ICOS Ecosystem Station Labelling Report

Station: FR-Fon (Fontainebleau-Barbeau)

Viterbo (Italy), Antwerp (Belgium), Bordeaux (France), October 28th 2019

Description of the Labelling procedure

The Step2 procedure has the aims to organize the building the station in accordance with the ICOS Instructions, to establish the link with the ETC, and to validate all the data formats and submission. Furthermore, it involves also defining the additional steps needed after the labelling to complete the station construction according to the station Class. During the Step2 a number of steps are required and organized by the ETC in collaboration with the PI.

Preparation and start of the Step2

The station started the Step1 of the labelling on April 13th 2016 and got the official approval on November 15th 2016. The Step2 started officially on March 14th 2017 with a specific WebEx between the ETC members and the station team members where the overall procedure was discussed and explained.

Team description

The station PI has to describe the station team and provide the basic information about the proposed station using the BADM system. The submission is done using a specific ICOS interface.

Sampling scheme implementation

The sampling scheme is the distribution of points in the ecosystem where a number of measurements must be done. It is composed by two different type of sampling locations: the Sparse Measurement Plots (SP) that are defined by the ETC following a stratified random distribution on the basis of information provided by the PI and the Continuous Measurement Plots (CP) where continuous measurements are performed.

Measurements implementation

The measurement of a set of variables must be implemented in the Step2 labelling phase. The compliance of each proposed sensor and method is checked by the ETC and discussed with the PI in order to find the optimal solution. In case for specific reasons it is not possible to follow the ICOS agreed protocols and Instructions an alternative solution, equally valid, is defined and discussed also with the MSA if needed.

Once the sensors and methods are agreed the station Team has to implement the measurements using calibrated sensors, submit the metadata to the ETC and start to submit data Near Real Time for the continuous measurement. Also vegetation samples must be collected and shipped to the ETC chemical laboratory in France. The list of variables to be implemented during Step2 is reported in Table 1. Adaptation of the table to specific ecosystem conditions are possible and always discussed with the PI and the MSA.

In addition to the variables reported in Table 1 there is an additional set of measurements that are requested and that must be implemented after the labelling in the following 1-2 years. For all these variables (in particular for the soil sampling) an expected date and specific method to be used is discussed and agreed before the end of the Step2 process.

Group	Variable
EC fluxes CO2-LE-H	Turbulent fluxes Storage fluxes
Radiations	SW incoming LW incoming SW outgoing LW outgoing PPFD incoming PPFD outgoing
Meteorological above ground	Air temperature Relative humidity Air pressure Total precipitation Snow depth Backup meteo station
Soil climate	Soil temperature profiles Soil water content profiles Soil heat flux density Groundwater level
Site characteristics	History of disturbances History of management Site description and characterization
Biometric measurement	Green Area Index Aboveground Biomass
Foliar sampling	Sample of leaves Leaf Mass to Area Ratio
Additional variables for Class1 stations	
Radiation	SW/PPFD diffuse
Meteorological	Precipitation (snow)
Biometric measurement	Litterfall

Table 1 – Variables requested for Step2

Data evaluation

Stations entering Step2 have been already analyzed during Step1 of the labelling but the optimal configuration and the possible presence of issues can be checked only looking to the first data measured. For this reason a number of tests will be performed on the data collected during the Step2 (NRT submissions, that can be integrated if needed by existing data) and the results discussed with the PI in order to find the best solution to ensure the maximum quality that is expected by ICOS stations. Four tests are performed:

Test 1 - Percentage of data removed

During the fluxes calculation the raw data are checked by a number of quality tests and some of them will lead to data exclusion and gaps. It is calculated the number of half hours removed by these QAQC filters and the target value is to have less than 40% of data removed. If the test fails, an in depth analysis of the reasons is performed in order to find solutions and alternatives.

Test 2 – Footprint and Target Area

The Target Area is the area that we aim to monitor with the ICOS station. The test will analyze using a footprint model (Klijun et al. 2015) the estimated contribution area for each half hour and check how many records have a contribution coming mainly from the target area. The target is to have at least 70% of measurements that are coming mainly (70% of the contribution) from the Target Area. If the test fails, a discussion with the PI is started in order to find solutions and alternatives, in particular changing the measurement height or wind sectors to exclude.

Test 3 – Data Representativeness in the Target Area

The aim is to identify areas that are characterized by different species composition or different management (and consequently biomass and density) and analyze, using the same footprint model (Kljun et al. 2015), the amount of records coming from the different ecosystems, checking their representativeness in terms of day-night conditions and in the period analyzed. The target is to get, for the main ecosystem types, at least 20% of the data during night and during day and also distributed along the period analysed. If not reached, a discussion with the PI is started in order to find solutions and alternatives, in particular changing the measurement height or wind sectors to exclude.

Test 4 – CP Representativeness in the Target Area

The CPs must be as much as possible representative of the Target Area and this will be checked on the basis of the results of the site characterization, in particular in relation to species composition, biomass and management. The target is to have the percentage of the two main species and their biomass in the CP not more that 20% different respect to the measurements done in the SP plots. In case the CPs proposed do not represent a condition present in the Target Area they are relocated or one or more additional CPs can be added.

Station Description

The Fontainebleau-Barbeau station, with ICOS code FR-Fon, is located about 50 km South-East of Paris (France), within the Atlantic Biogeographical Region and it is a deciduous oak forest. The coordinates in WGS84 system are: Latitude 48.476358 °N, Longitude 2.780096 °E, the elevation above sea level being 103 m, and having an offset respect to the Coordinated Universal Time (UTC) equal to +01. The climate is temperate oceanic, well representative of a large North-Western part of Europe and the site is marked by the following climate characteristics: Mean Annual Temperature 11.44 °C, Mean Annual Precipitation 678.99 mm, Mean Annual Radiation 134.97 W m^{-2}. The forest is dominated by *Quercus petraea* (Matt.) Liebl. and *Quercus robur* L., with a hornbeam coppice understory established on a gleyic luvisol.

Figure 1 - The FR-Fon tower

Team description

The staff of the site has been defined and communicated in March 2017. It includes in addition to the PI, the CO-PI, the Manager and the technical-scientific staff. Below the summary table of the Team members is reported.

MEMBER_NAME	MEMBER_INSTITUTION	MEMBER_ROLE	MEMBER_MAIN_EXPERT
Eric Dufrêne	CNRS	PI	BIOMASS
Nicolas Delpierre	Université Paris-Sud	CO-PI	DATAPROC
Daniel Berveiller	CNRS	MANAGER	MICROMET
Kamel Soudani	Université Paris-Sud	SCI-ANC	BIOMASS
Gaëlle Vincent	CNRS	TEC-ANC	SOIL
Alexandre Morfin	Université Paris-Sud	TEC	PLANT

Spatial sampling design

For the spatial sampling design at FR-Fon, the Station Team (ST) proposed, in addition to the Target Area (TA), 2 areas to be excluded from sampling (EA). Four continuous measurement points (CP) were submitted in a later stage and their area was not excluded from sampling. Figure 2 shows the extent and position of such spatial features in relation to the actual site area, in addition to the randomly sampled first order sparse measurement plots SP-I. Being a forest ecosystem, and after having verified their compliance, CP areas have been further subsampled to extract the coordinates of the 5+5 subplots for biomass sampling. The field location of the SP-I points correctly matched with the proposed design. Such coordinates are currently definitive and used for specific vegetation and soil samplings. It has been agreed that SP-II points will be marked physically before the soil sampling and at that time ETC will perform the control on the field positioning.

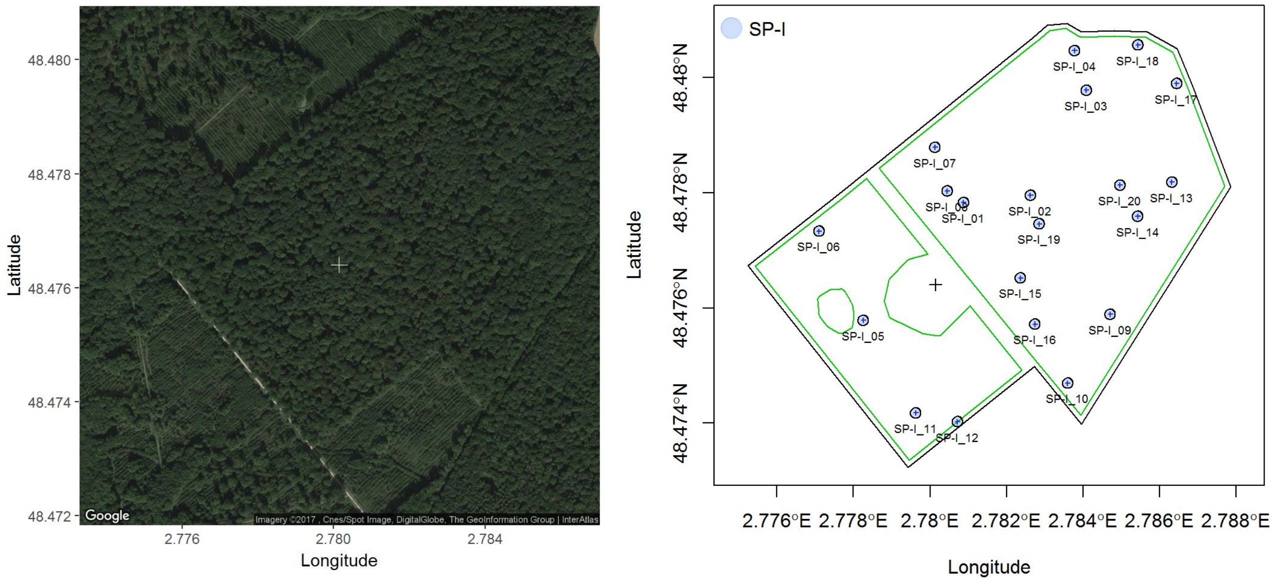


Figure 2: Aerial map of FR-Fon and proposed spatial features according to the reported target area, exclusion area and ICOS requirements. Note that the CP areas have not been excluded from the sampled area. The TA surface is 45.26 Ha, the total excluded area is of 2.23 Ha.

