LIFE17 CCA/ES/000063

Deliverable Nº 4

DETAILED FOREST INVENTORY

UPV

1/31/2019

This Deliverable updates the forest inventory of the Serra's village according to the latest data available and focusing on climate change issues.

DETAILED FOREST INVENTORY

ACTION A.1: Updating and modelling of Serra's forest and biomass management approach

INDEX

Deliverable 4; name: *Detailed forest inventory*

Beneficiary responsible: UPV

Action A1: *Updating and modelling of Serra's forest and biomass management approach*

From month 1 – month 3

Name of the Deliverable	Number of associated action	Deadline
Detailed forest inventory	A1	01/2019

1. Introduction

Forests are one of the major sources of livelihood that need to be conserved. This conservation necessarily implies applying sustainable forest management (SFM), as it combines social and environmental needs. Forest management is the process of planning and implementing practices for the stewardship and use of forests and other wooded land targeted at specific environmental, economic, social and cultural objectives.

Forest management planning is a fundamental component of SFM, and it may be required at various scales, from local to national. Obtaining the data needed for effective forest management planning is an important part of the process. Information is needed on the terrain (e.g. in maps showing contour lines and watercourses) and on the growing stock, such as species, number of stems, basal area and volume per hectare. This information is usually grouped into forest working units (FWUs), as they represent continuous and homogeneous forest characteristics, which makes the management and planning feasible. Thus, forest management planning begins with an:

- assessment of the forest resource – including a **forest inventory** and often also environmental and social impact assessments;
- analysis of market and economic conditions – that is, an analysis of market opportunities for forest goods and services and other economic factors that may affect forest management; and
- assessment of the social, environmental, legal and other aspects – that is, clarifying the social, environmental, legal and other requirements for SFM, which set the framework conditions for the implementation of SFM in specific national and local conditions. This assessment may also include the clarification of tenure and government environmental licensing. The obligations of the forest manager or owner may include obtaining government approval for social responsibility agreements.

2. Background

During 2016, UPV and Serra's municipality developed a forest zoning into Forest Working Units (FWU) and its detailed forest inventory. The forest zoning was carried out by using field campaigns, aerial photograph and LiDAR technology. As a result, 60 FWU were stablished attending to silvicultural, habitat, hydrological, etc. criterion (Figure 1). The forest inventory was developed by using dasometric methodology and statistical sampling, where 58 circular plots of 20 m diameter were characterized.

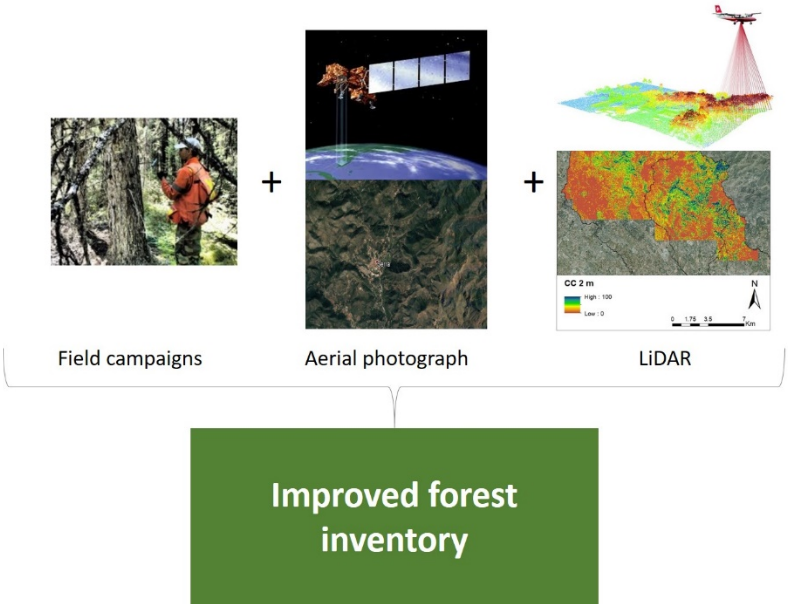

Figure 1: Scheme of the followed methodology.

