MEDACC

Demonstration and validation of innovative methodology for regional climate change adaptation in the Mediterranean area

LIFE12 ENV/ES/000536

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Duration of project: 5 years

Report describing the location and access to demonstrative activities

Implementation of on-site demonstrative activities

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Executive summary

MEDACC project (LIFE12 ENV/ES/000536 Demonstration and validation of innovative methodology for regional climate change adaptation in the Mediterranean area) is a 5-year multi-actor project which started in the summer of 2013.

MEDACC aims at testing innovative solutions in order to adapt agro-forest and urban systems to climate change in the Mediterranean basin. Thus, MEDACC contributes to the design and implementation of adaptive strategies and policies which are being carried out at the national and regional levels in the Euro-Mediterranean area. In Catalonia, MEDACC will be a key tool in the implementation of the Catalan Strategy for Climate Change Adaptation (ESCACC 2013-2020).

In order to achieve these objectives, MEDACC has started pilot actions in the Muga, Ter and Segre watersheds, according the experimental / demonstrative scheduling.

These actions can permit the testing of adaptation measures in the agriculture, forestry and water management sectors. All these measures have been designed and deployed together with local stakeholders.

Contents

1. Introduction

As stated in project proposal, the Life MEDACC project will focus on three specific watersheds of Catalonia (Muga, Ter and Segre). These watersheds have been chosen to represent Mediterranean diversity at a local scale, with a wide range of topographic, climatic and environmental conditions, land uses and water demands (Fig. 1).

The Muga watershed, with 758 km^2, is fully characterized by Mediterranean conditions. According to the 2005 Land Cover Map of Catalonia, this catchment is mostly occupied by forests (71%) and agricultural lands (24%), with 11,225 ha dedicated to irrigation. Crops consume the 75% of the water demand of the watershed (about 83 hm^3/year in 2007) whereas urban users consume 20%, having 140,000 inhabitants. The Muga River is mainly stressed by irrigation abstraction, which threatens alluvial groundwater recharge and the ecological stream flow of the river.

The Ter watershed occupies 2,955 km^2. It presents high forest diversity, with forestlands occupying 75% of the surface, while agricultural lands (19%) are concentrated in the middle and lower parts of the watercourse. The irrigated area is around 32,390 ha. Together with the Llobregat River, the Ter supplies water for Metropolitan Region of Barcelona and Girona. More than 50% of the renewable water resources of the Ter River are transferred to the Metropolitan Region of Barcelona every year. Water demand is mainly for urban users (74% in 2007), whereas irrigation consumes only 24% of total demands. Due to these current demands, the ecological flows defined for the low part of the river are not satisfied.

The Segre watershed, about 11,822 km^2, hosts the largest Catalonian river, which is tributary of Ebro River. Forestlands occupy 63% of the area and there is a high predominance of croplands (34%), whereas 140,000 ha are under irrigation. This watershed is highly stressed by agricultural demands which are approximately 95% of total water demands.

One of the main objectives of the Life MEDACC project is to test adaptation measures in water use, agriculture and forest management through demonstrative activities performed in the three watersheds. As a result, the project will innovatively contribute to validate for first time how acting and investing at the present can help the territory to resist impacts of climate change in the future. The demonstrative activities will be performed in different pilot sites representative of the watersheds in terms of major forest and agricultural species and their derived ecological, social and economical value. The objective of these activities is to quantify and demonstrate management strategies making forest and agricultural systems more resilient to climate change. By establishing managed and control test plots, we test different management practices and we compare the development of the vegetation.

The involvement of local stakeholders in the design, performance and monitoring of the demonstrative activities provides relevance and ensures future replicability of the measures, methods and policies in other areas of the watersheds.

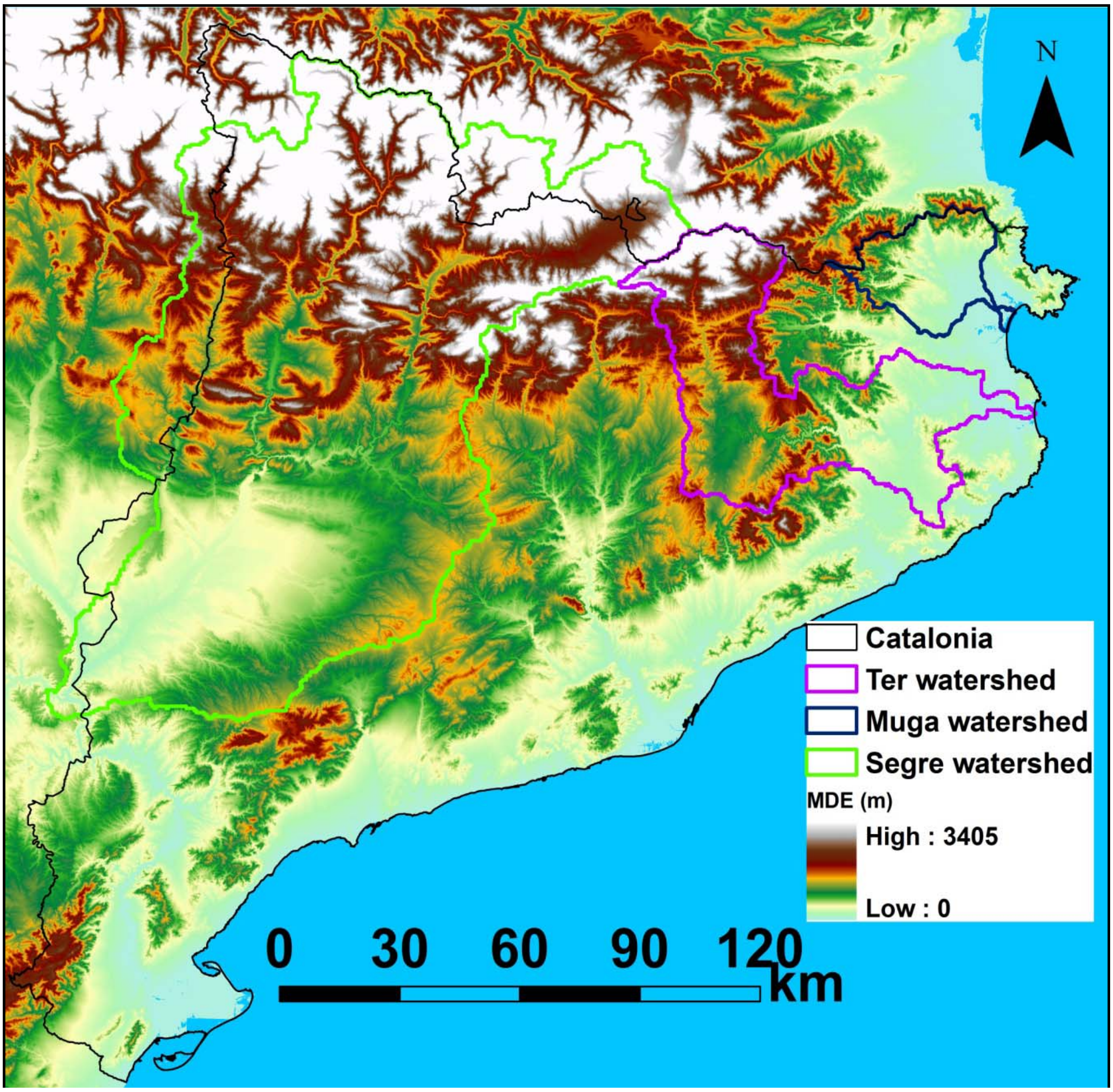


Figure 1. Delineation of watersheds studied in Life MEDACC project.

2. Agriculture

2.1 Sub-action B.2.1: Preparation of pilot experiments

2.1.1 Muga Watershed

a. Description of the area and its interest

La Muga watershed has an area of 758 km^2, with a 24% used in the agriculture. The irrigated surface is 11,225 ha.

The alluvial plain developed from deltas of Muga and Fluvià rivers is a very important agricultural area of Catalonia (Spain) and contributes significantly to the economy of the territory. Agricultural infrastructures, mainly irrigation systems are managed primarily by irrigation communities at both sides of the Muga River, water is from Boadella reservoir. These channels with well from groundwater potentially provided sufficient water to develop irrigated crops.

In the last years, due to new marina or sportive harbor facilities, new crops, seaside resorts and uses, etc., saltwater intrusion have started to be a problem in this area (Fig. 2). Thus, salinity has increased in groundwater reservoir, which has promoted and promotes serious agricultural problems.

The main agricultural crops irrigated in this area are corn, forage crops, rice fields and to a lesser extent fruit trees plantations.

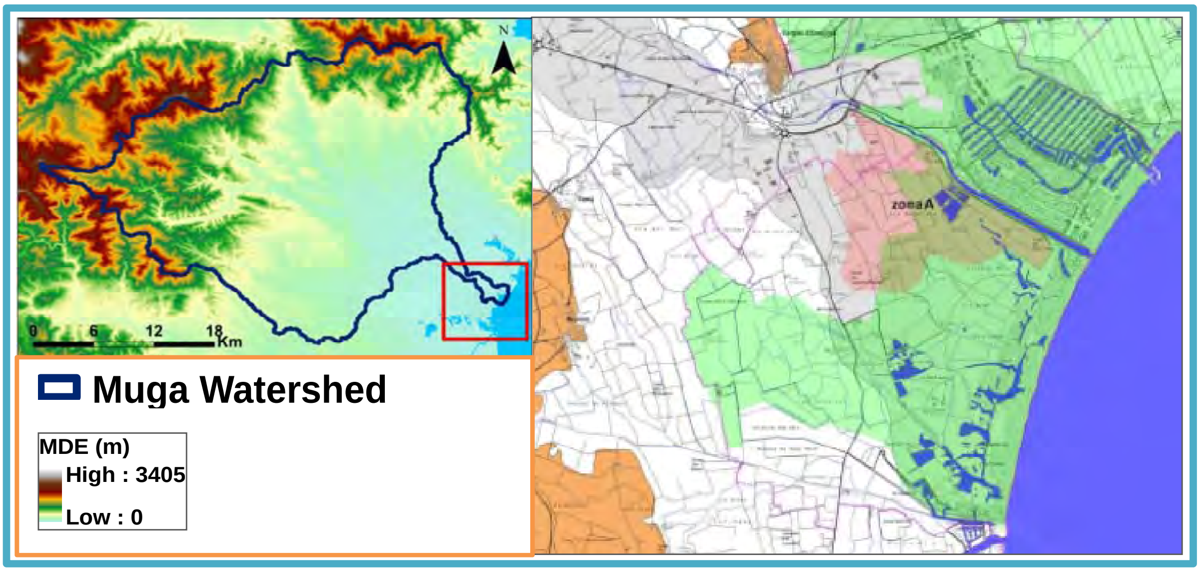


Figure 2. Map of the coastal aquifer of Muga River (Right).Zona A (brown color) is showing the salty area. Location map of the area in Muga watershed (Left).

During 2012 and 2013, Fundació Mas Badia (IRTA) and Geoservices S.A., tried to minimize the advance of salt in the area A by means to reduce water extraction from groundwater.

b. Location of experimental plot and access

Based on previous experiences in the watershed and according MEDACC objectives, the development and implementation of an irrigation advice system for farmers belonging to certain irrigation areas (described below) were proposed as demonstration tasks. The objective is to decrease water supply without reducing crop productivity.

Demonstration and research activities were coordinated by IRTA (Environmental Horticulture Program) and Fundació Mas Badia-IRTA.

Activity has been conducted on irrigated areas placed on the left and right sides of Muga River, designated as areas I, II, III, IV and V (Fig. 3). Irrigated areas VI and VII (Fig.3, in red) were planned but are not operative. At present, according Irrigation of Catalonia, the Community of Irrigators from the left side has an area of 4,363 ha and 646 irrigators, while in the right side; the irrigation community has an area of 1,400 ha and 450 irrigators.

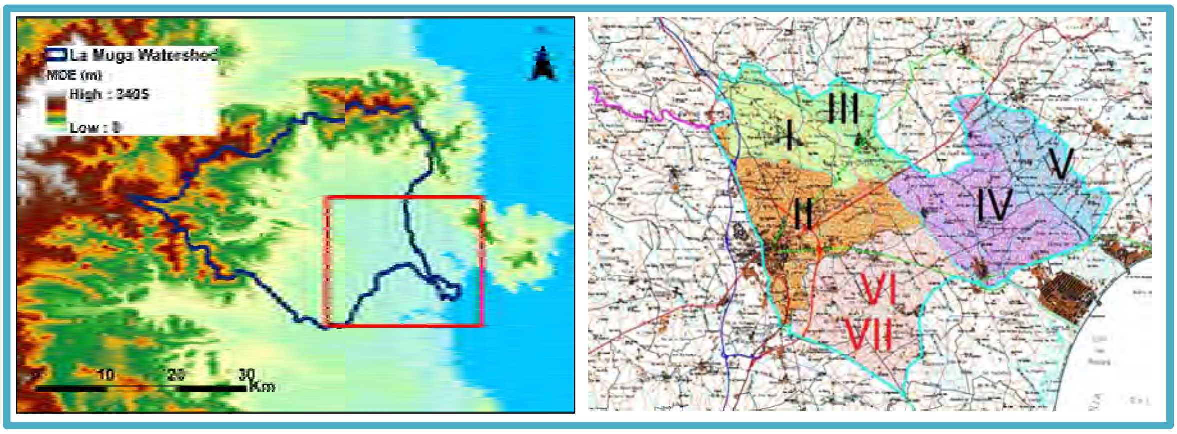


Figure 3. Irrigation project of Muga River (Girona, Catalonia, Spain). The scope of the left bank are the areas I, III, IV and V. The scope of the right bank is the area II. Areas VI and VII (red) are not operatives (Right). Location map of irrigation area in the lower course of Muga watershed (Left).

