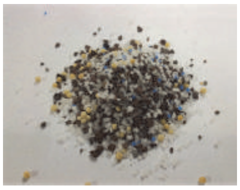
Monitoring of SustAffor field trials

A large set of data from SustAffor field trials has been gathered. Hereby we present the main variables measured and equipment utilized.

Sustaffor project: novel techniques and field trials

The aim of SUSTAFFOR is to conceive, produce, develop and on-field validate novel techniques aiming at improving afforestation / reforestation projects from an environmental, technical and economic point of view, as well as to explore the synergies between them.

These novel techniques aim at mitigating the negative effect of drought and competitive vegetation, while minimizing the need for maintenance. They include a new generation of soil conditioners and innovative mulching models, either biodegradable or reusable:


New soil conditioner with a new complex of hydro-absorbent polymers (TerraCottem Internacional)


Recycled rubber based mulch anti-UV, reusable in successive tree plantations. 1.5 mm thick (EcoRub)


Woven jute cloth treated with furan bio-based resin for increased lifetime, 100% biodegradable (La Zeloise)


New biopolymer-based semi-rigid plate, 100% biodegradable (DTC)


New biopolymer-based frame 100% biodegradable, fused to a commercially available biofilm (DTC)

This **third newsletter** presents the monitoring performed during the first and second vegetative period (2014-2015), at 8 field trials, comprising almost 4,000 experimental trees, installed in NE Spain, across a range of four significantly contrasted climatic areas (Semiarid, Mediterranean Continental, Mediterranean Humid, Montane), described in Newsletter 2.

The monitoring consist in four activities:

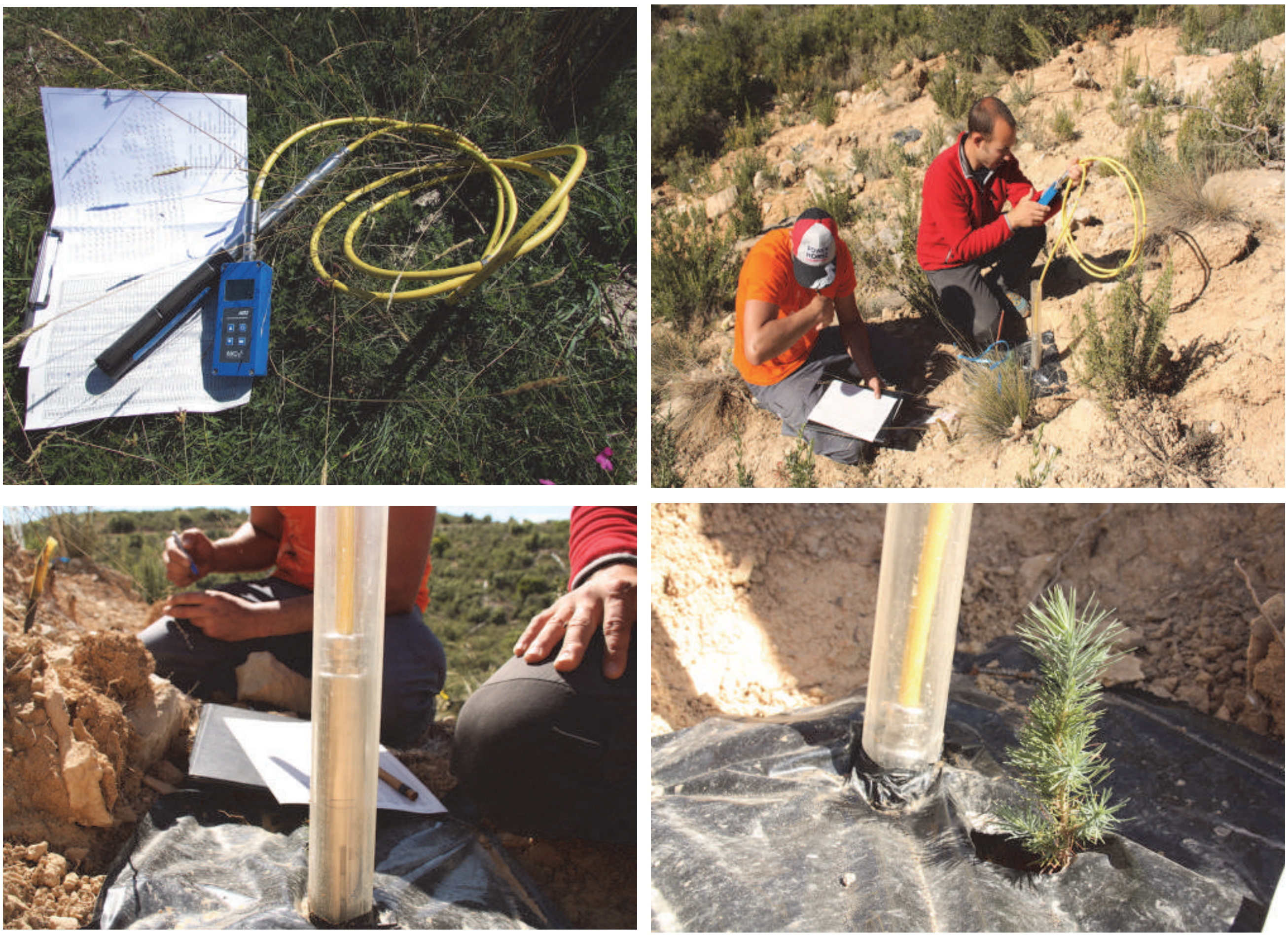
A. Environmental data
B. Tree performance & fitness
C. Soil sampling
D. Mulch degradation sampling

