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Forest Bioenergy in the Protected Mediterranean Areas

Forest Management Plan of the Biomass District in the protected areas

D3.7.1 Forest Management Plan of the Biomass district in the protected areas

Workpackage 3 - Testing

WP3 – Testing

Activity A.3.7 - Biomass oriented forest planning at local level in the protected areas

Partner in charge: LP – Sicily Region, Regional Department for the Rural and Territorial Development

June 2019

Deliverable 3.7.1

Forest Management Plan of the Biomass district in the protected areas

Responsible Partner:

LP: Sicily Region - Regional Department for the Rural and Territorial Development

Contributing Partners:

PP1 - Municipality of Petralia Sottana

PP2 - Enviland Ltd

PP3 - Slovenian Forestry Institute

PP4 - Regional Development Agency Green Karst Ltd

PP5 - The Forestry Municipalities Association of Comunitat Valenciana

PP7 - Zadar County

PP8 - Public institution Nature Park Velebit

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Deliverable:	D. 3.7.1 Forest Management Plan of the Biomass district in the protected areas
Summary:	The document contains the main results of the Forest Management Plans (FMPs) drawn up in a selected Biomass District by each partner. The FMPs are crucial tool to allow the quantification of the woody biomass available for energy use following the principles of sustainable forest management, protecting biodiversity, improving the conservation of forest resources, as well as ensuring socio-economic sustainability. Indeed, the potential biomass production and the share available for bioenergy production have been assessed taking into account the environmental and legislative restrictions occurring in the protected area, as well as the connections with the other planning tools and the assessment of impacts by the FMP.
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1. BACKGROUND

The drafting of the Forest Management Plan is one of the crucial steps for the setting up of an efficient and sustainable local forest-wood-energy supply chain. Each partner provides in the Deliverable a description of the main abiotic characteristics affecting the possibility of forest utilization within a detected and chosen Biomass District. The main goal of the FMP is to assess the woody biomass effectively available for energy use (e.g. woodchips) and other woody assortments. The FMP should prove that the wood coming from the sustainable management of forest areas and permanent crops could feed a local supply chain, having multiple environmental and socio-economic benefit for local community. The FMP is also a crucial tool allowing to distinguish the forest areas effectively exploitable from those which have to be left to natural evolution or to full protection regime, either for the naturalistic or scientific value or for abiotic (e.g. high slope, intense erosion processes) or legislative constraints (Natura 2000 sites, landscape restrictions) which impede the forest utilization at all. Each partner will assess the quantity of biomass which can be harvested, and it generally accounts only for a small share of the total growing stock.

2. DESCRIPTION, OBJECTIVES, PARTNERS INVOLVED AND PILOT AREAS

The Forest Management Plan (FMP) will be drawn up at the Biomass District (BD) level identified within the Activity A.3.4. The plan will be drawn up starting from the model developed in the ProForBioMed project and properly adapted to the context of the pilot protected area. In the plan, for each forest type the best forestry practices will be identified in order to preserve and conserve forest ecosystems and to assess the biomass that may be available for energy purposes. In the plan, also the exploitable biomass for energy purposes deriving from other forest-wood supply chains will be evaluated, following the concept of the cascade use of biomass.

Involved partners:

Country	Pilot area	Participating partners per pilot area	
Italy	Regional Natural Park of Madonie	LP	Sicily Region
		PP1	Municipality of Petralia Sottana
		PP2	EnviLand Ltd
Slovenia	Notranjski krajinski park	PP3	Slovenian Forestry Institute
	Primorsko-notranjska region	PP4	Regional Development Agency Green Karst Ltd.
Spain	Valencia	PP5	The Forestry Municipalities Association of Comunitat Valenciana
Croatia	Zadar	PP7	Zadar County
	Zadar Ličko-Senjska županija	PP8	Public institution Nature Park Velebit

Deliverable:

Title of the deliverable	Target value	Type of deliverable	Description
D3.7.1 Forest Management Plan of the Biomass district in the protected areas	1 Unit produced	Tool	The plan will be based on the model developed in the ProForBioMed project adapted to the protected area. The biomass assessment will be carried out according to two scenarios: 1) current context with many barriers, 2) future scenarios without barriers.

2. SYNTHETIC RECOMMENDATIONS FOR THE DRAFTING OF BIOMASS-ORIENTED FOREST PLAN AT LOCAL LEVEL IN THE PROTECTED AREAS

The Forest Management Plan (FMP) must be drawn up at least for one Biomass District (BD), representative of the Protected Area and identified in the Activity A3.4. The management plan must be drawn up according to the national and regional regulations in force in each country/region and in the national language. The deliverable of the activity (D.3.7.1) must contain a summary of the results of the management plan of the pilot BD of each protected area. In the FMP and in the deliverable, the connections with the other planning tools (Landscape, Natura 2000 Network, Fire prevention and firefighting, hydrogeological risk, desertification risk, ecc.) must be described. The FMP must also contain, in the presence of Natura 2000 habitats, the assessment of the impacts of the silvicultural interventions provided for by the plan.

3. MAIN RESULTS OF THE FOREST MANAGEMENT PLAN OF THE BIOMASS DISTRICT OF PETRALIA SOTTANA, PETRALIA SOPRANA AND CASTELLANA SICULA IN THE MADONIE REGIONAL NATURAL PARK (ITALY)

3.1 National and regional legislative framework

The organization of the Italian State in Regions, provided for by the Constitution, was implemented in the Seventies and was completed with the Presidential Decree 616 of 24 July 1977, which provided for the transfer to the Regions of the responsibilities related to the protection of nature, including reserves, natural parks and urban planning. National parks and nature reserves of national importance are under the responsibility of the State, as well as the protection of the landscape and the historical and artistic heritage. The Italian national legislative framework is based on "*Legge quadro sulle aree protette* 394/91", which defines a classification of the protected natural areas and establishes the official list of the protected areas, according to the criteria established by the National Committee for Protected Areas. According to this law, it is possible to distinguish national parks, regional and inter-regional natural parks, natural reserves, international heritage wetlands and other natural protected areas. In Sicily, the regional legislative framework is based on the regional law 98/1981, "*Norme per l'istituzione nella Regione Siciliana di parchi e riserve naturali*", which is the main regional law about regional parks and natural reserves. Put sides by sides to the 98/1981 regional law there are the regional law 14/1988, with amendments and additions to the regional law 98/1981, and the regional law 71/1995, "*Disposizioni urgenti in materia di territorio e ambiente (Modifiche ed integrazioni alla L.R. 98/81 e alla L.R. 14/88)*". The biomass district of Petralia Sottana, Petralia Soprana and Castellana Sicula is part of the Madonie regional natural park, established in 1989, with the decree 1489 issued by the regional bureau "*Assessorato Regionale Territorio e Ambiente*".

3.2 Geographical framework

The Biomass District 4 is located in the Madonie Regional Natural Park. The District area is about 30.700 hectares and includes three Municipalities: Petralia Sottana, Petralia Soprana and Castellana Sicula. Petralia Sottana is the Municipality more extended, accounting for 57,8% of the overall District area (about 17.700 hectares), followed by Castellana Sicula, which accounts for

23,6% of the area (about 7.200 hectares), and Petralia Soprana, which covers 18,6% of the District area (about 5.700 hectares).

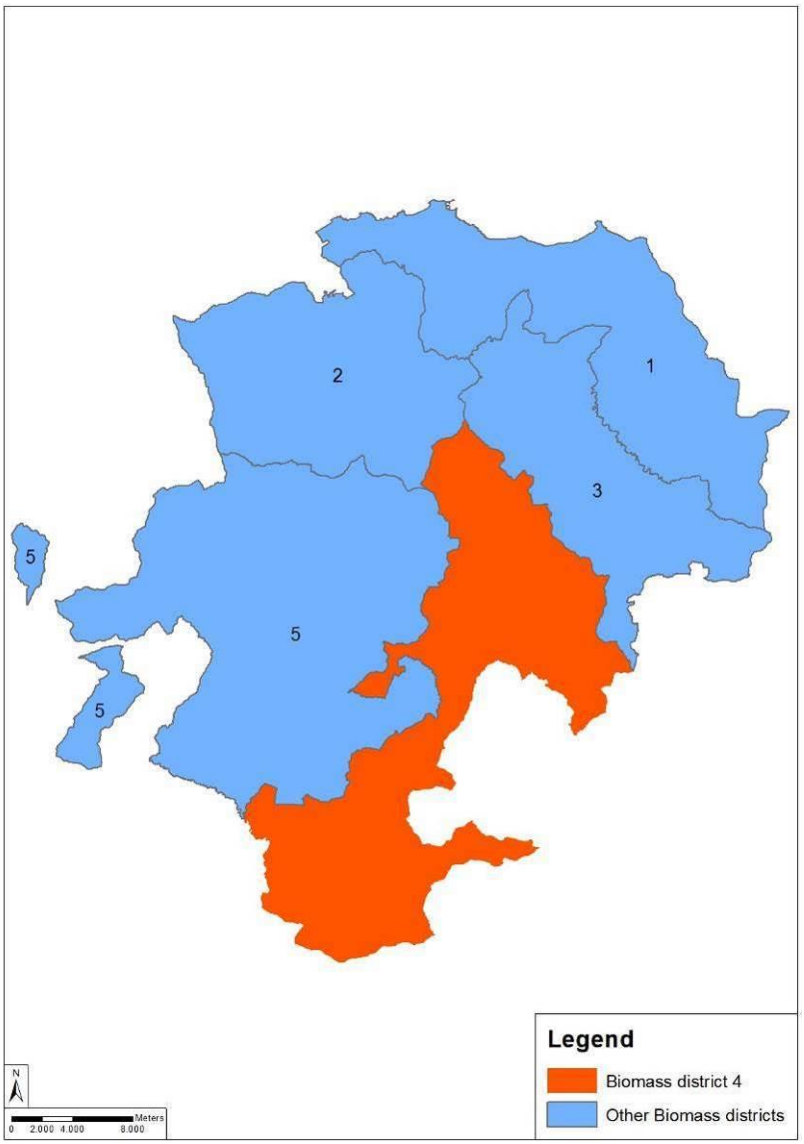

Figure 1. Position of Biomass District 4 with respect to the other districts.

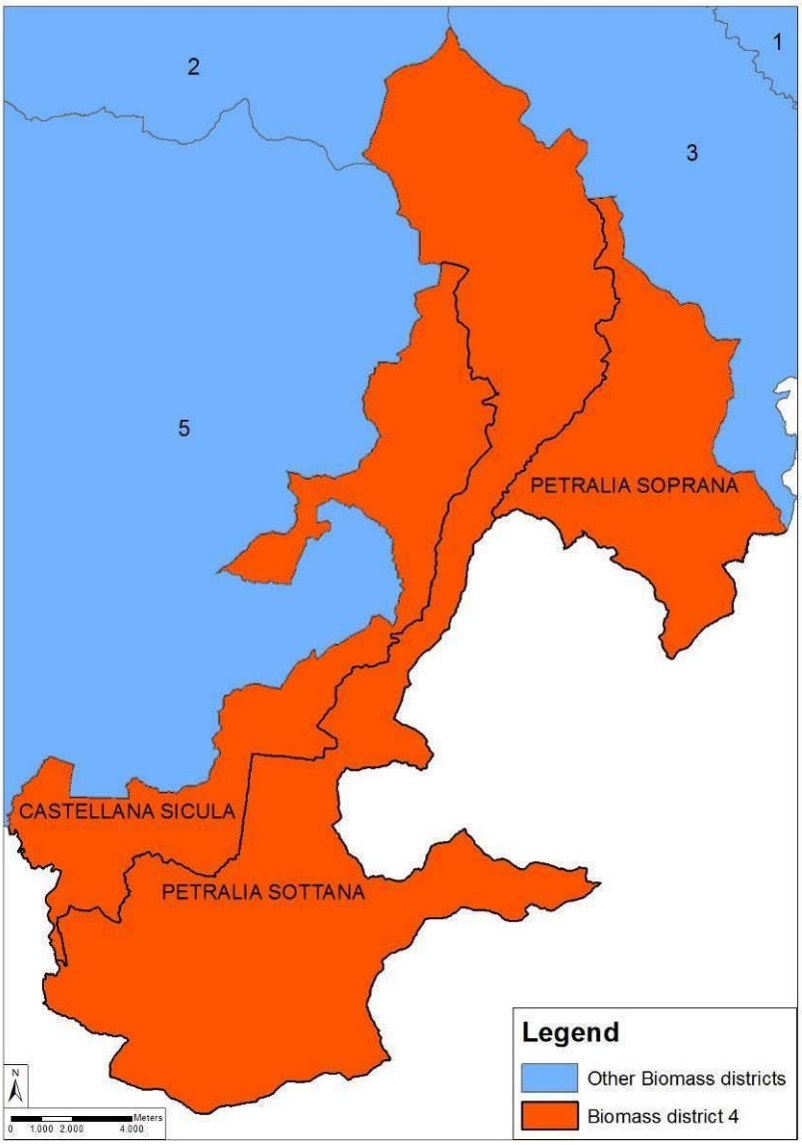

Figure 2. Municipalities within Biomass district 4.

Table 1. Overview of the area data of the municipalities and of agro-forestry resources, as well as the energy needs associated with BD 4 identified within the Madonie Regional Natural Park.

District ID	Municipality	Municipal area	Municipal area within the park	Forests[1]			Permanent crops[2]			Total area (forests plus permanent crops)	Energy needs	Energy needs/agro-forestry areas ratio
				Within the park	Outside the park	Total	Within the park	Outside the park	Total			
				a	*b*	*c=a+b*	*d*	*e*	*f=d+e*	*g=c+f*	*h*	*i=g*100/h*
		ha	ha	ha	ha	ha	ha	ha	ha	ha	MWh	%
4	Castellana Sicula	30.765	8.812	2.736	5	2.740	0	219	219	2.960	161.886	1,8
	Petralia Soprana											
	Petralia Sottana											

[1]*Corine Land Cover (classes 311, 312, 313)* [2]*Corine Land Cover (classes 221, 222, 223)* [3]*Energy needs not available*

3.3 Type and description of the forest ownership

The forest management plan (FMP) concerns areas belonging to different owners. 1.089 hectares belong to the Municipality of Petralia Sottana, which is located on the southern side of the Madonie, at an elevation between 900 and 1.100 m a.s.l. The municipal territory is 178 km² wide, the forest stands are located in the northern part of the territory, whereas in the southern part extensive arable lands are largely prevalent.

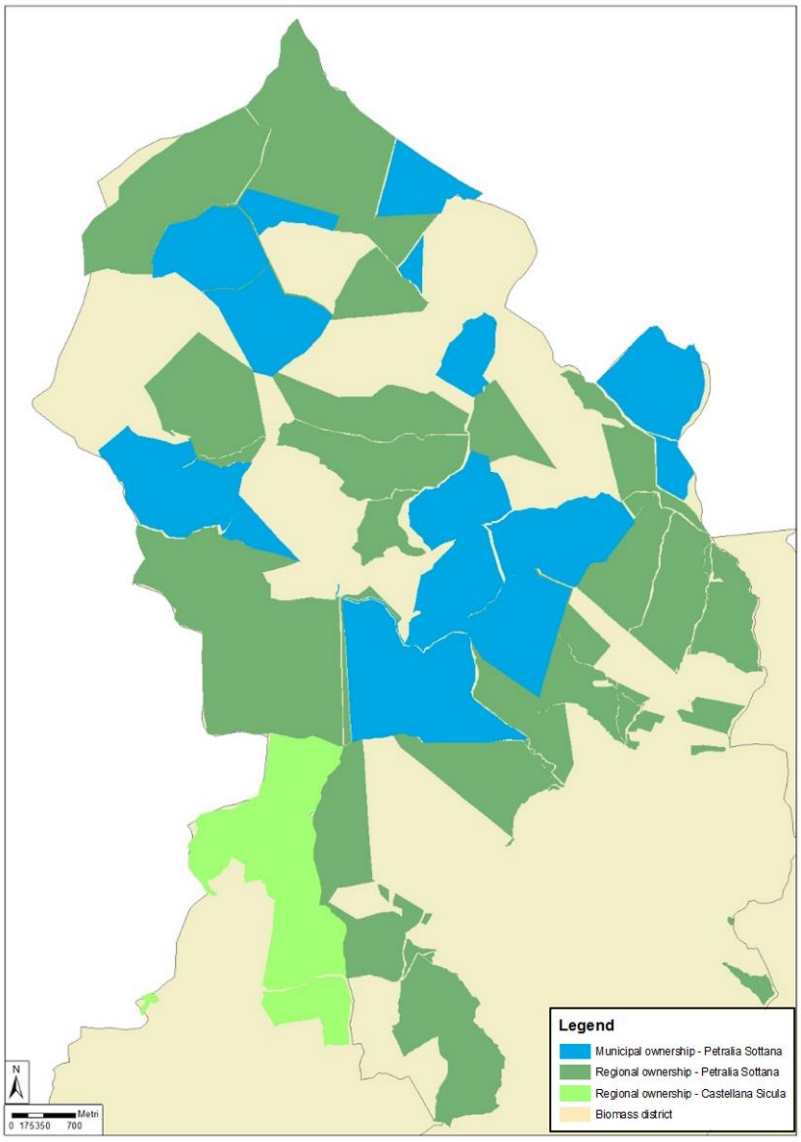

Figure 3. Forest ownership in the BD 4.

About 2.800 hectares belong to Sicily Region, Regional Department for the Rural and Territorial Development. In more detail, about 2.500 hectares fall within the Municipality of Petralia Sottana, whereas about 294 hectares fall within the Municipality of Castellana Sicula.

3.4 Synthesis of the environmental features

The Regional Natural Park of Madonie is very diversified both from the lithological and pedoclimatic point of view. It is characterized by a number of different environments and ecosystems, hosting a significant animal and plant biodiversity, including many rare and endemic species. In the Biomass District 4, there are many lithological complexes, the more represented are the following: clay complex (63,1%), conglomerate arenaceous complex (11,3%), and arenaceous-clay complex (10,2%). Other complexes are present in District 4 in a percentage lesser than 10%.

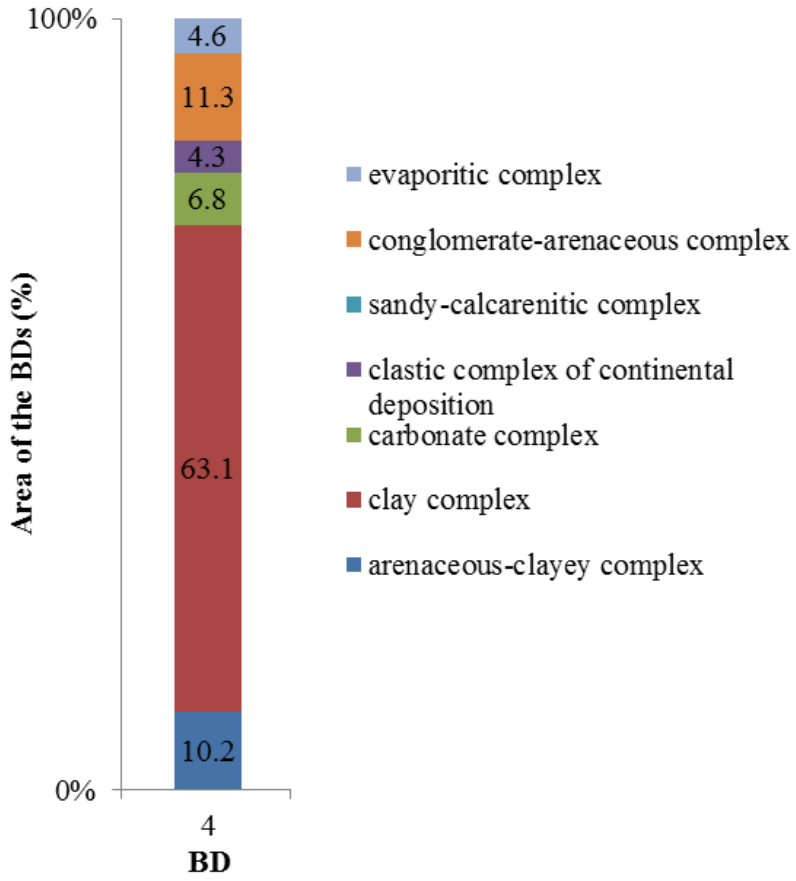

Figure 4. Lithological complexes in the BD 4. The percentage values lower than 1% are not reported in the graph.

The soil association more represented in the District is the number 13 “Typic Xerorthents - Typic e/o Vertic Xerochrepts” (according to U.S.D.A definition), which is the most widespread soil association in Sicily. The agronomic potential and the fertility of these soils vary from discrete to good, so that their prevailing destination is cereal cultivation.

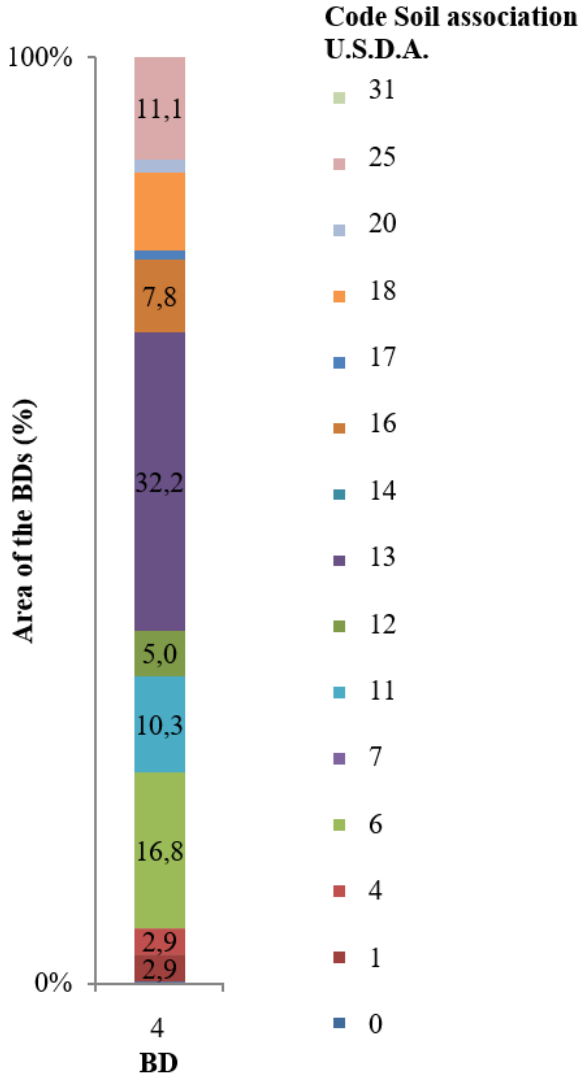

Figure 5. Soil associations in the BD 4. The percentage values lower than 2% are not reported in the graph.

The District includes many bioclimatic belts, but the majority of the territory falls within the Mesomediterranean – upper dry (T = 13-16 °C/year; P = 450-600 mm/year) and Mesomediterranean – lower sub-humid (T = 13-16 °C/year; P = 600-800 mm/year) belts.

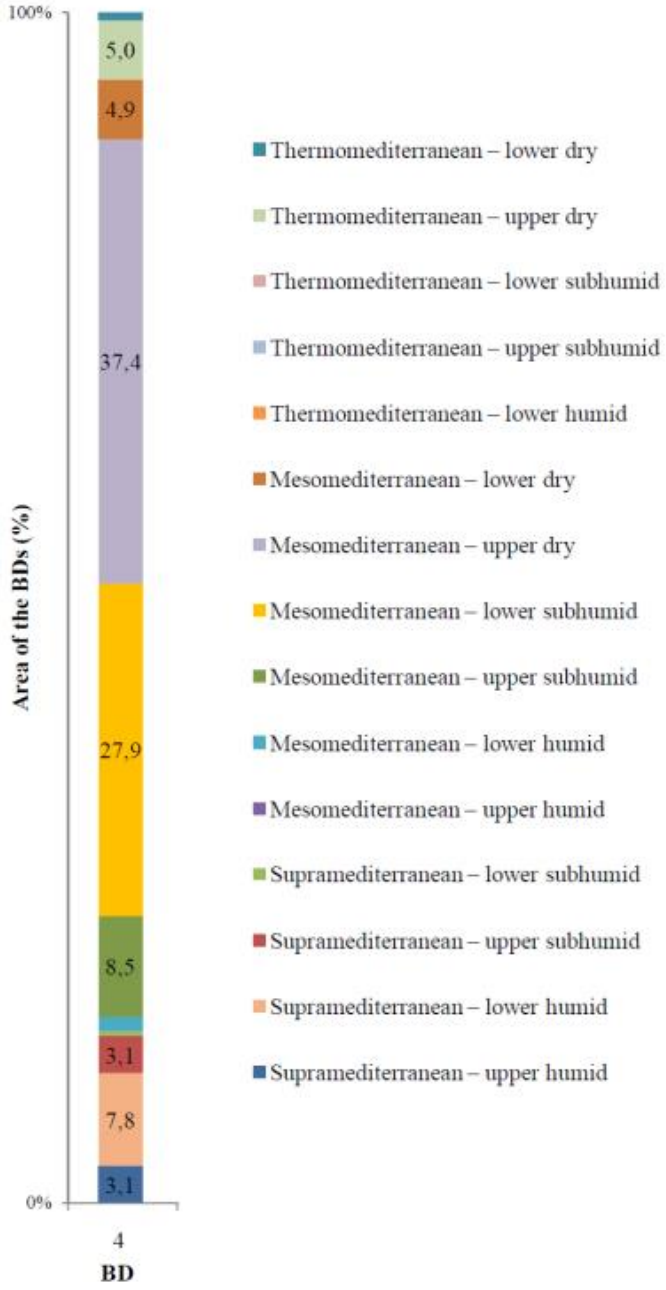

Figure 6. Bioclimate distribution in the BD 4. The percentage values lower than 2% are not reported in the graph.

3.5 Naturalistic, environmental and landscape restrictions

In the pilot protected area, there are several types of restrictions that may limit forest utilization, including naturalistic, hydrogeological and landscape restrictions.

3.5.1 Environmental restriction

The main restriction to which the pilot area is subject to is the environmental restriction, especially deriving from the establishment of the Madonie Regional Park.

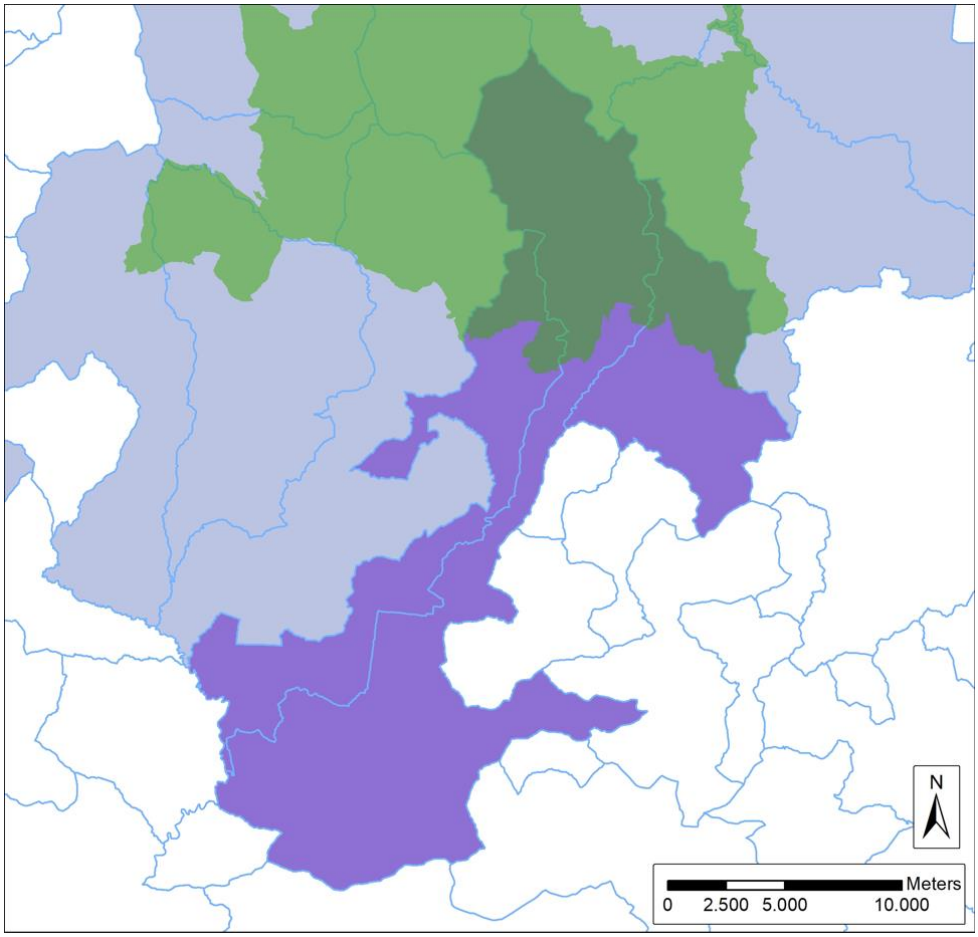

Figure 7. Naturalistic restriction in the BD 4.

<u>Regional Natural Park of Madonie</u>

The Regional Natural Park of Madonie was established in 1989, by a decree of "Assessorato Regionale Territorio e Ambiente" n.1489, which included a specific regulation. The Park covers a total of 39,679 hectares, and is divided into the following four zones:

- - Zone A (*integral reserve*, extended 5,733 ha) in which the natural environment is preserved in its integrity and which includes natural ecosystems of great naturalistic and landscape interest;
- - Zone B (*general reserve*, extended 16,535 ha) in which land transformation works are forbidden, whilst agro-forestry-pastoral activities are allowed;
- - Zone C (*of protection*, extended 427 ha) in which tourist-accommodation and cultural facilities are allowed;
- - Zone D (*control*, extended 16,984 ha) in which all activities compatible with the purposes of the Park are permitted.

The 28.3% of the territory of the District 4 falls within the boundaries of the Park. Considering that the presence of the different zones has a strong influence on the possibility to carry out forest interventions, we report that almost 24% of the area of district 4 in the Park (about 28% of the total area) is in Zone A, 38.4% falls in Zone B and almost 37% falls in Zone D.

3.5.2 Natura 2000 Network

Many Special Areas of Conservation (SACs) are present in the pilot area of the project. Particularly, SACs occupy 29.3% of District 4. The localization of the Natura 2000 sites falling within the BD is showed in figure 8.

Table 2 - Natura 2000 Sites in BD area.

CODE	NAME
ITA020004	M. S. SALVATORE, M. CATARINECI, V.NE MANDARINI, AMBIENTI UMIDI
ITA020016	M. QUACELLA, M.DEI CERVI, PIZZO CARBONARA, M. FERRO, PIZZO OTIERO
ITA020015	COMPLESSO CALANCHIVO DI CASTELLANA SICULA
ITA020050	MONTI MADONIE

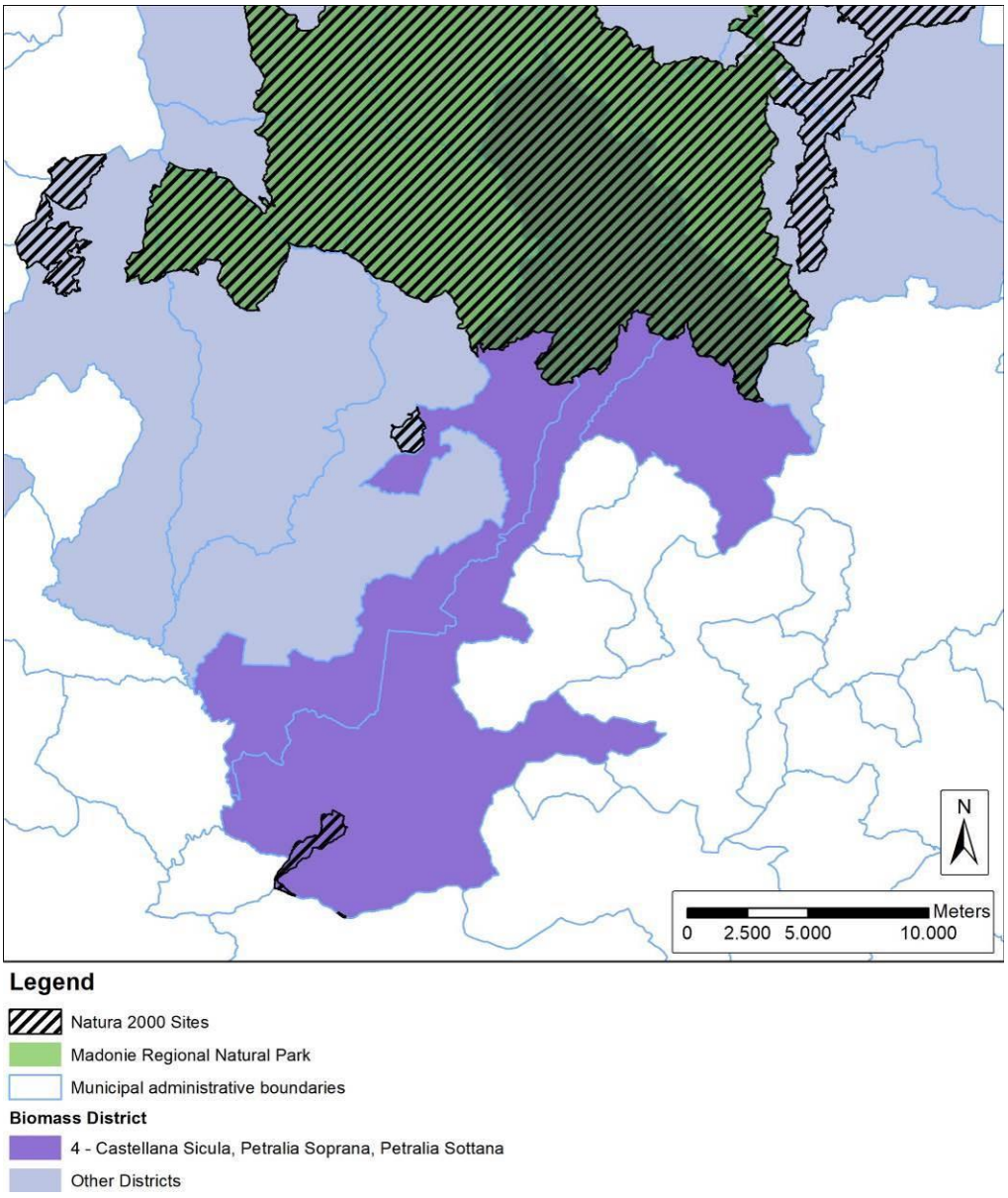

Figure 8. Natura 2000 Sites in the BD 4.

3.5.3 Hydrogeological restriction

The hydrogeological restriction applies to the great part of the territory of the BD, affecting 61% of its total area. The localization of the areas subject to hydrogeological restriction, including the BD 4, is showed in figure 9.

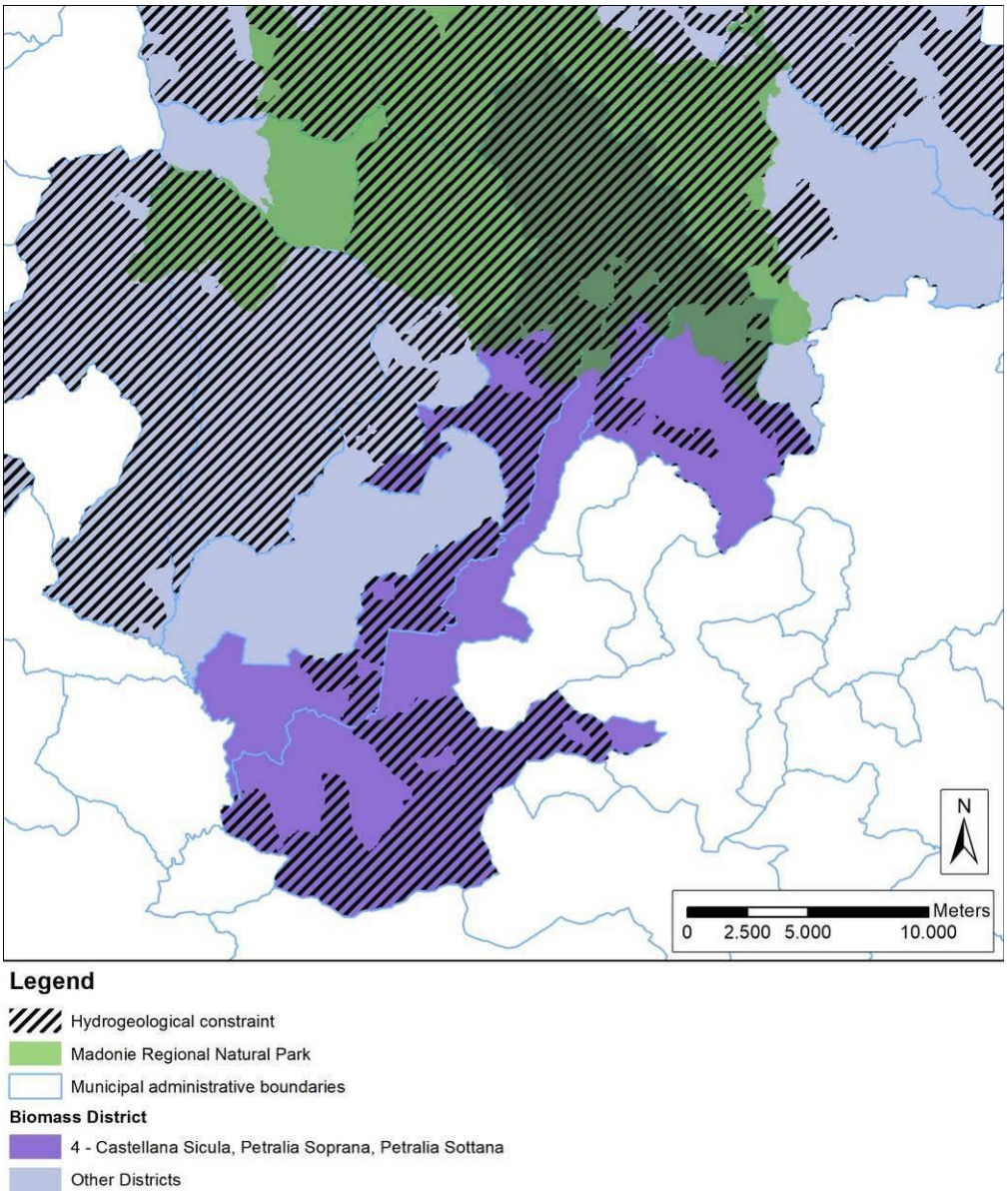

Figure 9. Area of the BD 4 subject to hydrogeological restriction.

3.5.4 Landscape restriction

The landscape restriction applies to 43.2% of the territory within the District 4. The localization of the area subject to landscape restriction in the BD is showed in figure 10.

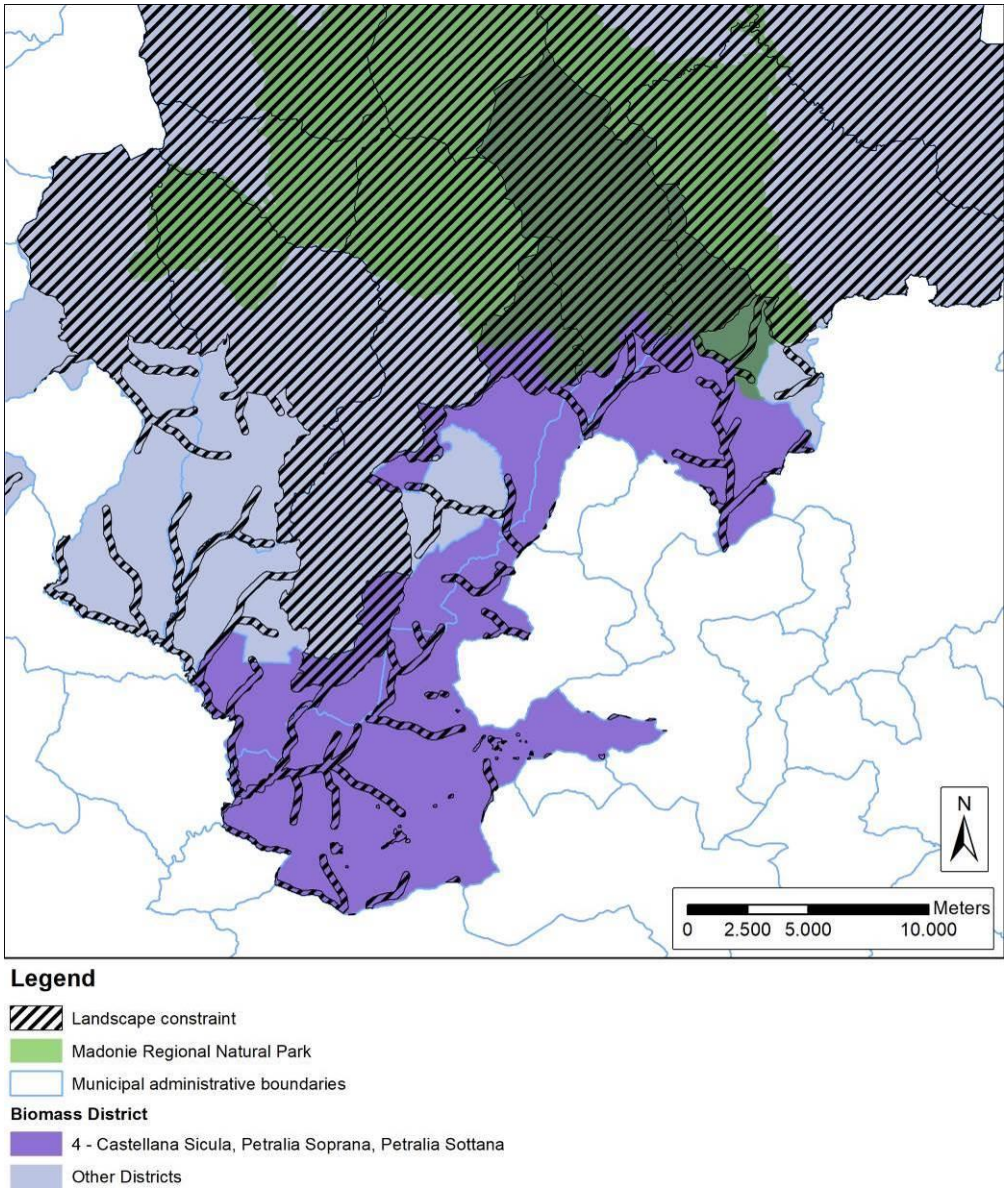

Figure 10. Area of BD 4 subject to landscape restriction.

3.5.5 Overall restricted area

In this paragraph we analyze all the restrictions as a whole, assessing how much they may affect the biomass harvesting activity. Considering the area not subject to any restriction, District 4 has a considerable non-constrained area (about 26% of the total area). In order to plan the production of energy based on the use of forest biomass, it is very important to analyze and understand the type of restrictions that concurrently are in force in the area of interest. As seen in the previous paragraph, the main restrictions that persist in the territory of the BD derive from the presence of the Madonie Regional Park, the sites of the Natura 2000 Network, and the hydrogeological and the landscape restrictions. Considering the areas included in the Natura 2000 network, simultaneously

subject to hydrogeological and landscape restrictions, but falling outside the Madonie Park, they cover 0.3% of District 4 area. The percentage of the area of the District 4 simultaneously subject to hydrogeological and landscape restrictions is equal to 7.5%.

3.5.6 Slope

In order to assess the ease of biomass harvesting in each BD, the range (grade) and the slope class of the territory were taken into account (Table 3).

Table 3. Slope class.

Range (grade)	Slope class
0-10	flat/sub-flat
10-30	moderate
30-50	high
50-80	very high

Most of the territory of the BDs have a moderate slope. In District 4, the area with a slope ranging between 10 and 30 degrees is about 57%. The percentage of area with a slope between 0 and 10 degrees occupies about 40% of the total area. The area with a slope between 30 and 50 degrees (high slope) is about 3%. The area with a slope between 50 and 80 degrees (very high) covers less than 1% of the total BD area.

3.6 Forest types and agricultural land use

3.6.1 Forest categories

It is possible to recognize 10 forest categories (Table 4), covering 5.835 hectares of forest areas within the district.

Table 4. Forest categories within the Biomass district 4.

Forest Category	Area (ha)	%
Shrub formations (AS)	697	2,27
Other broad-leaf forests (BA)	367	1,19
Pioneer formations (BS)	81	0,26
Chestnut formations (CA)	46	0,15
Beech formations (FA)	1157	3,76

Forest Category	Area (ha)	%
Riparian formations (FR)	556	1,8
Holm oak formations (LE)	378	1,23
Mediterranean scrubs (MM)	557	1,81
Various oak forests (QU)	838	2,72
Reforestations (RI)	1158	3,77

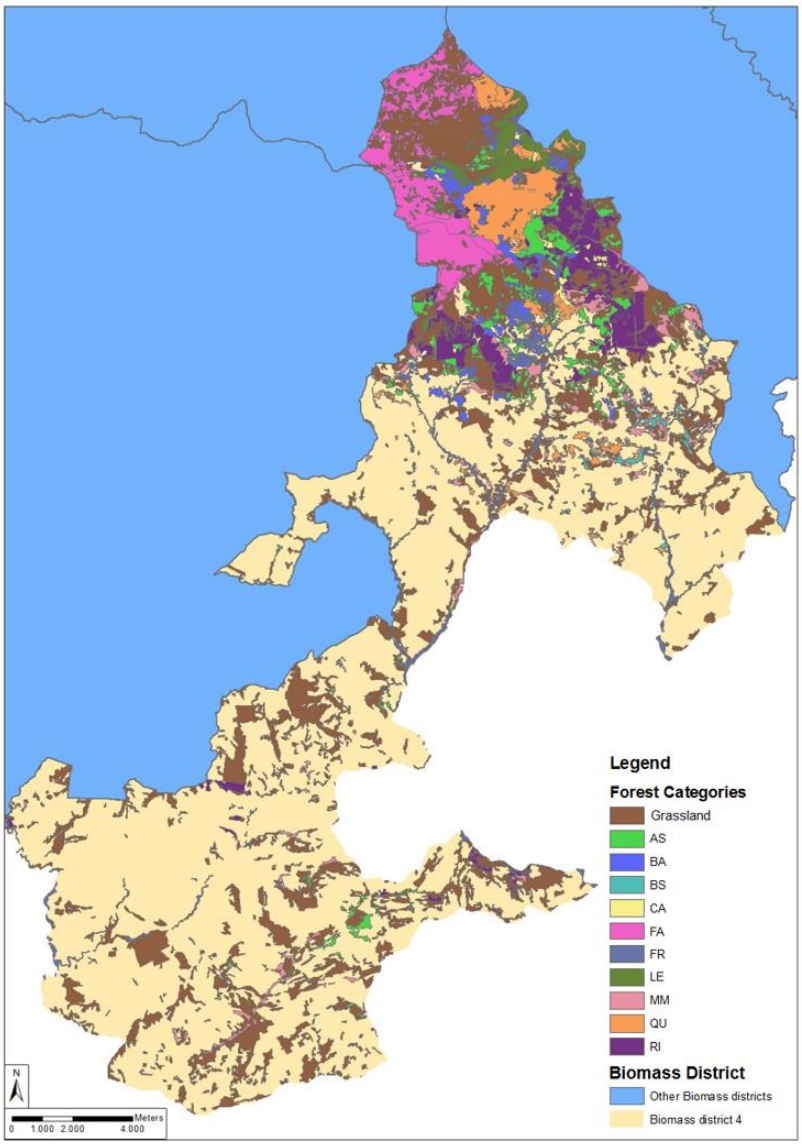

Figure 11. Forest categories within the District 4.

3.6.2 Forest types

Forests (CLC classes 311, 312, 313) cover about 2,700 ha, 9% of the total District area, and are mostly located within the Madonie Park. Many forest types occur within the District 4 (Table 5).

Table 5. Forest types in BD 4.

Code	Forest type
AS40X	Holly formations
AS50X	Rosaceae shrub formations
BA10X	Other broad-leaf forests
CA20X	Mesophile mountain chestnut formations
FA30X	Mesophile calciphile beech woods
FA40X	Meso-xerophile calciphile beech woods
FA11X	Pioneer beech woods on quartz arenite
FR20X	Poplar-willow woodlands
FR30X	Riparian willow shrub formations
FR50X	*Fraxinus oxycarpa* riparian formations
LE41A	Holm oak woods in association with downy oak and holly
LE40A	Meso-xerophile holm oak woods in association with downy oak
LE10X	Pioneer holm oak woods on rock
LE41X	Sub-mountain holm oak woods in association with holly
LE40C	Meso-xerophile holm oak woods in association with *Acer monspessulanum* and *A. campestre*
MM30X	*Calicotome infesta* shrub formations
MM40X	Spanish broom formations
QU31X	Meso-xerophile oak forests in association with holly and holm oak
QU10A	Sessile oak with beech woods
QU10X	Sessile oak formations
QU30A	Meso-xerophile downy oaks in association with European hop-hornbeam and/or *Acer*
QU50X	Xerophile downy oak forests on siliceous substratum
RI40G	Mountain conifer reforestations in association with broad-leaved trees
RI40X	Mountain conifer reforestations
RI40A	Mountain conifer reforestations in association with *Pinus nigra* or *P. nigra* subsp. *laricio*
RI20X	Broad-leaved trees reforestations
RI30A	Mediterranean conifer reforestations with *Pinus pinea*
RI30X	Mediterranean conifer reforestations

Looking at the table 5 it is clear that there is a wide range of forest types in the District, including 9 macro-categories: Holly formations, rosaceae shrub formations, other broad-leaf forests, chestnut formations, beech wood formations, willow formations, holm oak formations, scrub formations of

broom and *Calicotome*, various oak forests, and reforestations with conifers or broad-leaved species.

3.6.3 Agricultural land use

Permanent crops (CLC classes 221, 222, 223) are extended a little more than 200 ha, accounting for only 1% of the total District 4 area. Differently from forests, *permanent crops* are largely located outside the Madonie Natural Park. Crop type and relative extension are resumed in Table 6.

Table 6. Permanent crops within Biomass District 4.

CLC Code	Type	Area (ha)
221	Vineyards	215
222	Fruit trees and berry plantations	118
223	Olive groves	779

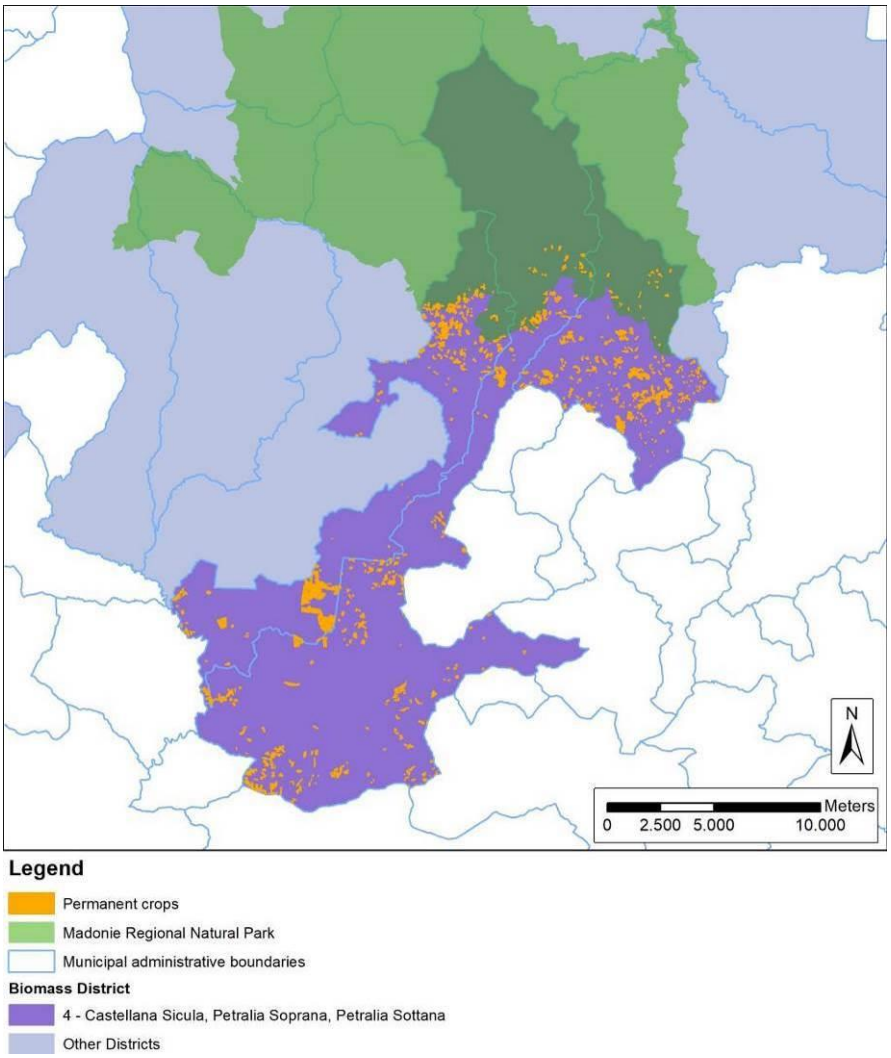

Figure 12. Permanent crops distribution in the BD 4.

3.7 Forest partitioning and description

3.7.1 Methodology

The first step for forest partitioning is to divide the land into suitable compartments. Each compartment holds biophysical characteristic as much as possible homogenous. In our forest management plan the main parameter taken into account to divide the land was topography, thus allowing to identify the compartments with homogeneous topographic characteristic (e.g. slope), and making each compartment easily identifiable for mapping and location on the ground. To individuate the border of each compartment on the map and making it easily recognizable on the ground, natural boundaries, such as streams, ridges, pronounced slope changes, and permanent elements such as roads or buildings, were primarily used.

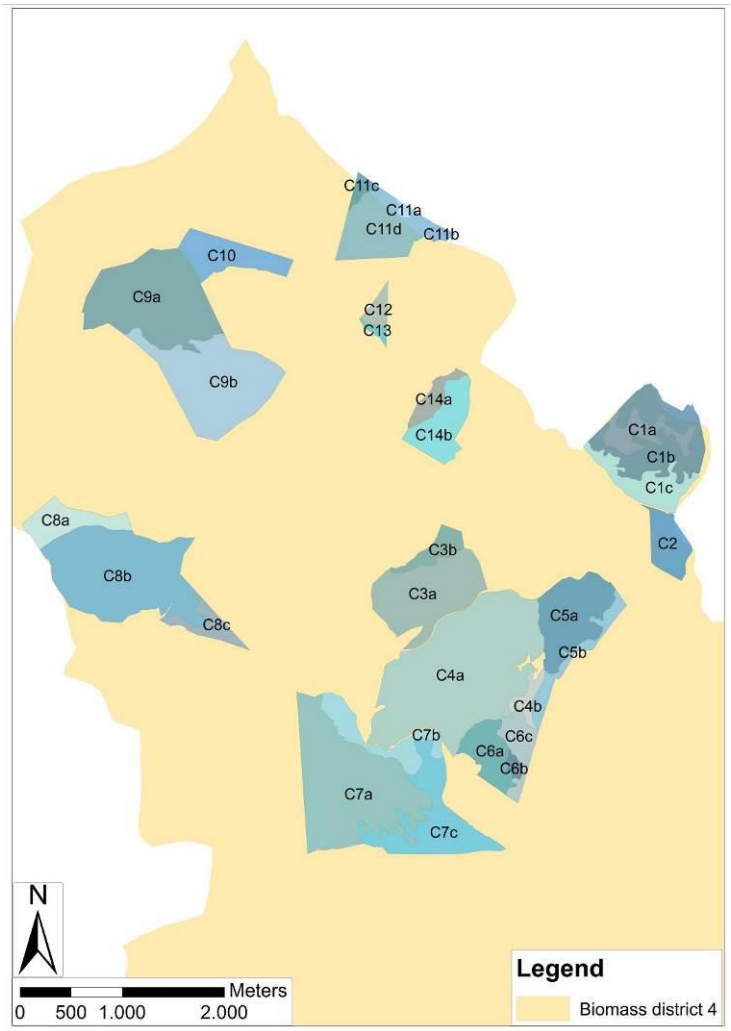

Figure 13. Forest partitioning for the forest areas falling within the Municipality of Petralia Sottana. Different colours identify different compartments.

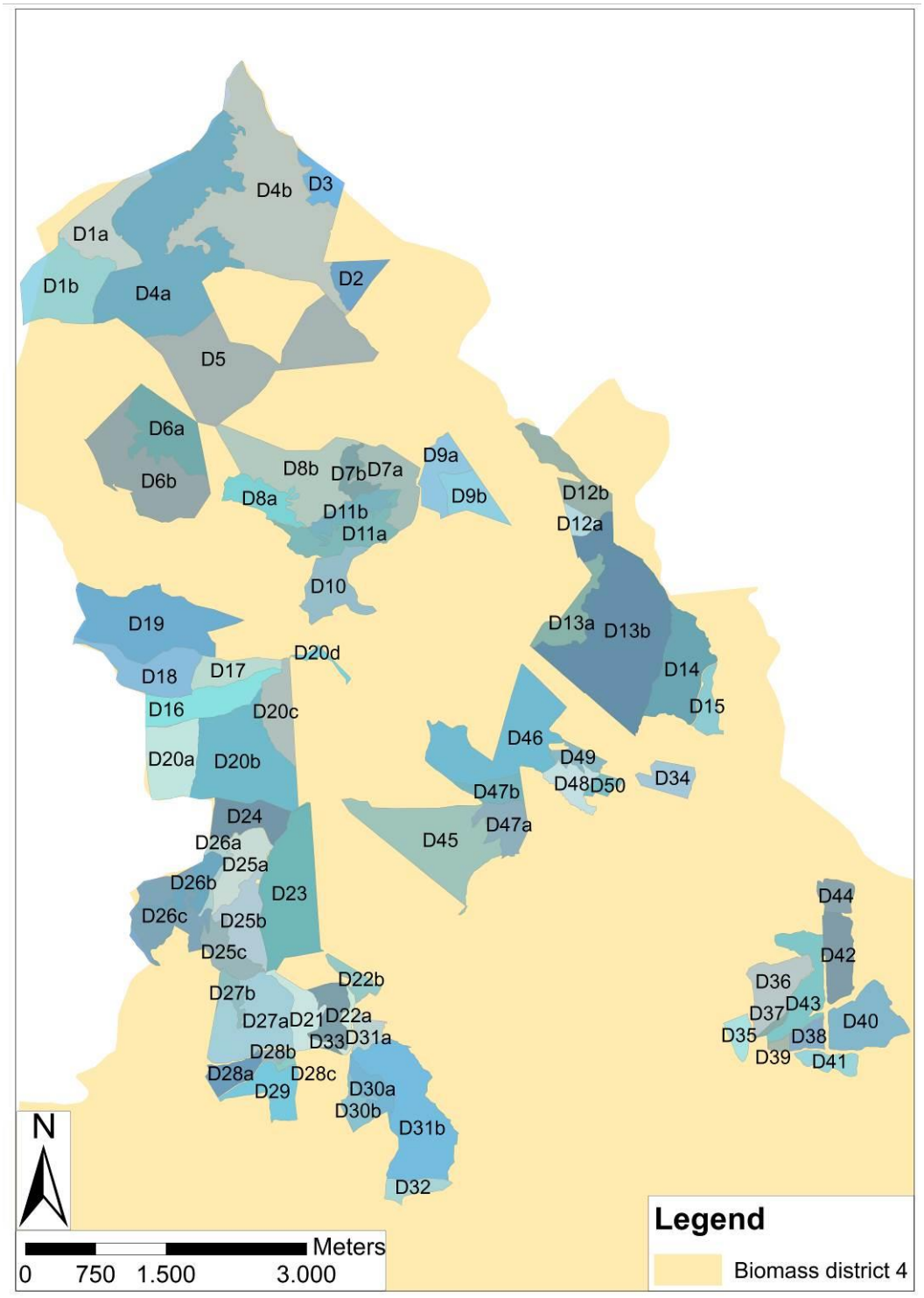

Figure 14. Forest partitioning for the forest areas belonging to the Sicily Region. Different colours identify different compartments.

Within each compartment, it is possible to identify different forest types, on the basis of table 5, which need different management. Therefore, sub-compartments have been identified. Sub-compartments are the smallest management units and they are identified by homogeneous land

use and, consequently, characterized by homogeneous management operations. Each compartment contains a variable number of sub-compartments according to the heterogeneity of land use.

The partitioning has been realized on GIS environment, on the basis of the Regional Technical Map, scale 1:10,000, overlapping the forest type map and drawing the borders of the compartment considering the municipal and Sicily Region (Regional Department for the Rural and Territorial Development) ownership. Then, all the compartments were described in an operation called "Compartment description". The description of each compartment was made after dedicated field surveys and the filling out of the dedicated form which has been developed within the Ri.Selv.Italia project, and which is considered well suited for the aims of the current project.

3.7.2 Results

From the forest partitioning activity, 29 compartments falling within the Municipality of Petralia Sottana, and 73 compartments falling within territories belonging to Sicily Region, were identified and located on the ground. It's important to underline that 11 cadastral units are still under investigation to discover the real owner as both the municipality of Petralia Sottana and the Regional Department for the Rural and Territorial Development, lay claim their ownership. Hence, the final number of compartments for each owner may be different. In total, the sub-compartments are 136 with a mean area of 19 hectares each. Table 7 shows the main data for all the compartments, including the morphological characteristics (altitude, slope, aspect), the damages by livestock and wild fauna, as well as the accessibility. Overall, only 54 compartments were actively managed. In figure 15, the geographical distribution within the district of the actively managed and non-managed compartments can be seen.

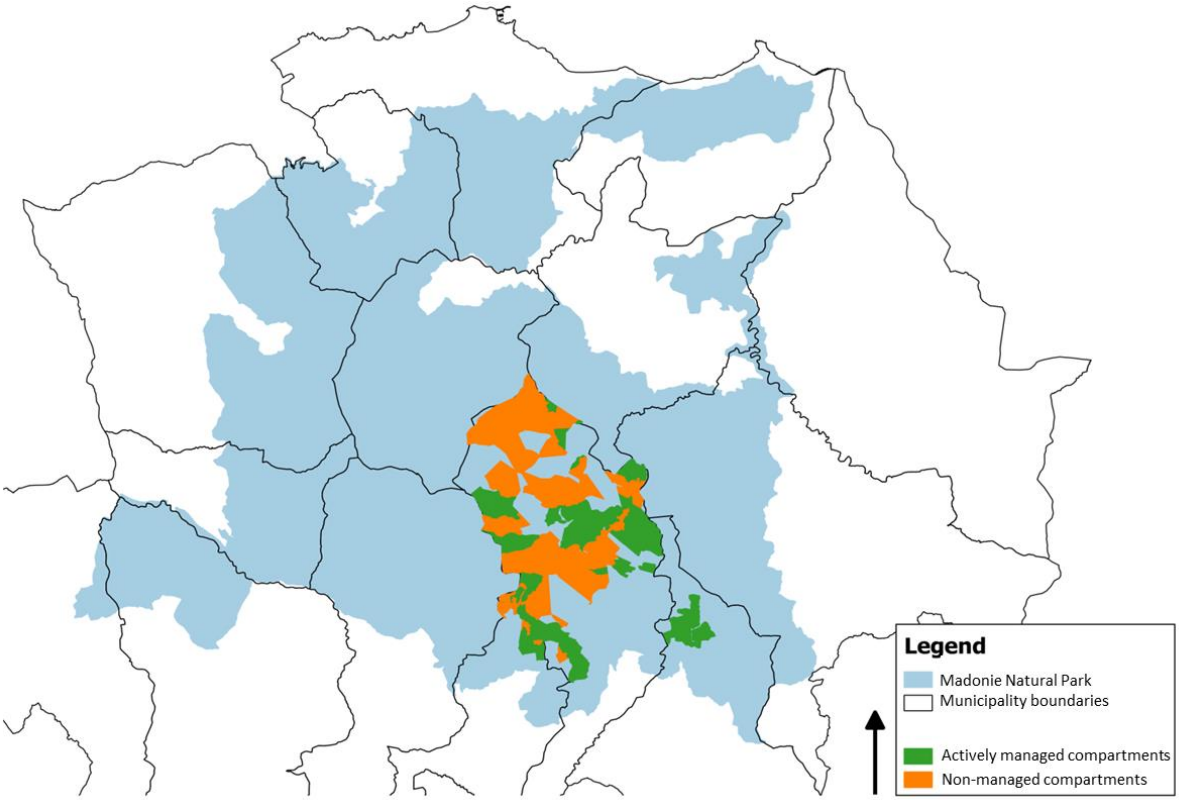

Figure 15. Geographical distribution within the district of the actively managed (in green) and non-managed compartments (in orange).

