with this transition process influenced by fire recurrence. Thus, in the study area, fire recurrence is considered to drive important shifts in plant communities (from woodland to shrublands, from shrublands to open herb-sedgeland), and associated ecosystem functioning such as reduced post-fire regeneration rates leading to higher soil erosion risk. Therefore, short-interval fire cycles are promoted, driving positive ecosystem degradation feedbacks. Under these circumstances, the disappearance of keystone species, such as pines (due to repeated fires before producing viable seeds) and oaks (charcoaling and change of land use for cropping), represents a change in the ecosystem that needs external inputs through restoration to be reversed.

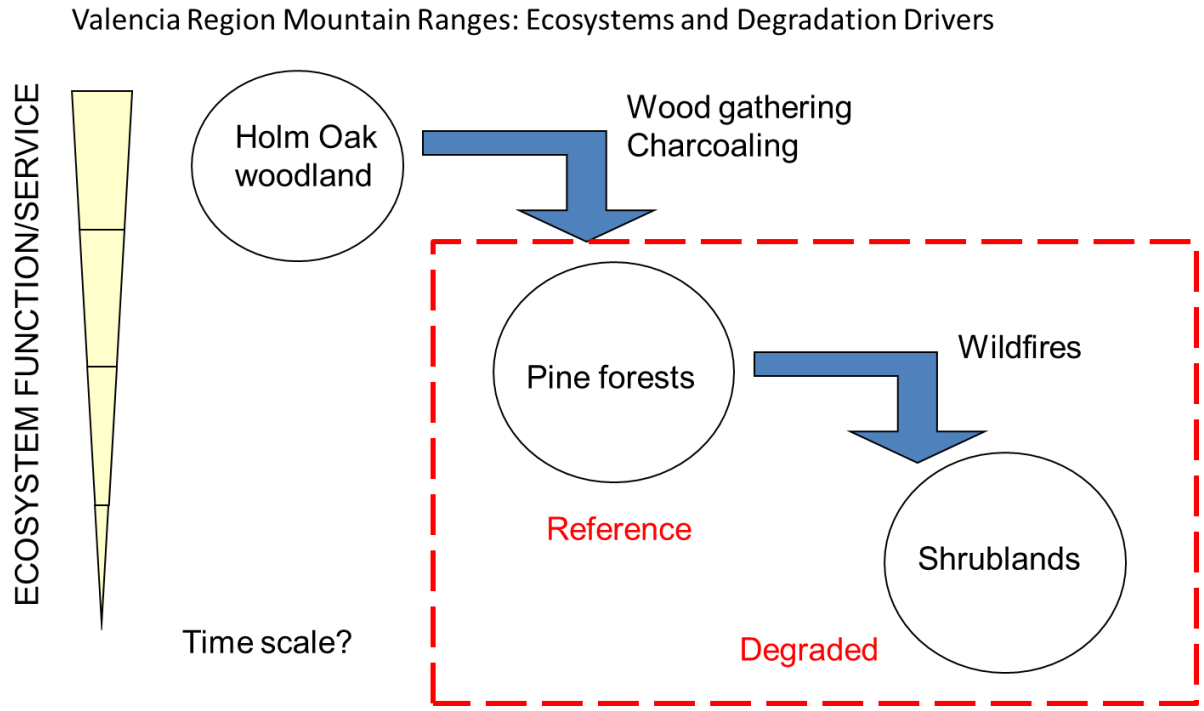

Figure 2: Ecosystems and degradation drivers

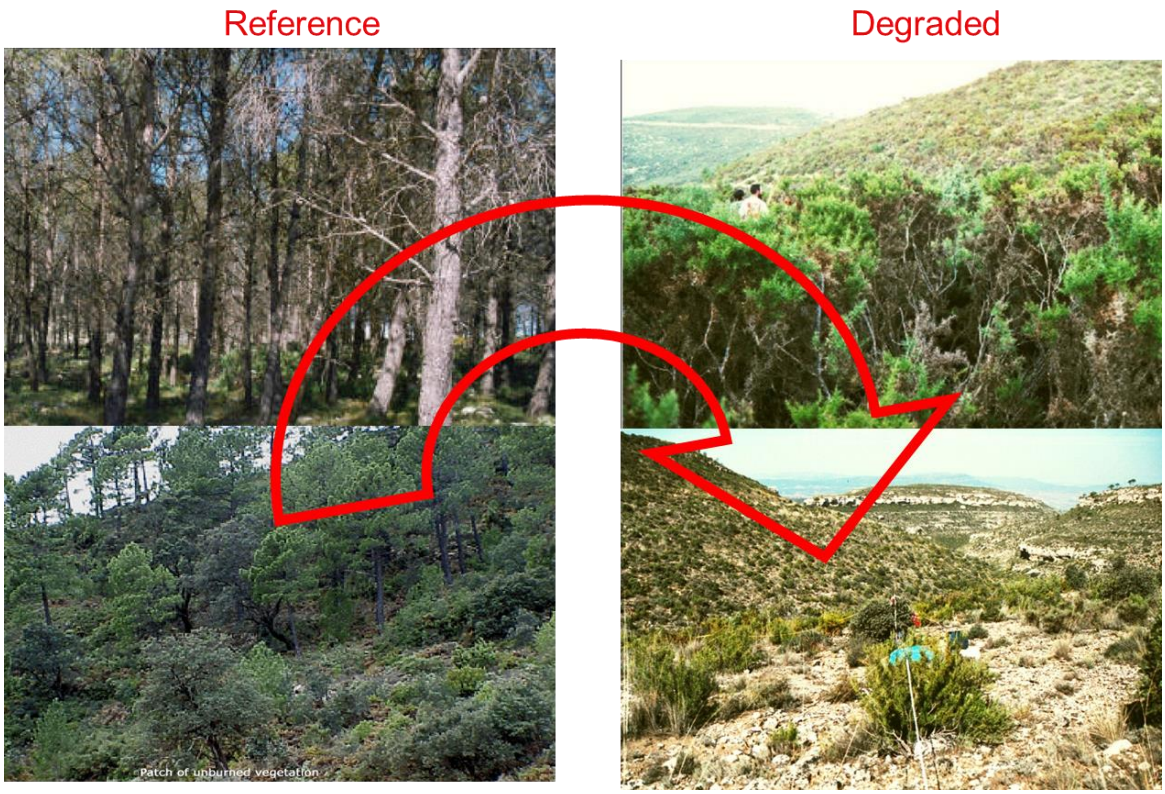

Figure 3. Different ecosystems along the degradation gradient (recurrent fires), from mixed pine-oak forests (bottom left) to low and sparse shrubland dominated by seeder species (bottom right). Intermediate states include managed pine forests (top left) and successional mixed shrublands (top right).

5. Proposed experiments

Landscape and soil degradation is associated with a plant regeneration strategy in a scenario of recurrent fires. Short fire intervals (e.g. < 20 years) in natural and managed ecosystems facilitate the spread of shrublands. Shublands dominated by obligate seeder species facilitate fire occurrence triggering short-term fire cycles, promoting positive feedback degradation processes. Within this vegetation/ecosystem-scale scheme, there is a pattern of soil fertility/degradation patchiness generated by the occurrence of shrubs with contrasting regeneration strategy after fire. Resprouter shrubs generate resilient plant-size patches in front of fires, preserving resources (soil, nutrients, soil structure-physical properties, seeds). Obligate seeder shrubs are exposed to short-term post-fire degradation that would eventually generate bare soil (from temporal to permanent). Extreme patch degradation may occur when thresholds of disturbance (recurrent fires, short-term fire intervals) and (perhaps) climate change are crossed. Therefore, micro-patches occupied by obligate seeders are prone to move along a degradation pathway that can eventually end in a vegetation-bare soil pattern under extreme conditions (high fire frequency and drought). This process may be driven by soil degradation and loss of resources (including soil seed bank depletion).

We will take two different plant-soil systems along the degradation gradient (fire frequency), one considering a resprouter species and the other one with an obligate seeder

species. Our target resprouter species will be kermes oak (*Quercus coccifera*) while the seeder will be rosemary (*Rosmarinus officinalis*). These two shrub species are easily found, although with different densities and sizes, in many plant communities, from pine forests to low and sparse shrublands burned several times.