A. Environmental monitoring of Sustaffor field trials (CTFC & EDMA Innova)

The environmental monitoring focuses on the most relevant variables regarding tree performance, including those that may be affected by the treatments applied. The following table shows the list of variables gathered and the method of monitoring.

Variable	Equipment	Monitoring points and periodicity
Air temperature	Thermometer	5 sampling points Continuous logging weather station (DAVIS Vantage Pro2)
Precipitation	Pluviometer	
Radiation	Total radiation	
UV radiation	UV radiation	
Wind speed	Anemometer	
Relative humidity	Hygrometer	
Soil temperature	Hobo Pendant 64 k (252 units)	6 sampling points (2 depths) per weeding treatment Hourly logging
Soil humidity	IMKO Trime-Pico T3 TDR & Tecanat access tubes (294 tubes)	3 sampling points per treatment 9 measurements during dry period


Weather stations in Mediterranean continental & Montane conditions



Soil moisture measurement equipment: IMKO TDR probe with reading device; different moments of soil moisture measurement at two depths

Soil temperature equipment: HOBO Pendant thermometer; datalogger built-in

Thermometer and optical station for data downloading

B. Tree monitoring (CTFC)

The monitoring of tree performance consists in the following variables and methods:

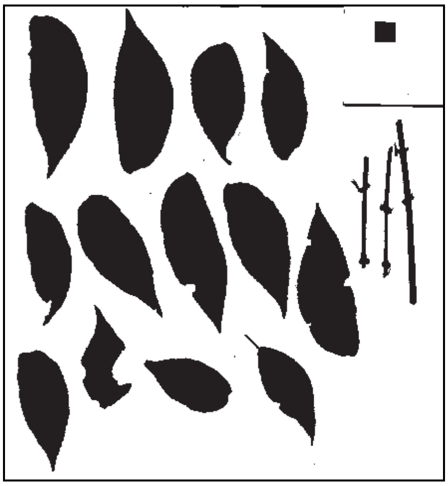
Variable	Measurement method	Sampled trees and periodicity
Survival and plant vigor	Visual assessment	All field trials, all trees June, October
Growth in diameter and height	Digital caliper and measuring tape	All field trials, all trees April 2014 (initial size), October
Leaf water potential	Pressure Chamber	Field trials 3, 5 and 7; 6 trees per treatment July, August
Needle relative water content	Weighting fresh & dry needles	Field trials 1 and 2; 8 trees per treatment4 July, August
Nutrition status	SPAD-meter	Field trials 3, 4, 5 and 7; 6 trees per treatment July, August
Specific Leaf Area	Scanner / precision scale	Field trials 3, 4, 5 and 7 August
Biomass allometry	Dry biomass of: aerial part, coarse roots, fine roots; root length & width	Field trials 1, 2 and 3 April (initial allometry), November

Measurement of basal diameter with electronic calliper, communicated with a tablet by bluetooth