Table 7 – Main characteristics of the compartments

Compartment	Municipality	Altitude (m a.s.l.)	Slope (%)	Aspect	Livestock damage (incidence on the total area)	Wild fauna damage (incidence on the total area)	Phytopathogen damage (% on total area)	Good accessibility (% on total area)
D1a	Petralia Sottana	1.900	30%	Null	<1/3	>2/3 (growing risk)	<5%	0%
D1b	Petralia Sottana	1.870	30%	Null	<1/4	>2/3 (growing risk)	<5%	0%
D2	Petralia Sottana	1.500	40%	W, E	<1/3	>1/3	<5%	20%
D3	Petralia Sottana	1.550	25%	E	>1/3	>2/3 (growing risk)	>2/3 (growing risk)	60%
D4a	Petralia Sottana	1.850	25%	Null	<1/3	>2/3 (growing risk)	<5%	5%

Compartment	Municipality	Altitude (m a.s.l.)	Slope (%)	Aspect	Livestock damage (incidence on the total area)	Wild fauna damage (incidence on the total area)	Phytopathogen damage (% on total area)	Good accessibility (% on total area)
D4b	Petralia Sottana	1.680	30%	SE, E	<1/3	>2/3 (growing risk)	<5%	20%
D5	Petralia Sottana	1.800	30%	NW, W, SW, S, SE	>1/3	>2/3 (growing risk)	<5%	0%
D6a	Petralia Sottana	1.600	50%	SW, S, SE	>1/3	>2/3 (growing risk)	<5%	0%
D6b	Petralia Sottana	1.520	25%	SW, S	>1/3	>2/3 (growing risk)	<5%	20%
D7a	Petralia Sottana	1.160	70%	E, NE	<1/3	<1/3	<5%	0%
D7b	Petralia Sottana	1.230	35%	E	<1/3	<1/3	<5%	20%
D8a	Petralia Sottana	1.370	60%	SW, S	<1/3	<1/3	<5%	5%
D8b	Petralia Sottana	1.460	45%	SW, S	<1/3	<1/3	<5%	5%
D9	Petralia Sottana	1.250	60%	NE, N	>1/3	>2/3 (growing risk)	<5%	10%
D10	Petralia Sottana	1.280	30%	N	>1/3	>1/3	<5%	60%
D11a	Petralia Sottana	1.200	80%	S	<1/3	<1/3	<5%	10%
D11b	Petralia Sottana	1.380	40%	S	<1/3	<1/3	<5%	5%
D12a	Petralia Sottana	1.270	25-30%	N,NW	>1/3	>1/3	<5%	50%
D12b	Petralia Sottana	1.200	25%	N,NW	>1/3	>1/3	<5%	20%
D13a	Petralia Sottana	1.490	60%	SE, E	<5%	>1/3	<5%	10%

Compartment	Municipality	Altitude (m a.s.l.)	Slope (%)	Aspect	Livestock damage (incidence on the total area)	Wild fauna damage (incidence on the total area)	Phytopathogen damage (% on total area)	Good accessibility (% on total area)
D13b	Petralia Sottana	1.260	25-30%	E, SE	<1/3	<1/3	>1/3	80%
D14	Petralia Sottana	1.150	15-20%	W	>1/3	<1/4	<1/3	90%
D15	Petralia Sottana	1.220	25-30 %	W	<1/3	>1/3	>2/3 (growing risk)	70%
D16	Petralia Sottana	1.600	25%	S	<1/3	>1/3	<1/3	50%
D17	Petralia Sottana	1.530	35%	N	<1/3	>1/3	<1/3	30%
D18	Petralia Sottana	1.580	40-45%	N, NW	<1/3	<1/3	<1/3	30%
D19	Petralia Sottana	1.750	50%	SW, NE	<1/3	<1/3	<5%	5%
D20a	Petralia Sottana	1.750	40%	N	<1/3	>1/3	<1/3	10%
D20b	Petralia Sottana	1.800	40%	N	<1/3	>1/3	<1/3	5%
D20c	Petralia Sottana	1.680	70%	NW	<5%	<5%	<5%	0%
D20d	Petralia Sottana	1.350	60%	NW	<1/3	>1/3	<5%	10%
D21	Petralia Sottana	1.280	35-40%	SW, S, SE	<5%	<1/3	>1/3	40%
D22a	Petralia Sottana	1.250	30%	SE, E, NE	<5%	<1/3	>1/3	60%
D22b	Petralia Sottana	1.240	25%	SE	<1/3	>1/3	<5%	40%
D23	Petralia Sottana	1.650	45%	E, SE	<1/3	<1/3	<5%	5%
D24	Castellana Sicula	1.780	30%	S	<5%	>1/3	<1/3	30%

Compartment	Municipality	Altitude (m a.s.l.)	Slope (%)	Aspect	Livestock damage (incidence on the total area)	Wild fauna damage (incidence on the total area)	Phytopathogen damage (% on total area)	Good accessibility (% on total area)
D25a	Castellana Sicula	1.680	40%	SW, S, SE	<5%	>1/3	<1/3	25%
D25b	Castellana Sicula	1.700	50%	SW	<1/3	>1/3	<5%	60%
D25c	Castellana Sicula	1.500	20%	W, SW	<5%	>1/3	>2/3 (growing risk)	80%
D26a	Castellana Sicula	1.650	35%	SE	<5%	>1/3	<1/3	5%
D26b	Castellana Sicula	1.600	45%	SE, E	<1/3	>1/3	>2/3 (growing risk)	30%
D26c	Castellana Sicula	1.570	50%	S	>1/3	>1/3	<5%	20%
D27a	Castellana Sicula	1.280	45%	S	<5%	<1/3	>1/3	40%
D27b	Castellana Sicula	1.450	50%	S	<5%	<1/3	<5%	0%
D28a	Castellana Sicula	1.150	30%	SE, E	>1/3	<1/3	<1/3	60%
D28b	Castellana Sicula	1.160	130%	SE, E	<5%	<1/3	<5%	60%
D28c	Castellana Sicula	1.160	40%	SW,S,SE	<5%	<1/3	<1/3	80%
D29	Castellana Sicula	1.100	25%	S	<5%	<1/3	<1/3	80%
D30a	Petralia Sottana	1.200	20%	SW	>1/3	<1/3	>1/3	85%
D30b	Petralia Sottana	1.160	25%	SW	<1/3	<5%	<5%	0%
D31a	Petralia Sottana	1.160	20%	E, SE	<1/3	>1/3	<5%	40%
D31b	Petralia Sottana	1.130	20%	S, SE, E	<1/3	>1/3	>1/3	50%

Compartment	Municipality	Altitude (m a.s.l.)	Slope (%)	Aspect	Livestock damage (incidence on the total area)	Wild fauna damage (incidence on the total area)	Phytopathogen damage (% on total area)	Good accessibility (% on total area)
D32	Petralia Sottana	1.100	30%	S	>2/3 (growing risk)	<1/3	>1/3	80%
D33	Petralia Sottana	1.200	30%	SE	<5%	<1/3	>2/3 (growing risk)	50%
D34	Petralia Sottana	1.250	25%	W,NW	<5%	>1/3	>2/3 (growing risk)	70%
D35	Petralia Soprana	1.150	20%	SW	<5%	<1/3	<1/3	80%
D36	Petralia Soprana	1.190	20%	W,NW	<5%	>1/3	>1/3	80%
D37	Petralia Soprana	1.200	15%	S	<1/3	>1/3	>2/3 (growing risk)	80%
D38	Petralia Soprana	1.180	20%	S	>2/3 (growing risk)	<1/3	>2/3 (growing risk)	90%
D39	Petralia Soprana	1.160	10%	S	>2/3 (growing risk)	<1/3	<1/3	80%
D40	Petralia Soprana	1.200	15%	S	>2/3 (growing risk)	>1/3	<5%	80%
D41	Petralia Soprana	1.150	10%	S	>2/3 (growing risk)	<5%	<5%	80%
D42	Petralia Soprana	1.300	20%	S	>1/3	<1/3	>1/3	80%
D43	Petralia Soprana	1.250	15%	S	<1/3	>1/3	<1/3	90%
D44	Petralia Soprana	1.460	10%	S	<5%	>1/3	>1/3	60%
D45	Petralia	1.500	40%	SE, E	>1/3	<1/3	<5%	10%

Compartment	Municipality	Altitude (m a.s.l.)	Slope (%)	Aspect	Livestock damage (incidence on the total area)	Wild fauna damage (incidence on the total area)	Phytopathogen damage (% on total area)	Good accessibility (% on total area)
	Sottana							
D46	Petralia Sottana	1.290	60%	SE	<1/3	>1/3	<5%	10%
D47a	Petralia Sottana	1.250	35%	SE, E	>1/3	>1/3	<1/3	40%
D47b	Petralia Sottana	1.270	30%	N, NE	<5%	>1/3	>2/3 (growing risk)	70%
D48	Petralia Sottana	1.130	25%	SW, S, SE	>1/3	>1/3	>2/3 (growing risk)	60%
D49	Petralia Sottana	1.100	20-25%	SW, S, SE	>2/3 (growing risk)	>2/3 (growing risk)	>1/3	70%
D50	Petralia Sottana	1.090	20%	NW	>1/3	>1/3	<5%	70%
C1a	Petralia Sottana	1.180	30-35%	NW	<5%	>1/3	<5%	50%
C1b	Petralia Sottana	1.200	35%	N, NW	<5%	>1/3	<5%	40%
C1c	Petralia Sottana	1.270	45%	SW, S, SE	>1/3	>1/3	<5%	10%
C2	Petralia Sottana	1.250	35%	N, NE	>1/3	>1/3	<5%	30%
C3a	Petralia Sottana	1.300	25-30%	NW,N, NE	>1/3	>1/3	<5%	30%
C3b	Petralia Sottana	1.280	80%	NW	<5%	<5%	<5%	0%
C4a	Petralia Sottana	1.450	30%	NW	>1/3	>1/3	<5%	40%
C4b	Petralia Sottana	1.340	20%	SE, NW	<1/3	>1/3	<5%	0%
C5a	Petralia Sottana	1.430	30%	N, NW,	>1/3	>1/3	<5%	30%

Compartment	Municipality	Altitude (m a.s.l.)	Slope (%)	Aspect	Livestock damage (incidence on the total area)	Wild fauna damage (incidence on the total area)	Phytopathogen damage (% on total area)	Good accessibility (% on total area)
				W				
C5b	Petralia Sottana	1.450	40%	NW	<5%	>1/3	<5%	20%
C6a	Petralia Sottana	1.470	60%	E, NE	<5%	<1/3	<5%	0%
C6b	Petralia Sottana	1.380	15%	NE	<5%	<1/3	<5%	70%
C6c	Petralia Sottana	1.350	25%	E, NE	<5%	<1/3	<5%	40%
C7a	petralia sottana	1.680	60%	NE	<5%	>1/3	<5%	0%
C7b	Petralia Sottana	1.400	25%	NE	>1/3	>1/4	<5%	10%
C7c	Petralia Sottana	1.550	50%	E	<1/3	>1/3	<5%	5%
C8a	Petralia Sottana	1.750	35-40%	NE, E, SE	>1/3	>1/3	<5%	40%
C8b	Petralia Sottana	1.620	45-50%	N, NE	>1/3	>1/3	<5%	30%
C8c	Petralia Sottana	1.620	60%	SE	<1/3	<1/3	<5%	0%
C9a	Petralia Sottana	1.850	30%	SE	<1/3	>2/3 (growing risk)	<5%	5%
C9b	Petralia Sottana	1.800	30%	NW, W, SW, S, SE	>1/3	>2/3 (growing risk)	<5%	0%
C10	Petralia Sottana	1.850	30%	SE	<1/3	>2/3 (growing risk)	<5%	0%
C11a	Petralia Sottana	1.400	15%	NE	<1/3	>2/3 (growing risk)	<5%	60%
C11b	Petralia	1.360	20%	SE	>2/3	>2/3	<5%	40%

Compartment	Municipality	Altitude (m a.s.l.)	Slope (%)	Aspect	Livestock damage (incidence on the total area)	Wild fauna damage (incidence on the total area)	Phytopathogen damage (% on total area)	Good accessibility (% on total area)
	Sottana				(growing risk)	(growing risk)		
C11c	Petralia Sottana	1.500	40%	W, NE	>1/3	>2/3 (growing risk)	<5%	10%
C12	Petralia Sottana	1.400	25%	SW	>1/3	>1/3	<5%	50%
C13	Petralia Sottana	1.400	20%	SW	>1/3	>1/3	<5%	70%
C14a	Petralia Sottana	1.200	25%	NW	<1/3	>1/3	<5%	70%
C14b	Petralia Sottana	1.170	70%	SE	<1/3	>1/3	<5%	0%

3.8 Dendrometric inventory

3.8.1 Methodology

Field surveys have been carried out to collect dendrometric data, thus building a dendrometric inventory. The dendrometric data were collected according to the following procedure. Each parcel was classified by management typology in actively managed and not managed. The field survey was carried out only in the parcels with active management. The plot areas are round with a radius of 10 meters in the coppice woods (about 300 m^2 of total area) and 15 meters in the high forests (about 700 m^2 of total area). The trees immediately out of the boundary line were marked with biodegradable marking paint. The diameter at breast height (at 1.30 m above ground) was surveyed in all the tree individuals exceeding 4 cm, while the tree height (in m) was measured in at least 20 representative individuals.

The DBH was measured by means of a tree caliper, while the height was measured with an ultrasound instrument, the Vertex IV by Haglof, which affords to take accurate measurements in different environmental conditions. Data from field surveys are reported according to the Form D1 for high forests (from Ri.Selv.Italia project, modified), and to the Form D2 for coppice forests (from Ri.Selv.Italia project, modified).

3.8.2 Results

Field surveys were carried out in 54 actively managed compartments.

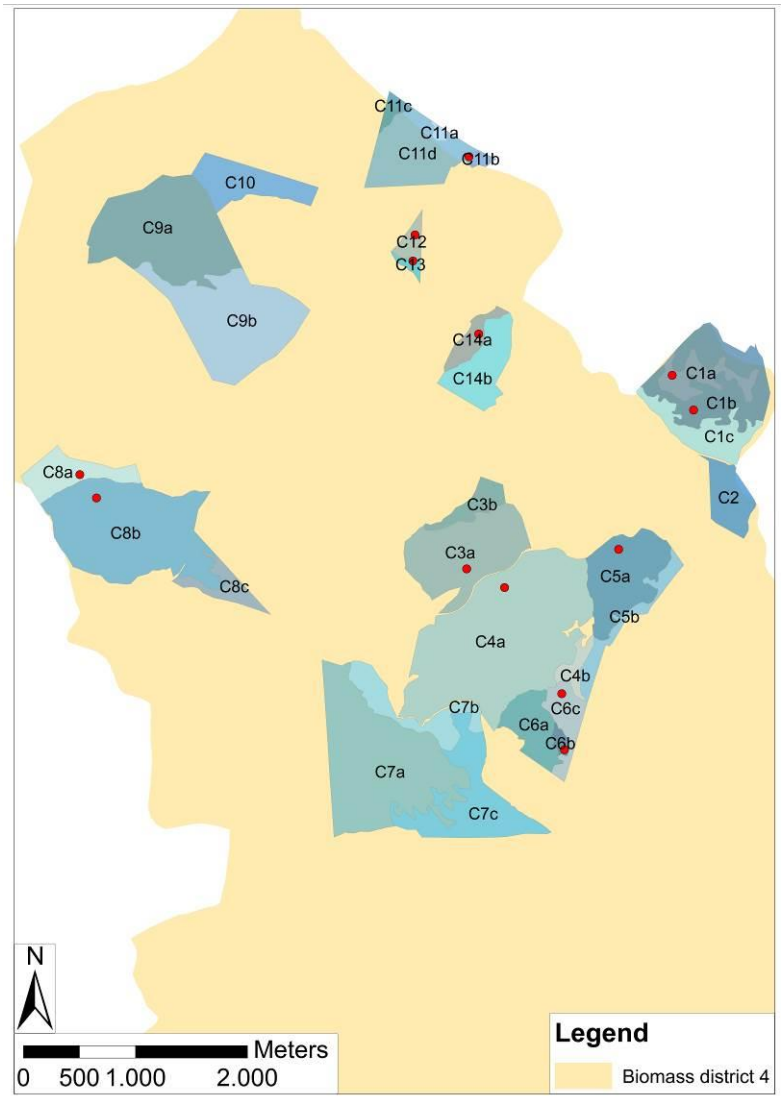

Figure 16. Compartments falling within the Municipality of Petralia Sottana. Different colours identify different compartments. The red dots identify the center of the compartment.

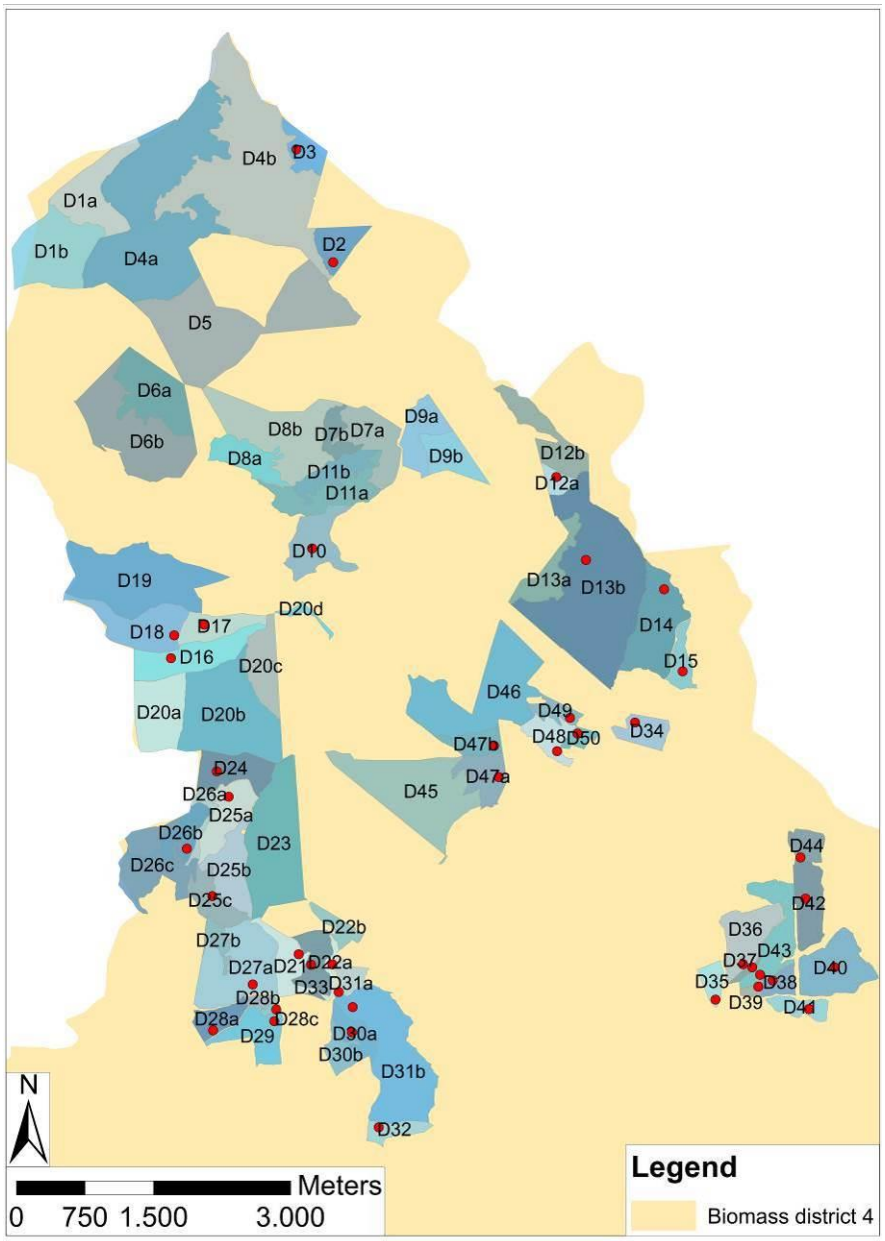

Figure 17. Compartments falling within areas belonging to the Sicily Region. Different colours identify different compartments. The red dots identify the center of the compartment.

In table 8, the main data for each compartment are reported.

Table 8 – Main silvicultural characteristics of the surveyed compartments.

Compartment	Forest type	Structure	Stand regeneration	Cover (%)	Natural Regeneration	Main silvicoltural purpose	Silvicoltural orientation
D2	QU10A	Old coppice	Agamic	80%	Sufficient	Naturalistic	Uneven-aged

Compartment	Forest type	Structure	Stand regeneration	Cover (%)	Natural Regeneration	Main silvicoltural purpose	Silvicoltural orientation
							high forest
D3	FA40X	Old coppice (beech) / Mature high forest (pine)	Agamic / Artificial	70%	Poor	Naturalistic	Coppice
D10	QU10X	Old coppice	Agamic	80%	Poor	Naturalistic	Uneven-aged high forest
D12a	QU10X	Mature high forest	Agamic	80%	Poor	Naturalistic	Uneven-aged high forest
D13b	RI40A	Stratified mature high forest	Artificial	80%	Poor	Hydrogeological protection	Uneven-aged high forest
D14	RI40A	Stratified mature high forest	Artificial	60%	Poor	Hydrogeological protection	Uneven-aged high forest
D15	RI40A	Stratified mature high forest	Artificial	70%	Poor	Hydrogeological protection	Uneven-aged high forest
D16	FA10X	Old coppice	Agamic	60%	Poor	Naturalistic	Coppice and high forest
D17	FA30X	Adult high forest	Agamic	80%	Poor	Naturalistic	Uneven-aged high forest
D18	FA30X	Adult high forest	Agamic	80%	Poor	Naturalistic	Uneven-aged high forest
D21	RI40G	Young high forest	Artificial	50%	Poor	Hydrogeological protection	Uneven-aged high forest
D22a	CA10A	Uneven aged coppice	Agamic	70%	Sufficient	Naturalistic	Coppice
D24	FA11X	Old coppice	Agamic	60%	Poor	Naturalistic	Natural evolution

Compartment	Forest type	Structure	Stand regeneration	Cover (%)	Natural Regeneration	Main silvicoltural purpose	Silvicoltural orientation
D25a	FA11X	Old coppice	Agamic	90%	Poor	Naturalistic	Natural evolution
D25c	RI40A	Adult high forest	Artificial	90%	Poor	Hydrogeological protection	Uneven-aged high forest
D26b	RI40A	Adult high forest	Artificial	70%	Poor	Hydrogeological protection	Uneven-aged high forest
D27a	RI40G	Stratified adult high forest	Artificial	60%	Poor	Hydrogeological protection	Uneven-aged high forest
D28a	RI40G	Stratified mature high forest	Artificial	80%	Poor	Hydrogeological protection	Uneven-aged high forest
D28c	RI40A	Young high forest	Artificial	70%	Poor	Idrogeological protection	Uneven-aged high forest
D29	RI40G	Adult high forest	Artificial	60%	Poor	Idrogeological protection	Uneven-aged high forest
D30a	RI40G	Stratified mature high forest	Artificial	70%	Poor	Idrogeological protection	Uneven-aged high forest
D31a	RI20F	Young high forest	Artificial	60%	Poor	Hydrogeological protection	Uneven-aged high forest
D31b	RI40G	Stratified adult high forest on coppice	Artificial	60%	Poor	Hydrogeological protection	Uneven-aged high forest
D32	RI20D	Very young high forest	Artificial	15%	Poor	Hydrogeological protection	Uneven-aged high forest
D33	CA20X	Uneven aged coppice	Agamic	50%	Sufficient	Naturalistic	Coppice and high forest
D34	RI40G	Stratified mature high forest	Artificial	80%	Poor	Hydrogeological protection	Coppice and high forest

Compartment	Forest type	Structure	Stand regeneration	Cover (%)	Natural Regeneration	Main silvicoltural purpose	Silvicoltural orientation
D35	RI40D	Young high forest	Artificial	35%	Poor	Hydrogeological protection	Uneven-aged high forest
D36	RI40D	Adult high forest	Artificial	50%	Poor	Hydrogeological protection	Uneven-aged high forest
D37	RI40A	Adult high forest	Artificial	50%	Poor	Hydrogeological protection	Uneven-aged high forest
D38	RI40A	Adult high forest	Artificial	30%	Poor	Hydrogeological protection	Uneven-aged high forest
D39	RI40D	Young high forest	Artificial	40%	Poor	Hydrogeological protection	Uneven-aged high forest
D40	RI40D	Young high forest	Artificial	30%	Poor	Hydrogeological protection	Uneven-aged high forest
D41	RI40D	Young high forest	Artificial	40%	Poor	Hydrogeological protection	Uneven-aged high forest
D42	RI40G	Adult high forest	Artificial	50%	Poor	Hydrogeological protection	Uneven-aged high forest
D43	RI40G	Young high forest	Artificial	70%	Poor	Hydrogeological protection	Uneven-aged high forest
D44	RI40A	Mature high forest	Artificial	80%	Poor	Hydrogeological protection	Uneven-aged high forest
D47a	RI40G	Adult high forest	Artificial	20%	Poor	Hydrogeological protection	Uneven-aged high forest
D47b	RI40G	Stratified adult high forest	Artificial	70%	Poor	Hydrogeological protection	Uneven-aged high forest
D48	RI40A	Young high forest	Artificial	40%	Poor	Hydrogeological protection	Uneven-aged high forest
D49	RI20D	Adult high forest	Artificial	80%	Poor	Hydrogeological protection	Uneven-aged high forest
D50	RI30A	Stratified mature high forest	Artificial	60%	Poor	Hydrogeological protection	Uneven-aged high forest
C1a	QU10X	Mature high forest	Agamic	70%	Poor	Naturalistic	Uneven-aged high forest

Compartment	Forest type	Structure	Stand regeneration	Cover (%)	Natural Regeneration	Main silvicoltural purpose	Silvicoltural orientation
C1b	LE41X	Adult high forest	Agamic	90%	Poor	Naturalistic	Uneven-aged high forest
C3a	QU10X	Old coppice	Agamic	80%	Poor	Naturalistic	Uneven-aged high forest
C3b	LE10X	Adult high forest	Natural	90%	Sufficient	Naturalistic	Natural evolution
C4a	QU10X	Adult high forest	Agamic	80%	Poor	Naturalistic	Uneven-aged high forest
C5a	QU10X	Adult high forest	Agamic	60%	Poor	Naturalistic	Uneven-aged high forest
C6b	RI40A	Adult high forest	Artificial	30%	Poor	Hydrogeological protection	Uneven-aged high forest
C6c	RI40G	Adult high forest	Artificial	30%	Poor	Hydrogeological protection	Uneven-aged high forest
C8a	FA30X	Adult high forest	Natural	70%	Poor	Naturalistic	Uneven-aged high forest
C8b	FA30X	Old coppice	Agamic	60%	Poor	Naturalistic	Uneven-aged high forest
C11b	QU31X	Mature coppice	Agamic	50%	Poor	Naturalistic	Uneven-aged high forest
C12	QU10X	Stratified over-mature high forest	Natural	90%	Sufficient	Naturalistic	Uneven-aged high forest
C13	QU10A	Stratified over-mature high forest	Natural	80%	Sufficient	Naturalistic	Uneven-aged high forest
C14a	LE40A	Adult high forest	Agamic	70%	Sufficient	Naturalistic	Natural evolution

To summarize the data collected during the field surveys, the dendrometric data organized by forest category are reported in table 9. For each category, the tree species and the related dendrometric data, are shown.

Table 9. Dendrometric data sorted by forest category. All data are mean values. Basal area (G) is the cross-sectional area of tree stem measured at 1.3 m above ground level.

Forest Category	Surveyed areas (number)	Tree Species	Density (number/ha)	Diameter [cm]	Height [m]	G [m^2/ha]	Volume [m^3/ha]
Chestnut	**2**	Chestnut	1336,9	12,3	10,6	15,7	79,8
		Holm oak	127,3	14,6	10,9	2,1	10,5
		Sessile oak	222,8	12,4	8,5	2,7	12,3
		Narrow-leafed ash	127,3	10,6	8,6	1,1	4,5
Beech	**8**	Beech	4761,2	11,3	9,2	34,0	148,1
		European crab apple	1082,3	5,6	4,8	2,6	5,3
		Black pine	286,5	33,1	10,9	24,6	123,4
		Sessile oak	604,8	10,7	6,7	5,4	19,4
Holm oak	**2**	Holm oak	617,4	25,4	12,0	30,8	186,2
		Sessile oak	113,2	25,4	13,2	5,8	41,8
Other oaks	**10**	Sessile oak	2320,5	20,5	14,7	46,1	381,8
		Holly	1605,0	7,0	5,5	7,3	23,9
		Beech	668,5	11,5	13,1	6,9	41,0
		Holm oak	642,5	11,9	9,1	5,0	29,1
		Downy oak	1909,9	11,4	8,0	19,5	83,7
		Other broad-leaved	342,4	7,1	6,1	1,1	3,4
Reforestation	**32**	Black pine	436,1	26,8	12,9	24,6	169,8
		Black pine and Cedar	499,9	32,3	15,4	37,2	267,1
		Black pine and Cypress	447,4	22,6	9,1	18,8	90,5
		Black pine and Aleppo pine	183,9	28,9	9,6	12,9	58,1
		Aleppo pine	339,5	35,7	16,1	33,3	271,1
		Stone pine	268,8	41,4	17,3	36,2	154,7
		Cypress	240,5	19,6	11,8	6,4	33,3
		Sessile oak	309,2	9,6	5,8	3,2	13,6
		Downy oak	97,3	5,0	3,8	0,2	0,4
		Manna ash	276,7	10,1	8,2	2,9	14,6
		Narrow-leafed ash	390,5	9,2	7,0	3,5	10,7
		Chestnut	119,9	10,9	9,2	1,3	7,1
		Holm oak	46,0	7,8	4,9	0,3	0,7

Forest Category	Surveyed areas (number)	Tree Species	Density (number/ha)	Diameter [cm]	Height [m]	G [m^2/ha]	Volume [m^3/ha]
		Holly	382,0	7,4	7,4	1,6	4,7
		Other broad-leaved	107,5	7,7	5,3	0,5	2,0

3.9 Plan of treatment types and silvicultural operations

In the table 10, information about the silvicultural operations for each forest type are provided. Most of treatments are addressed to favour the natural successional dynamics and the progressive replacement of planted trees. Mountain conifer reforestations include *Pinus nigra*, *P. nigra* subsp. *laricio*, *Pseudotsuga menziesii*, *Cedrus* spp., and *Cupressus* spp.

Table 10. information about the silvicultural operations for each forest type

Compartment	Forest Type	Total area [ha]	Woody area [ha]	Last treatment	Future treatment	Period of treatment
D16	Beech woods	38,64	38,64	High forest initial cut (20%)	Selective and light thinning (15% of overstory trees)	I
D17	Mesophile calciphile beech woods	20,59	20,59	High forest initial cut	Seed cut on transient high forest	II
D18	Mesophile calciphile beech woods	39,56	39,53	High forest initial cut	Seed cut on transient high forest	II
C8a	Mesophile calciphile beech woods	22,64	19,45		Selective and light thinning (15%)	II
C8b	Mesophile calciphile beech woods	106,87	90,90		High forest initial cut (eliminate subdued suckers)	II
D3	Meso-xerophile calciphile beech woods	15,36	14,71		Thinning of pine trees	I
D32	Broad-leaved trees reforestations	11,08	5,31	Reforestation activities	Broadleaf increasing	II

Compartment	Forest Type	Total area [ha]	Woody area [ha]	Last treatment	Future treatment	Period of treatment
D49	Broad-leaved trees reforestations with coniferous trees	9,98	9,45		Thinning	I
D31a	Broad-leaved trees reforestations with sessile oak	9,75	8,86		Light thinning	I
D50	Mediterranean conifer reforestations with *Pinus pinea*	5,8	4,27	Thinning	Thinning	I
C14a	Meso-xerophile holm oak woods in association with downy oak	9,79	9,59	High forest starting cut (more than 10 years ago)	Light thinning	II
C11b	Meso-xerophile oak forests in association with holly and holm oak	2,68	0,50		High forest starting cut (eliminate subdued suckers)	I
D22a	Mountain chestnut formations	21,22	19,75	Coppicing	Coppicing	II
D33	Mountain chestnut formations	5,15	5,12	Coppicing	Coppicing under high forest	II
D21	Mountain conifer reforestations in association with broad-leaved trees (ash trees)	20,90	15,39		To increase the broadleaves cover	I
D27a	Mountain conifer reforestations in association with broad-leaved trees	60,00	55,89	Thinning	Conifers reduction and broadleaves increasing	II
D28a	Mountain conifer reforestations in association with broad-leaved trees	17,74	16,69	Thinning	Conifers reduction and broadleaves increasing	II
D29	Mountain conifer reforestations in association with broad-leaved trees	25,55	19,92	Light Thinning	Conifers reduction and broadleaves increasing	I

Compartment	Forest Type	Total area [ha]	Woody area [ha]	Last treatment	Future treatment	Period of treatment
D30a	Mountain conifer reforestations in association with broad-leaved trees	13,46	12,28	Thinning	Conifers reduction and broadleaves increasing	II
D31b	Mountain conifer reforestations in association with broad-leaved trees	84,41	66,35	Coppicing and Thinning	Thinning and high forest starting	II
D34	Mountain conifer reforestations in association with broad-leaved trees	11,69	11,20		Thinning of pine trees and Coppicing of chestnut	I
D42	Mountain conifer reforestations in association with broad-leaved trees	95,24	19,84		Thinning	I
D43	Mountain conifer reforestations in association with broad-leaved trees	14,94	14,94		Thinning	I
D47b	Mountain conifer reforestations in association with broad-leaved trees	14,06	12,83		Conifers reduction and broadleaves increasing	I
D13b	Mountain conifer reforestations in association with Manna ash	161,91	135,72	Thinning (20%)	Conifers reduction and broadleaves increasing	I
D14	Mountain conifer reforestations in association with broad-leaved trees	51,46	46,19		Thinning	I
D15	Mountain conifer reforestations in association with broad-leaved trees	12,92	9,83		Thinning	I
D25c	Mountain conifer reforestations in association with broad-leaved trees	20,47	18,45		Thinning	I
D26b	Mountain conifer reforestations in association with broad-leaved trees	18,85	14,96		Weak conifers reduction and broadleaves	I

Compartment	Forest Type	Total area [ha]	Woody area [ha]	Last treatment	Future treatment	Period of treatment
					increasing	
D28c	Mountain conifer reforestations in association with broad-leaved trees	2,19	2		To increase the broadleaves cover	I
D37	Mountain conifer reforestations in association with broad-leaved trees	12,03	12,03	Thinning	Conifers reduction and broadleaves increasing	II
D38	Mountain conifer reforestations in association with broad-leaved trees	35,02	35,01	Pruning	Conifers reduction and broadleaves increasing	I
D44	Mountain conifer reforestations in association with broad-leaved trees	133,48	27,81		Reduction	I
D48	Mountain conifer reforestations in association with broad-leaved trees	16,95	12,25		To increase the broadleaves cover	II
D35	Mountain conifer reforestations with broad-leaved trees	41,22	41,22		To increase the broadleaves cover	II
D36	Mountain conifer reforestations with broad-leaved trees	11,85	11,38	Thinning (60% of overstory trees)	Thinning	I
D39	Mountain conifer reforestations with broad-leaved trees	27,05	27,05	Thinning	Conifers reduction and broadleaves increasing	I
D40	Mountain conifer reforestations with broad-leaved trees	33,20	33,11	Pruning	To increase the broadleaves cover	I
D41	Mountain conifer reforestations with broad-leaved trees	16,18	16,18	Thinning	Conifers reduction and broadleaves increasing	I
D24	Pioneer beech woods on quartz arenite	27,70	24,49		Selective thinning (eliminate the little and subdued	I

Compartment	Forest Type	Total area [ha]	Woody area [ha]	Last treatment	Future treatment	Period of treatment
					suckers)	
D25a	Pioneer beech woods on quartz arenite	28,46	28,37		Selective thinning (eliminate the little and subdued suckers)	I
D10	Sessile oak formations	33,22	32,00		High forest starting cut (eliminate the subdued suckers)	II
D12a	Sessile oak formations	7,19	6,04	High forest starting cut	Seeding cut on transient high forest	II
C1a	Sessile oak formations	16,84	16,84	High forest starting cut (more than 10 years ago)	Light Thinning	II
C3a	Sessile oak formations	54,91	50,11		Thinning	II
C4a	Sessile oak formations	163,00	158,89		Thinning	II
C5a	Sessile oak formations	45,27	43,33		Thinning	II
C12 D2	Sessile oak formations Sessile oak with beech woods	5,83 18,84	4,12 18,06		Thinning of thicket stage High forest starting cut (eliminate subdued suckers)	I I
C13 C1b	Sessile oak formations Sub-mountain holm oak woods in association with holly	2,62 50,79	2 47,38	 High forest starting (more than 10 years)	Thinning of thicket stage Light Thinning	I II

The table 11 shows a summary of the data concerning the compartments with non-active management. All these areas are currently addressed to “natural evolution”, except for the compartment C11a, which deserves protection due to the presence of monumental trees.

Table 11. Collected data about non-actively managed compartments.

Compartment	Forest type	Structure	Stand regeneration	Woody cover (%)	Natural regeneration	Main purpose
D1a	FA40X	Old coppice	Agamic	80%	Poor	Naturalistic
D1b	FA40X	Old coppice	Agamic	180%	Poor	Naturalistic
D4a	FA40X	Old coppice	Agamic	80%	Poor	Naturalistic
D7a	LE10X	Mature high forest	Natural	70%	Sufficient	Naturalistic
D8a	LE10X	Mature high forest	Natural	60%	Poor	Naturalistic
D9	LE40C	Old coppice	Agamic	80%	Poor	Naturalistic
D11a	LE10X	Mature high forest	Natural	60%	Sufficient	Naturalistic
D19	FA40X	Old coppice	Agamic	60%	Poor	Naturalistic
D20a	FA10X	Old coppice	Agamic	70%	Poor	Naturalistic
D20b	FA10X	Old coppice	Agamic	80%	Poor	Naturalistic
D20c	FA30X	Mature high forest	Natural	70%	Sufficient	Naturalistic
D20d	QU10A	Old coppice	Agamic	70%	Poor	Naturalistic
D26a	FA11X	Old coppice	Agamic	70%	Poor	Naturalistic
C3b	LE10X	Mature high forest	Natural	90%	Sufficient	Naturalistic
C4b	QU10X	Mature high forest	Agamic	40%	Sufficient	Naturalistic
C5b		Old coppice	Agamic	40%	Poor	Naturalistic
C6a	FA11X	Mature high forest	Natural	60%	Sufficient	Naturalistic
C7a	FA30X	Old coppice	Agamic	70%	Poor	Naturalistic
C7b	QU10A	Mature high forest	Natural	40%	Poor	Naturalistic
C9a	FA40X	Old coppice	Agamic	80%	Poor	Naturalistic
C10	FA40X	Old coppice	Agamic	80%	Poor	Naturalistic
C11a	AS40X	Over-mature high forest	Agamic	90%	Sufficient	Naturalistic
C11c	QU10X	Over-mature high forest	Agamic	60%	Poor	Naturalistic
C14b	LE40A	Adult high	Natural	70%	Sufficient	Naturalistic

Compartment	Forest	Structure	Stand	Woody	Natural	Main purpose
		forest				

Pasture and shrub formations areas are resumed in the table 12.

Table 12. Pasture and shrub formations found in the study areas.

Compartment	Short description
D4b	Wooded pasture with scattered beech, holm oak, sessile oak, field maple and rosaceae shrubs
D5	Wooded pasture with scattered beech, holm oak, field maple and rosaceae shrubs
D6a	Wooded pasture with scattered beech, holm oak, field maple and rosaceae shrubs
D6b	Wooded pasture with scattered beech, holm oak, field maple and rosaceae shrubs
D7b	Rosaceae shrub formation with scattered holm oak, ashes, oak and maples.
D8b	Wooded pasture with scattered holm oak, field maple and rosaceae shrubs
D11b	Wooded pasture with scattered holm oak, field maple and rosaceae shrubs
D12b	Wooded pasture with scattered holm oak, field maple and rosaceae shrubs
D13a	Rosaceae shrub formation with scattered beech, sessile oak and holly
D22b	Rosaceae shrub formation with scattered holm oak, ashes, oak and maples.
D23	Wooded pasture with scattered beech, holm oak, field maple and rosaceae shrubs
D25b	Wooded pasture with scattered beech, holm oak, field maple and rosaceae shrubs
D26c	Wooded pasture with scattered beech, rosaceae shrubs and juniper
D27b	Wooded pasture with scattered holm oak, field maple and rosaceae shrubs
D28b	Rosaceae shrub formation with scattered holm oak, chestnut and grassland with *Pteridium aquilinum*
D30b	Pasture with scattered rosaceae shrubs
D45	Wooded pasture with scattered beech, holm oak and rosaceae shrubs
D46	Rosaceae shrub formation with scattered beech, rosaceae shrubs, holm oak and maples
C1c	Wooded pasture with scattered holm oak, holly and rosaceae shrubs
C2	Rosaceae shrub formation with scattered beech, holm oak and maples
C7c	Rosaceae shrub formation with scattered beech, rosaceae shrubs, holm oak, maples and holly
C8c	Wooded pasture with scattered beech, holm oak, field maple and rosaceae shrubs
C9b	Wooded pasture with scattered beech, holm oak, field maple and rosaceae shrubs

3.10 Potential biomass production and share available for bioenergy production

The potential biomass available for energy use was calculated considering only woody products (trunk and branches) deriving from tree species with little commercial value for lumber (Table 13).

For the trunks, we considered a maximum DBH of 10 cm for holm oak, other oaks, and ash trees, of 20 cm for cypress and cedar, and of 30 cm for all the pine trees, except for *Pinus halepensis*, the parts of which were always considered as combustible.

Table 13. The available woody biomass for energy use in each compartment.

Compartment	Forest Type	Available woody biomass [t/ha]	Available biomass for energy use [t/ha]	Available biomass for other assortments (firewood, timber, ecc.) [t/ha]	Area [ha]	Total available biomass for energy use in the compartment [t]
D16	Beech woods	11,7	5,0	6,8	16,3	191,29
D17	Mesophile calciphile beech woods	22,4	6,5	15,9	6,0	133,82
D18	Mesophile calciphile beech woods	19,8	5,1	14,7	10,2	201,60
C8a	Mesophile calciphile beech woods	5,9	2,5	3,5	8,1	47,66
C8b	Mesophile calciphile beech woods	7,3	3,2	4,1	39,7	289,94
D3	Meso-xerophile calciphile beech woods	77,2	21,4	55,8	4,1	314,93
D24	Pioneer beech woods on quartz arenite	28,4	28,4	0,0	24,4	694,30
D25a	Pioneer beech woods on quartz arenite	24,4	24,4	0,0	28,4	692,21
D31a	Broad-leaved trees reforestations	17,8	5,5	12,3	2,8	49,00

Compartment	Forest Type	Available woody biomass [t/ha]	Available biomass for energy use [t/ha]	Available biomass for other assortments (firewood, timber, ecc.) [t/ha]	Area [ha]	Total available biomass for energy use in the compartment [t]
	with sessile oak					
D50	Mediterranean conifer reforestations with *Pinus pinea*	92,1	53,0	39,1	2,5	226,23
C11b	Meso-xerophile oak forests in association with holly and holm oak	13,5	8,4	5,1	0,3	4,24
D22a	Mountain chestnut formations	14,2	4,9	9,3	6,9	97,42
D33	Mountain chestnut formations	10,9	3,1	7,8	1,5	16,08
D27a	Mountain conifer reforestations in association with broad-leaved trees	77,6	20,8	56,8	15,0	1162,67
D28a	Mountain conifer reforestations in association with broad-leaved trees	61,4	16,6	44,8	3,6	220,41

Compartment	Forest Type	Available woody biomass [t/ha]	Available biomass for energy use [t/ha]	Available biomass for other assortments (firewood, timber, ecc.) [t/ha]	Area [ha]	Total available biomass for energy use in the compartment [t]
D29	Mountain conifer reforestations in association with broad-leaved trees	21,4	5,4	16,0	5,0	107,17
D30a	Mountain conifer reforestations in association with broad-leaved trees	79,8	79,8	0,0	12,3	979,29
D31b	Mountain conifer reforestations in association with broad-leaved trees	42,6	17,0	25,6	26,5	1127,35
D34	Mountain conifer reforestations in association with broad-leaved trees	142,3	37,0	105,3	4,2	594,56
D42	Mountain conifer reforestations in association with broad-leaved trees	18,1	7,5	10,6	9,7	175,49
D43	Mountain conifer	12,1	6,7	5,4	17,2	207,98

Compartment	Forest Type	Available woody biomass [t/ha]	Available biomass for energy use [t/ha]	Available biomass for other assortments (firewood, timber, ecc.) [t/ha]	Area [ha]	Total available biomass for energy use in the compartment [t]
	reforestations in association with broad-leaved trees					
D47b	Mountain conifer reforestations in association with broad-leaved trees	19,7	5,3	14,4	3,5	68,27
D13b	Mountain conifer reforestations in association with Manna ash	264,4	71,4	193,1	14,6	3873,28
D14	Mountain conifer reforestations in association with broad-leaved trees	122,8	118,1	4,7	44,4	5453,48
D15	Mountain conifer reforestations in association with broad-leaved trees	107,0	28,1	78,9	2,6	276,54
D25c	Mountain conifer reforestations in association	82,9	22,0	60,9	4,9	406,58

Compartment	Forest Type	Available woody biomass [t/ha]	Available biomass for energy use [t/ha]	Available biomass for other assortments (firewood, timber, ecc.) [t/ha]	Area [ha]	Total available biomass for energy use in the compartment [t]
	with broad-leaved trees					
D26b	Mountain conifer reforestations in association with broad-leaved trees	89,8	36,6	53,2	6,1	547,59
D37	Mountain conifer reforestations in association with broad-leaved trees	59,0	13,3	45,7	0,4	25,61
D38	Mountain conifer reforestations in association with broad-leaved trees	23,3	6,2	17,1	9,4	218,04
D44	Mountain conifer reforestations in association with broad-leaved trees	64,6	17,6	47,0	1,7	108,41
D36	Mountain conifer reforestations with broad-leaved trees	61,3	26,7	34,6	15,2	934,06

Compartment	Forest Type	Available woody biomass [t/ha]	Available biomass for energy use [t/ha]	Available biomass for other assortments (firewood, timber, ecc.) [t/ha]	Area [ha]	Total available biomass for energy use in the compartment [t]
D41	Mountain conifer reforestations with broad-leaved trees	31,3	7,4	23,9	2,7	86,00
D10	Sessile oak formations	103,6	23,4	80,2	7,2	749,31
D12a	Sessile oak formations	51,3	8,8	42,5	1,0	53,14
C1a	Sessile oak formations	67,2	8,4	58,8	2,1	141,13
C3a	Sessile oak formations	93,4	20,4	73,0	10,9	1020,49
C4a	Sessile oak formations	49,6	9,6	40,0	30,7	1524,80
C5a	Sessile oak formations	69,8	16,0	53,8	9,9	692,97
C12	Sessile oak formations	20,2	20,2	0,0	4,1	83,40
D2	Sessile oak with beech woods	48,8	32,4	16,4	12,0	584,41
C13	Sessile oak formations	14,9	14,9	0,0	0,9	12,93

In Figure 18, the share of available woody biomass for energy use sorted by tree species is reported. Only within 10 compartments, the percentage of biomass for energy use exceeds 50%, as it can be observed from the horizontal red line showing the 50% threshold. Within 5 compartments, all the biomass (100%) is destined for energy purposes (100%). This has to be put in relation to the peculiar planned forest interventions and silvicultural orientation. In the D24 and D25a compartments (aged coppices), only thinning of medium intensity (30% of density reduction)

against the lower diameter classes (4-8 cm), was foreseen. In the C12 and C13 compartments (two-layer stratified high forests), thinning (50% of density reduction) only against the sessile oak was foreseen. In the D30a compartment, thinning (30% of density reduction) is foreseen against the higher diameter classes.

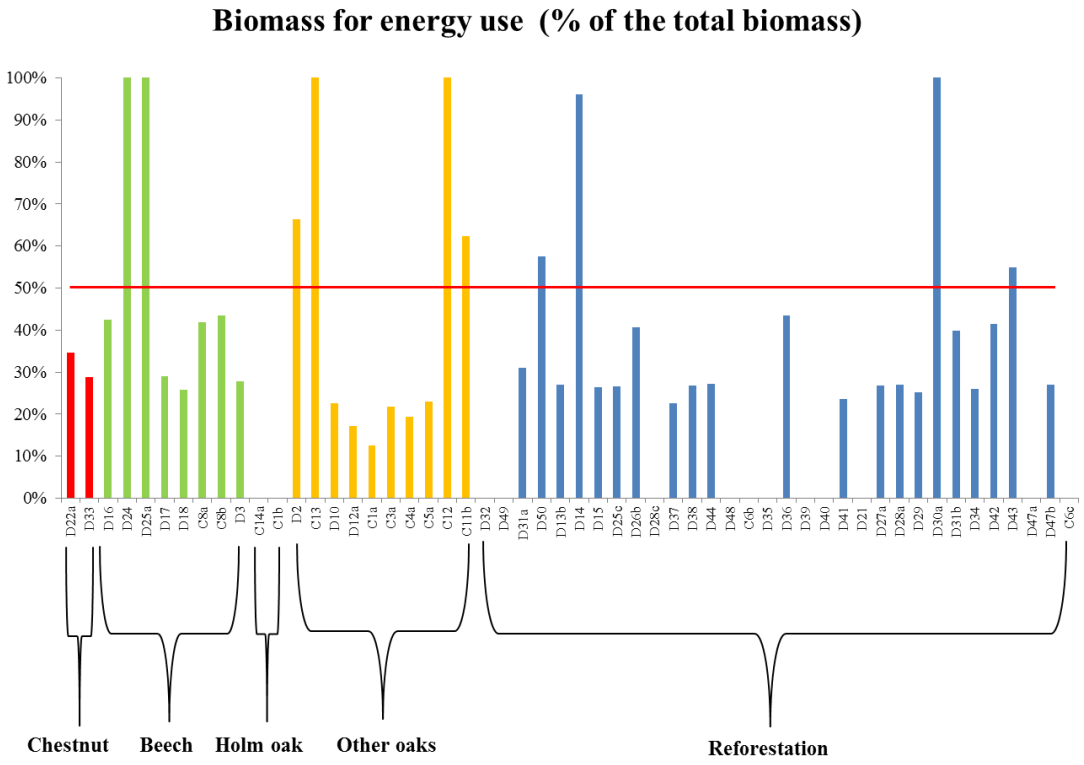

Figure 18. The available woody biomass for energy use sorted by tree species. The horizontal red line indicates the 50% threshold.

In Figure 19, the coefficient of woody biomass utilization sorted by tree species is shown. The coefficient recorded the highest value (generally higher than 30%) within the forest category "reforestation". In the other forest categories, the coefficient is generally less than 20%. An exception is the compartment D3 (a beech stand). However, the particularly high value (>50%) of the coefficient is due to the necessary phytosanitary cutting against the black pine trees to contrast the spread of the pine processionary.

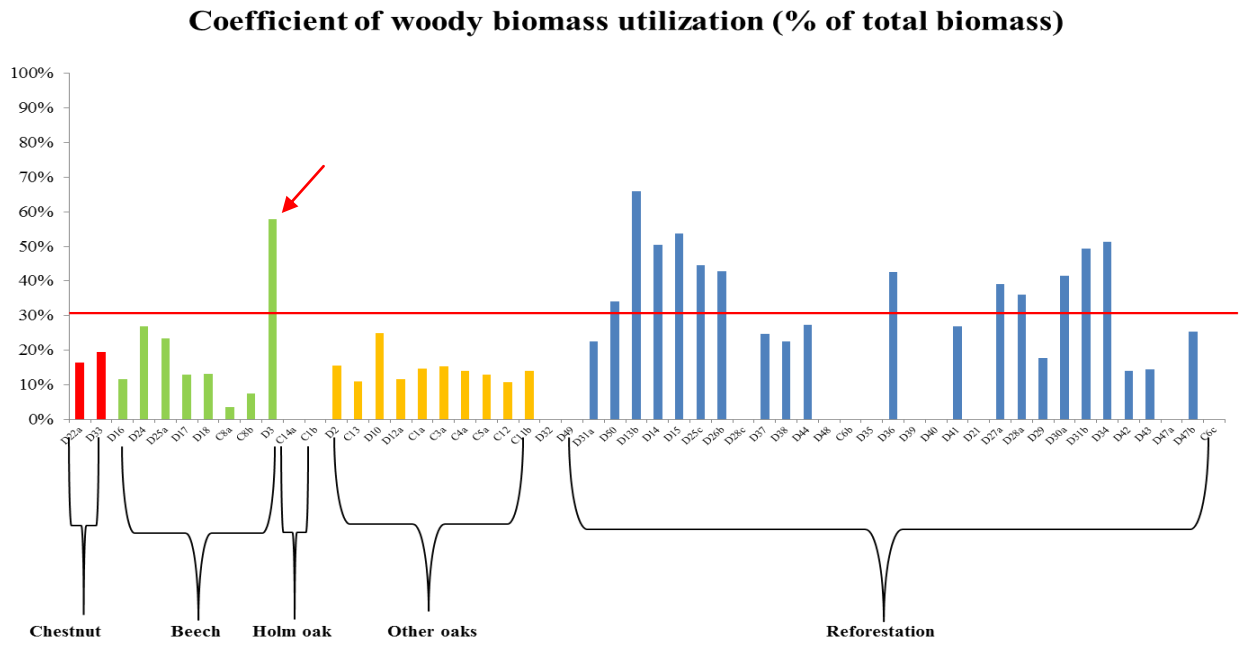

Figure 19. The coefficient of woody biomass utilization in each compartment and grouped by tree species. The horizontal red line indicates the 30% threshold. The red arrow highlights a particularly high value within beech stands.

The average values of the coefficient of woody biomass utilization sorted by tree species is shown in Table 14. On average, the coefficient of woody utilization was about 19% regardless of forest category. Within reforestation forest category the highest value was observed (23,3%), while, conversely, the lowest values were recorded in Downy oak and Sessile oak stands, ranging from 13 to 14%.

Table 14 – The coefficient of woody biomass utilization sorted by tree species.* except the holm oak value.

Forest Category	Coefficient of woody biomass utilization in terms of volume (%)	Coefficient of woody biomass utilization in terms of biomass (%)
Chestnut stands	19,0%	18,0%
Beech stands	19,6%	19,6%
Holm oak stands	0,0%	0,0%
Downy oak and Sessile oak stands	13,4%	14,5%
Reforestation	23,3%	23,3%
Average*	18,8%	18,9%

The woody biomass available from the utilization of forest areas in the Biomass District 4 is shown in Table 15. The available biomass is distinguished in biomass for other assortments (mostly firewood) and biomass for energy use (mostly woodchips). Overall, almost 88,000 t of woody biomass are available, about 63% for other assortments and the remaining 37% for energy use. In detail, almost 30,000 t of woody biomass could be exploitable for energy use in a 10 years long time frame. Furthermore, the availability of woody biomass was also distinguished according to two periods of intervention within within the validity period of the FMP. With this regard, about 71% of the biomass available for energy use can be obtained in the first period (within 5 years), while the remaining 29% can be obtained in the second period (within 10 years). Overall, in the first period (within 5 years), more than 59% of the woody biomass for other assortments is available compared to the biomass potentially available for the whole period of validity of the FMP. This difference between the first and the second period is due to the urgency of the forest interventions in conifers reforestation and aged coppices; however it could be partly adjustable as some interventions could be moved from the first to the second period. These data are very important also to establish an efficient and local forest-wood-energy supply chain.

Table 15 – The woody biomass available within the Biomass District sorted by assortment type and considering the period of intervention within the validity period of the FMP.

Period of Intervention	Total available biomass (t)	% with respect to total biomass	Biomass for other assortments (t)	% with respect to total biomass	Biomass for energy use (t)	% with respect to total biomass
I	55.539 t	63,2%	34.506 t	59,3%	21.033 t	70,9%
II	32.340 t	36,8%	23.708 t	40,7%	8.632 t	29,1%
Total	87.879 t		58.214 t		29.665 t	

For what regards the ownership of forest compartments, most of woody biomass (84,4%) is concentrated in areas belonging to Sicily Region, and only 15,6% to areas belonging to the municipality of Petralia Sottana.

3.11 Inventory of the forest viability and other infrastructures and management prescriptions

Simultaneously to the dendrometric survey, the forestry viability was also surveyed with the compilation of the B3 form. Viability is optimally connected in all the Biomass District (Figure 16).

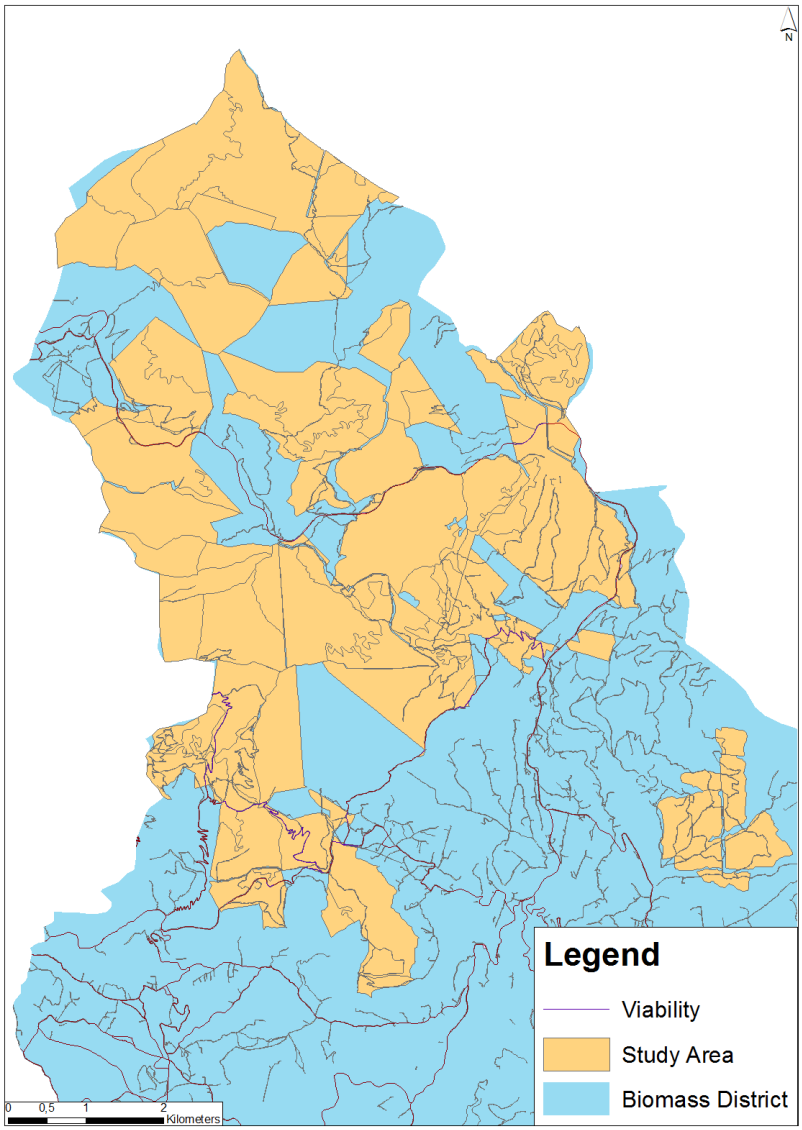

Figure 20. Viability map.

Within the study area, there are three kinds of roads: main viability, ordinary roads and forestry roads. The overall road system is composed of 2 km of main viability, 52,6 km of ordinary roads and 70 km of forestry roads (Forestry Informative System of the Sicily Region). All this road types are easily accessible to forestry tractor, and an off-road vehicle can traverse these roads during all the year. This is an optimal condition to fire prevention activity. Unfortunately, some road tracts are in bad conditions to permits the transit to vehicles. In these sections, the remaking of the road surface is necessary to guarantee a safe journey to the vehicle. All the track must be at least 2,5 meters

wide. The tracts with high slope should be provided with drainage facilities, the function of which is to convey the water flow out of the roadway, thus avoiding the formation of rill erosion and the deterioration of the road surface. These drains must be of a type suitable for the passage of vehicles and pedestrians. The spacing between drains and their positioning along the road must follow the instructions given by Hippoliti, 2003 (Table 15).

Table 15. The recommended distance between drains according to road condition.

Slope (%)	**Spacing between drains [m]**	
	Good conditions	Bad conditions
8	40	30
10	36	26
12	32	22
14	28	18
16	25	15
18	22	12
20	20	10

3.12 Management prescriptions for the pasture and the wild fauna

Sicily is a large island reaching the extension of the Apennine area. During the phases of connection with the mainland, in the Quaternary, the coastal chains, from the Peloritans to the Madonie, were colonized by species of northern origin. Today they are mainly concentrated in the beech woods on the most humid slopes facing the sea. The Sicily fauna includes a significant number of paleo-Mediterranean and paleotyrrenic species deriving from the tertiary faunas of the Tyrrhenian areas. These species are not only found in the hypo- and endogenous fauna, but they are also numerous in the epigean fauna and constitute a much richer pre-quaternary contingent than in the Apennine province. It's high the importance of the faunistic heritage in Madonie mountains. Among rapacious birds there are the golden eagle (*Aquila chrysaetos*), the smallest eagle of Bonelli, peregrine falcons and many others. In recent years, a deer population is increasingly colonizing large areas in the park, and the same holds for the wild boar population. Forest grazing is a common practice in Mediterranean environments, enabling livestock to find either alternative forage sources during summer, when herbs and grasses are not available, or to have shelter during the hottest hours of the day. However, the maximum grazing pressure tolerable by forest stand must not be exceeded,

especially for its strong negative effect on natural regeneration by tree species. It is also necessary to establish and implement appropriate control plans against wild fauna.

3.13 Connections of the FMP with the other planning tools

Analyzing the management objectives and what is indicated for the aforementioned areas in the FMP in question, there is no direct or indirect interference regarding the realization of the prescribed works, which, conversely, do not conflict with the other planning tools actually in force in the area. Particularly, the forest interventions were planned not to impact the conservation status of habitat and species of scientific and conservation importance, like those listed in the management plans of the Natura 2000 areas falling within the Madonie Natural Park (i.e. ITA020004 “M. S. Salvatore, M. Catarineci, V.ne mandarini, Ambienti umidi”, ITA020016 “M. Quacella, M.Dei Cervi, Pizzo Carbonara, M. Ferro, Pizzo Otiero”, ITA020015 “Complesso calanchivo di Castellana Sicula”, and ITA020050 “Monti Madonie”).

3.14 Assessment of impacts by the FMP

The planned interventions are not expected to cause significant, persistent and non-reversible changes to the current characteristics of habitats, particularly those of European or Regional interest. As explained in the Deliverable 3-5-1, the Reduced-Impact Logging (RIL) prescriptions were adopted in the FMP. Such prescriptions consider both the biotic and the abiotic elements of forest ecosystems. Particularly, we considered that:

1. The more intensive harvesting practices, such as clear cutting or shelterwood system, may have tangible impacts on the amount of deadwood and litter, on the activation of erosive phenomena, on changes of fuel model features;
2. Thinning and salvage cuttings or (in limited cases) crown pruning activities are more sustainable;
3. Storing and yarding operations by tractors and winches have more impacts than by raceways;
4. Chipping is always a sustainable post-harvesting practice.

Silvicultural operations such as thinning, aimed at constituting coppice with standards systems and high forest systems, would be beneficial in some instances, with the long-term goal of creating more evolved ecosystems and favouring seed reproduction instead of agamic reproduction. Regarding storing activities, the use of raceways should be preferred when technically possible. Then, a small number of trails could reduce the direct impact on natural vegetation and

regeneration and associated impacts due to personnel activity. Fire prevention measures should take place as well, taking into account vegetation spatial distribution and different plant adaptations to fire.

Such silvicultural practices are expected to be beneficial on the long-term, leading the conversion towards coppices with standards and high forests, with expected increases in habitat complexity and resource availability for animal taxa strictly linked with forest ecosystems (e.g. the saproxylic beetles). In effect, such silvicultural practices are actually similar to the effects of natural small-scale disturbance, resulting in an increased environmental heterogeneity, and possible beneficial effects on the local biological communities.

3.15 Final remarks

The field surveys carried out for the drawing up of the forest management plan are a crucial step for the opportunity of setting up an efficient and sustainable local forest-wood-energy supply chain. The naturalistic, environmental and landscape restrictions were taken into account for the drafting of the FMP. The woody biomass could be obtained from forests, which cover about 2,700 ha, 9% of the total District area. From the forest partitioning activity, 29 compartments falling within the Municipality of Petralia Sottana, and 73 compartments falling within territories belonging to Sicily Region, were identified and located on the ground. For each compartment, the morphological characteristics (altitude, slope, aspect), the damages by livestock and wild fauna, as well as the accessibility data were provided. Field surveys have been carried out to collect dendrometric data, only in the 54 actively managed compartments. The necessary information to define the silvicultural orientation has been collected (e.g. information about any recent interventions). The overall woody biomass available from forest management activities was distinguished in two possible assortments: energy use (woodchips) and other assortments (mostly firewood). The potential biomass available for energy use was calculated considering only woody portions (trunk and branches) deriving from tree species with little commercial value for lumber (Table 13). For the trunks, we considered a maximum DBH of 10 cm for holm oak, other oaks, and ash trees, of 20 cm for cypress and cedar, and of 30 cm for all the pine trees, except for *Pinus halepensis*, the parts of which were always considered as combustible. Only within 10 compartments, the percentage of biomass for energy use exceeds 50%. The coefficient of woody biomass utilization recorded the highest value (generally higher than 30%) within the forest category “reforestation”. In the other forest categories, the coefficient is generally less than 20%. On average, the coefficient of woody

utilization was about 19% regardless of forest category. Within reforestation the highest value was observed (23,3%), while, conversely, the lowest values were recorded in Downy oak and Sessile oak stands, ranging from 13 to 14%. Overall, almost 88,000 t of woody biomass are available, about 63% for other assortments and the remaining 37% for energy use. Almost 30,000 t of woody biomass could be exploitable for energy use in a 10 years long time frame. About 71% of the biomass available for energy use can be obtained in the first period of interventions (within 5 years), while the remaining 29% can be obtained in the second period (within 10 years). Overall, in the first period (within 5 years), more than 59% of the woody biomass for other assortments is available compared to the biomass potentially available for the whole period of validity of the FMP. This difference between the first and the second period is due to the urgency of the forest interventions in conifers reforestation and aged coppices; however it could be partly adjustable as some interventions could be moved from the first to the second period. These data are very important to establish an efficient and local forest-wood-energy supply chain. In the Biomass District 4, the woody biomass for energy use that can be obtained from the sustainable forest management (within a FMP) is significant (≈ 30,000 t). There is the potential to build small biomass plants, which must be suitably sized and placed so as to constitute a short supply chain that is actually sustainable from an ecological and socio-economic point of view. There are many critical aspects (highlighted in other activities of the Project), which can only be overcome through the involvement of all the stakeholders along the whole potential supply chain (managers of protected areas, regional forestry body and departments, DRSRT, environmental associations, producers of biomass, forest companies, etc.).