Corn is the most important crop in these irrigated areas, occupying close to 810 ha according DUN, 2013 (Declaration of eligible agricultural area for Common Agricultural Policy payments, Catalonian Government) (Fig. 4). This crop needs large amounts of water which in this region must be provided by irrigation in order to maintain high productivity.

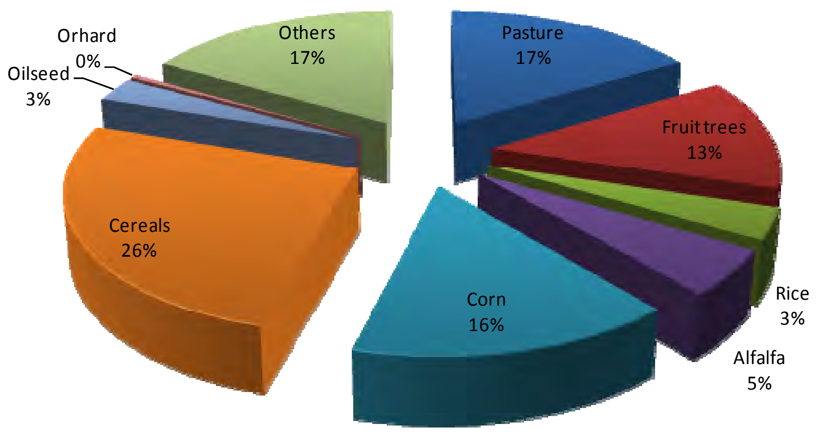


Figure 4. Crops surface distribution (%) in the Muga watershed. Source: DUN, 2013 (Catalonian Government).

c. Stakeholder networking

The stakeholders that utilized the irrigation advisory system implemented by this action were:

- Cooperativa Agrícola de Castelló d'Empúries (Castelló d'Empúries Agricultural Cooperative)
- Associació de Pagesos i Cortals de Castelló d'Empúries (Castelló d'Empúries Association farmers)
- Comunitat de Regants del marge esquerra de la Muga (Muga left bank watershed Community irrigation)
- Associació de Defensa Vegetal de l'Arròs de Pals (Pals Plant Protection Association for Rice)
- Associació de Defensa Vegetal Cooperativa de Castelló (Castellón Plant Protection Association Cooperative)
- Associació de Pagesos Propietaris i Entitats de l'Empordà (l'Empordà Association of Farmers)
- GEOSERVEI S.L

2.1.2 Ter Watershed

a. Area of interest and description

In the alluvial plain of the river Ter (Baix Emporda, Girona, Catalonia, Spain) there is a large area of irrigated land, close to 9,000 ha,which is managed by four irrigation communities: Presa de Colomers (a), Molí de Pals (b), Regadius de SantJulià de Ramis, Medinyà, Cervià de Ter, Sant Jordi Desvalls, Colomers i Jafre (c), and la Sèquia Vinyals (d) (Fig. 5).

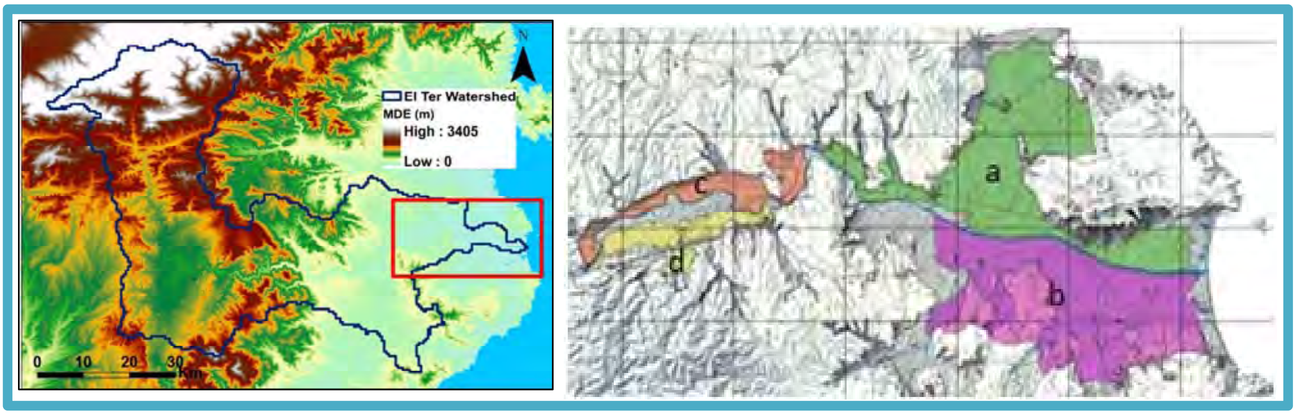


Figure 5. Geographical distribution of four irrigation communities in lower course of Ter watershed (Right).Location map of the area in Ter watershed (Left).

These communities obtain water from the river Ter at different locations, which is distributed by gravity to 24 municipalities. On average the communities use about 70 hm^3/year. In areas falling outside of irrigation communities, farms pump water from the Ter's aquifer by means of wells.

The irrigation network is very old, developed beginning in the Middle Ages, consequently its efficiency must be improved by means of technological options based on ecophysiological knowledge of crops.

Crop distribution in this watershed is shown in Fig. 6.

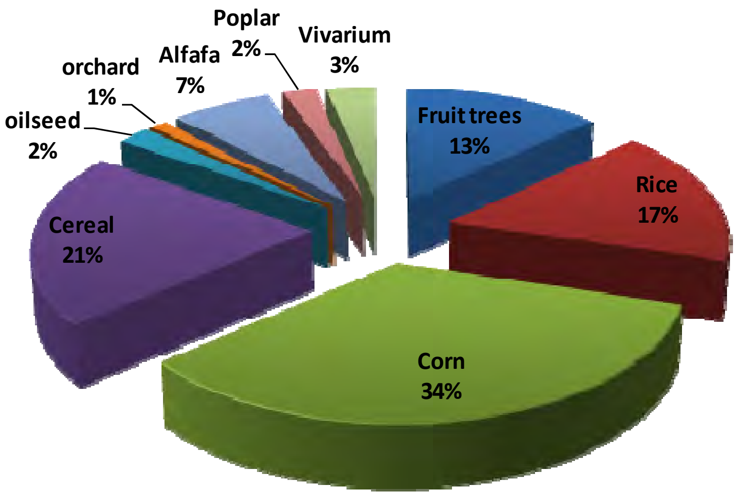


Figure 6. Crop surface cover in the Ter watershed. Source: DUN, 2013 (Catalonian Government).

b. Location of experimental plot and access

Taking into account both the particular local situation and MEDACC objectives, demonstration tasks for the development and implementation of some comparative assays between the traditional gravity irrigation system and a located drip irrigation system were proposed.

Demonstration and research activities were coordinated by IRTA (Environmental Horticulture Program) and Fundació Mas Badia-IRTA.

The assay was undertaken with corn, the most important crop of this area, at Pla de Torroella (Girona; 42º 01' 55" N, 3º 09' 42" E; 3 m above sea level) (Fig. 7 and 8).

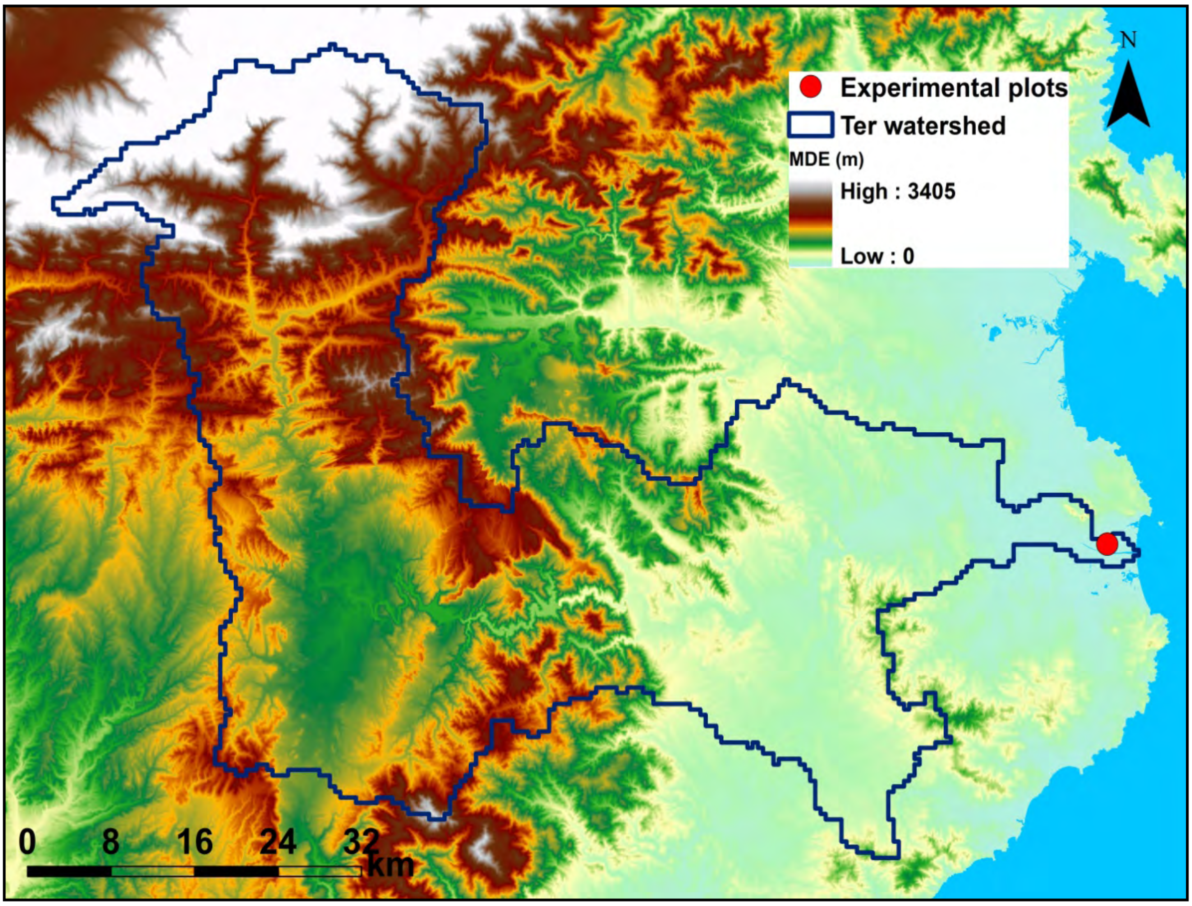


Figure 7. Location of agricultural experimental plots within the Ter watershed.

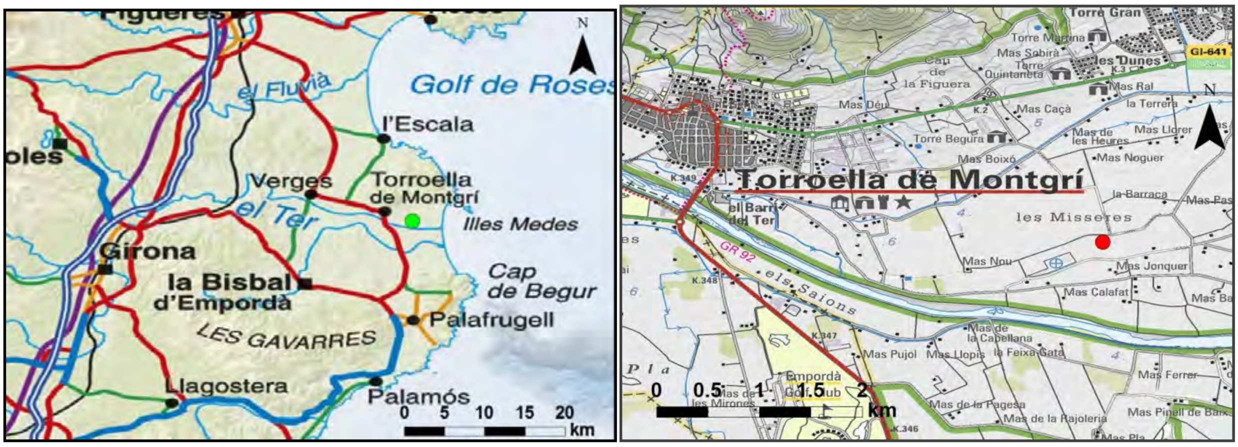


Figure 8.Ter watershed experimental /demonstrative plot location (green dot, left) and detailed access map (red dot, right).

c. Stakeholder networking

The assays carried out in Ter watershed benefit from the support of stakeholders. Their participation has been necessary in order to demonstrate economic and technical viability of drip irrigation in corn crops. These stakeholders pertain to irrigation communities managing water sources in lower course of the Ter River: Presa de Colomers (particularly, Mas Duran Collectivity), Molí de Pals, Regadius de Sant Julià de Ramis, Medinyà, Cervià de Ter, Sant Jordi Desvalls, Colomers i Jafre i la Sèquia Vinyals.

2.1.3 *Segre Watershed*

a. Interest of area and description

In the Segre watershed (13,000 km^2), the most important agricultural area of Catalonia (4,420 km^2) with 1,400 km^2under irrigation, we have focused demonstrative efforts on viticulture.

Viticulture is very sensitive to climate and changes in wine production have been used as a proxy to elucidate past climate change. Temperature and moisture regimes are among the primary elements of *terroir*, the most important characteristic of a wine. Growing season temperature is important for delimiting regions suitable for growing wine grapes (*Vitis vinifera*). Regions with a Mediterranean climate (warm and dry summers; cool and wet winters) are particularly suitable for viticulture, and also have high levels of biodiversity and endemic species, making them global biodiversity hotspots.

Vineyards have long-lasting effects on habitat quality and may significantly impact freshwater resources. Vineyard establishment involves removal of native vegetation, typically followed by deep plowing, fumigation with methyl bromide or other soil sterilizing chemicals, and the application of fertilizers and fungicides. Mature, producing vineyards have low habitat value for native vertebrates and invertebrates, and are visited more often by nonnative species. Thus, where vineyards are established, how they are managed, and the extent to which they replace native habitats are important considerations for conservation.