Height measurement with measuring tape

Leaf water potential measurement with pressure chamber

Portable SPAD-meter



Scanned walnut leaf for SLA calculation

Steps in biomass allocation study: pulling out of a tree, root washing, measurement of root system dimensions and aspect of scanned roots

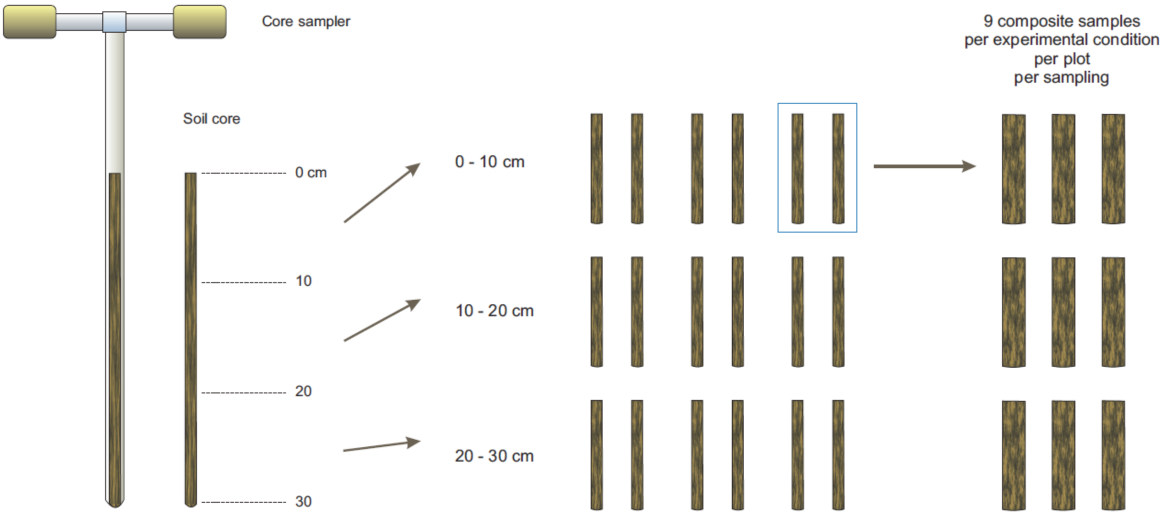
Biomass allocation study: separation of a tree in four components: needles, aerial part, coarse roots (>2mm), fine roots (<2mm). The dry weight of each component is calculated.

C. Soil monitoring (CTFC & CNRS)

A preliminary sampling (6 samples x 8 field trials) was performed in April 2014, aiming at characterizing the most relevant physical and chemical features: Total organic carbon, carbonates, texture and pH. In November 2014, a new soil sampling was done, for characterizing the effect of the different treatments in soil features. In 5 field trials six digs were sampled with a cylindrical core sampler, down to 30 cm depth. The obtained cores were divided in situ in three depths: 0-10, 10-20 and 20-30 cm. Each sample (dig x depth) was stored separately, and sent to laboratory.

Soil samples gathering

To rationalize the number of analyses to implement, the six samples from each field trial were merged into three composed replicates (17 treatments x 3 replicates x 5 sampled plots x 3 depths), with a final amount of 765 samples to be analysed in the laboratory.



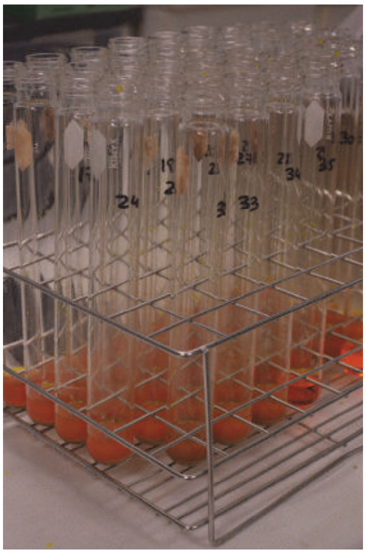
Procedure for compositing samples

In the laboratory, samples were air-dried to constant weight, and sieved through a 2 mm mesh. A subsample of the sieved soils was finely ground for analysing the main indicators of chemical fertility that are expected to be affected by the treatments applied, as shown below:

	Analysis	Methodology
1	Total organic carbon	Mebius (Soon & Abboud, 1991)
2	Extractable organic carbon	Extraction with K_2SO_4 (Ciavatta et al., 1991)
3	Total N	Dry combustion in a ThermoQuest CHN analyzer
4	Extractable ammonium	Extraction with K_2SO_4 (Baethgen & Alley, 1989)
5	Soluble nitrate	Extraction with K_2SO_4 (Cataldo et al., 1975)
6	Available phosphorus	Olsen (Olsen & Sommers, 1982).
7	N and C recalcitrance	Acid hydrolysis (Rovira & Vallejo, 2002)
8	Molecular characterization of soil organic matter	Thermochemolysis with TMAH (Grasset et al. 2009)

Properties 3-6 are indicators of soil fertility and main nutrients availability, which are likely to be limiting for plant growth. The rest of properties reflect another side of soil fertility which is related to soil biochemistry: they are related to the availability of substrates that may be used as source of carbon and energy by soil microflora: fungi, bacteria, actynomycota. These properties are expected to result in a higher abundance of labile substrates and, because of the increased microbial activity, in a higher abundance of microbial-derived biochemical indicators.

Soil samples sieving

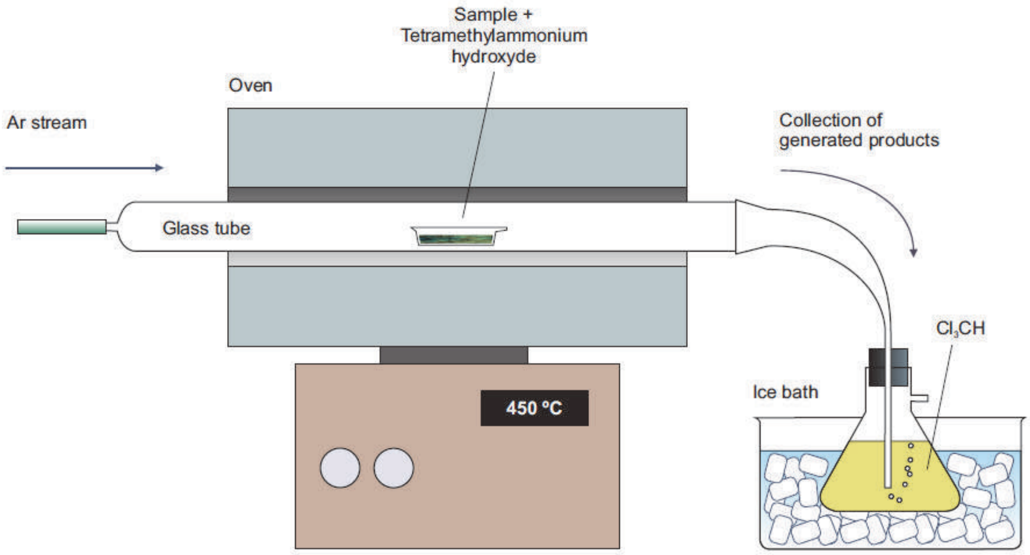


Analysis of total organic C

Potential of thermochemolysis as an interesting analytical tool for SUSTAFFOR

One objective of Sustaffor soil study is to follow the biochemical changes of soil organic matter (SOM) subjected to various treatments (soil conditioners and mulching). An analytical technique allowing the analyses of both mulches / soil conditioners and SOM is required. However SOM is composed from complex molecular structures which are difficult to identify.

Under proper conditions (high temperature, >400ºC, and inert atmosphere such as N2 or Ar), tetramethylammonium hydroxyde (TMAH) breaks polymeric materials into smaller fragments, often (albeit not necessarily) the monomeric bricks that build the macromolecules. These smaller fragments become methylated, which makes them resistant to further oxidations or secondary reactions. These methylated fragments are released into a stream of either N2 or Ar, cropped in a cold chloroform bath, concentrated and injected into a gas chromatograph / mass spectrometer system for their identification and quantification.



Scheme of the experimental setup of Thermochemolysis with TMAH

Thermochemolysis (thermally assisted hydrolysis and methylation) has been applied to a wide variety of polymeric organic materials, including complex and intractable samples (i.e. soils and sediments) or synthetic polymers (i.e. acrylates) (Shadkami and Helleur, 2010) for their rapid structural characterization. In SUSTAFFOR, the use of TMAH-thermochemolysis will be focused to two main purposes:

a) To detect in the soil traces of the applied mulches, thus allowing characterizing the possible accumulation of their decomposition products in soils.

b) To obtain a wide picture of the biochemical composition of soil organic matter, with special emphasis in distinguishing plant-derived from microbial-derived compounds. The proportion between them is an indicator of the degree of microbial reworking of plant debris (main original source of soil organic matter).