Station implementation

Eddy covariance:

EC System		
MODEL	GA_CP-LI-COR LI-7200	SA-Gill HS-50
SN	72H-0204	H000186
HEIGHT (m)	37	37
EASTWARD_DIST (m)	0	0
NORTHWARD_DIST (m)	2.5	2.5
SAMPLING_INT	0.05	0.05
LOGGER	1	1
FILE	1	1
GA_FLOW_RATE	15	-
GA_LICOR_FM_SN	FM1-0188	-
GA_LICOR_AIU_SN	AIU-0388	-
SA_OFFSET_N	-	0
SA_WIND_FORMAT	-	U, V, W

SA_GILL_ALIGN	-	Spar
ECSYS_SEP_VERT	0	
ECSYS_SEP_EASTWARD	-0.02	
ECSYS_SEP_NORTHWARD	-0.15	
ECSYS_WIND_EXCL		
ECSYS_WIND_EXCL_RANGE		

The station has ICOS eddy covariance sensors installed: Gill HS sonic anemometer and LI7200 gas analyser. EC data are collected on the LICOR logger SmartFlux2. The PI installed the EC system at the end of 2017, after sending the SAT to the factory for calibration: a new calibration will be needed after a new agreement between ETC and Gill will be found. The IRGA was shipped to LICOR for calibration and repair on 20190212, was back on 20190315 (calibration will expire in 2021), but it was installed only on May 7th 2019 as the station was operating maintenance operations at the tower for security reasons (after agreement with the ETC): for that reason a gap of almost 3 months is present in EC raw data. The sonic height is compliant with what proposed and agreed during the Step 1 (37 m). An agreement on the sonic orientation instead was not found during the Step1: due to the influence of several factors in the footprint that made it difficult to predict the best orientation, it was decided to postpone the decision at the Step2 taking advantage of measured data (preliminary data analysis). The preliminary test showed that the footprint was not exceeding the target area (homogeneous) often. For that reason the ETC acknowledged the station PI to orient the sonic towards N.

Storage: For the storage system the PI proposed the sequential sampling scheme using the LI-840 (LiCor) as gas analyzer (GA, latest factory calibration = 06 Dec. 2017) and two pumps for the air circuit (a rotary vanes purge pump and a Teflon-membrane sampling pump). This scheme is appropriate for the concerning ecosystem and was accepted.

Although with the actual EC system height (37 m) the suggested number of levels in the profile is 11, it was agreed to use 8 levels, placed at of 0.13, 0.85, 2.57, 5.62, 10.31, 16.93, 25.74 and 37 m from the ground. Five sampling points have been installed on a plane across the lowest (# 8), and three points on a plane across the second-lowest (# 7) level. In addition, the lowest five are located 20 meters away from tower to avoid interaction with the tower infrastructures. All the sampling tubes have the same length (i.e. 50 meters, 10mm ID), from the inlet to the manifold. Except the inlet filters (swagelok SS-4FW4-2) and the mass flow controller (MFC) mado of stainless steel, the rest of the system (raincap, tubes, fittings, manifold, and valves) is made of Teflon® (PTFE or PFA). Inlet filters are heated (pic 1) with constantan wires and heating is controlled through a managed power. The system air pressure is controlled and monitored to prevent filter clogging. Nominal pressure of the system is around 800 mbars. Each level is flushed continuously at around 52L/min. It results a 185 mbars of pressure drop and a flow-rate of 19.5 m/sec and a 4.5s of residence time in each line. The GA is automatic calibrated every 2 to 3 months.

A definitive solution must be agreed for both the individual level sampling interval (proposed 45 s, suggested 35 s) and the buffer volumes (proposed 400 mL, suggested 3.5-7.0 L). Hower, given that these two open points do not prevent a proper sampling, ETC decided to accept the current system design. The station team will anyway resolve them in the shortest possible time.

Radiations:

MODEL	SN	HEIGHT (m)	EASTWARD_DIST (m)	NORTHWARD_DIST (m)	VARIABLE_H_V_R
RAD_4C-K&Z CNR4	110653	36	0	-3.5	SW_IN_1_1_2
					SW_OUT_1_1_1
					LW_IN_1_1_1
					LW_OUT_1_1_1
RAD_SW-K&Z CMP22	110294	36	0	-2	SW_IN_1_1_1
RAD_PAR-K&Z PQS1	181594	36	0	-3.5	PPFD_IN_1_1_1
RAD_PAR-K&Z PQS1	181595	36	0	-3.5	PPFD_OUT_1_1_1
RAD_PAR-DeltaT BF5	35/05	36	-0.3	-2.5	PPFD_IN_1_1_2
					PPFD_DIF_1_1_1

For short- and long-wave radiations FR-Fon will use both a *CNR-4* (*Kipp & Zonen*) with its CNF4 ventilation and heating unit and a CMP22 (*Kipp & Zonen*) equipped with a CVF3 unit. For the PPFD radiations the PQS1 (*Kipp & Zonen*) quantum sensor will be used. Concerning the diffuse radiation the Team proposed to use the BF5 (*Delta T*) sensor, which is not fully ICOS compliant. However, the PI specified that the BF5 sensor will be used to give only diffuse PPFD and diffuse/total ratio. The total incoming PPFD will be measured with PQS1 and the CMP22 will give global radiation, thus the proposed solution has been accepted.

Precipitation:

MODEL	SN	HEIGHT (m)	EASTWARD_DIST (m)	NORTHWARD_DIST (m)	VARIABLE_H_V_R
PREC-Geonor T200x	49617	1.7	1317	222	P_1_1_1

For precipitation measurements, the PI expressed the impossibility to find a compliant area around the tower (and to install the gauge on top of the tower), and the willing to install the main weighing gauge (a T200B, *Geonor*) on the backup station. Consequently ETC proposed to install it at the backup station and a secondary gauge (tipping bucket) on the tower. The latter will be used as back-up sensor and for reference of the local condition at the tower place. The PI agreed but with the constraint of not using the heating because there is not a power line at the backup station (only a small solar panel). Given that the heating of the orifice rim is not mandatory and that at FR-Fon critical cold and snowfall are not expected (PI communication) ETC accepted the proposal because it will not be critical. The main weighing gauge will be used in combination with the Geonor Alter type windshield.

For snow depth measurements, manual readings with a graduated steel rule will be achieved.

Air temperature, relative humidity and air pressure

MODEL	SN	HEIGHT (m)	EASTWARD_DIST (m)	NORTHWARD_DIST (m)	VARIABLE_H_V_R
RHTEMP-Vaisala HMP155	P4920370	37	-0.6	1.4	TA_1_1_1
					RH_1_1_1
RHTEMP-Meteolab or Thygan VTP	397	36	-0.9	0.9	TA_1_1_2
					RH_1_1_2
RHTEMP-Vaisala HMP155	P4920369	29	-2.5	3.6	TA_2_1_1
					RH_2_1_1
RHTEMP-Vaisala HMP155	G4930026	23	-2.5	3.6	TA_2_2_1
					RH_2_2_1
RHTEMP-Vaisala HMP155	G4930025	17	-2.5	3.6	TA_2_3_1
					RH_2_3_1
RHTEMP-Vaisala HMP155	G4930024	11	-2.5	3.6	TA_2_4_1
					RH_2_4_1
RHTEMP-Vaisala HMP155	P4920368	3	-11.3	13.6	TA_3_1_1
					RH_3_1_1
PRES-Young 61302	BPA3925	35.5	-0.7	0.7	PA_1_1_1
WDWS-Gill WindsonicX	11460082	37	-0.6	1.4	WD_1_1_1
					WS_1_1_1
WDWS-Gill WindsonicX	11460081	29	-2.5	3.6	WD_2_1_1
					WS_2_1_1
WDWS-Gill WindsonicX	18010088	23	-2.5	3.6	WD_2_2_1
					WS_2_2_1
WDWS-Gill WindsonicX	11460079	17	-2.5	3.6	WD_2_3_1
					WS_2_3_1
WDWS-Gill WindsonicX	11380017	11	-2.5	3.6	WD_2_4_1
					WS_2_4_1

WDWS-Gill WindsonicX	11460080	3	-11.3	13.6	WD_3_1_1
					WS_3_1_1

The TA/RH and PA sensors are ICOS compliant: Vaisala HMP155 and Young 61302. A calibration plan exists for these sensors, and was accepted by the ETC. The plan is to use three brand-new sensors as spare sensors during the calibration periods. Some additional sensors are also present at the station: a profile of TA sensors used for the storage (same model) and a mirror dew point for duplicate measurements of TA (Meteolabor Thygan VTP); a profile of wind sensors with ICOS compliant 2D sonic anemometers (Gill WindsonicX). Some VAISALA HMP155 sensors were recently sent to calibration according to the plan. The TA, RH and WS/WD sensors in the profile are placed at six different heights, however those at the top and those at the bottom are some meters away from the others to avoid disturbances to the sensors nearby and from the tower structure. The ETC accepted this configuration. 2D sonic is mandatory for Class 1 stations while a wind profile is not. The plan for calibration was accepted by the ETC also in this case.