4. THE FOREST MANAGEMENT PLAN WITHIN THE BIOMASS DISTRICT OF PIVKA WITHIN PIVKA LAKES NATURE PARK (SLOVENIA)

In Slovenia, Forest Management Plans (FMP) are prepared by Slovenian Forest Service (SFS). They are prepared on the scale of forest management units, regardless the ownership. In case that forest owners express the need for more detailed forest management guidelines, summaries from the forest management plans are prepared.

Due to the reason the Forest Management Plans are already prepared and in use in Slovenia, we decided to prepare Forest Property Management Plans (FPMP), which are more adjusted and forest owners could put in direct use. We tried to identify forest owners with larger areas, several forest owners, willing to cooperate and with combination of municipal land (representative of the Protected Area – Pivka lakes nature park) to define an area, for which the FPMP is prepared.

As the detailed area for FPMP is not yet defined, the following chapters (4.1 – 4.6) are prepared for forest management units, within which the area for FPMP will be defined.

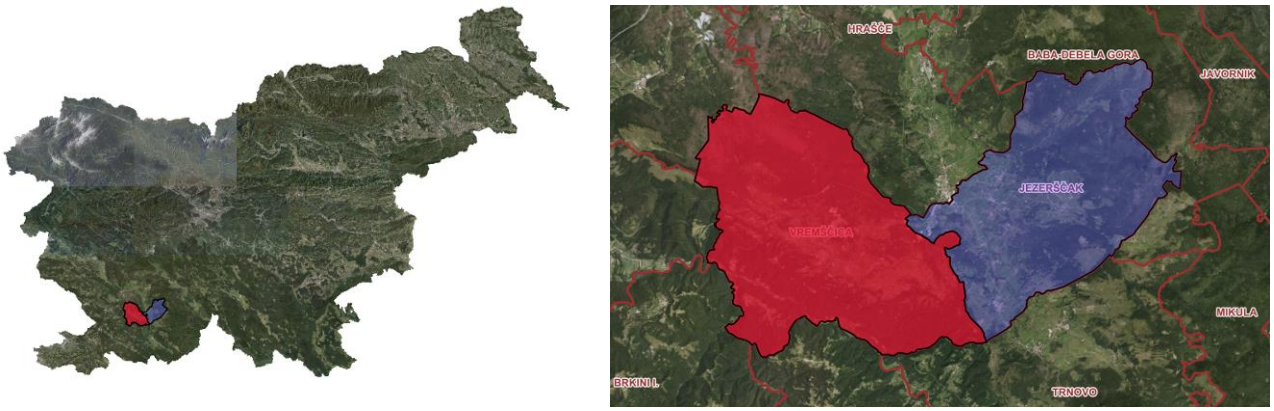

Figure 1: The forest management units Jezerščak (blue colored) and Vremščica (red coloured) (source: ZGS, Pregledovalnik podatkov o gozdovih, 2019)

The Pivka municipality forest lies in two management units – Jezerščak and Vremščica. FMP of forest management units Jezerščak and Vremščica that cover the core and buffer zone of Pivka lakes nature park as well as the buffer zone of Škocjan Caves Regional Park were used as a source of information to complete the following chapters (4.1 – 4.5). The area for which the FPMP will be prepared is a part of the core and buffer zone (influence area) of Pivka lakes Nature Park and the buffer zone of Škocjan Caves Regional Park (Figure 2).

Figure 2: Core (violet coloured area) and buffer zone (beige coloured area) of Pivka Lakes Nature Park and buffer zone of Škocjan Caves Regional Park (green coloured area) on the IR DOF (source: ARSO, Atlas okolja, 2019)

4.1 National and regional legislative framework

Small scale forestry parcels are common in Slovenia. Larger and undivided forest estates of state-owned forests enable good professional management. Private forest estates are small, with an average area of only 3 ha and even these are further fragmented into several separate plots. For the great majority of the owners these estates are not of economic interest.

Forest management districts are territorial ecosystem units that are defined to ensure the sustainability of forests and forest management plans, to guide development and to ensure forest development monitoring, regardless the ownership. Forest management districts are divided into smaller forest management units.

National legislation is covered by the Act on Forests (Zakon o gozdovih, 1993) and all of the rules and decrees, subsidiary to this act.

Under the Act on Forests, the property right has to be carried out in such way that ecological, social and production function of the forests is ensured. Forest owners have to manage their forest in accordance with the forest management and silviculture plan.

In Slovenia forest management plans are prepared by Slovenian Forestry Service (SFS) for all forests in the country, regardless the ownership. Preparation of forest management plans is a task of public forestry service of each regional unit of SFS, that is entirely financed by Republic of Slovenia.

Forest Management Plans for Forest Management Districts (Figure 3, left picture) and for Forest Management Units (Figure 3, right picture) are prepared every 10 years. The Minister responsible for forestry determines the public disclosure of the forest management plan. As well he is responsible to adopt the forest management plan with a rule on the forest management plan for certain forest management district or unit.

Forest owners have a right to participate in the process of forest management plan preparation and adoption. Their needs, proposals and requirements are taken into account in accordance with ecosystem and legal constraints.

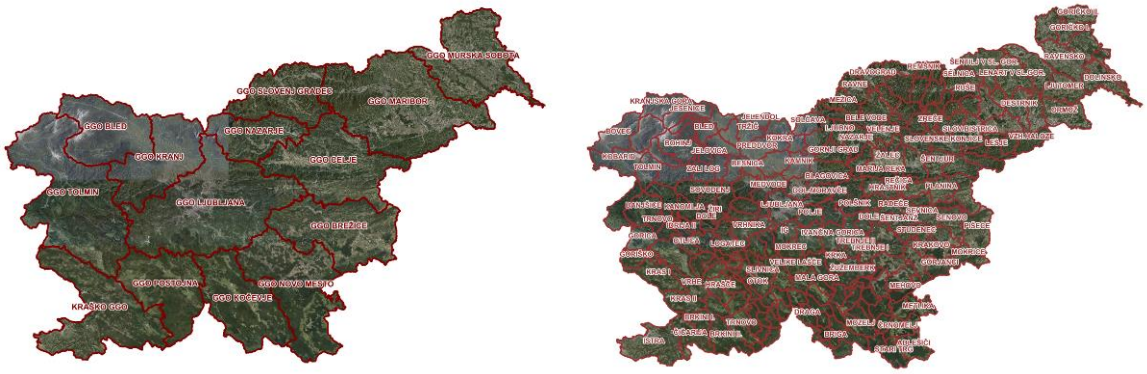

Figure 2: Forest management districts (left) and forest management units (right) (source: ZGS, Pregledovalnik podatkov o gozdovih, 2018))

4.2 Geographical framework

Pivka Lakes Nature Park is a landscape park founded by the Pivka municipality, in which it covers almost 15.000 ha. The Pivka Lakes Nature Park buffer zone covers approximately 66% of the Pivka municipal area. The FPMP will be prepared for the area within the core and buffer zone of Pivka Lakes Nature Park and as well within buffer zone of Škocjan Caves Regional park.

Municipality of Pivka belongs to Primorsko-notranjska statistical region, that lies on the southwestern part of the country. The area for FPMP has been defined mainly within the municipality of Pivka, the area that was defined as a biomass district in the previous project activities (3.4). Due to the reason, already explained above, the area for which the FPMP will be prepared is smaller than the recognized biomass district.

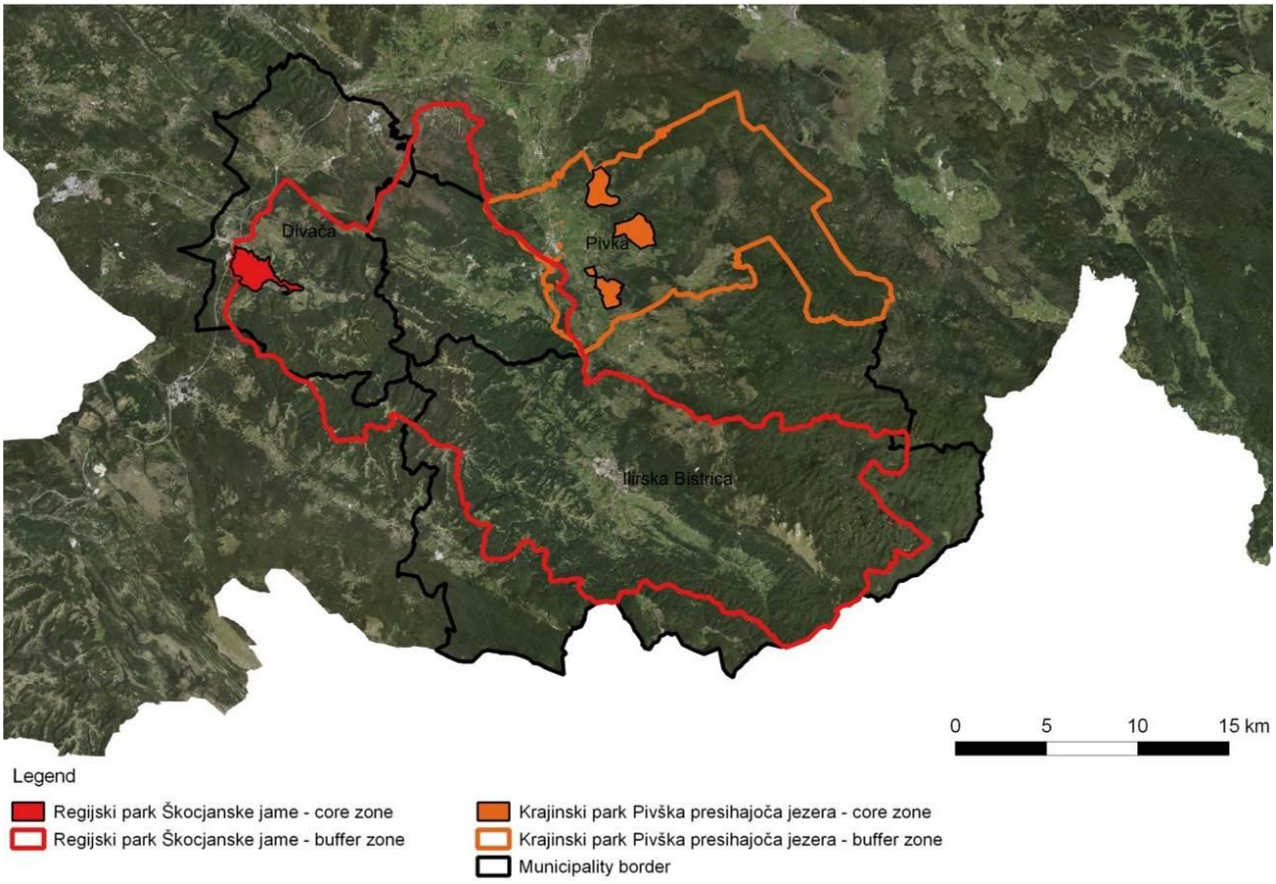

Figure 3: Administrative borders and protected areas (source: ARSO, Atlas okolja, 2018)

The Pivka basin where the Pivka Lakes Nature Park lies is a large depression among high karst plateaus of Nanos (1313 m), Hrušica (1264 m), Javorniki (1268), low plateau Slavenski ravnik (600 – 700 m), Snežnik (1796 m), and flysch hills that form a catchment area of the Reka river. The northern part of the basin was formed in noncarbonate flysch rocks with superficial drainage, while the southern part of the Upper Pivka basin was formed in limestone and has some characteristics of a karst polje. The surface of the Upper Pivka basin can be divided into two distinctive morphological units: levelled bottom of the basin and higher rocky terrace along the Javorniki mountains. Depressions of the Pivka lakes are deepened into the terrace. Most of the depressions of the Pivka lakes are doline-like. High karst water table enables appearance of water on the surface and formation of the lakes. It also influences that soil and sediments are not washed away deeper into the karst. As many as 17 regularly occurring lakes are as follows: Šembijsko jezero, Kalsko jezero, Laneno jezero, Bačko jezero, Kljunov ribnik, Veliki dol (za Kalcem), Malo Zagorsko jezero, Veliko Zagorsko jezero, Veliko Drskovško jezero, Malo Drskovško jezero, Parsko jezero, Radohovsko jezero, Klenski dol, Palško jezero, Petelinjsko jezero, Krajnikov dol and Jeredovce. Furthermore, several

other flooded karst depressions of different extent were observed, such as Nariče, which is a part of Šembijsko jezero, and the extensive flooding area around Knežak and Bač (Mulec et al, 2005). In addition to the relief, the climate of the cultivated area is primarily a decisive geographical position between the Adriatic Sea in the continental part of Europe. The climate effects of the Atlantic and the Mediterranean on the continent are mixed here, so the swamp regions are of a very transient type. For the local microclimate, the high-quality karst plateaus and peaks, which direct the air currents and the proximity of the Trieste and Kvarner Bay, are of decisive importance (ZGS, 2012).

4.3 Type and description of the forest ownership

The data on the forest ownership are obtained from the forest management plans of forest management units Jezerščak and Vremščica. Within the management unit Vremščica that covers 7.430,72 ha, 67,5 % of the area is covered by forests. The forest is mainly private forest (92 %), 7 % represent the state-owned forest and a small share (0,5 %) of the forests is owned by local communities.

Table 1: Ownership of forests within Vremščica forest management unit

ownership	private forests	state owned forests	community forests	sum
surface of forests (ha)	4.599,97	390,76	24,59	5.015,32
share (%)	91,70	7,80	0,50	100

Private forest properties are medium size, 17 % of the landowners own a forest estate, smaller than 1 ha. Properties smaller than 1 ha together cover 24 % of the forest areas within the management unit. Only six forest estates are larger than 30 ha and there is no forest estate bigger than 100 ha in this management unit. On average forest estate covers 2,2 ha.

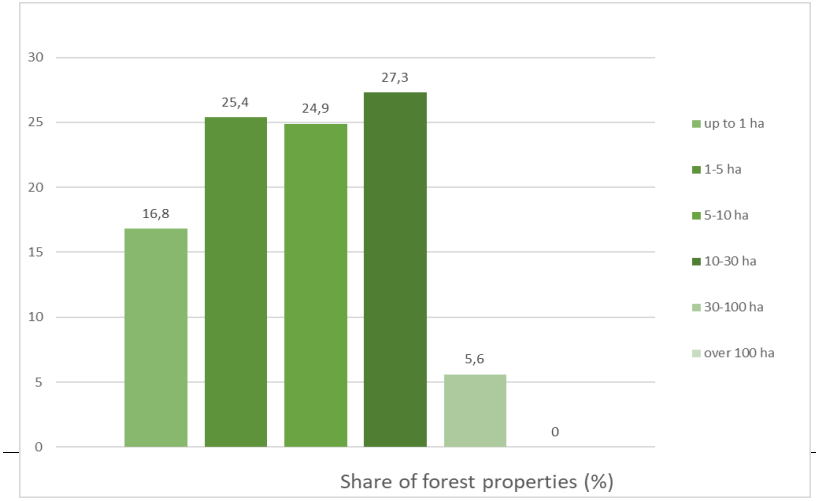

Figure 4: Share of private forest properties considering their size

Within the forest management unit Jezerščak that covers 6.128,37 ha, 57% of the area is covered by forests. The forest is mainly private forest (89%), 11% represent the state-owned forest and a negligible share of the forests is owned by communities.

Table 2: Ownership of forests within Jezerščak forest management unit

ownership	private forests	state owned forests	community forests	sum
surface of forests (ha)	3.122,74	367,22	3,59	3.493,55
share (%)	89,40	10,50	0,10	100

In private forest, there are 1.077 forest properties. Forest properties are small; 57% of the forest owners' own properties, smaller than 1 ha and they cover 6% of the forest area. Only 2% of forest owners own forest estate larger than 30 ha. On average forest estate covers 3,24 ha.

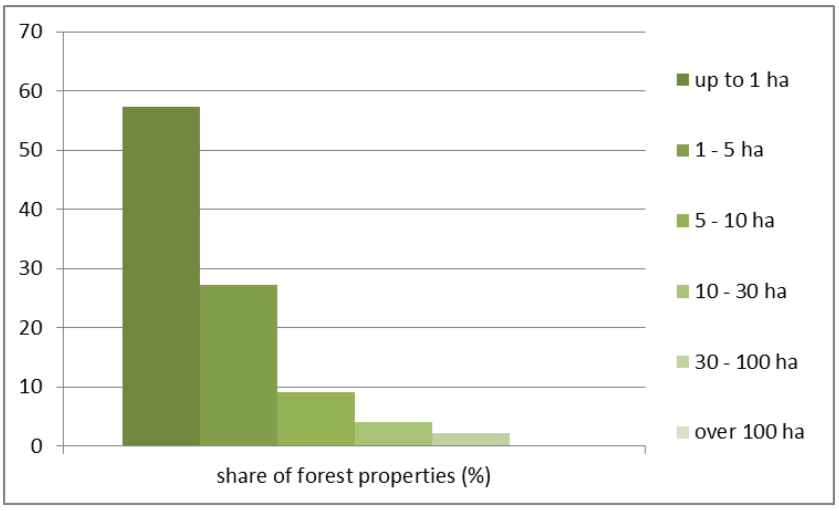

Figure 5: Share of private forest properties considering their size

Forest owners in this two forest management units are generally older people, that are already retired. Younger forest owners are employed in other sectors, mainly in Pivka and Postojna, some of them commute to Ljubljana and Koper. Although there are not many farmers who depend on the income from forests, it represents an important complementary activity for forest owners that own larger forest properties.

4.4 Synthesis of environmental features

The nature in the Pivka lakes nature park faces two contradictions: on one hand lack of water and heavy droughts during dry summers, and on the other vast volumes of water and floods during high precipitations, which prevent maintaining of adequate dry fields and meadows. Generally, it is a hilly karst area that belongs to high karst. It is characterized by diverse relief with sinkholes, valleys, ridges and slight tops of the hills. The highest peak in the area is Lonica (1124 above sea level) and the lowest point is 510 above sea level.

Generally, the project area is geologically divided between permeable limestone bedrock areas and impermeable flysch with alluvium. The most represented soils in the area are *Rendic Leptosol, Chromic cambisol, Dystric Cambisol and Eutric Cambisol*.

Duality in the bedrock is visible in the soils. On the carbonate rich bedrock in karst and mountainous part of the area are formed *Chromic Cambisol*, brown forest soil and rendzina; the type of the soil and their depth alternate over short distances. On flysch district cambisol is formed. Due to quicker weathering the soil is deeper but because of impermeable bedrock, it is more affected by erosion.

The great share of the area lies on the carbonate rich bedrock and due to this reason, no surface watercourse is present on this part the major part of the year. The most important is River Pivka which is a disappearing river, typical for karst areas.

The Pivka valley belongs to two phytogeographical areas: Submediterranean and Dinaric. The seasonal flooding of the Pivka lakes creates special growing conditions for some very interesting plant species as the floods last from some days to, in extreme circumstances, even to half a year.

Vegetation period is generally in lowlands from end of April until end of October, in mountains from middle of May until the end of September and varies each year. The annual timing of spring phenological phases (beech (*Fagus sylvatica* L.) and oak (*Quercus robur* L.) leaf unfolding, hazel (*Corylus avellana* L.) flowering and spruce (*Picea abies* A. Dietr.) growing young shoots), which are largely a response to temperature and reflect thermal conditions of the current year and location, shows around a difference of a month between area around Divača and Ilirska Bistirca and highest parts of Snežnik.

Considering the climate classification, the area is classified as an area with moderate climate or hilly region. Only a small part is classified as an area with Submediterranean climate.

4.5 Naturalistic, environmental and landscape restrictions

When talking about forest management we need to consider naturalistic, environmental and landscape restrictions. Slovenian FMPs already contain the restrictions which we follow and integrate in forest management

4.5.1 Environmental restrictions

Municipal forest of Pivka, for which the forest property management plan will be prepared are part of the protected area Pivka Lakes Nature Park. The Park is founded by the Pivka municipality, in which it covers almost 15.000 ha. The core and buffer zone of Pivka Lakes Nature park are present in the municipal forest as well as the buffer zone of Škocjan Caves Regional Park (Figure 7). Škocjan Caves Regional Park covers 4,13 km^2 of protected area and 450 km^2 of buffer zone, which extends all the way to Pivka.

Many outstanding natural values are present in the protected area around municipal forest. Their origin is strongly connected with karst area and the limestone bedrock (intermittent lakes and river, karstic caves…).

Figure 6: Protected areas (ARSO, Atlas okolja, 2018). Grey = municipal forest, Striped = buffer zone of Škocjan Caves Regional Park and Pivka Lakes Nature Park, Green = Pivka Lakes Nature Park

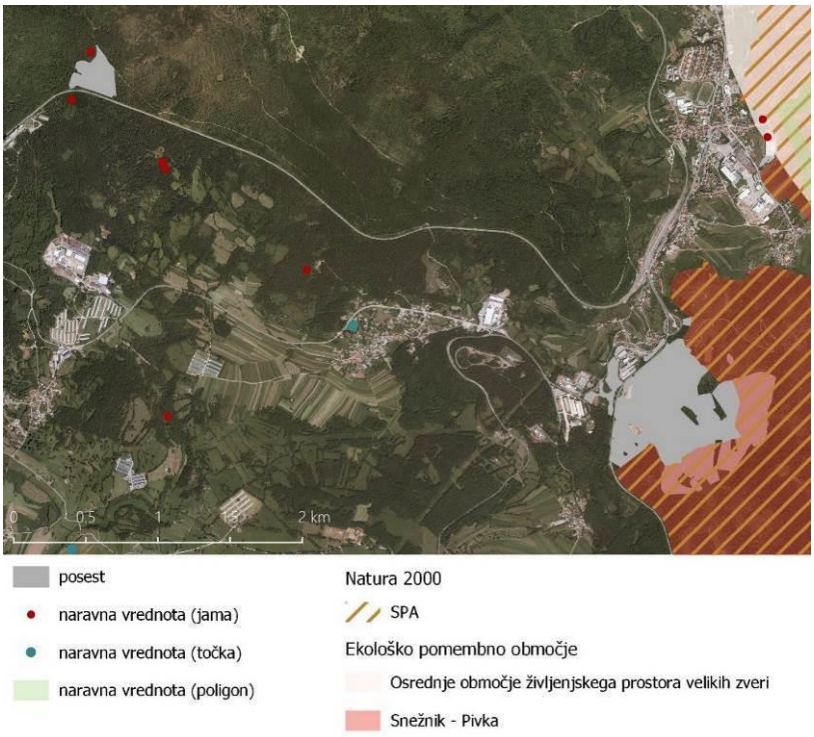

Figure 7: Natural values of local (red and blue colour) and Natura 2000 area (striped and pink colour). The municipal forest is marked in grey colour (ARSO, Atlas okolja, 2018)

4.5.2 Natura 2000 network

Natura 2000 Network is covering a great part of forest management units Jezerščak Vremščica. Within the area of our concern (municipal forest), characteristic species and habitat types and their needs will have to be assessed from the forest management point of view. The following Natura 2000 sites cover a major part of Pivka Lakes Nature Park:

- SI 5000002 Snežnik – Pivka (Special Protection Area) and
- SI 3000231 Javorniki – Snežnik (Special Area of Conservation).

In municipal forest of Pivka, Natura 2000 SPA Snežnik – Pivka covers a part of the property (Figure 8), the same part is protected as Ecologicaly important area. The major part of Pivka municipality is a living area of brown bear (*Ursus arctos*).

4.5.3 Forest functions

Close to nature forestry is based on management that considers all functions as important (forest management and ecological function can be equally important). Functions and their importance (3 levels) are recorded in FMPs. Function of the 1st level is in superior position; all other functions are subordinate to this function. In the area of municipal forest next functions are stressed out:

- Ecological functions (1st level): climate function and biodiversity conservation function (figure 9)
- Social functions (1st level): protective, hygienic and defensive (military) function (figure 10)

Due to the development of the area and the development of the Military History Park, more attention should be paid to the recreational and tourist functions. Production functions of the 1st level in the area of municipal forest are not defined.

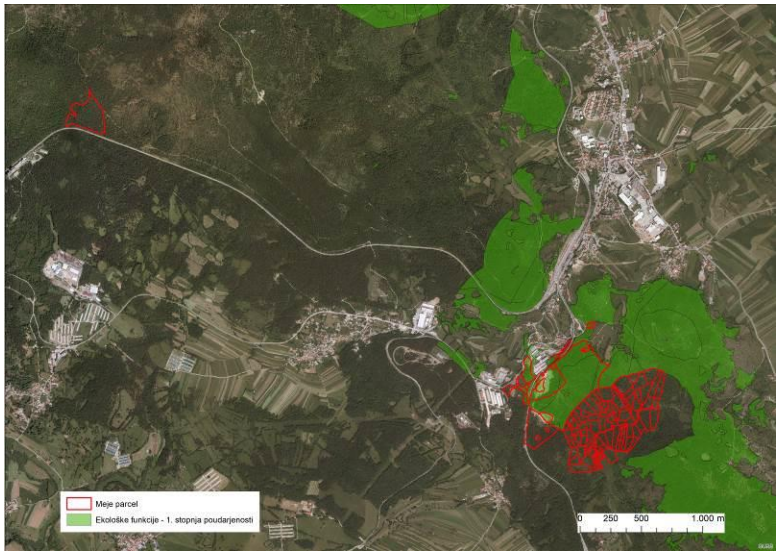

Figure 8: Ecological functions of 1st degree (green coloured), red lines represent the borders of municipal forest (ZGS, 2019a; GURS, 2019)

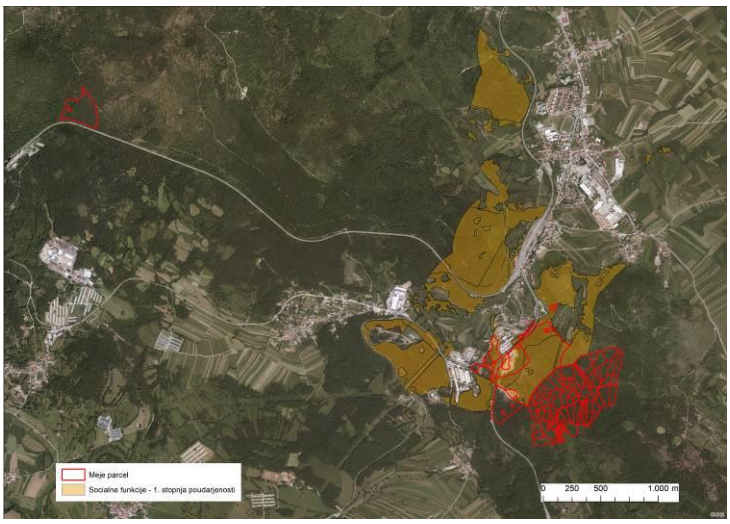

Figure 9: Social functions of 1st degree (brown coloured), red lines represent the borders of municipal forest (ZGS, 2019a; GURS, 2019)

4.5.4 Fire risk

In the forests in forest management unit Jezerščak the fire risk is high due to mainly western slopes, Submediteranean climate and thermophilus vegetation. 77% of the forest are categorized as a forest with extremely high fire risk. This are the forests of *Pinus nigra* and *Pinus sylvestris*, predominant in the forest management unit.

Forests of *Pinus nigra* that cover 19 % of the forest management unit Vremščica are as well categorized as a forests with extremely high fire risk. High fire risk is present on 18% of the forests in FMU Jezerščak and 21% of FMU Vremščica. The most endangered are pine plantations and deciduous warmth-loving species (*Ostrya carpinifolia*, *Quercus sp.)* on droughty sunny slopes.

Due to high risk of fire, fire separators and paths are frequent within the area.

4.6 Forest types and agricultural land use

The area for which the forest property management plan will be prepared is mainly heavily changed forest of *Pinus nigra* and forests or a former agricultural area, used as pastures, that are more and more overgrown with shrubs.

Overgrowing of the meadows and pastures present quite a big problem in the area. Because of the abandonment of the agriculture and farming, the meadows are becoming more and more overgrown with bushes and are somewhere changing into forest already. In the municipal forest the share of meadows and pastures, mainly overgrowing, is high - 36 % (20 ha). The main species overgrowing these areas are hazel (*Corylus avellana)* and different types of shrubs. The meadows and overgrowing areas in the Municipal forest are presented in figure 11.

Municipality of Pivka plans to preserve meadows and pastures in their ownership, since they are an important cultural and natural heritage. Many of them are protected as Natura 2000, because of rare animal and plant species, such as birds, butterflies and other.

In the table 3 some basic information of the forest sections within municipal forest are present. More information about Municipality forest is present in chapter 4.8.2 Results of dendrometry inventory.

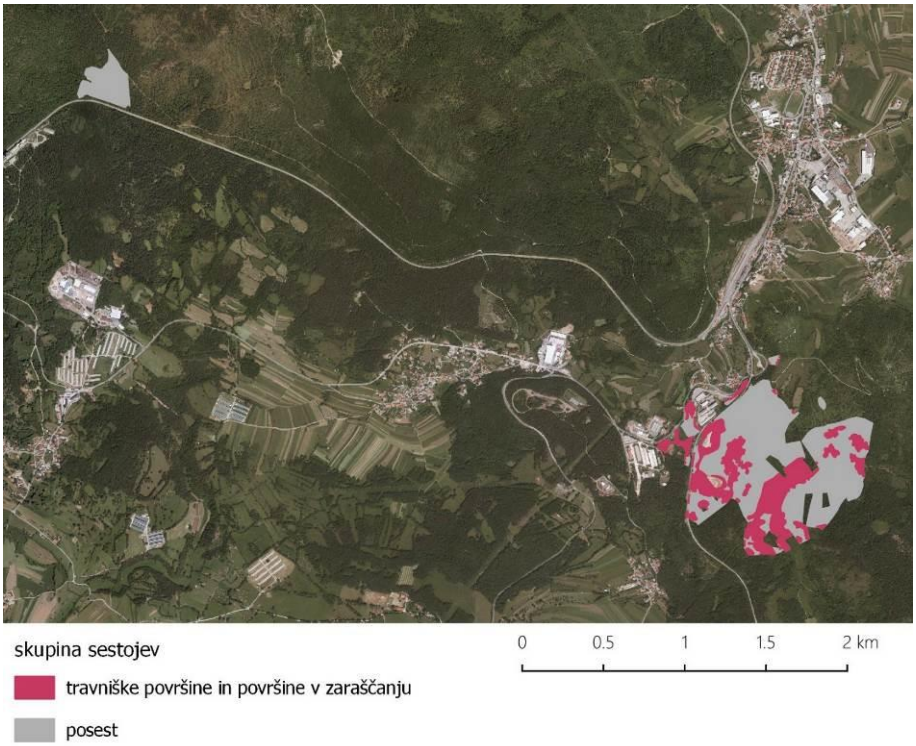

Figure 10: Red patches present overgrowing areas within the municipal forest (MKGP, 2019; GURS, 2018)

Table 3: Plant communities, tree species and other details regarding municipal forest ZGS, Pregledovalnik podatkov o gozdovih, 2019)

Section	surface (ha)	Plant community	Tree species	Forest functions of 1. degree	Growing stock m^3/ha	Naturalness
FMU Jezerščak						
05C03	42.35	Pine stand on Seslerio-autumnalis - Fagetum typicum	Mature stand of Pinus nigra mixed with Pinus sylvestris, Ostrya carpinifolia, Fraxinus ornus and F. excelsior.	Biotop, protective, recreational functions	100	Heavily changed forests (71 do 90 %)
05C07	3,60	Pine stand on Seslerio-autumnalis - Fagetum typicum	Regeneration stand – Pinus nigra mixed with Ostrya carpinifolia	Protective fundtion	165	Heavily changed forests (over 90 %)
05C08	4.98	Pine stand on Seslerio-autumnalis - Fagetum typicum	Mature stand of Pinus nigra and Pinus sylvestris. Young stand of Quercus sp., Pinus nigra and Fraxinus	-	140	Heavily changed forests (71 do 90 %)

			ornus.			
05C09	16.37	Pine stand on Seslerio-autumnalis - Fagetum typicum	Mature stand of Pinus nigra mixed with Pinus sylvestris, Ostrya carpinifolia, Fraxinus ornus and F. excelsior	Protective fundtion	112	Heavily changed forests (71 do 90 %)
05C10	18.16	Pine stand on Seslerio-autumnalis - Fagetum typicum	Mature and pole stand of Pinus nigra mixed with Pinus sylvestris and Fraxinus ornus	Biotope and protective function	107	Changed forests (31 do 70 %)
FMU Vremščica						
04058B	9.27	Pine stands at sites of heat-resistant deciduous trees on carbonate - coastal oaks and Ostrya carpinifolia - secondary society	Regeneration stand of Pinus nigra, Qercus cerris, Picea abies and Abies alba	Hydrological function	117	Heavily changed forests (71 do 90 %)
04081A	48.09	Pine stands at sites of heat-resistant deciduous trees on carbonate - coastal oaks and Ostrya carpinifolia - secondary society	Mature stand of Pinus nigra, Qercus cerris Pole stand of Fraxinus ornus, Ostrya carpinifolia, other decidous trees and Pinus nigra	Defense function	133	Heavily changed forests (71 do 90 %)
04081B	50.45	Forests of heat-resistant deciduous trees on carbonates - coastal oak and Ostrya carpinifolia - secondary society	Pole stand of Quercus cerris, Pinus nigra and other deciduous trees	Protecting forest land and stands, tourist function and hounting founction	85	Changed (31 do 70 %)

4.7 Forest partitioning and description

In Slovenia, Forest management plans (FMP) are prepared by Slovenian Forestr Service. Plans are prepared on tree levels:

- FMP for forest management district

- FMP for forest management unit and
- Silvicultural plan, which is more detailed plan, prepared on the level of a forest section.

All management units are further divided to forest sections and further to forest stands (figure 12).

Figure 11: Map of forest stands within the Municipal forest of Pivka (source: ZGS, Pregledovalnik podatkov o gozdovih, 2019)

4.7.1 Methodolgy

Forests owned by the municipality of Pivka are part of the management units Jezerščak and Vremščica. Because of the changes of the stands, which are the result of natural disasters (wind and ice storm), the description of the stands is not summarized by the forest management plans of these two units. On the basis of field measurements carried out in March 2019, a new stand map was prepared for these forests (area of 55.76 ha). The previous stand map was last updated in 2009 (management unit Jezerscak) and 2017 (management unit Vremščica). In the same years, the Forest Management Plans was updated; 2009 (Jezerščak) and 2017 (Vremščica).

The estate of the municipality of Pivka, for which we made the stand map, is divided in two locally separated units. The larger forest complex near Pivka covers 49.80 ha (89.3%) of forests, while the smaller part, which lies approximately 3 km NW from the larger complex, covers 5.96 ha (10.7%) of forests. The stands were grouped on the basis of:

• development phases,

• tree species mixture and

• crown closure.

The minimum surface area of the mapping was 1,000 m^2 (0,1 ha). We separated 33 stands (polygons), with an average area of 1.69 ha.

4.7.2 Results

The forest owned by Pivka municipality is 68,0 ha big and fragmented (Figure 13). In this FPMP we have focused on 2 biggest parts which presents 55,8 ha. The property was divided in 33 different forest stands (Figure 14), where the dendrometric inventory was conducted.

33 stands were identified, and were grouped into seven groups in the next step according to similar characteristics (e.g. the development phase, the share of each tree species in the timber stock):

- Mature pine stands
- Oak pole stands
- Pine pole stands
- Young stands
- Regeneration stands of deciduous trees
- Regeneration stands of pine trees
- Meadows and overgrowing areas

The map of forest stands is presented in Figure 14.

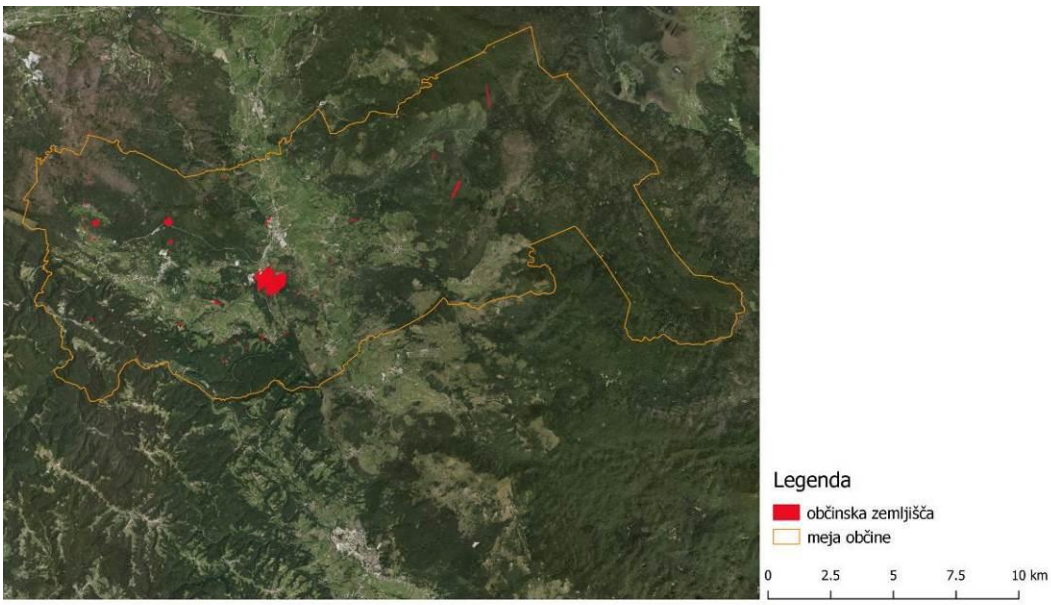

Figure 12: Municipality of Pivka (the orange line) and forests owned by the Municipality (red areas) (GURS, 2018)

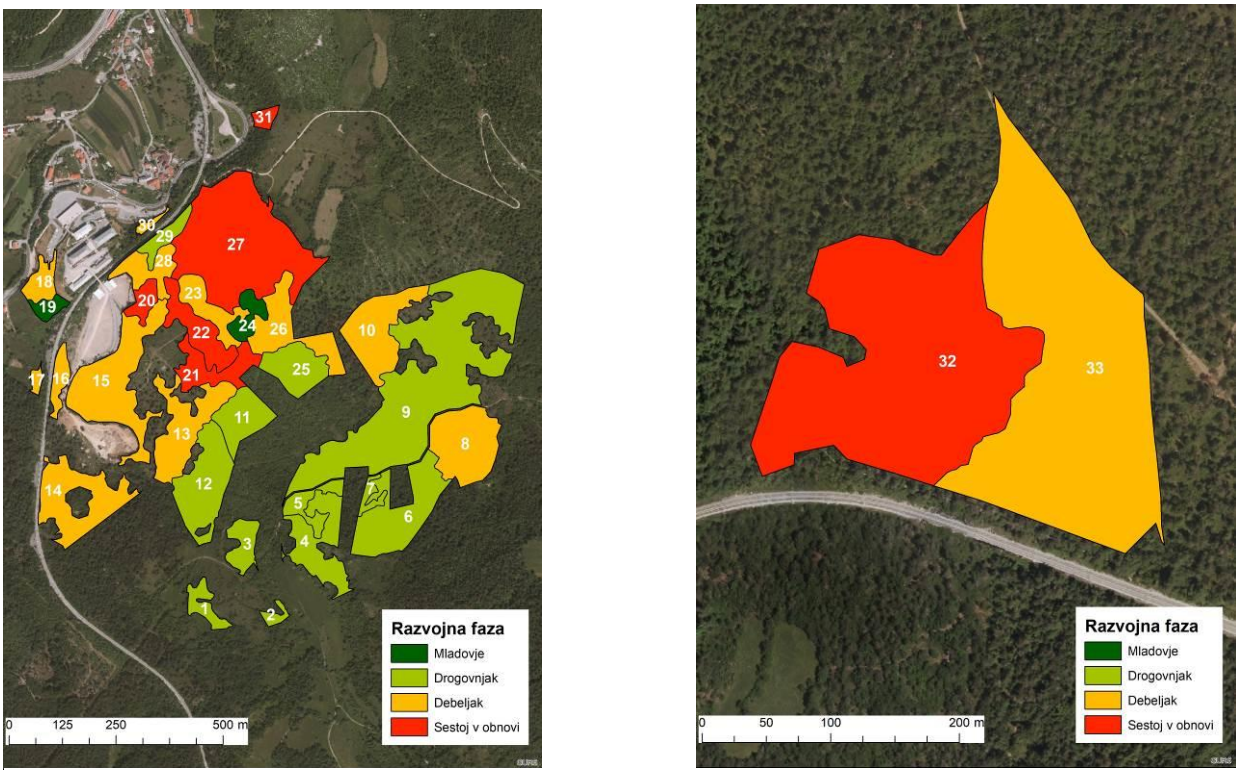

Figure 13: The map of forest stands within the forest owned by Municipality of Pivka (GURS 2018; GURS 2019; MKGP 2019). Dark green = young forest, light green = pole stand, orange = mature stand and red = regeneration stand.

4.8 Dendrometric inventory

First, the maps and data from Forest management plans produced by Slovenian Forestry Service were checked. We discovered that the situation in the field has changed in the last 5 years due to the ice break damage (in 2014). To get more precise data of these stands we decided to remeasure the stands and conducted a dendrometric inventory based on **Bitterlich angle count sampling** (Hočevar, 1995). The method was selected on the basis of a preliminary review of the area after which we found out that these stands are mainly low-productive forests and overgrowing areas. On the map we divided forest into a groups based on the development stages (e.g. pole stand, young stand, adult stand), mixture and canopy closure. In the field we have verified the stands and later set a sampling network on the map which were 50 m apart. The density of the sampling network was 50 × 50 m. Together 184 plots were set and measured. Dendrometric inventory of the stands within municipal forest was conducted in March 2019.

Figure 15: Field measurements in Pivka municipality forests

4.8.1 Methodology

Trees on these plots were measured by the principle of **Bitterlich angle count sampling** (Hočevar, 1995). To capture trees we used dendrometer with different basal area factor (factor k). Based on the tree stand we decided which basal area factor will be chosen (factor 1 for young stands and factor 2 for adult stands). Using a dendrometer, we see a tree; if the tree is wider than the visure angle, we record it; if not, we do not record it. With altimeter we measured mean stand height, which was then used to determine a growing stock on the plot. With this method, the basal area and growing stock of the stand in the plot was determined.

The growing stock was calculated for dominant tree species (*Pinus nigra, Pinus sylvestris, Fraxinus ornus, Ostrya carpinifolia and Qurcus species (Q. cerris and Q. petraea*)), other tree species were grouped into different groups: other conifers, other broadleaves and broadleaves of high value.

4.8.2 Results

After the measurement we calculated the growing stock for each stand (Table 4). The average growing stock for all stands together within the Municipal forest is low (136,6 m^3/ha). This is a reflection of a heavily changed forests and a consequence of the ice break. Conifer stands (pole and mature stands) are most frequent in the area (figure 16), the share of young stands is very low (1,6 %). Due to the ice break damage, canopy closure is full of gaps (figure 17). The bottom layer of the stand is sun exposed which causes the appearance of shrubs (e.g. *Prunus spinosa, Rosa canina and Rubus* sp.) and consequently difficult terrain crossing. The main tree species are black pine (*Pinus*

nigra) which represent 60,3 %, oak (*Quercus* sp., 11 %) and scotch pine (*Pinus sylvestris*, 7,4 %) (table 5).

Table 4: Basal area and growing stock by tree species by the stands

					Growing stock m^3/ha by tree species								Growing stock (m^3/ha) by classes						
Number of a stand	Surface (m^2)	Development phase	Basal area (m^2/ha)	Growing stock (m^3/ha)	Pinus nigra	Pinus sylvestris	Other conifers	Fraxinus ornus	Quercus sp.	Broadleaves of high value	Ostrya carpinifolia	Other broadleaves	10-30 cm	30-50 cm	>50 cm	Growing stock conifers (m^3/ha)	Groving stock broadleaves (m^3/ha)	Mixture	Crown closure
1	5155,1	Pole stand	6,0	27,0	0,0	0,0	0,0	4,8	15,9	4,8	1,6	0,0	22,2	4,8	0,0	0,0	27,0	4	4
2	1819,1	Pole stand	7,4	41,3	0,0	0,0	0,0	3,8	31,9	0,0	0,0	5,6	37,6	3,8	0,0	0,0	41,3	4	4
3	6803,5	Pole stand	5,9	27,6	4,8	0,0	0,0	0,0	9,6	0,0	0,0	13,2	21,6	6,0	0,0	4,8	22,8	4	4
4	18435,5	Pole stand	15,8	89,7	0,0	0,0	0,0	21,5	58,1	1,3	2,5	6,3	84,7	5,1	0,0	0,0	89,7	4	4
5	6501,0	Pole stand	22,5	147,6	49,9	45,7	0,0	4,2	29,1	2,1	12,5	4,2	89,4	54,0	4,2	95,6	52,0	2	4
6	26791,0	Pole stand	24,4	173,6	33,9	15,5	0,0	8,5	42,4	22,6	29,6	21,2	100,2	73,4	0,0	49,4	124,2	3	3
7	2635,0	Pole stand	7,9	50,6	16,9	16,9	0,0	0,0	11,3	0,0	0,0	5,6	22,5	28,1	0,0	33,8	16,9	3	4
8	23867,3	Mature stand	20,8	142,6	45,0	49,6	0,0	6,2	20,2	0,0	15,5	6,2	77,5	63,6	1,6	94,6	48,1	2	3
9	97080,1	Pole stand	7,8	50,5	18,5	9,9	0,0	0,6	12,9	0,6	1,2	6,8	24,7	22,2	3,7	28,4	22,2	2	4
10	21740,	Mature	31,8	243,1	219,	4,0	0,0	4,0	0,0	0,0	10,0	6,0	88,4	138,6	16,1	223,0	20,1	1	4

					Growing stock m^3/ha by tree species								Growing stock (m^3/ha) by classes						
Number of a stand	Surface (m^2)	Development phase	Basal area (m^2/ha)	Growing stock (m^3/ha)	Pinus nigra	Pinus sylvestris	Other conifers	Fraxinus ornus	Quercus sp.	Broadleaves of high value	Ostrya carpinifolia	Other broadleaves	10-30 cm	30-50 cm	>50 cm	Growing stock conifers (m^3/ha)	Groving stock broadleaves (m^3/ha)	Mixture	Crown closure
	0	stand			0														
11	12412,3	Pole stand	6,1	36,2	4,8	0,0	0,0	1,2	12,1	1,2	0,0	16,9	18,1	16,9	1,2	4,8	31,3	4	4
12	22788,2	Pole stand	6,4	38,7	7,0	2,3	0,0	7,0	13,2	0,8	0,0	8,5	28,6	9,3	0,8	9,3	29,4	4	4
13	20984,4	Mature stand	21,4	150,6	136,3	3,6	0,0	5,4	0,0	0,0	5,4	0,0	62,8	77,1	10,8	139,9	10,8	1	4
14	23579,9	Mature stand	21,1	168,5	151,9	11,1	0,0	5,6	0,0	0,0	0,0	0,0	53,7	101,9	13,0	163,0	5,6	1	3
15	33118,7	Mature stand	29,1	228,9	183,1	32,2	0,0	5,1	1,7	5,1	1,7	0,0	59,3	154,3	15,3	215,3	13,6	1	4
16	4620,3	Mature stand	23,8	199,5	172,9	26,6	0,0	0,0	0,0	0,0	0,0	0,0	66,5	128,6	4,4	199,5	0,0	1	4
17	1350,6	Mature stand	23,8	199,5	172,9	26,6	0,0	0,0	0,0	0,0	0,0	0,0	66,5	128,6	4,4	199,5	0,0	1	4
18	5637,9	Mature stand	24,1	217,1	165,4	0,0	0,0	10,3	0,0	10,3	0,0	31,0	72,4	113,7	31,0	165,4	51,7	2	4
19	3141,2	Young stand	14,5	80,0	22,9	0,0	0,0	0,0	0,0	0,0	0,0	57,2	45,7	34,3	0,0	22,9	57,2	3	4
20	4478,5	Regener	9,5	67,0	59,5	0,0	0,0	0,0	7,4	0,0	0,0	0,0	29,8	29,8	7,4	59,5	7,4	1	4

					Growing stock m^3/ha by tree species								Growing stock (m^3/ha) by classes						
Number of a stand	Surface (m^2)	Development phase	Basal area (m^2/ha)	Growing stock (m^3/ha)	Pinus nigra	Pinus sylvestris	Other conifers	Fraxinus ornus	Quercus sp.	Broadleaves of high value	Ostrya carpinifolia	Other broadleaves	10-30 cm	30-50 cm	>50 cm	Growing stock conifers (m^3/ha)	Groving stock broadleaves (m^3/ha)	Mixture	Crown closure
		ation stand																	
21	11693,7	Regeneration stand	16,1	131,4	117,9	0,0	0,0	0,0	0,0	0,0	0,0	13,5	37,1	84,2	10,1	117,9	13,5	1	4
22	13055,8	Regeneration stand	9,2	60,4	43,9	0,0	0,0	5,5	0,0	8,2	2,7	0,0	30,2	30,2	0,0	43,9	16,5	1	4
23	9986,5	Mature stand	19,6	158,8	137,9	0,0	0,0	4,2	12,5	4,2	0,0	0,0	41,8	112,8	4,2	137,9	20,9	1	4
24	5619,8	Young stand	7,8	33,8	0,0	0,0	0,0	0,0	18,0	0,0	15,8	0,0	33,8	0,0	0,0	0,0	33,8	4	3
25	13173,2	Pole stand	4,9	32,6	17,2	0,0	1,7	0,0	1,7	0,0	0,0	12,0	18,9	10,3	3,4	18,9	13,7	2	4
26	17620,8	Mature stand	31,6	305,5	273,5	8,7	0,0	0,0	2,9	0,0	11,6	8,7	40,7	209,5	55,3	282,2	23,3	1	4
27	66152,3	Regeneration stand	14,1	131,8	85,4	7,5	0,0	13,5	4,5	0,0	16,5	4,5	52,4	56,9	22,5	92,9	39,0	1	4
28	9223,0	Mature	24,7	211,0	112,	40,4	0,0	13,5	0,0	22,4	22,4	0,0	98,8	80,8	31,4	152,6	58,4	2	4

					Growing stock m^3/ha by tree species								Growing stock (m^3/ha) by classes						
Number of a stand	Surface (m^2)	Development phase	Basal area (m^2/ha)	Growing stock (m^3/ha)	Pinus nigra	Pinus sylvestris	Other conifers	Fraxinus ornus	Quercus sp.	Broadleaves of high value	Ostrya carpinifolia	Other broadleaves	10-30 cm	30-50 cm	>50 cm	Growing stock conifers (m^3/ha)	Groving stock broadleaves (m^3/ha)	Mixture	Crown closure
		stand			2														
29	5107,7	Pole stand	13,4	78,0	12,7	0,0	0,0	43,5	1,8	0,0	10,9	9,1	61,7	16,3	0,0	12,7	65,3	3	4
30	1202,9	Mature stand	24,7	211,0	112,2	40,4	0,0	13,5	0,0	22,4	22,4	0,0	98,8	80,8	31,4	152,6	58,4	2	4
31	2261,5	Regeneration stand	20,7	118,9	22,9	0,0	0,0	4,6	64,0	27,4	0,0	0,0	59,4	59,4	0,0	22,9	96,0	2	4
32	28684,1	Regeneration stand	21,2	200,1	26,7	0,0	55,3	17,1	55,3	9,5	32,4	3,8	131,5	57,2	11,4	81,9	118,1	2	4
33	30888,9	Mature stand	27,0	276,0	190,9	0,0	2,1	18,7	37,4	0,0	16,6	10,4	97,5	159,8	18,7	193,0	83,0	2	4

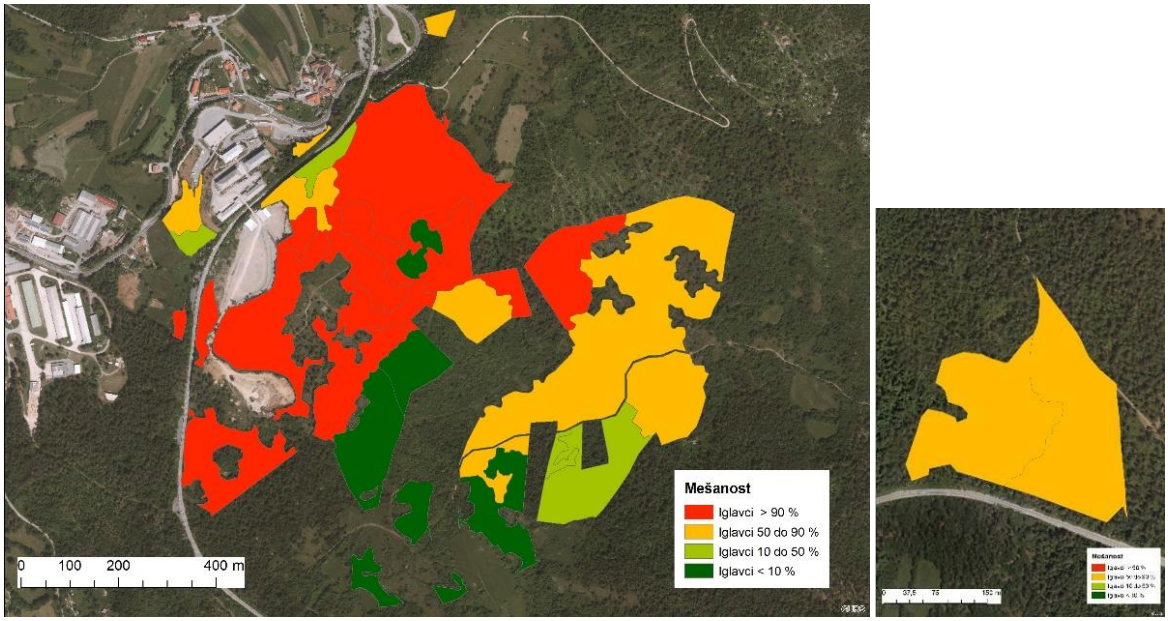

Figure 14: The stand mixture of the bigger part (left) and smaller part (right) of the estate (GURS 2018; GURS 2019; MKGP 2019). Red = conifers > 90%, Yellow = Conifers 50 – 90%, Light green = conifers 10 – 50 %, Dark green = conifers < 10%

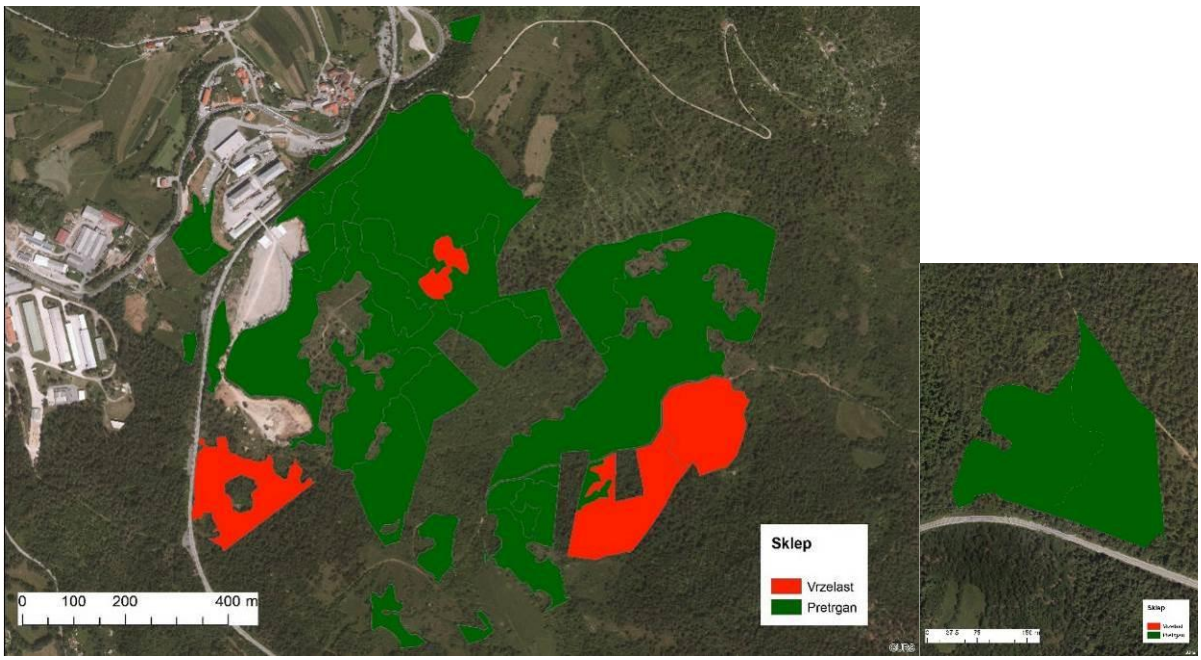

Figure 15: Canopy closure of the bigger part (left) and the smaller part (right) of the estate (GURS 2018; GURS 2019; MKGP 2019). Red colour = Canopy closure with gaps, Green colour = Canopy closure with bigger gaps

Table 4: Growing stock (m^3/ha) by tree species

Drevesna vrsta		m^3/ha	%
Pinus nigra	32	82,4	60,3
Pinus sylvestris	31	10,2	7,4
Other conifers	38	3,0	2,2
Fraxinus ornus	77	7,3	5,3
Quercus sp.	50	15,1	11,0
Broadleaves of high value	60	3,1	2,2
Ostrya carpinifolia	76	8,9	6,5
Other broadleaves	88	6,7	4,9
Sum		**136,6**	**100,0**

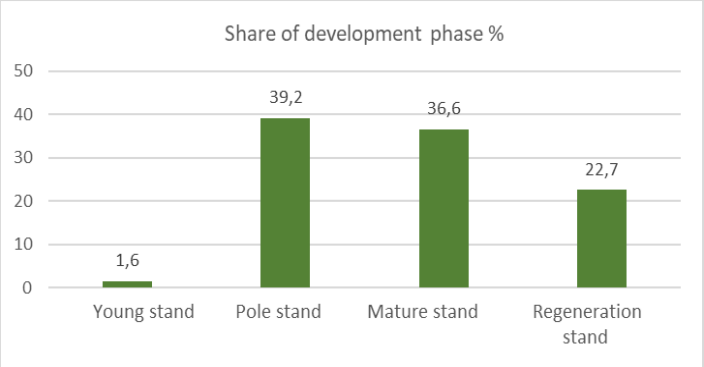

Figure 16: Share of development phases

4.9 Plan of treatment types and silvicultural operations

Treatment types and silvicultural operations are given by groups that were identified according to similar characteristics (e.g. the development phase, the share of each tree species in the timber stock, table 6).

Mature and regeneration stands are heavily damaged by the windbreak. The resulting gaps are overgrowing with shrubs, which worsen the natural regeneration of tree species. For this reason, it would be necessary to prepare the ground for natural regeneration and to protect the young trees from game browsing.

Matur pine stands are gradually introduced into the regeneration, as the pine is not a natural species in this area, and these stands have already reached a high age. Deciduous tree species are promoted on the cost of pine.

At least 3% of the dead biomass is left in the stands.

Tree species which bear fruits in the autumn are promoted in the stands. If necessary young trees are protected from the game browsing. Forest tending has to be done regularly.

The meadows and pastures are maintained and regularly cleaned. If necessary, overgrowing areas are cut and returned to the previous state (meadows or pastures).

For successful rejuvenation it is necessary to harmonize the abundance of game with the carrying capacity of the environment.

When working in a forest on a karst terrain, great attention must be paid to measures that prevent the spread of motor oil into the environment. It is recommended to use biodegradable oils for motor chainsaws.

All forestry infrastructure should be regulated in a way that it will play a multifunctional role, especially in connection with recreation and tourism.

Table 6: Plan of treatment types divided by groups

Groups of stands	Goals	Silvicultural measure	Detailed guidelines	Assortment quality
Mature pine stands (8, 10, 13, 14, 15, 16, 17, 18, 23, 26, 28, 30, 33)	Unevenaged pine stand, share of Pinus sp. 60-100 %	Gradual initiation into regeneration Increasing share of oak and ash on the expense of pine In the cores with young trees tending is planned Pine and shrub logging where overgrowing is present	Where seedlings are present, we begin with the initiation into regeneration	Saw logs III., low quality saw logs
Oak pole stands (1, 2, 3, 4, 6, 11, 12, 29)	Older oak pole stand Increasing share of oak in the growing stock (above 50%)	No planed measures	/	Biomass
Pine pole stands (5, 7, 9, 25)	Increasing share of oak in the growing stock (above 50%) at the expense of pine (sanitary	Maintaining groups of deciduous trees Preparation of stand to natural regeneration,	/	Biomass – pine and hazel trees

Groups of stands	Goals	Silvicultural measure	Detailed guidelines	Assortment quality
	cut)	promotion of natural seedlings Where necessary, removing hazel trees in deciduous cores Where necessary protecting seedlings from game browsing		
Young stands				
19	Pasture with individuall fruit-bearing tree species	Clearing of shrubs and bushes (*Robinia pseudoacacia, Rubus* sp.) Protection of trees from game browsing		
24	Younger pole stand, Share of oak 60%	Tending of the stand Promotion of oak trees		
Regeneration stands of deciduous trees				
32	Maintaining of the regeneration stand	Continuing with the regeneration Tending of young stands in regeneration cores (oak, high value broadleaves and fir)		Saw logs I. in II. Firewood, mostly from hardwood

Groups of stands	Goals	Silvicultural measure	Detailed guidelines	Assortment quality
Regeneration stands of pine trees (20, 21, 22, 31)		Promotion and finish with the regeneration Increasing the share of broadleaves at the expanse of pine Tending of young trees in cores (promoting broadleaves, mostly oak and ash)		Saw logs I.
27		Tending of young trees in cores (promotion of broadleaves; mostly oak and ash, fir on the shady side)		
Meadows	Maintaining of meadows and pastures	Mowing or pasturing, where necessary logging and mulching	Clearing of shrubs overgrowing, regular maintaining of meadows	Biomass
Overgrowing areas	Maintaining of scrubs	No planed measures		
	Establishment of agricultural areas	Clearing of overgrown areas, mulching, if necessary, stump removing, regular mowing or pasturing	Primary clearing of those areas that have overgrown the last	Biomass

4.10 Potential biomass production and share available for bioenergy production

Potential felling is described in FMP for every forest section for 10 years. To determine maximum possible felling in the frames prescribed in FMP for unit Jezerščak and Vremščica, we calculated the share of the growing stock (%) according to prescribed felling rate in the FMPs separately for conifers and broadleaves (Table 7). Due to the windbreak damage, these stands were already thinned, that is why we assume this potential felling rate is not realistic.

Similarly, we used the calculation of the estimation for the increment. We assumed that the share (%) of increment on the growing stock recorded in FMP Jezerscak and Vremščica is correct. For the calculation of the increment we took in account the share of increment separately for conifers and deciduous trees, for all forests in both management units (Table 8).

Table 7: The share of the maximum potential felling by the sections

Forest managament unit	**Section**	**Maximum possible felling rate**		
		% of growing stock		
		Conifers	**Broadleaves**	**Together**
Jezerščak	05C03	12	8	11
Jezerščak	05C06	15	1	14
Jezerščak	05C07	33	3	31
Jezerščak	05C08	20	-	18
Jezerščak	05C09	8	2	7
Jezerščak	05C10	10	8	9
Vremščica	04058B	69	48	58
Vremščica	04081A	24	23	23
Vremščica	04081B	14	13	13

Table 8: Wood increment in m^3/ha and % of growing stock according to Forest management unit

Forest management unit	**Wood increment**					
	m^3/ha			% of growing stock		
	Con.	Broad.	Together.	Con.	Broad.	Together.
Jezerščak	3,23	1,43	4,66	2,6	2,9	2,7
Vremščica	1,44	5,42	6,87	2,6	3,1	3,0

4.11 Inventory of the forest viability and other infrastructures and management prescriptions

The length of existing forest roads and skidding trails are calculated according to two main complexes shown on the map below. It is a large part of the Municipality estate, a complex near the Park of Military History, and a smaller, locally spaced part of the property (Figure 19). The surface of the forest sections, average skidding distance and openness with roads and skidding trails are summarized according to FMPs for units Jezerščak and Vremščica. The average openness of forests is 77,2% (this is average openness of sections where Municipal forest is located, Table 9).

According to the guidelines from the forest management plans, the main management system is tree felling with chainsaw and skidding with tractor (100 %). According to the field inspection, we estimate that harvester logging would also be possible.