Mulch degradation monitoring (CENTEXBEL & CTFC)

In order to estimate the service life of both novel and reference mulching techniques a network of 3 mulch degradation trials was installed in Semiarid, Mediterranean Humid and Montane conditions. Each trial consists on 10 models of each mulch type.


Trials of mulch degradation study in Semiarid and Montane conditions

Mulch degradation in function of time will be evaluated at 6-month intervals (6, 12 & 18 months outdoors). Each time, 1 sample per mulch model is removed from the test site and sent to the research centres for evaluation. Simultaneously, a set of units kept indoors are evaluated, in order to have a value of reference.

The materials are evaluated:

- Visually: materials are assessed visually for damage such as cracks, holes, deformation (shrinkage), thermal damage due to melting. Also damage due to birds, rodents or animals is registered.
- Handling: materials are manipulated with small forces to evaluate if a considerable shift in stiffness, brittleness, etc. is observed.
- Mechanical analysis: samples that are still sufficiently intact are tested for mechanical properties. Especially ultimate strength and elongation at break are evaluated according to relevant standards for the specific products (foil, woven cloth, rubber mats and injected plates).

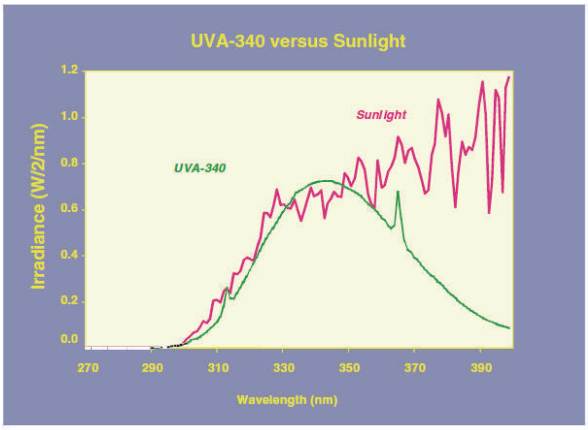
Changes in properties are reported as percentage of reduction in function of time, unless a too harsh degradation is observed and handling for clamping the materials in test apparatus is no longer possible. Once products reach this level of degradation it is concluded that the groundcover is at its end of service life.

Artificial weathering

In addition to the field trials artificial weathering conditions are applied to the same set of materials. Q-UV test methodology using UVA and/or UVB illumination (ISO 4892-3) (see included figures) is applied to the samples. The respective spectra of the light from UVA and UVB are presented below. Light intensity in both cases is 0.76 W/m². In addition to the illumination, also temperature is raised to 60°C during the 4 h illumination cycle and 50°C during the 4 hour dark cycle. The humidity in the test chamber is high resulting from water condensation on the samples during the dark cycle period.

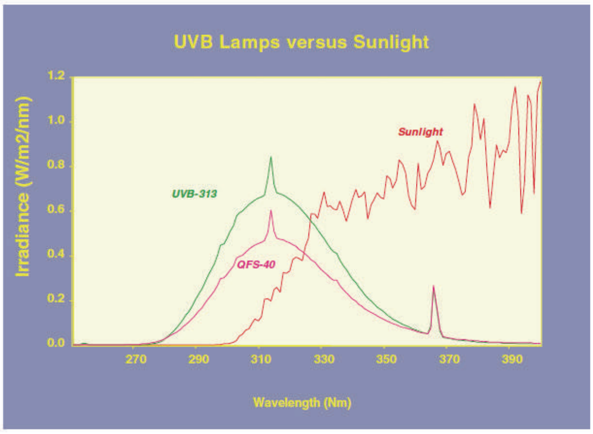
After illumination at 500, 1000, 1500 or 2000 hours, the corresponding mechanical analysis is performed in order to assess the degradation in properties. According to this procedure the durability of groundcovers during real life field tests along with artificial durability tests will be reported at the end of the evaluation period.

Figure 1: UVA-340 spectrum



By courtesy of QPanel

Figure 2: UVB-313 spectrum



Artificial Weathering: comparison wavelength UVA lamp, and UVB lamp with sunlight.

QUV test chambers