Backup meteorological station

The backup station is powered by solar panels: the PI confirmed that he expects that it can provide enough power to allow the backup station to run continuously and without gaps in every condition. The ETC reserves the right to ask an update of the system in case of missing data. TA+RH are measured by a Vaisala HMP155 in naturally ventilated radiation shield (exception accepted), while the radiation sensor is a CMP6 from Kipp&Zonen (ICOS compliant). The precipitation sensor is an ARG100 (tipping bucket, compliant); however, due to space limitation, an exception was accepted to install it at the main tower, and have in the backup station the main weighing gauge. In addition, two more Tipping buckets are present at the top of the main tower (EML ARG100, PrecMec R013029), and an ICOS compliant 2D sonic anemometer (Gill WindsonicX).

Need for calibrations will be checked against the main sensors.

MODEL	SN	HEIGHT (m)	EASTWARD_DIST (m)	NORTHWARD_DIST (m)	VARIABLE_H_V_R
RAD_SW-K&Z CMP6	172500	2.5	1320	219	SW_IN_2_1_1
RHTEMP-Vaisala HMP155	H1920007	1.9	1320	219	TA_4_1_1
					RH_4_1_1
PREC-EML ARG100	113041	1.2	1320	222	P_1_1_2
PREC-EML ARG100	86224	36	0.3	1.4	P_2_1_1
PREC-PrecMec R013029	22251	36	0.8	-0.8	P_2_1_2
WDWS-Gill WindsonicX	12200113	2.5	1320	219	WS_4_1_1
					WD_4_1_1

Soil temperature, soil water content, soil heat flux density and water table depth

MODEL	SN	HEIGHT (m)	EASTWARD_DIST (m)	NORTHWARD_DIST (m)	VARIABLE_H_V_R
TEMP-Generic PT100(0) Class A	TCSA_PT100-35-06	0	-14.296	-39.492	TS_1_1_1
TEMP-Generic PT100(0) Class A	TCSA_PT100-25-01	-0.04	-14.296	-39.492	TS_1_2_1
TEMP-Generic PT100(0) Class A	TCSA_PT100-25-02	-0.08	-14.296	-39.492	TS_1_3_1
TEMP-Generic PT100(0) Class A	TCSA_PT100-25-03	-0.16	-14.296	-39.492	TS_1_4_1
TEMP-Generic PT100(0) Class A	TCSA_PT100-25-04	-0.32	-14.296	-39.492	TS_1_5_1
TEMP-Generic PT100(0) Class A	TCSA_PT100-25-05	-0.64	-14.296	-39.492	TS_1_6_1
TEMP-Generic PT100(0) Class A	TCSA_PT100-35-07	0	-38.105	-22	TS_2_1_1
TEMP-Generic PT100(0) Class A	TCSA_PT100-30-01	-0.04	-38.105	-22	TS_2_2_1
TEMP-Generic PT100(0) Class A	TCSA_PT100-30-02	-0.08	-38.105	-22	TS_2_3_1
TEMP-Generic PT100(0) Class A	TCSA_PT100-30-03	-0.16	-38.105	-22	TS_2_4_1
TEMP-Generic PT100(0) Class A	TCSA_PT100-30-04	-0.32	-38.105	-22	TS_2_5_1
TEMP-Generic PT100(0) Class A	TCSA_PT100-30-05	-0.64	-38.105	-22	TS_2_6_1
TEMP-Generic PT100(0) Class A	TCSA_PT100-35-08	0	-28.784	3.534	TS_3_1_1
TEMP-Generic PT100(0) Class A	TCSA_PT100-35-01	-0.04	-28.784	3.534	TS_3_2_1

TEMP-Generic PT100(0) Class A	TCSA_PT100-35-02	-0.08	-28.784	3.534	TS_3_3_1
TEMP-Generic PT100(0) Class A	TCSA_PT100-35-03	-0.16	-28.784	3.534	TS_3_4_1
TEMP-Generic PT100(0) Class A	TCSA_PT100-35-04	-0.32	-28.784	3.534	TS_3_5_1
TEMP-Generic PT100(0) Class A	TCSA_PT100-35-05	-0.64	-28.784	3.534	TS_3_6_1
TEMP-Generic PT100(0) Class A	TCSA_PT100-35-09	0	30.495	-16.765	TS_4_1_1
TEMP-Generic PT100(0) Class A	TCSA_PT100-30-06	-0.04	30.495	-16.765	TS_4_2_1
TEMP-Generic PT100(0) Class A	TCSA_PT100-30-07	-0.08	30.495	-16.765	TS_4_3_1
TEMP-Generic PT100(0) Class A	TCSA_PT100-30-08	-0.16	30.495	-16.765	TS_4_4_1
TEMP-Generic PT100(0) Class A	TCSA_PT100-30-09	-0.32	30.495	-16.765	TS_4_5_1
TEMP-Generic PT100(0) Class A	TCSA_PT100-30-10	-0.64	30.495	-16.765	TS_4_6_1
SWC-Sentek EnviroSCAN	FRFON-SWCP1_01	-0.05	-12.979	-39.944	SWC_1_1_1
SWC-Sentek EnviroSCAN	FRFON-SWCP1_02	-0.15	-12.979	-39.944	SWC_1_2_1
SWC-Sentek EnviroSCAN	FRFON-SWCP1_03	-0.25	-12.979	-39.944	SWC_1_3_1
SWC-Sentek EnviroSCAN	FRFON-SWCP1_04	-0.35	-12.979	-39.944	SWC_1_4_1
SWC-Sentek EnviroSCAN	FRFON-SWCP1_05	-0.45	-12.979	-39.944	SWC_1_5_1
SWC-Sentek EnviroSCAN	FRFON-SWCP1_06	-0.55	-12.979	-39.944	SWC_1_6_1
SWC-Sentek EnviroSCAN	FRFON-SWCP1_07	-0.65	-12.979	-39.944	SWC_1_7_1

SWC-Sentek EnviroSCAN	FRFON-SWCP1_08	-0.75	-12.979	-39.944	SWC_1_8_1
SWC-Sentek EnviroSCAN	FRFON-SWCP1_09	-0.85	-12.979	-39.944	SWC_1_9_1
SWC-Sentek EnviroSCAN	FRFON-SWCP1_10	-0.95	-12.979	-39.944	SWC_1_10_1
SWC-Sentek EnviroSCAN	FRFON-SWCP1_11	-1.05	-12.979	-39.944	SWC_1_11_1
SWC-Sentek EnviroSCAN	FRFON-SWCP1_12	-1.15	-12.979	-39.944	SWC_1_12_1
SWC-Sentek EnviroSCAN	FRFON-SWCP1_13	-1.25	-12.979	-39.944	SWC_1_13_1
SWC-Sentek EnviroSCAN	FRFON-SWCP1_14	-1.35	-12.979	-39.944	SWC_1_14_1
SWC-Sentek EnviroSCAN	FRFON-SWCP1_15	-1.45	-12.979	-39.944	SWC_1_15_1
SWC-Sentek EnviroSCAN	FRFON-SWCP2_01	-0.05	-39.144	-22.6	SWC_2_1_1
SWC-Sentek EnviroSCAN	FRFON-SWCP2_02	-0.15	-39.144	-22.6	SWC_2_2_1
SWC-Sentek EnviroSCAN	FRFON-SWCP2_03	-0.25	-39.144	-22.6	SWC_2_3_1
SWC-Sentek EnviroSCAN	FRFON-SWCP2_04	-0.35	-39.144	-22.6	SWC_2_4_1
SWC-Sentek EnviroSCAN	FRFON-SWCP2_05	-0.45	-39.144	-22.6	SWC_2_5_1
SWC-Sentek EnviroSCAN	FRFON-SWCP2_06	-0.55	-39.144	-22.6	SWC_2_6_1
SWC-Sentek EnviroSCAN	FRFON-SWCP2_07	-0.65	-39.144	-22.6	SWC_2_7_1
SWC-Sentek EnviroSCAN	FRFON-SWCP2_08	-0.75	-39.144	-22.6	SWC_2_8_1
SWC-Sentek EnviroSCAN	FRFON-SWCP2_09	-0.85	-39.144	-22.6	SWC_2_9_1

SWC-Sentek EnviroSCAN	FRFON-SWCP2_10	-0.95	-39.144	-22.6	SWC_2_10_1
SWC-Sentek EnviroSCAN	FRFON-SWCP2_11	-1.05	-39.144	-22.6	SWC_2_11_1
SWC-Sentek EnviroSCAN	FRFON-SWCP2_12	-1.15	-39.144	-22.6	SWC_2_12_1
SWC-Sentek EnviroSCAN	FRFON-SWCP2_13	-1.25	-39.144	-22.6	SWC_2_13_1
SWC-Sentek EnviroSCAN	FRFON-SWCP2_14	-1.35	-39.144	-22.6	SWC_2_14_1
SWC-Sentek EnviroSCAN	FRFON-SWCP2_15	-1.45	-39.144	-22.6	SWC_2_15_1
SWC-Sentek EnviroSCAN	FRFON-SWCP3_01	-0.05	-25.415	3.0755	SWC_3_1_1
SWC-Sentek EnviroSCAN	FRFON-SWCP3_02	-0.15	-25.415	3.0755	SWC_3_2_1
SWC-Sentek EnviroSCAN	FRFON-SWCP3_03	-0.25	-25.415	3.0755	SWC_3_3_1
SWC-Sentek EnviroSCAN	FRFON-SWCP3_04	-0.35	-25.415	3.0755	SWC_3_4_1
SWC-Sentek EnviroSCAN	FRFON-SWCP3_05	-0.45	-25.415	3.0755	SWC_3_5_1
SWC-Sentek EnviroSCAN	FRFON-SWCP3_06	-0.55	-25.415	3.0755	SWC_3_6_1
SWC-Sentek EnviroSCAN	FRFON-SWCP3_07	-0.65	-25.415	3.0755	SWC_3_7_1
SWC-Sentek EnviroSCAN	FRFON-SWCP3_08	-0.75	-25.415	3.0755	SWC_3_8_1
SWC-Sentek EnviroSCAN	FRFON-SWCP3_09	-0.85	-25.415	3.0755	SWC_3_9_1
SWC-Sentek EnviroSCAN	FRFON-SWCP3_10	-0.95	-25.415	3.0755	SWC_3_10_1
SWC-Sentek EnviroSCAN	FRFON-SWCP3_11	-1.05	-25.415	3.0755	SWC_3_11_1