As mentioned before, the FWU are not just homogeneous in biomass terms, but also in hydrological and wildfire terms, being therefore very similar to the zoning carried out in Deliverable 3. Hence, from now on, this project will use the forest discretization developed by Serra's village together with UPV in 2016 (Figure 2).

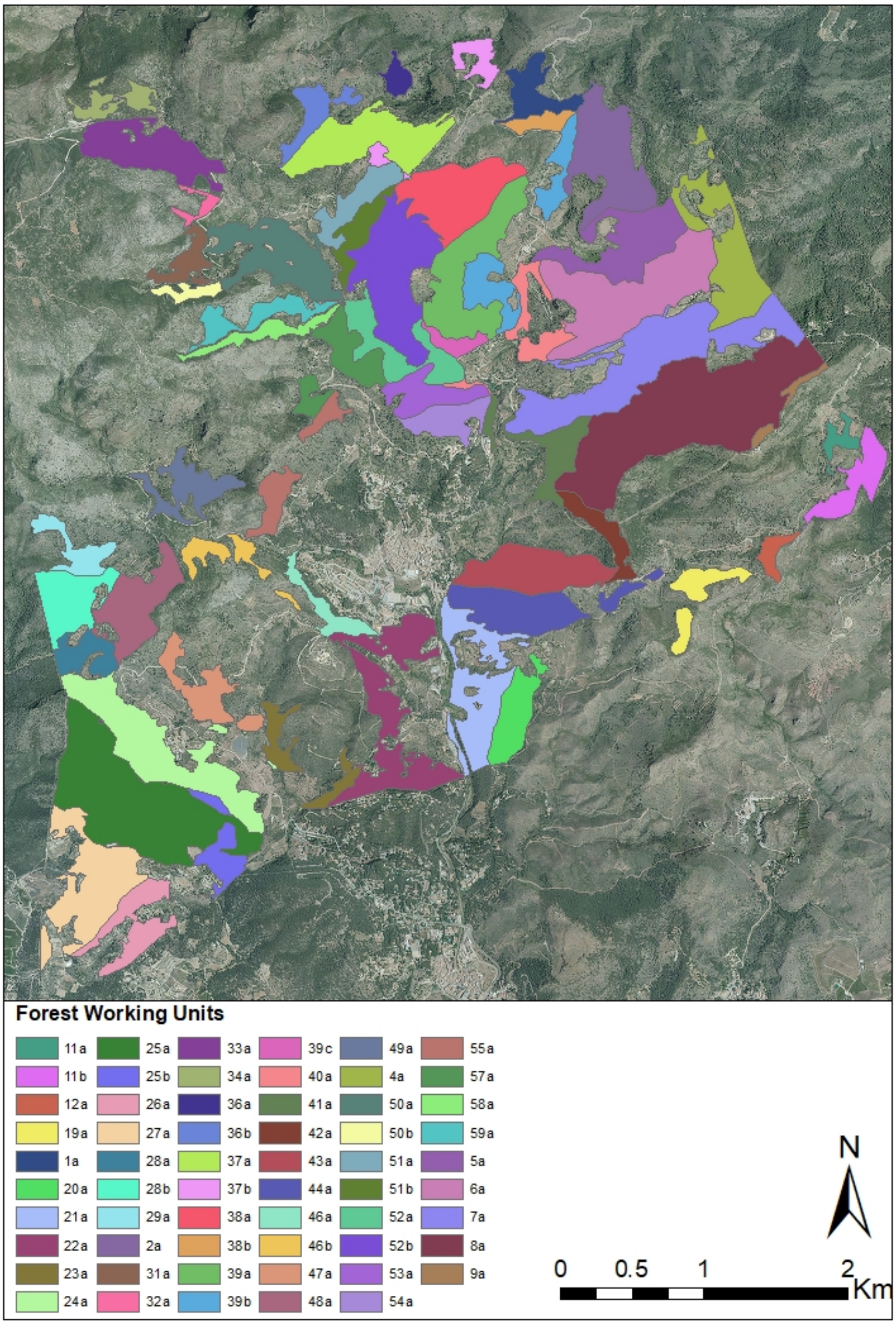

Figure 2: Forest Working Units of Serra's village.