Water use by vineyards can conflict with conservation of freshwater habitats. In a warming climate, water use may increase as vineyard managers attempt to cool grapes on the vine to reduce quality loss from heat stress and to reduce drought stress.

Potential damage to freshwater environments is generally highest where water is already scarce. Climate change may bring precipitation decreases to some regions, increasing the need for irrigation, which may result in impacts on freshwater ecosystems.

Traditional vineyard irrigation may moderate or accentuate these water use issues. Overall, how vineyards are established and managed is important for water conservation, and these systems may be significantly impacted by climate change (www.pnas.org/cgi/doi/10.1073/pnas.1210127110).

b. Location of experimental plots and access

In order to reduce the water use in vineyards, two different strategies can be considered:1) using a mulching treatment and 2) moving the crop to the mountain. Figure 9 shows the location of both assays (mulching and altitude assay) in the Segre watershed.

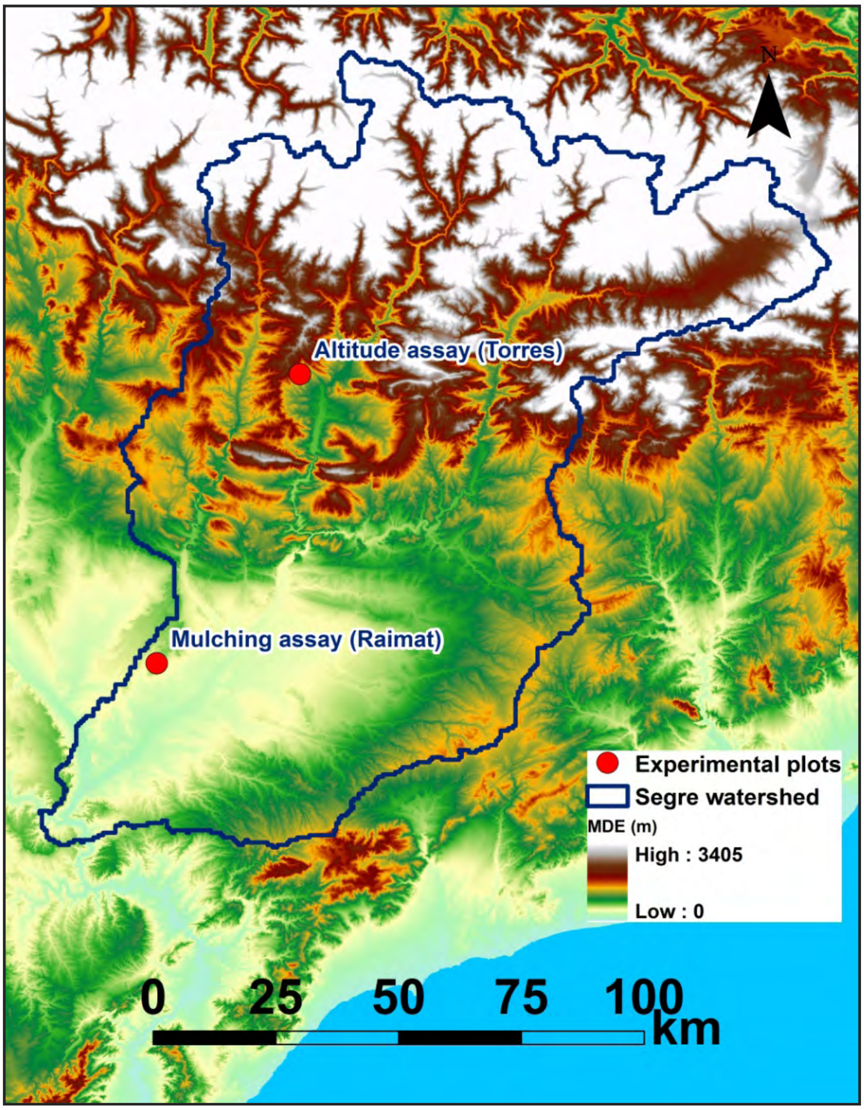


Figure 9. Locations of agricultural experimental plots in the Segre watershed.

Mulching assay

This assay was located at Raimat (Bodegas Codorniu; 41º 39' 40.30"N, 0º 31' 4.23"E; 350 m above sea level, Lleida, Spain), at 300 m altitude. The area is part of the Costers del Segre P.D.O. (Protected Designation of Origin), which is very varied, ranging from plains to hillsides (Fig 10.). However, the whole area shares a marked continental climate characterized by temperature extremes.

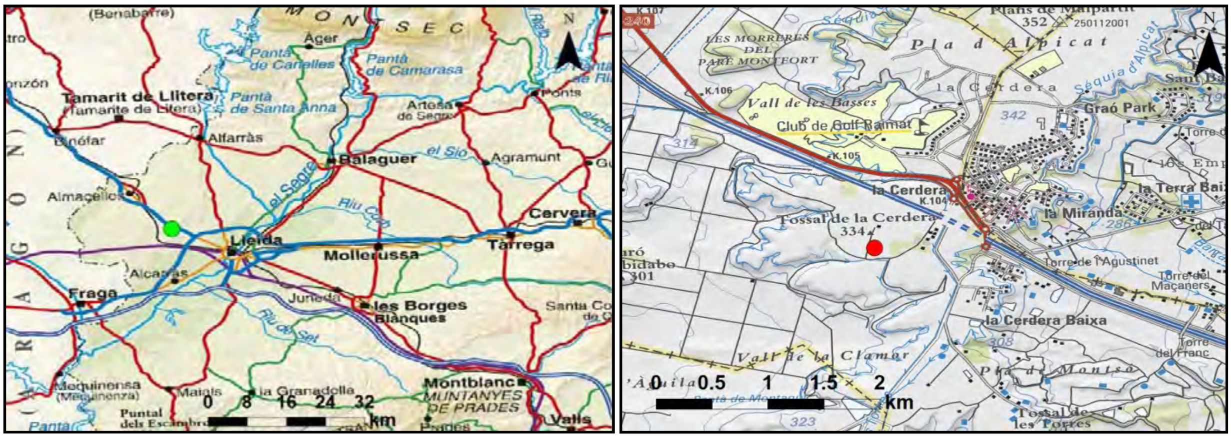


Figure 10. Location (left) and detailed access (right) maps of mulching assay in Raimat.

This very dry area (rainfall around 300 mm/year) was positively affected by the building of the Aragon and Catalonia Irrigation Channel in 1910, which permitted the irrigation of these vineyards.

Despite this resource, climate change will reduce the water availability and will increase the crop water demand, promoting large water deficits and productivity losses.

Altitude assay

This assay was located at Finca San Miguel (Bodegas Miguel Torres; 42º 12' 13"N, 0º 51' 01" E, 950 m altitude) located in the Sierra de Gurb (Lleida, Spain), in the municipality of Tremp (Fig. 11). The site for this assay was chosen with the intention of growing the vineyard on a site with colder weather as a strategy of adaptation to the future (warmer) climatic situation.

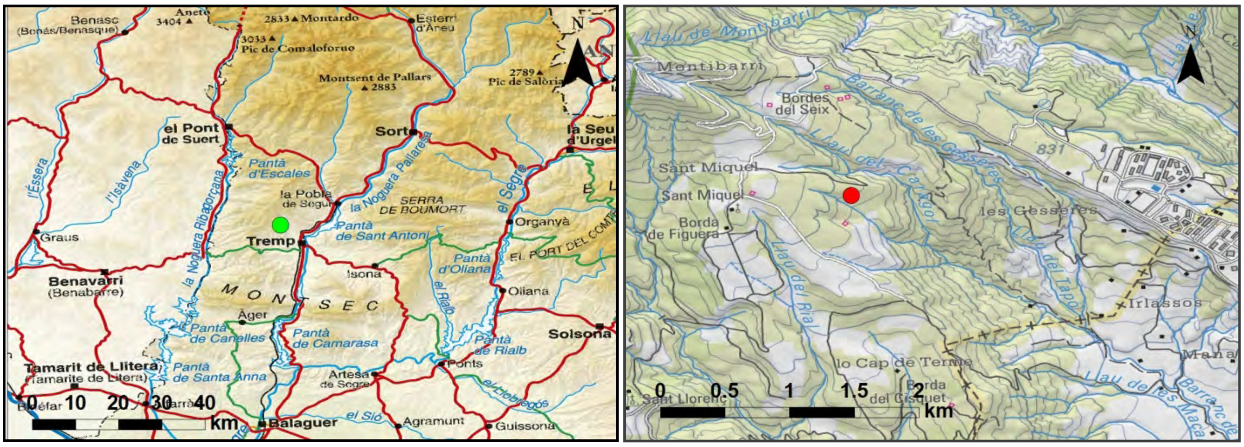


Figure 11. Location (right) and detailed access (left) map of altitude assay (green point, right; red point, left) in Finca San Miquel.

Contemporary average rainfall is 650 mm with maximums in spring and autumn. The average annual temperature is 13ºC; the coldest month is January with an average temperature of 3ºC and the warmest is July with an average temperature of24ºC.

c. Stakeholder networking

Pilot assays in the Segre watershed have been a process of interaction between the IRTA partner and different stakeholders. In this process, several institutions have contributed directly in both assays, including the **Codorniu Group and Bodegas Torres Group**, or have taken part indirectly as observers of the process:

- Irrigation advisors and irrigation communities in the Segre watershed
- Canal d'Urgell General Irrigation Community
- Segarra-Garrigues Irrigation Community
- Confederación Hidrográfica del Ebro (CHE, Ebro River Hydrographic Confederation)
- Consell Comarcal de la Segarra (Segarra County Council)
- Diputació de Lleida (Province Government of Lleida)
- ENDESA
- Universitat de Lleida (University of Lleida)

2.2 Sub-action B.2.2: Implementation of the demonstrative adaptation measures

2.2.1 Muga Watershed

Daily corn crop potential evapotranspiration (ETc) was calculated in the Muga watershed according to FAO procedure: first, daily potential evapotranspiration (ET0) was calculated using the FAO Penman-Monteith equation using data from weather stations in this area; second, ETc was calculated for the land surface occupied by corn crops in different areas, and a crop coefficient (Kc) modified by crop phenological stage was also calculated. Then, for the land surface occupied by crop, weekly soil water content for two types of soil (with RFU= available soil water mean and high) and real evapotranspiration (Eta, which considers the limitation to ET imposed by actual soil water content) were calculated, recurrently from previous week's soil water content, precipitation and Eta. Then, if ETc was higher than the sum of rainfall and soil water content, then this sum was taken as ETa. Finally, the weekly irrigation needs of the crop was calculated as the difference between ETc and ETa.

Results were sent weekly to the different stakeholders in order to reduce water consumption for each irrigated area (Fig. 12). Due to this strategy and also due to weather conditions, water requirements for irrigation were reduced 38% in 2014.

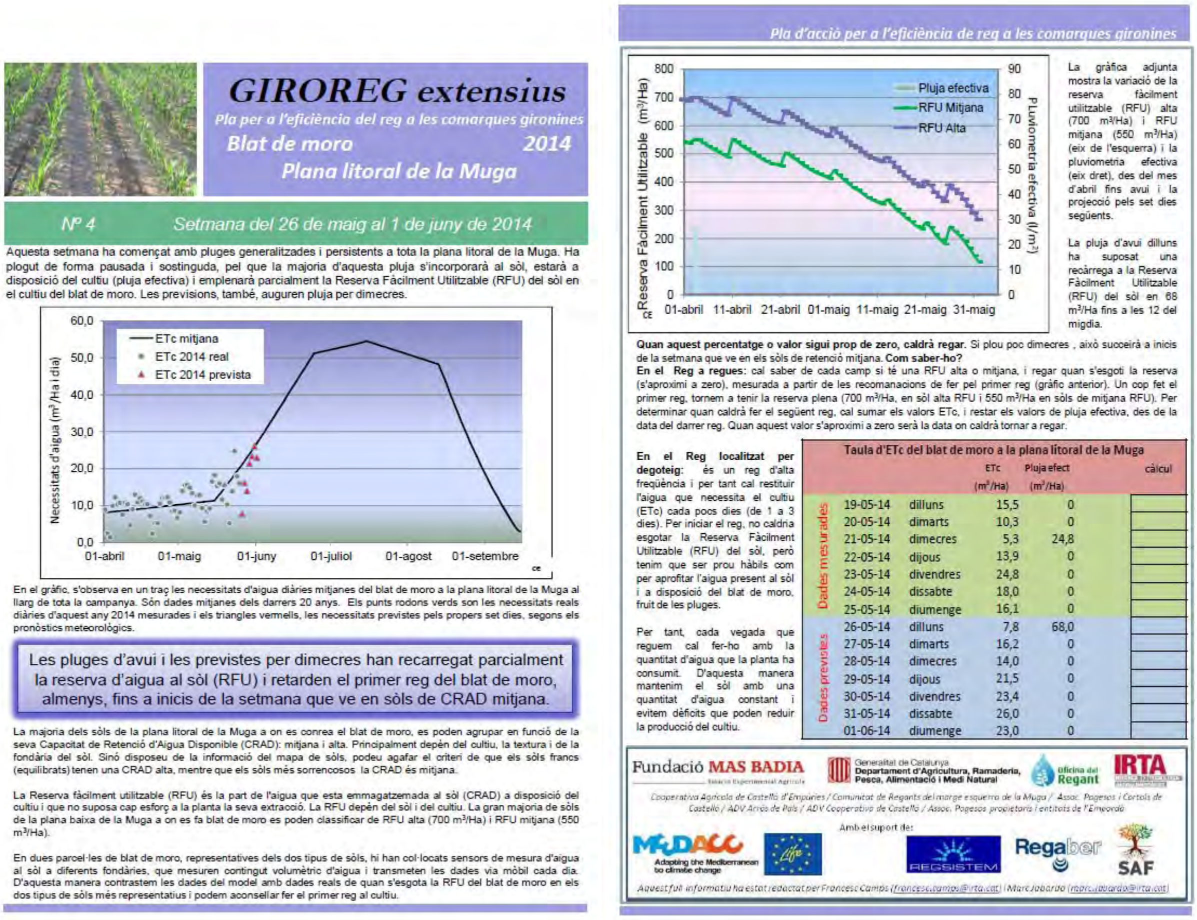


Figure 12. Example of recommendation brochure about water needs based onETc FAO calculation for corn crop delivered to farmers within irrigation communities of the Muga watershed alluvial plain.