SWC-Sentek EnviroSCAN	FRFON-SWCP3_12	-1.15	-25.415	3.0755	SWC_3_12_1
SWC-Sentek EnviroSCAN	FRFON-SWCP3_13	-1.25	-25.415	3.0755	SWC_3_13_1
SWC-Sentek EnviroSCAN	FRFON-SWCP3_14	-1.35	-25.415	3.0755	SWC_3_14_1
SWC-Sentek EnviroSCAN	FRFON-SWCP3_15	-1.45	-25.415	3.0755	SWC_3_15_1
SWC-Sentek EnviroSCAN	FRFON-SWCP4_01	-0.05	32.177	-15.694	SWC_4_1_1
SWC-Sentek EnviroSCAN	FRFON-SWCP4_02	-0.15	32.177	-15.694	SWC_4_2_1
SWC-Sentek EnviroSCAN	FRFON-SWCP4_03	-0.25	32.177	-15.694	SWC_4_3_1
SWC-Sentek EnviroSCAN	FRFON-SWCP4_04	-0.35	32.177	-15.694	SWC_4_4_1
SWC-Sentek EnviroSCAN	FRFON-SWCP4_05	-0.45	32.177	-15.694	SWC_4_5_1
SWC-Sentek EnviroSCAN	FRFON-SWCP4_06	-0.55	32.177	-15.694	SWC_4_6_1
SWC-Sentek EnviroSCAN	FRFON-SWCP4_07	-0.65	32.177	-15.694	SWC_4_7_1
SWC-Sentek EnviroSCAN	FRFON-SWCP4_08	-0.75	32.177	-15.694	SWC_4_8_1
SWC-Sentek EnviroSCAN	FRFON-SWCP4_09	-0.85	32.177	-15.694	SWC_4_9_1
SWC-Sentek EnviroSCAN	FRFON-SWCP4_10	-0.95	32.177	-15.694	SWC_4_10_1
SWC-Sentek EnviroSCAN	FRFON-SWCP4_11	-1.05	32.177	-15.694	SWC_4_11_1
SWC-Sentek EnviroSCAN	FRFON-SWCP4_12	-1.15	32.177	-15.694	SWC_4_12_1
SWC-Sentek EnviroSCAN	FRFON-SWCP4_13	-1.25	32.177	-15.694	SWC_4_13_1

SWC-Sentek EnviroSCAN	FRFON-SWCP4_14	-1.35	32.177	-15.694	SWC_4_14_1
SWC-Sentek EnviroSCAN	FRFON-SWCP4_15	-1.45	32.177	-15.694	SWC_4_15_1
SOIL_H-Hukseflux HFP01SC	2685	-0.06	-13.853	-39.12	G_1_1_1
SOIL_H-Hukseflux HFP01SC	2706	-0.06	-38.633	-21.68	G_2_1_1
SOIL_H-Hukseflux HFP01SC	2707	-0.06	-28.025	3.939	G_3_1_1
SOIL_H-Hukseflux HFP01SC	4065	-0.06	31.219	-16.044	G_4_1_1
WTD-Campbell CS45X	20010874	-0.85	35.623	-5.197	WTD_1_1_1
WTD-Campbell CS45X	20010882	-0.855	19.879	22.469	WTD_1_1_2

The station team has installed the full set of soil meteo sensors required for a Class 1 forest station*. The sensors are installed at locations in the target area that comply with the ICOS Instructions, ie. one soil plot inside each of the four continuous Measurements Plots (CPs) (see Figure 3). The set-up of each soil plot is compliant with the ICOS Instructions in terms of sensor models, number of sensors* and sensor depths (Figure 4). The station team has submitted all requested metadata on the installed sensors.

* The station team has installed only two of the four required WTD sensors. These two sensors are moreover not installed at locations that comply with the ICOS Instructions. The team must install more WTD sensors to bring the station in agreement with the ICOS standard. Given the need for heavy drilling equipment to drill wells in the site’s heavy clay soil, the ETC suggests that the station seizes the opportunity of having the heavy drilling tool at the station in June 2020 for a scheduled soil core sampling to drill the missing wells and install the missing WTD sensors. The wells must be located inside the CPs, or else as close as possible to the CPs if fences and other obstacles prevent accessing the CPs with the drilling tool without damaging infrastructure and vegetation.

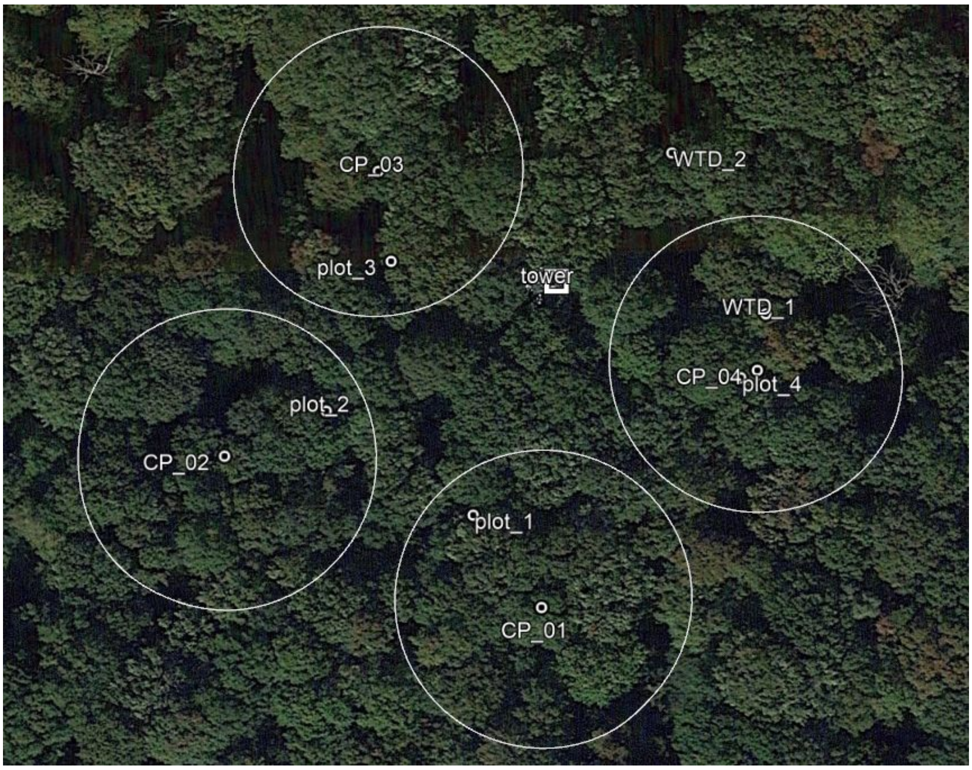


Figure 3: Location of the four soil plots (plots 1 to 4) and two WTD wells (WTD_1 and WTD_2) around the EC tower. CP = Continuous Measurements plot.

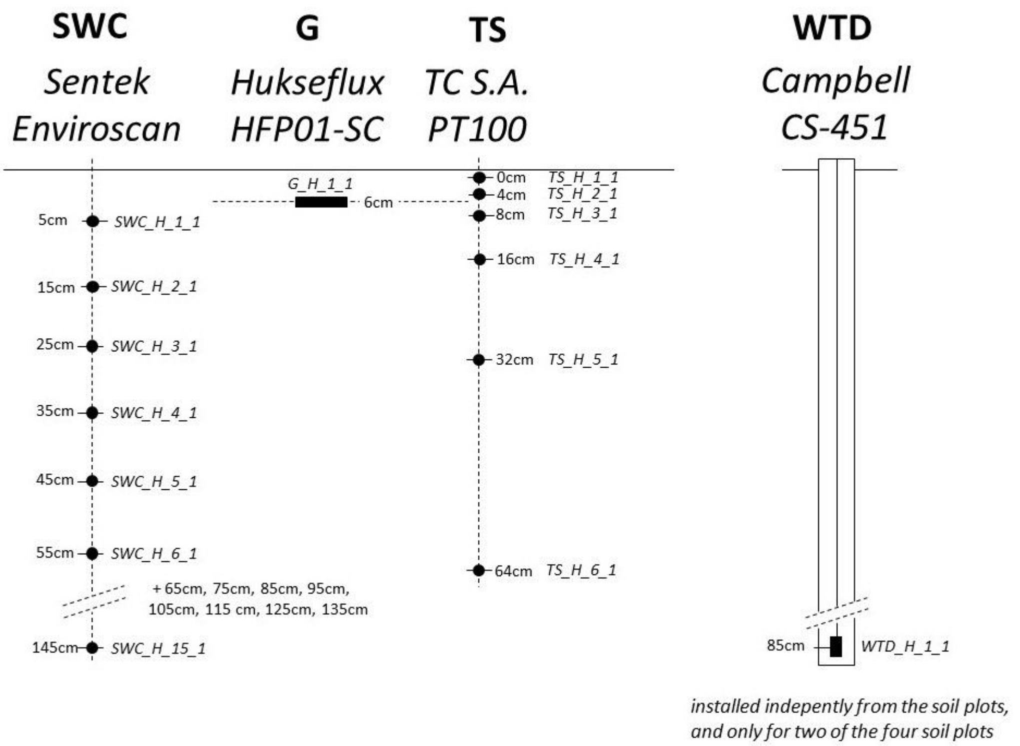


Figure 4: Set-up of the four soil plots. WTD = water table depth, SWC = soil water content, G = soil heat flux density, TS = soil temperature.