3. Objectives

The aim of this Deliverable is to develop a detailed forest inventory of Serra's forest area that allows to optimize its forest management, and therefore the biomass production, water budget and fire risk decrease. When developing a forest inventory for forest management, the basic unit is Forest Working Unit, and therefore the Serra's forest will be inventoried using this metric.

4. Methodology

Based on the previous inventory developed by Serras's village and UPV in 2016, this project has improved it by combining, the values obtained from previous field campaigns of 2016 (basal area, tree density, biomass and height), the parameters obtained by means of LiDAR technology and current validation field campaigns (Table 2).

LiDAR data was collected in 2015 by PNOA (The National Plan of Aerial Ortophotogrammetry, Spanish Government), using an Optech ALS50-II sensor, with a minimum laser pulse rate frequency of 45 kHz, a field of view angle of 50° and a scan rate of 70 Hz. The final average density was 0.88 pulses m2. Vertical and planimetric (X, Y) reported errors were less than 40 and 36 cm, respectively. The point classification was carried out by the National Cartographic Institute (CNIG) as: ground, building, low vegetation, high vegetation, low points (noise), overlap points, and unclassified. Based on this classification, the digital terrain model and the canopy surface model were created using Fusion v3.30 software (McGaughey, 2009).

Canopy cover was estimated using the canopy surface model of 10x10 m pixels as the proportion of first returns that hit above a specified height threshold (Korhonen ET AL 2011), defined as 2 m to be considered tree crowns in this study. The canopy height was calculated for pixels of 10x10 m as the 90th percentile of the first returns that hit above a specified height threshold (Korhonen ET AL 2011), defined as 2 m to be considered tree crowns in this study. LAI was estimated from the proportion of total returns that hit above 1.5m from the ground (height at which the LAI is normally measured in field inventories) and following the empirical equation of Manrique-Alba et al 2015.

5. Description of the activities

1.- Analysing Serra's forest division into FWU of 2016: this information was shared by Serra's municipality, which together with UPV was analysed by using statistical approaches and QGIS 2.18 software.

2.- Canopy Cover and LAI calculation and validation: this activity used the LiDAR information developed in Deliverable number 3. This information was adjusted to the FWU, where a statistical analysis was developed to confirm the homogeneity of the FWU, and sub-divide it if necessary. This activity used FUSION, RStudio and QGIS 2.18 softwares.

3.- Establishing relationships between one of the basic metrics in forestry, Basal Area (BA), and relevant metrics in eco-hydrological modelling, such as canopy cover or LAI. This relationships were established by combining forest inventory data with LiDAR processing, so they could be extrapolated to the rest of Carraixet's catchment, where the DSS tool will be developed.

4.- Field campaigns to validate the previous information: 3 field visits were carried out to validate the previous results. During these visits we measured the following variables: LAI, tree density, canopy cover and DBH.

6. Results and conclusion

The forest area of Serra's village (Figure 3) has an extension of 2736.0770 ha, where 49 % is public forest and 51 % private. The climate is typical Mediterranean semi-arid (17.3 De Martonne aridity index), with a mean annual precipitation and temperature of 452.5 mm and 16.1 C^0, respectively. Soils are generally shallow (approximately 30–60 cm deep) where limestones, dolomites and loams occupy the main part of the territory. The area is mainly occupied by *Pinus halepensis* Mill. (Aleppo pine) forests and shrub-lands, although it is also possible to find a few forest gaps of *Quercus ilex, Quercus suber* and *Pinus pinaste*r. In the same way, there are some scattered rainfed agricultural fields, which have been progressively abandoned.