Table 9: The length of forest roads and skidding trails and the share of forest openness

Forest section	Surface (ha)	Forest roads		Skidding trails	
		The length of existing forest roads (m)	The average skidding distance (m)	The length of existing skidding trails (m)	The share of openness (%)
05C03	42,35	0	300	4046	60
05C06	16,59		300		100
05C07	3,60		300		100
05C08	4,98		500		80
05C09	16,37		600		40
05C10	18,16		300		100
04081A	30,74		150		70
04081B	54,28		130		50
04058B	9,28	195	150	11	95
Together	196,35	195	303,3	4057	77,2

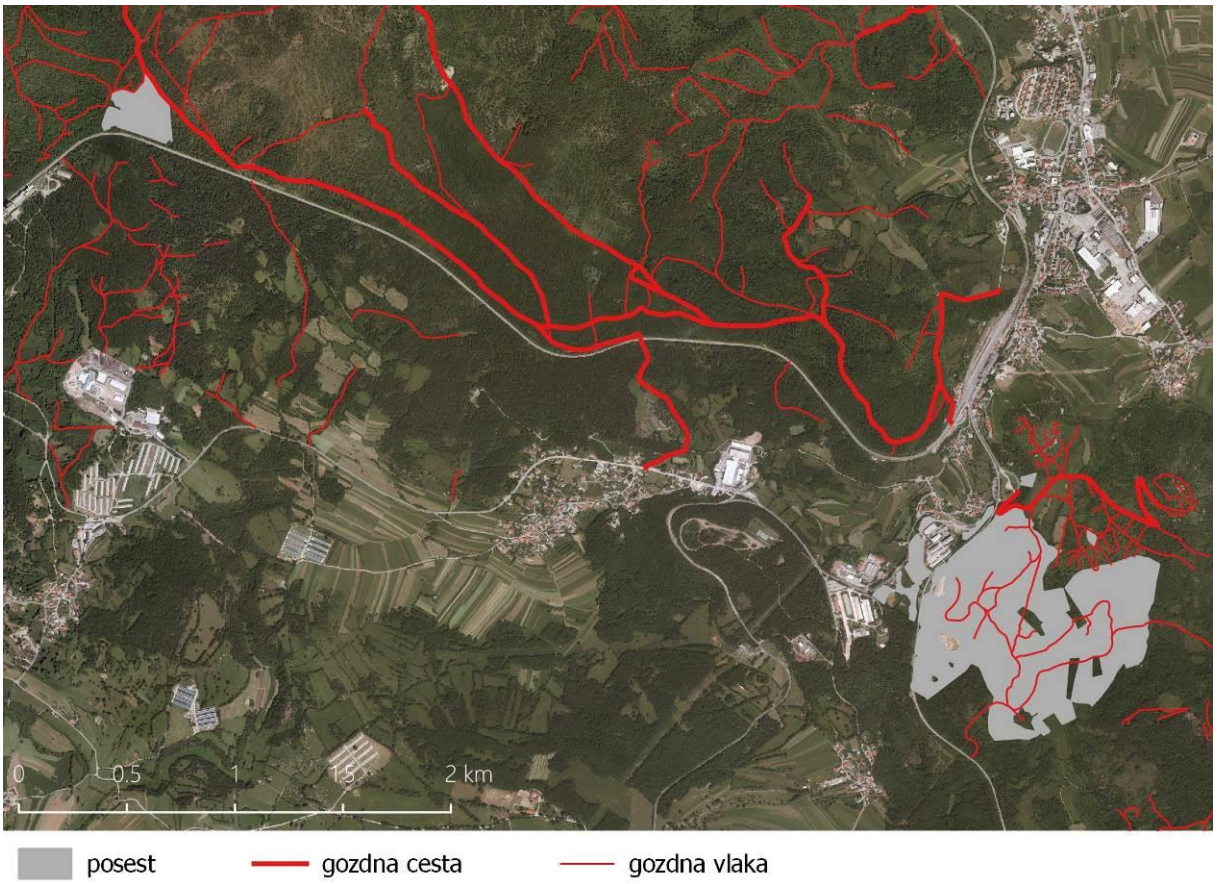

Figure 19: Map of the forest roads (thick red line) and skidding trails (thin red line) (GURS, 2018; GURS, 2019; ZGS, 2019)

4.12 Management prescriptions for the pasture and the wild fauna

There is 20,04 ha of pastures and meadows within the property (Figure 20). Because of the abandonment of the pasture in the past, these areas have been severely overgrowing with bushes and trees.

One of the measures for these areas could be harvest of the overgrowing bushes and trees and mulching. Furthermore, the wood from the harvest could be used as wood chips for heating. Restoration of pastures and meadows is reasonable only if in following years grazing or mowing is foreseen.

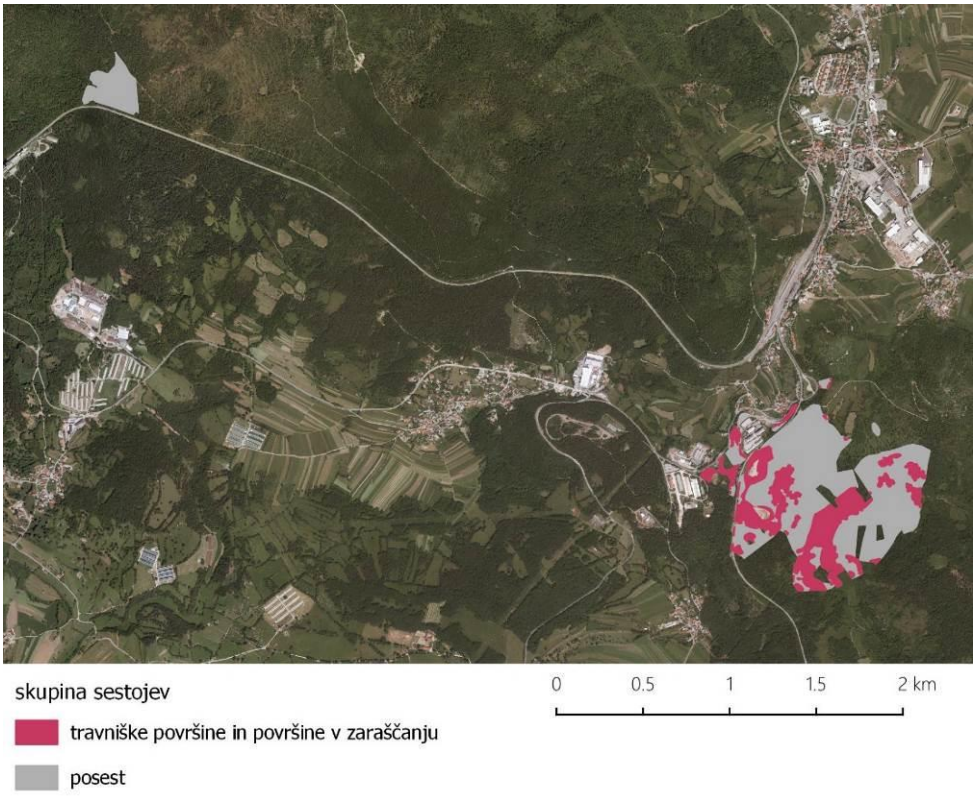

Figure 20: Meadows, pastures and overgrowing areas (MKGP, 2019; GURS, 2018)

4.13 Connections of the FMP with the other planning tools

The social functions are extremely emphasized in the area. Park of Military History is located by the municipal forest and they already use a part of this forest for their touristic activities. Several paths (recreational and educational) runs in this area. Forest infrastructure must be therefore properly managed and maintained. After each harvesting and skidding process forest and infrastructure must be restored to a previous state. Old and overgrown paths and skidding trails should be cleaned and maintained. The municipality of Pivka and Park of Military History should prepare a plan of recreational and educational paths around the area. These paths should be marked with uniform markings, information boards should be displayed, which show the network of paths and attractions alongside them. On the way, the accompanying infrastructure (benches, tables, viewpoints, etc.) should be arranged. Natural materials, such as wood and stone, should be used for the infrastructure.

4.14 Assessment of impacts by the FMP

The economic part of the plan (Annex 1) is intended to present an economic assessment of the entire forests on the property. Because of condition of the stands, which we have described in the previous chapters, the economic assessment is very difficult. In the next 10 years, the owner may expect the costs of urgent sanitary cuts or the cost of some necessary silvicultural works. The owner could acquire a bigger quantity of timber by clearing overgrowing areas. However, these are regarded primarily as one-off events.

In this area pine is not a natural species. One of the solutions is to begin the initiation into regeneration and to replace pine with other broadleaved species, which are present mostly in the lower part of the stands. However, due to the very intense overgrowing with hazel and other shrubs, we advise caution with initiation of stands into regeneration, and above all, a regular tending of young trees in regeneration cores.

The quality of the assortments is poor and include mainly fuel wood (wood chips and firewood), lower quality saw logs and saw logs classes II. and III. The profit from harvest would not be high, the focus would be on biomass extraction and using it for the heating of buildings owned by the Pivka municipality. In this way the wood-energy supply chain would be created.

4.15 Final remarks

In Slovenia, Forest Management Plans (FMP) are prepared by Slovenian Forest Service (SFS). They are prepared on the scale of forest management units, regardless the ownership. Due to this reason, we decided to prepare Forest Property Management Plan (FPMP) for forest owned by the municipality of Pivka. This plan is more detailed and adjusted to the local conditions and forest owners could put it in direct use.

The property of Pivka municipality is 76,02 ha big of which 55,76 ha is forest and the rest non-forest areas. Forest is mainly conifer forest with some broadleaves tree species (*Quercus* sp., *Ostrya carpinifolia, Fraxinus* sp.). Forest is severely damaged after the windstorm in 2014 and therefore bigger sun exposed gaps have been formed in the stands. Meadows, pastures and agricultural areas with trees represent 20,04 ha. These areas have been overgrowing with bushes, shrubs and trees, because of the abandonment of pasture. From clearing overgrowing areas, we could get biomass (e.g. wood chips) for heating and at the same time preserve the meadows. Municipality plans to preserve these meadows as a natural and cultural heritage, biomass from clearing could be used in wood chips heating system in Krpanov dom, which heats also a local school and kindergarten.

These forests have high social and ecological functions (1st degree). It is important to consider that when planning the management. This FMP is prepared for next 10 years and covers a description of the forest estate, forest roads and skidding trails, forest functions, management plan and economic part of the plan.

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5. THE FOREST MANAGEMENT PLAN OF THE BIOMASS DISTRICT OF ENGUERA IN NATURA 2000 PROTECTED AREAS (COMUNITAT VALENCIANA, SPAIN)

5.1 National and regional legislative framework

The studied public forests (MUP) - V072 "Los Altos"; V072v3002 "Los Altos"[1]; V074 "Navalón" and *Muela de Cortes*) and Municipal protected sites (*Barrancs Carrasca-Gatillo* and *Barranco la Hoz*).

Table 5. Influence of the management regulation "Macizo del Caroig" in Enguera (Source: Decreto 10/2017, de 27 de enero[2])

Code	Natura 2000 sites	Involved municipalities
ES5233045	SAC "Serra d'Enguera"	Enguera, Vallada, Moixent/Mogente, la Font de la Figuera
ES0000212	SPA "Sierra de Martés-Muela de Cortes"	Requena, Yátova, Macastre, Alborache, Turís, Montroy, Real, Llombai, Catadau, Tous, Millares, Dos Aguas, Cortes de Pallás, Cofrentes, Jalance, Jarafuel, Teresa de Cofrentes, Bicorp, Ayora, Quesa, Navarrés, Guadassuar, Alzira, Bolbaite, Chella, Anna, Enguera, Vallada, Moixent/Mogente

Table 6. Surface of the Protected sites in Enguera (Source: Conselleria d'Infraestructures, Territori i Medi Ambient)

Protection figure	Surface (ha)[3]	% of the protected surface
SPA	9.395,08	52,13
SCI	8.895,05	49,35
SAC	8.895,05	49,35
Municipal protected sites	1.809,43	10,04
Micro-reserve	25,48	0,14

Concerning the legislative framework, a selection and classification have been done according to the forest and protected areas normative at the national and regional level. Following, the regulations are included in the mentioned levels:

National legislative framework[4]

[1] V072 and V072v3002 are the same forest "Los Altos". Nevertheless, juridically V072v3002 is different due to it is a consortium forest. For this reason, the most part of the information is included separately, also according with the data obtained of the Forest Management Plan of Enguera (2014-2034).

[2] DECRETO 10/2017, de 27 de enero, del Consell, por el que se declaran como zonas especiales de conservación (ZEC) los lugares de importancia comunitaria (LIC) la Sierra de Martés y el Ave, la Muela de Cortes y el Caroche, Valle de Ayora y la Sierra del Boquerón, Sierra de Enguera, y Sierra de Malacara, se modifica el ámbito territorial de la zona de especial protección para las aves (ZEPA) denominada Sierras de Martés-Muela de Cortes, y se aprueba la norma de gestión de tales ZEC y ZEPA, así como de la ZEPA la Sierra de Malacara. [2017/1237] http://www.dogv.gva.es/datos/2017/02/16/pdf/2017_1237.pdf

[3] Total protected surface in Enguera amounts to 18.023 ha, 75,55% regarding the municipal surface (24.175 ha); there is an overlapping of figures.

[4] More information:
General: https://www.mapa.gob.es/es/desarrollo-rural/legislacion/legislacion_areas_normativa_espaniola.aspx
Forests: http://www.agroambient.gva.es/es/web/medio-natural/nacional-2593
Protected areas: http://www.agroambient.gva.es/es/web/espacios-protegidos/legislacion-espacios-naturales-protegidos-2286

Ley 13/2015, de 24 de junio, de Reforma de la Ley Hipotecaria aprobada por Decreto de 8 de febrero de 1946 y del texto refundido de la Ley de Catastro Inmobiliario, aprobado por Real Decreto Legislativo 1/2004, de 5 de marzo.

Ley 21/2013, de 9 de diciembre, de evaluación ambiental.

Ley 42/2007, de 13 de diciembre, del Patrimonio Natural y de la Biodiversidad.

Ley 43/2003, de 21 de noviembre, de Montes.

Ley 19/1995, de 4 de julio, de Modernización de las Explotaciones Agrarias.

Real Decreto Legislativo 7/2015, de 30 de octubre, por el que se aprueba el texto refundido de la Ley de Suelo y Rehabilitación Urbana.

Real Decreto 1093/1997, de 4 de julio, por el que se aprueban las normas complementarias al Reglamento para la ejecución de la Ley Hipotecaria sobre Inscripción en el Registro de la Propiedad de Actos de Naturaleza Urbanística.

Regional legislative framework[5]

Ley 6/2014, de 25 de julio, de la Generalitat, de Prevención, Calidad y Control Ambiental de Actividades en la Comunitat Valenciana.

Ley 5/2014, de 25 de julio, de Ordenación del Territorio, Urbanismo y Paisaje, de la Comunitat Valenciana.

Ley 11/1994, de 27 de diciembre, de Espacios Naturales Protegidos de la Comunitat Valenciana.

Ley 3/1993, de 9 de diciembre, Forestal de la Comunidad Valenciana.

Ley 2/1989, de 3 de marzo, de la Generalitat Valenciana de Impacto Ambiental.

Decreto 58/2013, de 3 de mayo, del Consell, por el que se aprueba el Plan de Acción Territorial Forestal de la Comuntitat Valenciana.

Decreto 60/2012, de 5 de abril, del Consell, por el que regula el régimen especial de evaluación y de aprobación, autorización o conformidad de planes, programas y proyectos que puedan afectar a la Red Natura 2000.

Decreto 1/2011, de 13 de enero, del Consell, por el que se aprueba la Estrategia Territorial de la Comunitat Valenciana.

Decreto 162/1990, de 15 de octubre, del Consell de la Generalitat Valenciana, por el que se aprueba el Reglamento para la ejecución de la Ley 2/1989, de 3 de marzo, de Impacto Ambiental.

Decreto 98/1995, de 16 de mayo, del Gobierno valenciano, por el que se aprueba el reglamento de la Ley 3/1994, de 9 de diciembre, Forestal de la Comunidad Valenciana.

Orden 23/2017, de 10 de agosto, de la Conselleria de Agricultura, Medio Ambiente, Cambio Climático y Desarrollo Rural, por la que se establecen las bases reguladoras para la concesión de ayudas para la

5 More information:
Forests: http://www.agroambient.gva.es/es/web/medio-natural/montes-de-utilidad-publica
Protected areas: http://www.agroambient.gva.es/es/web/espacios-protegidos/legislacion-espacios-naturales-protegidos-2286
https://www.miteco.gob.es/es/biodiversidad/temas/espacios-protegidos/espacios-protegidos-por-instrumentos-internacionales/default.aspx

aplicación de medidas de gestión forestal sostenible en el marco del Programa de desarrollo rural de la Comunitat Valenciana 2014-2020.

ORDEN 10/2015, de 8 de abril, de la Conselleria de Infraestructuras, Territorio y Medio Ambiente, por la que se regulan los aprovechamientos forestales de la Comunitat Valenciana.

Local (Enguera): Normas subsidiaria del Plan General de Ordenación Urbana de Enguera. *Subsidiary regulations of the General Urban Plan of Enguera.*

EU: Regulation (EU) No 1305/2013 of the European Parliament and of the Council of 17 December 2013 on support for rural development by the European Agricultural Fund for Rural Development (EAFRD) and repealing Council Regulation (EC) No 1698/2005

5.2 Geographical framework

The MUP under study area located in the Province of Valencia, concretely in the region of "La Canal de Navarrés".

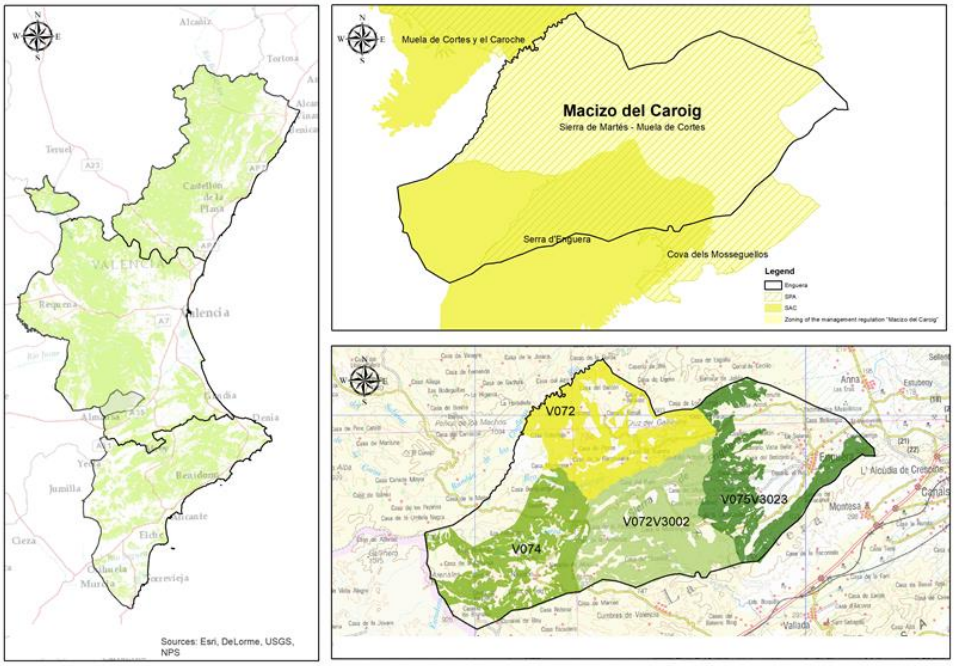
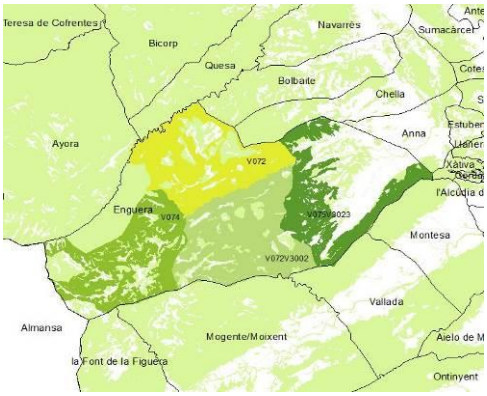


Figure 17.Situation of the MUP in Enguera (Source: Esri, DeLome, USGS, NPS, ICV, Servicio de Vida Silvestre, Conselleria, Generalitat Vaenciana -ICV)

Figure 18. Geographical limits of the public forest in Enguera (Source: Conselleria,

Table 7. Geographical limits of the MUP of Enguera

Cardinal point	MUP of Enguera



	V-072	V3002v072	V-074	V3023V075
North	Municipalities of Ayora, Quesa and Bolbaite	MUP V-072	Municipality of Ayora and its forest "El Coto".	Municiaplity of Chella
South	Municipalities of Moixent and Vallada	Municipality of Moixent and MUP V-077	Municipalities of Moixent and La Font de la Figuera	Municipalities of Vallada and Montesa
East	MUP V-3023V075 and municipalities of Bolbaite and Chella	MUP V-3023V075	MUP V3002v072	Municipalities of Anna and Xàtiva
West	MUP V-074 and managed forests by public administration (GVA) V-1005	MUP V-074	Municipality of Almansa (Province of Albacete	MUP V-072 and MUP-3002v072

5.3 Type and description of the forest ownership

The Spanish Forestry Law (Law 3/1993) classifies the forest land according to the ownership - public and private land. Table 8 represents the surface (ha) and percentage (%) of the ownership distribution (public, private and unknown).

Table 8. Public-private forest ownership by provinces (Source: PATFOR 2013)

Provincia	Pública		Privada		Desconocida- No asignada[352]	
	Ha	%	Ha	%	Ha	%
Castellón	106.133,0	23,2%	325.158,5	71,2%	25.523,5	5,6 %
Valencia	325.810,9	51,8%	251.855,6	40,0%	51.830,6	8,2 %
Alicante	96.639,6	34,0%	179.000,2	63,0%	8.580,1	3,0 %
CV	528.583,5	38,6%	756.014,2	55,2%	85.934,2	6,2%

On the one hand, the regional administration - Regional Ministry of Agriculture, Environment, Climate Change and Rural Development - manages 1/3 of the Valencian forest land (independently of the ownership of the land). Concretely, the forests which are classied as MUP are included in Table 9:

Table 9. Type of forest according to the ownership (Source: Ministry of Agriculture, Environment, Climate Change and Rural Development, Generalitat Valenciana)

Type	Ownership
Forests cataloged as a public use	Generalitat-Councils-Provincial government-JHCC*
Forests of the Generalitat	Public domain forests belonging to the Generalitat
Forests with consortium/agreement of repopulation and management	Councils –Individuals-JHCC-State
Forests with agreement of management	Individuals

*Jucar Hydrographic Confederation in Valencia (JHCC)

On the other hand, the forest area which is not managed by the Generalitat Valenciana (2/3 of the forest land) are considered as discretionary forests and, whether under public or private ownership.

The forests of individual owners constitute more than half of the total forest area. Generally, in these lands the forest management is implemented directly by the owner, being supervised by the regional administration.

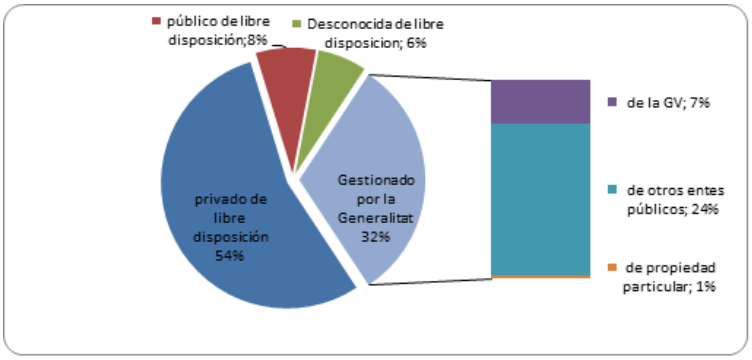


Figure 19. Distribution of the forests surface according to the ownership and management (PATFOR 2013)

Concretely, the forest land managed by the autonomic administration (Generalitat Valenciana) in the province of Valencia represents 302.770 ha, distributed as follow:

Total catalogued forests of Generalitat Valenciana (GV): 64 (19,90 %)

Total non-catalogued forests of GV: 7 (0,08 %)

Total catalogued municipality forests: 125 (75,36 %)

Total non-catalogued municipality forests: 15 (4,40 %)

Total non-catalogued forests, other ownerships (JHCC): 1 (0,04 %)

Total private non-catalogued forests: 2 (0,22 %)

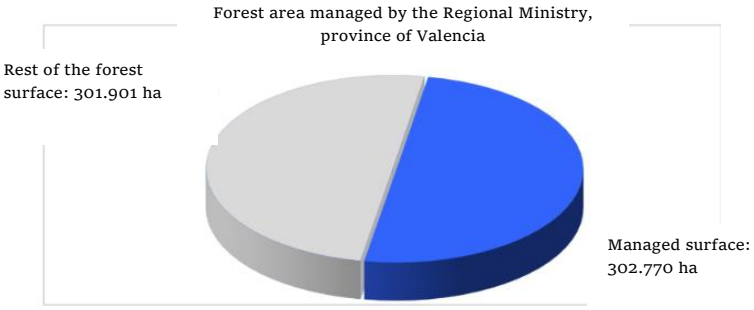


Figure 20. Forest surface managed by the autonomic government in the province of Valencia[6] (Source: Ministry of Agriculture, Environment, Climate Change and Rural Development, Generalitat Valenciana)

The forest area cataloged in the Valencian Community exceeds 381.000 ha. The regional administration is also entrusted with the management of those forests belonging to the Generalitat Valenciana which are not

[6] http://www.agroambient.gva.es/es/web/medio-natural/listado-resumen-de-montes-gestionados

included in the catalog and the forests consortiated for their management, so that the figure of managed surface amounts to 429.000 ha (33% of the forest area of the Region).

Regarding the studied forests, all of them belong to the Council of Enguera. More detailed data is provided in table 10.

Table 10. Characterization of the public forests in Enguera (Source: Catalog of MUP[7])

	Public forest surface (ha)	Total forest surface (ha)	Number of agricultural enclaves	Delimited	Forest settlement
V072	7.451,5	9.856,6	64	Yes and modifications 04/03/1932	Yes (15/02/1973)
V074	2.870,7	5.015,9	28	Yes and modifications (28/04/1931)	Yes (15/02/1973)
V3023V075	4.114,7	6.592,8	75	Yes(20/09/1917)	Partial (28/03/1980)

5.4 Synthesis of environmental features

GEOLOGY

The geology of the MUP of Enguera is mainly categorized as “Mesozoic Era- Cretaceous system” (V-072, V-3002V072, V-074). The public forest V-3023V075 has different geology that is “Mesozoic Era-Cretaceous system, “Cenozoic Era-Neogene system and “Cenozoic Era-Quaternary system”.

GEOMORPHOLOGY OR MORPHOSTRUCTURE

The slopes in the MUP under study have key importance in the development of the forest management, since among other parameters, the choice of silvicultural treatments to implement in the stands, are directly determined by the slope. So, the forest works depend on the slopes as follows:

S <10% work without apparent impediment

10 <S <30% work with special machinery

30 <S<60% only manual work

S> 60% a forestry work cannot be performed

[7]Catalog of public forest: http://www.agroambient.gva.es/documents/20551003/167083561/Catalogo_Montes_Utilidad_Publica_librodivulgativo2015.pdf/5c48f384-fcfe-44ff-a3b0-17a63c41faa9

V072: The slopes in this MUP are, in average, clearly under 10%. The average altitude of this forest is around 600 meters above sea level (asl), with the minimum altitude at 430m asl and the maximum altitude at 890m asl. The lowest altitudes are located in the northeast area and the highest in the southwest area.

V3002v072: The slopes in this forest are more pronounced and heterogeneous than in V072. Being the largest surface area with less than 10% slopes and slopes between 10-30%, occupying 35,6% and 33,8% of the surface respectively. The altitude range is between 480 and 790m asl. The lowest areas are distributed in the eastern part. The highest areas are in the central and western part.

V074: It is a heterogeneous forest according to slopes, with almost 50% of the forest with slopes under 10%. The altitudes are distributed approximately between 750 and 1,050m asl.

V3023v075: This forest has gentle slopes, especially in the areas located in the south. The steep slopes are not very representative, being located in the west and northwest part. It is characterized by slopes under 10% and slopes between 10 and 30%. The altitude range is between 350 and 620m asl.

Table 11. Type of slopes in the public forests of Enguera

	v072	v3002v072	v074	V3023v075
Slope	Surface (%), *total ha = 3.536,67*	Surface (%), *total ha = 4.286,22*	Surface (%), *total ha = 4.407,94*	Surface (%), *total ha = 2.827,28*
S<10%	40,41	33,82	49,61	34,92
10%<S<30%	28,96	35,94	28,02	35,30
30%<S<60%	26,47	21,76	20,77	9,66
S>60%	4,17	8,47	1,60	10,11

LITHOLOGY

Lithology classifies rocks into three types according to their origin: igneous, metamorphic and sedimentary. Specifically, sedimentary rocks form the study area, which can be classified as detrital, chemical, biochemical and organic, regarding the genetic point of view. The main lithology are mostly SC/9 Dolomite (V-072); SC/9-10 Dolomites and marls, SC/9 Dolomites and SC/5-6 calcareous and calcarenite (V3002v072); SC/9 Dolomites y SC/5-10 Calcareous and marls (v074) and SC/5-6 Calcareous and calcarenite and SC/9-10 Dolomites and marls (v3023v075).

CLIMATOLOGY

The study area is dominated by the Mediterranean Mesomediterranean stage climate, which is characterized by summer droughts and continuous presence of fire. Frosts are scarce in the study area.

EDAPHOLOGY

The soil is the result of edaphogenetic factors: climate, relief, organisms, the original material or parent rock and the time.

Following the Soil Taxonomy (USDA) classification system, the main types of soil which appear in the study area are included in table 12: Xerorthent, Xerochrept and Orthent. These three types of soils belong to the order entisoles (orthent and xerorthent) and inceptisols (xerochrept).

Table 12. Edaphology of the MUP of Enguera

	V-072	V-3002V072	V-074	V-3023V075
Order	Entisols	Entisols	Entisols	
Suborder	Orthents	Orthents	Orthents	
Group	Xerorthent	Xerorthent	Xerorthent	

	XERORTHENT	XEROCHREPT	XEROFLUVENT
Order	Entisols	Inceptisols	Entisoles
Suborder	Orthents	Ochrept	Fluvents
Group	Xerorthent	Xerochrept	Xerofluvent

HIDROLOGY

Superficial hydrology: No large streambeds appear. Most of the streambeds have intermittent runoff, only carrying water in rainy seasons, being the most remarkable the following:

V072: high percentage (99.15%) of the route belonging to ravines and very small rivers. Only two rivers are in the N and S, which are Rio Grande (0.1%) and Anna River (0.75%), respectively.

V3002v072: Almost all ravines, with the exception of the Anna River, are located in the N.

V074: Ravine route (99.25%) and small route of the Anna River with 0.75% of the total hydrology route are in this area.

MUP v3023v075: Only 1.9% of the total route is due to the Anna River. The entire area is distributed by ravines.

Underground hydrology: Hydrogeological unit 8.28 Caroche Sur. This unit belongs to the *Júcar* river basin. The aquifer systems belonging to this unit are exposed in the following table.

Table 13. Aquifer systems belonging to the Caroche Sur unit

	Aquifer system	Lithology	Geological age	Average thickness (m)	Type
Caroche Sur	52.02.01	Limestone, dolomites and calcarenite	Jurassic-Cretaceous	600	Mixed

Canals	50.01.02.01	Sands and gravels	Miocene-Quaternary	100	Multilayer

Table 14. Water collection of this system which falls in the study area or in its nearness

Key	Name	Type of supply	Total area (km^2)	% of the municipality within the hydrological unit
46039	Anna	Underground	5,15	100
46071	Bicorp		135,84	70,54
46107	Chella		42,57	96,69
46118	Enguera		241,79	100
46121	Estubeny		6,27	98,88
46128	Font de la Figuera		83,96	62,51
46170	Moixent		150,08	70,57
46174	Montesa		46,68	81,77
46179	Navarres		47,28	89,8
46206	Quesa		73,69	68,7

Concerning the studied public forests:

V072: "Marín" is located in the NW and "Comandante" in the SE.

V3002v072: "Comandante" is one of the largest aquifer in the forests under study. It is located in the N and NE; Aptian-Jurassic from the Caroche Sur to the center; "Torquillo" is located in the S and "Santos" in the W.

V074: "Marín" is a small area of the aquifer in the NE; "Comandante" is located in the NE and occupies a large underground space of the forest; "Muela" is the aquifer located in the N part and center of the forest; "Aptiense-Juridico" of Caroche Sur is located diagonally in the middle of the forest; "Arenas" in the S and "Torquilo" even more in the southern.

v3023v075: "Comandante" is in the W and saints in the E.

AIR

According to the General Directorate of Environmental Quality of the Generalitat Valenciana, the study area is framed in the municipality of Enguera which corresponds to the Zone (Júcar-Cabriel) (A. Interior) ES 1010[8].

FAUNA

There is a certain variety in relation to the biotopes. This allows the establishment of a large number of wildlife species. Elements such as vegetation, cover and water characterize the territory. Fundamental elements, in the response of biological needs, determine the species that can be established there.

For each species[9], the Red lists produced by the World Conservation Union (IUCN), the National Catalog of Endangered Species of Fauna and the Valencian Catalog of Endangered Species of Fauna are considered.

FLORA[10]

Following the series of potential vegetation, the total study area belongs to series 22b and 22 ba. Sector 22b occupies the western and higher areas, while 22ba is circumscribed to the eastern end and lower zones.

Generally, the following units of current vegetation are:

Adult pine of *Pinus halepensis*.

Adult pine of *Pinus pinaster*.

Pine regenerated pine areas of *Pinus halepensis*.

Areas with predominance of heliophilous scrub: oaks and rosemary.

Burned areas with very low regeneration.

Ravines and small rivers with forest and riverside vegetation.

Crops and pastures.

BIODIVERSITY

There is a wide intraspecific, interspecific diversity and some diversity in terms of ecosystems. The protected flora species existing in the study area which are noted are:

Pinguicula sp.: Insectivorous plant that lives in limestone walls. It has a very sparse population.

Sideritis sericea: endemism of the "Macizo del Caroig".

Chaenorhinum tenellum: endemism of the Comunitat Valenciana that has suffered a significant decrease in its populations in recent years.

[8] More information in: http://www.agroambient.gva.es/documents/20549779/164404040/ZONA+ES1010.+J%C3%9ACAR-CABRIEL.+%C3%80REA+INTERIOR/d20a8409-0ced-4142-a370-a2753d19d593

[9] Detailed information in www.bdb.gva.es

[10] Detailed information in www.bdb.gva.es

DISEASES, PESTS AND ABIOTIC NOXIOUS AGENTS[11]

The main diseases that can affect the Aleppo pine woodland in the study area are:

Mushroom *Sirococcus conigenus.*

"Puntisecado" of the Aleppo pine: disease or physiopathy of unknown origin.

Tuberculosis of the Aleppo pine: hypertrophy caused by the action of the bacterium *Corynebacterium halepensioides.*

Coleosporium senecionis: Uredal basidiomycete fungus of the Coleosporiaceous family - rust of the needles of the pines.

Pests

Defoliator insect: Pine processionary – *Thaumetopoea pythiocampa*. In the study area has been found the presence of this pest in several areas.

Bark beetles: Families of the Coleoptera order, mainly the families Scolytidae, Curculionidae, Cerambycidae and Buprestidae:

Tomicus destruens: this driller presents a great winter activity.

Pityogenes sp.: secondary bark beetle. It is installed on tree branches already infected.

Buprestidae: larvae belonging to these families of beetles that feed mainly on deadwood, so they are not considered important as causal agents of tree death.

Cerambycids: they are also larvae belonging to the other main family that feeds on deadwood.

HARMFUL ABIOTIC AGENTS

The main abiotic noxious agent is the fire, which must be controlled by preventive silviculture and proper planning. Drought is also considered an abiotic agent due to the damage that generates in the forest vegetation. When it becomes very intense there is a vegetative decay, decreases in growth and vulnerability to pests and fires. Frost and snow can occasionally cause damage, although these are not significant in the study area.

Finally, the chlorotic mottle has an appearance of yellow orange spots on the young needles of the pines. It may be caused by pollution, specifically by the excessive concentration of O_3 at the tropospheric level.

LANDSCAPE UNITS

[11] More information about the results of the phytosanitary survey (2000-2011) in the Comunitat Valenciana are in the following link: www.agroambient.gva.es/es/web/medio-natural/resultados-de-la-prospeccion

Landscape is considered in this study as a "heterogeneous area composed of an interacting set of ecosystems whose structure is repeated in space" (Forman and Godron 1986). The definition of landscape as "multisensory perception of a system of ecological relationships", proposed by professor González-Bernáldez, synthesizes its relevance in ecology.

Concerning the studied MUP, the definition provided by the IGN on the CORINE data includes:

112. Discontinuous urban fabric
211. Arable dry land
221. Vineyards
222. Fruit trees
223. Olive trees
242. Cultivation mosaic
243. Mainly agricultural land, but with important spaces of natural and semi-natural vegetation
312. Coniferous forests
321. Grasslands
323. Sclerophyllous scrub
324. Forest scrub of transition.

ENVIRONMENTAL RISKS

Erosion

Current erosion: the current predominant erosion is classified as moderate to high. However, in the central zone, there are areas where the current erosion can be classified as low and even as very low.

Table 15. Type of erosion and definition in the public forest of Enguera

Type of erosion	Definition	V072 %	V3002-V072 %	V074 %	V3023v075 %
1	Very low: 0-7 Tn/ha/año	93,80	83,26	19,51	97,77
2	Low: 7-15 Tn/ha/año	0,24	0,15	19,30	0,49
3	Moderate 15-40 Tn/ha/año	X	0,10	X	X
4	High 40-100 Tn/ha/año	X	X	19,11	0,002
5	Very high > 100 Tn/ha/año	4,23	X	22,49	0,21
6	Unqualifed (lytic phase)	1,73	16,49	19,59	1,53

Potential erosion: In the most of the studied MUP, the potential erosion is very high. Being defined as the existing erosive rates if the protective role of the vegetation cover disappeared, it can be concluded that the maintenance of the vegetation cover is essential for the homeostasis and the resilience of the forest ecosystems.

Forest fires

The study area is included in the Forest Fire Prevention Plan of the Xàtiva Forest District. Following these plan, the three infrastructures for the defense against forest fires are: fire-fighting areas, the road and water network (Figure 21,22 and 23).

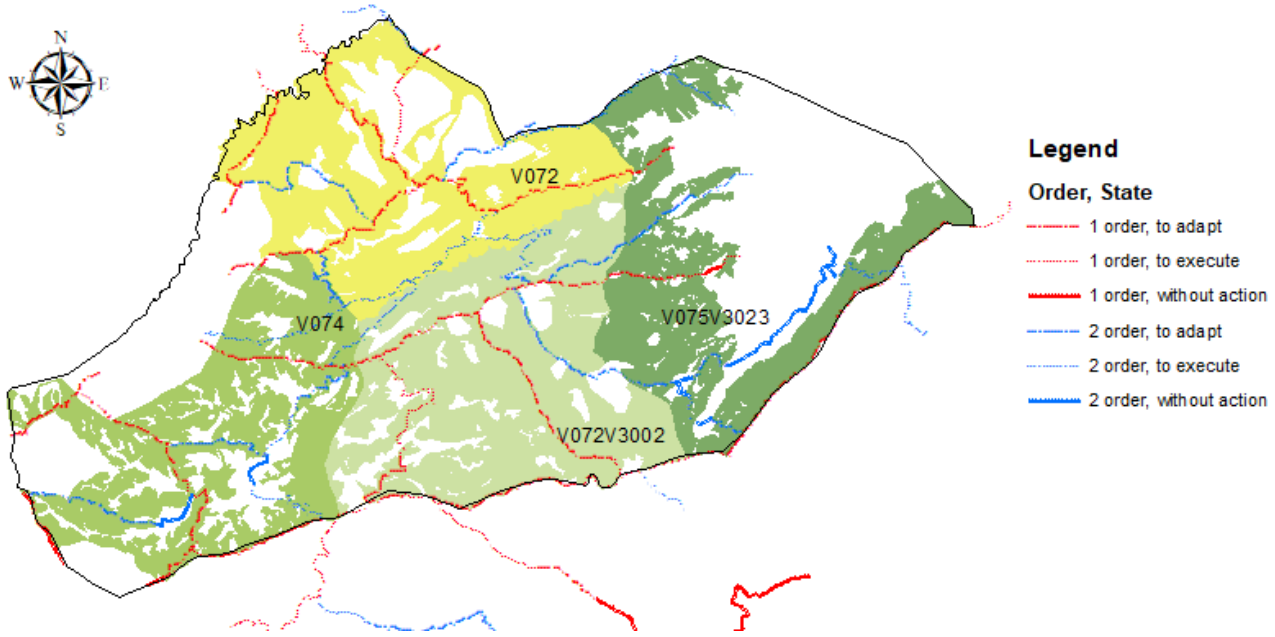


Figure 21. Order and state of the road network in the MUP of Enguera (Source: ICV, GVA)

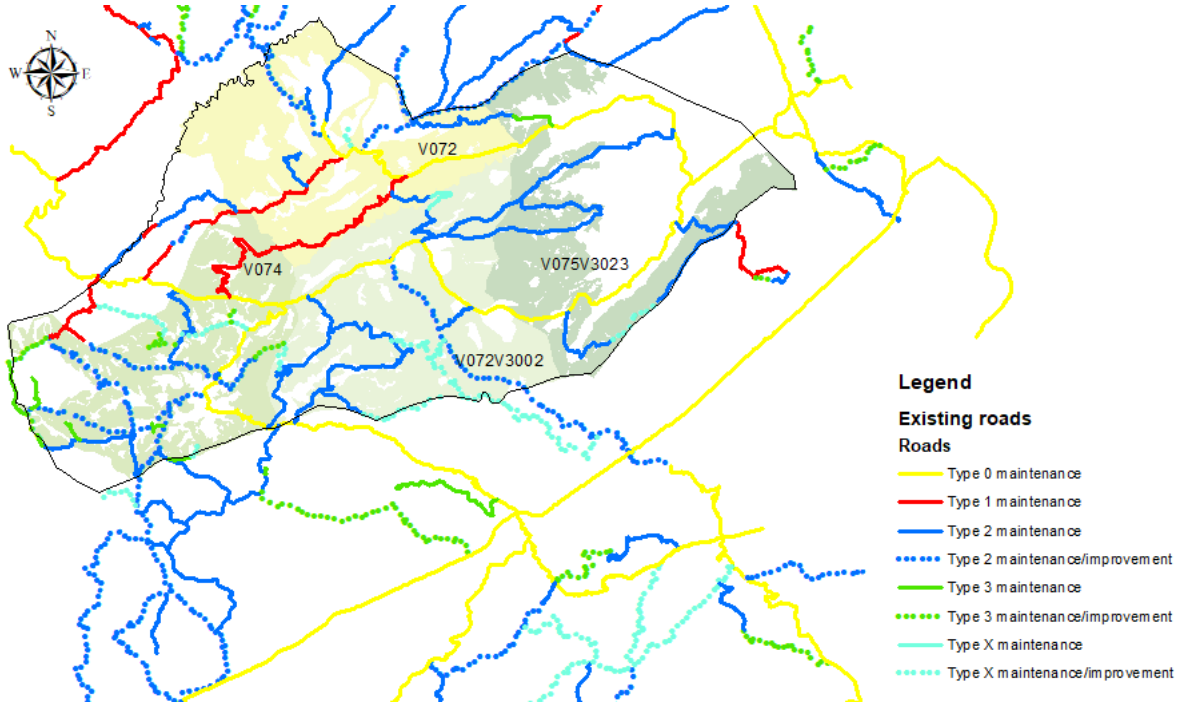


Figure 22. Existing roads in the MUP of Enguera (Source: ICV, Generalitat Valenciana – Plan of prevention of forest fires of the forest district of Xàtiva)

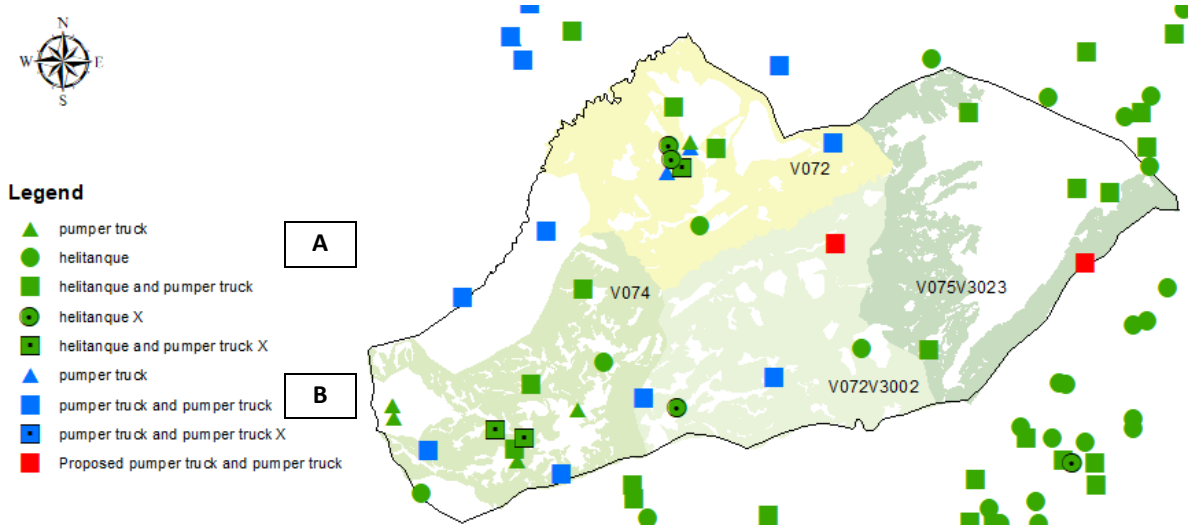


Figure 23. Water nertwork: A (multiple-use water point) and B (water point) (Source: ICV, Generalitat Valenciana – Plan of prevention of forest fires of the forest district of Xàtiva)

On the other hand, concerning the forest fires, in figure 24 can be appreciated the remarkable risk in Enguera (low, medium and high)[12].

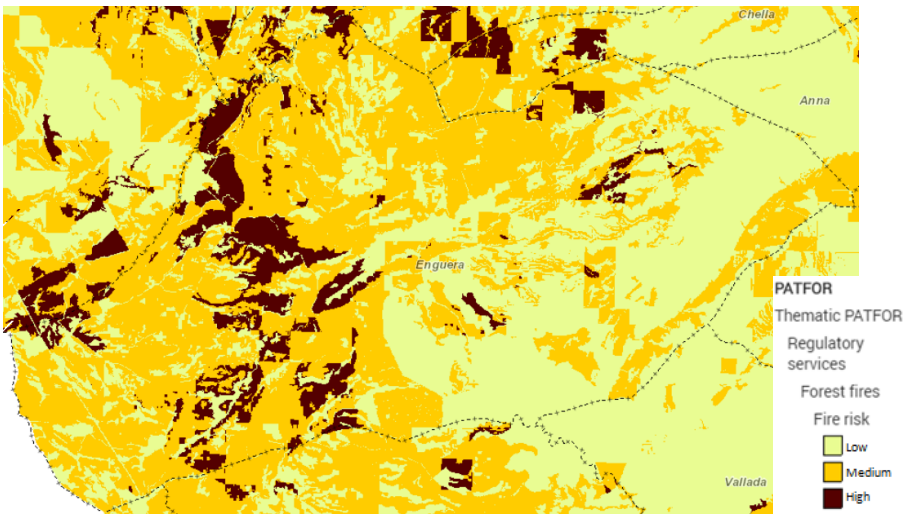


Figure 24. Risk of forest fires in the municipality of Enguera (Source: PATFOR 2013)

RISK OF LANDSLIDE AND ROCKFALL

The instabilities of the terrain are framed in mountain and interior areas, with difficult or scarce access, causing generally low impacts.

[12] More information in: http://www.agroambient.gva.es/auto/prevencion-incendios/Por-demarcacion/X%C3%A0tiva/08.%20Informes%20municipales/Enguera.pdf

The zones with risk of landslides and rockfalls are disseminated throughout all MUP of Enguera. However, these risks (mainly landslides) are presented mostly in the V3002V072. The public forests that have less risk of landslides are V072, V074 and V3023v075, classified as low-medium.

5.5 Naturalistic, environmental and landscape restrictions

The current regional legislation (Decree 60/2012) includes the special regime of evaluation and approval, authorization or conformity of plans, programmes and projects which can affect Natura 2000 sites[13].

Specifically, Chapter II - Section 1 “Regime of evaluation and repercussions of evaluation on the Natura 2000 sites" includes:

- Article 6. Obligation to evaluate.
- Article 7. Preliminary evaluation of repercussions.
- Article 8. Preliminary assessments and management rules of the Natura 2000 areas.
- Article 9. Study of affections to the Natura 2000 sites.
- Article 10. Declaration of repercussions on the Natura 2000 sites.
- Article 11. Duty of information.

Specifically, article 9 is included as an Annex in the Forest Management project which is "the report of affections to the Natura 2000 area”. The detail to be considered is:

- The wooded protected areas.
- Relation of the list of habitat types with significant presence in the forest, listed in the Annexes to the Directive 92/43/EEC.
    - Article 4 of Directive 2009/147/EC and listed in the Annexes to the Directive 92/43/EEC.
- Relation (list) of birds and mammals with significant regular presence and its immediate surroundings, referred to in Article 4 of Directive 2009/147/EC and listed in the Annexes to Directive 92/43/EEC
    - Law 42/2007 of 13 December on Natural Heritage and Biodiversity, complying with the provisions of Article 6.3 of the Habitats Directive, establishes that plans and projects which do not have a direct relation with the management of Natura 2000 sites and that may affect them appreciably must be submitted to an adequate evaluation. It is required to ensure that these actions will not produce significant detrimental effects in those sites, considering their conservation objectives. In principle, only the regional government could authorize those projects that do not cause a loss of ecological integrity in any space of the Natura 2000 area.

[13] DOGV núm. 6750 de 10.04.2012) Ref. Base Datos 003548/2012: http://www.dogv.gva.es/datos/2012/04/10/pdf/2012_3481.pdf

- Justification and not affecting of habitats and species of the Natura 2000 sites: preventive and corrective measures; limitations of felling of trees; management measures aimed at the protection of species; prohibitions.

All the information to the management regulation is included in the Decree 10/2017[14], in which the conservation and management objectives related to the habitats of community interest, management of species and to the whole site are included. In this decree, direct application regulations and repercussion assessment regime are enclosed. On the other hand, measures are established to prevent the deterioration of habitats and alterations on the species, specifying the rules of protection of common interest natural habitats and those with special priority, as well as species of fauna and flora.

The repercussion assessment regime is noted, in addition to the criteria of guiding and active management measures (guiding criteria for planning and forest management, hunting management, creation and maintenance of water points, construction or modification of infrastructures).

Finally, in Decree 10/2017 (http://www.dogv.gva.es/datos/2017/02/16/pdf/2017_1237.pdf) is included the description, the state of conservation, the conservation and management objectives, the assessment to be done, criteria and mesures, as well as the indicators of the protected sites of the study area.

5.6 Forest types and agricultural land use

The forestry use is the main one of the MUP of Enguera, following to the agroforestry use and the agricultural use, as it can be observed in table 16.

Table 16. Main use of the public forest of Enguera (Source: PATFOR 2013)

Main use	V072 %	V074 %	V075 %
Agricultural	0,01	0,01	0,21
Agroforestry	2,85	3,68	3,26
Forestry	97,14	96,31	96,53

[14] http://www.dogv.gva.es/datos/2017/02/16/pdf/2017_1237.pdf

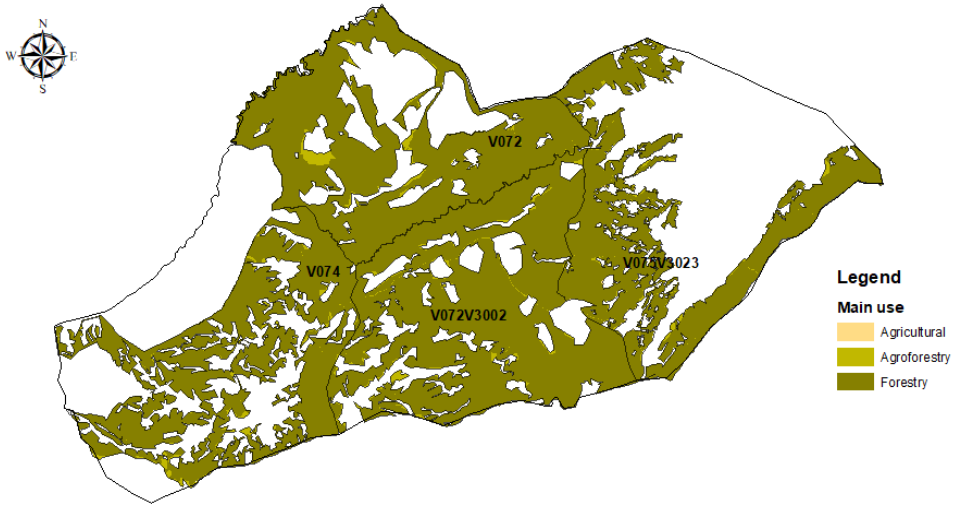


Figure 25. Main use of the land in the MUP of Enguera (Source: PATFOR 2013)

The main forest ecosystems are *Pinus halepensis* woodland in V074 and *Pinus halepensis* woodland and garrigue in V072 and V075 (table 15):

Table 17. Forest ecosystems in the MUP of Enguera (Source: PATFOR 2013)

Type of ecosystem	Surface (%)		
	V072	V074	V075
Mediterranean gorse	1,85	24,60	X
Pinus halepensis woodland	51,86	65,91	40,48
Pinus pinaster woodland	0,33	3,38	x
Quercus ilex woodland	x	1,18	x
Garrigue	35,73	x	54,40
Sclerophyllous arborescent scrub (maquis and other high scrubs)	0,16	0,43	0,12
Scrubland or grassland of mountain and cool environments	x	0,52	x
Other Mediterranean calcicolous scrubs and grasslands	0,99	0,27	0,77
Other non-forestry use	0,31	0,37	1,04
Mediterranean calcicolous rosemary bush thicket or thyme scrub, of optimal mesomediterranean	8,43	0,99	3,14
Riparian vegetation	0,34	0,05	0,05

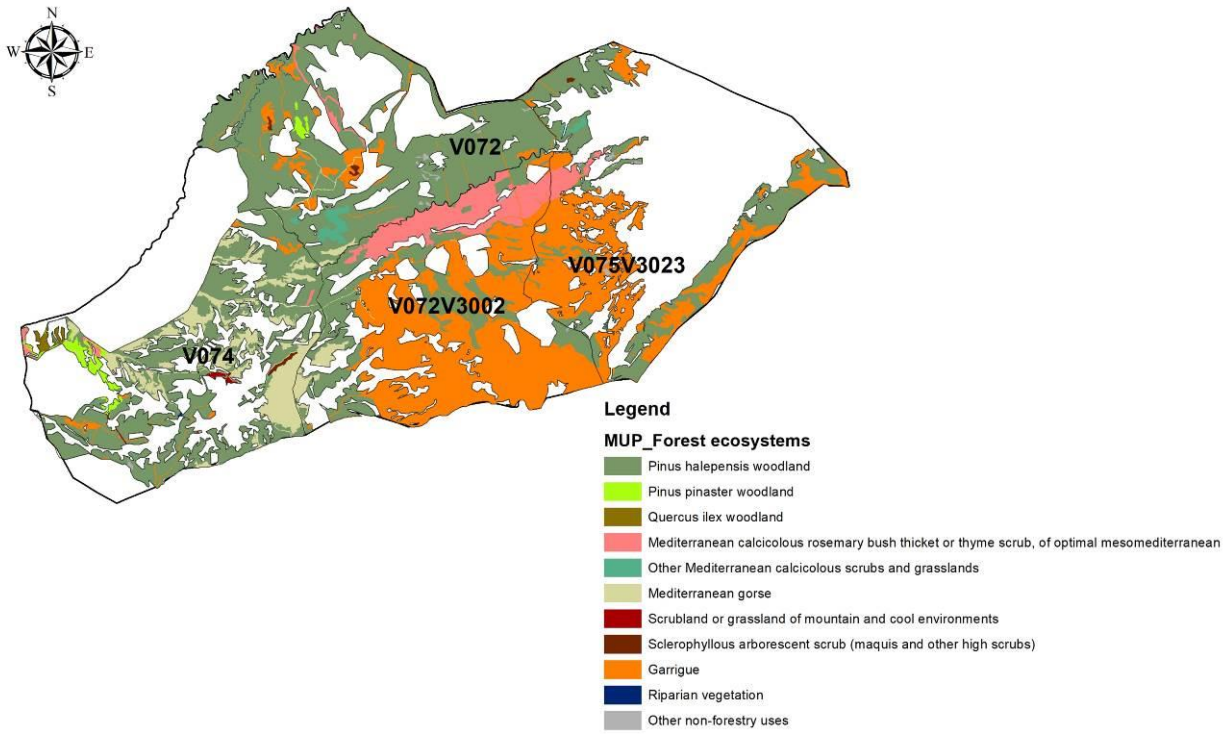


Figure 26. Forest ecosystems in MUP of Enguera (Source: PATFOR 2013)

5.7 Forest partitioning and description

A multifunctional and sustainable approach is acquired (environmental, social and economic), including the multiple uses: wood, livestock, apiculture, mycological use, etc.

In the forest partitioning, the regulatory and cultural services are considered, as the mitigation of climate change (carbon capture, reduction of flood risk or desertification, conservation and improvement of the soil, etc.), as well as its risk in the planning of silvicultural treatments and environmental services.

In order to facilitate the rural development and improve the forest health, some studies of the viability of small plants feeded by biomass are foreseen in a circular bioeconomy.

For the environmental services, the state and abundance of road network in forestlands have a key importance. Therefore, it is important to develop a detailed inventory of these infrastructures to improve their use efficiency.

5.7.1 Methodology

INVENTORY AND DASOCRATIC DIVISION

The chosen methodology for the Forest Management Project of Enguera, concerning the inventory and dasocratic forest division, is based on “Manual de ordenación por rodales; gestión multifunctional de los espacios

forestales - Manual for the management by stands; multifunctional management of forest spaces“ made by the Centre Tecnològic Forestal de Catalunya.

Permanent dasocratic division

For the permanent dasocratic division, the forest area is divided into permanent territorial units (management area (=logging unit), and within these, the stands); these units are normally invariable in the subsequent revisions. The permanent dasocratic division is established previously to the differentiation of stands, being definitive.

Division in logging units: criteria and results

According to the Forest Management Instructions of 1971, article 28, each logging unit constitutes an independent and homogeneous dasocratic unit, considering the degree of homogeneity that is possible in a large area. These management areas are large territorial units in which a forest can be divided to facilitate its management.

Nomenclature: Capital letters to identify these units (A, B, C...)

Area of the logging unit: According to the recommendation of Pita (1973), the area is recommended to be between a minimum of 100 ha and a maximum of about 1,000 ha.

Systematics followed: Logging units have been established for each forest due to this homogeneity and well delimited in territorial terms. In addition, the inhabitants of neighbouring towns are already familiar with the boundaries and names of these forests.

As these forests are very extensive, the physical barriers are also considered (ravines, firewalls, roads…)

Division in stands: criteria and results

The logging units are divided into stands; the stands are the minimum permanent territorial unit in which a forest will be divided. Specifically, the stands are territorial units roughly homogeneous, in ecological characteristics or station quality, with easily identifiable boundaries.

Nomenclature:

Cardinal numbers to identify the stands (1, 2, 3 ...)

Time sense, following a spiral pattern from outside to inside.

Start point (canton no. 1) located at the outer end further north.

Stand area: between 20 and 40 ha; the average surface area is around 30 ha (Pita 1973).

Systematics followed: Homogeneity of ecological conditions (orientation, altitudinal range, slope, type of soil etc.) and clearly defined boundaries (roads, small rivers or talweg etc.).

Forest partitioning

Definition of the parameters of the forest partitioning

According to Pita (1973), the stand is a temporary forestry and dasocratic unit, which is fixed more in the stand structure than in the occupied territorial area. The validity of the stand is effective for the immediate management period (20 years).

The boundaries of the stand are not permanent and may vary over time. This variation is due to the evolution of the stand structure or the silvicultural treatments which are applied. In addition, the stand is not marked on the ground. The forest partitioning is made depending on the forest status of the stand and the existing canopy cover (FCC). Following these criteria, the existing forest area is divided into the following categories:

State of the forest:

Without vegetation or seedling

Repopulated

Young stand (= thicket)

Pole stage

Adult stand (= high forest)

Canopy cover (FCC):

0-10 %

10-25 %

25-50 %

50-75 %

75-100 %

Typologies of the stand

Firstly, a pilot sampling is implemented in the forests based on the established criteria of the FCC and the state of the forest. The 3rd National Forest Inventory (NFI 2008) is used for the sampling, selecting the homogenous areas in terms of vegetation, orography, orientation, etc. However, even having 100 samples in the field of two selected forests, the obtained results had a maximum admitted error higher than 20% due to the dispersion produced after the fire. Therefore, more samples had to be obtained in forests where fires have occurred in the last 60 years.

Hence, the next step was to obtain samples (200 in total) from the forest where no fires have occurred to have a better representation of the state of forest structure and FCC. Nevertheless, the error with this methodology was around 20%. In consequence, this zoning was not valid.

Consequently, a reclassification on the orthophoto in 2010 was opted, looking for areas as homogeneous as possible. Through the orthophoto on paper and later together with the ArcGis software, the most homogenous stands were obtained. In addition, the error calculated was reduced to the corresponding 20%. The LIDAR data were used to test validity. In this way, it was favourably proved that the data obtained were valid.

Finally, the forest was partitioned again according to the FCC and the height, being very similar to those obtained by zoning over orthophoto.

It is important to note that the use of the appropriate software in the handling of Lidar data facilitates the analysis both in time saving, reliability and accuracy in results, avoiding the costly process described above.

FOREST INVENTORY WITH REMOTE SENSING

During the ForBioEnergy project, a model has been developed based on remote sensing. The use of this technology allows to reduce the cost of forest inventory and minimize the time to quantify the stock of biomass. Specifically, a study of carbon fixation by tree growth in two terms (2011-2017) has been done, calculating both *in situ* and through the satellite constellation of the Copernicus program of the ESA and the European Commission. The study establishes a correlation between the calculation of biomass in mature stand by field inventory and the reflectance values of the satellite image (Aleix-Amurrio 2018). For the forest inventory, the material used was a calliper (measurement of diameters), hypsometer (measurement of total height and distances), GPS (UTM coordinates of the plot center) and Oruxmaps viewer (visualization of cartographic maps).

Concerning the study of satellite images, even though two satellites were used for the comparison (Landsat 5 and Landsat 8), it is noted the use of Landsat 8 (L8) for the current biomass quantification (2017).

To manage the data, it is required to use:

(a) Software ENvironment for Visualizing Images (ENVI): Software specialized in processes and analysis of geospatial images. ENVI is written entirely in IDL (Interactive Data Language) (Gumley and Madison 2002).

(b) Geographic Information System (GIS): creation, edition, analysis and visualization of data linked to a spatial reference using ArcGIS.

(c) MATrix LABoratory - matrix laboratory (Matlab): mathematical software tool that offers an integrated development with its own programming language.

Finally, to obtain and analyse the images, the “reflectivity and bands” have been processed, as well as the connection of the biomass and the reflectivity through Gaussian processs Regression according to the methodology described by Vinué-Visús *et al.* 2018.

5.7.2. Results

Through the orthophoto, the dasocratic division is possible to implement it homogenously according to the state of the forest and the FCC; being different from what was included in the 3rd NFI.

On the other hand, with the classified LIDAR data, progress was made efficiently. Since the result of the data classification was done in a shorter time than with any other method. The processus to obtain these data are essential for the forest planning; the results were very similar to reality.

Finally, with the entire field executed (samples taken, orthophoto analysis, digitalization of the dasocratic divisions, classification of the LIDAR data through the appropriate software and results evaluation) a correct division was obtained.

5.8 Dendrometric inventory

5.8.1. Methodology

Design of the forest inventory

The forest inventory is the most expensive operation in the forestry planning.

The forest inventory allows to obtain quantitative parameters of the forest cover at the stand level. Specifically, these parameters inform on the state and dynamics of the tree cover, besides correlating with the quality of the habitat.

Types of inventory depending on the characteristics of the stand

The two basic criteria of an inventory are:

1. The forest status of the stand
2. The FCC

The type of the implemented sampling includes a general description of the study plot - arboreal and shrub structure, as well as a measurement of the existing trees with potential timber production. The geographical coordinates and the data related to the plot's geomorphology and other practical data: access status, type of sampling etc. coordinates are also noted in the inventory.

Regarding the herbaceous, shrub and arboreal structure, the FCC is recorded for the dominant herbaceous species. The species, the FCC and the average height are recorded for the shrub state. All the data that allow characterizing the state of the stand (height of the stand species, existence of damages and pests etc.) are recorded for the arboreal state.

Finally, an extended sample trees of the three thicker diametric classes is additionally inventoried. In this sample a Pressler driller is used to determine the age and annual growth of the trees, in addition to measure the Normal Diameter (ND) at 4 m height, the stem height and the average crown width.

Characteristics and measures of the immediate expert estimation

The objective of the immediate expert estimation is to obtain average values of reference at the stand level. The main estimated variables are:

Density (trees/ha) or average spacing between trees

Average and dominant diameter.

Basal area.

Average and dominant tree height.

Volume per hectare, which is directly estimated or calculated depending on the basal area, the average height and the approximate tree form factor.