Spatial heterogeneity characterization

Aboveground biomass:

The station team has collected in the winter of 2018-2019 the full set of tree data that is requested for the characterization of the target area and its spatial heterogeneity. This dataset comprises the species, DBH, height, and health status of all trees above the stem diameter threshold of 5 cm that are growing inside the 20 SP-I plots and four CP plots installed in the target area. The ETC has quality-checked and processed these data. Figures 5, 6 and 7 summarize the dataset, showing for each plot respectively the tree density per species, the basal area per species, and the percentage-wise species contribution to the total basal area of the plot. Basal area is used here as a proxy for Aboveground biomass. As can be seen in the figures, the target area is dominated by Hornbeam (*Carpinus betulus L.*) and sessile oak (*Quercus petraea (Matt) Liebl.*), with sparse presence of mountain-ash (*Sorbus sp.*), apple trees (*Malus sp.*), and hawthorn (*Crataegus sp.*).

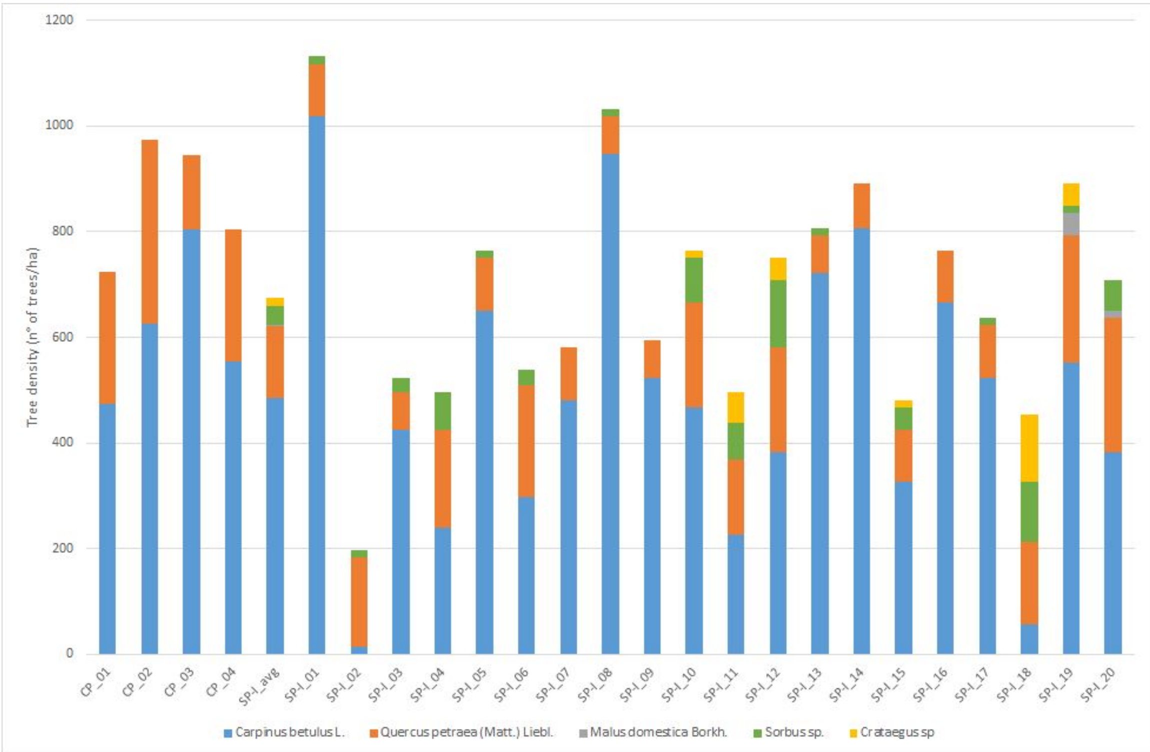


Figure 5: Tree density per species, shown for the twenty SP-I plots and the four CPs installed in the target area.

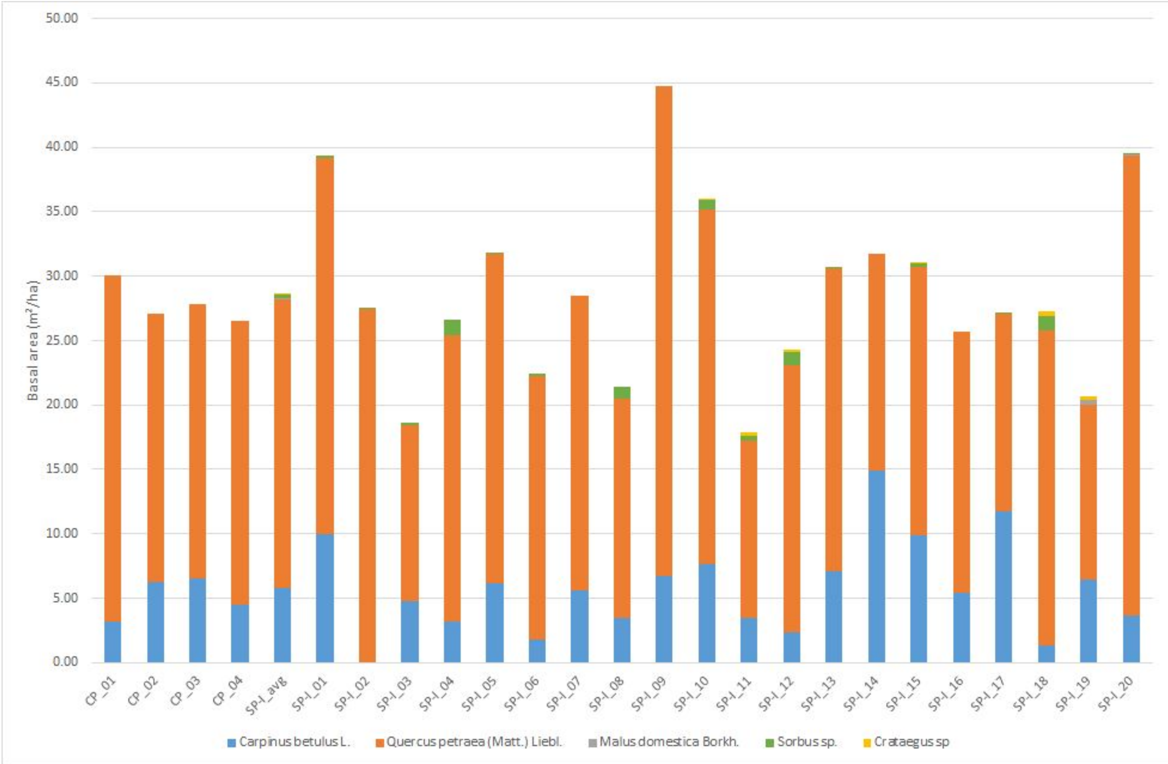


Figure 6: Basal area per species, shown for the twenty SP-I plots and the four CPs installed in the target area.

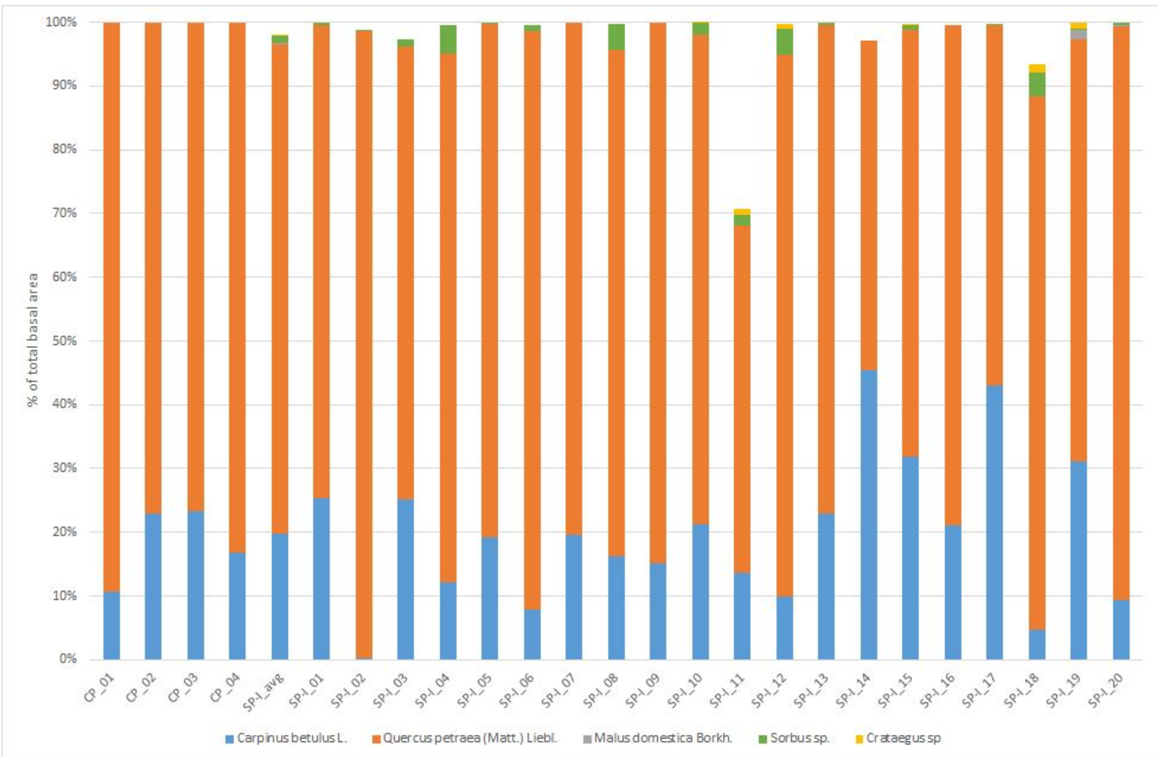


Figure 7: Percentage-wise contribution of each species to the total basal area of the plot, shown for the twenty SP-I plots and the four CPs installed in the target area.