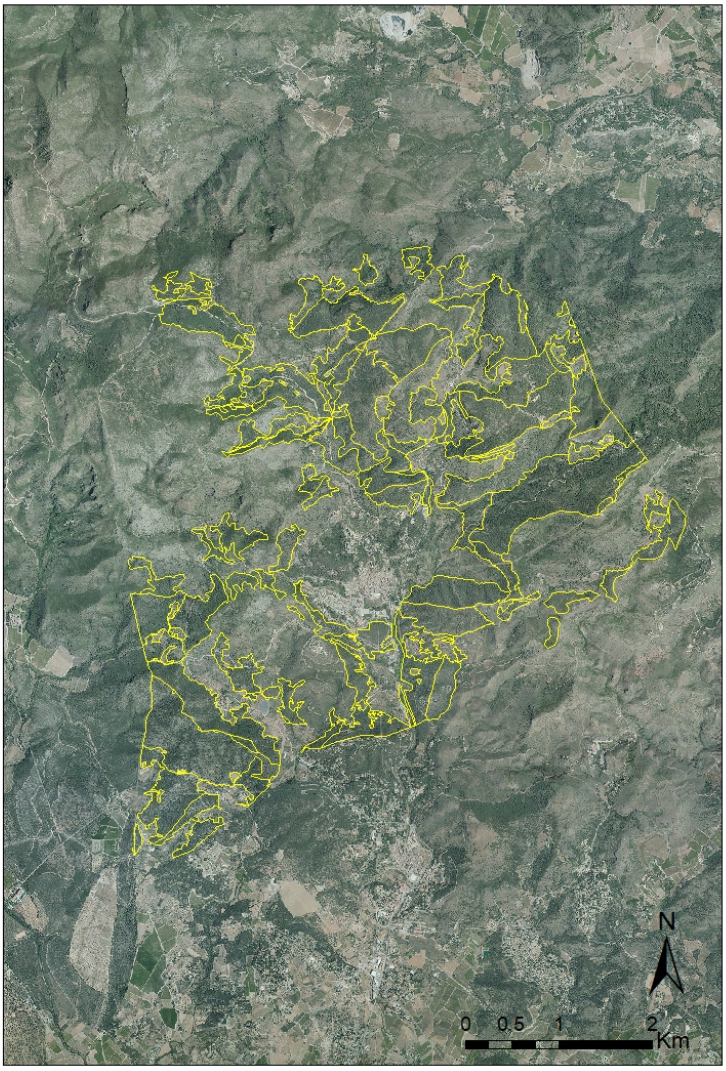

Figure 3: Forest area of Serra's village.

The region has historically suffered wild fires as lightning is highly frequent here (one of the most frequent zones in Spain), and agricultural field burning practices are very common in its rural areas. These recurrent wildfires together with the onset of drought periods reduces the forest development capability and produces mature stage forests that would be considered juvenile under better circumstances.

According to the Spanish Forest Map (2005) we can find the following forested areas:

1. Forest: (1.321,97 ha).

   a) Pure *Pinus halepensis* stands in initiation stage. (19.74 ha).
   b) Pure *Pinus halepensis* stands in stem exclusion stage. (40.75 ha).

c) Pure *Pinus halepensis* stands in stem exclusion stage (580.16 ha).

d) Pure mature *Pinus pinaster* stands (22.87 ha).

e) Mix forest of *Pinus halepensis* and deciduous species. (598.21 ha).

f) Mix mature forest of *Pinus pinaster* and deciduous species (2.86 ha).

g) Rainfed agricultural fields (*Olea europea*) (57.38 ha).

2. Forest complements: firewalls, etc. (3.10 ha).

3. Burned (no trees) (394.36 ha).

4. Shrub (642.26 ha).

5. Field crops and artificial meadows (219.70 ha).

The total forest existences of Serra's village are presented in Table 1. Likewise, Table 2 shows the vegetation parameters of each FWU obtained from both field campaigns and LiDAR technology.

Table 1: Summary of the total forest existences at Serra's village.

Spices	**Tree/ha**	**m^2/ha**
Ceratonioa siliqua	6.6	0.13
Olea europea	11	0.27
Dead trees	96.7	1.96
Pinus halepensis	592.7	22.15
Pinus pinaster	37.3	0.59
Quercus ilex	<1	<0.01
Quercus suber	2.2	0.04

Table 2: Vegetation parameters of each Forest Working Unit (FWU) obtained from both, field campaigns and LiDAR technology. CC is Canopy Cover, LAI is the Leaf Area Index. CC, LAI and Plot average tree were obtained using LiDAR technology.