2.2.2 Ter Watershed

El Ter watershed has an area of 2,995 km^2, with 19% occupied by agriculture. The irrigated surface is 32 390 ha.

Experimental corn plots are located in Pla de Torroella (Girona), lower course Ter watershed, and occupy15,322 m^2. Figure 13 shows detailed plots.

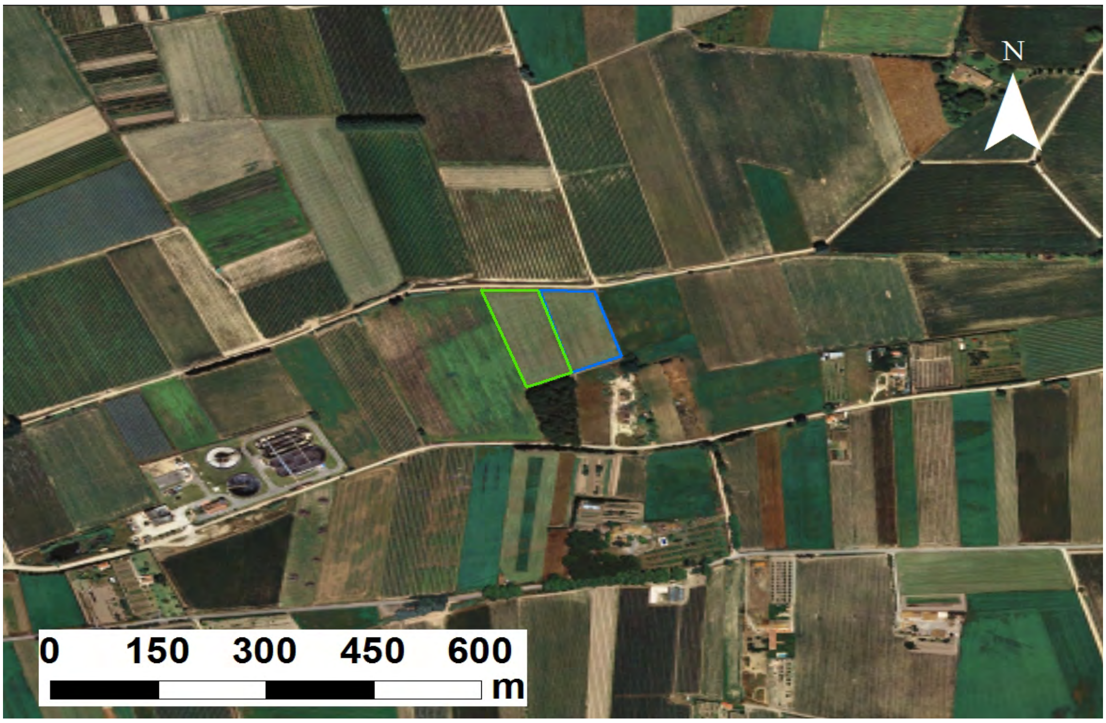


Figure 13. Detailed map of experimental plots. Drip (blue polygon) and gravity (green polygon) irrigation systems.

The surfaces used in the assay were 8,510 and 6,812 m^2 for the gravity and drip (FLATNET and MINITODY of REGABER) irrigated systems, respectively.

Figure 14. Corn experimental plot.

In both plots of corn established in the Ter watershed (traditional gravity irrigation system and located drip irrigation system) soil water content was measured every four hours at depths of 15, 30 and 45 cm by means of capacitive water sensors. Soil water content was maintained between 0.300 and 0.190 m^3/m^3.

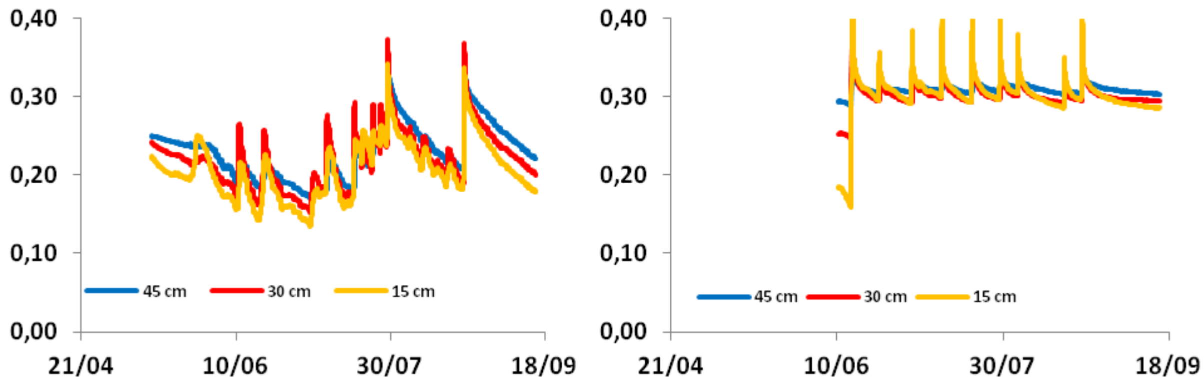


Figure 15. Time evolution of soil water content (SWC, m3/m3) in drip (left) and gravity (right) irrigated plots

Results showed that located irrigation system reduced the amount of water used in irrigation and increased water use efficiency of corn crop (Table 1).

Table 1. Average values of water supplied and water use efficiency (WUE) of corn crop in both irrigation systems.

Water used (m^3/Ha)		WUE (Kg grain/m^3)	
Drip	Gravity	Drip	Gravity
1.850	3.090	7.470	4.880

Also, both irrigation systems resulted in the same level of nitrates in the soil. Nitrates are a very important pollutant in Catalonia, associated with serious negative effects on groundwater quality.

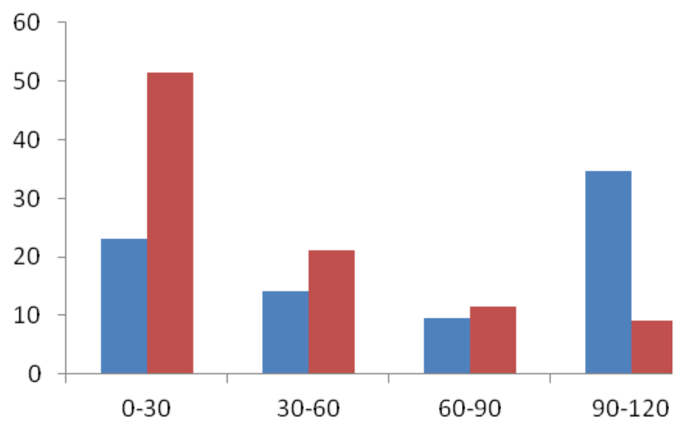


Figure 16. Average values of nitrate content (%) at different soil depths in drip (red) and gravity (blue) irrigation systems in mid-August 2014.

Daily corn crop potential evapotranspiration (ETc) was calculated, as in Ter watershed, according to FAO procedure: first, daily potential evapotranspiration (ET0) was calculated as usual using the FAO Penman-Monteith equation from the weather stations of this area; second, ETc was calculated for the land surface occupied by the corn crop in different areas and a crop coefficient (Kc) modified by crop phenological stage. Then, for the land surface occupied by crop, weekly soil water content and real evapotranspiration (Eta, which considers the limitation to ET imposed by actual soil water content) were calculated, recurrently from the previous week's soil water content, precipitation and Eta. Then, if ETc was higher than the sum of rainfall and soil water content, then this sum was taken as ETa. Finally, the weekly irrigation needs of the crop were calculated as the difference between ETc and ETa.

Results were sent weekly to the different stakeholders in order to reduce water consumption (Fig. 17). Due to this strategy as well as weather conditions, water requirements for irrigation were reduced in 21% in 2014.

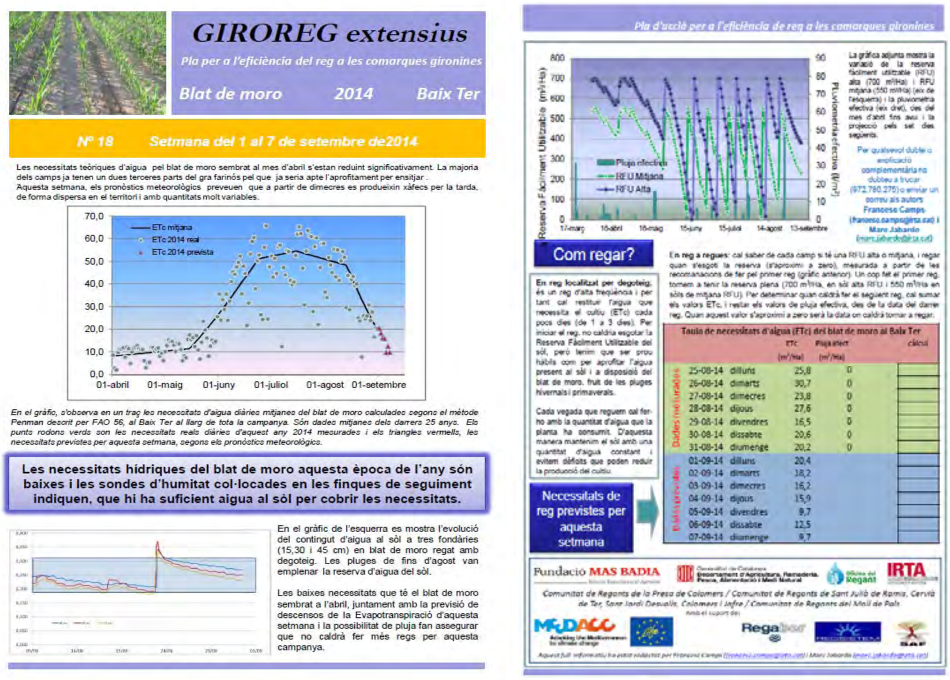


Figure 17. Example of recommendation brochure about water needs based in ETc FAO calculation for corn crops delivered to farmers within irrigation communities of the Ter watershed lower course.

2.2.3 Segre Watershed

The Segre watershed has an area of 13,000 km^2, with34% dedicated to agriculture. This is the largest irrigated area of Catalonia (140,000 ha).

Mulching is the coverage of soil surface by different materials (organic or not). This reduces soil evaporation by means of reducing soil temperature due to reduction of direct radiation on the soil surface and due to changes in size pores, which break evaporation pathways from soil to atmosphere.

The mountain location is associated with more water availability, lower temperature, less evapotranspiration or high temperature contrast between day/night. These changes may potentially permit maintenance of the vineyards' productivity in mountainous areas.

Theoretically, both strategies are acceptable, but they must be studied and contrasted since even though they both have positive effects on the water cycle, they may negatively affect biodiversity, cause habitat loss, promote fungal attacks, etc.

a. Muching assay

The objective of this demonstrative assay is to evaluate the effects of mulching on crop water availability and the effect on productivity.

The assay was established on a 3-year-old vineyard of Cabernet Sauvignon withR110 rootstock, irrigated at a rate of235 mm/year. The crop received a fertilization input of NKP complex.

Experimental plots were located at Raimat (Lleida) and have an area of 3,200 ha. Figure 18 shows detailed plots.

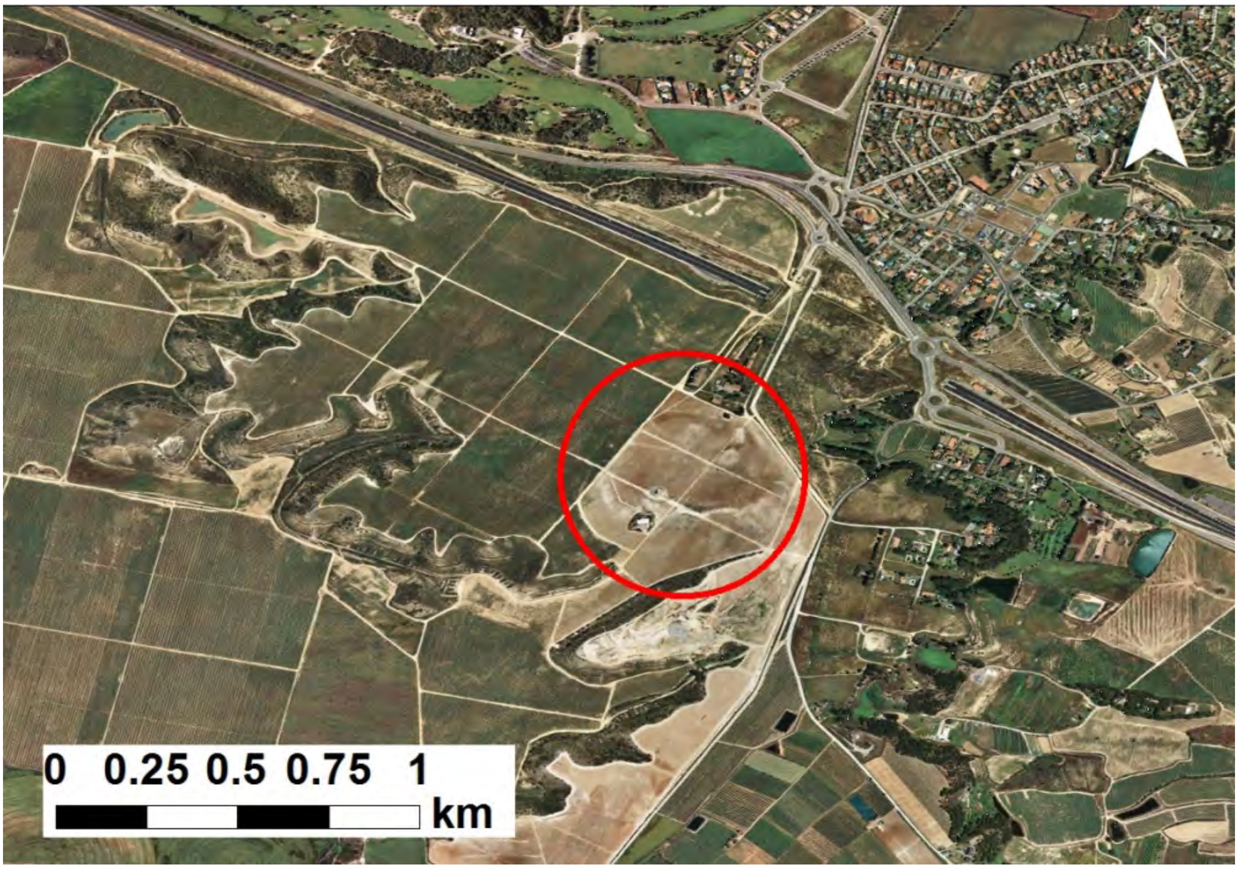


Figure18. Detailed map of mulching assay plot location.