It is also useful to note other variables such as:

FCC

Average age of the stand: sample with Pressler driller

Regeneration: state and percentage of the cover.

The rapid quantification of any other necessary parameter, such as forest certification (FSC or PEFC).

To obtain the data, inventory measurement instruments are used such as diametric belt, LaserAce hypsometer and Pressler borer.

Design of the conventional dasometric inventory

The planning and design of the forest inventory are relevant since the cost-precision relation of the inventory will depend on it.

The inventory focusses on each stratified type. Each typology has its inventory and, within the same type of stand, different inventories can be designed for different groups of stands.

The fundamental aim of the type and design of the inventory is to provide specific information sufficiently precise for each stand, so that the approach of the forest dasometric inventory must fulfil some conditions. For this forest planning, it is required:

To decide the inventory typology for each stand (sampling)

To decide the sampling intensity (type and size of plots and sampling density).

To distribute the inventory plots.

To select the parameters to be measured.

Inventory by sampling

The dasometric estimation is based on a sample of the population.

- Type of sample: systematic. The study plots are arranged centrally in the squares formed by the net (100 x 100 m^2) that is superimposed on the plane of the forests.
- Treatment of inventory data.

Table 18. Formulas used to process inventory data (Source: LIFE+ Bioenergy and Fire prevention 2013)

Estadísticos	$\vec{x} = \frac{\sum_{i=1}^{n} x_i}{n}$	$S = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \vec{x})^2}{(n-1)}}$	$CV = \frac{S}{\vec{x}} * 100$	$S_{\vec{x}} = \frac{S}{\sqrt{n}}$ (población infinita)	$S_{\vec{x}} = \frac{S}{\sqrt{n}} * \sqrt{1 - \frac{n}{n_p}}$ (Población finita)	AB=Eq$\sum_{i=1}^{n} \pi \left(\frac{Dn_i}{2}\right)^2$
Cálculo intensidad	$n = \frac{t^2 * CV^2}{[\varepsilon(\%)]^2}$ población infinita	$n = \frac{t^2 * CV^2}{[\varepsilon(\%)]^2 + \frac{t^2 * CV^2}{N_p}}$ población finita	$\frac{n}{N} \leq 0{,}05$			
error	$\varepsilon = \pm t * S_{\vec{x}}$					

X = average of the inventory sample

X_i = value of the study variable in inventory plot

n: total number (nº) of inventory plots

S: standard deviation of the sample.

N_p: total nº of plots that fit on the surface to be inventoried

CV: coefficient of variation of the sample

t: value of the t-Student; 95%

D_{ni}: normal diameter of the tree measured

Ep: equivalence (m^2/ha)

Sampling intensity

The sampling intensity or sample size is the result of the combination of the size plots and sampling density:

Type and size of plots - fixed radius of 15 m and sampling density depends on the structure of the stand.

The sampling or inventory plots have a sample area per plot of 706.5 m^2. The equivalence (Eq) (m^2/ha) is calculated as follows:

Eq = 10,000 / 706.5

For a level of significance of 95%, the maximum error allowed is 20% for productive forests[15]. The basal area is distributed in the population according to the Student's probability function t. Therefore, the number of inventory plots, to be made with the error, is associated with this distribution.

The sample plots are homogeneous zones, which have not suffered any fire and which does not present large areas with slopes over 60%.

Distribution of plots

[15] L'inventari Forestal dels Plans Tècnics de Gestió i Millora Forestal i del Plans Simples de Gestió Forestal de Cataluña

The goal of planning different inventories is to optimize the cost-precision relationship. For this, the centre points of the grids, included in the net, are calculated.

FOREST INVENTORY WITH REMOTE SENSING

The data of forest biomass is obtained following the methodology described in the National Forest Inventory (NFI) (DGCN 2006) with plots of 5, 10 or 15 m radius according to their density (Vinué-Visús *et al*. 2018)*;* total plots done amount to 20.

5.8.2 Results

Analysis of the forest silvicultural organization

The analysis of the silvicultural organization of the forest includes:

1. Identification of the forest species and its general distribution, identification of the species and site quality (if considered necessary) at the stand level.
2. Identification of the types of stands present in the forest and their surface distribution.
3. Distribution of stocks (standing volume) by species and stand.

Species and site quality

The site quality is the capacity of this site or station to allow the growth of the trees it supports, according to the climatic, edaphic and biological characteristics. This capacity is defined for a specific species and an ecologically homogeneous area, allowing the evaluation of the potential area to produce wood.

Site quality for *Pinus halepensis* has been estimated indirectly by seasonal attributes or factors (Ortega and Montero 1988), which can be intrinsic or extrinsic to the stand. According to Barrio (2003), the intrinsic factors contribute to the best results in the estimation of site quality.

Intrinsic factors:

Estimation by the historical production (total volume at the shift end)

Estimation based on maximum average growth data of the stand.

Estimation based on stand height data.

Among them, the dominant height is the dasometric variable that has been mostly used due to easy determination. In addition, it has a good correlation with volumetric production which indicates the quality of season for all ages of the population, being relatively independent of population density (except for extreme values) and the applied silvicultural treatments. The age structure indicates whether the forest stand is regular

(when, at least, 90% of the trees belong to the same age class), semi-regular (if> 90% trees belong to two contiguous age classes) or irregular (if> 90% trees belong to three or more contiguous stands of age). For the determination of tree age in dependence on ND and growth rate the age, in the Forest Management Project in Enguera, a multiple regression analysis was implemented to obtained a model.

According to the state of the stand, In Enguera is represented as follows (Figure 27):

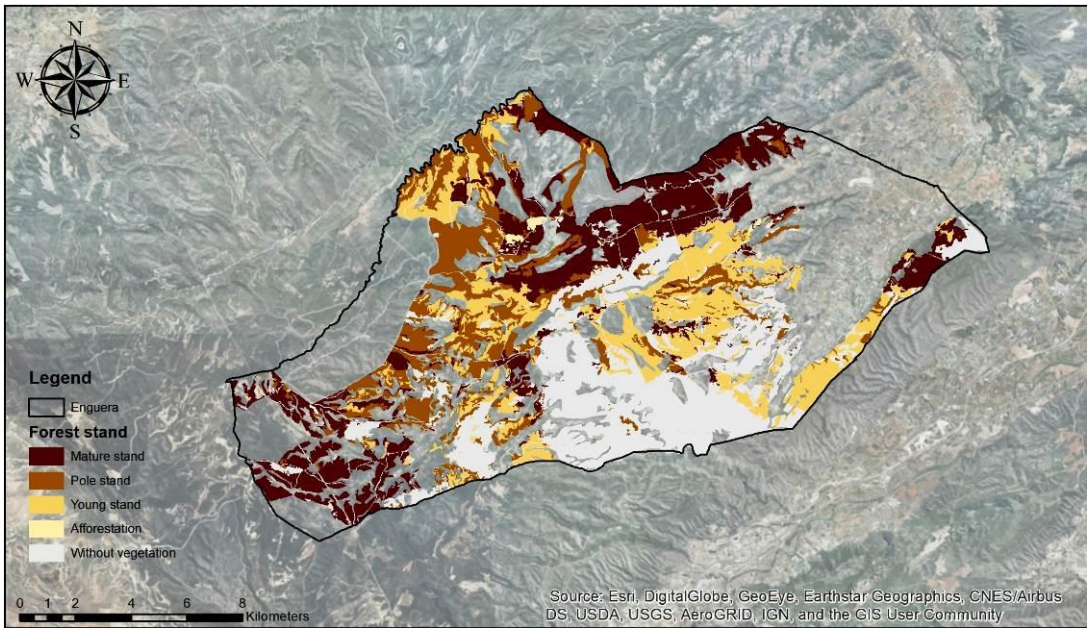


Figure 27. State of the forest stand in the MUP of Enguera (Source: Life+ Bioenergy and Fire Prevention 2013)

Valuation of the dasometric and silvicultural parameters

After performing the statistical analysis of the main dasocratic parameters, it was observed that the combination of a few independent variables allowed to explain most of the data variability.

The principal components analysis (PCA) allows to know the relationships among the variables, as well as the relative weight of each of them in the total data variability. The qualitative variables, such as state, canopy cover and tree vitality have been typified to be able to introduce them in the model, since the PCA is used only for the quantitative variables. However, it should be considered that the variables measured in larger scales will dominate over the rest, so that the typified variables will have a lower relative weight in the analysis.

To explain 83% of the variability of the data analyzed, the dasocratic parameters are combined into four new variables or components, as follows:

- Volume without bark (VwB), total timber volume (TV), volume of bark (VB), basal area (BA) and harvesting possibility (P) are directly related. TV is the variable that better explains the observed variation of all variables in the model. This parameter is considered a good indicator of the forest stand, so it would

be enough to analyse this parameter to draw conclusions about the structure of the forests and their possible forest use, not being necessary to obtain the other indicators. FCC is strongly related to these variables, but as it is a standardized parameter, its relative importance regarding the variability is unknown.

- The variable number of trees (N/ha) turns out to be the second variable in importance in the determination of the observed variability. The measurement of this parameter is fundamental for the characterization of the forest stand.

  The variables that form a 90º angle are not related, so the growth and vigour would not be related to the number of trees nor to the height or nominal diameter of the trees.
- The growth is inversely related to the height, the diameter class and the diameter.

Calculation of standing biomass

The highest value of timber volume with bark (m^3/ha) per homogeneous unit corresponds to mature stands 75-100 and 50-75, since it is the fractions that have a greater number of larger trees (Figure 28). It follows that there are significant differences between the different stands (evaluated with an analysis of variance).

The total timber volume per stand is calculated where the mature stand has greater standing volume, especially FCC 50-75 and 75-100. Therefore, these units are the most interesting from the point of view of logging forest biomass use.

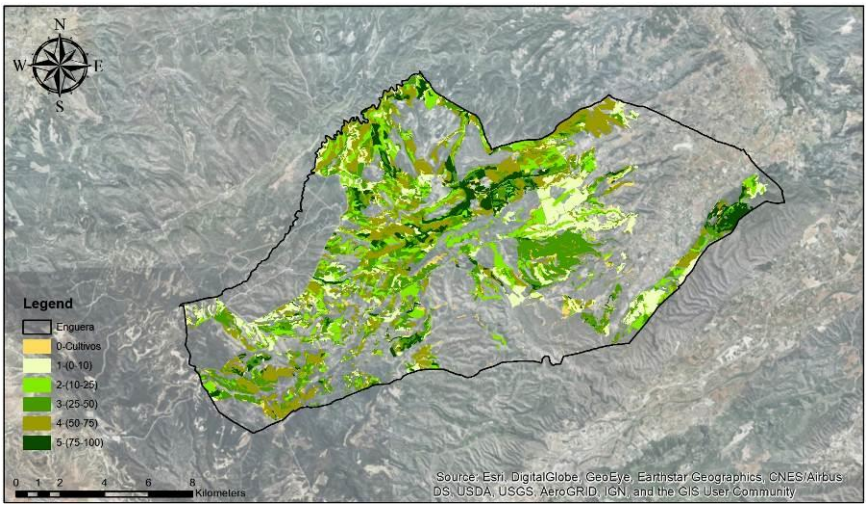


Figure 28. Forest cover (FCC) of the studied MUP (Source: Life+ Bioenergy and Fire prevention 2013)

Standing biomass per MUP

The results obtained in the FMP of Enguera regarding the standing volumes of the studied MUP are included in table 19.

Table 19. Timber volume (m^3) and standing biomass (Tm) per studied MUP

Dasocratic divison	Timber volume (m^3)	Standing biomass Tm
V-072	91.962,84	107.499,19
V-072V3002	40.844,44	22.872,88
V-074	110.142,38	61.679,73
V-3023V075	80.265,99	44.948,95
Total general	323.215,65	237.000,75

Being the following the results obtained by the forest inventory done in 2017:

Table 20. Characterization of the data processed in the 2017 plots (Forest inventory data)[19]

	N (trees/ha)	Average DBH (cm) ± SEM	Average quadratic diamete (cm^2)	Hart-Becking %	Average Tree heigh (H) (m) ± SEM	Hmax (m)
Min.	127	19,36 ± 0,36	21,11	22,66	8,65 ± 0,23	10,30
Average	251	25,36 ± 1,43	26,19	51,05	10,32 ± 0,44	13,33
Max.	481	31,14 ± 4,34	34,30	481,00	62,60 ± 13,43	0,77

As it has been indicated previously, the most important stock of biomass corresponds to mature stands of 50-75 and 75-100 of FCC. Therefore, the results of biomass with remote sensing are valid for these specific conditions. Hence, the stock of biomass obtained is 60t/ha, with a determination coefficient (R^2) = 0,91 (Figure 29).

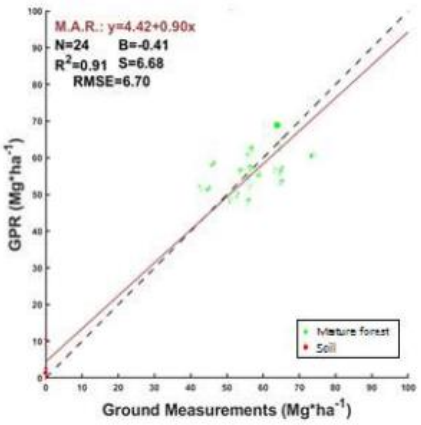


Figure 29: Measured biomass values vs. estimates with Landsat 8 in 2017[16]

As it is included in the study done, the biomass equations can provide more accurate estimates than the Biomass Expansion Factors (BEF). For this reason, these equations are used more frequently to estimate forest biomass (IPCC 2003). These biomass estimation models are constructed through destructive sampling

[16] http://hdl.handle.net/10251/109094

associated with a high cost. Specifically, in the relations between the dry biomass weight with some dendrometric characteristic, the normal diameter and/or the tree height (Crow and Laidly 1980, Pardé 1980).

The inventory costs are being reduced, an elevated R^2 is obtained with only a sample of 20 plots. This demonstrates a large goodness-of-fit of the obtained model.

5.9 Plan of silvicultural treatments

TYPES OF SILVICULTURAL TREATMENTS

In this section the grouping by stands is made where the silvicultural treatment will be the same. That is, the operation to be done will be implemented depending on the real harvesting possibility of each compartment (see temporal planning) and its stand type. The work will begin by the compartment with larger area, giving time to the rest of the compartment to its development. There are also compartments with a surface larger than 60% of the slope, where silvicultural treatments cannot be implemented. Hence, these compartments will fulfil the function of protection for wildlife and flora conservation.

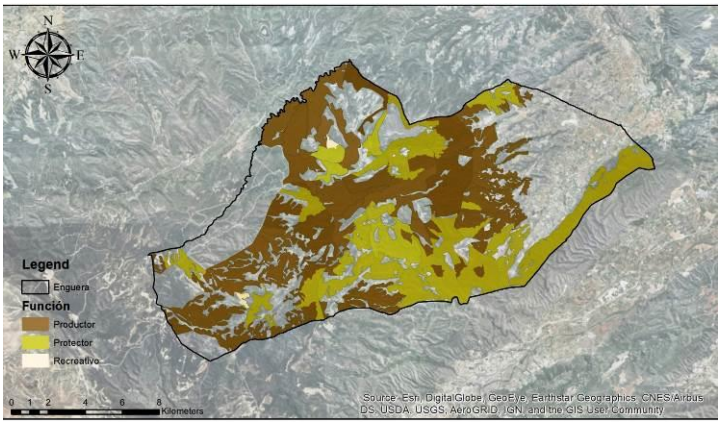


Figure 30. Main function of the studied MUP (production, protection and recreational forest)

Actions to be implemented on mature stands

Felling type: Forest use

Period of use within the forest management project (FMP): Preferably within the first 5 years

Methodology of the felling:

Regenerative cutting: The 250 best trees will be chosen, which will serve as seed trees for the next generation; these trees will be the ones with the best genotypic and phenotypic characteristics. In the case of compartments designated for protection or recreational areas, seed trees will never be less than 350 trees and 50% of the FCC.

Thinning: it will be made in those compartments that are wished to reserve as mature stands for the following period of the FMP (It may be due to the fact that there is not enough map projection area in the pole stand). The 350 best trees will be conserved both phenotypically and genotypically, the rest will be removed.

Actions to be implemented on pole stands

Felling type: Improvement

Period of use within the FMP: Preferably between 5-15 years of the FMP.

Surfaces with an FCC higher than 50%: The 700 best trees will be chosen, both phenotypically and genotypically - said trees will be fundamentally the ones with the greatest health, as well as better stem and greater growth.

Surfaces with a FCC lower than 50%: If the number of existing trees is less than 700 trees/ha, only sanitary cuts will be made (trees affected by snow, damaged by wind or pests). If the number of trees is higher than 700 trees/ha, the remaining trees will be removed, especially damaged trees.

Actions to be implemented on young stands

Cut type: Improvement

Time of use within the FMP Preferably between 5-15 years of the FMP

Surfaces with a FCC higher than 50%: The 1,400 best trees will be chosen, both phenotypically and genotypically - trees will be fundamentally the healthier, with better stem and growth.

The cutting methodology would be the one described below (the present methodology would be applicable in areas of post-fire regeneration, where the density of trees is greater than 10,000 trees/ha and the diameter less than 6 cm.

SYLVICULTURAL OPERATIONS PER ANNUITY

Table 21. Silvicultural operations

FIRST ANNUITY	SECOND ANNUITY
Where there are areas covered by an important pine forest, streets are opened 2 m width leaving a covered band of 1 m between streets through a chain-type haulm slasher or hammers slasher. **Areas with slope <30%:** – Opening of streets following the contour lines, always trying to connect clear surfaces. – The equidistance between street axes: 3 m. – Area brushed out to this occupation: 67% of the total of these areas. – In the pine wood between streets (10 m wide): clearing of pine with a cleaning saw, leaving the best pine trees opening gaps in 25% of the surface. **Areas with a slope higher than 50%:** – Opening of gaps in 40% of the surface with motor-cutter making a clearing to it. – The waste coming from the action will be collected and stacked (in the open streets in the areas of slope less than 50%); they will be eliminated with a chain cutter (p <30%) and with a crusher disk (p> 30%). **Brush out:** – 55% of the stand surface will be brushed (p <50%) – 50% of the surface will be brushed (p> 50%)	In the pine forest that remains between the streets of the previous annuity there will be a clearing of trees in lines with a cleaning saw, leaving the best pine trees opening gaps in 25% of the surface, selecting the best tree. **Areas with slope >50%**[17] The pine forest will be treated by opening gaps in 20% of the surface with a cleaning saw making a clearing to it, selecting the best trees. **Opening of streets with areas with slope <50%** – The waste derived from the forest operation will be collected and piled; they will be eliminated with chain-type haulm slasher (p> 30%) or with disc crusher (p> 30%). – Planned clearings, 55% of the stand surface will be brushed with p> 50% and 50% of the surface with p> 50%. **Surfaces with a FCC lower than 50%:** – If the number of existing trees is less than 700 trees/ha, only sanitary cuts will be made (trees affected by snow, damaged by the wind or sick). – If the number of trees is greater than said 700 trees/ha, the remaining trees will be eliminated. In this state, it will always be cut positive so that felling occurs in sick trees or poor condition and if a higher number of trees still existed, the trees with lower growth would be eliminated.

[17] Even though in the FMP of Enguera was included to work in areas with slope more than 50%, technically it was concluded that only it could be worked in areas with less than 35% of slope.

5.10 Potential biomass production and share available for bioenergy production

Analyzing the demand for wood in Spain, it is observed that in the Northwest of Spain the total harvesting rates in m^3 are significantly higher than in the Mediterranean. Specifically, in the Valencian Community, the total harvesting are normally below 20,000 m^3.

Figure 31. Total harvesting rates by provinces in Spain in 2016. Source: MAPA 2016

Regarding the distribution of harvesting between species of conifers and hardwoods, the following figure shows the percentages of each type by Autonomous Community:

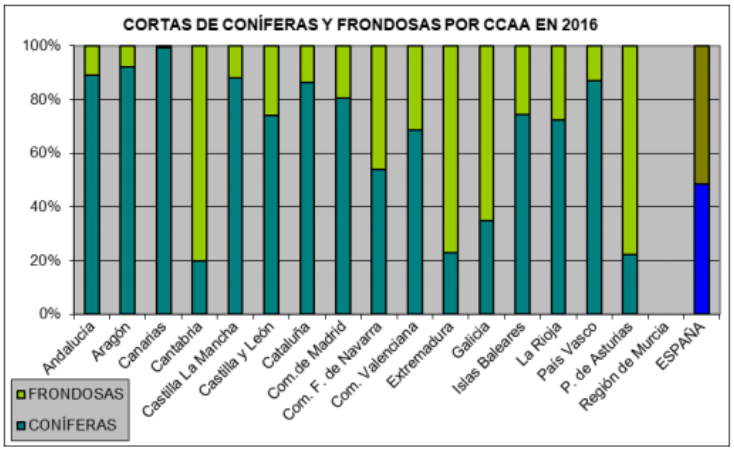


Gráfico 4.2: Porcentaje de cortas de coníferas y frondosas por comunidad autónoma.

Graph 1. Distribution of conifers and hardwoods harvested by Autonomous Community. Source: MAPA 2016

It is observed that in the Comunitat Valenciana, approximately 70% are coniferous and 30% hardwoods. Specifically, as indicated in the PATFOR's report (2013), the Valencian forests are accumulating wood and biofuel, which could be extracted from the interior areas of the region: southern half of the province of Castellón, interior of the province of Valencia and north of the province of Alicante - pine forests of *Pinus halepensis;* north of

Castellón and Rincón de Ademúz - pine forests *Pinus nigra* and in the north of Castellón and north of Alicante - holm and quejigo oaks.

Table 22. Standing volume and harvesting possiblity of wood and biofuel in the forest lands of the Comunitat Valenciana (PATFOR 2013 based on NFI3 –National Forest Inventory).

			Datos medios por hectárea					
	EM (m^3)	EB (t)	PM (m^3/año)	PB (t /año)	EMH (m^3/ha)	EBH (t /ha)	PMH (m^3/ha/año)	PBH (t /ha/año)
Castellón	5.915.753	5.379.255	183.058	63.906	29,5	27,3	0,9	0,4
Valencia	6.489.067	4.193.948	193.130	59.379	24,1	15,7	0,7	0,2
Alicante	2.014.710	1.552.847	60.518	19.340	19,8	15,3	0,6	0,2
Comunitat Valenciana	14.419.531	11.126.050	436.705	142.625	27,0	20,8	0,8	0,3

Abbreviations: EM (=Standing volume), EB(= Biomass), PM (= Harvesting possibility of biomass), EMH (= Standing volume per hectare), EBH (= Biomass per hectare), PMH (= Harvesting possibility per hectare), PBH (= Harvesting possibility of biomass per hectare)

According to the INE (2018), biomass represent 19% of the domestic primary energy production (2016), with respect to primary energy consumption. Concretely, the primary energy consumption in Spain (2016) is 123,484 ktep, slightly higher than the previous year. The generation with coal is reduced by 23.7% and the hydraulics increase by 30.6%, being the contribution of renewable energies higher with respect to 2015. The final energy consumption, excluding non-energy uses, amounts to 81,550 ktep, a 1,5% more than in 2015. The set of renewable energies account for 38.1% of total gross electricity production. Therefore, the energy dependence has been reduced almost 8% regarding the one registered ten years ago.

Spain is the third European country by absolute forest biomass resources (only behind Sweden and Finland) and the seventh in terms of per capita. It has a forest area of 27,664,674 hectares (57% of the total), and it is the European country with the highest increase in forests, with an annual growth rate of 2.2%, much higher than the EU average (0.51%). However, Spain is one of the EU states with lower use of forest resources and agricultural livestock in the generation of electricity, thermal, biogas/biomethane and recovery of the organic fraction of municipal solid waste (OFMSW).

The biomass represents a very modest percentage of the electricity generation mix in Spain. Of the total national electricity production in 2017, biomass, biogas and OFMSW alone account for around 2% of the total. In thermal generation, fossil fuels are widely used in buildings and industries, at the expense of other sources of sustainable and indigenous generation such as biomass. Spain, despite its abundance of biomass resources, consumes significantly less than the EU average. According to the EurObserv'ER report of December 2017[18], Spain occupies position 22 of the EU in energy consumption from solid biomass per capita (0.114 toe/inhab).

[18] https://www.eurobserv-er.org/category/barometer-2017/

5.11 Inventory of the forest viability and other infrastructures and management prescriptions

The use of forest biofuels would favour the consolidation of a diverse and competitive bioenergy market, increasing energy independence and contributing to the consumption of renewable energy and to compliance the Renewable Energy Plan of Spain (PER).

In the Valencian Community, the solid biofuel production plants with high added value (woodchips and pellets), located near the forest production areas and with the capacity to supply raw materials, are considered the best alternative to enhance this resource, promoting the emerging market at the local/regional level. Specifically, the use of pellets for domestic heating is more economical than the use of other fossil fuels, saving 20% of total expenses (including investment in boiler, fuel cost and generation cost).

Once the operation of this type of facilities has been consolidated and depending on the demand of the bioenergy market, plants with higher requirements such as power generation plants (CHP) would be viable. Woodchip plants could diversify production, in addition to generate thermal/electric energy by combustion or gasification for a power between 500 KW to 5 MW (medium scale). In Enguera, a 2 MW connection point for power generation (district heating) could be established. In a radius of 20 km it covers all of MUP to obtain forest biomass, in addition to the several existing rural roads that facilitate the access of the forest to the plant.

All MUP have an optimal network of forest roads, divided into main and secondary roads; in addition to have old forest loggings. There are also conventional roads, highliting:

- CV-590 goes through the MUP V074, V3002V072 and V3023V075. All this road goes through areas belonging to municipality of Enguera.
- CV-589 passes through the MUP V077 and V074, belonging to the municipality of Moixent and Enguera respectively.

In the project, the road network is only studied for the planning of the stands and for the work to do be effective, in addition to the purpose of prevention of forest fires (to see point 5.4 *forest fires*).

Analysis of the production and demand of biomass for energy purposes

The MUP studied have a well-known potential for the biomass resources that could be used for energy purposes. As established in point 3.1 "Wood and Biomass" of the PATFOR report, it is included that the Valencian forests are accumulating wood and biomass, which could be extracted in the interior areas of the Community, specifically in the pine forests of *Pinus halepensis*. Pine forests of *Pinus halepensis* are simultaneously producing wood and biofuel in significant quantities that could make profitable a joint and integral use of both products.

Concretely, in the Valencian Community it could be extracted, through sustainable forest management, 7 times more than what is now extracted from wood (59,938 m^3/year) (INE, 2005) and more than 142,600 t/year of forest biomass that can be harvested for energy.

In addition, the rise in gas and oil prices, the foreseeable stabilization for pellet prices, technological development and the foreseeable decrease in boiler prices favours the consolidation of the pellet market in the Community. The use of pellets for domestic heating versus other fossil fuels is much cheaper, saving 20% of total expenses (includes investment in boiler, fuel cost and generation cost (PATFOR 2013).

Enguera has the approval of a 2 MW connection point for power generation (district heating). In a radius of 20 km, it covers all of the forests under study to obtain forest biomass, in addition to exist several rural roads that facilitate the access of the forest to the plant.

Cooperatives, companies and forest industries of the Comunitat Valenciana

The number of cooperatives, companies and forest industries registered in the Comunitat Valenciana are included in table 23.

Table 23. Services of the cooperatives, companies and forest industries of the Comunitat Valenciana[19]

Engineering services (S.)	Forestry S.	Logging S.	Related to logging S.	Wood production S.
51	60	50	49	30

Felling of tres S.	Related forestry S.	Forest management S.	Management of the forest resources S.	Control of forest pests S.
43	58	52	50	36

Forest administration S.	Forest inventory S.	Forest monitoring and evaluation S.	Reforestation S.	Management of forest nurseries S.
34	42	42	43	27

5.12 Management prescriptions for the pasture and the wild fauna

Pasture utilization plan

The forest management project of Enguera has not studied the specific pasture charge that the forest could support in references to the cattle density. Anyhow, the livestock uses are compatible with the different uses established in the FMP. The legislation to be considered for the pastoralism use is:

State Legislation

Law 43/2003, of November 21, on Forestry – *Ley 43/2003, de 21 de Noviembre, de Montes.*

[19] Complete information aobut forest enterprises: http://www.agroambient.gva.es/documents/20551003/162434335/REGISTRO_empresas_forestales_26_02_2019.pdf/0f54151b-0d09-4262-9b4a-1a199bd24a04

Law 10/2006, of April 28, which modifies Law 43/2003, of November 21, of Forestry - *Ley 10/2006, de 28 de abril por la que se modifica la Ley 43/2003, de 21 de Noviembre, de Montes*

Extracted information of Article 36 and 50:

Article 36. Forest uses

3. The forestry body of the autonomous community will regulate non-timber use. Said uses, and in particular that of pastures, should be expressly appropriate in the corresponding forest management instruments or plan for the management of forest resources (PORF – *Planes de Ordenación de los Recursos Forestales*) in whose area where the forest in question is located.

Article 50. Maintenance and restoration of the forest character of the burned land

2. The competent body of the autonomous community will fix the measures aimed at the removal of the burnt wood and the restoration of the vegetation cover affected by the fires that, in any case, should include the temporary delimitation of those uses or activities incompatible with their regeneration and, in particular, grazing, for a period that must be longer than one year, except for lifting of the bounded by express authorization of said body.

Autonomous law

Law 3/1993, of December 9, Forestry of the Valencian Community

Extracted information of Article 34 and 59:

Article 34:

3. The use of pastures will be made taking care not to damage the vegetal layer or degrade the soil. The authorization of these uses in public and private forests may be conditioned in their intensity and even prohibit when the conditions of the soil, climate or animal species that they graze may jeopardize the maintenance of the ecosystems.

Article 59:

2. Forest lands that have suffered the effects of a fire cannot be used for grazing in the following five years; they may not be dedicated or transformed into agricultural land until, at least, twenty years have elapsed, or to extractive activities for up to ten years, unless expressly authorized and reasoned by the Forestry Administration, following a report from the Forestry Council (The Law of the Valencian Government 4/1992, of June 5, of Non-Urbanizable Land, establishes the limitation to grazing in the 5 years after having suffered a fire).

According to PATFOR, pastures would be defined as:

Pastures are another of the multiple environmental services of production that the forests offer to society, understood as any vegetable resource that serves as food for livestock, and fauna in general, including hunting. This service has also influence on the dynamics of forest ecosystems, providing other environmental services (dynamizing the landscape, providing nutrients to the soil, promoting biodiversity, etc.).

In the majority of Valencian ecosystems, whose characteristic pasture is woody, there are species of certain pastoral interest that could be dedicated to the production of livestock in extensive regime, although with limited productivities (at most 40 LU[20]/100 ha), especially in the pine forests.

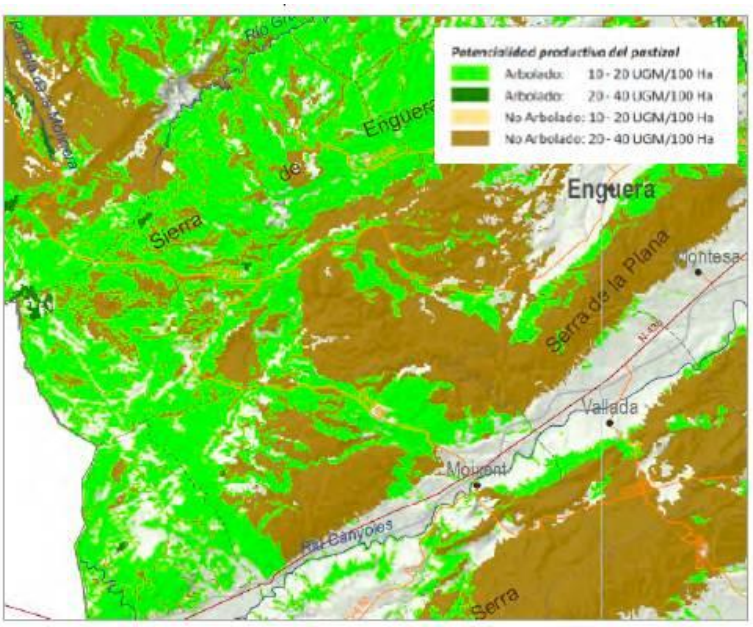
Guidelines

Through an adequate management of the ecosystems, it could increase its quality as pasture and, therefore, the production of this service, avoiding the negative impacts derived from both overgrazing (desertification) and under-grazing (fire spread).

The management focused on the usage of pastures generates important synergies with other environmental services. One example is the important involvement it has with the forest fire regulation service, both in the maintenance of firewall areas, and in the reduction of fuel load in general.

For the study area, the established cattle density would be as follows:

Figure 32. Pasture productive potential (Source: Life+ Bioenergy and fire prevention 2013)



[20] Unidad Ganadera mayor o bovina = Greater Livestock unit (LU) or bovine

Management standards of pastures

Recommendations of management are:

To take advantage of the surfaces occupied by auxiliary belts for livestock pastures.

To promote the use by shepherds of the different sheepfolds located in the municipal areas of Enguera and Moixent (most of these sheepfolds are located on private areas or forest managed by the Regional Ministry).

Do not graze in the regeneration stands until the regenerated one is consolidated (5-10 years). Said consolidation would be established by the managing body, in the different annual reports.

Do not exceed the LU established by PATFOR.

Improvement of livestock infrastructure

Within the different municipal property forests under study, there are no specific livestock infrastructures. In the FMP the construction of any livestock infrastructure has not been considered. Despite this, it is considered that livestock is the best way for controlling heliophilous scrub in a natural way.

Improvement of infrastructures for fauna

Within the improvements to be made in the different areas of the forests, it has been considered of vital importance the construction and maintenance of the different infrastructures for the fauna.

Among the improvements proposed, the following are included:

Maintenance of old dry land cultivation fields in the interior of the forest.

Improvement of existing troughs in the different sources distributed by the municipalities.

Maintenance and creation of small water infrastructures.

Maintenance and improvement of the feeders distributed by the different study areas.

Regarding the existing species in SCI “Sierra de Enguera”, the most important are the following: *Aquila chrysaetos; Circaetus gallicus; Falco peregrinus* and *Hieraetus fasciatus.* The outlined fauna of the MUP are *Capra pirenaica* and as plant species are *Sideritis sericea* and *Teucrium buxifolium.*

5.13 Connections of the FMP with other planning tools

There is no record of the existence of other inventories or study of non-timber forest resources in the last 15-20 years. In the FMP, the rest of the resources would be invented, but the aim is the quantification of biomass and the correct management of the forests.

However, it is noted that of the 11 forestry fire prevention plans by demarcation (Alcoi, Altea, Crevillent, Chelva, Llíria, Polinyà de Xúqer, Requena, Xàtiva, Sant Mateu, Segorbe, Vall d'Alba), the demarcation affected of the studied MUP is Xativa. Regarding local plans for the prevention of forest fires, Enguera has its fire prevention plan in process. Concerning the prevention plans of the protected areas, there is a plan of the Protected Nature Sites and others affected by the Valencian Hunting Reserve of the Muela de Cortes – *Reserva Valenciana de Caza de la Muela de Cortes,* included in the Decree 10/2017 mentionned before.

Finally, it is emphasized that sylvicultural operations are compatible with the principle required by Protected Natral Spoaces and the Natura 2000 sites, as long as they are carried out in accordance with the criteria of sustainable forest management and favor the environmental services that motivated your statement

5.14 Assessment of impacts by the FMP

Practically all of the study forests are included in the Natura 2000 sites. Therefore, in addition to comply with the different guidelines and regulations in place, the monitoring of the different species protected by the Natura site is proposed to study the real environmental impact in the FMP.

Specifically, at Valencian Community level, the regulations for environmental impact assessment are divided into:

(1) EU Community: Directive 2011/92/EU of the European Parliament and of the Council of 13 December 2011 on the assessment of the effects of certain public and private projects on the environment

(2) State: Law 21/2013, of December 9, on environmental evaluation (BOE nº 296, if 11/12/13 - *Ley 21/2013, de 9 de diciembre, de evaluación ambiental (BOE nº 296, de 11/12/13)*[21]

(3) Autonomic - Valid in what is not regulated by the state and when it supposes a higher level of environmental protection:

- Law 2/1989, of March 3, of the Generalitat Valenciana, of Environmental Impact (DOCV nº 1021, of 03/08/89) - *Ley 2/1989, de 3 de marzo, de la Generalitat Valenciana, de Impacto Ambiental (DOCV nº 1021, de 08/03/89).*
- Decree 162/1990, of October 15, of the Consell de la Generalitat Valenciana, which approves the regulation for the execution of Law 2/1989 (DOCV nº 1412, of 30/10/90) - *Decreto 162/1990, de 15 de*

[21] Ley 21/2013, de 9 de diciembre, de evaluación ambiental (BOE nº 296, de 11/12/13)

octubre, del Consell de la Generalitat Valenciana, por el que se aprueba el reglamento para la ejecución de la Ley 2/1989 (DOCV nº 1412, de 30/10/90).

- Order of January 3, 2005, of the Department of Territory and Housing, which establishes the minimum content of environmental impact studies that must be processed before this Ministry (DOCV no. 4922, of 12/01/05) - *Orden de 3 de enero de 2005, de la Conselleria de Territorio y Vivienda, por la que se establece el contenido mínimo de estudios de impacto ambiental que se hayan de tramitar ante esta conselleria (DOCV nº 4922, de 12/01/05).*
- Decree 32/2006, of March 10, of the Consell de la Generalitat, which modifies Decree 162/1990, of October 15, of the Consell de la Generalitat, by which the Regulation was approved for the execution of Law 2/1989, of March 3, of the Generaltiat, of Environmental Impact (DOCV nº5218, of 03/14/06) - *Decreto 32/2006, de 10 de marzo, del Consell de la Generalitat, por el que se modifica el Decreto 162/1990, de 15 de octubre, del Consell de la Generalitat, por el que se aprobó el Reglamento para la ejecución de la Ley 2/1989, de 3 de marzo, de la Generaltiat, de Impacto Ambiental (DOCV nº5218, de 14/03/06).*

On the other hand, following the methodology implemented in the ForBioEnergy project, impacts on habitats (with regard to Directive 92/43/EEC) and on forest plantations will be evaluated. The study of impacts is done in the (a)biotic and socioeconomic and demographic components, as well as in the environmental services.

- Biotic components: vegetation sampling/diversity indices, presences of protected, endemic, synanthropic and alien species, life form spectrum, presences and damages to natural regeneration.
- Abiotic components: Deadwood, litter, soil organic carbon, erosion, bulk density and fire risk.
- Socio-economic and demographic components:
    - *Socio-demographic*: population growth rate, population structure, per capita family income, unemployment rate, educational level, energetic self-sufficency.
    - *Socio-economic*: total firms, legal form, net income, labour productivity, workforce, workforce age, type of contracts, positions or jobs, R&D investment, innovations introduction, tangible resources.
    - *Environmental services*: commercial wood value, fuelwood value, wood energy production value, sequestered carbon value, cost of replacing the protective function, cultural service value.

According to Aleix-Amurrio (2018), sustainable forest management has a direct influences on the dynamics of carbon fixation. The total carbon fixation is clearly positive in the management scenario, more considering the substitution effect of biomass in its energy valorisation faced to fossil energy sources.

More studies are foreseen in the future to assess the (a)biotic components in different terms. Hence, in order to conserve the studied plots and their environment, reducing the risk of forest fires, forest works have been implemented with the equipment acquired during the project.

5.15 Final remarks

The use of the forest biomass has influence on the forest stands. Concretely, there is an improvement of their phytosanitary status and they become more stable to face perturbances as forest fires, pests, climate change, etc. The forest management stimulates their growth and the quality of their products, increase the wood production and forest biofuels, in addition to allow a continued use of forest products with continued incomes. Therefore, it favours the consolidation of markets for diverse and competitive productions based on solid biofuels as pellets and woodchips to generate thermal/electrical energy in the Comunitat Valenciana.

It is noted the potential establishment of a 2 MW connection point for power generation (district heating). In a radius of 20 km it covers all of the forests under study to obtain forest biomass, in addition to the several existing rural roads that facilitate the access of the forest to the plant. According to the Integral and Sustainable Forest Management Project of Enguera (2014-2034), there is a real possibility of 8.000 tons per year of municipal forest biomass.

This study continues with D.3.8.1 in which different business units will be proposed to valorise the forest resources: Biomass logistic platform - sustainable forest management and biomass classification and supply (Business unit 1), Industrial plant of solid biofuels (Business unit 2) and local district heating (Business unit 3).

Finally, it is worth mentioning the use of remote sensing for the forest management and inventory in Mediterranean conditions as essential tool due to the small database which is required, allowing to avoid the long and expensive forest inventories.

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Annexes: Maps of the Forest management project of Enguera

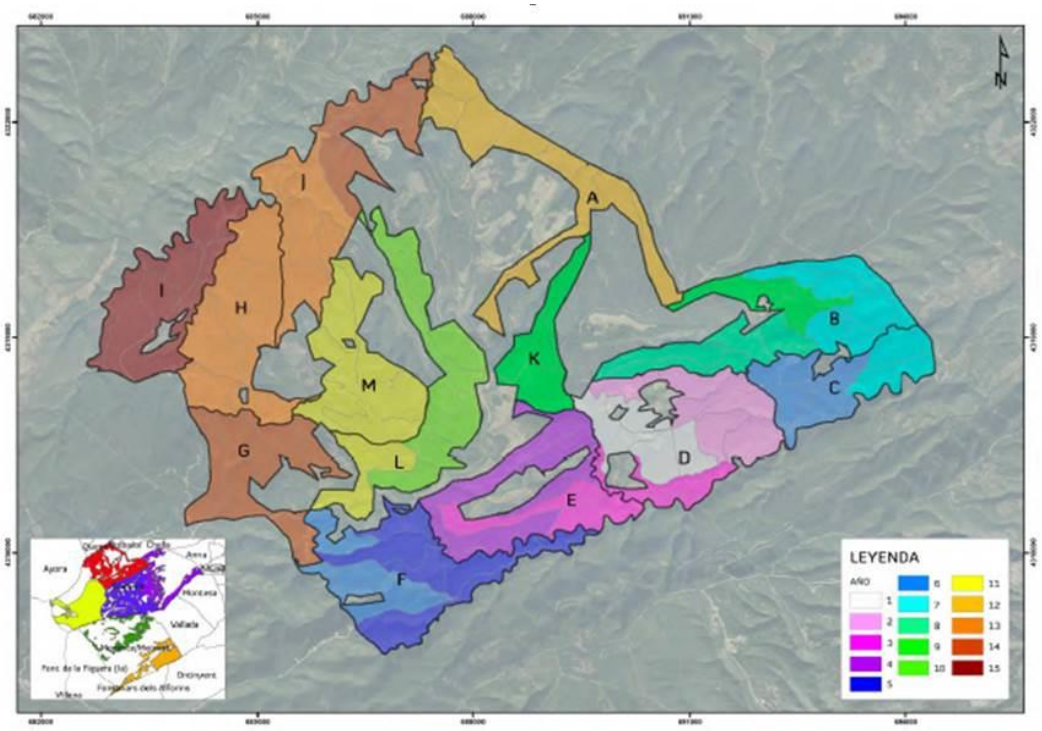

Figure 33. Temporary zoning in the MUP V-072 (Life + Bioenergy and Fire Prevention 2013)

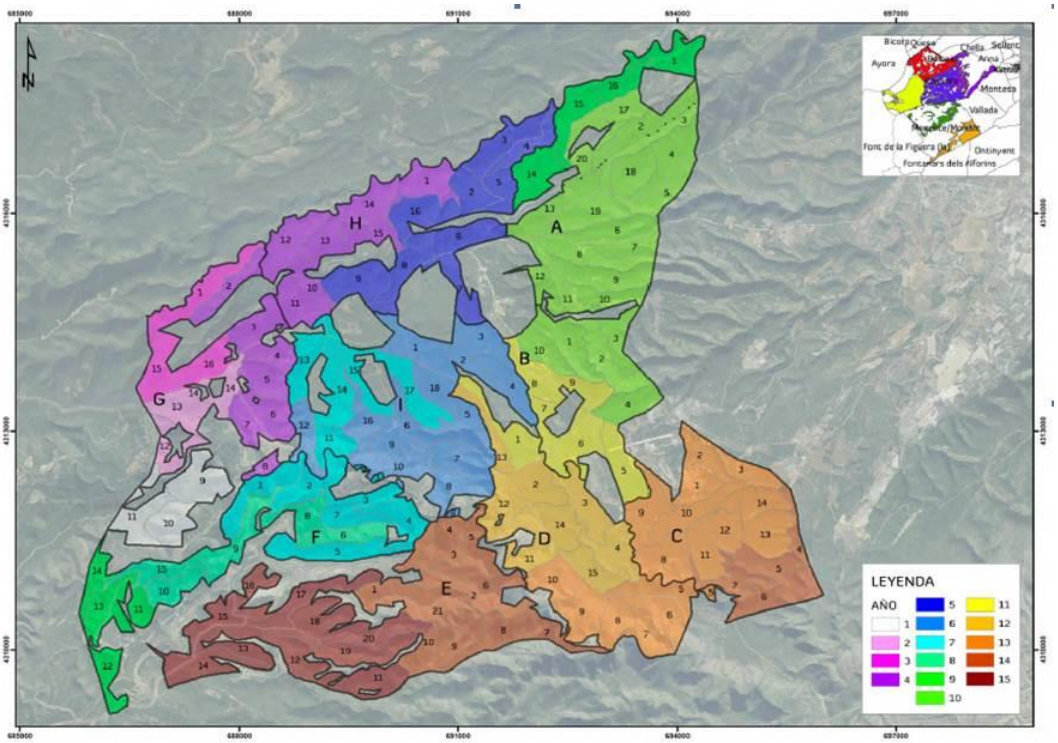

Figure 34. Temporary zoning in the MUP v-3002v072 (Life + Bioenergy and Fire Prevention 2013)

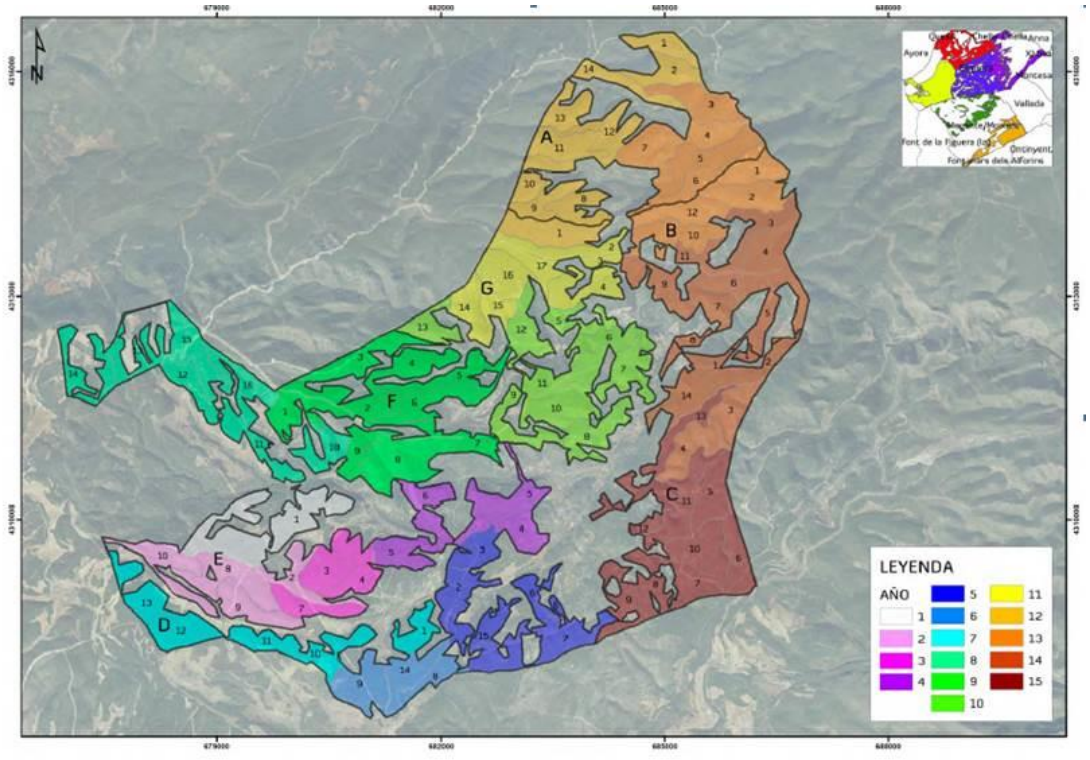

Figure 35. Temporary zoning in the MUP V-074 (Life + Bioenergy and Fire Prevention 2013)

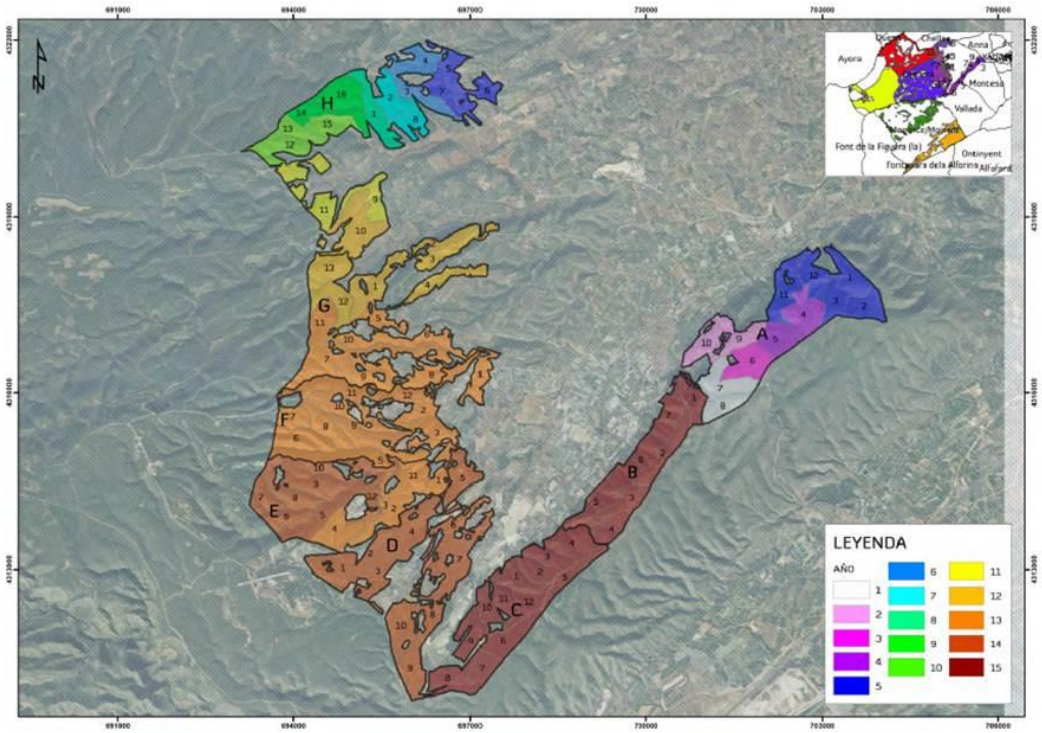

Figure 36. Temporary zoning in the MUP V-3023v075 (Life + Bioenergy and Fire Prevention 2013)

6. MAIN RESULTS OF THE FOREST MANAGEMENT PLAN OF THE BIOMASS DISTRICT OF ZADAR COUNTY IN Velebit and Vrana Lake Nature Parks (CROATIA)

6.1 National and regional legislative framework

Some of the laws that define the basis for biomass energy issues:

- **Law on Forests** (OG 140/05, 82/06, 129/08, 80/10, 124/10, 25/12, 68/12, 148/13, 94/14) defines sustainable management as the underlying principle of forest planing and management, which strives to achive a lasting balance between the overall biomass production, general benefits of forests and the overall use, by using a part of the biomass to maintain permanent production of all the benefits of the forests, considering the forest is as a renewable source of energy.
- **Energy Act** (OG 120/12, 14/14, 95/15, 102/15) determines the authority and responsibilities for establishing and implementing the policy of promoting energy production from renewable energy sources (RES), the conditions and production mode and use of energy from the RES in the energy market, the financial incentive to use the RES and other issues related to the use of RES.

- **Law on Renewable Energy** (OG 100/15) regulates the planning and promotion of production and consumption of electricity produced in production facilities using RES and high efficiency cogeneration, establish incentive measures for electricity generation using RES and high efficiency cogeneration etc.

- **National Forest Policy and Strategy** (OG 120/2003) determines annd defines the national policy of forestry and wood industry and ensures its compliance with the strategic documents of the Republic of Croatia.

- **Act on Sustainable Waste Management** (OG 130/2005) which purpose is to establish a framework within which Croatia will have to reduce the amount of waste it produces and to manage produced waste on a sustainable way. In order to improve the waste management system, biomass utilization should be encouraged.

- **Nature Protection Act** (OG 80/13, 153/13, 78/15) provides for a legal basis for instruments that encourage the use of the RES and mentions the activities of financing for the preparation, implementation and development of programs, projects and similar activities in the field of conservation, sustainable use, protection and improvement of the environment, rational use of natural resources and energy as basic conditions for sustainable development and the realization of

citizens' rights to a healthy environment, is carried out by the Fund for Environmental Protetection and Energy Efficiency in accordance with a special law.

- **Law on Excises** (OG 22/13, 32/13, 81/13, 100/15, 120/15, 115/16) supports the production of energy from RES by determining that excise duty is not paid on the electricity generated by the use of RES and if the producer uses it for its own needs: wind, waves, tides, geothermal sources, solar energy or if produced from biomass or biomass products.

- **Electricity Market Act** (OG 22/13, 95/15, 102/15) supports the production of electricity using RES in a way that an electric energy entity or legal or physical entity who simultaneously produces heat and power using electric energy in a highly efficient way, uses RES or sources or waste fro the production of electc energy in an economically feasible way and in accordance with regulations from the adminitrative area of environmental protection can acquire the status of eligible electicity producer.

- As more and more initiatives for wood biomass and woodcutting plants are emerging recently, for potential investors **the Ordinance on Acquiring the Status of Eligible Electricity Producer** is important, which prescribes the conditions for obtaining and abolishing the previous decision on acquiring the status of eligible producer, i.e. decisions on gaining of the status, rights and obligations arising from the previous decision or decisions, the technical and operating conditions for production facilities, the duty of reporting by the eligible electricity producer and the supervision of the operation of production plant based on the decision about acquiring statu as an eligible producer of electric energy.

- **Directive 2009/28/EC on the promotion of the use of energy from renewable sources** based on which Croatia and other EU Member States have undertaken to increase the use of renewable energy sources, with the share of renewable energy sources in gross direct consumption in 2020 of at least 20%, observed at the European Union level.

When planning a Forest Managemnt Plan it is necessary to follow these laws and subordinate legislation:

- Law on Forests (OG 140/05, 82/06, 129/08, 80/10, 124/10, 25/12, 68/12, 148/13, 94/14)
- Law on Hunting (OG, 140/05, 75/09, 14/14, 21/16 – Decision of the Constitutional Court of the Republic of Croatia, 41/16 - Decision of the Constitutional Court of the Republic of Croatia and 67/16 -Decision of the Constitutional Court of the Republic of Croatia)
- Law on Agricultural Advisory Service (OG 50/12, 148/13)

- Law on Fire Protection (OG 92/10)
- Plant Protection Products Act (OG 70/05, 80/13 , 117/03)
- Law on Croatian Chamber of Forestry and Wood Processing Engineers (OG 22/06)
- Law on Forest Reproductive Material (OG 75/09, 61/11, 56/13, 14/14)
- Law on the Recognition of Taxes of Forest Trees and Shrubs (OG 113/03, 33/05)
- The Water Act (OG 153/09, 130/11, 56/13, 14/14)
- Agricultural Land Act (OG 39/13, 48/15)
- Roads Act (OG 84/11, 22/13, 54/13, 148/13, 92/14)
- Physical Planning and Building Act (OG 153/13, 54/14)
- Nature Protection Act (OG 80/13, 153/13, 78/15)
- Act on Transboundary Movement and Trade in Wild Species (OG 94/13)
- Strategy and Action Plan for the Protection of Biological and Landscape Diversity of the Republic of Croatia (OG 143/08)
- Environmental Protection Act (OG 80/13, 153/13, 78/15)
- Law on Waste Management (OG 174/04, 153/05, 111/06, 110/07, 60/08, 87/09)
- Act on State Survey and Real Estate Cadastre (OG 16/07, 152/08, 124/10, 56/13, 121/16)
- Land Registration Act (OG 152/08, 126/10, 55/13, 60/13)
- Ordinance on Forest Management (OG 79/15)
- Ordinance on Fire Protection of Forests (OG 33/14)
- Ordinance on Forest Conservation (OG 28/15)
- Ordinance on Land Cadastre (OG 84/07, 148/09)
- Ordinance on the Content and Manner of Carrying out the National Inventory of Forest Resources (OG 53/06, 137/08)
- Ordinance on the Selecting and Marking Trees, Marking Wood Sortiments, Forest Support Documentation and Forest Residues Management (OG 17/15)
- Ordinance on Register of Forest Owners (OG 137/14)
- Ordinance on Types of Forestry Operations, Minimum Conditions for their Implementation and Works that could be undertaken by Forest Owners Independently (OG 16/15)
- Ordinance on the Conditions and Standards for Approval of Required Amount of Selected and Marked Trees in Private-Owned Forests (OG 135/14)
- Ordinance on Measures for Determination of Seized Agricultural Land, Forests and Forest Land (OG 18/04)
- Ordinance on the Procedure of Gaining Rights on the Funds of Scientific and Research Work in Croatian Forests Funded by the General Forests' Benefits Fund (OG 25/15, 93/15)

- Ordinance on the Method of Calculation, Forms and Deadlines for Payment on the Fee for the Use of the General Forest Functions (OG 19/15)
- Ordinance on Strictly Protected Species (OG 144/13, 73/16)
- Ordinance on the List of Habitat Types, Habitat Map, and Threatened and Rare Habitat Types (OG 88/14)
- Ordinance on the Protection of Amphibians (OG 80/09)
- Ordinance on the Mushroom Protection (OG 34/02)
- Ordinance on the Amount of Damage Compensation Caused by Unauthorized Activity on Protected Animal Species (OG 84/96, 79/02)
- Ordinance on the Collection of Protected Wild Plants for the Purpose of Processing, Trade and Other Traffic (OG 154/08)
- Ordinance on Conservation Objectives and Main Measures for Bird Conservation Ecological Network Area (OG 15/14)
- Ordinance on Wildlife Corridors (OG 5/07)
- Ordinance on the Assessment of Acceptability for the Ecological Network (OG 146/14)
- Ordinance on the Way of Monitoring the Damage of Forest Ecosystems (OG 67/13, 122/14)
- Ordinance on Determination of Fees for Transffered and Restricted Rights to Forests and Forest Land (OG 105/09, 98/11)
- Ordinance on the Method of Data Collection, Keeping the Register and the Conditions of Use of Forest Fire Data (OG 126/06, 101/07, 74/08, 10/09)
- Ordinance on Forest Inspector Official Identity Card and Badge (OG 76/13, 142/12)
- Ordinance on the Content and Method of Taking Proffesional Exams for Authorized Forestry and Wood Technology Engineers (OG 74/07)
- Ordinance on Conditions and Criteria for Classification of Forest Reproductive Material nto Categories and Qualitative Classes, as well as the Manner of its Declaration, Labeling and Packaging (OG 61/08)
- Ordinance on the Provenance of Forest Trees (OG 147/11, 96/12, 115/14)
- Ordinance on Conditions for Granting Equivalence of Forest Reproductive Material and a List of Countries from which it can be Imported (OG 60/13, 46/15)
- Ordinance on the National List of Forest Seed Objects (OG 60/13)
- Ordinance on the Ban on Placing of Specific Forest Reproductive Material on Market (OG 60/13)
- Ordinance on the Method of Determining the Quality of Forest Seed (OG 147/11)
- Ordinance on Quality and Declaration for Forest Reproductive Material (OG 68/13)
- Ordinance on the Provenance of Forest Tree Species (OG 147/11, 96/12, 115/14, 114/15)

- Ordinance on the Form, Content and Manner of Use of the Information Document (OG 91/09)
- Ordinance on the Inspection of Imported Forest Reproductive Material (OG 91/09)
- List of Forest Species (OG 4/11)
- Ordinance on the Method of Design and Content of the Forest Seed Management Program in the Category "Quallified" or "Tested" (OG 4/11)
- Ordinance on the Terms and Methods of Enrollment in the Register of Forest Reproductive Material Suppliers (OG 4/11, 58/11)
- Ordinance on the Manner and Tasks of the Commision for Forest Reproductive Material (OG 4/11)
- Ordinance on Amendments to the Ordinance on the Manner and Tasks of the Commision for Forest Reproductive Material (OG 60/13)
- Ordinance on the Form, Content and Manner of Keeping the Register of Forest Seed Objects (OG 4/11)
- Ordinance on the Evaluation of Potential Forest Seed Objects and Expert Supervision (OG 4/11)
- Ordinance on the Content, Format and Costs of Issuing the Main Certificate (OG 4/11, 42/11, 21/17)
- Ordinance on the Terms and Methods of Enrollment in the Christmas Tree Suppliers Register (OG 27/15)
- Regulation on the Proclamation of the Ecological Network (OG 124/13, 105/15)
- Order of Taking Measures for Preventing the Spread and Suppresion of the Harmful Organism- Ips typographus (OG 103/16)
- Convention of Wetlands of International Importance Especially as Waterfowl Habitat (Ramsar, 1971.)- Nostrfication of succession (OG 12/93)
- Convention on Biological Diversity (Rio de Janeiro, 1992)
- Agreement on the Conservation of African-Euroasian Migratory Waterbirds (AEWA, 1995.)
- Agreement on the Conservation of Populations of Europaean Bats (EUROBATS, 1991.)
- Convention on the Conservation of European Wildlife and Natural Habitats (Bern, 1979)
- Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES, Washington 1973.)
- A new EU Forest Strategy: for forests and the forest-based sector (Bruxelles, 20. 9. 2013.)
- The EU forest-based idustries plan (20.9.2013.)
- Decision No 529/2013/EU of the European Parliament and of the Council of 21 May 2013 on accounting rules on greenhouse gas emissions and removals resulting from activities relating to land use, land-use change and forestry and on information concerning actions relating to those activities
- Regulation on the Ecological Network (OG 124/13, 105/15)

- Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora
- Decision No 529/2013/EU of the European Parliament and of the Council of 21 May 2013 Land use, land-use change and forestry (LULUCF)
- FOREST EUROPE (Ministerial Conference on the Protection of Forests in Europe) - The panEuropean policy process for sustainable management of the continent's forests
- GREEN PAPER On Forest Protection and Information in the EU, COM(2010)66
- United Nations Framework Convention on Climate Change (UNFCCC) confirmed by Republic of Croatia (Law on Ratification of the United Nations Framework Convention on Climate Change OG 2/96)
- Act on Ratification of the Kyoto Protocol to the United Nations Framework Convention on Climate Change (OG 05/07)

6.2 Geographical framework

There are 6 categories of nature protection in Zadar County area with 22 protected areas in total. These are: two national parks (Paklenica and Kornati), three nature parks (Velebit, Telašćica and Vrana Lake), five special reserves (Saljsko polje, Kolansko blato, Veliko and Malo blato, Dubrava Hanzina Forest and reserve Vrana lake), four monuments of nature (Modrić Cave, Vrelo Une, Zeleni hrast and Cerovac Caves), six significant landscapes (Dubrava Hanzina, Zrmanja Canyon, Island of Ošljak, NW part of island Dugi otok, part of Kornati and Zrće) and two park architecture monuments (Vladimir Nazor Park and Borelli Park).
The total area of state and private owned forests in Zadar County is 127.606,45 ha. Selected pilot areas in Zadar County within the *ForBioEnergy* project are:

- Velebit Nature Park (area in Zadar County),
- Telašćica Nature Park,
- Vrana Lake Nature Park (area in Zadar County).

Pilot areas are dispersed throughout Zadar county. Telašćica Nature Park is situated on the island of Dugi otok, Vrana Lake is in the middle of the county, while Velebit Nature Park stretches from the northern part of the county through Lika-Senj County. Because of its size and other characteristics, Telašćica and Vrana Lake are represented as special biomas districts.
Within the Velebit Nature Park (the part in Zadar County), two BD have been created, one in the northern part (the inner part) and other in the southern part (towards the coastal side). These two districts differ

significantly because the inner part is dominated by beech forest while the coastal part is dominated by the degraded sumbediterranean forest.

Territorially, Vrana Lake Nature Park is located in the Zadar-Biograd area, between Biograd and Pirovac, along the Pakoštane settlement. The Nature Park and the lake itselfs is situated parallel with the sea shore, which is, in some places, no more than a kilometer away and they are northwest-southeast oriented. Altitudes in the Pakoštane municipality range between 0 and 100 m in the northeastern part of the area.

Administratively, Vrana Lake Nature Park is situated at the border of two counties: Zadar County and Šibenik-Knin County. In Zadar County it is located in the Pakoštane and Stankovci municipalities and the city of Benkovac (FigureFigure 1.). The Park is on an area of 5.748,99 ha and the rea of the part that is located in the area of Pakoštane Municipality is 3.923,94 ha (about 68 % of the total area of NP), and comprises mostly of the area of Vrana Lake itself (about 3.000 ha).