Green Area Index:

The station team has carried out all the Green Area Index measurements in the 20 SP-I plots that are requested for the characterization of the target area and its spatial heterogeneity. The measurements have been done in August 2018 by means of Digital Hemispherical Photography. As prescribed in the ICOS Instructions, five hemispherical images were taken in each SP-I plot and nine pictures for each CP plot. The ETC has quality-checked and processed the images. Figure 8 shows the plot results.

<u>Green Area Index</u>

The station team has collected the minimum of two sets of GAI measurements that are requested for the step 2 labelling. As prescribed in the ICOS Instructions, GAI was measured by means of Digital Hemispherical Photography and at each measurement date nine hemispherical images were taken in each CP. The first set of measurements was collected in April 2018 in four CPs. The ETC quality-checked and processed the images. The second set of measurements was collected in july 2018 in four CPs. All pictures from the SP-I plots were taken in August 2018. The ETC quality-checked and processed the images, some pictures need to be retaken, which was done by the station team. The preliminary results for the representativity analysis are shown in Figure 8.

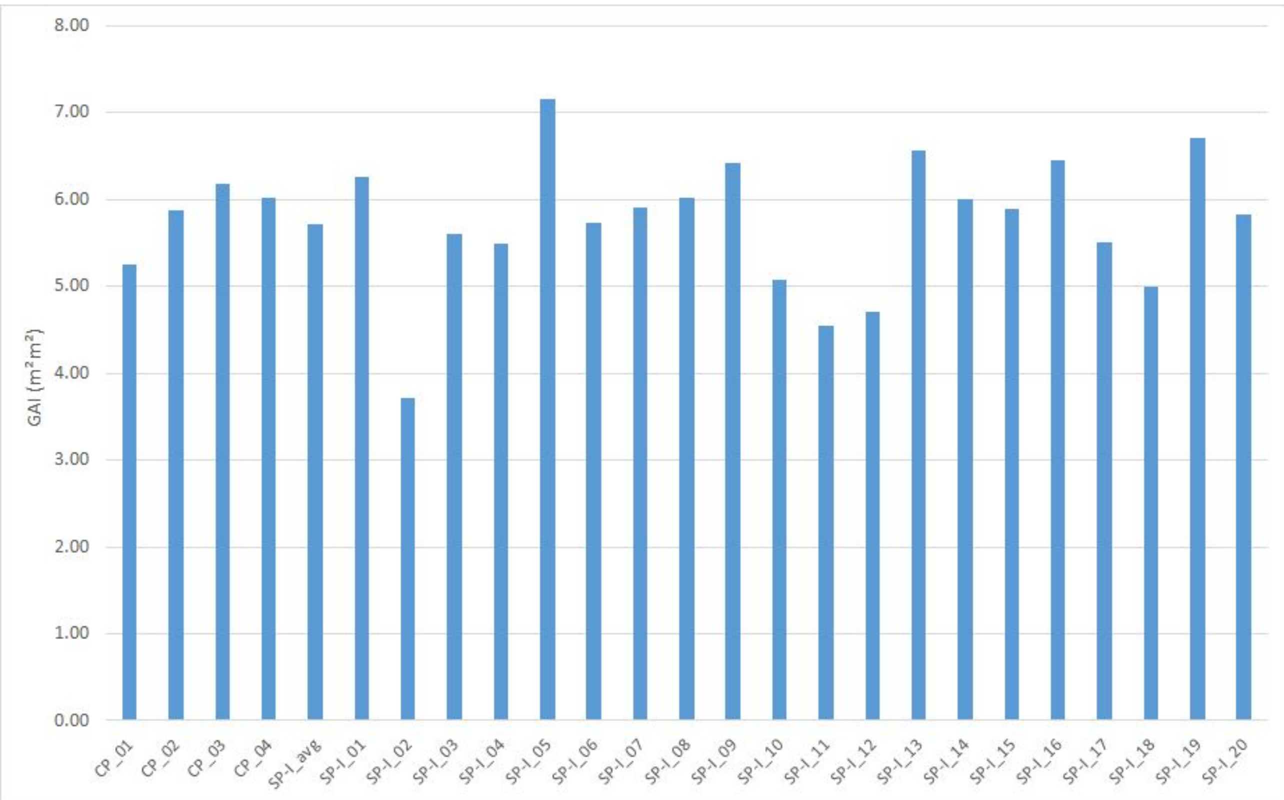


Figure 8: Green Area Index (GAI) for the twenty SP-I plots and the four CPs installed in the target area. All measurements were performed in August 2018.

The site characterisation revealed a normal variability in Green Area Index within the target area for a mixed deciduous forest. The present variability is due to natural variability and there was no pattern or gradient in the species composition within the target area, as confirmed by the station team. Therefore we decided to consider the target area as one vegetation type.

Above Ground Biomass

The station team has collected in the winter of 2018-2019 the tree data required for the Aboveground biomass assessment in the step 2 labelling phase. These data comprise the position, species, DBH, height, health status and dendrometer presence of all trees above the stem diameter threshold of 5 cm that are growing inside the four proposed CPs that the station team has installed. The ETC quality-checked and processed these data. Figures 5, 6 and 7 show for each of the four CPs respectively the tree density per species, the basal area per species, and the percentage-wise species contribution to the total basal area of the plot. Basal area is used here as a proxy for Aboveground biomass. As can be seen in the figures, the CPs are entirely dominated by Hornbeam (*Carpinus betulus L.*) and sessile oak (*Quercus petraea (Matt) Liebl.).*

Vegetation sampling and analysis

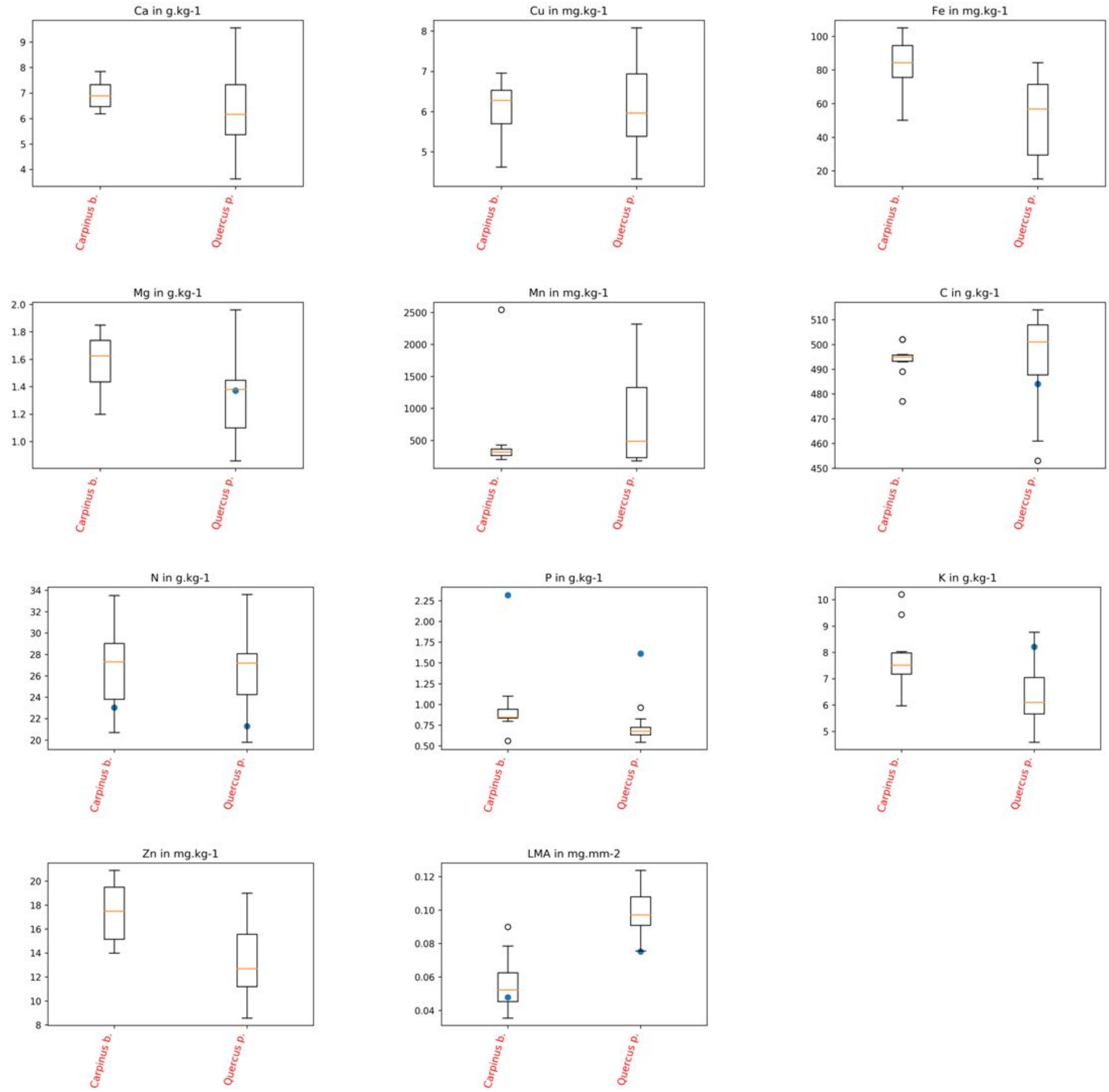
As agreed with ETC, the NA and LMA samples are collected from 30 dominant or co-dominant trees located within the 4 CPs, split among the two main species growing in the forest of Barbeau.