Figure 19. General views of the mulching assay vineyard plot

Results showed that plants in the mulch treatment have morphological and physiological (cuticular transpiration, relative water content at turgor lost point…) characteristics associated with increased water availability as compared with control plants (Fig. 20 and 21).

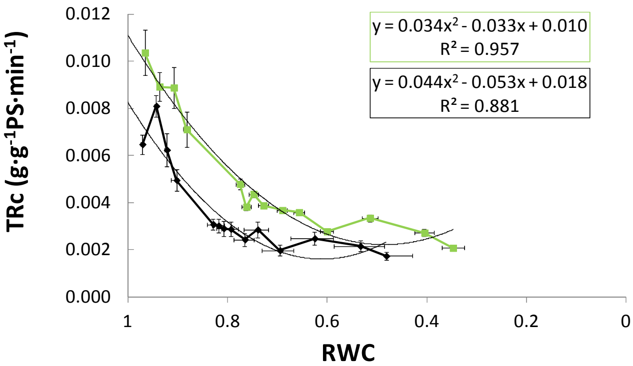


Figure 20. Cuticular transpiration (TRc) related to relative water content (RWC) in control (black color) and mulch (green color) treatment.

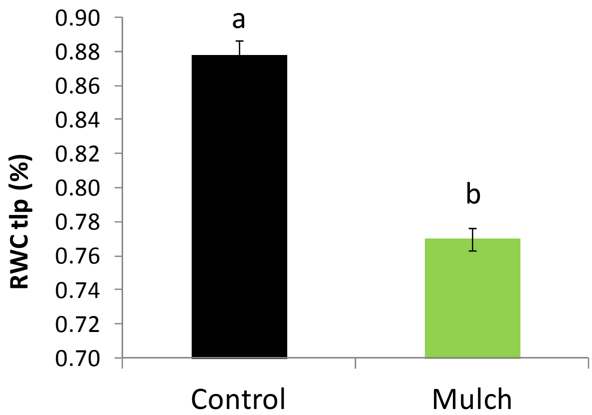


Figure 21. Relative water content control at turgor lost point (RWCtlp) in control and mulching treatment.

These ecophysiological traits promote beneficial changes in grain, grape, wine properties (berry quality). Some berry quality parameters for both control and mulching treatments are represented in Figure 22.

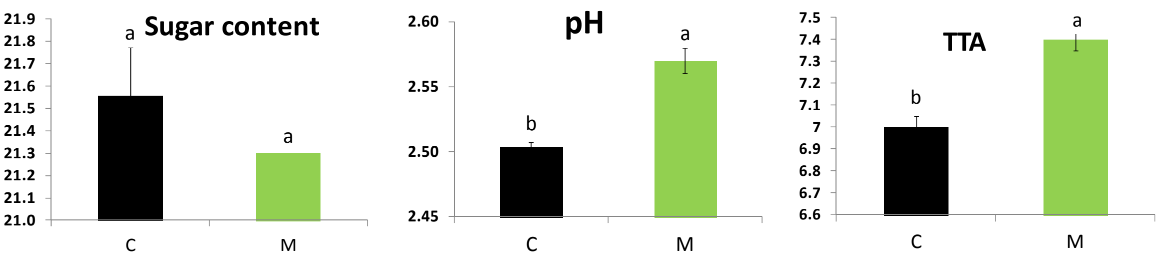


Figure 22. Berry quality parameters: sugar content at 20º BRIX (left), pH (middle) and total tartaric acidity (TTA, g/l) (right). Black color represents average values of control treatment (C) and green color average values of mulching treatment (M).

b. Altitude assay

Experimental plots have been located at Finca San Miquel (Lleida),having an area of 124 ha. Figure 23 shows plot detail.

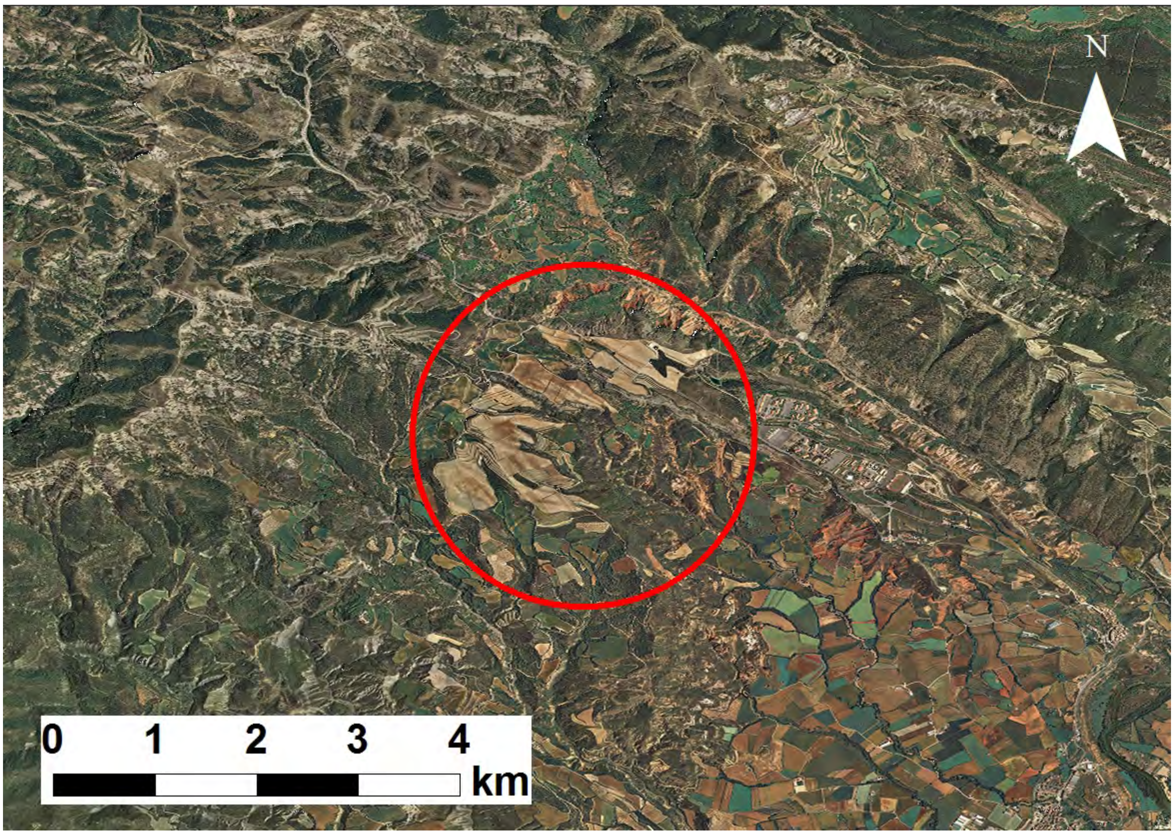


Figure 23. Detailed map of altitude assay location (Finca Sant Miquel).

This demonstrative/productive plot has been designed to accommodate short cycle varieties to cool climates, where excessive temperature can reduce the quality of the grapes. The cultivated varieties are mainly Sauvignon Blanc, Riesling and Chardonnay (white) and Merlot and Pinot Noir (black), grafted on SO4 and R110 rootstocks, planted at 2.20 x 1 m. The conduction/ pruning system is mostly Royat 2 buds and 6 heads and buds, but Guyot is also present in some plots. Fertilization and drip irrigation are applied following crop demand. Yield is between 4,000 – 5,000 kg/ha. The site is located on a calcareous soil with gravel deposits.

Figure 24. Some general views of the altitude assay at San Miquel.

Results show that low night temperatures reduce respiration rates and consequently are increasing the total net assimilation rate of vines. Similarly, extremes of day /night temperatures increased anthocyanin concentrations and flavors, which are fresh. Acidity is maintained.

3. Forest

3.1 Sub-action B.2.1: Preparation of pilot experiments

As it was mentioned in the MEDACC proposal, forestland is the main land cover in Catalonia. It occupies 1,868,314 ha, or 58.4% of the Catalonian surface. In the selected watersheds, forestland is the major cover, occupying 53,007 ha in Muga (71% of the total surface), 221,700 ha in Ter (75%) and 744,194 ha in Segre (63%) watersheds. Three forests in each watershed of particular interest have been selected to perform the demonstrative activities.

3.1.1 Muga Watershed

a. Description of the area and its interest

The Holm oak (*Quercus ilex*) is one of the most representative evergreen oaks in the Mediterranean, and it is especially characteristic of the Muga forests. We have selected Holm oak forests in this area considering three different criteria:

- The representativeness of the selected species and forest ecosystem. In this sense, the selected forest ecosystem is highly representative of Mediterranean coastal mountain forests.

- The vulnerability of the area to climate change impacts. This is a highly fire-prone forest and it was unmanaged for the last 40 years. The surrounding area experienced a 2012 wildfire, and a sudden change in wind direction was the only reason that this area was not burned.

- The feasibility of pilot experiment implementation. Easy access and the collaboration of estate owners have been crucial factors in area selection.

Holm oak (*Quercus ilex*) is the dominant species in the area (80-90% of basal area), with some escort species: cork oak (*Quercus suber*), oak (*Quercus pubescens*), *Phillyrea angustifolia, Erica arborea,* among them. According to estate owners, the forest has not been managed for the last 40 years (approximate). An initial inventory determined that this forest is highly dense (over 2,000 trees/ha) with a basal area of 30 m^2/ha and an irregular coppice forest structure. Figures 25 and 26 show the forest's initial appearance.

Figure 25. Forest appearance.

Figure 26. Holm oak detail.

b. Location of experimental plots and access

The Muga watershed forest pilot is located in a Holm oak forest in the lower part of the Eastern Pyrenees (Protected Natural Area of l'Albera), specifically, in the Requesens estate. It is a private estate within the Jonquera municipality (Girona province), close to the sea and to the French-Spanish border (Fig. 27). Coordinates are (Lat, Long) 42.436001, 2.941144. Altitude: 400 masl. The access to the pilot experiment area is by trail from Cantallops village. Following Medàs pass (Coll de Medàs) there is an access gate to the Requesens estate. A more detailed map can be found in Figure 28. We have the permits necessary to implement the demonstrative adaptation measures.