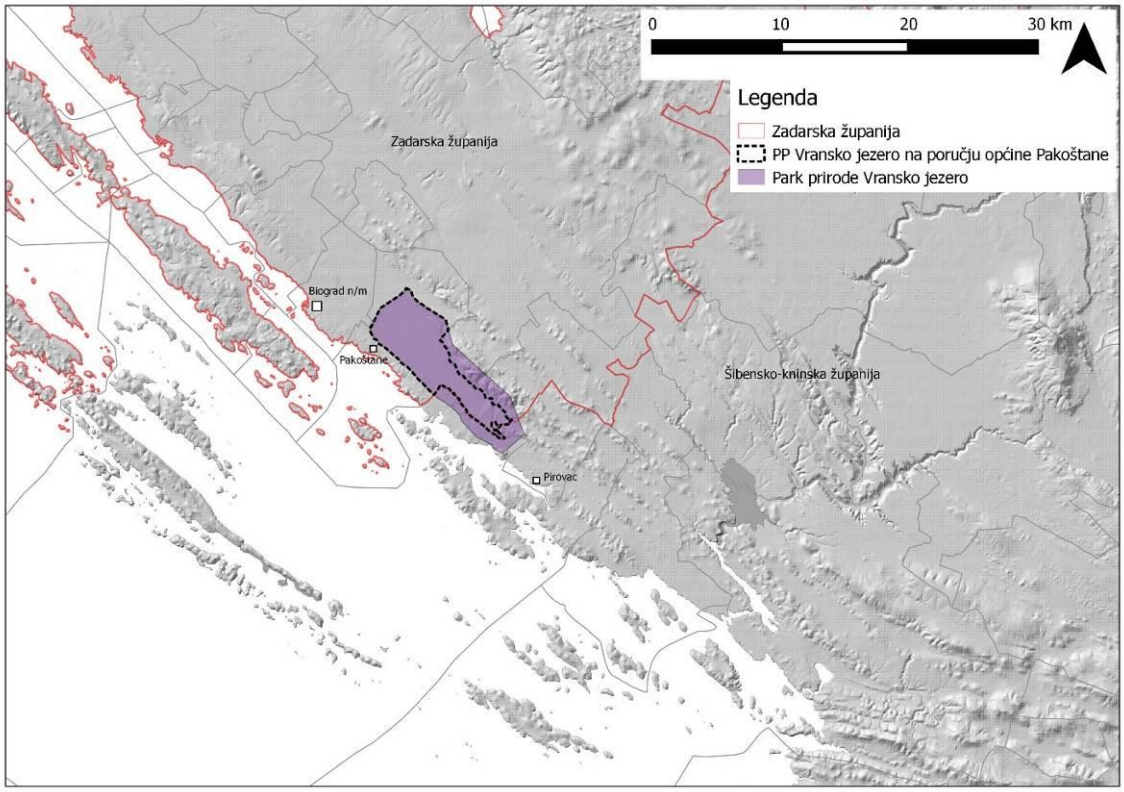

Figure 1:. Administrative distibution of the Vrana Lake Nature Park

6.3 Type and description of the forest ownership

Forests in the area of Vrana Lake Nature Park are predominantly state-owned (FMU Vrana, Donji Krš and Biograd). Private forest areas are only in the far north-west section and are in the management unit FMU Biograd-Benkovac forest) (Figure 2).

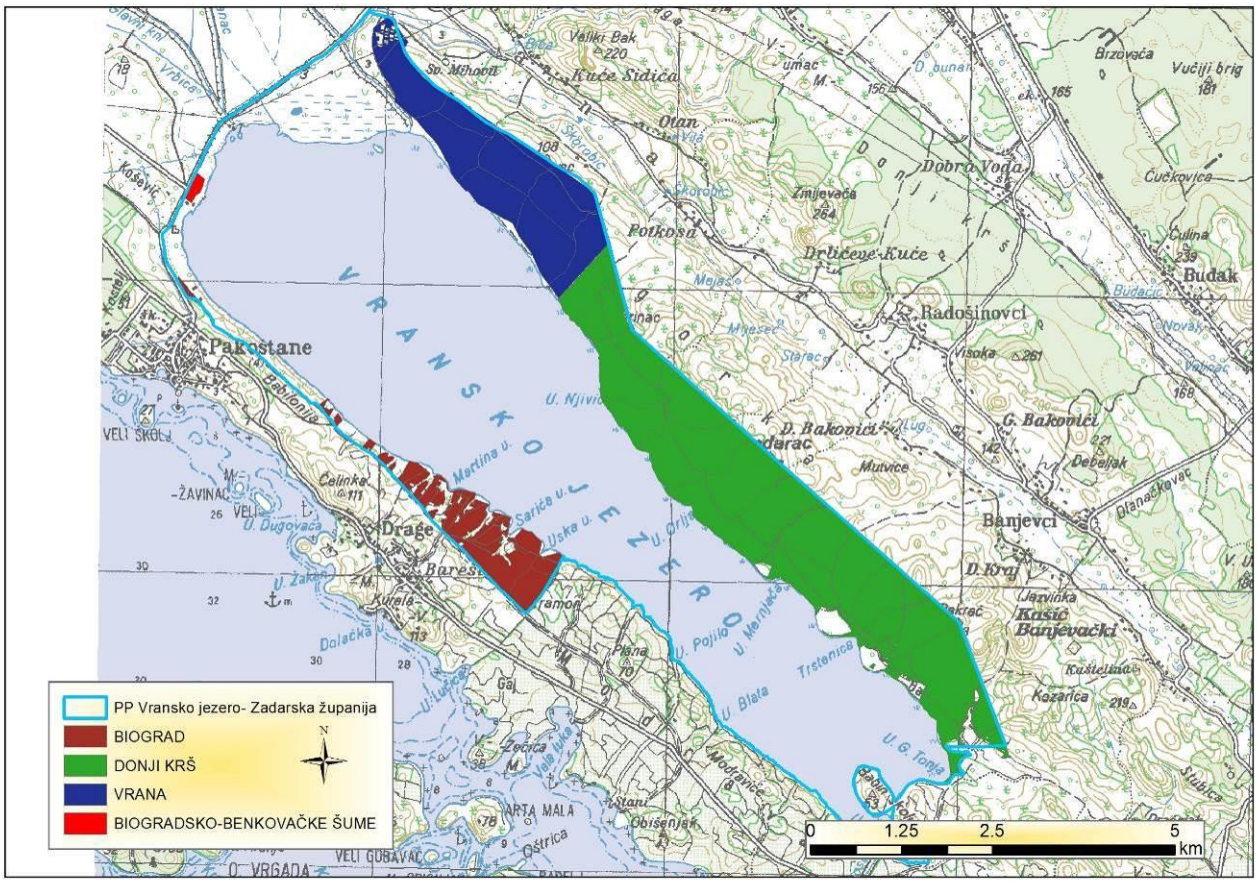

Figure 2. Forest division by ownership and forest management units

State-owned forest management units in the area of Vrana Lake NP are shown in Table 1.

Table 1. Forest management units in the area of Vrana Lake Nature Park (state ownership); Source: Hrvatske šume Ltd., FA Split, March 2017.

ŠIFRA GJ	Gosp. jed.	Važnost	Iskaz površina					Park prirode "Vransko jezero"		
			Obraslo	Neobraslo		Neplodno	Ukupno	Površina		
				Proizvodno	Neproizvodno			Obraslo	Neobraslo proizvodno	Ukupno
			ha							
			1	2	3	4	5=1+2+3+4	ha		
796	VRANA	2016. - 2025.	1998,74	45,42	9,23	3,05	2056,44	336,89		336,89
789	DONJI KRŠ	2007. - 2016.	5111,65	0,93	6,86	21,67	5141,11	1048,44		1048,44
794	BIOGRAD	2016. - 2025.	1223,60	53,82	20,82	34,54	1332,78	117,06	0,63	117,69
Ukupno :			**8333,99**	**100,17**	**36,91**	**59,26**	**8530,33**	**1502,39**	**0,63**	**1503,02**

Total area of forest land in Nature Park Vrana Lake is 1.503,02 ha, of which forests cover 1.502,39 ha. The area of degraded stands and 1st age class stands is 1.434,07 ha. Total wood stock is 9.471 m^3 and increment

323 m^3. Management classes by management units are shown in Table 2 along with an overview of area, wood stock and increment and Figure 3.

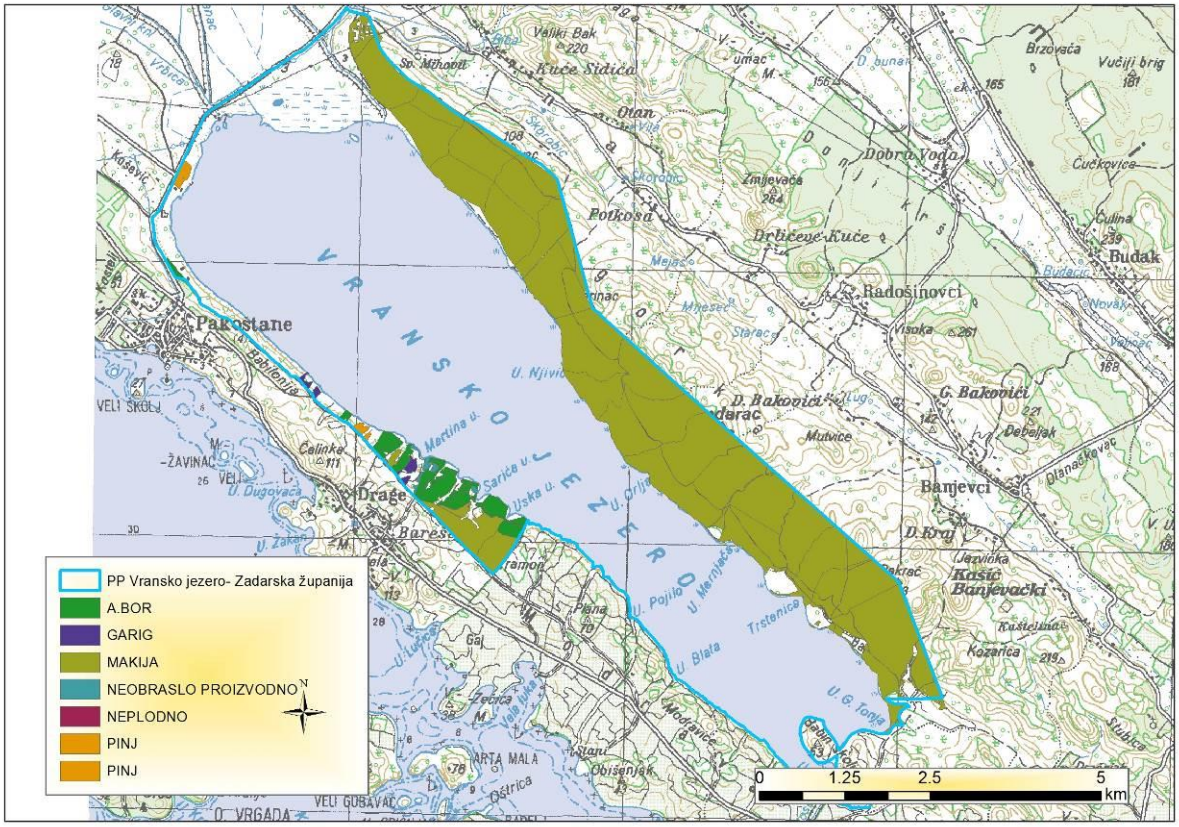

Figure 3. Division of forests according to management classes

Table 2. Management classes by forest management units, with shown areas, wood stock and increment (state ownership); Source: Hrvatske šume Ltd., FA Split, March 2017.

ŠIFRA GJ	Gosp. jed.	Uređajni razred								
		Naziv uređajnog razreda	Površina degr. sast. i I. dobni raz.	Površina	Drvna zaliha		Prirast		Etat	
			ha	ha	m^3	m^3/ha	m^3	m^3/ha	m^3	m^3/ha
796	VRANA	Makija - posebni rezervat	299,72							
		Makija - park prirode	37,17							
789	DONJI KRŠ	Makija - park prirode	1048,44							
794	BIOGRAD	Alepski bor		68,32	9471	135	323	4,62		
		I. dobni	1,62							
		Makija	46,89							
		Garig	0,23							
Ukupno			**1434,07**	**68,32**	**9471**	**135**	**323**	**4,62**		

The total area of private-owned forests in FMU Biograd-Benkovac Forests is 6,04 ha withmanagement classes Aleppo Pine and Umbrella Pine. Wood stock is 149 m^3/ha and annual increment is 3,97 m^3/ha. A detailed overview of wood stock and increment is provided in (Table 3).

Table 3. Wood stock by management classes (private-owned forests); Source: Savjetodavna služba, Split, February 2017.

Tree species	*Thickness class*							*Total*		*Yield*
	Area	*10 - 30*		*31 - 50*		*>50*				
		Wood stock	*Increment*	*Wood stock*	*Increment*	*Wood stock*	*Increment*	*Wood stock*	*Increment*	
	ha	*m^3*								
P.halepensis		32	1	300	7	96	2	428	10	0
P.pinea		106	4	366	10			472	14	0
maquis	0,16									
T o t a l	**6,04**	**138**	**5**	**666**	**17**	**96**	**2**	**900**	**24**	**0**

6.4 Synthesis of environmental features

The area of Vrana Lake Nature Park is predominantly made of limestone from the era of Cretaceous and Paleocene. Vrana Lake is in actuality a karst valley filled with mildly briny water at 0 m.a.s.l. and represents a cryptodepression. The altitude in the Park area is about 0-100 m.a.s.l. in the northeast part of the area (Figure 4).

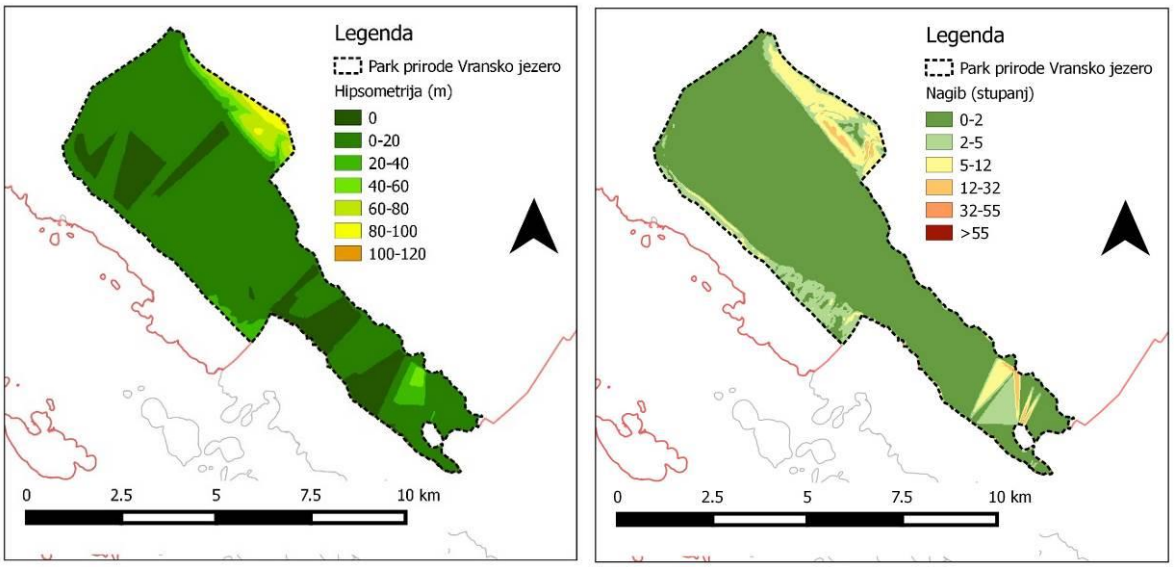

Figure 4: Hipsometry and inclination in the Vrana Lake Nature Park (Pakoštane municipality)

Altitude (°)	Area (km^2)	%
0-20	35,40	90,19
20-40	1,64	4,18
40-80	1,78	4,54
80-100	0,39	0,99
100-120	0,04	0,10
Total	39,25	100

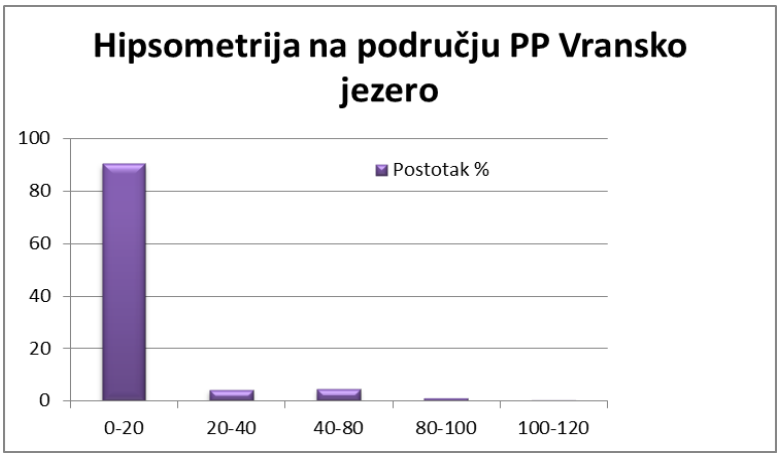

Table 4. and Figure 5. Altitude in the Vrana Lake Nature Park (Pakoštane Municipality)

Inclination (°)	Area (km^2)	%
0-2	30,99	78,04
2-5	4,93	12,42
5-12	3,33	8,39
12-32	0,46	1,16
32-55	0,00	0,00
50+	0,00	0,00
Total	39,71	100

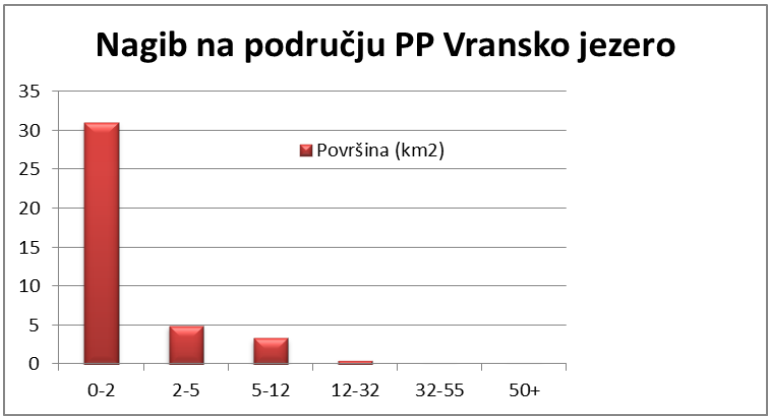

Table 5. and Figure 6. Inclination in the area of Vrana Lake Nature Park

Most of the area (about 365 ha or about 9%) includes Lithic and Haplic Leptosols containing different proportions of other types of soils, as shown in Table 6. Other types of soils in the area of Vrana Lake Nature Park (Pakoštane Municipality) according to the World Reference Base for Soil Resources (WRB) include *Leptosols* and *Gleysols, Gleysols (drained), and Rendzic Leptosols.* Spatial distribution of pedogenetic units according to Croatian Soil Classification is shown on Figure 7. and Figure 8.

Table 6: The most common cartographic units of soil in the area of Vrana Lake NP (Pakoštane Municipality)

Number	Systematic soil unit name	% share
54	Rocky soil	50
	Limestone dolomite black – earth soil	25
	Rendzina	10
	Brown on limestone	10
	Terra rossa	5

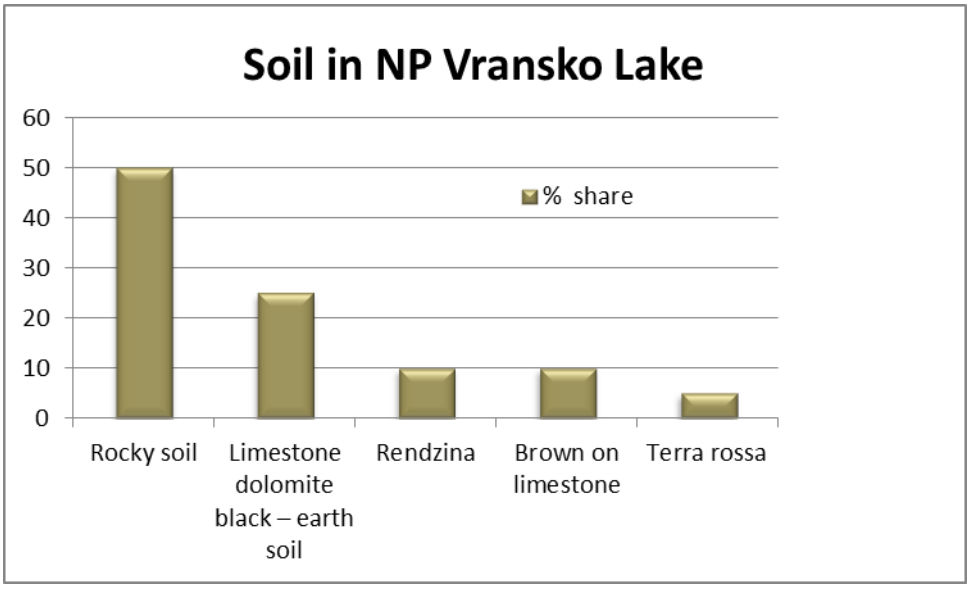

Figure 7: Types of soil in the Vrana Lake Nature Park (source: Oikon Ltd.)

More detailed description of this cartographic units of soil is given in previous document related to the description of the Vrana Lake BD.

Aspect	Area(km^2)	%
S	0,92	9,42
SI	1,56	15,97
I	0,80	8,19
JI	0,52	5,32
J	1,33	13,61
JZ	3,31	33,88
Z	0,97	9,93
SZ	0,36	3,68
Total	9,77	100
Jezero bez aspekta	29,47	100

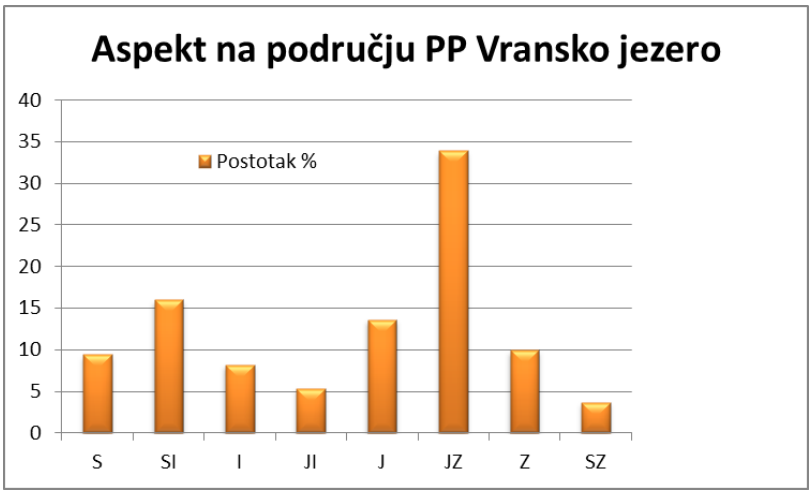

Table 7. and Figure 9. Aspect in the NP Vrana Lake (source: Oikon Ltd.)

Bioclimatic characteristics

According to Köppen climate classification, the area of Vrana Lake belongs to the Mediterranean climates and it is classified as an Csax climate. Hot-summer Mediterranean climate (Csa) is characterized by hot summers and mild winters with intermittent cold waves which can be unfomfortably cold. It corresponds to an average temperature of the coldest month higher than -3°C and lower that 18° C. The average monthly temperature is higher than 10 °C for at least 4 months a year. During the year there are no dry months, and in annual rainfall there are two maxima, spring and autumn ("x").

6.5 Naturalistic, environmental and landscape restrictions

According to the Nature Protection Act, the Ministry of Environmental Protection and Energy permits and determines the nature protection conditions prior to the initiation of the procedure or during the procedure for granting the permit (location permit) for the project (including exploatation of biomass) in protected area within the category „Nature Park“.

According to the nature protection zones, Vrana Lake Nature Park is divided into three basic zones: strict conservation zone, active conservation zone and management zone (Majdan ecological center and tourist infrastructure).

Strict conservation zone covers 7,4 % (426,131 ha) of the Park area and is entirely located in the ornithological reservation Vrana Lak. It includes cane ecosystems and the surrounding free water important

for reproduction and conservation of swamp bird populations. Projects in the strict conservation zone are not allowed, except of the reconstruction of existing bird watching facilities in the area of "Južna bara" (*lit. South pond*) in accordance with the special nature protection requirements prescribed by the competent Ministry. Projects are allowed only in cases of need for localization of fire or removal of invasive species.

Active conservation zone covers most of the Park area with 5.274 ha (91,8 %) and encompasses land water, forests, grasslands and cultivated agricultural areas. In active protection, it is essential to apply active conservation measures. Measures are recommended for the restoration of natural water regimes, the revitalization of the ecosystems and the maintenance of the pastures.. One way of preserving the ecosystems is promoting of extensive (traditional) cattle breeding. The Spatial plan determines the maintenance of traditional agriculture (vineyard and olive groves) and forbids land conversion.

Management zone covers 0,8 % (45 ha) of total Park area and represents all the existing roads inside and outside of the Park, forest roads and the area of Majdan eco-village, separated areas of already existing or planned visitors or tourist infrastructure and hydro technical structures.

Business facilities within the Park boundaries must respect local conditions, not be harmful for the environment, not exacerbate the quality of water and land surfaces and achieve nature protection requirements.

Agricultural area of primary purpose (fields, gardens, orchards, pastures, etc.). Intended for traditional or ecological agriculture, with the exeption of greenhouse construction, on parcels larger than 10 000 m^2 with procurment of special requirements for nature protection.

The spatial plan encourages the use of renewable energy sources (sun and biomass) for personal needs as much as possible because they contribute to reducing the use of traditional sources, there is less damage to the environment and the consumption is more rational.

The spatial plan defines measures for preventing bad impacts to the environment, which encompass a range od environmental-focused activities in an orignal or slightly changed state.

Soil protection:

- Long-term quality and quantity of soil must me ensured and maintained.
- Measures needed to be taken are mainly focused on the use of land suitable for habitats, avoiding erosion and adverse impact on soil structure, as well as reducing agrochemical intake.
- The principle of preventiveness is particularly important , which ensures functionality and use of soil for different purposes, as well as availability for future generations.
- In case of predictable dangers to important soil functions, priority conservation should be given to the above functions prior to the interests of the user.

- For the purpose of preventive protection of soil functions, priority areas for specific purposes must be marked. In addition, appropriate measures should ensure valuable land and sites, including their use.
- It is partricularly important to support aspirations and measures compatible with soil protection and the goals of environmentally-oriented land use.
- Areas damaged by erosion and sliding must be preventively protected from repeating the denudation process.
- For the purpose of protection against erosion and harmful soil compaction, appropriate procedures specific to each region of agriculture and foresty should be applied ("Good Acricultural and Forestry Practice").
- It is necessary to encourage ecological or biological agriculture and minimize the use of pesticides and mineral fertilizers.
- In order to protect the soil from natural destruction, it is necessary to stimulate the processes of natural regeneration of forests and autochtonus forest communities.
- It is necessary to strive for a protected forest habitat. Maintenance and use of forests should be adapted to soil conditions.

Wetland that are used in agriculture should be managed to prevent degradation of organic matter in the soil and to ensure sustainable management of pastures. All valuable land should be preserved, if possible improved, while abandoned agricultural land shouldbe revived for agricultural production.

6.6 Forest types and agricultural land use

From a phytocenological view, the area is covered with forests and maquis of Holm Oak (*Quercus ilex*) and Manna Ash (*Fraxinus ornus*), forests of Aleppo Pine (*Pinus halepensis*) and Holm Oak, shrubs of Jerusalem thorn (*Paliurus spina-christi)* and *Rhamnus intermedia*, and alohtone coniferous trees.

Land cover according to the CORINE Land Use (CLC) classification

According to the CORINE Land Use classification for reference year 2018, Vrana Lake Nature Park is dominated by forest and semi-natural vegetation (about 15 %): predominantly sclerophyllous vegatation (320,98 ha) with 150,58 ha (4%), transitional woodland-scrub (324), broad-leaved forest (311) and sparsely vegetated areas (333) with about 3 % each.

Agricultural areas are represented on about 7% of total area, dominated by *agricultural areas with significant share of natural vegetattion* (243). Water bodies (512) (Vrana lake) are the most represented category, whith about 63 % of the total area of nature park in Pakoštane Municipality (3.052,64,64 ha). Detailed area distribution by categories is shown in Table 8., Figure 10. and Figure 11.

Table 8. Land cover and land use in the area of Vrana Lake Nature Park (Pakoštane Municipality) (Source: AZO, CLC RH 2012).

Code	CLC categories of land cover and land use	ha	%
Agricultural areas			
211	Non-irrigated arable land	51.40	1.06
221	Vineyards	90.82	1.88
223	Olive groves	0.81	0.02
231	Pastures	11.27	0.23
242	Complex cultivation patterns	72.73	1.51
243	Land principally occupied by agriculture, with significant areas of natural vegetation	92.63	1.92
Forests and semi-natural areas			
311	Broad-leaved forest	257.99	5.34
312	Coniferous forest	75.40	1.56
321	Natural grasslands	230.70	4.78
323	Sclerophyllous vegetation	320.98	6.65
324	Transitional woodland-shrub	151.14	3.13
333	Sparsely vegetated areas	112.97	2.34
334	Burnt areas	162.10	3.36
Wetlands and water bodies			
411	Inland marshes	146.02	3.02
512	Water bodies	3052.34	63.20
	Total	4829.30	100.00

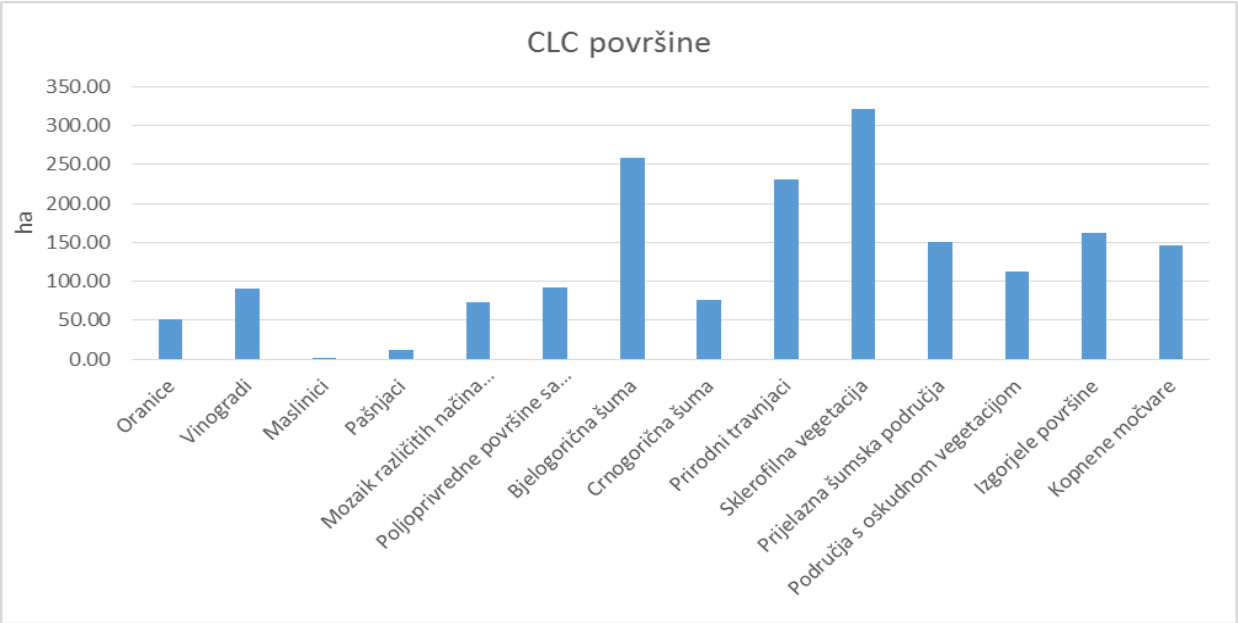

Figure 10. Distribution of Land cover and land use in the area of Vrana Lake Nature Park (Pakoštane Municipality) (Source: AZO, CLC RH 2012).

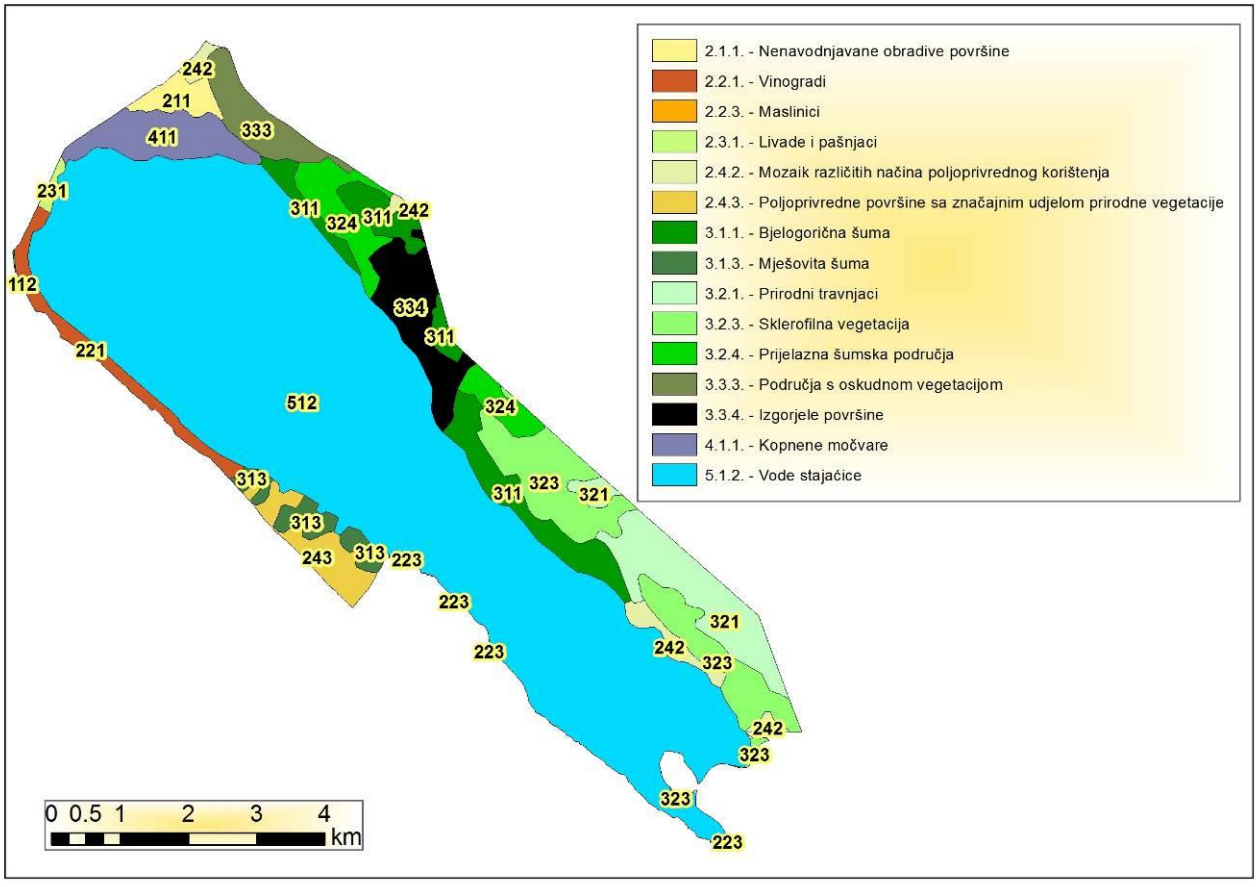

Figure 11. Land cover and land use in the area of Vrana Lake Nature Park (lake surface has been left out of the display) (Source: AZO, CLC RH 2018.)

6.7 Forest partitioning and description

6.7.1 Methodology

By comparing the official data and CLC land cover maps we notice that division according to “Hrvatske šume” is very general and that the “maquis” class covers the entire northern coast of Vrana Lake. Also, as a part of the “maquis” management class there are many areas which, according to CLC, are characterized as pastures. Therefore, it was decided to use the division according to CLC layer.

6.7.2 Results

Using the above methodology, we can state that 1.080 ha of Vrana Lake Nature Park area is covered with forests areas.

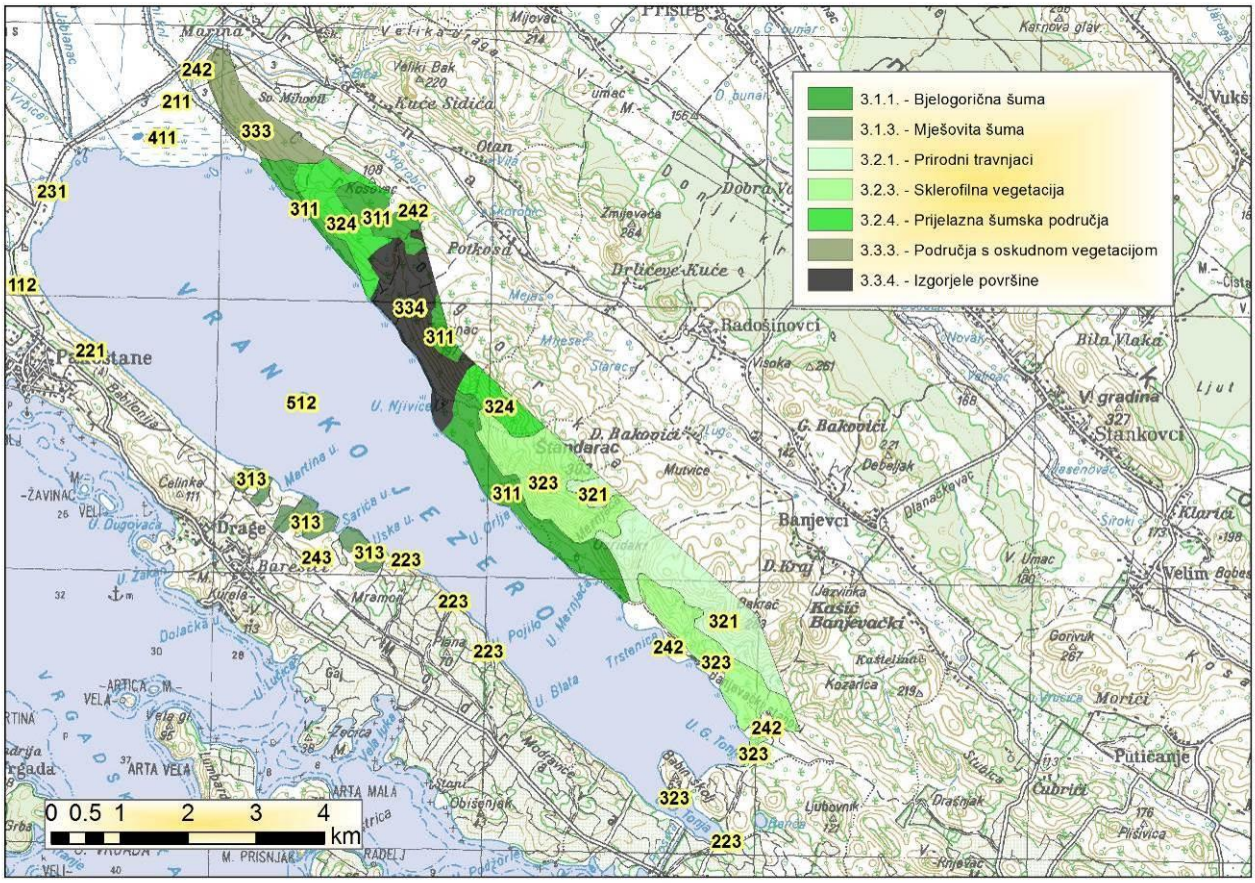

Figure 12. CLC categories of forests and semi-natural vegetation in the area of Vrana Lake Nature Park (Pakoštane Municipality); Source: AZO, CLC, RH 2012.

Table 9. CLC categories of forests and semi-natural vegetation in the area of Vrana Lake Nature Park (Pakoštane Municipality); Source: AZO, CLC, RH 2012.

Code	CLC kategorije površinskog pokrova i načina korištenja zemljišta	ha	%
Forests and semi-natural areas			
311	Broad-leaved forest	257.99	23.88
312	Coniferous forest	75.40	6.98
323	Sclerophyllous vegetation	320.98	29.70
324	Transitional woodland-shrub	151.14	13.99
333	Sparsely vegetated areas	112.97	10.45
334	Burnt areas	162.10	15.00
	Total	**1080.58**	100.00

Detailed description of these categories is shown in the following text.

Broad-leaved forest (311) is the forest of holm oak (*Quercus ilex*) and mock privet (*Phllyrea* spp.), where trees are generally below the taxation boundary, while thicker trees come in groups. On the shore of the lake willow grows. Parts of the area are covered with maquis or degraded to rockeries. In the shrub layer there are: mock privet (*Phyllirea latifolia, P. angustifolia),* strawberry tree *(Arbutus unedo)*, turpentine tree (*Pistacia terebinthus),* mastic *(Pistacia lentiscus),* Jerusalem thorn (*Paliurus spina-christi*), common smilax (*Smilax aspera*), bladder senna (*Colutea arborescens*), prickly juniper (*Juniperus oxycedrus*), savin (*Juniperus sabina*), common juniper (*Juniperus communis*), Spanish broom (*Spartium junceum*), butcher's broom (*Ruscus aculeatus*) and individually comes olive (*Olea europaea*).

Coniferous forest (312) is a forest of aleppo pine with individual trees of holm oak and mock privet. On smaller areas are olive groves. The forest is mostly passable With the occassional shrub layer, mostly sparse, dense only on smaller areas, with species such as: mock privet, strawberry tree, butcher's broom, turpentine tree and common juniper.

Sclerophyllous vegetation (323) represents the area with alternating maquis, rock terrain, garigue and groups of mock privet, holm oak and aleppo pine. The shrub layer consists of: mock privet, strawberry tree, turpentine tree, mastic, Jerusalem thorn, common smilax, bladder senna, prickly juniper, savin, common juniper, Spanish broom and butcher's broom. The area is mostly impassable.

Transitional woodland-shrub (324) represents the area covered mostly with maquis and forest of holm aok and mock privet. Smaller areas are degraded to garigue and rock terrain. The shrub layer consists of: mock privet, strawberry tree, turpentine tree, mastic, Jerusalem thorn, common smilax, Bladder senna, prickly juniper, savin, common juniper, Spanish broom and butcher's broom. Threa is mostly impassable.

Sparsely vegetated areas (333) are areas with rare groups of mock privet trees and individual trees of aleppo pine. On smaller areas there is impassable maquis. Most of the area consists of scarce vegetation. Common species are: mock privet, strawberry tree, turpentine tree, mastic, Jerusalem thorn, common smilax, bladder senna, prickly juniper, savin and common juniper.

6.8 Dendrometric inventory

6.8.1 Methodology

The centre location of each field plot is recorded with the RTK GNSS GPS with millimetre accuracy for accurate point cloud and field plot overlay.

Due to degradation of the area, all trees thicker than 1 cm and in 1,3 m height (DBH) were measured. Therefore, within the circular plots of 11 m diameter (380 m^2) where all trees above 10 cm (lower taxation boundary in forestry) were measured, while only trees of 1 to 5 cm radius at DBH were measured on square subplot 1 (size 3x3 m). Also, for the measurement of trees from 5-10 cm at DBH, another square subplot (subplot 2, size 6x6 m) was made.

6.8.2 Results

In total, 499 trees were measured on 31 plots (on plot 31, no trees were measured) On most of the plots on Vrana Lake, only trees up to 10 cm of breast height diameter (plots 1 to 23) were measured.

The number of trees by region and by diameter classes is shown in Table 10.

Table 10. Measured number of trees by areas and thickness classes

Area	**Number of trees 1-5 cm (subplot 1- 3x3 m)**	**Number of trees 5 do 10 cm (subplot 2- 6x6 m)**	**Number of trees 10-30 cm (plot radius 11m)**	**Number of trees >30 cm (plot radius 11m)**	**In total**
Vrana Lake (plots 1-31)	247	42	201	9	499
In total	**247**	**42**	**201**	**9**	**499**

Also, the height of 231 trees was measured to produce the height curves using the „Mihajlov“ formula, given that the input parameters for the calculation of wood stock/biomass are height and diameter at breast height of the tree.

Field data calculations

Based on field data, calculated height curves and formulas for tree volume calculation, wood stock/biomass was calculated. For the DBH over 10 cm, the usual formulas for wood stock calculation in forestry was used, and for those under 10 cm formulas were used for the inventory of wood stock obtained by field research within the project "Estimation of carbon stock in dead organic matter and estimation of average wood stock in the biomass of maquis, shrubs and stands of the 1st age class in the forests of Republic of Croatia" (Client HAOP).

The volume of trees on subplots were converted to a plot level of of 380 m^2 and summed up with other data and were also converted to the hectare level. Table 11. shows a summary of calculated volumes with basic statistical values, while Table 12. shows the volumes located on plots and hectare level with the volumes according to certain thickness categories.

Table 11: Summation of calculated wood stock

Area	Average	Median	Minimum	Maximum	St. deviation
	(m^3/ha)				
Vrana jezero	70.48	59.96	3.21	167.98	47.02

We notice a very different situation where volume per hectare ranges from 3 m^3/ha to 170-180m^3/ha. If we look at the volume situation by thickness classes, we notice that 45% of measured volume is below the forestry taxation limit (10 cm of DBH), which represents a significant percentage and possibility of exploitation.

Table 12: Wood stock on field plots

Area	Plot	Vol/ plot	Vol/ ha	Tree volume 1-5 cm	Tree volume 5-10 cm	Tree volume 10-30 cm	Tree volume >30 cm
		m3/ha		%			
Vrana Lake	1	0.38	10.08	0	100	0	0
	2	2.68	70.47	95.44	4.56	0	0
	3	1.60	42.08	84.74	15.26	0	0
	4	0.61	16.18	100	0	0	0
	5	0.91	23.87	73.11	26.89	0	0
	6	1.66	43.67	77.39	22.61	0	0
	7	1.85	48.59	80.38	19.62	0	0

	8	1.30	34.31	80.39	19.61	0	0
	9	0.47	12.37	74.33	25.67	0	0
	10	3.30	86.86	92.29	7.71	0	0
	11	3.92	103.18	93.51	6.49	0	0
	12	3.45	90.74	96.5	3.5	0	0
	13	2.02	53.05	100	0	0	0
	14	0.16	4.08	100	0	0	0
	15	2.44	64.20	65.36	34.64	0	0
	16	2.34	61.68	89.7	10.3	0	0
	17	1.00	26.36	74.6	25.4	0	0
	18	2.14	56.22	100	0	0	0
	19	4.22	111.04	93.97	6.03	0	0
	20	2.21	58.24	89.09	10.91	0	0
	21	0.12	3.21	0	100	0	0
	22	2.67	70.33	90.97	9.03	0	0
	23	1.84	48.51	86.77	13.23	0	0
	24	6.38	167.98	0	0	92.25	7.75
	25	5.89	154.97	0	0	91.6	8.4
	26	4.83	127.00	0	0	89.75	10.25
	27	5.71	150.33	0	0	74.02	25.98
	28	4.89	128.62	0	0	57.65	42.35
	29	5.07	133.37	0	0	90.24	9.76
	30	4.28	112.68	0	0	100	0
Total		**2.68**	**70.48**	**47.44%**	**6.45%**	**39.23%**	**6.89%**

Observing the species ratio, i.e. the share of species onplots, most of it is Aleppo pine (almost two thirds), which is understandable since the pine trees mostly have higher diameters. Half of the species in mixture are Phillyrea, Junipers and evergreen oak. Other hard wood (OHW) species like manna ash, wild olives, willow, European white elm, strawberry tree and common myrtle makes 7% of average volume per plot.

Table 13: Mixture ratio by plots

Area	Plot	OHW*	*Quercus ilex*	*Phyllirea angustifolia*	*Pinus halepensis*	*Juniperus spp.*
Vrana Lake	1	0	0	0	100	0
	2	40.33	38.78	20.89	0	0
	3	2.42	54.28	43.29	0	0
	4	0	0	100	0	0

	5	0	72.02	12.82	0	15.16
	6	0	0	88.63	0	11.37
	7	100	0	0	0	0
	8	0	30.28	0	0	69.72
	9	50.41	24.86	24.73	0	0
	10	0	0	39.73	0	60.27
	11	7.35	0	51.1	0	41.55
	12	5.62	21.49	52.01	0	20.89
	13	0	0	100	0	0
	14	100	0	0	0	0
	15	33.19	0	18.02	0	48.79
	16	0	24.96	75.04	0	0
	17	32.62	0	48.54	0	18.84
	18	0	15.52	28.77	0	55.71
	19	6.82	0	44.73	0	48.45
	20	0	0	49.95	0	50.05
	21	0	100	0	0	0
	22	0	0	56.49	0	43.51
	23	0	29.1	70.9	0	0
	24	0	0	0	100	0
	25	0	0	0	100	0
	26	0	0	0	100	0
	27	0	0	0	100	0
	28	0	0	0	100	0
	29	0	0	0	100	0
	30	0	0	0	100	0
Total		**6.55%**	**6.71%**	**24.65%**	**46.59%**	**15.51%**

* manna ash, wild olives, wilow, European white elm, strawberry tree and common myrtle.

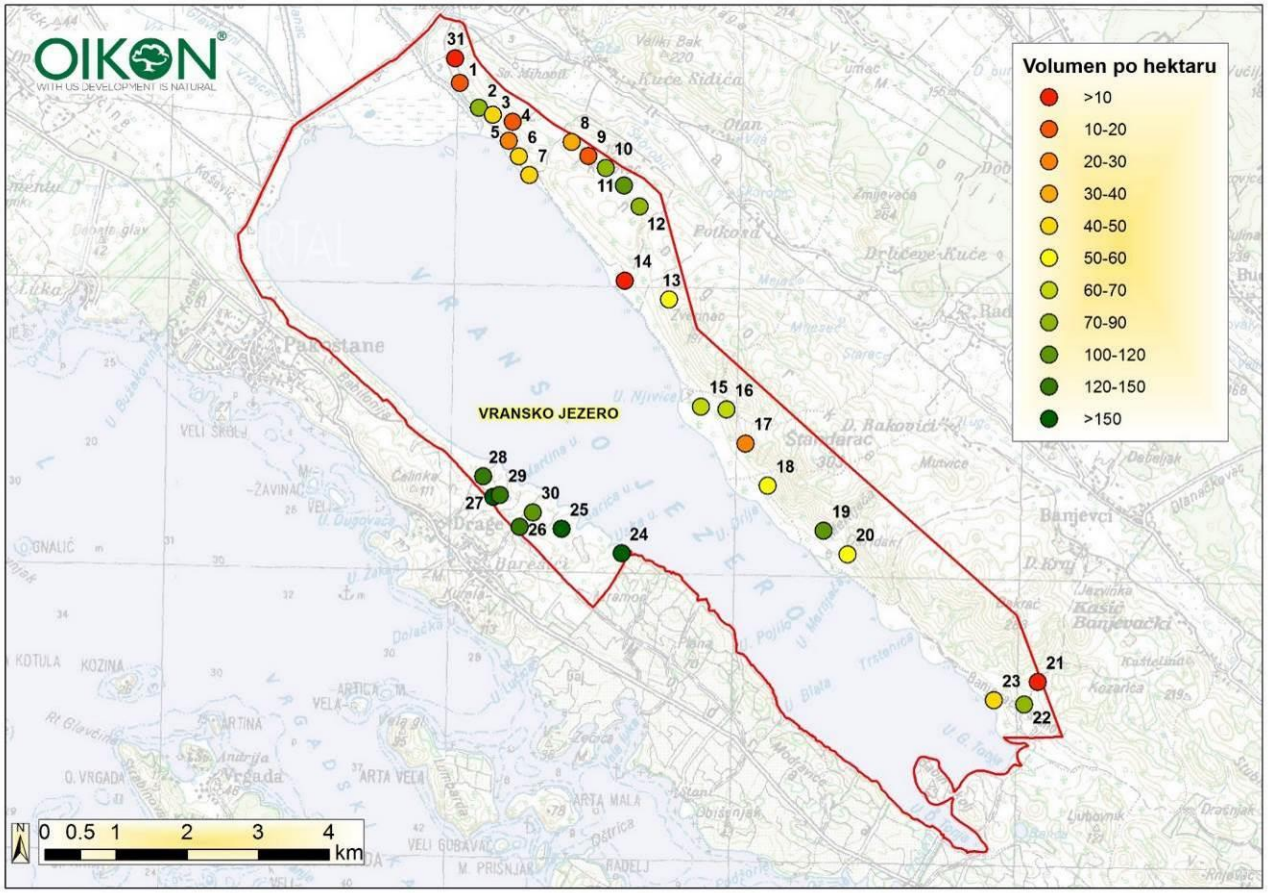

Figure 13: Calculated wood stock per hectare per plot– Vrana Lake Nature Park (source: Oikon Ltd.)

As part of this project, the entire area of Vrana Lake Nature Park was recorded with UAV (unmanned aerial vehicle). It is planned to record in RGB channels and in NIR (near-infrared) channel which has proved to be very important when researching vegetation. Based on these data it is planned develop a detailed map of biomass in the whole area of the Nature Park Vrana Lake. However, only recording with RGB channels was done, and models of biomass assesment of the Vrana lake NP were developed within the "*Assesment of wood mass/biomass in the area of Telašćica and Vrana jezero Nature Parks based od data collected by unmanned aerial vehicle*".

For the area of NP Vrana jezero, a point cloud with approximate density of 50 points/m^2 was created, with almost a 1.5 billion points (1.424.185.916). Each point as a data has its own altitude and RGB channel value. Based on this, the following variables were calculated: highest relative height (height between the lowest and the highest point on surface), standardized height and intensity. From these values (along with RGB values), minimum, maximum and average values and standard deviations were calculated (all together 23 dependent variables for modelling).

The final model has in itself the following variables: maximum value of B (blue) channel, maximum value of the standardized height, minimum intensity value, average value of G (green) channel and average value of R (red) channel.

The form of the model is:

Biomass (m^3/ha)= 5,42562

- 0,0001* **Max of B**
-1.64691* **Max of standardized z**
-0,00052* **Min of I**
+0,00083 ***Average of G**
-0,00052* **Average of R**

The strength of this model shown in determination coefficient (R2) is 0,68, and the statistical probability that this model is accurate is higher than 0,99 (p=0,00000). This determination coefficient, although it falls under lesser value, is in line with relevant research.

Based on the analysis results, we can conclude that this model in categories of degraded areas produces high quality wood stock while for other categories like coniferous stands is extremely applicable.

Therefore, although accurate map of biomass distribution can't be obtained, further conclusions can be drawn from data obtained from remote sensing, which could not be perceived only on the basis of field measurements. By overlapping field data, CLC layers and remote sensing data, average values of wood stock for certain areas i.e. Corine Land Cover types are calculated (Table 14.).

Table 14. Average wood stock per land cover categories

Code	**CLC categories of land cover and land use**	**Area (ha)**	**Average wood stock m^3/ha**	**Total (m^3)**
311	Broad-leaved forest	257.99	63.73	16440.54
312	Coniferous forest	75.40	139.28	10501.50
323	Sclerophyllous vegetation	320.98	64.06	20561.96
324	Transitional woodland-shrub	151.14	23.34	3527.68

333	Sparsely vegetated areas	112.97	27.76	3136.12
334	Burnt areas	162.10	28.56	4630.33
	Total	**1080.58**	**57.58**	**58798.12**

These data are in acoordance with data from FMP, related to coniferous stands (135m^3/ha). All wood stock is stored in trees above 10 cm DBH, and total of 10.501 m^3 of wood stock is distributed on 75 ha of area (average 139 m^3/ha).

Observing other categories and comparing with measured data, the remainder of approximately 48.000 m^3 of wood stock is deployed in trees under 10 cm DBH, which represents very aggravating circumstances and unprofitable management of these areas. Observing this on an average level, on the rest of the area (1.000 ha) there is 48 m^3 of wood stock per hectare, but only in trees under 10 cm.

6.9 Plan of treatment types and silvicultural operations

According to Article 1. of the Forest Law, the purpose of forest management is to maintain biodiversity and to ensure management by the principles of economic sustainability, social responsibility and environmental acceptability.

The primary objective of forest management is to preserve and improve forest ecosystems with the improvement of production and beneficial forest functions (protection of soil from water and wind erosion, balance of water relations in the landscape and flood prevention, water purification through forest land and supply of underground streams and sources with drinking water, purification of polluted air, impact on the beauty of landscape, creation of favorable conditions for human health, providing space for rest and recreation, development of ecological, hunting and rural tourism, conservation of the forest genofonds and other types of forest biocenosis, the mitigation of greenhouse effect by carbon binding and enrichment environment with oxygen).

Forest stands of this management unit are special purpose forests. The main goal of management of all stands within this management unit is common, and it is to improve the structure of wood stock with conservation and improvement of forest soil.

By supporting and bringing autochthonous forest communities into an optimal state we will achive their production (wood stock) and indirect (beneficial forest function) role and within that, the goals of management. The aim of the forest management, which is bringing the stands into an optimal state on suitable habitat, can be achieved by tending, thinning and natural regeneration in high quality stands, and conversing coppice forests and shrubbed areas into high forest stands.

The basic principle in management of these forests is natural regeneration by regeneration felling and in parts of the section trees from stump prevail, regeneration is according to principles of felling.

During management (felling) unititi s necessary to leave 3-5 dry trees, trees with cavities as well as fruit trees on a few hactares. Trees that are inhabited by bat colonies are not allowed to be felled.

Time of harvesting is determined in accordance with Article 31. of the Forest Law and Ordinance on Selecting and Marking Trees, Marking Wood Sortiments, Forest Support Documentation and Forest Residues Management (OG 17/15 and 57/17).

In uneven-aged stands, tree felling in the first two months of the vegetation period is not allowed.

In uneven-aged stands where forestry works are planned (tending, cleaning), they are usually carried out during the vegetation period. In coppice stands for which managenment guidelines still determines management as for coppice stands, felling is carried out in the dormancy period.

Harvesting of timber assortments is done in such a way to achive maximum protection of young growth and protection of the remainig standing trees in the felling site.

Timber assortments are not allowed to be stacked next to standing trees, and extraction can be done only on marked skidding routes. The technology of harvesting and skidding must be adapdeted to the terrain, age and density of the forest stands.

All legal entities who are managing with state-owned forests, and forest owners managing with their private forests, are obligated to establish and maintain the forest residues management, generally during the harvesting works, and no later than 3 months after the work is done.

After felling, timber assortments on felling sites or in a storage facility, in the period from February 25th to September 1st, must me debarked or treated with permitted chemical agents, in order to prevent the development of bark beetles. Tretament must be done before the development of bark beetles. Branches, bark and unused parts of the trees must be stacked without negative impact on the young growth.

Time of felling and skidding in part of the management unit within the NATURA 2000 area, will be performed in accordance to the *Ordinance on Conservation Objectives and Basic Measures to Conserve Birds in an Ecological Network Area (OG 15/14.).*

General recommendations for forest management of these areas:

Aleppo pine forests

In forest stands of this management class, thicker and thin roundwood and pulpwood is produced.

Cleaning is necessary in groups of thin trees.

When choosing trees for cutting, sick and damaged trees should be chosen first, supernumerary trees from groups and trees that prevent the quality development of main tree species.

In groups of medium thick and thick trees, mature, sick, damaged, coppice trees and supernumerary trees should be chosen for cutting.

Small-scale natural regeneration must be carried out in groups of mature trees.

In underbrush areas, where trees from stumps dominate and on other suitable parts conversion of black pine stands to high cultivated autochtonus trees must be performed by introducing forest reproduction materialdominateand tend to these surfaces if necessary and muliple times.

Carry out recontruction of burnt areas.

Coppice forests of pubescent oak

Main tree species of this management class is pubescent oak. Firewood is produced in these stands..

In groups of young trees, felling must be carried out with the intensity conditioned by site opportunities in forest stand. Particular attention should pay to the trees that will create an undergrowth floor in the future which is important in a biological sense, as they increase stand mixture.. When selecting trees for felling, sick and damaged trees, supernumerary trees from groups and trees that prevent the quality development of main tree species should be chosen first.

In groups of medium thick and thick trees, only mature, sick, damaged, coppice trees and supernumerary trees should be choosed for cutting.

Small-scale natural regeneration must be carried out in groups of mature trees.

Fire rehabilitation should be carried out in burned areas.

This management class includes degraded forests of pubescent oak which need to be converted in high stands. Conversion works are prescribed for shrubbery is with introduction of forest reproduction material of autochtonus tree species, and tending of areas.

Sparsely vegetated areas

Aresa of this management class should be left to natural regeneration, if necessary reforestation should be carried out.

In Table 15 groups of work for all above mentioned management classes are shown according to the Rorest management regulation

Table 15. Prescribed silvicultural works of biological regeneration

Group of works	Type of work
Ordinance on Forest Management Planning: art.27 p. 1. s. 1-9	
Preparation of habitat for natural regeneration of stands intended for natural regeneration	area cleaning (natural regeneration)
Sanation of burned areas	Removal of fire damaged wood material
	area cleaning (sanation of burned area)
	Seeding and planting (sanation of burned area)
	Tending of young growth (sanation of burned area)

Selecting and marking trees for felling and supervision in the execution of works (subparagraph 2. article 27. of Ordinance)	Selection of trees by prescribed yield (uneven-aged stand)
	Supervision of execution of tree selection works
	Supervision in execution of works (s. 2. Art. 27. of Ordinance)
Ordinance on Forest Management Planning: art.27 p.1 s. 10-15	
Reconstruction and conversion of forests	Removal of undergrowth and shrubs (reconstruction and conversion)
	area cleaning (reconstruction and conversion)
	Stumps coating (reconstruction and conversion)
	Seeding and planting forest reproduction material (reconstruction and conversion)
	Tending of young growth (reconstruction and conversion)

6.10 Potential biomass production and share available for bioenergy production

Current scenario

The reference possibilities of this area are stated in current forest management plans and management division to compartments and subcompartments. Compared to the CLC layer, there are many disadvantages of such plans and division. Many areas, according to the CLC, are categorized as pastures or sparsely vegetated areas while according to the FMP, the whole area is characterized as a maquis. For the "maquis" management unit, according to the Law on Forests and Ordinance on Forest Management Planning, no wood stock and active management is defined and prescribed. Also, certain areas may have grown to "coppice" stage which can be managed but which are according to CLC, categorized as broad-leaved forests.

Therefore, according to the current FMP, wood stock is defined only for „aleppo pine and umbrella pine" management unit, which is approximately 135 m^3/ha, with an annual increment of 4,62 m^3/ha, and the total area of this unit is about 70 ha. In such stands active management is prescribed and is usually to perform harvesting in one term during the validity of FMP (which is 10 years in Croatia). The term of harvesting is planned in advance at the level of forestry office that manages this area to ensure the sustainability of work and profit.

However, on this 70 ha of stands that could be managed, harvesting is not prescribed, and according to the data obtained from "Hrvatske šume", in the last 10 years only 1 m^3 was harvested, and it was just random income.

This is a common case on the Croatian coast, because simply managing such areas is not profitable and any active exploitation is not prescribed. This also applies to the coniferous cultures and thin coppices. Forestry works on these areas are primarily focused on protection from fires and eventual investment in roads that would be in service of protection from fires.

What can be done in this scenario is the sanation of burnt areas, which is an extraordinary work and does not have to be prescribed within the FMP. Even some EU co-financing can be obtained. This paper consists of:

1. Removing the burnt wood material
2. Weed removal from soil
3. Seeding and planting of forest reproductive material (in this case only planting is reccomended)
4. Nurturing of young growth (after planting)

In the Vrana Lake Nature Park there are 152,10 ha of burnt areas with an average wood stock of 28,56 m^3/ha, which makes a total of 4.500 m^3 of available wood mass if these works were to commence.

"No restriction" scenario

Observing the whole area and calculated wood stock data (Table 16), there is about 58.000 m^3 of wood stock in total. In coniferous forest, 10.501 m^3 of wood stock is distributed on 75 ha (average 139 m^3/ha), and all is stored in trees above 10 cm DBH.

Observing the other categories and comparing with measured data, the rest of about 48.000 m^3 and is distributed in trees under 10 cm DBH, which represent aggravating circumstance and unprofitable management of these areas. Observing on an average level, on the rest of the area (about 1.000 ha) there is 48 m^3 of wood stock per hectare, but only under 10 cm.