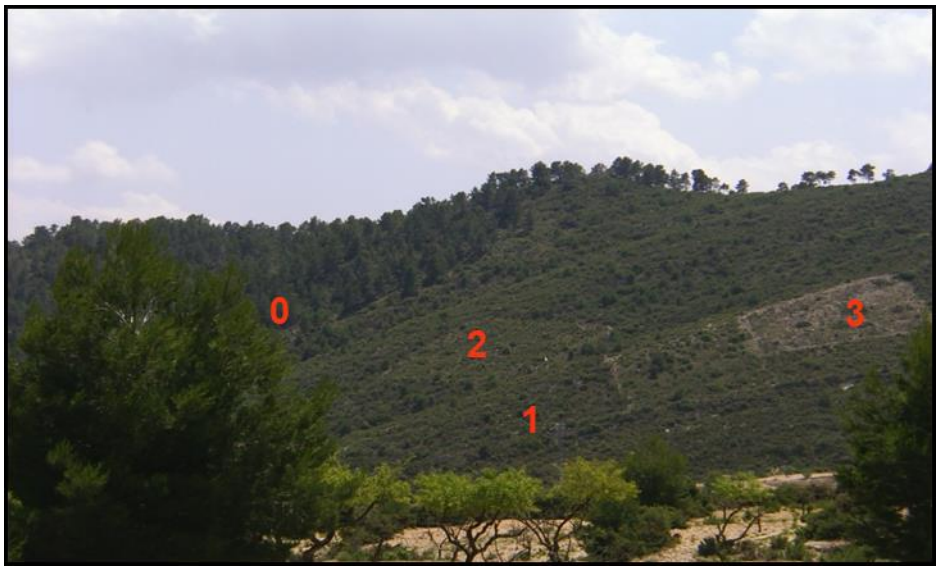

Figure 4. Mariola field site with different fire recurrences

Assessment of planting and selective clearing as restoration techniques of Mediterranean fire-prone ecosystems will also be carried out. Shrublands dominated by obligate seeder species are fire-prone and show low resilience after fire. Therefore, the main objective of land restoration in these regions should be to increase formations dominated by resprouter shrubs and trees to improve their resilience, diversity, and structure. Fuel management through vegetation clearing presents some positive aspects with respect to the other techniques, e.g. the generation of a slash layer that protects the soil from erosion, carbon conservation, and the possibility of being selective in order to preserve desired species or individuals. The afforestation of Mediterranean degraded lands, especially with *Quercus* spp. and other late-successional species, usually results in low percentages of seedling establishment and growth rates. The monitoring of restoration actions is often carried out only during the first years. We plan to measure ecosystem services, such as biodiversity, C sequestration (in soils and vegetation), plant composition and cover, stability, infiltration and nutrient cycling by landscape metrics and *ad hoc* samplings, in unburned pine forests, once burned shrubland, and restored areas in order to quantify how effective the restoration actions were on improving ecosystem services and how far we moved the system towards the reference situation.

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

- Ministry of Environment (MARM, Spanish Government)
- Regional Forest Services (Regional Government of Valencia, Generalitat Valenciana)
- Research and Academic institutions (CEAM, University of Alicante, University of Barcelona, IAMZ-CIHEAM)
- Ayora, Zarra, Enguera, Bañeres, Bocairent and Albaida Municipalities

- Environmental NGOs: Asociación para la Defensa de la Naturaleza de Enguera (ADENE), Asociación Cultural para la Recuperación del Bosque (ACREBO), Asociación de Lucha contra Incendios Forestales de Ayora, Coordinadora Ecologista de la Vall d'Albaida, Colla Ecologista d'Alacant, Colla Ecologista La Carrasca.
- Recreational and cultural associations: Asociación Naturalista de Ayora y su Valle, Asociación Turismo Rural Valle de Ayora, Asociación Valle Historia y Miel, Club Senderismo La Trocha, Grupo Excursionista Ayora, Sociedad de Cazadores de Ayora, Centro Excursionista Alcoy

7. Anticipated activities and workshops with stakeholders

- Annual reports and/or workshops will be delivered to the Regional Forest Services of the Government of Valencia. Reports will include detailed information about the progress of the different Work Packages in CASCADE as well as the action plan for further periods. In case of workshops (CEAM organized in the past annual or by-annual conferences), stakeholders, scientists form other centers and environmental managers will be invited to attend and conduct presentations of interest in the framework of CASCADE. Visits to the field sites will be included when feasible.
- Majors or councilors of villages will be informed periodically of the progress of the project. Meetings with local users will be organized at the end of the project on the basis of the previous stakeholders platform established under the PRACTICE project.

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

- Land use change interactions with fire in Mediterranean landscapes (LUCIFER). European Commission (Environment and Climate Programme, nº env4-ct96-0320), 1997-2000. (http://www.ucm.es/info/lucifer/)
- Geomatics in the assessment and sustainable management of Mediterranean rangelands (GEORANGE) nº evk2-ct-2000-00091. 2001-2003. (http://www.georange.org/georange/)
- Integrated analysis of forest fire risk using remote sensing data and geographic information systems. Ecosystems vulnerability to fire. (FIREMAP). Spanish Ministry of Education and Science, CGL2004-06049-c04-04, 2005-2007. (http://www.geogra.uah.es/firemap/)
- Fire recurrence in Mediterranean ecosystems: consequences for regressive or progressive successional trajectories in a global change scenario (FIREMED) AGL2008-04522/FOR, 2009-2011.
- Forest fires under climate, social and economic changes in Europe, the Mediterranean and other fire-affected areas of the world (FUME), European Commission, GA243888, 2010-2013. (http://www.fumeproject.eu/)
- Prevention and Restoration Actions to Combat Desertification. An Integrated Assessment (PRACTICE). EC DG Research, ref. FP7-ENV-2008-1 nr. 226818, September 2009-August 2012. (http://80.24.165.149/drupal/)

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

Santana, V.M., **Baeza**, M.J., Marrs, R.H., **Vallejo**, V.R., 2010. Old-field secondary succession in SE Spain: can fire divert it? *Plant Ecology*, 211:337-349.

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Baeza M.J., Roy J. 2008. Germination of an obligate seeder (*Ulex parviflorus*) and consequences for wildfire management. *Forest Ecology and Management* 256; 685–693.

Röder, A., Hill, J., Duguy, B., Alloza, J.A., **Vallejo**, R. 2008. Using long time series of Landsat data to monitor fire events and post-fire dynamics and identify driving factors. A case study in the Ayora region (eastern Spain). *Remote Sensing of Environment* 112: 259-273.

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