FWU	**BasalArea(m2/ha)**	**Density (tree/ha)**	**Biomass(T/ha)**	**Height (m)**	**Main species**	**CC(%)**	**LAI (m2/m2)**	**Plot tree height average (m)**
11a	13	800	18	7.6	*P. halepensis*	72.6	1.4	11.1
11b	3	500	5	5.7	*P. halepensis*	49.1	0.9	7.3

					and P. pinaster			
12a	2	500	5	4.6	*P. halepensis and P. pinaster*	37.8	0.7	6.7
19a	5	500	5	6.4	*P. halepensis*	9.0	0.2	7.7
1a	2	250	2	6.42	*P. halepensis*	32.8	0.9	6.2
20a	24.6	1019	34.2	8.4	*P. halepensis*	48.2	1.2	5.7
21a	4	500	5	6	*P. halepensis*	47.9	1.2	6.0
22a	28.3	367	47.3	13.1	*P. halepensis*	46.2	1.1	5.7
23a	4	600	5	5.6	*P. halepensis*	43.4	1.1	5.8
24a	19	605	28.38	9.3	*P. halepensis*	52.8	1.3	5.9
25a	1	250	2	4.9	*P. halepensis*	31.1	0.9	5.0
25b	2	250	2	5.6	*P. halepensis*	43.7	1.1	5.7
26a	1	250	2	5	*P. halepensis*	34.3	0.9	5.0
27a	1	250	2	4.7	*P. halepensis*	31.5	0.9	5.0
28a	5	500	5	6.5	*P. halepensis*	31.8	0.9	6.0
28b	27.6	828	43.85	9.9	*P. halepensis*	51.0	1.3	6.3
29a	21	701	32.49	8.6	*P. halepensis*	37.7	1.3	6.4
2a	4	300	7	6.97	*P. halepensis*	56.4	1.3	7.8
31a	0	13000	118	4.5	*P. halepensis*	28.4	0.8	3.9
32a	0	13000	118	4.5	*P. halepensis*	23.0	0.7	3.7
33a	0	13000	118	4.5	*P. halepensis*	29.2	0.8	5.0
34a	0	13000	118	4.5	*P. halepensis*	30.6	0.9	4.0
36a	4	200	6	8.2	*P. halepensis*	46.0	1.2	6.9
36b	4	200	6		*P. halepensis*	29.6	0.9	5.8
37a	95	20000	182	5.1	*P. halepensis*	35.0	0.9	5.0
37b	3	700	6	4.7	*P. halepensis*	40.3	1.1	6.1

38a	1	500	5	4.4	*P. halepensis*	25.3	0.7	4.4
38b	10	600	13	7.8	*P. halepensis*	42.7	1.1	6.8
39a	4	720	7	5.2	*P. halepensis*	19.3	0.6	4.9
39b	31.34	892	50.72	10.6	*P. halepensis*	48.3	1.2	6.6
39c	3	530	5	5.6	*P. halepensis*	40.9	1.1	6.3
40a	10	800	18	7	*P. halepensis*	48.2	0.1	6.7
41a	2	200	2	6.71	*P. halepensis*	33.4	0.9	6.4
42a	3	400	4	6	*P. halepensis*	41.6	1.1	6.5
43a	5	400	9	7.1	*P. halepensis*	47.9	1.1	7.5
44a	20	860	30.48	8.6	*P. halepensis*	45.9	1.2	6.3
46a	26.2	462	43.4	11.4	*P. halepensis*	46.4	1.2	5.9
46b	38	7500	114	5.18	*P. halepensis*	21.3	0.6	4.8
47a	2	225	2	5.95	*P. halepensis*	41.0	1.1	5.8
48a	3	300	3	6.5	*P. halepensis*	36.2	1.0	6.2
49a	40	10000	117	5.3	*P. halepensis*	27.5	0.8	4.6
4a	14.67	955		7	*P. halepensis, P. pinaster and Q. suber*	60.4	1.0	10.0
50a	3	350	3	6.4	*P. halepensis*	43.7	1.1	6.1
50b	0	13000	118	4.5	*P. halepensis*	26.0	0.7	3.9
51a	4	600	5	5.7	*P. halepensis*	43.7	1.2	5.7
51b	1	360	3	4.1	*P. halepensis*	31.5	0.9	4.7
52a	5	500	5	6.6	*P. halepensis*	45.1	1.2	6.8
52b	2	900	8	3.9	*P. halepensis*	27.8	0.8	4.4
53a	32.16	860	51.6	27.1	*P. halepensis*	61.1	1.5	6.9
54a	15.6	604	23.4	8.7	*P. halepensis*	51.1	1.3	6.0