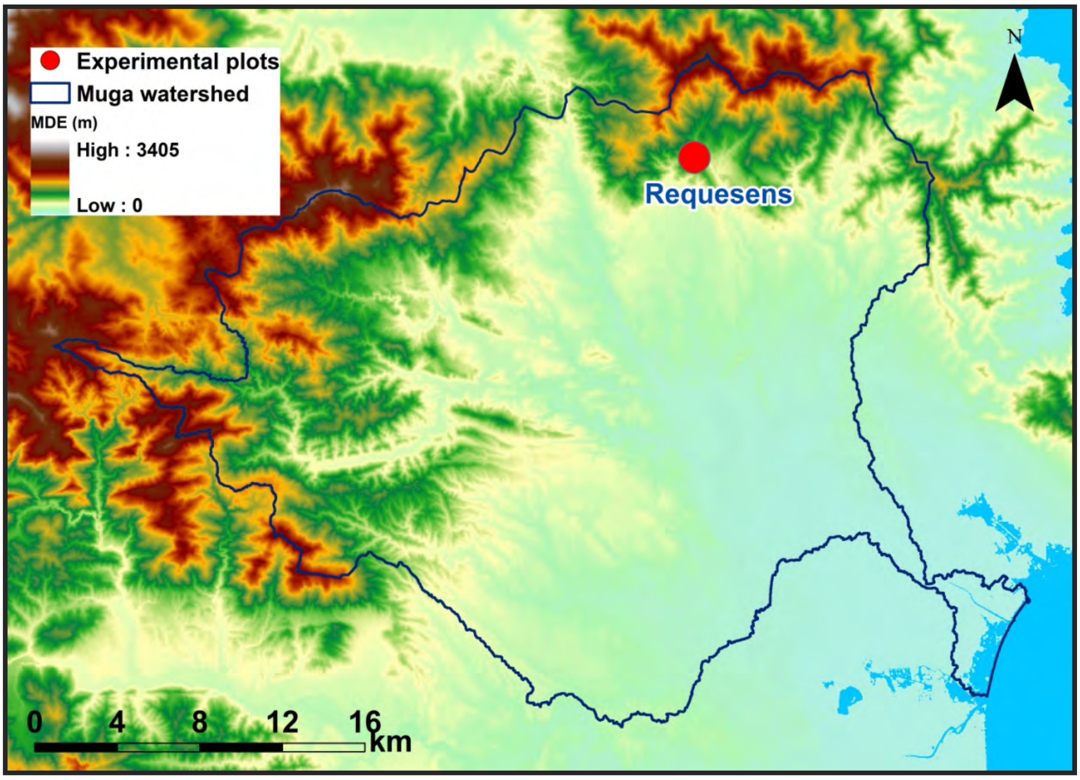
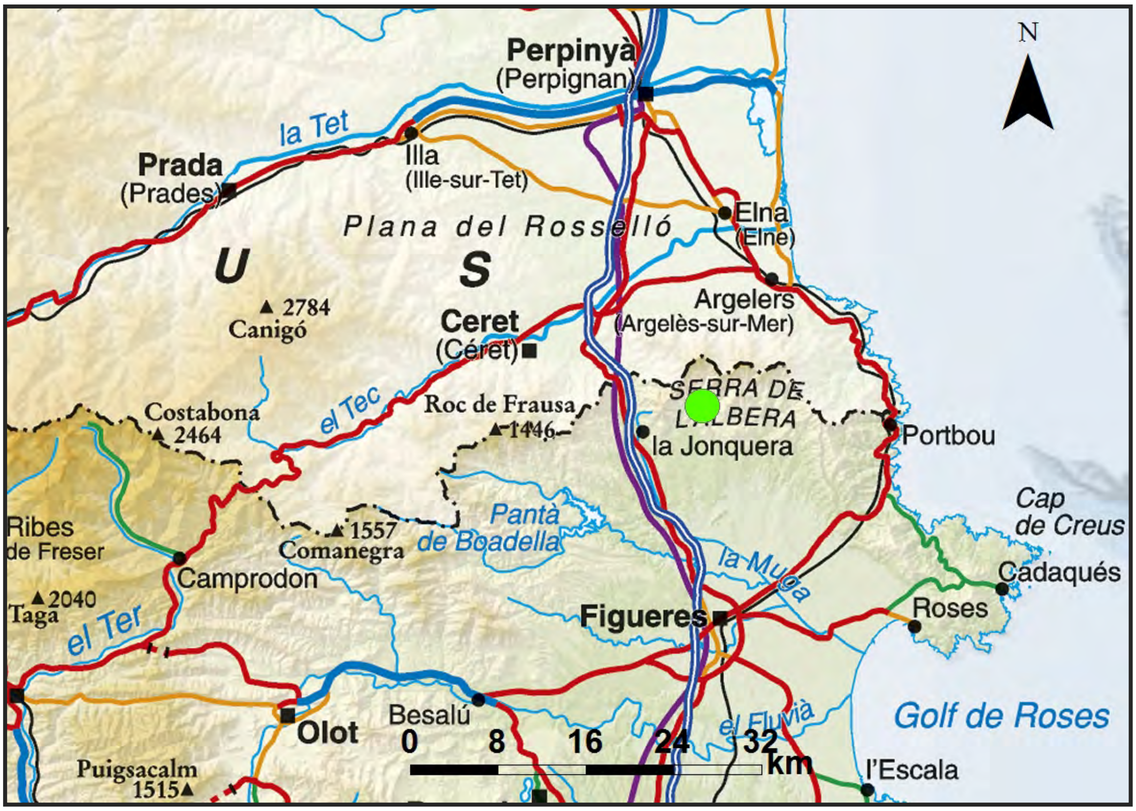


Figure 27. Location of the forest pilot in Muga watershed



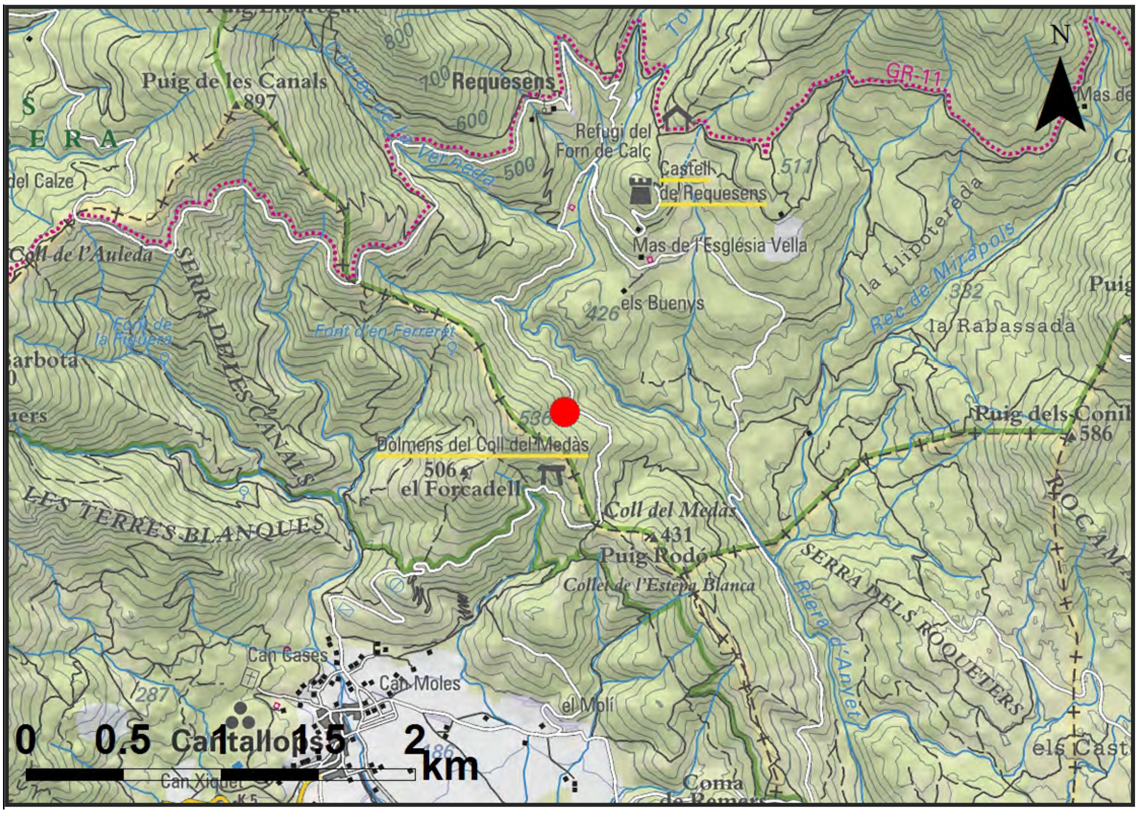


Figure 28.Detailed location of the forest pilot in the Muga watershed (green dot, top figure) and detailed map of access to the forest pilot (red dot) area from Cantallops village through the Requesens estate trail (lower figure)

c. Stakeholder networking

Pilot area selection has been an interactive process between the project partner CREAF and different stakeholders. In this process, several institutions have contributed:

- Local forest technicians from the Agriculture Department of Catalonia
- Technicians from the Forest Ownership Centre (Centre de la Propietat Forestal) of the Catalan Government.
- L'Albera Protected Natural Area staff
- Requesens estate owner

Management practices have been designed together with local stakeholders, particularly with the public body in charge of forest management (CPF), and with the Centre Tecnològic Forestal de Catalunya (CTFC) according to the adaptive management guidelines compiled in ORGEST (CPF, 2009).
http://cpf.gencat.cat/ca/cpf_03_linies_actuacio/cpf_transferencia_coneixement/cpf_orientacions_gestio_forestal_sostenible_catalunya/

3.1.2 Ter Watershed

a. Description of the area and its interest

Scots pine (*Pinus sylvestris*) is an evergreen coniferous with a wide range of distribution across Europe, the Iberian Peninsula being the Southern limit of its distribution. We have selected a Scots pine forest in this area considering three different criteria:

- The representativeness of the selected species and forest ecosystem. In this sense, the selected forest ecosystem is highly representative of montane forests in the Pyrenean foothills.

- The vulnerability of the area to climate change impacts. In recent years an increasing number of studies have reported forest declines and shifts in species composition in Scots pine forests in the Mediterranean region as a response to changing climatic conditions. The selected pilot area has suffered recent tree decline episodes and plagues, which park managers attribute to episodes of drought as the main cause.

- The feasibility for implementation of pilot experiments. Ease of access and the collaboration of the Montesquiu Castle Park staff have been crucial factors in selection of the area.

Scots pine (*Pinus sylvestris*) is the dominant overstorey species in the area. There is also a significant presence of oak (*Quercus pubescens*) in the understorey. Some escort species: maple (*Acer monspessulanum*), *Crataegus monogyna* and *Buxus sempervirens*, among others. According to park managers, the forest has not managed in the last 30 years (approximate). An initial inventory showed a medium-dense forest (over 1 000 trees/ha) and a basal area of 20 m^2/ha, with a regular structure. Figures 29 and 30 show the forest's initial appearance.

Figure 29. Forest appearance in the Montesquiu pilot area

Figure 30. Forest detail with dominant Scots pine in the overstorey and deciduous broadleaved species in the understorey.

b. Location of experimental plots and access

The forest pilot in Ter watershed is located in a Scots pine (*Pinus sylvestris*) forest in the Pyrenean foothills region, specifically, in Montesquiu Castle Park (protected natural area). It is a public estate pertaining to the Diputació de Barcelona (province government) in Montesquiu Municipality (Barcelona province, Fig. 31). Coordinates (Lat, Long): 42.116028, 2.217342. Altitude: 700 masl. The access to the pilot experiment area is through a trail from Montesquiu Castle. A more detailed map can be found in Figure 32. We have the permits necessary to implement the demonstrative adaptation measures.