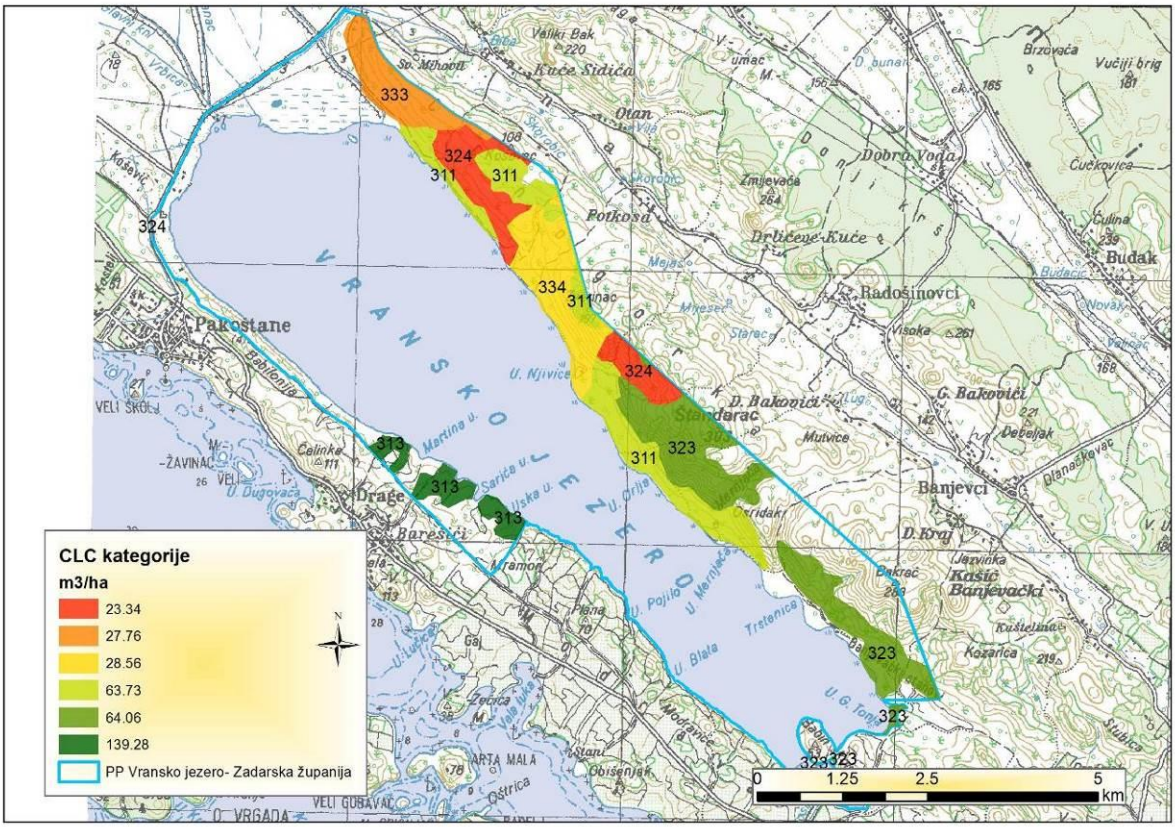

Figure 14. Spatial distribution of average wood stock by land cover categories

Table 16. Spatial distribution of average wood stock by land cover categories

code	CLC categories of land cover and land use	Area (ha)	Average wood stock m^3/ha	Total (m^3)
311	Broad-leaved forest	257.99	63.73	16440.54
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334	Burnt areas	162.10	28.56	4630.33
	Total	**1080.58**	**57.58**	**58798.12**

The first stage of the "no restriction" scenario would be to actively manage the areas covered by coniferous cultures. For this, it is necessary to conduct revisions of existing FMP or to prescribe cutting when updating after 10 years. According to the current regulations and the increment in these stands, it would be able to get the 25% of the existing wood stock in the next 10 years. This represents approximately 2.500 m^3 of gross wood stock. According to the "Forest Management Plan of the Republic of Croatia", 15% of waste is producing when harvesting and skidding coniferous trees. Therefore, 2.125 m^3 of wood would be available for processing to biomass fuel.

The second stage of this scenario would be when the areas with significant wood mass (over 60 m^3/ha) would be characterized as young forests in the next FMP and when cleaning works start. These works belong to the "filling, tending and cleaning works" in the 1st age class of even-aged, selection and uneven-aged stands. Also, in this case thinning can be prescribed.

These works are very similar and cleaning represents thinning trees in dense areas with positive selection of wanted tree species and stump shoots, while thinning represents only removing excessive steam shoots.

This would be related to the CLC categories 311 and 323, total area of approximately 560 ha and 37.000 m^3 of wood stock (average wood stock is 66 m^3/ha). With these works, stand can be reduced by 25%, which in this case, amounts to approximately 9.000 m^3 or 15 m^3/ha.

The problem in this part of the scenario is that all this wood stock is stored in trees under 10 cm and it is necessary to cut 142 trees/shoots of 4-5 cm or 45 trees of 5-10 cm DBH to get only 1 m^3 of wood mass. Extracting of the wood mass would have to be performed with horses or small articulated tractors which would have little efficiency due to small wood masses. Forest workers would also have small efficiency so subsidisation of these works is necessary.

6.11 Inventory of the forest viability and other infrastructures and management prescriptions

Road network is calculated from official data given by Hrvatske ceste Ltd. and Hrvatske šume Ltd. To get other road categories, vector data from digital topographic maps (1:25000) were drawn. Later, additional visual classification was made to select the roadways into three categories. Total length of roads inside the BD is shown in Table 13.

Table 17. Roadway categories inside the biomass district

Nature Park	BD	Asphalt	Macadam	Skid trail	Total
Vrana Lake	3	2.06	36.26	31.64	69.96
Total		2.06	36.26	31.64	69.96

In the area of Vrana Lake Nature Park there is about 1.500 ha of forests, which results with total openness of 25,3 km/1000 ha. Considering that only 75 ha are exploitable commercial forest and are located on southern part of the Park, it results with an openness of 10 km/1000 ha (for karst regions the recommendation is 15 km/ 1000 ha).

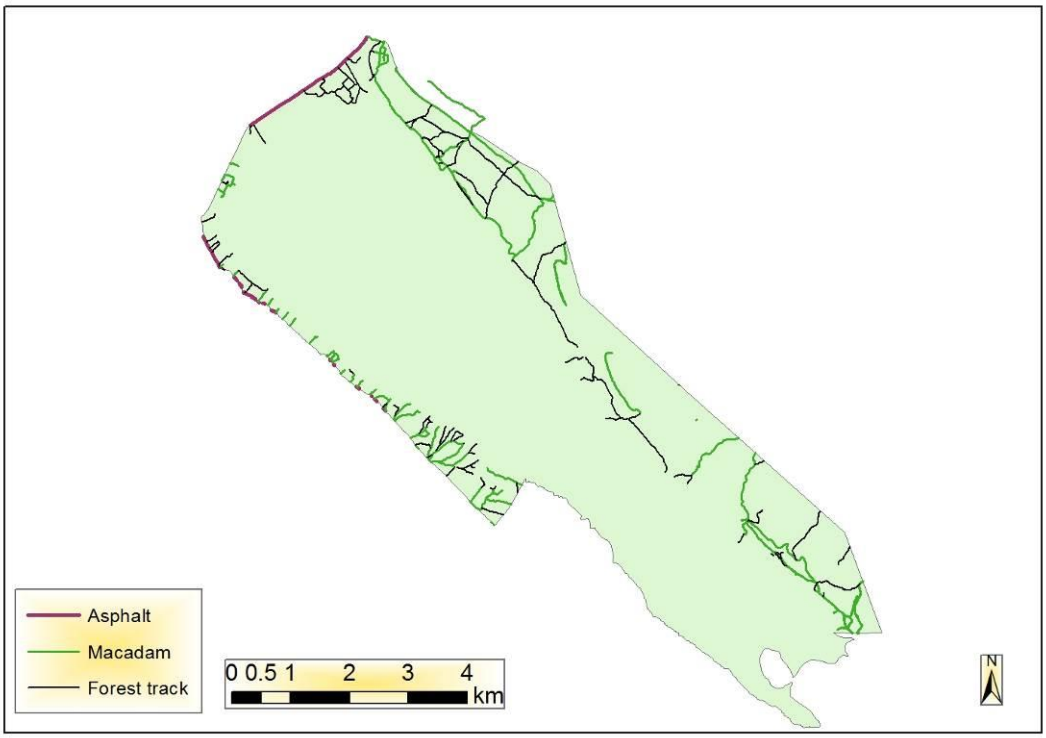

Figure 15. Roadway categories inside the biomass district

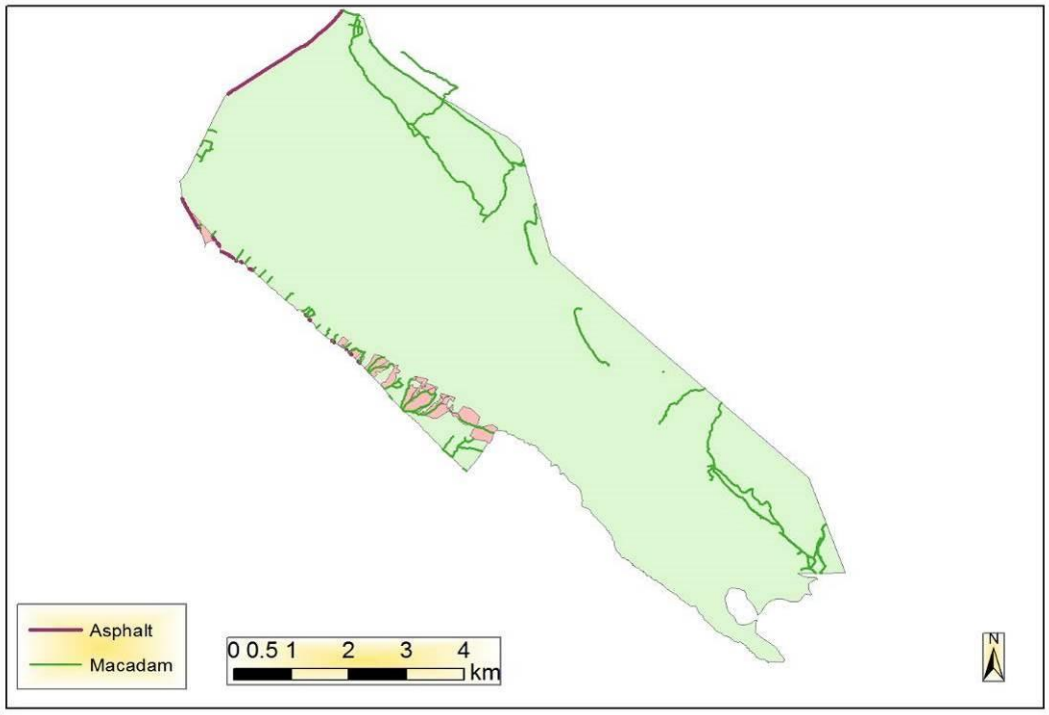

Figure 16. Overlapping of commercial forest and roadways

For more efficient management and application of „no restriction“ scenario, it is highly important to increase the secondary openness i.e. density of skidding trails towards better mobility of small articulated tractors and skidding of timber.

6.12 Management prescriptions for the pasture and the wild fauna.

Pasture management

Within the FMP, management of pastures and meadows is not perscribed, particulary here where protection of these areas is needed, according to NATURA 2000 guidelines. This management can be presrcibed under the “Protected Areas Management Plan” and it may also be subsidized by certain amounts to encourage the local population to maintain these areas in their original state.

Pasture management

The management of pastures and meadows is not regulated under the FMP, especially in these areas where NATURA guidelines need to protect such areas. This management can be prescribed under the Protected Areas Management Plans, and it may also be subsidized by certain amounts to encourage the local population to maintain their surfaces in their original state.

Game management

Vrana Lake Nature Park is situated between two mediterranean hunting grounds (Biograd and Vrana): Biograd hunting ground, total size of 5.339 ha, from which 265 ha (5 % of the area) inside the Park area and Vrana hunting ground, total size of 9.741 ha, from which 4.591 ha (47 % of the area) inside the Park area. Biograd hunting ground includes European hare (*Lepus europaeus*), pheasant (*Phasianus colchicus*) and grey partridge (*Perdix perdix*) and Vrana hunting ground also includes mallard (*Anas platyrhynchos*), common coot (*Fulica atra*), comon quail (*Coturnix coturnix*), rock partridge (*Alectoris graeca*) and chukar partridge (*Alectoris chucar*), since the lake takes up most of the area.

Basic management guidelines are given based on the "Professional background for bonitization and determination of productive hunting areas in the hunting grounds of the Republic of Croatia 2006" (in following text "Professional background"), which is an integral part of the "Ordinance on content, preparation method and procedure for adoption or approval of hunting management plan, game breeding programme and game protection programme" (OG, 40/06, 92/08, 39/11, and 41/13).

Hunting authorities in the area of the management unit who manage the hunting ground and game are obligated to abide by the Law on Hunting (OG, 140/05, 75/09, 14/14, 21/16 – Decision of the Constitutional Court of the Republic of Croatia, 41/16 - Decision of the Constitutional Court of the Republic of Croatia and 67/16 - Decision of the Constitutional Court of the Republic of Croatia), Ordinace that defines the matter of hunting, Law on Forests (OG, 140/05, 82/06, 129/08, 80/10, 124/10 i 25/12, 68/12, 148/13, 94/14) and Nature Protection Act (OG, 80/13 i 15/18).

Hunting authorities should take care of all game species, as well as other animal species in accordance with positive legal acts and international conventions, taking into account biological diversity, biological stability and habitat opportunities, and accordingly adapt hunting management while taking care of the conservation of wild game genofund.

With the aim of preventing damage on forest cultures and forest land caused by wild game (biting terminal and side buds, scratching, breaking, stamping, peeling, digging and consuming of forest seed) hunting authorities are obligated to:

• adopt an annual plan of measures for preventing wild game damages for each hunting season (seasonally, by game species and type of damage, culture etc.), if necessary provide protection for the execution of the annual plan (mechanical or chemical repellents);

• provide protective equipment to land owners free and on time, at their request, with prior public notice and givinginstructions for their use;

• maintain the number of wild game within the permitted capacity limits prescribed by the hunting management plan;

• implement nutrition measures;

• implement measures for conservation and improving habitats prescribed by hunting management plan;

• implement conservation measures relevant to this area and game species that reside in the hunting ground.

In order to reduce the damage on forest cultures caused by wild game, for hunting authorities and in colaboration with forest owners, planting and tending wild fruit trees is recommended.

Caring of other animal species and their habitats is the obligation of forest owners and hunters in accordance with the Internationally Verified Conventions and Nature Protection Act.

6.13 Connections of the FMP with the other planning tools

Forest management plans must aligne with spatial plans at all levels (county, city, protected area).

6.14 Assessment of impacts by the FMP

Impact of the current scenario is manifested in leaving the stands to natural regeneration. This can have negative effects because if the development of the stands is not backed up by certain breeding works it can ultimately end with degradation of the habitat.

Also, by managing areas covered with coniferous trees, these areas remain dense and impassable and the risk of fire is increased.

Impact of the "no restriction" scenario results in the development of quality of degraded forests, at least those that have already developed to the coppice stands phase where certain breeding works would allow faster and better development.

Also, management of coniferous forests reduces their density and therefore the risk of fire.

Table 18. Review of possible impacts of suggested breeding works

Actions and activities planned in Programe	**Impact of planned activities on conservation goals and the integrity of ecological network**
Preparation of habitats for natural regeneration of stands planned for natural regeneration	Preparation of habitats for natural regeneration encourages the development of autochtonus forest communities and prevents the degradation of habitats. Preparation will be carried out in small areas and there will be no significant negative impacts on the conservation goals and integrity of ecological network, i.e. on habitats and target species of the ecological network area.
Selection and marking of felling trees and supervision in the execution of works reffered to s. 2. article 27of	The felling intensity stipulated by the Programe may not exceed 30% of wood stock in each subcompartment. Selection and marking of felling trees will be carried out on small areas. When selecting and marking, make sure that cavity trees with bat colonies are not marked, and that 3-5 dead trees, fruit trees and cavity trees must be left per hectare evenly. After selecting and marking it is necessary to supervise the finished works. In this way,

	there will be no negative impacts on the conservation goals and integrity of the ecological network, i.e. on habitats and target species of the ecological network area.
Reconstruction and conversion of forests/sanation of burned areas	Reconstruction and conversion of degraded forest areas and existing cultures/plantation of alohton species will gradually be translated into the natural autochtonus forests. Reconstruction and conversion will be carried out on small areas. Reconstruction, conversion and sanation of burned areas will not have significant negative impacts on the conservation goals and integrity of ecological network, i.e. on habitats and target species of the ecological network area.

6.15 Final remarks

Currently, it is possible to cut all wood mass from burned areas at one time (4.500 m^3), but for planning sustainable wood-energy supply chains, it is necessary to ensure a constant supply of biomass. In the "no restriction" scenario, when developing the FMP of coniferous cultures (possibility of obtaining 2.125 m^3 on 70 ha in 10 years of FMP validity) must be prescribed and revision of areas covered by management class "maquis" and some areas should be "transfered" into management class "coppice forest", so that certain works (the possibility of obtaining 9.000 m^3 on 560 ha in 10 years of FMP validity) can be carried out. However, these areas are primarily managed by "Hrvatske šume", for which the regulations in FMP are binding and they avoid prescribing regulations because management of these areas although necessary, is unprofitable.

Comparing the other pilot areas, a similar situation is in Telašćica Nature Park and in the coastal part of Velebit Nature Park where the problem is not primarily in administrative obstacles, but in degraded areas with little wood stock. These result in unprofitable management without additional subsidies and road and technology investment.

7. MAIN RESULT OF THE FOREST MANAGEMENT PLAN OF THE BIOMASS DISTRICT OF Otočac. Perušić, Gospić, Karlobag, Lovinac, Gračac (local level, in Lika-Senj County) IN Nature Park Velebit protected area (CROATIA)

7.1 National and regional legislative framework

The basic principles of the Croatian legislative framework for the administrative area of forestry are the permanent management of the preservation of the natural structure and diversity of forests, and the permanent increase in the stability and quality of the economic and general forest functions, which as such are incorporated into legislative solutions that govern the management of forests.

In the Republic of Croatia, all relevant forest management issues are defined at the national level, with relatively little to any role of regional self-government, the impact of which is mostly reflected in the adoption of spatial plans on lower level (spatial plans of local self-government units and counties) also have to be aligned with the higher level spatial plans (nature parks, national parks and prior approval of different ministries).

Til this document production new National Forest Policy and Strategy (NFPS) 2017.-2030. and Wood Processing and Furniture Manufacturing Strategy of the Republic of Croatia 2017-2020. still not adopted and their main analysis was presented in Project document - Administrative and technical barriers to the production of biomass in Lika-Senj County - focusing on the Nature park “Velebit” protected areas (MFBE – RP 3/1 – B).

The most important legislative document in forest management is the new Croatian Forest Law (Act) , which stipulates that forests and forest land are goods of the Republic of Croatia's interest and enjoy its special protection.

This Law establishes the principles of sustainable forest management and forest land, defines the general and economic functions of forests (the production of wood forest products is one of the economic functions of forests) and the prescribed basic procedures for the management of forests.

The basic prescribed plannes (ductments) are:

- National Forestry Strategy; defines and defines national forestry policy
- National Forestry Program; sets out the conditions for implementing the elements of forestry policy

 National Inventory of Forest Resources; gathering information on the state of forests for different needs (forestry policy and operations, ecology, hunting, environmental and nature protection, wood industry, various state and intergovernmental organizations).

Forest management plans (FMP)

FMP and their coverage are prescribed by Article 27 of the Forest Law and are the basic documents for the management and use of forests and forest land, which prescribe the conditions, scope of forest breeding and protection, the degree of exploitation and protection of the living world.

The Republic of Croatia has been declared a forest management area covering all forests and forest land and is viewed as a functional unit. The forest management area is divided into economic units for which the forest management plans are being drafted.

The most significant forest management plans are the forest management principle of the area of the Republic of Croatia (Basin area), the basis of the management of the economic unit (Management Basis) and forestry programs.

The basics of management are documents that prescribe forests on forests and forest land of public forest holdings or for a period of 10 years, plan for sustainability of income for the next 10 years and for the next 20 years and are renewed every 20 years, with revision every 10 years.

Private forests have forest management programs.

In the area of Biomass District: Otočac, Perušić, Gospić, Karlobag, Lovinac, Gračac (hereinafter: Biomass District), all state forests are covered by management bases while private forest management programs are continually being introduced. Private forests management is currently of little productivity importance due to small areas, large fragmentation, unresolved property-legal relations and low productivity.

Management Programmes with The Environmental Management Plans for each economic unit also define general protection measures based on expert backgrounds on endangered and strictly protected species, endangered and rare habitat types, protected areas and the ecological network. These measures include the release of at least five dead standing trees per hectare, the protection of pests and diseases by systematically monitoring the health status of stands using biological and biotechnical resources, implementation of environmental rehabilitation along forest roads, hiking trails, paths, roads after logging and draining, disinhibition of waste disposal in the environment, implementation of fire protection measures, etc.

In addition to the Legislative Framework for Forestry in the area of the Velebit, the most significant document is the Spatial Plan of the Nature Park Velebit and the Nature Park Velebit (hereinafter: NP Velebit) Management Plan, which represent the basic implementing acts of the Public Institution NP Velebit, which manages the protected area.

From the Biomass District point of view, the most significant documents are the implementation documents on the basis of which Croatian Forest d.o.o., Forest Administration (branch) Gospić (hereinafter: FA Gospić) owns state forests, ie the basis of management and the fact that the Croatian forests d.o.o. hold of the FSC Forest Management Certificate.

Croatian Forests d.o.o. have the FSC (Forest Stewardship Council) forest management certificate since 2002. FSC certification means that the forest is governed by strict ecological, social and economic standards. In Croatian Forests d.o.o. a group system of FSC forest certification has been organized. In this system, the Certified Certifier transfers the rights to the Group Manager (Croatian Forests) which then assures its internal system that all members of the group (forest management - affiliates) adhere to FSC standards. A group system of FSC certification in "Croatian Forests is currently the largest in the world“. The Croatian Forest Consult d.o.o., daughter company operates the group's system on behalf of the Forest Stewardship Council (FSC).

7.2 Geographical framework

Regionally, Velebit can be divided into two parts or complexes, the western Adriatic, which belongs to the Kvarner and Northern Dalmatia and the eastern, Lika. These two parts are different in several natural features, also observed and analized in project delivery - Planning biomass based energy production in protected areas in Lika-Senj County (regional level) - focusing on the Nature Park “Velebit” protected areas (incl. municipalities/LAUs within Nature Park, sub-regional level) (IMFBE – WP 3 – A 3.4) which together affect the spatial distribution of natural habitats that define the area where biomass exploitation can be carried out.

The Biomass District would be the most significant biomass district in the area of NP Velebit, which would include the western coastal area (Municipality of Karlobag), the continental slopes of Velebit and parts of Gacko and Ličko polje.

Administratively, most of the biomass district would be located within the Lika-Senj County, where it would include parts of LSU: Senj, Otočac, Perušić, Gospić, Karlobag and Lovinac. Within Zadar County, it would include part of the Gračac Municipality.

In the area of NP Velebit Croatian Forests d.o.o. The Gospić branch office (UŠP Gospić) manages all economic forests, suggesting that the biomass district includes all economic units that are wholly or partly located in the area of NP Velebit. In this way, the existing division of the forests on the economic units for which they were created and the corresponding management bases would be respected for decades.

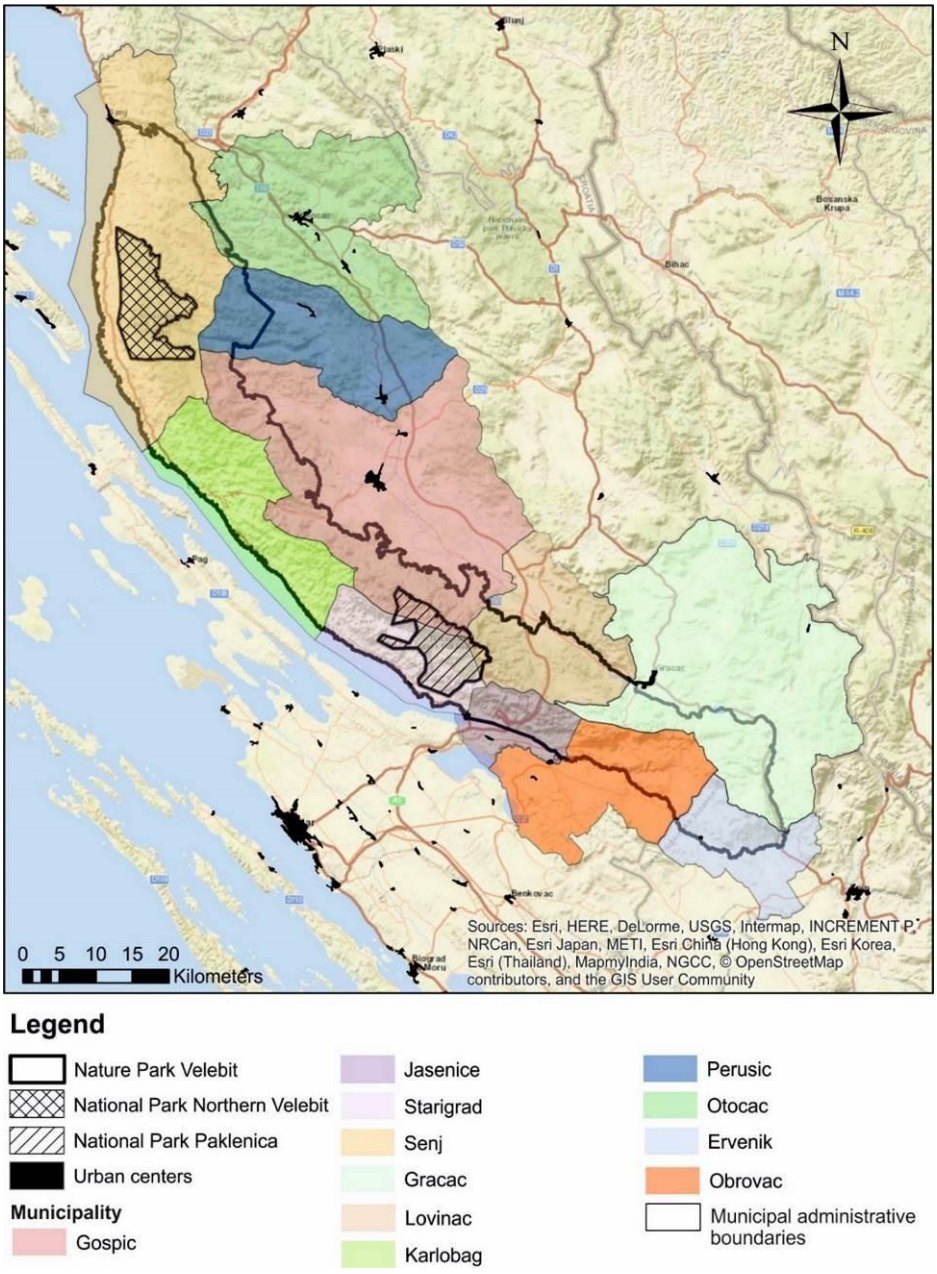

Figure 1. Local Self-Government Units (LAU) within NP Velebit. (Source: Planning biomass based energy production in protected areas in Lika-Senj County (regional level) - focusing on the Nature Park "Velebit" protected areas (incl. municipalities/LAUs within Nature Park, sub-regional level) (IMFBE – WP 3 – A 3.4).

The Biomass District is oriented towards the continental part of the Lika-Senj County. This is the area most densely populated in two LAUs : towns - Gospić and Otočac, where the largest settlements are Gospić and Otočac. In the area of the settlement Gospić there are, apart from the potential consumers of the management of Public Institution NP Velebit and FA Gospić. Also, Gospić is the administrative center of Lika-Senj County and there is a relatively large number of public buildings (compared to the number of inhabitants).

This area is entirely attached to Karlobag Municipality because the most valuable part of the area, from the standpoint of exploitation of biomass, lies in the hinterland and the LAUs. In the coastal part of the Karlobag, forests has mostly features of erosion protection.
The Biomass District is connected to the settlements of Gospić and Otočac primarily by the state road D25, Korenica (D1) - Bunić - Lički Osik - Gospić - Karlobag (D8) and the section of Karlobag to Gospić, in total length of 39.5 km. Another significant public road passing through the Biomass District is the state road D50, Žuta Lokva (D23) - Otočac - Gospić - Gračac (D27) and the share Otočac - Gospić – Gračac, in total length of 97.20 km.

The area of the Biomass District is mostly build by carbonate rocks of Cretaceous and Jurassic age, which, if they are represented by limestone, will often condition karstic appearances, and, if they are represented by dolomites, the surface covers more plant cover. The weakest herbal cover is in the areas with the Velebit (Jelar) breccia, which coincides with the most developed karst areas (Municipality of Karlobag).
From a hydrogeological point of view, the rocks of a different lithological composition will generally have different porosity, which will then condition a certain permeability in the rocks, i.e. their leakage capacity through the porous system. Velebit's porous rocks mostly represent carbonates, the limestone, due to its fractures and developed cavernous system, represent the medium through which fluids pass quickly. The Dolomites, depending on the degree of weathering, but and composition, may represent the environment in which the water will retain a little longer. Triassic, Permian and Carbon clastic rocks on Velebit mostly represent impermeable units, probably because of the high proportion of clay component in them or their compactness. Velebit is known as a mountain without a lot of water springs, but on the contacts of carbonate and clastic there are well-known major springs, such as the springs of Ljubica on Baške Oštarije or the spring on Štirovača.

The catchment areas mostly coincide with the valleys and the karst fields, on the Lika side of the Velebit, while the calculated water flows are well matched with the drawn watercourses taken from Bioportal sites. On the Adriatic side of Velebit is visible a number of smaller catchment areas (watersheds) that, close to the shoreline, sloping down to the sea. These watersheds coincide with smaller canyons that are probably cut into the carbonate bedrock by the action of torrents, which occur during stronger precipitation. It is also possible to observe several larger watersheds and associated calculated flows that descend towards the sea, for which we know that there are no large streams within them except occasional torrents.
Velebit is located in one of the largest soil erosion areas in Europe. The upper layer of the soil is shallow, and is mostly found on limestone and dolomite, and by the loss of the forest cover, the soil is rapidly washed away by mountain torrents. The problem of soil erosion is particularly visible in the coastal part of the NP Velebit, in Karlobag Municipality area within Biomass District.

Most of the Biomass District area prevails bown soil soil on limestone, clastites (acidic brown soil) and smaller brown soil on dolomites. Brown soils represent a very rocky forest soil created on clean, often karstificated limestones and dolomites. They prevail in a wide range, from sea ranges up to 1700 meters above sea level. This is the ground of a discontinuous cover with a varying depth of several centimeters and up to several meters.

The largest part of the Biomass District is characterized by a moderately warm, airy climate with uniformly divided precipitation, and the coldest part of the year falls into the warm season of the "Cfsbx" mark according to Koppen's classification. Within the littoral hinterland, the great variety of climate is particularly pronounced under the modifier effect of the relief because there are great differences between closed depressions (curbs, fields) and mountains, dotted and sloping slopes, privets and cloaks. The climate is less intrusive and sharper than the northwest to the southeast. There are also low winter temperatures, higher amounts of rainfall and significant snow drifts.

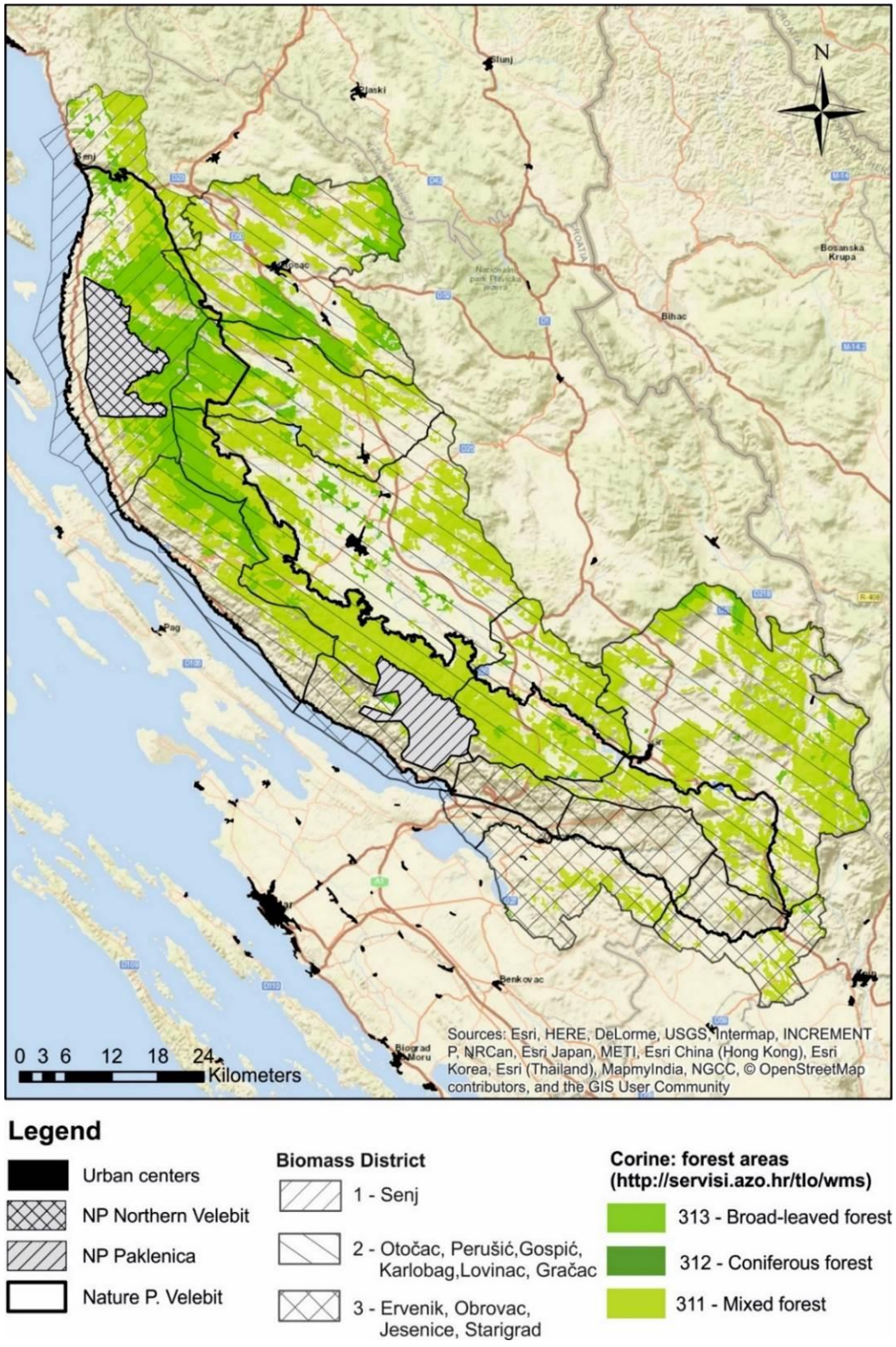

Figure 2. Map of defined Biomass Districts with separeted forest areas. (Source: Planning biomass based energy production in protected areas in Lika-Senj County (regional level) - focusing on the Nature Park "Velebit" protected areas (incl. municipalities/LAUs within Nature Park, sub-regional level) (IMFBE – WP 3 – A 3.4).

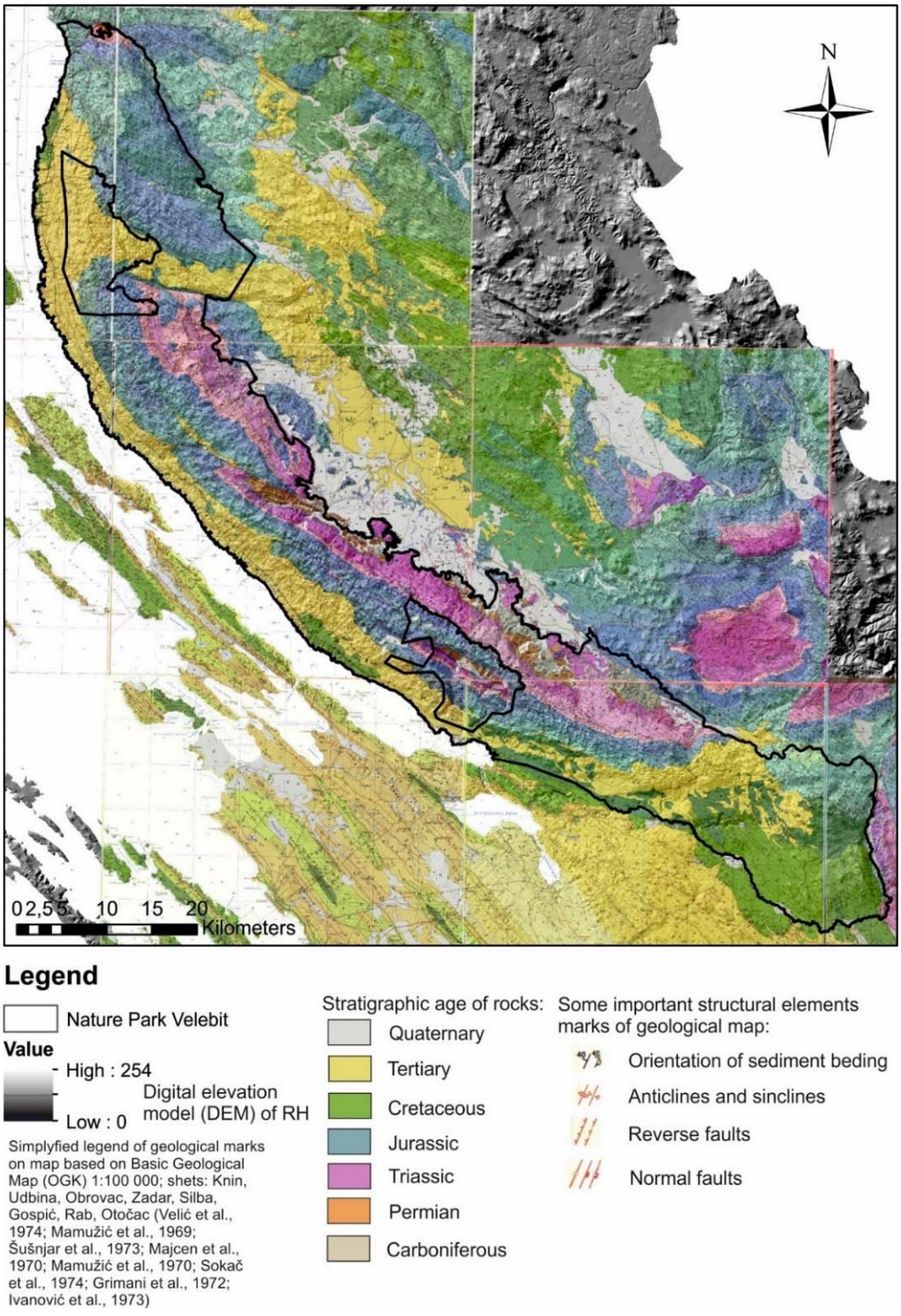

Figure 3. Compilation geological map. (Source: Planning biomass based energy production in protected areas in Lika-Senj County (regional level) - focusing on the Nature Park “Velebit” protected areas (incl. municipalities/LAUs within Nature Park, sub-regional level) (IMFBE – WP 3 – A 3.4).)

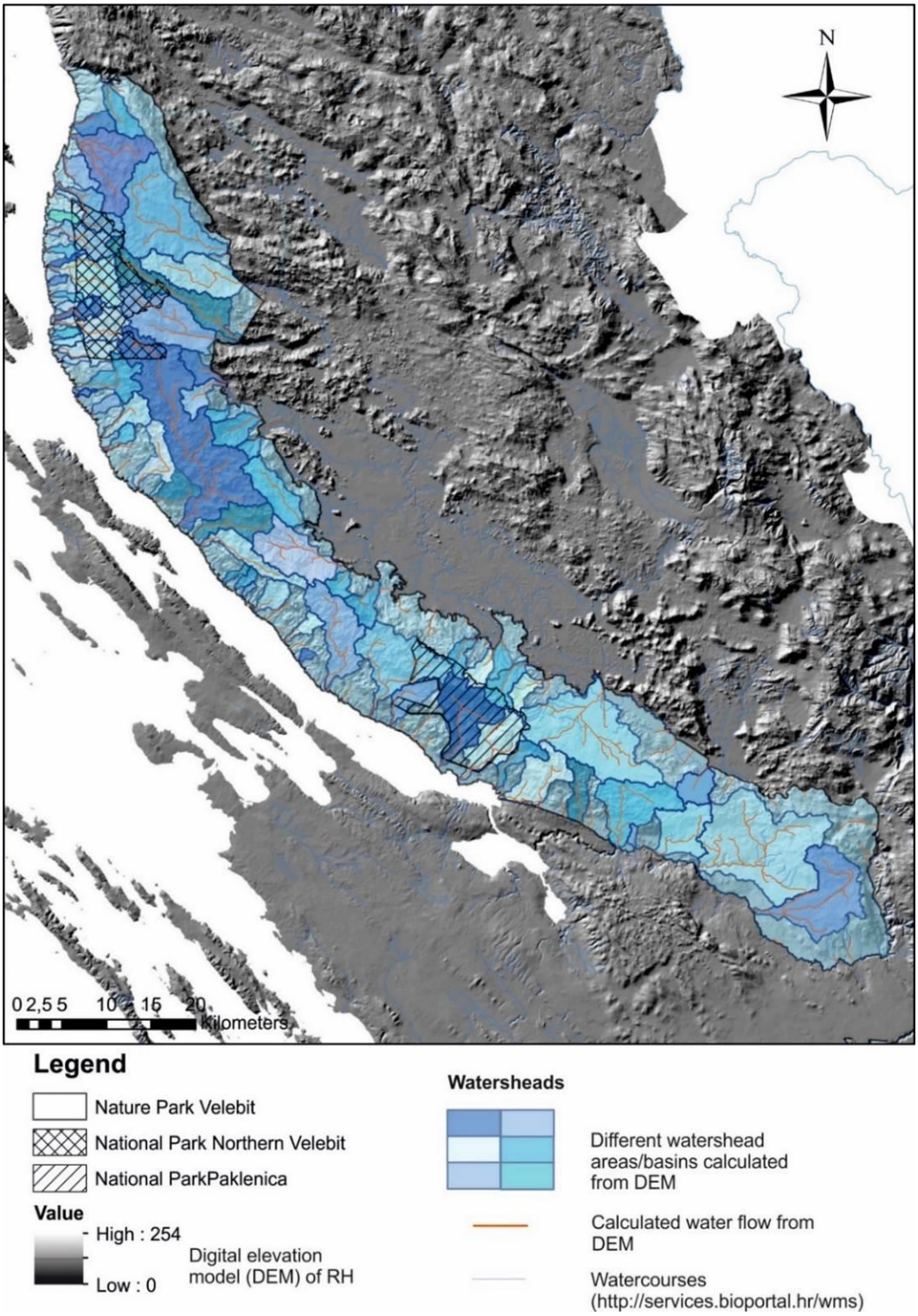

Figure 4. Calculate basins in NP Velebit area. (Source: Planning biomass based energy production in protected areas in Lika-Senj County (regional level) - focusing on the Nature Park "Velebit" protected areas (incl. municipalities/LAUs within Nature Park, sub-regional level) (IMFBE – WP 3 – A 3.4).

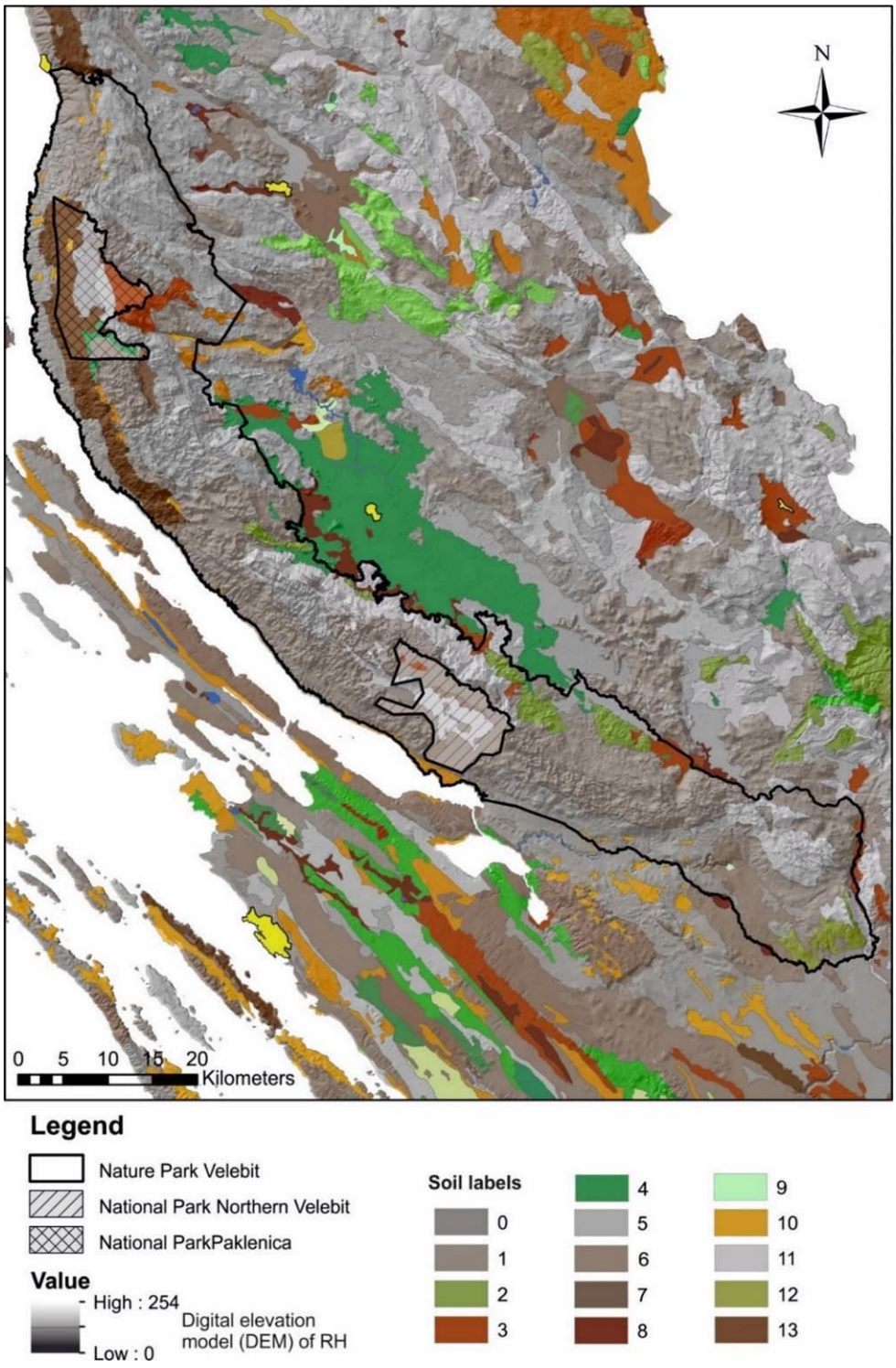

Figure 5. Pedological map. (Source: Planning biomass based energy production in protected areas in Lika-Senj County (regional level) - focusing on the Nature Park "Velebit" protected areas (incl. municipalities/LAUs within Nature Park, sub-regional level) (IMFBE – WP 3 – A 3.4).

7.3 Type and description of the forest ownership

The characteristic of the forestry sector in the Republic of Croatia is that most of the state-owned forests are managed by a number of state-owned legal entities (Croatian Forests d.o.o.. and Public Institutions -

National Parks, Ministry of Agriculture and the Ministry of Environmental Protection and Energy, Croatian Forestry Institute, Forestry faculty of the University of Zagreb).

This situation is accepted by the public and it is difficult to identify any changes regarding state-owned forests management, since all ownership changes since 1991. have been considered to have long-term negative consequences for the society as a whole and there is a significant number of resistance stakeholders (trade unions, the public, part of the profession) to change the owner's title. It is therefore expected that there will be no significant changes in ownership over the forests that are now in state ownership for a further 30 years.

For the area of Biomass District there are no publicly available data on the ownership of forests because publicly available data is obtained at the level of the entire Park.

It is proposed that the Biomass District include all economic units (29) located in the area of PP Velebit, wholly or in part, managed by the FA Gospić and gravitational (currently undetected areas) of private forests. In the so-defined area of the Biomass District there are 92.663,31 ha of state-owned forests and approximately 4.000 ha of private forests (estimates). The Biomass District's boundary area thus encompasses the area of influence of NP Velebit through management plans, Spatial Planning of NP Velebit and allows within the set limits of public-legal powers of the Public Institution NP Velebit the realization of the set goals and the implementation of the measures and activities that may be the bearer and / or one of holder of the Public Institution Nature Park Velebit (which controls the area within park boundaries).

It is estimated that the area of private forests within the District was about 2.500 hectares, and it is predominantly located near the settlements of the Park (Konjsko, Baške Oštarije, Trnovac, Brušane, Pazarište). Part of private forests are neglected meadows, which gradually pass through the forest through succession. Like elsewhere within the NP Velebit, private forests are most often enclaves or semi-enclaves within state forests.

7.4 Synthesis of environmental features

Pursuant to statutory regulations the Nature Park is a protected area of state importance, with strict reserve, national park and special reserve. By definition, the Nature Park is a naturally or partly cultivated land area and / or has a great biodiversity and / or geo- diversity with valuable ecological features, accentuated landscape and cultural and historical values. Its purpose is scientific, cultural, educational and recreational. Also in nature parks it is allowed to carry out economic and other activities, provided that the activities carried out in it do not jeopardize its essential characteristics and role.

NP Velebit is the most important floristic area of Croatia and one of the most important floristic centers of flora diversity in Europe. Previous research has covered approximately 15% of the Park area and the wealth of flora is far from explored. So far, the established flora consists of 1854 species and subspecies. The number of endemic taxa amounts to 4.3% of taxa, and the number of taxa protected by different

international conventions is 6%. The vegetation of the area can be divided into forest, grassland and plant communities of rocks and rocks, which grow in extreme conditions.

There are a number of protected and endangered species of flora and fauna in the Biomass District; mammals, birds, amphibians, reptiles. At the same time there are no records on protected and endangered species of fungi and insects per individual farms, which also indicates insufficient exploration of biodiversity in the area of NP Velebit (and therefore the Biomass District).

In the area of Biomass District, 46 habitat types were recorded, of which 19 were classified into the category of endangered and rare habitat types. Of the endangered and rare habitat types in the area of the Park, the most common ones are the Dinaric beech and fir forest and submountain beech forest. Also in the area of the Biomass District there are forest communities 41.11 Beech forest Luzulo-Fagetum and 41.16 Beech forest on lime subsurface (Cephalanthero-Fagion) in Council Directive 92/43 / EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora as a naturally occurring and translogic forest vegetation of native species forming high forest stands with a typical ground layer and meeting the following criteria: rare or relict and / or hosts species of Community interest.

7.5 Naturalistic, environmental and landscape restrictions

In the area of the Biomass District there are several different biomass exploitation segments. The limitations arise from the fact that the biomass district comprises part of the PP Velebit covered by the Natura 2000 burial ground (prohibiting the afforestation of valuable habitats that are not registered as forest) and that the nature conservation measures are prescribed in the management bases for a particular economic unit, and the most important model of management is selection method (which completely and optimally ensures economic, protective and social function of the forest).

Restrictions are also linked to the natural and landscape features of the Biomass District.

One of the most important natural limitations is the terrain's roughness and the slope of terrain that make it difficult to use existing forest machinery (forest tractors).

The area of the Biomass District has a distinct relief, its higher elevated inclinations in values exceeding 30% of the incline (yellow to red on the ground elevation map). Within relatively steep sloping hues, there are numerous surfaces with significantly lower slope values (green on the map), often featured on smaller surfaces from all sides surrounded by higher slopes. Such a slope schedule is expected in the karst area within which numerous ropes and ponies appear. Such a slope schedule is expected in the karst area within which numerous ropes and ponies appear. These sites are often covered with forest cover because they are found in morphologically protected domains of adverse climatic influences, such as strong wind influences, and again due to topographical downturn at a more favorable location, hydrologically. The biggest obstacle to exploitation of such locations is road insulation, which limits the rapid and efficient transport of biomass. In this sense, the slope map for the area of the Biomass District could, at a larger scale, define individual

locations within the morphologically enclosed zones that could be planned for the transport system. Such maps are not created and such data is not available.

Significant limitations in the exploitation of forests arise from climatic conditions. The current system of exploitation of commercial forests requires significant use of labor force (woodcutters) that interrupt the execution of works in the woods in case of adverse climatic conditions (rain, snow, snow, strong wind).

The most significant environmental and landscape constraints arise from the fact that the Biomass District comprises part of PP Velebit that is part of the Ecological Network of the Republic of Croatia.

The ecological network Natura 2000 is based on EU Directives (Birds Directive - Directive 2009/147 / EC and Habitats Directive - Council Directive 92/43 / EEC).

The Birds Directive was adopted with a view to the long-term conservation of all wild bird species and their important habitats on the territory of the EU. Special emphasis is placed on the protection of migratory species.

The Habitats Directive was adopted with a view to preserving the biodiversity of EU members through the protection of natural habitats and wild flora and fauna.

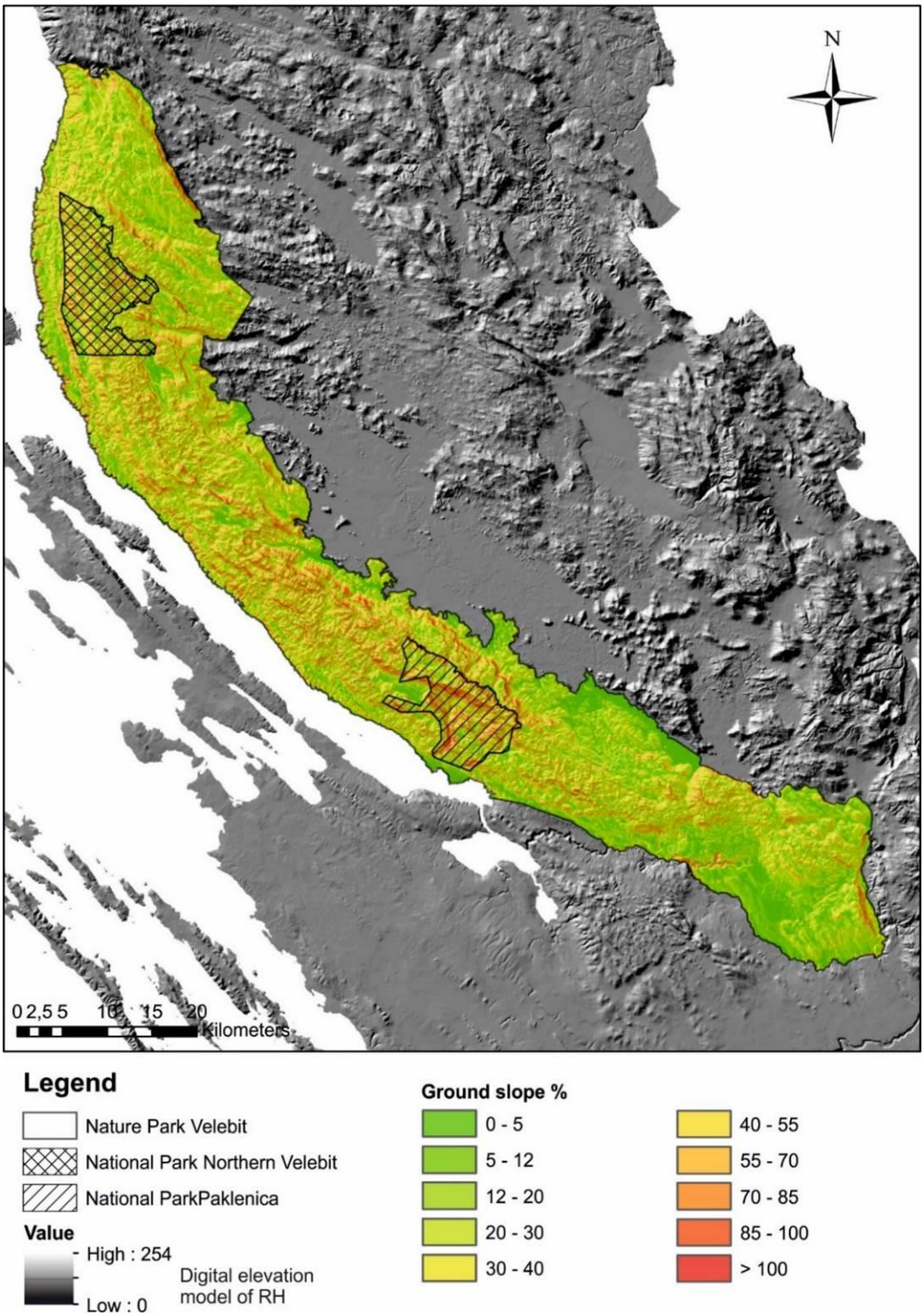

Figure 6. The ground elevation map, expressed in percentages. (Surce: Planning biomass based energy production in protected areas in Lika-Senj County (regional level) - focusing on the Nature Park "Velebit" protected areas (incl. municipalities/LAUs within Nature Park, sub-regional level) (IMFBE – WP 3 – A 3.4).

The main way of achieving this goal is to establish a Natura 2000 ecological network. In managing Natura 2000 areas, apart from the scientific ones, economic, social and cultural requirements, as well as regional and local characteristics are taken into account. Protection of the area is carried out by evaluating the

impact of certain plans and interventions and by implementing conservation measures through legislative provisions, contractual and other arrangements with owners and land users and, if necessary, through separate management plans. Article 6. of the Habitats Directive prescribes the obligation to assess the acceptability of any plan or project that alone or in combination with other plans or interventions can have a significant negative impact on the target species and habitat types of Natura 2000 ecological network. According to the Habitats Directive, also in the areas separated into the network in accordance with the Birds Directive (so-called SPA areas). It is not important to locate the project, ie whether it is located within or outside the Natura 2000 area, the potential impact on target species and habitat types is the one that "initiates" the process of acceptability.

Ecological Network in Croatia (Natura 2000) accroding Article 6. Article 6 of the Ordinance on the Ecological Network (Official Gazette No. 124/2013, 105/2015) makes the conservation areas important to the birds - POPs (areas of importance for the conservation and exploitation of the favorable status of wild birds of interest to the European Union as well as their habitats , and areas of importance for the preservation of migratory species of birds, particularly wetland areas of international importance) and conservation areas important for species and habitat types - POVS (areas of importance for the conservation and exploitation of favorable conditions of other wild species and their habitats as well as natural habitat types of interest to the European Union).

Table 1. Croatian Ecologial Network areas in Biomass District.

NATURA 2000 areas			
No.		Area name	Code
1.	Conservation areas important for birds - POP (Special Protection Areas - SPA)	Velebit	HR1000022
2.	Areas of conservation important for species and habitat types - POVS (Areas of Community Importance - SCI)	Nature park Velebit	HR5000022
3.	Areas of conservation important for species and habitat types - POVS (Areas of Community Importance - SCI)	Gacko polje	HR2000635
4.	Areas of conservation important for species and habitat types - POVS (Areas of Community Importance - SCI)	Ličko polje	HR2001012

Source: Bioportal, December 2018.; www.haop.hr

Given that some basic measures for conservation of forest target species of birds in certain areas of conservation important for birds (POPs) refer to the required minimum dry mass (m3 / ha), it should be noted that dry wood masses include the quantity of dry standing and laying forest trees, and is defined by the National List of Indicators as an Indicator of BR 14 "Dry trees in forests" .

When designing the basis of management for a particular economic unit, nature protection measures that respect all environmental and natural constraints stemming from the status of protected area (nature park), records of endangered and protected plant and animal species and habitat types within a particular economic unit are established.

7.6 Forest types and agricultural land use

Corine Land Cover analysis defined the area of NP Velebit there are no agricultural woody crops areas but there are only forest areas in the presence of deciduous (311), coniferous (312) and mixed (313) forests. Also, in areas of LAU outside the NP Velebit borders, there is no agricultural woody crops marked with: 221, 222, 223.

Table 2. gives data for the area of NP Velebit, which also includes the protected forest reserve of the Štirovača valley, which is about 1100 m above sea level, known for its large preserved coniferous forests. The area of Štirovača covers 123,41 ha (administrative site is located in JLS Karlobag (40,96 ha) and JLS Senj (82,45 ha). Štirovača is also not economically used, therefore the total area of forests for economic use in the area of PP Velebit 217,675.26 ha.

In the area of Biomass District, the most important forest habitats are dinaric beech and fir forests, mesophilic and neutrophilic beech forests, southeast alpine-illyrian mountain, thermophilic beech forests and submountain beech forests.

Dinaric beech and fir forests (As. Omphalodo-Fagetum (Tregubov 1957) Marinček et al. 1993) In the tree stage, in the optimal phase, beech and fir are represented alike, although their relationship depends on the conversion phase. They´ve been managed with selection method. They are at an altitude of 600 to 1100 m, more or less on all terrain, slopes and exposures. They give a fundamental characteristic to the vegetation of NP Velebit. These forests are a fundamental ecological reference for all natural systems, including human life in the Dinarides.

Submountain beech forest with wood colt˙s foot (Homogyno sylvestris-Fagetum sylvaticae /Ht. 1938/ Borh. 1963), grow on the height between 1100 to 1650 m, above Beech-Fir forests and before dwarf mountain Pine. Beech in Dinarides again builds strong vegetation belt. Fir and Jela i many mountain species are gradually losing, predominantly overtaking beech trees characteristic of the lower part of the trunk.

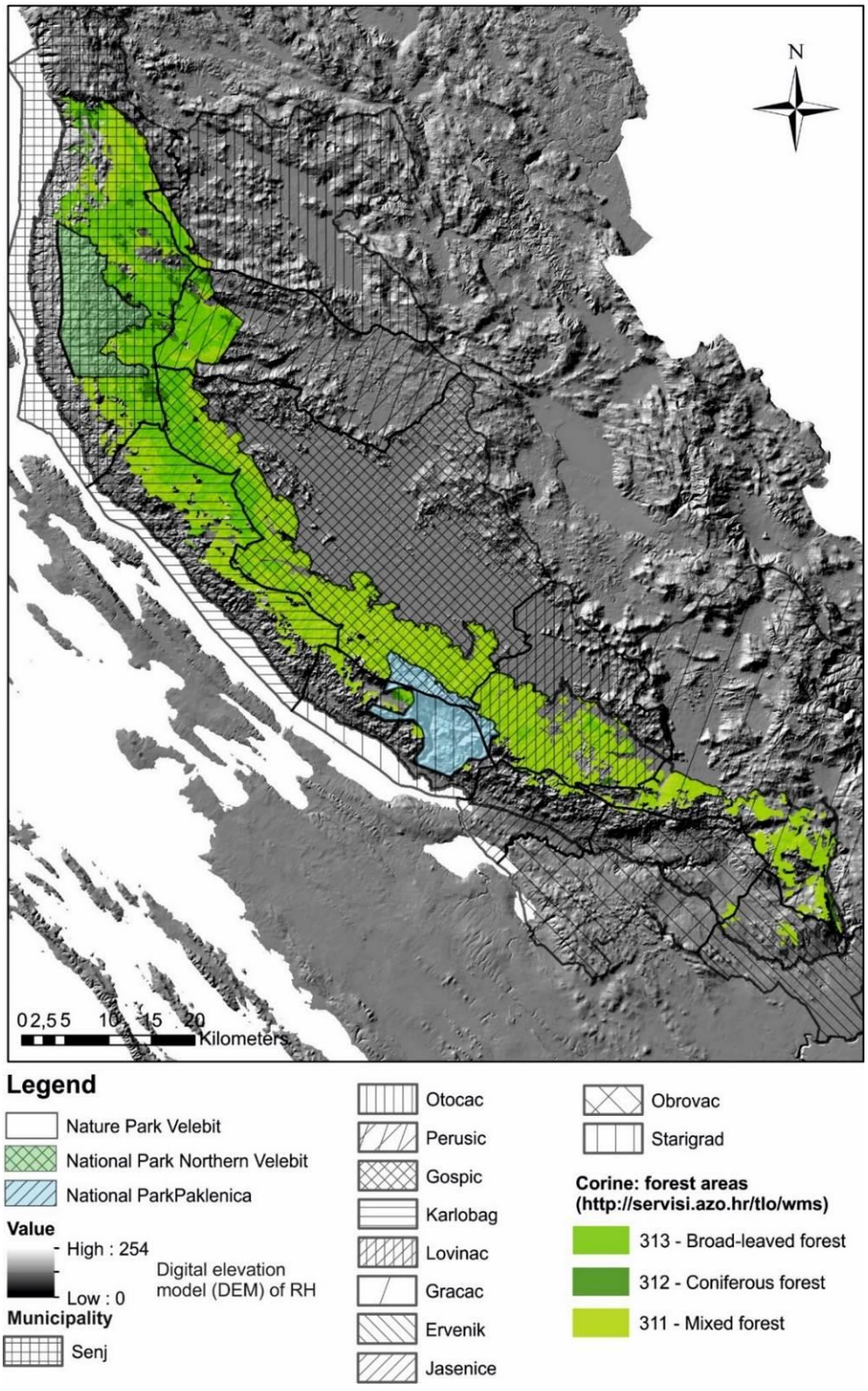

Figure 7. Forest Cover Map in the area of NP Velebit. (Source: Planning biomass based energy production in protected areas in Lika-Senj County (regional level) - focusing on the Nature Park "Velebit" protected areas (incl. municipalities/LAUs within Nature Park, sub-regional level) (IMFBE – WP 3 – A 3.4).

Mesophilic and neutrophilic beech forests - forest community of beech with dead neetle is a community of clean, Illyrian, mountain beech forests of the mountainous vegetation belt. It is rich in floristic composition.

Southeast alpine-illyrian mountain, thermophilic beech forests

Beech forest with autumn moor grass (Seslerio-Fagetum sylvaticae /Ht.1950/ M. Wraber 1960) is Beech community of vertical Karst, is developed on skeletal carbonate soils and occupies big areas at the littoral slopes of Dinarides. The biggest areas are developed on rock plateaus above 1000 altitude the north and middle Velebit, where they are often surrounded by sub alpine Beech forest and on the north side by beech and fir forest.

Central European acidophilous beech forests

Illiryan mountain beech forest with dead nettle (Lamio orvalae-Fagetum sylvaticae Ht. 1938) the most important climazonal community of mountain belt. The forest stands are very stable, with regular growth and with rich floristic composition. It grows between 400 and 500 m altitude. This is a natural areal for the growth of beech. The biggest areas can be found on north slopes of Velebit, precisely between Otočac and Gospić. They have been marked only around the estates as protective forests and the rest of them have economic importance. Luzulo-fagetum beech forests (Luzulo-Fagetum sylvaticae Mausel 1937) occurs on mountain belt, on Lika plateau. This community belongs to the economic zone.