Ten units are collected from hornbeam trees (Carpinus betulus) trees and 20 units from oak trees (Quercus sp.), according to their contributions to LAI. A fixed sampling scheme is applied for Carpinus and a roving sampling scheme is applied for Quercus (table below). For NA, one unit is composed of 20 leaves from Quercus, or 30 leaves from Carpinus, which represents at least 3g dry weight and more than 7g fresh weight. For LMA, one unit is composed of 10 leaves, for both Quercus and Carpinus. Leaf area measurements are operated using a planimeter (Li 3100C).

NA samples are collected twice a year. The first sample was collected by July 2nd 2018 at the time of full leaf development (after reaching both maximum LMA and maximum GAI). A second sample is planned to be picked up by the end of the growing season and before the start of leaf yellowing, in September. LMA samples will be collected at the same time that the first NA sampling.

The first data set analysed is shown below. The values obtained for both NA and LMA are in the range expected, nitrogen and phosphorus mass ratio being however quite high, that could be related to elevated atmospheric deposition. The second set of samples was collected by 17-19 September 2018, metadata provided by the station team are correct and analysis are on their way.

Foliar Analyses for station FR-Fon, 2018-07-02



● *Mean value of the* ***Carpinus betulus L.*** *and* ***Quercus petraea*** *from TRY-db Data when available. (*https://www.try-db.org/TryWeb/Home.php*)*

Data check and test

Data quality analysis (Test 1)

The test aims at quantifying the availability of NEE half-hourly data after the application of Quality Control (QC) procedures. The requirement expected for the Step 2 of labelling is that the total percentage of missing and removed data after the QC filtering does not exceed the 40% threshold value.

Tests involved in the QC procedure aim at detecting NEE flux estimates contaminated by the following sources of systematic error: (i) EC system malfunction occurring when fluxes originate from unrepresentative wind sectors or evidenced by diagnostics of sonic anemometer (SA) and gas analyzer (GA); (ii) instruments malfunction as provided by Vickers and Mahrt (1997) statistical tests; (iii) inappropriateness of the spectral correction method as provided by anomalous values of the spectral correction factor; (iv) lack of well developed turbulence regimes (Foken and Wichura, 1996); (v) violation of the stationary conditions (Mahrt, 1998). By comparing each test statistic with two pre-specified threshold values, flux data are identified as affected by severe, moderate or negligible evidences about the presence of specific sources of systematic error (hereinafter denoted as SevEr, ModEr and NoEr). Subsequently, the data rejection rule involves a two-stage procedure: in the first stage half-hourly fluxes affected by SevEr are directly discarded, whereas, in the second stage, those affected by ModEr are removed only if they are also identified as outliers.

Concerning FR-Fon site, the testing period involves raw data sampled in 2018 from July, 4th to November, 8th. Of 6123 expected half-hourly files for NEE fluxes, 70.3% were retained after data cleaning procedures as illustrated in Figure 5. In particular, about 6.6% of raw-data was missed, 27.3% of calculated half-hourly fluxes was discarded because affected by SevEr, while an additional 2.4% was discarded because identified as outliers and affected by ModEr. Being the percentage of missing data equal to 30%, we conclude that FR-Fon site reaches the minimum requisite expected for the Step 2 of the labelling.

References

Foken T and Wichura B (1996) Tools for the quality assessment of surface-based flux measurements, Agric For Meterol, 78, 83-105

Mahrt L (1998) Flux sampling errors for aircraft and towers, J Atmosph Ocean Techn, 15, 416-429

Vickers D and Mahrt L (1997) Quality control and flux sampling problems for tower and aircraft data, J Atmosph Ocean Techn, 14(3), 512-526

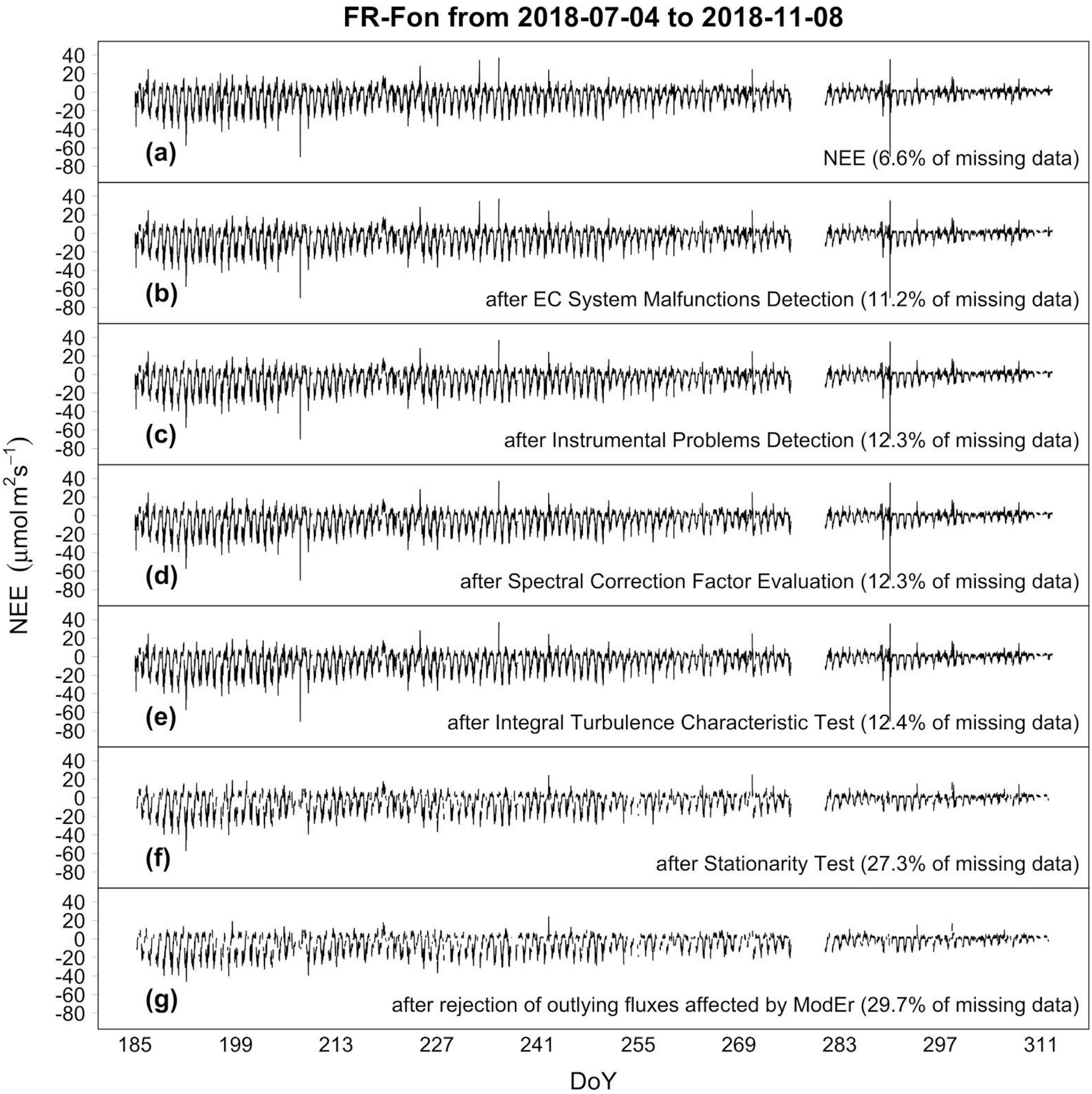


Figure 9: Summary of the quality control tests applied to the Net Ecosystem Exchange (NEE) of CO2 flux collected at FR-Fon site from 2018/07/04 to 2018/11/08. The original half-hourly flux time series is exhibited in the top panel. Panels b-f display the sequential removal of data affected by severe evidences of error according to the following criteria: (b) wind sectors to exclude and diagnostics provided by sonic anemometer (SA) and gas analyser (GA); (c) instrumental problems detection; (d) anomalous spectral correction factor (SCF) check; (e) integral turbulence characteristics test (ITC, Foken and Wichura, 1996); (f) stationarity test by Mahrt (1998). Bottom panel displays the time series of retained high-quality NEE after the additional removal of outlying fluxes affected by moderate evidences of error.

Footprint analysis (Test 2)

The test aims to evaluate whether half-hourly flux values are sufficiently representative of the target area (TA) or not. It was performed on 5 months of data, after QC filtering procedure (previous Section) has been achieved. The model by Klijun et al. (2015) has been used to obtain the 2-dimensional flux footprint for each half-hour, which was compared to the TA spatial extent. After the QC procedure and additional filtering according to footprint model requirements, the 70% of the data was used for the test.