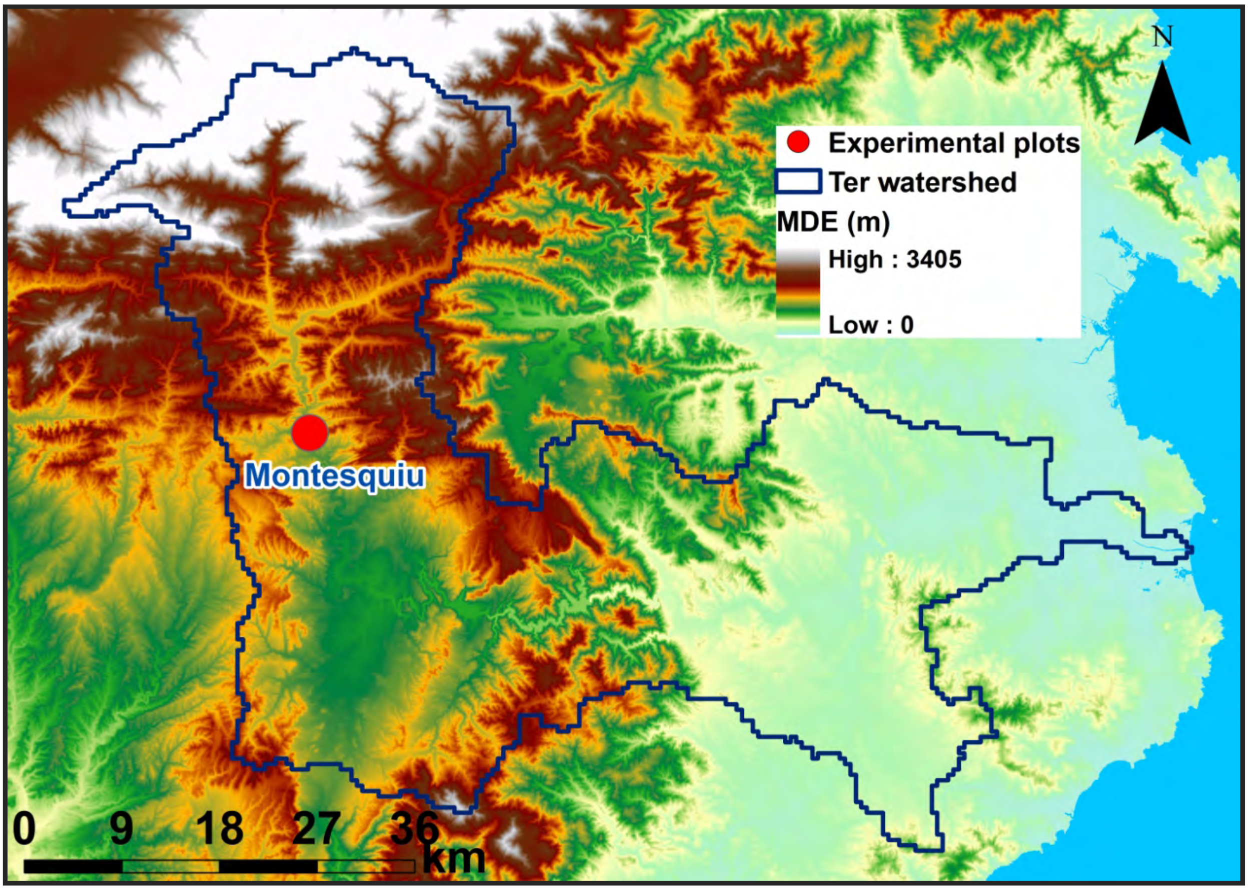


Figure 31. Location of the forest pilot in Ter watershed

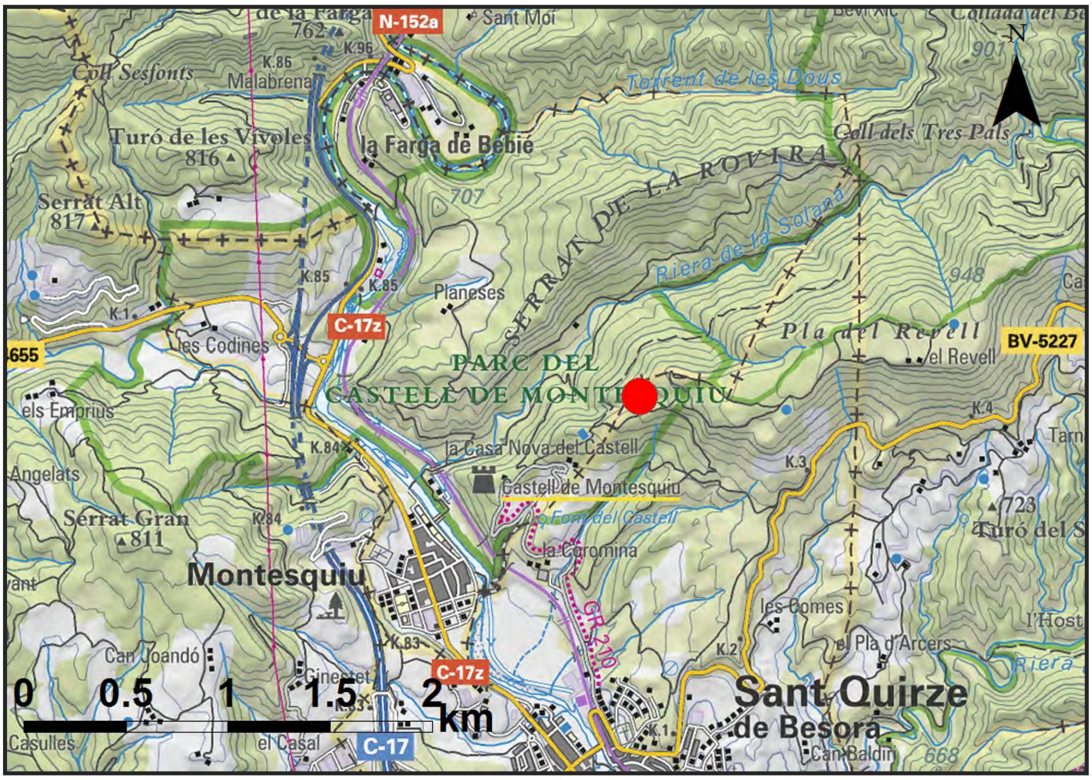


Figure 32. Detailed location of the forest pilot in Ter watershed (green dot, above) and detailed map of access to the forest pilot area from Montesquiu village and castle.

c. Stakeholder networking

Pilot area selection has been an interactive process between the project partner CREAF and different stakeholders. In this process, several institutions have contributed:

- Diputació de Barcelona. Servei de Parcs (Park service of the Barcelona provincial government)
- Staff of the Parc del Castell de Montesquiu Protected Natural Area
- Consorci d'Espais d'Interès Natural del Ripollès (Ripollès Natural Area Consortium)

Management practices have been designed together with local stakeholders, particularly with the park managers (Diputació de Barcelona) under the framework of an agreement between CREAF and the Diputació de Barcelona.

3.1.3 Segre Watershed

a. Description of the area and its interest

European black pine (*Pinus nigra*) is an evergreen conifer with a wide range of distribution across the Mediterranean region. We have selected a black pine forest in this area considering three different criteria:

- The representativeness of the selected species and forest ecosystem. In this sense, the selected forest ecosystem is highly representative of the central-Catalonian landscape. We have chosen two different areas because they represent different forest site qualities. According to fire prevention planning, these areas are considered Priority Action Areas for the reduction of fire risk.

- The vulnerability of the area to climate change impacts. Black pine forests were highly affected by forest fires in central Catalonia during the 1990s. In addition, there is a scientific concern about black pine regeneration following fire.

- The feasibility of implementation of pilot experiments. Easy access and collaboration with Life Demorgest project in the same area have been decisive factors in selection of the area.

European black pine (*Pinus nigra*) is the dominant overstorey species in the area, with a significant presence of oak (*Quercus pubescens*) in the understorey. Through an initial inventory, it was determined that this is a dense forest (over 2,000 trees/ha). Figures 33 and 34 show the forest's initial appearance.

Figure 33. Forest appearance in the Madrona pilot area

Figure 34. Forest appearance in the Llobera pilot area.

b. Location of the experimental plots and access

The forest pilot in Segre watershed is located in two different European black pine (*Pinus nigra*) forests in the Pyrenean foothills region, specifically, in the Solsonès region. They are private estates called Madrona (in Pinell del Solsonès municipality) and Llobera (Llobera municipality), both in the province of Lleida (Fig. 35). Coordinates (Lat, Long): Llobera: 41.951635, 1.469974. Altitude: 800 masl. Madrona: 41.968325, 1.336292. Altitude: 500 masl. Access to the pilot experiment area is by different local roads from the town of Solsona. More detailed maps can be found in Figures 36 and 37. We have the permits necessary to implement the demonstrative adaptation measures.

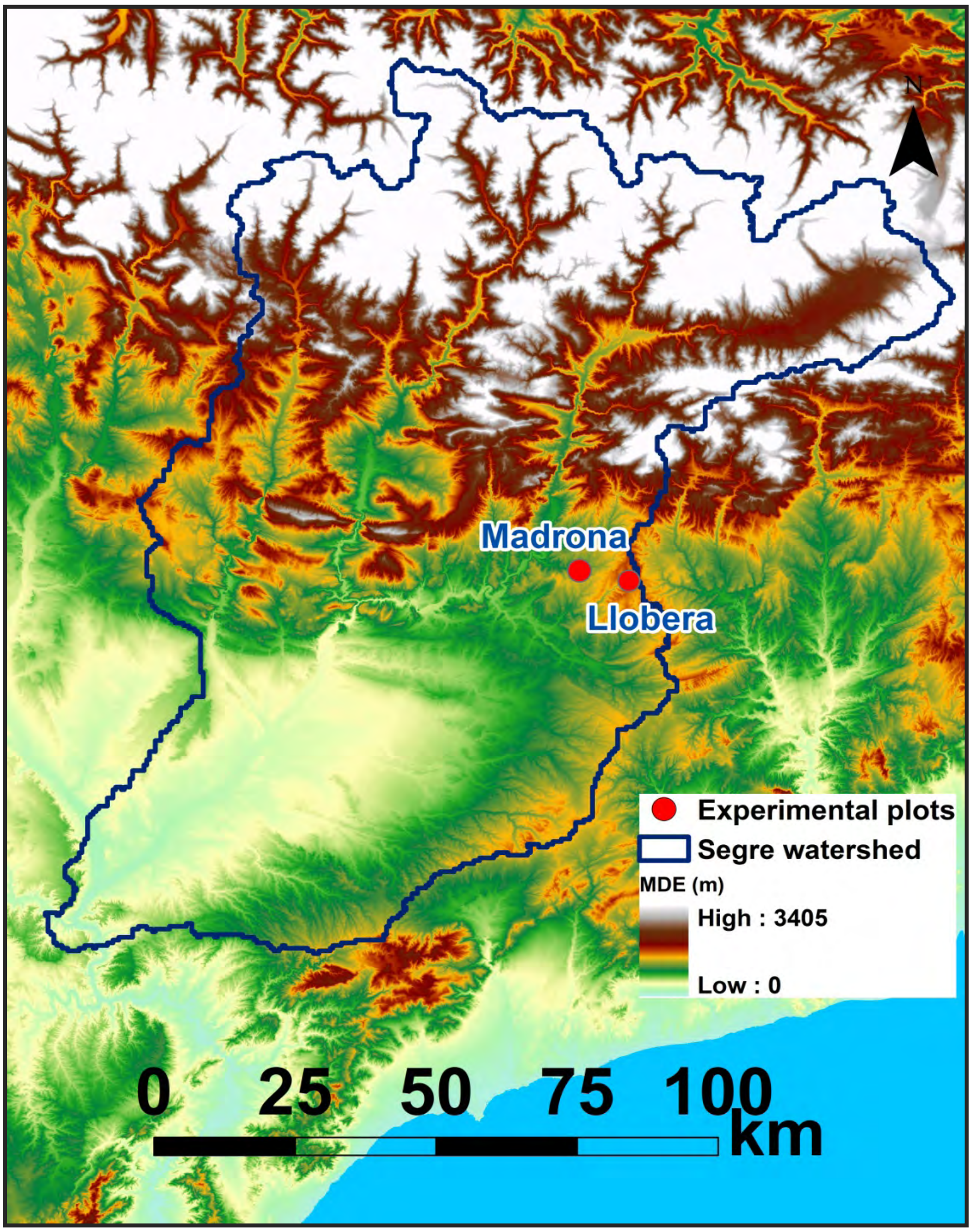
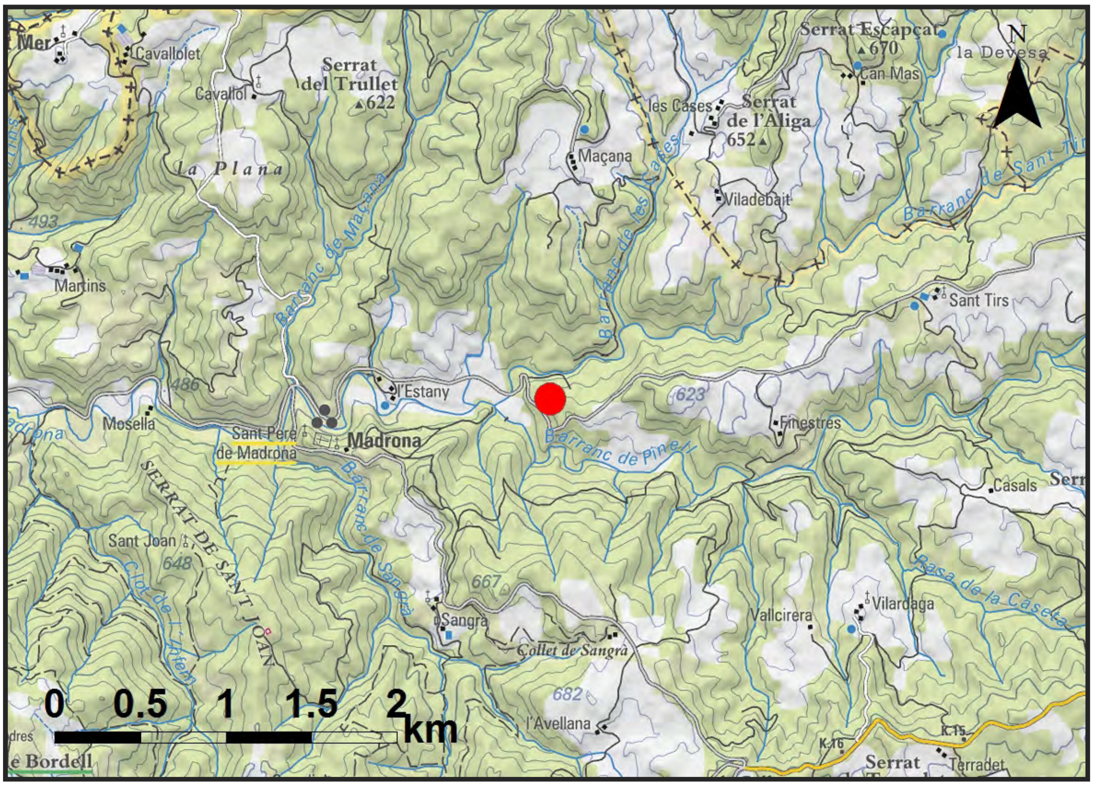


Figure 35. Location of the forest pilots in the Segre watershed

Figure 36. Detailed location of the forest pilots in the Segre watershed: Madrona pilot (orange point) and Llobera pilot (green point) and access from the town of Solsona.



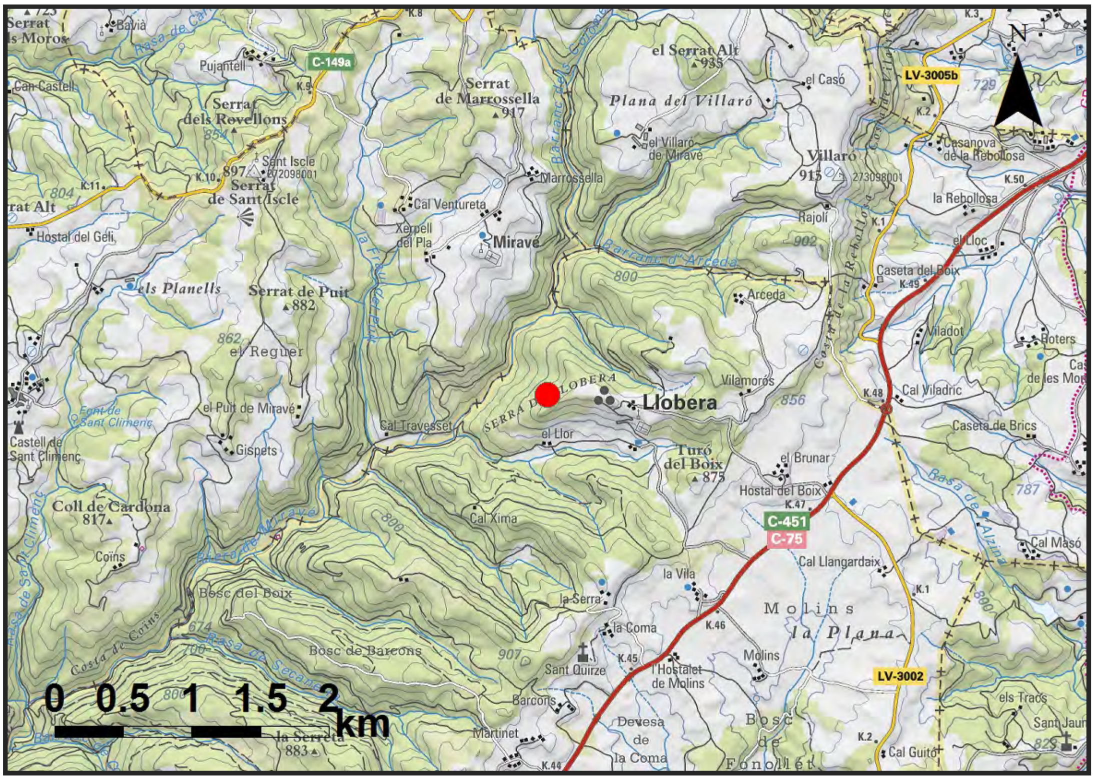


Figure 37. Detailed map of access to the forest pilot areas (red points) in the Segre watershed. The top figure corresponds to the Madrona site and the lower one to the Llobera site.

c. Stakeholder networking

Pilot area selection has been an interactive process between project partner CREAF and different stakeholders. In this process, several institutions have contributed:

- Cadí-Moixeró Natural Park
- Forest Ownership Centre (CPF) of Catalonia
- Forest Sciences Centre of Catalonia (Centre Tecnològic Forestal de Catalunya)

These pilot areas are shared between the projects Life MEDACC and Life Demorgest (lead by CPF), complementing different project approaches in the same pilot areas. This is a valuable result of project networking between these two Life projects.