55a	3	450	4	5.9	*P. halepensis*	29.9	0.9	5.8
57a	4	450	4	6.3	*P. halepensis*	39.1	1.0	6.3
58a	0	10000	153	7	*P. halepensis*	18.3	0.6	5.2
59a	0	13000	118	4.5	*P. halepensis*	21.7	0.7	4.3
5a	29.22	763		9.9	*P. halepensis*	61.8	1.3	8.1
6a	26.27	710		9.8	*P. halepensis*	59.6	1.3	7.7
7a	24.4	589.5	38.5	10.1	*P. halepensis*	53.6	1.1	8.8
8a	25.08	637.5	41.06	9.9	*P. halepensis*	61.1	1.3	10.0
9a	4	700	6	9.5	*P. halepensis*	32.8	0.9	8.3
34a	0	13000		4.5	*P. halepensis*	14.3	0.4	3

Both analysis, field campaigns and LiDAR technology, are necessary not just for the subsequent upscaling that will take place in the project, but for increasing the project replicability. In this sense, two significant regressions have been stablished between the basal area obtained in through field campaigns, and the LiDAR CC and LAI, respectively (Figure 4). The basal area is a basic parameter in forestry, as it can be a good estimator of total biomass, wood and maturity stage. Likewise, CC and LAI are key parameters in hydrological modelling. Therefore, combining these values will allow us to upscale to the rest of the catchment and therefore increase the replication possibilities.

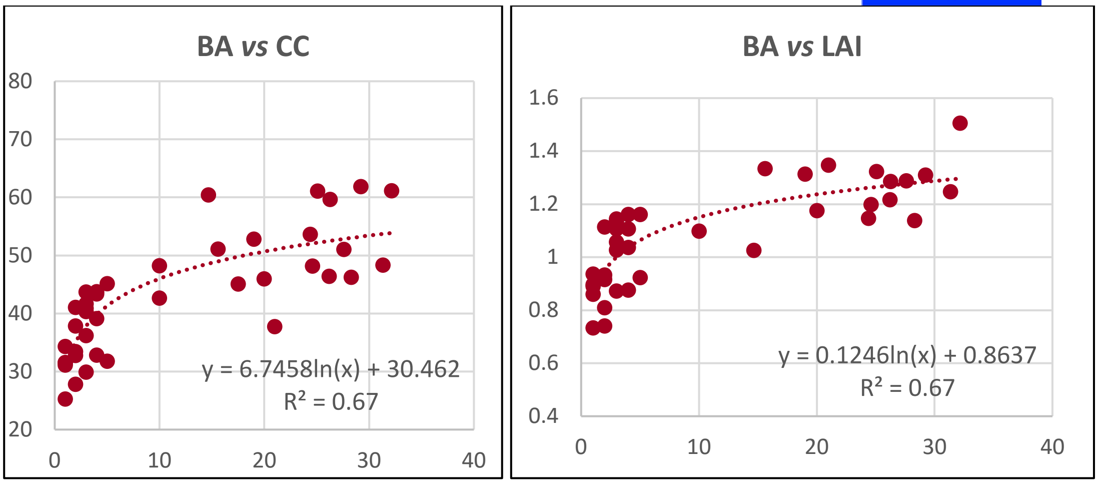

Figure 4: Empirical relationship between: left: Basl Area (BA) and Canopy Cover (CC); right: Basal Area (BA) and Leaf Area Index (LAI).