Results showed that about the 99% of the whole period data have a cumulative contribution of at least 70 % from the TA (Fig. 6, first bar on the left), and this holds for daytime and nighttime periods (Fig. 10, middle and right bar respectively).

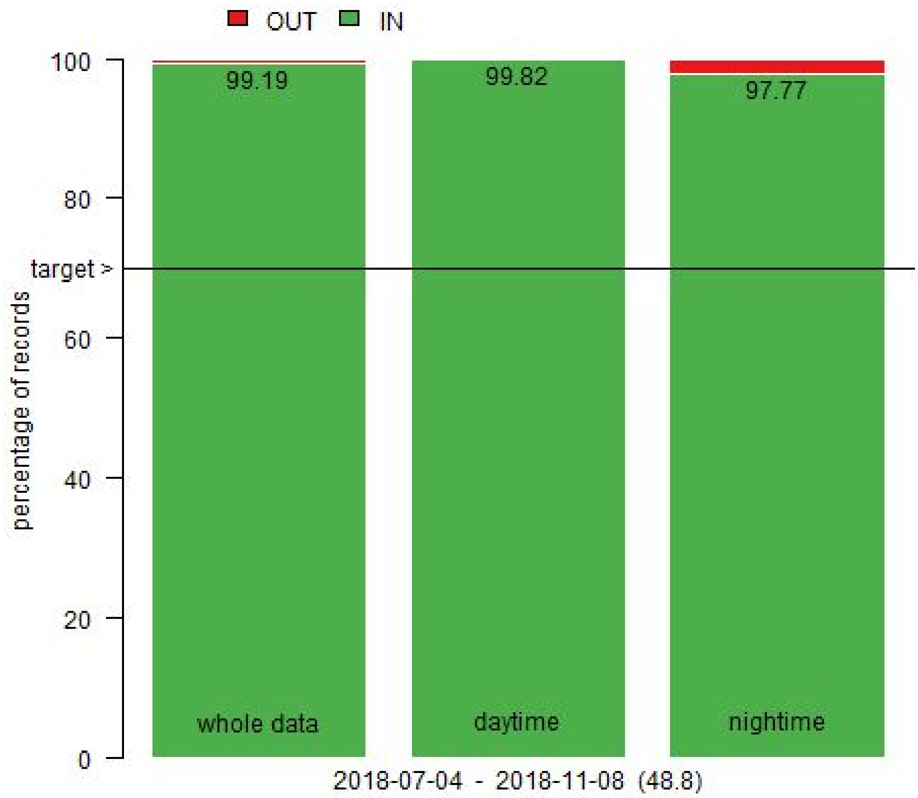


Figure 10: Test results over the whole analyzed period showing the percentage of half-hours with a footprint cumulative contribution of at least 70% from the target area. The target value is that the 70% of data (half-hourly fluxes) must hold this condition.

To verify the consistency of the results, the test was repeated on monthly sub-periods and results were always confirmed (Fig.11).

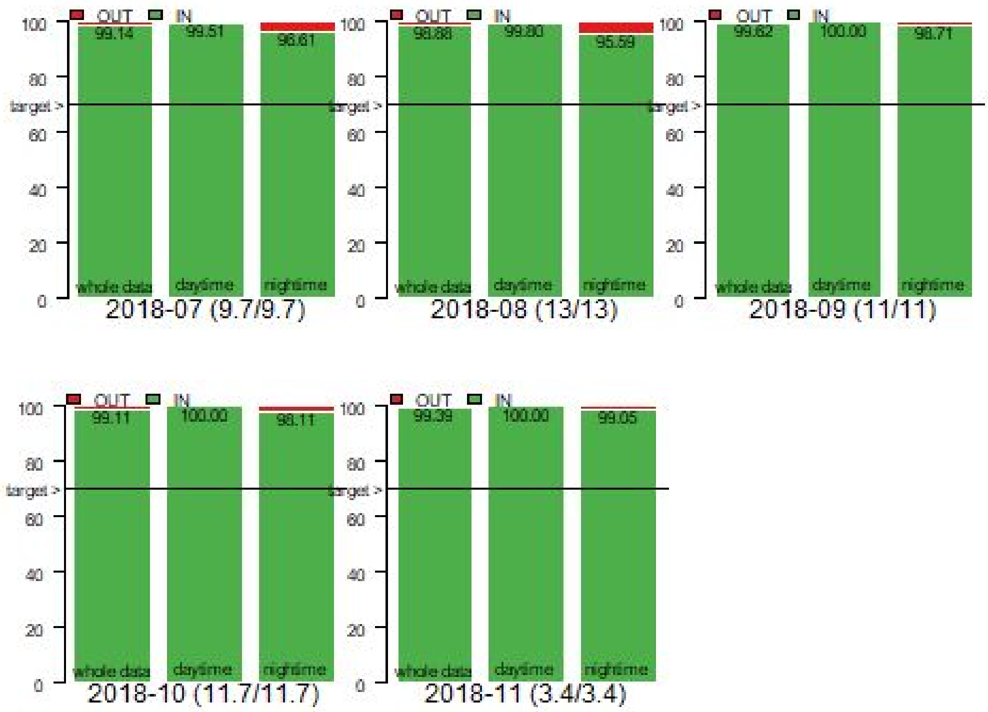


Figure 11: Test results over monthly sub-periods showing the percentage of half-hours with a footprint cumulative contribution of at least 70% from the target area. The target value is that the 70% of data (half-hourly fluxes) must hold this condition.

The footprint climatology at FR-Fon, calculated over the whole period under consideration is reported in Fig. 12, by which it is possible to noticed that not only the 70% but even the 80% footprint cumulative contribution is included in the TA.

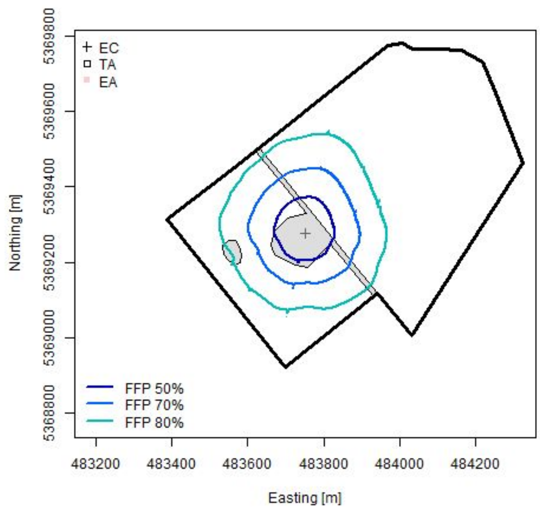


Figure 12: Footprint climatology at FR-Fon in relation to the TA, the EC tower (EC), and the excluded areas (EA, see the spatial sampling Section). The 50%, 70% and 80 % cumulative distribution isopleths are reported.

According to these results, the test is passed.

Data representativeness analysis (Test 3)

This test aimed to evaluate the representativeness of the possible different land cover tipologies inside the Target area (TA). At FR-Fon the analysis on vegetation (Test 4, Section below) revealed a single vegetation typology, e.g. sessile oak and hornbeam forest. Consequently, the entire TA was considered as homogeneous in terms of vegetation and the Test 3 became unnecessary.

Ancillary plot representativeness (Test 4)

The representativeness of the CPs was evaluated by comparing each CP with the SP-I-order plots in terms of (i) standing biomass, i.e. the tree density and the basal area of the plot, (ii) species composition, i.e the percentage basal area of the main species, and (iii) Green Area Index. As explained in the introductory section of this report, a CP is deemed representative when values are less than 20% different with respect to the target area's average, i.e. the average of the 20 SP-I-order plots.

A representativity analysis showed that the basal area of the all CP's differs less than 20% from the average basal area of the SP's, with an average of 29.2 m^2 ha^{-1} and 27.9 m^2 ha^{-1} respectively. When breaking the analysis down to species level, sessile oak contributes on average 82% to the basal area of the CP's, while this is 77% for the SP-I plots. For the Hornbeam this is 18% and 20% respectively. we therefore consider the CP's representative for the SP's and consider the target area as one vegetation type.

The results from the Green Area Index measurements showed that when comparing the GAI values of the CP's and the SP's for the campaign in August 2018 that the CP's are representative for the SP's because they all fall within the accepted range of 20%.

Near Real Time data transmission

NRT data submission started on February 21st 2018 for EC files to the ETC, and then switched to the Carbon Portal in July. On 20190228 the station got green light for submission of 2 BM files, and on 20190304 of a third one. The acquisition strategy of EC files is based on SmartFlux2 from LICOR. The EC files are ICOS compliant. The station was not sending EC raw data for a period of approx. 3 months due to maintenance events at the station. Also BM files were missing for a period since 20190411 due to an issue in the script they use to edit all of the BM files. Other green light to BM files were sent between July and October 2019. Few BM files are from time to time missing due to an error in the server. The PI is conscious about that issue and is working to fix it.

Plan for remaining variables

The first soil sampling is planned by June 2020 and no particular problem is expected. When the soil cores will be extracted the Station Team agreed to install the two additional WTD sensors requested for a Class1 station in the proximity of the CP (or even better inside the CPs)

Labelling summary and proposal

On the basis of the activities performed and data submitted and after the evaluation of the station characteristics, the quality of the data and setup, the compliance of the sensors and installations and the team capacity to follow the ICOS requirements for ICOS Ecosystem Stations we recommend that the station Fontainebleau-Barbeau (FR-Fon) is labelled as ICOS CLASS 1 Ecosystem station.

October 28th 2019

Dario Papale, ETC Director