Table 2. Types of habitats in the economic units of state forestry.

Economic unit	**Type of habitats - NKS**	**NKS Code**	**%** Economic unit
Bovan - Jelar	Dinaric beech and fir forests	E52	47.70
Crna duliba			75.20
Crne grede			32,98
Goli vrh			68,54
Jadovno-jazbine			21,580
Konjska draga-Begovača			92.77
Križići			97,23
Laktin vrh - Dabri			83,51
Oštrac bok			17,756
Padeška kosa – bijele grede			86,07
Ramino korito – Šugarska duliba			13,17
Rastovka – Kuterevske kose			83.73
Šedrvan – Bukova glava			22,379

Economic unit	**Type of habitats - NKS**	**NKS Code**	**%** Economic unit
Senjsko bilo			91,89
Štirovača			71.52
Visočica – Razbojna draga			14,25
Grabar dulibe	Central European acidophilous beech forests	E42	7.73
Medačka staza			0,88
Bovan - Jelar	Mesophilic and neutrophilic beech forests	E45	49.24
Crne grede			65,57
Jadovno-jazbine			71,468
Grabar dulibe			37.34
Jasensko bilo - Crnopac			54,01
Kosurina - Bogunica			89,97
Medačka staza			51,48
Oštrac bok			63,373
Ostrovica			84.95
Padeška kosa – bijele grede			12,73
Rastovka – Kuterevske kose			11.93
Šedrvan – Bukova glava			64,578
Smrdljivac - Kom			28,47
Sveto brdo – crveni potoci			49,18
Visočica – Razbojna draga			21,76
Crna duliba	Southeast alpine-illyrian mountain, thermophilic beech forests	E46	15.01
Goli vrh			3,43
Jasensko bilo - Crnopac			16,25
Grabar dulibe			29.77
Laktin vrh -Dabri			8,08
Malovan - Dušice			20.856
Medačka staza			16,82

Economic unit	**Type of habitats - NKS**	**NKS Code**	**%** Economic unit
Ramino korito – Šugarska duliba			17,30
Sjeverne karlobaške šume			12,67
Sveto brdo – crveni potoci			31,05
Goli vrh	Submountain beech forest	E61	19,41
Kozjak			83,62
Medačka staza			24,77
Šarić – Duplje			65,26
Senjsko bilo			7,30
Visočica – Razbojna draga			59,17
Štirovača	Spruce Forest	E73	28.48
Oštrac bok	Conifer plantation	E92	8,008
Šedrvan – Bukova glava			10,445

Source: Stručne podloge za izradu mjera i uvjeta zaštite prirode za pojedine gospodarske jedinice, Državni zavod za zaštitu prirode, Hrvatska agencija za okoliš i prirodu

In the area of the Biomass District, some of the forests and forest land are contaminated with mines, thus preventing the implementation of forest works and harvesting of wood. These areas are mostly located in the southeast of the Biomass District.

Table 3. Forest land contaminated/suspected with land mines.

Forest administration	Land mines contaminated areas (forests)/ha
Gospić	7.835,48
Karlobag	70,19
Otočac	5.600,12
Perušić	1.660,63
Sveti Rok	1.665,53

Source: Croatian Forests d.o.o., FA Gospić, March 2017.

The data refer to several units managed by individual forests. Since Velebit was the line of demarcation, its southeastern part was mined. Apart from economic damages, mostly mine suspected areas within the NP

Velebit pose a major threat to security and prevent the nature monitoring and free movement of Park officials and visitors.

7.7 Forest partitioning and description

7.7.1 Methodology

Forest management implies directing and managing forest management in a manner that would make overall forestry production compatible with the needs and demand of the community (Čavlović, 2013). In other words, forests are regulated according to the needs of society. In Project delivery - Baseline review/Situational analysis of production / biomass potential of Lika-Senj County - focusing on the Nature park "Velebit" protected area (IMFBE – RP 3/1 – A) it has been established that in the last 10-12 years there have been significant changes in the needs of society (social community) for one of the products of forest - biomass, ie there has been an increase in demand for biomass to the extent that in some areas demand is growing and will either be or will be higher than the offer . This was due to the demand for biomass as a source of raw materials for newly built and planned pellet factories (which produce pellets for domestic and foreign markets) and cogeneration. These space-based interventions were planned and encouraged by the state through all strategic, spatial-planning and other documents aimed at promoting the use of renewable energy sources (RES) and energy efficiency (EE). It can be stated that the company clearly defined the priorities of using the RES and increasing EE in response to the use of fossil fuels and the support for greater energy independence of the Republic of Croatia. Within NP Velebit there are commercial forests managed by FA Gospić by the selection management model, which was established in the 19th century.

Forestry regulation in the Republic of Croatia is regulated by the national regulation where the most important regulation of the Forest Law, and only the editing of forests, is more closely regulated by the Forestry Ordinance.

On the territory of the Republic of Croatia, the management of forests is divided into regular, regular economic forests (most of the forests in Croatia as well as many other countries in the world) as well as selected and size structured forests.

According management forest compositions are:

1. Regular economic forests – the main tree species are even-aged with stand management
2. Selection forests – in which trees of different heights and diameter are distributed, and the management is per tree or group;

3. Size structured forests – where are tree groups (up to 1 ha) are in various age and growth phases, trees in one group are of similar dimensions and forest management is accomodated to each group of trees.

Regular economic forest is managed on the stand forst management principles. Forest is sectioned by the species of trees, their age, origin and management goals. According age of man species trees the stands are classified in classes. In the first class are the youngest trees while in the last class are trees mature for cutting and regeneration. Period of rotation is time needed from planting of the trees to final cutting and regeneration. Generally, in Croatian even-aged (regular) forests are beach, pedunculate oak (Quercus robur), sessile oak (Quercus petraea), european hornbeam, ash, etc.

Selected forest is type of forest where are trees of various thickness of trunks (in diameter) and various hights, in one area/unit. In Croatia, selected forests occupy cca. 140 ha, mostly in Gorski kotar and Lika regions, 700 – 1300 m above sea level. Selected forests are also in Medvednica, Macelj, Ivanščica and Papuk. Those forests are very valuable from economic end environmental point of view. Selection forest management was founded in 19th century with aim to improve forests management in karst areas. Trees are unevenly spaced and make specific selected complex. Selected forest management is posible only in forests where in its structure abies (Abies alba) dominates and it is basic species in selected forests and in selected forest management. In selected forests are very often beech and norway spruce. In selected forest volume production of wood is equally distributed, tree complex is cascaded, regeneration is permanent, the mature stand is not removed and it has great biological value with unstable structure. Forest management do not use real rotation but little rotation – usually 10 years rotation where economic unit is devided in 10 parts and each year one part is thin out, and in 11th year everything start over.

Selected forest management in the same time nurture, select, regenerate and exploit the forest. Intensity of cutting is 10-30%, optimum 20-25%. Optimal ratio of coniferous and broadleaved trees is 70%:30%. The broadleaved trees are often beech, maple-tree, lime-tree, wild cherry and rowan-tree.

Management of size structure forest stand is posible in forest on karst, private forests, and in forest with important protection purpose.

Table 4. The structure of the forest by economic units that are entirely or partly located in NP Velebit.

No.	Economic unit	Regular economic forest	Selection forests	Size structure forest	Total
		ha	Ha	ha	ha
1	Jadovno - Jazbine	1.380,10	1.340,54	4.130,73	6.851,37

No.	Economic unit	Regular economic forest	Selection forests	Size structure forest	Total
		ha	Ha	ha	ha
2	Goli vrh	46,39	564,48	1.833,86	2.444,73
3	Šedrvan - Bukova glava	538,18	0,00	1.116,59	1.654,77
4	Visočica – Razbojna draga	156,11	1.585,97	3.313,61	5.055,69
5	Kozjak	160,14	261,50	1.382,09	1.803,73
6	Kosurina - Bogunica	444,79	0,00	2.947,30	3.392,09
7	Medačka staza	0,00	416,89	3.127,81	3.544,70
	Malovan - Dušice	merged with economic units, No. 24			
8	Senjsko bilo	7,40	689,80	303,73	1.000,93
9	Rastovka – Kuterevske kose	1.375,98	974,66	487,91	2.838,55
10	Konjska draga - Begovača	31,14	4.541,66	635,21	5.208,01
11	Oštrac bok	2.028,21	0,00	440,29	2.468,50
12	Bovan – Jelar	933,79	779,47	671,53	2.384,79
13	Ostrvica	4.475,31	0,00	29,81	4.505,12
14	Padeška kosa - Bijele grede	0,00	2.103,58	1.588,76	3.692,34
15	Štirovača	0,00	410,28	158,38	568,66
16	Crne grede	628,92	528,89	1.311,46	2.469,27
17	Križić	4,68	727,25	217,57	949,50
18	Laktin vrh - Dabri	0,00	3.614,02	3.169,44	6.783,46
19	Sjeverne karlobaške šume	3.168,30	0,00	140,41	3.308,71
20	Južne karlobaške šume	3.436,39	0,00	17,10	3.453,49
21	Crna duliba - Metla	143,62	779,98	1.115,01	2.038,61
22	Ramino korito - Šugarska duliba	1.522,86	18,69	1.474,81	3.016,36
23	Šarić duplje	122,13	177,13	1.694,48	1.993,74
24	Sveto brdo - Crveni potoci	372,13	298,33	3.059,54	3.730,00
25	Grabar – Duliba	1.056,93	0,00	2.462,69	3.519,62
26	Duboke jasle - Jabukovac	829,82	0,00	179,15	1.008,97
27	Jaselsko bilo - Crnopac	826,35	475,74	4.122,85	5.424,94

No.	Economic unit	Regular economic forest	Selection forests	Size structure forest	Total
		ha	Ha	ha	ha
28	Smrdljivac – Kom	6.624,33	0,00	928,33	7.552,66
	TOTAL:	30.314,00	20.288,86	42.060,45	92.663,31

Data source: FA Gospić, April, 2019.

7.7.2 Results

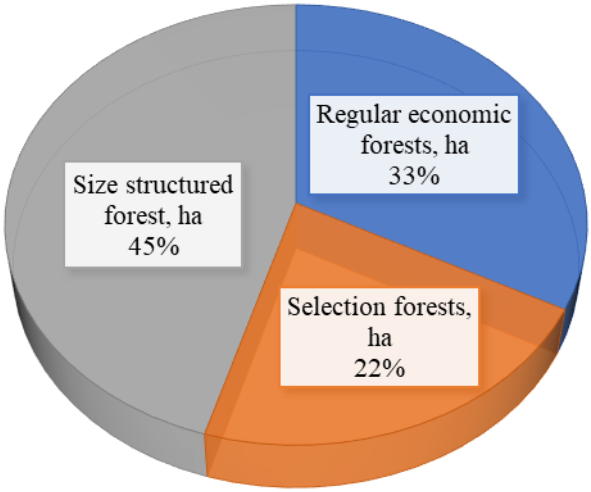

Figure 8. Structure of state owned forestry by management model.

In examining area is 92.662,31 ha of state forest managed by Croatian Forests d.o.o., FA Gospić. According that kind of management, they are divided on regular, size structure and selected forests. The most important is size structured forest management which is implemented on 42.060,5 ha or 45,39% of forest.

7.8 Dendrometric inventory

The base of management for regular foresta is structure of stands divided in classes according the age of trees, while the base of management of selected forests is structure of stands divided in classes according the thickness of trees.

In Biomass District area selected forest management is main economic moedl and the main operation of wood production is cutting of trees using labour force (loggers) and organized

dragging the tree trunks from the forest to temporary depots from where the trunks are furtherer transported by forest trucks. Under such model of forest exploatation 15% of cutted woodstock remain in forest, it is tree brances biger than 7 cm in diameter beacuse it is costly to exploit this biomass.

One of the aims of Forest management plan is to reduce this unexploited biomass. Using modern forest mechanisation (forvareders and harvesters) this biomass can be profitable exploited. Explotation of branches less than 7 cm in diamater is not profitable. Also this biomass is used in forest for producing of compost (branches are placed on the soil in piles, depending on managment of the forest).

7.8.1 Methodology

Part of the forest which represend unique unit according forest cultivaton characteristics is called forest stand and could be destinguished by species of trees, managing, age of trees, its stage o development and charasteristics of habitats. Generally it could be said that forest is composed of forest stands.

Exposure of a forest stands is the process of its demarcation from neighboring stands within a forest. Description and determining of forest stands demands procedure of analysis stand strucure elements.

The most important forest cultivation criteria for determination and decription of forest stands are

1) stand shape
2) cultivation model
3) development od stand
4) age of stand
5) habitat quality

The forest stand of high cultivation are formed by seed reproduction method. Trees are cultivated in long rotation. (Seed planted forest).

The forest stand of low cultivation are formed by vegetative reproduction method . Trees are cultivated in short rotation (stump forest).

The medium forest stand ic mixture seed planted and stump forest with mixed cultivation methods.

Three management models are implemented in the District of Biomass District, and the main model for implementing wood harvesting operations is the use of workforce (woodcutting) by dragging down trees to the handicraft dumps where the gained wood mass is further transported by forestry trucks. In this mode of exploitation in the woods remains about 15% of the wood stock hewn, the bulbs with a volume greater than 7 cm, because it is economically unjustified to extract this wood stock from the forest.

One of FMP's goals is to reduce this unused residue, which should be economically justified by the use of modern forest machinery (forwarders and harvesters).

Utilization of branches below 7 cm is not justified in breeding because this biomass, whose utilization is expensive, is needed to produce humus for which part of the branch must remain in the forest (down to the ground, depending on the mode of management and breeding in which the branch mass).

Table 5. Current state of the forests according to cultivation method.

No.	Economic unit	High	Intermediate	Low	Total
		ha	ha	ha	ha
1	Jadovno – Jazbine	3.737,64	0,00	3.113,73	6.851,37
2	Goli vrh	2.177,89	0,00	266,84	2.444,73
3	Šedrvan - Bukova glava	1.023,00	0,00	631,77	1.654,77
4	Visočica – Razbojna draga	3.714,89	0,00	1.340,80	5.055,69
5	Kozjak	1.643,59	0,00	160,14	1.803,73
6	Kosurina – Bogunica	532,99	0,00	2.859,10	3.392,09
7	Medačka staza	2.802,88	0,00	741,82	3.544,70
	Malovan – Dušice	merged with economic units, No. 24.			
8	Senjsko bilo	994,84	0,00	6,09	1.000,93
9	Rastovka – Kuterevske kose	1.703,11	0,00	1.135,44	2.838,55
10	Konjska draga – Begovača	4.976,07	0,00	231,94	5.208,01
11	Oštrac bok	930,97	0,00	1.537,53	2.468,50
12	Bovan – Jelar	1.836,53	0,00	548,26	2.384,79

13	Ostrvica	514,64	0,00	3.990,48	4.505,12
14	Padeška kosa - Bijele grede	3.090,74	0,00	601,60	3.692,34
15	Štirovača	568,66	0,00	0,00	568,66
16	Crne grede	1.032,18	0,00	1.437,09	2.469,27
17	Križić	731,93	0,00	217,57	949,50
18	Laktin vrh – Dabri	5.210,45	0,00	1.573,01	6.783,46
19	Sjeverne karlobaške šume	25,83	0,00	3.282,88	3.308,71
20	Južne karlobaške šume	35,93	0,00	3.417,56	3.453,49
21	Crna duliba – Metla	1.518,82	0,00	519,79	2.038,61
22	Ramino korito - Šugarska duliba	1.463,63	0,00	1.552,73	3.016,36
23	Šarić duplje	1.765,11	0,00	228,63	1.993,74
24	Sveto brdo - Crveni potoci	2.950,55	0,00	779,45	3.730,00
25	Grabar – Duliba	1.037,34	0,00	2.482,28	3.519,62
26	Duboke jasle – Jabukovac	161,75	0,00	847,22	1.008,97
27	Jaselsko bilo – Crnopac	1.934,09	0,00	3.490,85	5.424,94
28	Smrdljivac – Kom	837,84	0,00	6.714,82	7.552,66
	TOTAL:	48.953,89	0,00	43.709,42	92.663,31

Data source: FA Gospić, April, 2019.

There are no defined intermediate cultivation forms in the FMP.

7.8.2 Results

From the processed data, there is a large surface area under low forests of 43,709.42 ha or 47.17%, which have lower quality of wood growing and poorer overall forest function compared to high-growth forests. It is characterized by a variety of structures: from normally assembled, with well-shaped, vital trees, among which are numerous trees from seeds to those broken pieces, with deformed and shriveled shoots; from transient forms to seedlings to those who are so degraded that we put them into chicory. These forests represent a great potential for producing biomass for energy.

7.9 Plan of treatment types and silvicultural operations

Silvicultural operations in Biomass District will be furtherer maintained according management base for each economic with stand model of forest management. The forest is devided according

the species of trees, forest age, purpose, the way of origin and the main goal of nurturing. In forest stands are implemented three cuttings preliminary cutting, cutting after the good years in seed production or in year after the succeciful regeneration and finač cutting. Preliminary cutting removed trees which cannot produce healthy seed so the other trees have more posibility to increase seed production. Other cutting is done in the good year of seed production so the tree sprouts have more sun light. Part of trees remained because its cover and protect tree sprouts and also produce more seeds in next years. Final cutting is implemented when/on all regenerating area sprouts are visible and it is the area of other nurturing operations (pest protection, weed cleaning, adedd sprout planting).

In selected forest management is lot of using labour force (loggers). Also skidders and forest trucks are used.

Operations in even-aged forests needs less manwork, but in the same time workers have to be educated for using modern forest mechanisation – forwaredrs, harvesters and cable ways.

At the moment FA Gospić has only one harvester and forwarder and in case of increasing the areas of forest with stand management will be necessar to invest in education of workers and in acquisition of modern forest mechanisation.

It should also be taken into account that there is already a lack of workforce who, due to higher wages, goes to work in other EU countries and is already difficult to execute all planned works in the forest due to lack of labor force.

Potential impact of forestry operations on habitats - forest communities in NP Velebit is assessed uniquely in Project delivery document - Impact assessment of threats and benefits of increase the biomass use in the protected areas - focusing on the Nature park “Velebit” protected areas (IMFBE – RP 3/1 – C) for all forest communities. Given that forests manage on the principles of sustainable management, all efforts in the forests of forests include the continuous renewal and maintenance of forest communities with the aim of long-term continuous exploitation. In the various forest communities, medium-term impact on natural vegetation, plant composition, reduction and damage to natural regeneration have tree shredding operations and preparation for transport (the plant community structure or its function will be recovered in the period measured in years). This estimate of the impact of forestry operations on habitats - forest communities would not change significantly even in the event of a change in the management model in some economic units because despite the otherwise organized forest ecosystems, a modern forest

mechanization would be used which would lower the soil and less damage forest areas than forest tractors.

The use of more sophisticated forest mechanization would contribute to less damage to niches, reptiles and young trees. There would also be less noise in the forest soil and damage to plant and animal habitats. Also, due to lesser noise (and shorter exposure to noise), there will be less disturbance of wildlife in their habitats. New machines also emit lower emissions of pollutants into the atmosphere and have a lower engine oil loss (ending on a forest soil and further falling into the underground).

There is agreement that the performance of forest works without damaging the environment is unacceptable, regardless of any protection measures. Due to constant contact with the ground and especially due to movement on the stand, the greatest damage is caused by the vehicle. The new forestry machinery will have a lower fuel consumption in g / kWh, produce less noise, vibration, will have less oil losses on the work site and will less collapse the ground. In order to increase environmental acceptability, chains of forest mechanics can be obtained, which serve to increase the wheel traction and reduce the slip of forest mechanics. Rolling a wheel is limiting the movement factor on wet ground and tractor stability on dry ground. Rolling the wheel affects the formation of rolling and soil compaction.

Harvesters are non-stick moving vehicles, whose main purpose is to shred trees and make shortwood trees (Drushka and Konttinen 1997).

Harvester is used for trees cutting, branch cutting, trunk tailoring, preparing various sortiments and making the piles of trunks which forvarders can carry out of forest to temorary storage. In areas with total tree cutting harvester can be used without forest infrastructure. In selected forests harvester can be used only on forest infrastructure (various types of forest roads). After the cutting with harvesters and forvarders in stands nutritients remain in the soil and foster formation of humus and stability of habitat. If the space between forest paths is more than 20 m than using of harvesters is comnined with manwork or harvester is moved through stands between forest paths. Today, harvesters can perform more operations beside tree cuting and trunk tailoring such as carring out the biomass to temorary storages. Harvesters software controls tailoring to dimensions of trunks, according demands of buyers. Using computers, GPS and wireless data exchange contributes reducing forest exploatation costs.

Harvester can control process of tree cutting and so damages of remained trees in stand are reduced. Loggers will cut (chainsaw) branches which impedes harvesters operations. This model of

operating and total cut of small areas (0,5-3 ha in Austria, 4 ha in Poland) is not limitation for using of harvesters., but can significantly improve organisation and profitability. Also the damages in stands decrease (Moskalik and Paschalis, 1999.). In areas planned for total cutting harvester can move freely and harvest can prepare foresth paths 3,5-4 m width during the operations in planned intervals (Sambo, 1999.)

Forwarders are vehicles which can be driven in areas without forest roads and paths and their main purpose is collecting and carring out fallen trees (trunks, branches) from the stumps to the temoprary storages. Forwarders can classify and prepare high piles of trunks near forest roads and to reduce vast storages along forest roads. Carring out of fallen trees with forwarders is done in a way where the cargo is raised above the soil so driving of forwarders is easier and make less damage to the soils. Using harvesters and forwarders is more acceptible technology for environment than using chainsaws and skidders.

In Croatian forestry, trees cutting and tailoring trunks mostly is done by loggers and chainsaws which cut trees, branches, prepare trunks and firewood. This is the most expensive part od wood production (Slabak, 1983.) . The most important issue is posibility of damaging soils dragging the fallen trees over the soil or carring out on vehicles (tho soil coul be damaged by wheels). To keep soil in natural good conditions is needed to change planning and operating procedures. It could be done with reducing the movements of vehicles only on net on secondary forest roads and paths.

Important impact on soil conditions has the treading area of forwarders wheels (Poršinsky, 2005.) which are moving in the cutting plot during carring out fallen trees. Cut-to-lenght method and sortiment method with usage of forwarders cause less damages of soil.

Beside allready mentioned, the main goal of using forest mechanisation are increasing the production, decreasing the costs, decreasing of hard work and decreasing the demand for manwork (Krpan, 2000.).

In comparison of exploatation of forest using loggers, chansaws and skidders, work with harvesters and forwarders is more environmental friendly (Andersson, 1994.; Richardson and Makkoncn, 1994.). Efficinecy of harvesters depends on numbers of trees per area unit, the width of trees, because the biger diameter of trunks decrease costs of exploatation (Tufts, 1997; Bulley, 1999.; Meek, 2000.).

The diameter of tree trunks have direct imapact on productiviti of one intervention harvesters so harvesters today have several cuuting heads which can cut several thinner trees at once (Peltola i Papunen, 2001.). Productivity of forwarders is not much related with dimensions of trunks

beacause trunks are piled and it enables higher efficiency of forwarders crane (Krpan, 1992.; Porsinsky, 2002.).

In Central Europe harvester is used in boradleaved forest (used only in winter period) where its efficinecy is 25% lower than in coniferious forests (Pausch, 1999.). There are possible increased damaging of stands during the operating with felled beech trees.

Generally, heavier machines for cutting are used for cutting and tailoring relatively thinner broadleaved trees. The most important issue of using harvesters is need to have educated drivers. Their education is expensive and it could last up to two years before the driver is completly educated to operate with harvester.

One of the basic tasks of mechanization is the release of people from heavy, tedious and dangerous forest work. The physical workload of the harvester is inevitably less than that of a motor-driven saw. In fact, the handset in modern machines of state-of-the-art mechanical and computer technology is located in the comfortable environment of air-conditioned cabins and control panels, devoid of all unpleasant external influences. Despite the reduction in the physical load and the comfortable, ergonomically solved workplace environment, drivers suffer from a psychological burden. It is believed that it is due to the frequent repetition of simple operations with a persistent high degree of concentration and feelings of loneliness in the still encircled cabin space. Solutions are required to change work activities.

The system of fully mechanized harvesting of short wood was developed in Scandinavian countries and is based on the group work of a single-handed harvester and a forward-looking, harmonious production facility.

The aggregate work of harvesters and forvarders by a sorting method represents a rounded whole.

Table 6. Economical units in which it is made difficult (aggravate) use of forest mechanization (current situation, April 2019)

No.	Forest administration (FA)	Economic unit	Difficult use of forest mechanization
1	Gospić	Jadovno – Jazbine	No
2	Gospić	Goli vrh	Yes
3	Gospić	Šedrvan - Bukova glava	Yes

No.	Forest administration (FA)	Economic unit	Difficult use of forest mechanization
4	Gospić	Visočica – Razbojna draga	Yes
5	Gospić	Kozjak	Yes
6	Go/Sv.Rok	Kosurina - Bogunica	Yes
7	Go/Sv.Rok	Medačka staza	Yes
		Malovan – Dušice	Yes
8	Otočac	Senjsko bilo	Yes
9	Otočac	Rastovka – Kuterevske kose	No
10	Perušić	Konjska draga - Begovača	Yes
11	Perušić	Oštrac bok	Yes
12	Perušić	Bovan – Jelar	Yes
13	Perušić	Ostrvica	Yes
14	Perušić	Padeška kosa - Bijele grede	Yes
15	Perušić	Štirovača	No
16	Perušić	Crne grede	Yes
17	Perušić	Križić	No
18	Karlobag	Laktin vrh – Dabri	Yes
19	Karlobag	Sjeverne karlobaške šume	Yes
20	Karlobag	Južne karlobaške šume	Yes
21	Karlobag	Crna duliba – Metla	Yes
22	Karlobag	Ramino korito - Šugarska duliba	Yes
23	Karlobag	Šarić duplje	Yes
24	Sv. Rok	Sveto brdo - Crveni potoci	Yes
25	Sv. Rok	Grabar – Duliba	Yes
26	Gračac	Duboke jasle - Jabukovac	Yes
27	Gračac	Jasensko bilo - Crnopac	Yes
28	Gračac	Smrdljivac – Kom	Yes

Data source: FA Gospić, April, 2019.

Table 7. Economic units in which the use of modern forest mechanics would facilitate (make easier) forest management.

No.	Forest administration (FA)	Economic unit	It would be easier to handle the use of modern forest mechanics
1	Gospić	Jadovno – Jazbine	Yes
2	Gospić	Goli vrh	Yes
3	Gospić	Šedrvan - Bukova glava	Yes
4	Gospić	Visočica – Razbojna draga	Yes
5	Gospić	Kozjak	Yes
6	Go/Sv.Rok	Kosurina - Bogunica	Yes
7	Go/Sv.Rok	Medačka staza	Yes
		Malovan – Dušice	Yes
8	Otočac	Senjsko bilo	Yes
9	Otočac	Rastovka – Kuterevske kose	Yes
10	Perušić	Konjska draga - Begovača	Yes
11	Perušić	Oštrac bok	Yes
12	Perušić	Bovan – Jelar	Yes
13	Perušić	Ostrvica	Yes
14	Perušić	Padeška kosa - Bijele grede	Yes
15	Perušić	Štirovača	Yes
16	Perušić	Crne grede	Yes
17	Perušić	Križić	Yes
18	Karlobag	Laktin vrh – Dabri	Yes
19	Karlobag	Sjeverne karlobaške šume	Yes
20	Karlobag	Južne karlobaške šume	Yes
21	Karlobag	Crna duliba – Metla	Yes
22	Karlobag	Ramino korito - Šugarska duliba	Yes
23	Karlobag	Šarić duplje	Yes
24	Sv. Rok	Sveto brdo - Crveni potoci	Yes
25	Sv. Rok	Grabar – Duliba	Yes

No.	Forest administration (FA)	Economic unit	It would be easier to handle the use of modern forest mechanics
26	Gračac	Duboke jasle - Jabukovac	Yes
27	Gračac	Jasensko bilo - Crnopac	Yes
28	Gračac	Smrdljivac – Kom	Yes

Data source: FA Gospić, April, 2019.

From the submitted review it is obvious that it is necessary to invest in the modernization of the forest mechanization, with the adaptation of the mode of management if it is desired to increase biomass production in the observed area.

Table 8. Comparation table

No.	Forest administration (FA)	Economic unit	Difficult use of forest mechanization	It would be easier to handle the use of modern forest mechanics
1	Gospić	Jadovno – Jazbine	No	Yes
2	Gospić	Goli vrh	Yes	Yes
3	Gospić	Šedrvan - Bukova glava	Yes	Yes
4	Gospić	Visočica – Razbojna draga	Yes	Yes
5	Gospić	Kozjak	Yes	Yes
6	Go/Sv.Rok	Kosurina – Bogunica	Yes	Yes
7	Go/Sv.Rok	Medačka staza	Yes	Yes
		Malovan – Dušice	Yes	Yes
8	Otočac	Senjsko bilo	Yes	Yes
9	Otočac	Rastovka – Kuterevske kose	No	Yes
10	Perušić	Konjska draga - Begovača	Yes	Yes
11	Perušić	Oštrac bok	Yes	Yes
12	Perušić	Bovan – Jelar	Yes	Yes
13	Perušić	Ostrvica	Yes	Yes
14	Perušić	Padeška kosa - Bijele grede	Yes	Yes
15	Perušić	Štirovača	No	Yes
16	Perušić	Crne grede	Yes	Yes

No.	Forest administration (FA)	Economic unit	Difficult use of forest mechanization	It would be easier to handle the use of modern forest mechanics
17	Perušić	Križić	No	Yes
18	Karlobag	Laktin vrh – Dabri	Yes	Yes
19	Karlobag	Sjeverne karlobaške šume	Yes	Yes
20	Karlobag	Južne karlobaške šume	Yes	Yes
21	Karlobag	Crna duliba – Metla	Yes	Yes
22	Karlobag	Ramino korito - Šugarska duliba	Yes	Yes
23	Karlobag	Šarić duplje	Yes	Yes
24	Sv. Rok	Sveto brdo - Crveni potoci	Yes	Yes
25	Sv. Rok	Grabar – Duliba	Yes	Yes
26	Gračac	Duboke jasle - Jabukovac	Yes	Yes
27	Gračac	Jasensko bilo - Crnopac	Yes	Yes
28	Gračac	Smrdljivac – Kom	Yes	Yes

Data source: FA Gospić, April, 2019.

7.10 Potential biomass production and share available for bioenergy production

As previously mentioned, low-growth forests represent the most important source of biomass in the area of NP Velebit.

In all economic units, apart from the economic unit of Štirovača, there are low-growth forests, and their representation varies from 4.45% (economic unit Kosinjska draga-Begovača) to high 99.22% and 98.96% (north and south Karlobag forests). The main types of trees that are made of ordinary beech (Fagus silvatica l.), Oak Quercus (Quercus petreae Liebl), Oak hornbeam (Q. pubescens Willd), Oak cerber (Q. cerris L.), Common Grab (Carinus betulus L.), bark (C. orientalis Mill.) and black grab (Ostrya carpinifolia Scop.).

In Nature Park Velebit and in Lika-Senj county are more typs of stump forests such as intermedate stump forests to seed-plant forests, typical stump forests, stump forests with regression processes where domineering the sprouts of secondary tree species or stump forests where stands are so degradated that they are turning in bushes.

In stump forests in County average wood volume is 103 m3. Scientific research (Anić, Štimac et al., 2007.) confirmed that it is nessessary to increase nurtutive forest operations in stump forests (tree spacing,

clenanig of weeds, etc.) to increase average growth and increment for 1,3 m3/ha. (Also, such operations of nurturing in stump forests as result have producing the biomass).

On average, 66.75% of annual growth is cut. The Biomass District is a karst area and is a very important protective function of forests and it is important to increase the stock of wood.

Table 9. Data regarding wood stock, 10-year growth and annual yield in economic units.

No.	Economic unit	Wood stock	10-year growth	Annual yeild
		m^3	m^3	m^3
1	Jadovno – Jazbine	1.246.839,00	282.430,00	165.056,00
2	Goli vrh	495.774,00	94.210,00	59.321,00
3	Šedrvan - Bukova glava	417.534,00	98.480,00	59.629,00
4	Visočica – Razbojna draga	1.182.417,00	241.210,00	160.354,00
5	Kozjak	396.795,00	41.530,00	4.385,00
6	Kosurina - Bogunica	511.926,00	129.000,00	79.334,00
7	Medačka staza	1.061.297,00	203.760,00	195.090,00
	Malovan – Dušice	merged with economic units, No. 24.		
8	Senjsko bilo	391.690,00	61.810,00	62.618,00
9	Rastovka – Kuterevske kose	571.319,00	118.920,00	101.543,00
10	Konjska draga - Begovača	1.300.866,00	297.830,00	202.723,00
11	Oštrac bok	254.086,00	55.090,00	19.144,00
12	Bovan – Jelar	469.564,00	93.460,00	69.177,00
13	Ostrvica	497.731,00	173.470,00	10.854,00
14	Padeška kosa - Bijele grede	965.304,00	225.330,00	157.487,00
15	Štirovača	191.844,00	33.640,00	32.440,00
16	Crne grede	539.174,00	125.380,00	76.955,00
17	Križić	246.316,00	55.540,00	43.200,00
18	Laktin vrh – Dabri	1.503.141,00	213.660,00	209.141,00
19	Sjeverne karlobaške šume	16.208,00	3.630,00	0,00
20	Južne karlobaške šume	6.612,00	850,00	0,00
21	Crna duliba – Metla	436.689,00	77.010,00	55.087,00
22	Ramino korito - Šugarska duliba	320.604,00	43.740,00	13.771,00
23	Šarić duplje	469.208,00	54.040,00	33.350,00
24	Sveto brdo - Crveni potoci	771.064,00	138.010,00	115.575,00

No.	Economic unit	Wood stock	10-year growth	Annual yeild
		m^3	m^3	m^3
25	Grabar – Duliba	299.074,00	43.630,00	39.925,00
26	Duboke jasle - Jabukovac	40.749,00	11.110,00	2.625,00
27	Jaselsko bilo - Crnopac	686.428,00	137.570,00	65.606,00
28	Smrdljivac – Kom	163.954,00	2.455,00	6.080,00
	TOTAL:	15.454.207,00	3.056.795,00	2.040.470,00

Data source: FA Gospić, April, 2019.

In the area considered, it is estimated that approx. 4000 ha of forests of private forests characterized by lower productivity than in state forests. Private forest owners are mostly not market-oriented and use forest mainly for the production of firewood for personal use. The average increase in private forests can be estimated at 3m3 / ha as well as in other forests of ponds. There is no information on how much slices are cut, and because of unclear land registers, the aging of the population in the rural area of this forest is exposed to illegal cutting, which is fueled by an increasing demand for biomass. The cutting estimate moves from 50% up to the cut above the annual increase of 25-50%.

Table 10. Biomass production potential (estimation).

Estimation of biomass annual yield in state-owned economic forests in Biomass District	35.500 m^3
Estimation of biomass annual yield in private-owned economic forests in Biomass District	1.000 m^3

Estimation of annual yield in state-owned economic forests is estimaton of production of forest of low cultivation (stump forests).

Estimation of biomass annual yield in private-owned forests is very low because of bad demografic structure of forest owners, hard conditions for forest management, no forest mechanisations and undisolved ownership.

7.11 Inventory of the forest viability and other infrastructures and management prescriptions

The existing road network as well as the administrative framework are important parameters when defining the Biomass District. Velebit mountain has numerous road directions of different levels of transport importance. Through Gacko and Ličko polje pass the A1 motorway along the Adriatic coast same as passing through the Adriatic D8 and the state roads D25 and D23. County and local roads connect

settlements to the Park. In addition to the regular roads of local, county and state levels within the Park, there are a number of roads that are used for the purpose of forest management, forest roads. All roads in the Park area, other than the A1 motorway, are defined as roads that can be used for the purpose of transport and management of forests and are allocated for this purpose between individual forestry authorities (mostly FA Gospić) which manages the forest roads within LSU: Otocac, Perušić, Gospić, Karlobag, Lovinac and Gračac.

According to the attached road map it is clear that in the area of Biomass District are not sufficiently open. FA Gospić continuously investing in the construction of new forest roads, but in order to meet the demand for biomass and increase its production in the area of Biomass District (but also the entire state forest managed by FA Gospić), it is necessary to increase investments in the construction of forest infrastructure in as short a period of time.

Further increase in production can be expected by increasing forest openness, or by investing in the construction of forest roads. The optimum forest openness depends on the type of area.

Table 11. Forest openness, in km/1000 ha.

Area	**Minimum**	**Planned**	**Targeted**
Lowland	7,00	17,00	18,00
Hilly	12,00	20,00	25,00
Mountain	15,00	25,00	30,00
Carst	0,00	10,00	15,00

Source: Zavod za tehnologiju, Šumarski fakultet u Zagrebu; ožujak, 2017.

Table 12. Forest openness.

No.	FA	Economic unit	Opennes on total area	Openness on the surface with vegetation
			km/1000 ha	km/1000 ha
1	Gospić	Jadovno – Jazbine	14,21	14,38
2	Gospić	Goli vrh	15,30	15,93
3	Gospić	Šedrvan - Bukova glava	6,85	6,64
4	Gospić	Visočica – Razbojna draga	7,22	7,27
5	Gospić	Kozjak	2,28	2,82
6	Go/Sv.Rok	Kosurina - Bogunica	8,16	8,61
7	Go/Sv.Rok	Medačka staza	11,16	11,32

No.	FA	Economic unit	Opennes on total area	Openness on the surface with vegetation
			km/1000 ha	km/1000 ha
		Malovan – Dušice		
8	Otočac	Senjsko bilo	15,51	15,82
9	Otočac	Rastovka – Kuterevske kose	9,96	10,42
10	Perušić	Konjska draga - Begovača	13,82	14,02
11	Perušić	Oštrac bok	4,21	4,23
12	Perušić	Bovan – Jelar	15,59	15,67
13	Perušić	Ostrvica	7,26	7,96
14	Perušić	Padeška kosa - Bijele grede	14,48	15,13
15	Perušić	Štirovača	18,35	18,53
16	Perušić	Crne grede	15,01	15,11
17	Perušić	Križić	18,44	18,72
18	Karlobag	Laktin vrh – Dabri	13,52	14,37
19	Karlobag	Sjeverne karlobaške šume	7,39	9,99
20	Karlobag	Južne karlobaške šume	5,07	9,38
21	Karlobag	Crna duliba – Metla	17,14	19,41
22	Karlobag	Ramino korito - Šugarska duliba	14,82	19,76
23	Karlobag	Šarić duplje	9,29	11,38
24	Sv. Rok	Sveto brdo - Crveni potoci	7,51	9,89
25	Sv. Rok	Grabar – Duliba	10,81	11,05
26	Gračac	Duboke jasle - Jabukovac	3,99	9,74
27	Gračac	Jaselsko bilo - Crnopac	12,47	14,77
28	Gračac	Smrdljivac – Kom	7,14	8,34

Data source: FA Gospić, April, 2019.

From the data provided and insights into the road map it is clear that increased openness (forest roads construction) allowed for increased access to larger quantities of biomass.

List of forest roads and fire-fighting roads with forest fire protection elements in the area of FA Gospić:

1. Economic unit „Jadovno Jazbine“ – public roads Gospić –Karlobag, road Trnovac –Jadovno –Blatine, Trnovac –Gluvaja –Crne Grede, Ćaćić Draga (2 parts), Smiljan –Vaganac –Krčmar, Vaganac –Rastoka, Tisni

Most –Miškulinov Krč, Trnovac –Zablata, Ljuti Vrh, Milašinovac, Gušte (from 8th department), Gušte (from 7th to 11th department), Prlina –Kozjak –Stružnica –Rujina, Bužim –Rastoka, Gluvaja –Zalisina, Trnovac –Miškulinov Krč –Bužim and parts of the road on 4th, 6th and 8th km in Jadovno.

2. Economic unit „Goli Vrh“ – road Bušane –Brušanska Duliba, Brušane –Bezdanka –Ravne Drage, Brušane –Staro Selo, Rizvanuša –Ječmena Kosa – Samari and road Samarić –Rizvanuša i Samarić –Brušanska Duliba i cesta Šmrikov potok –Samari.

3. Economic unit „Šedrvan Bukova Glava“, „Visočica Razbojna Draga“, „Medačka Staza“, „Bogunica Kosurina“ available only on some parts. Those forests has parts contaminated by land mines and public can use only public roads. The is road Bunovac –Stajine i Međuvođe –Popov Panj.

4. Economic unit „Kozjak“ include 5,32km roads, Jandrina poljana –Kaino mirilo.

Table 13. Built firefighting roads with elements of the forest road in the area of the Biomass District.

No.	Economic unit	Firefighting road with forest road elements (km)
1	Jadovno – Jazbine	97,54
2	Goli vrh	41,15
3	Medačka staza	27,72
4	Visočica- Razbojna draga	27,56
5	Šedrvan – Bukova glava	10,98
6	Kozjak	5,32

Source: Procjena ugroženosti od požara i tehnoloških eksplozija Ličko-senjske županije

Economic unit "Jadovno -Jazbine"; a ramp on the forest road to the Gušte area. The key is located at the auditor Tomislav Barić and the guardian Ante Ćaćić. On the forest road Rastoka -Bužim and the key is located at the forest guard

The "Šedrvan Bukova Glava" commercial unit on the forest road towards Mali Kruš (Divoselo) is the key to the forest manager and the forest road ramp towards Divosela (Alanačka Kosica).

Economic unit "Visočica-Razbojna Draga", a ramps on the forest road towards Šimurin's port (Čitluka). The key is located at the forest manager.

Ramp on the forest road towards Visočica (Zovinovac), the key is located at the forest manager.

Figure 9. Road network map in the area of NP Velebit. (Source: Planning biomass based energy production in protected areas in Lika-Senj County (regional level) - focusing on the Nature Park “Velebit” protected areas (incl. municipalities/LAUs within Nature Park, sub-regional level) (IMFBE – WP 3 – A 3.4).

From this it is clear that the primary openness of forests in the area of the Biomass District is insufficient, which prevents the use of the existing boulder, and the lack of forest roads and other access

communications leads to the fire endangerment of the area of the Biomass District (but also of the entire NP Velebit).

From the point of view of nature protection, this threat is greater than the possible threat that could arise from the application (where justified) of the regular model of management of the forests in the Biomass District.

7.12 Management prescriptions for the pasture and the wild fauna

From the point of view of nature conservation, the most important economic unit in the area of Biomass District are Rastovka-Kuterev's hair, Konjska draga - Begovača, Ostrovica, Štirovača, North Karlovačka šuma, South Karlovačka šuma, Crna duliba - Metla and Grabar duliba.

In the expert analysis for the creation of nature conservation measures and conditions, the State Institute for Nature Protection of the Republic of Croatia does not state that forestry operations and harvesting are the most important cause of endangerment of certain species of flora and fauna in the area of biomass district.

The main causes of endangerment are florals that are excessively expensive because of decorativity and / or transplantation into gardens, natural succession of habitats, the disappearance of agriculture, the fragmentation of habitats.

The most important cause of birdlife threats in the area of the biomass district is primarily hunting and pest control, the extinction of traditional, extensive livestock farming in the District, and also the reduction of the number of small birds and the carnage poisoning, which is the cause of the threat of the pricelist. For some types of forestry operations are also one of the causes of endangerment (especially for Pernis apivorus and Tetrao urogallus).

For some types of cause, an important cause of the threat is the overcrowding of older trees with twigs and shrinkage of older stands and the use of pesticides in forestry.

The causes of endagerment of bats are related to the loss of habitats in caves (visits to caves, the use of caves as tastes of attraction, the installation of iron grids on cave entrances) and it is assumed that one of the causes of endangerment and the use of pesticides.

Some endemic species (eg. *Dinaromys bogdanovi*) are jeopardized by the relatively low fertility and the fact that relic populations can be affected by different external factors which result in a decrease in the number of populations.

All types of endangered mammal species most endanger hunting and bickering in the area of Biomass District.

In order to prevent/mitigate further reduction of the number of individuals, it is necessary to carry out the appropriate measures prescribed in the expert bases in the implementation of the forestry operations and

that are built into the forest management plan or plans for each individual economic unit, which is also the obligation of the forest owners (Croatian forests d.o.o., private forests owners).

Given that the goal of FMP is to increase the availability of spatial wood (biomass)

Table 14. Endangered and/or protected species that actually or potentially come or live in the area of economic units managed by the FA Gospić.

No.	Economic unit	Flora	Birds	Mamals	Amphibians	Reptiles	Butterflies
1	Jadovno- jazine	1	26	21	2	2	
2	Goli vrh	19	16	19			
3	Šedrvan- Bukova glava		23	16		1	
4	Visočica – Razbojna draga		20	20		2	
5	Kozjak		14	19		1	
6	Bogunica – Kosurina		18	19	2	4	
7	Medačka staza		22	21	1	1	
8	Malovan- Dušice	12	3	17		1	
9	Senjsko bilo II		16	17	1		
10	Rastovka – Kuterevske kose	19	21	20	1	1	5
11	Konjska draga- Begovača	31	19	21	1		7
12	Oštrac bok		24	20	1	1	
13	Bovan- Jelar	34	19	22	1	1	1
14	Ostrovica	28	20	20	1	1	6
15	Padeška kosa – bijele grede	24	15	20	1	1	
16	Štirovača	21	14	16	1		7
17	Crne grede	22	7	21	1	1	
18	Križić		24	17	1	2	
19	Laktin vrh- Dabri	6	27	19	3	4	
20	Sjeverne karlobaške šume	3	20	17	1	10	
21	Južne karlobaške šume	1	21	18	1	9	
22	Crna duliba- Metla	26	14	16	1		7
23	Ramino korito		16	20		2	

No.	Economic unit	Flora	Birds	Mamals	Amphibians	Reptiles	Butterflies
24	Šarić duplje		16	19		2	
25	Sveto brdo- Crveni potoci		25	17	1	1	
26	Grabar duliba	13	18	21	1	1	5
27	Duboke jasle- Jabukovac		25	17	1	2	
28	Jasensko bilo- Crnopac		16	17	1	1	
29	Smrdljivac – Kom		19	17	1	3	
	UKUPNO						

Source: Stručne podloge za izradu mjera i uvjeta zaštite prirode za pojedine gospodarske jedinice, Državni zavod za zaštitu prirode

In addition to the protected and/or endangered species of flora and fauna in the area of Biomass District, there are a number of protected habitats (national classification of habitats – NKS) from different forest communities to grassland habitats.

Table 15. The share of grassland habitat types in economic units within Biomas District.

Type of habitat	**Economic unit**	**NKS code**	**%**
Mesophyll meadows (grasslands) of Central Europe	Jadovno-jazbine	C23	0,002
	Oštrac bok		0,001
The wet (humid) meadows of the submediterranean vegetation zone	Kosurina-Bogunica	C25	0,02
European dry moors and grassland of nardetum strictae campicolum	Bovan –Jelar	C34	0,01
	Crne grede		0,13
	Jadovno-jazbine		1,664
	Kosurina-Bogunica		0,47
	Ostrovica		0.52
	Padeška kosa-bijele grede		0,12
	Šedrvan-Bukova glava		0,757
	Sjeverne karlobaške šume		0,60
	Visočica- Razbojna draga		0,04

Type of habitat	Economic unit	NKS code	%
European dry moors and grassland of nardetum strictae campicolum submetiranian and epimediteranian dry grasslands	Visočica- Razbojna draga	C34/C35	0,06
Subatlantic mesophyll grasslands and rolling meadows on carbonate soils	Bovan –Jelar	C33	0,89
	Crna duliba – Metla		2,81
	Grabar duliba		1,78
	Jadovno-jazbine		1,303
	Jaselsko bilo-Crnopac		1,09
	Južne karlobaške šume		0,73
	Konjska draga - Begovača		0,35
	Kosurina-Bogunica		0,08
	Kozjak		1,14
	Križići		1,35
	Laktin vrh-Dabri		1,96
	Malovan-Dušice		0.661
	Medačka staza		0,08
	Oštrac bok		2,173
	Ostrovica		5.60
	Padeška kosa-bijele grede		0,49
	Ramino korito		0,35
	Rastovka – kuterevske kose		2.79
	Senjsko bilo		0,09
	Sjeverne karlobaške šume		12,24
	Smrdljivac – Kom		3,85
	Sveto brdo-crveni potoci		0,11
	Visočica-Razbojna draga		0,16
Subatlantic mesophillic grasslands and mountain meadows and mesophilic and neutrophilic pure beech forest	Grabar duliba	C33/E45	0,07
	Jaselsko bilo-Crnopac		0,05
	Smrdljivac – Kom		0,11
Subatlantic mesophillic grasslands and rolling	Bovan –Jelar	C33/C23	0,43

Type of habitat	Economic unit	NKS code	%
meadows on carbonate soils/mesophyll medows of Central Europe	Crne grede		0,66
	Jadovno-jazbine		0,585
	Kosurina-Bogunica		1,68
	Ostrovica		2.07
	Padeška kosa-bijele grede		0,01
	Šedrvan-Bukova glava		0,001
	Visočica-Razbojna draga		0,30
Submediteranian and epimediteranian dry grasslands	Bovan –Jelar	C35	0,46
	Crna Duliba-Metla		2,86
	Duboke jasle-Jabukovac		80,77
	Goli vrh		0,75
	Grabar duliba		12,01
	Jadovno-jazbine		0,003
	Jaselsko bilo-Crnopac		27,68
	Južne karlobaške šume		15,47
	Konjska draga - Begovača		0.08
	Kosurina-Bogunica		0,62
	Kozjak		2,18
	Križići		1,07
	Laktin vrh-Dabri		1,70
	Malovan-Dušice		34.448
	Medačka staza		0,08
	Oštrac bok		2,678
	Ostrovica		2.63
	Ramino korito		10,95
	Rastovka-kuterevske kose		28.48
	Šarić-Duplje		0,66
	Senjsko bilo		0,63
	Sjeverne karlobaške šume		20,15
	Smrdljivac – Kom		49,55
	Sveto brdo-crveni potoci		16,39
	Visočica-Razbojna draga		0,01

Type of habitat	Economic unit	NKS code	%
Submediteranian and epimediteranian dry grasslands/rocky pastures and dry grasslands eu and stenomediteranian	Smrdljivac – Kom	C35/C35	0,29
Submediteranian and epimediteranian dry grasslands/ thornbushes areas	Grabar duliba	C35/D31	6,88
	Jaselsko bilo-Crnopac		0,35
	Južne karlobaške šume		0.21
	Sjeverne karlobaške šume		3,22
	Smlrdljivac – Kom		6,90
	Sveto brdo-crveni potoci		0,03
Thornbushes areas/ Submediteranian and epimediteranian dry grasslands	Južne karlobaške šume	D31/C35	61,86
	Ramino korito		1,12
	Šarić- Duplje		1,88
	Sjeverne karlobaške šume		26,36
Submediteranian and epimediteranian dry grasslands/wet (humid) meadows of submediteranian vetation zone	Grabar duliba	C35 /C25	0,61
	Jaselsko bilo-Crnopac		0,20
	Smrdljivac – Kom		1,19
Submediteranian and epimediteranian dry grasslands/coastal termophyll forests and bushes of pubescent oak	Južne karlobaške šume	C35/E35	1,76
	Malovan –Dušice		4.336
	Sjeverne karlobaške šume		5,59
	Smrdljivac – Kom		0,59

Source: Stručne podloge za izradu mjera i uvjeta zaštite prirode za pojedine gospodarske jedinice, Državni zavod za zaštitu prirode, Hrvatska agencija za okoliš i prirodu.

7.13 Connections of the FMP with the other planning tools

As already mentioned in chapter 6.1. National and regional legislative framework The most important operational document for the management of state forests is the basis of management for an individual economic unit, and in private forests it is a forest management program. Adhering to the measures prescribed by these documents is a legal obligation of forest owners, and their implementation is the cornerstone of all business decisions regarding forest breeding and exploitation.

Therefore, the FMP (Forest Management Plan) is a proposal to improve and increase the amount of biomass acquired and raw material insurance for the needs of customers in the area of Biomass District. The importance of this tool/proposal is reflected in the trend of increasing demand for biomass in the area

of FA Gospić (as well as in the Republic of Croatia), and demand is higher than supply with a tendency of further growth in demand for biomass.

In order to increase the exploitation of biomass in the area of Biomass District, it is necessary to consider first of all the possibility of changing the approach of making economic bases for economic units within the Biomass District because it is predominant in the forests that prevents the use of more common in other parts of Europe of conventional forestry mechanizations - harvesters, cable car.

Selective exploitation requires significantly higher utilization of labor force (logs), use of forest hinged tractors and forest trucks. In this way, by using the FMP, the possibility of using a modern forest mechanization would be opened up and consequently reduced the demand for labor which is already lacking.

Also considering that the Biomass District comprises part of the NP Velebit, it is necessary if the FMP accepts (wholly or partially) the possibility of reconciling the development of the basis for the management of state forests (including expert backgrounds that prescribe nature protection measures) with the objectives, measures and expected results in the Nature park Velebit Management Plan for the next ten year period (2017-2027)

In other words, incorporating FMP into three-year and annual work programs and financial plans is a step in which specific activities are defined and provided for funding for their implementation.

7.14 Assessment of impacts by the FMP

As previously defined in Chapter 6.3, the most important stakeholder in the management of forests in the area of NP Velebit, and therefore in the area of the Biomass District, are the Croatian Forests, which manage the state forests in the Park through FA Gospić. Internal Business Policy of Croatian Forests d.o.o. is decisive for the application of FMP in the area of the Biomass District.

The aim of the FMP is to increase biomass production in an economically viable way, ie to increase its profitability in a profitable or sustainable way (that is, the revenues cover all the costs of increased biomass gain from commercial forests in the area of Biomass District). Retention of FSC certificates and conservation of biodiversity in the area of NP Velebit are very important for Croatian Forests d.o.o.

The basic premise for the FMP implementation is the readiness of all stakeholders - the Ministry of Agriculture, the Ministry of Environmental Protection and Energy, the Public Institution NP Velebit and the Croatian Forests d.o.o. to consider the possibilities of changing the established forestry practices and the nature conservation model to increase the recovery of biomass from commercial forests, in order to meet the increasing demand for biomass increasingly used as a source of energy (thermal and electrical).

The basic task is to evaluate the possibility of changing the prescribed mode of management in pre-harvest logging, which prevents the use of, for Croatia – modern, common forestry machinery in Europe - harvesters, forvarders, lifts. This forestry mechanism would increase biomass gain by min 15-20%. The

increased procurement costs of the mentioned forestry mechanization would be compensated by the reduction of labor costs, which are already missing (the departure of forest workers to other EU countries). The introduction of forest mechanization (harvesters, lifts, etc.) would enable the forest to be harvested or cut into the so called, strips or circles, and the exploited areas could be accessed for afforestation.
Likewise, the cultivation areas of the conifers (E 92) in the economic units of Oštrac bok, Šedrvan - Bukova glava, which were planted for the needs of the former paper factory in Plaški (closed 30 years ago) can be removed because it is a plantation of conifers reached and exceeded the degree of maturity.

7.15 Final remarks

FMP is a non-formal document whose implementation depends on strategic decisions at Ministerial level (Ministry of Agriculture, Ministry of Environment and Energy) and it is conected with business policy of Croatian Forests d.o.o.
For the purpose of accepting, elaborating and possible adaptation of the FMP to the needs of the Public Institution NP Velebit, Croatian Forests, FA Gospić (in whose area the Biomass District is located) it is necessary for the representatives of the relevant Ministry of Agriculture to be acquainted with the proposals and goals of FMP implementation.
Also NP Velebit and/or Lika-Senj County can adapt and support the fragmented use of FMP for the purpose of improving the management of private forests in the area of NP Velebit and/or the County.

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Annexes: Forest management plan

FMP involves improving the acquisition of biomass in state and private forests. As previously stated (Baseline review / Situation analysis of production / biomass potential of Lika-Senj County - focusing on the Velebit protected area (IMFBE - RP 3/1 - A) in the Lika-Senj County area, but and the Biomass District is a significant difference in economic importance, model of management, ethos and carrying out breeding works and biomass recovery operations between state and private forests, whereby biomass gained from

state-owned forests represents the main source of raw materials for fuel wood, pellet production and electrical and heat energy in cogeneration.

Therefore, the most important part of FMP aimed at increasing the attractiveness of biomass in state-owned forests, which are managed by the Croatian Forest in the area of Biomass District, FA Gospić. This section of the FMP includes a proposal for measures relating to the increase of biomass collection in the area of biomass district through changes in the management of state forests, the increased opening of state forests by economic units, the use of modern forest mechanization and the implementation of demining of mine suspected/contaminated areas in the Biomass District (state and private forests).

The premise for the implementation of the FMP in the area of the Biomass District is its compliance with the economic bases for an individual economic unit, which also includes nature protection measures (flora, fauna, habitats). It is necessary to consider the basis for the management of state forests in the area of NP Velebit - a selective cutting that greatly impedes the use of modern forest mechanization.

Situation of the private owned forests requires primarily the direct action of the administration at the state and regional level, the regulation of property and legal relations, the encouragement of the association of private forest owners and the possible application of modern forest mechanization in the operations of the acquisition of biomass and the implementation of demining of mine suspected areas in private forests. Implementation of FMPs in private forests requires significant engagement of professionals, public bodies and forest owners themselves, with the provision of financial resources from various sources. The outcome of these activities should be to increase the attractiveness of biomass from private forests over a longer period of time, since from the standpoint of meeting the established increased demand for biomass, the contribution of the captured biomass from private forests will not be of great importance primarily because of their small areas.

The planning of the change of management mode in economic units in the area of biomass district should be based on a continuous analysis of the situation in relation to the objectives and management requirements, which together define the guidelines and management procedures, determine the means of implementation of all the measures of care and recovery of wood and return on the basis of monitoring results management with feedback is made possible by any changes.

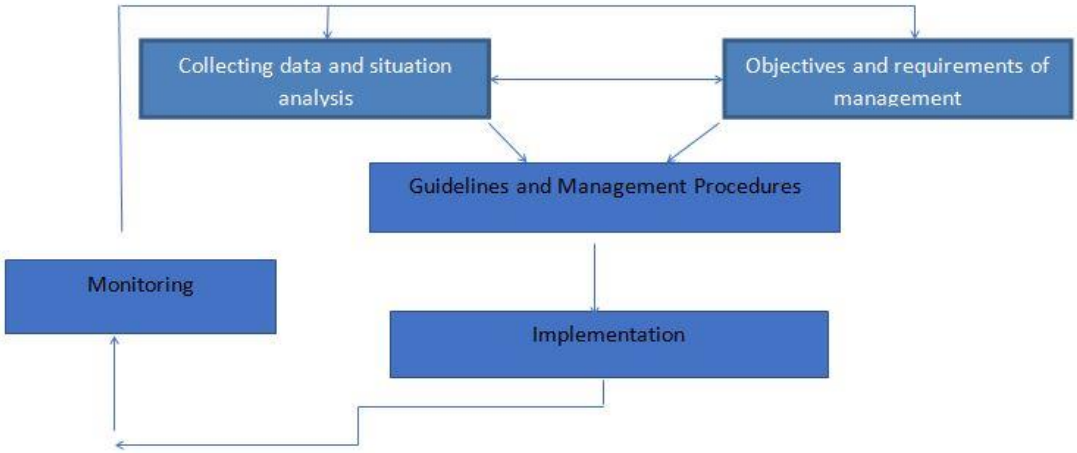

Figure 10. Circular model of FMP implementation.

State-owned forests

Level of strategic decision-making (Ministry of Agriculture, Ministry of Environment and Energy)

1. At the level of the relevant ministries, in cooperation with the expert public, it is necessary to improve / modernize the principles on which the management bases for individual economic units are set, with the aim of abandoning a predominant model of felling in individual forests.
2. Determine when and under what conditions the pre-emptive model is cut in economic units.
3. When designing expert backgrounds that determine the nature protection measures to take into account the circumstances - apply modern mechanization and abandon the precious model of felling in state forests, and define in more detail nature protection measures at the economic unit level (for each department / department)
4. Start the revision of economic bases for individual economic units in the area of Biomass District
5. Provide funding for demining of forest areas in the Rural Development Program of the Republic of Croatia 2021-2027.
6. In the NP Management Plan for the period 2017.-2027. provide more financial resources and more monitoring activities of protected and endangered habitats, flora and fauna in economic units where biomass gains on other principles
7. Determine the deadlines (5, 10, 15 years) to consider the results of monitoring protected and endangered habitats, flora and fauna in order to improve and adapt to forestry practices.

Operational level (Biomass District, Croatian Forests – FA Gospoć, Public Institution NP Velebit, Croatian De-mining Centre and Lika-Senj County)

1. Development and adoption of one-year and three-year operational and financial plans at the level of FA Gospić, harmonized with the revised management bases for each economic unit and the need for enhanced primary forest opening

2. Development of a study of primary forest opening (to determine priorities for forest roads in the area of biomass district)

3. Procurement of modern forest mechanization needed to carry out biomass recovery operations

4. Workforce training for handling modern forest mechanization

5. Početak provedbe revidiranih osnova gospodarenja (UŠP Gospić)

6. Implementation of primary forest opening activities in Biomass District

7. Construction of new fire-fighting roads with elements of the forest road

8. Drafting of demining projects for economic units that are part or all in the area of NP Velebit by the Croatian De-mining Centre

9. Podnošenje zahtjeva za potporu na temelju natječaja APPRRR-a za razminiranje minski sumnjivih šumskih površina (Ličko-senjska županija)

10. Ceation and adoptation of yearly and multi annual operational and financial plans of the NP Velebit, in line with NP Velebit Management Plan for 2017.-2027. These plans will be the basis for the implementation of monitoring of endangered and protected habitats, flora and fauna in the area of economic units with revised management bases

11. Operational start of monitoring of endangered and protected habitats, flora and fauna in the area of economic units with revised management bases.

12. Drafting of the first monitoring report to be presented to the Croatian Forests, the Ministry of Agriculture and the Ministry of Environmental Protection and Energy

Private-owned forests

Level of strategic decision-making (Ministry of Agriculture, Ministry of Environment and Energy)

1. At the level of the relevant Ministries, in cooperation with the expert public, improve / modernize the principles underpinning the forest management program of private forests

2. Determine when and under what conditions the pre-emptive model is cut into the forests of private foresters

3. When designing expert backgrounds that define nature conservation measures to take into account the resulting circumstances - apply modern mechanization and abandon the predominant model of logging in the forests of private forests, and more specifically define nature conservation measures at the level of forests of private forest owners

4. Provide funds for demining of forest areas in the Rural Development Program of the Republic of Croatia 2021-2027.

5. In the NP Velebit Management Plan for the period 2017-2027 to provide more financial resources for the implementation of support for improvement of the management of forests of private forests in the area of NP Velebit

6. To implement the Forest Management Program for Private Forests on the level of Lika-Senj County, with the provision of financial resources for its implementation over a longer period of time

7. Determine the deadlines (5, 10, 15 years) to consider the results of the implementation of the Forest Management Program for Private Forests in the area of PP Velebit

Operational level (Croatian Agricultural and Forestry Advisory Service in Ministry of Agriculture, Public Institution NP Velebit, Lika-Senj County, Private Forest Associations)

1. Implementation of auditing/adoption of new forest management programs for private forest owners.

2. Implementation of the Forest Management Program for Private Forests at Lika-Senj County

3. Implementation of activities/programs for improving the management of forests of private foresters at NP Velebit/Biomass District

4. Implementation of demining of mine suspected areas in forests and forest lands of private foresters

5. Preparation of the first report of Lika-Senj County and Public Institution NP Velebit on the implementation of the Program for Improvement of the Management of Forests of Private Forests on the Lika-Senj County and NP Velebit/District of Biomass

8. OVERALL CONCLUSIONS

The Forest Management Plan is an essential tool for the opportunity of setting up an efficient and sustainable local forest-wood-energy supply chain in the protected areas. The ecological sustainability is ensured by the fact that the connections with the other planning tools occurring in the Biomass District (Landscape, Natura 2000 Network, etc.) have been considered, along with the assessment of the impacts of the silvicultural interventions on Natura 2000 habitats. Indeed, the naturalistic, environmental and landscape restrictions were strongly considered for the drafting of the FMP. In the selected pilot areas, the woody biomass obtainable from the sustainable management of forests could feed a short supply chain providing a different kind of wood assortments (firewood, ecc.), including wood chips and pellet for energy use. Each partner provided a general description of the morphological characteristics (altitude, slope, aspect) of the study areas, and the necessary silvicultural interventions were defined and described. Clearly, the large differences in the current status of forest planning in each partner's respective pilot areas play a major role in the chance to realize the planning at an operational scale, which is useful for the planning and management of forest-wood-energy supply chain. Moreover, the main aim of the interventions may differ in each country. However, all the foreseen interventions are addressed to improve the conservation status of forests and to promote the protection of biodiversity and native habitats. The final goal is to obtain forest systems more complex, diversified and stable, which could be much more resistant to abiotic and biotic stresses, including those deriving from the ongoing climate change.

Although some important differences exist, in each biomass district there the potential woody biomass available is sufficient to feed a local forest-wood-energy supply chain. Hence, small biomass plants, which must be suitably sized and placed, could be built so as to constitute a short supply chain effectively sustainable from an ecological and socio-economic point of view. Finally, each partner highlighted many critical aspects (here and in other activities of the Project), which can be overcome only through the involvement of all the stakeholders along the whole potential supply chain.