3.2 Sub-action B.2.2: Implementation of the demonstrative adaptation measures

3.2.1 Muga Watershed

As stated in the project proposal, the objective of the pilot experiment is to demonstrate and quantify the impacts of management which makes forests less vulnerable to climate change. Management practices will address three main objectives: reduction of forest water stress, reduction of fire risk, and increase of wood production/carbon sequestration when possible. In the case of Holm oak, adaptive management practices will mainly consist of thinning to different degrees and utilizing different strategies) in order to reduce tree density and to promote mature structures with bigger trees and fuel discontinuity.

In the selected area, three pilot plots of approximately 1 hectare have been designed (Fig. 38) according to different adaptive management practices. Plot C is the control plot, with no intervention. Two management strategies will be compared: T1 will be a low thinning to adapt the forest to a regular structure. T2 will be a selection system in order to adapt the forest to an irregular structure and to stimulate forest regeneration.

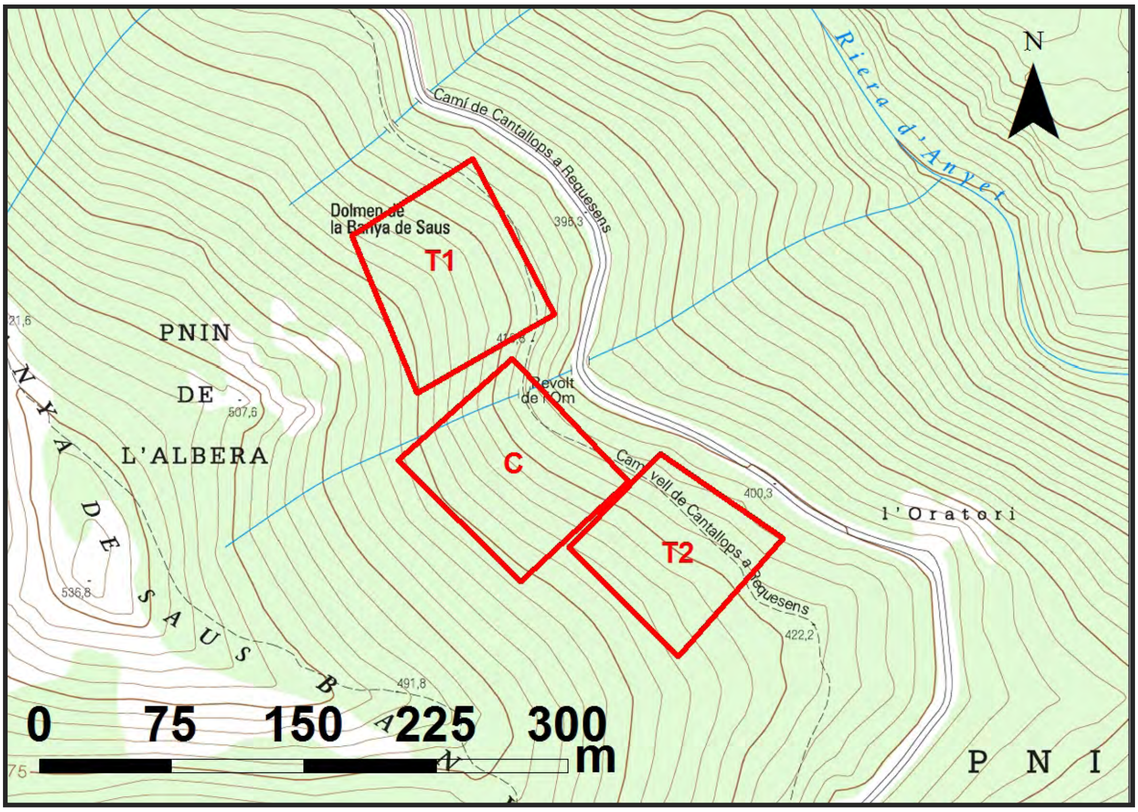


Figure 38. Plot design in pilot experiment area. C is the control plot, T1 and T2 are different treatments corresponding to different adaptive management practices.

3.2.2 Ter Watershed

As described in the project proposal, the objective of the pilot experiment is to quantify and demonstrate that management can make forest less vulnerable to climate change impacts. Management practices will address three main objectives: reduction of forest water stress, improvement of tree health, and increase of wood production/carbon sequestration when possible. In the case of this pilot forest experiment, adaptive management practices will be mainly understorey clearing and thinning in order to reduce tree competition. In addition, another pilot experiment objective is to assess the potential of oak replacement of Scots pine under conditions of climate change.

In the selected area, four pilot plots of approximately 1 hectare of surface have been designed (Fig. 39) according to different adaptive management practices. Plot C is the control plot, with no intervention. Three management strategies will be compared: T1 and T2 will be different understorey clearing intensities in Scots pine forests. T3 will be a treatment accelerating the replacement of Scots pine by oak.

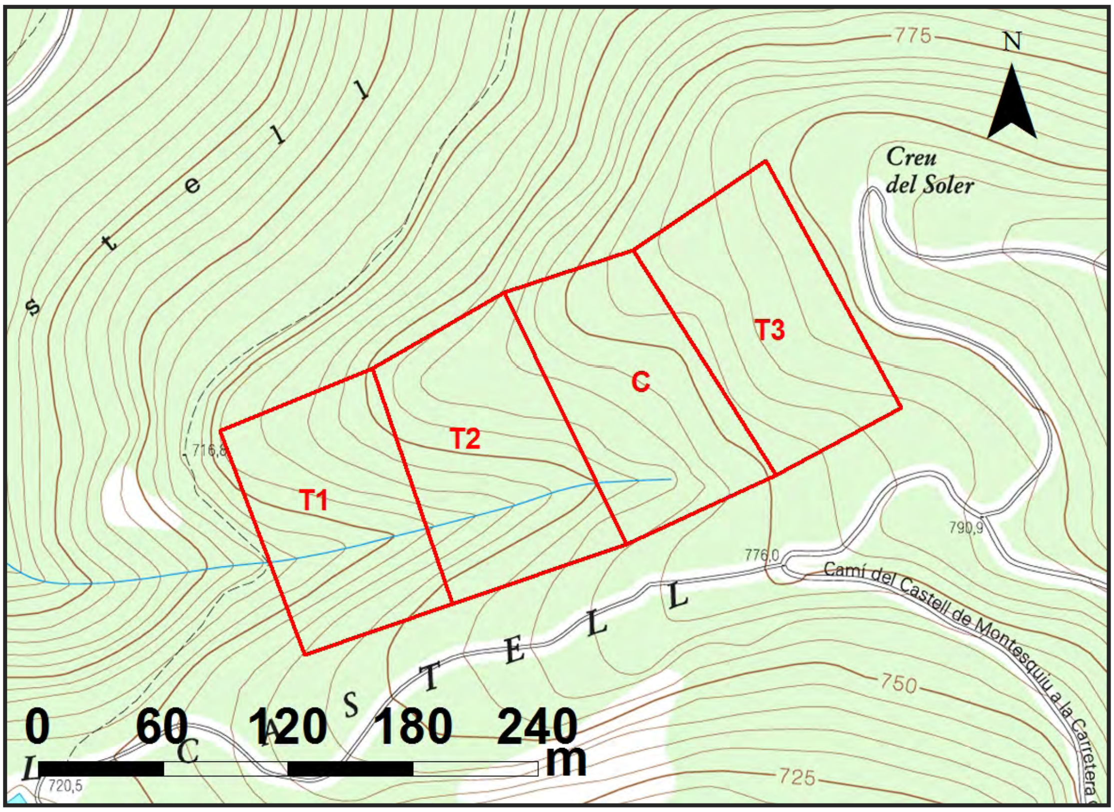


Figure 39. Plot design in pilot experiment area. C is the control plot, T1, T2 and T3 are different treatments corresponding to different adaptive management practices.

3.2.3 Segre Watershed

According to the project proposal, the objective of the pilot experiment is to quantify and demonstrate that management can make forests less vulnerable to climate change impacts. Management practices will address three main objectives: reduction of fire risk, reduction of forest water stress, and increase of wood production/carbon sequestration when possible. In the case of this pilot forest experiment, adaptive management practices will be mainly clearing and thinning in order to reduce tree competitiveness.

In the selected areas, five pilot plots (corresponding to different stands) of approximately 1 hectare have been designed (Fig. 40) according to different adaptive management practices. The C plot is the control plot, with no intervention. In the Llobera forest pilot, two management strategies will be compared: T1 will be selective understorey clearing and low thinning and T2 will be selective clearing and intensive tree thinning. In Madrona, T1 will be understorey selective clearing and T2, in addition to selective clearing, an intensive tree thinning.

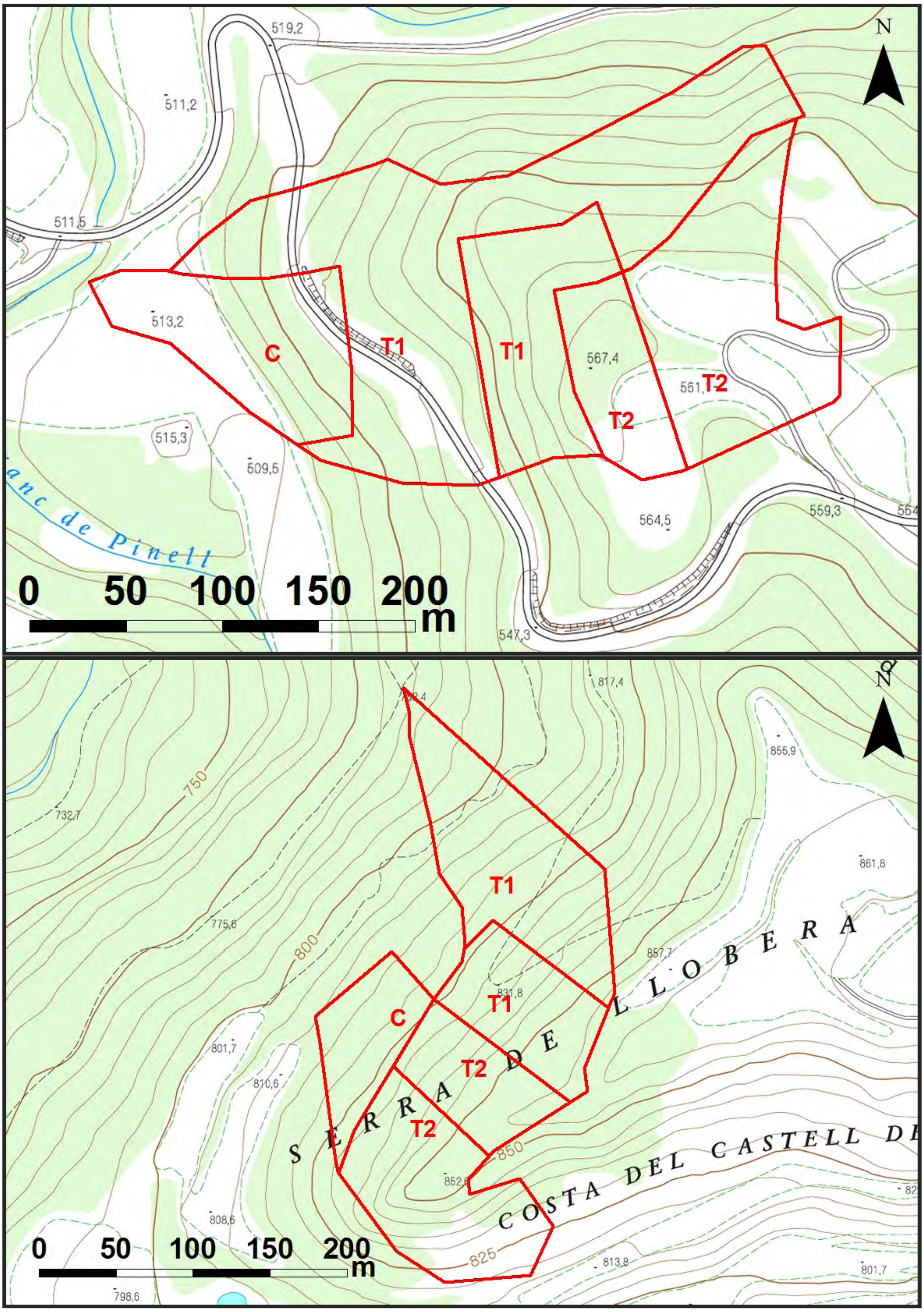


Figure 40. Plot design in pilot experiment areas (top figure corresponds to the Madrona site and the lower one to the Llobera site). C is the control plot T1 and T2 are different treatments corresponding to different adaptive management practices.

4. Conclusions

Both agriculture and forest experimental and demonstrative activities have started according to the previously described schedule, together with a significant, real and positive relationship with local stakeholders.