The Forest in the Vjosa River basin: an assessment of the situation

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1. Description of the forest conditions in the region

1.1. Vjosa river catchment

The Vjosa river is located in the Pindus Mountains east of Ioannina in north-western Greece, taking with it many tributaries until it empties into the Adriatic Sea in Albania.

Figure 1. Vjosa river catchment and major cities (modified after image from Shumka et al. 2018)

It has a length of 272 km, of which 80 km are in the territory of Greece and 190 km in Albania, before it flows into the Adriatic Sea north of the city of Vlore, where it temporarily forms and nourishes the Narta Lagoon. The Vjosa river basin within the Albanian border covers an area of 4536.4 km². The average water flow is about 204 m³/sec. Some of the main streams along the Vjosa river are: Radova, Bnja, Langarica, Pagria, Shtika, Suka and Mezhgorani, Peshtani, Bna, Luftinja, and Selenica. Near Tepelena, the Vjosa river absorbs the water from the Drinos River, coming from the south. The Drinos river is the largest tributary of the Vjosa with a catchment area of about 1320 km², of which 256 km² are in Greece. The Shushica river, with a length of 80 km and a catchment area of about 587 km^2, flows between the Kundeshi Mountains and the Cike-Lungare mountain range in Albania and joins the Vjosa downstream from Selenice. Recently, the Vjosa river has not undergone any dam construction or other canalization projects. Because of this the river is considered as one of the last “wild rivers” with a natural flow regime in Europe.

1.2. Altitude and slope in the Vjosa river basin

In Albania, the Vjosa river basin has a mean elevation of about 885 m and is shared by seven districts: Ersek, Permet, Gjirokastr, Tepelen, Mallakastr, Fier, and Vlor. The elevation above sea level of the Vjosa river basin varies from 0 m at the confluence of the Vjosa river into the Adriatic Sea to an elevation of 2477.5 m above sea level (m.a.s.l.) at the Maja e Drites peak along the Arshov-Suh ridge. In the Vjosa river basin, altitude classes from 0 to 400 m above sea level dominate, occupying 38.3% of the catchment area.

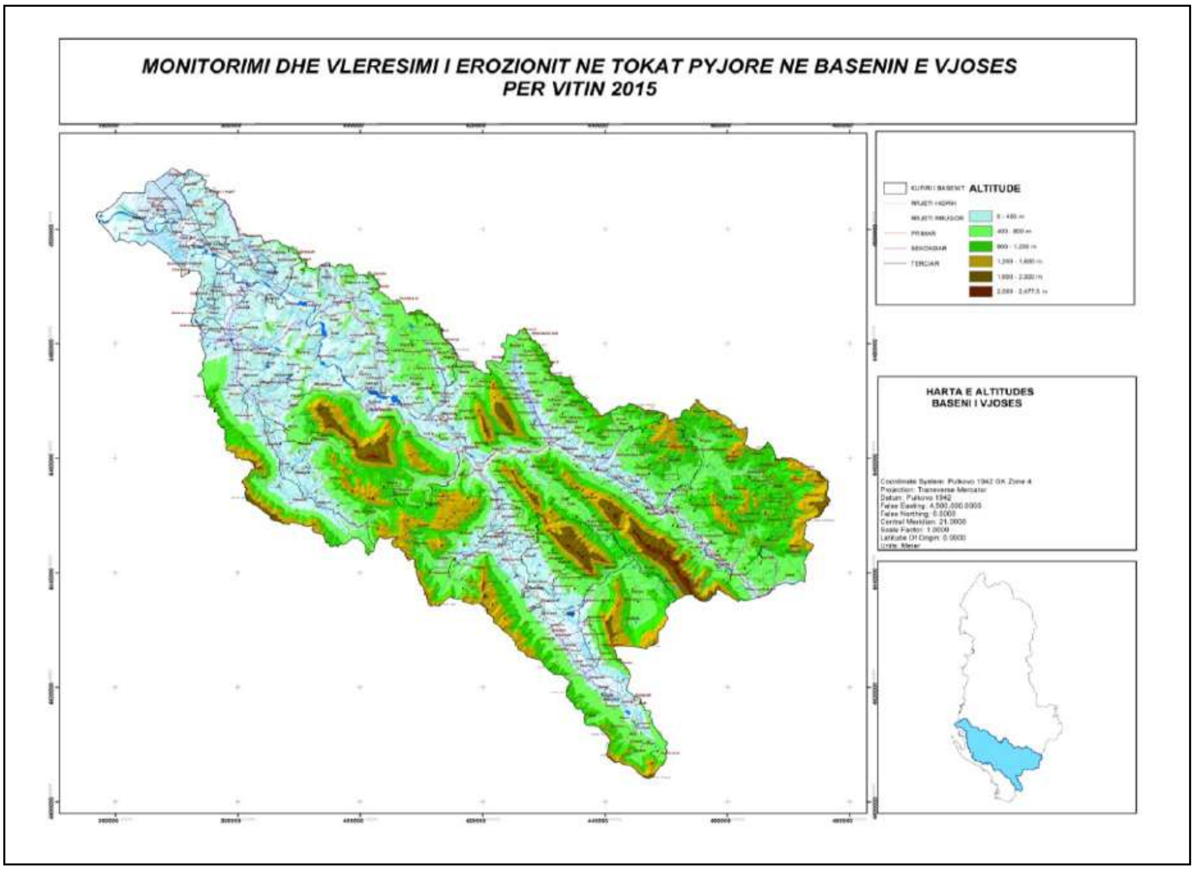

Figure 2. The altitude classes in the Vjosa river basin based on DEM

Altitude and slope information was obtained from the Digital Elevation Model (DEM) developed by Ing. Elson Salihaj. Table 1 shows the area of the different altitude classes in total and in percentage of the river basin area.

Table 1. Altitude classes and their respective area and percentages within Vjosa river basin

Altitude (m.a.s.l.)	Area (km²)	Area (%)
0-400	1736.94	38.29
400-800	1184.42	26.11
800-1200	945.68	20.85
1200-1600	514.81	11.35
1600-2000	136.14	3.00
2000-2477.5	18.45	0.41
Total	**4536.44**	**100.00**

The slope of the terrain is one of the main factors affecting the speed of surface water flow, and therefore the degree of erosion. These impacts vary by land use and land cover. The DEM (Digital Elevation Map) show that the gradient of the Vjosa catchment ranged from 0° to 88°. The measurements show that the slope classes up to 40° prevail in the Vjosa catchment. Dips in the 41° to 88° range are not so common and occur mainly in the mountainous areas of the Vjosa Basin, and these dips are even more likely to have been eroded. Based on the slope values, we categorized the terrain into slope classes of 10° (see Figure 3).

The river's lower reaches are characterized by a low gradient and are surrounded by a wide, flat floodplain with terraces that were formed during the Quaternary period about 2.59 million years ago. This region includes the Myzeqe floodplain near the city of Vlore, the Kota valley, which is part of the Shushica river tributary basin, and the Drinos valley with the Gjirokastr and Dropulli areas. The river gradients in these zones are very low.

The middle course of the river features hills composed of highly fragmented terrigenous sedimentary rocks eroded over time by the tributaries of the Vjosa. In this area we find very steep slopes around the Kundeshi highlands and in the mountains of Nemerka, Lunxheri, Bureto, Postnan, and Melesini. There are canyons and deep gorges in Bn, Klcyr, and Langaric. The upper reaches of the river cover large mountains with abrupt crests and very steep slopes, which are the result of water erosion in limestone (karst) terrain.

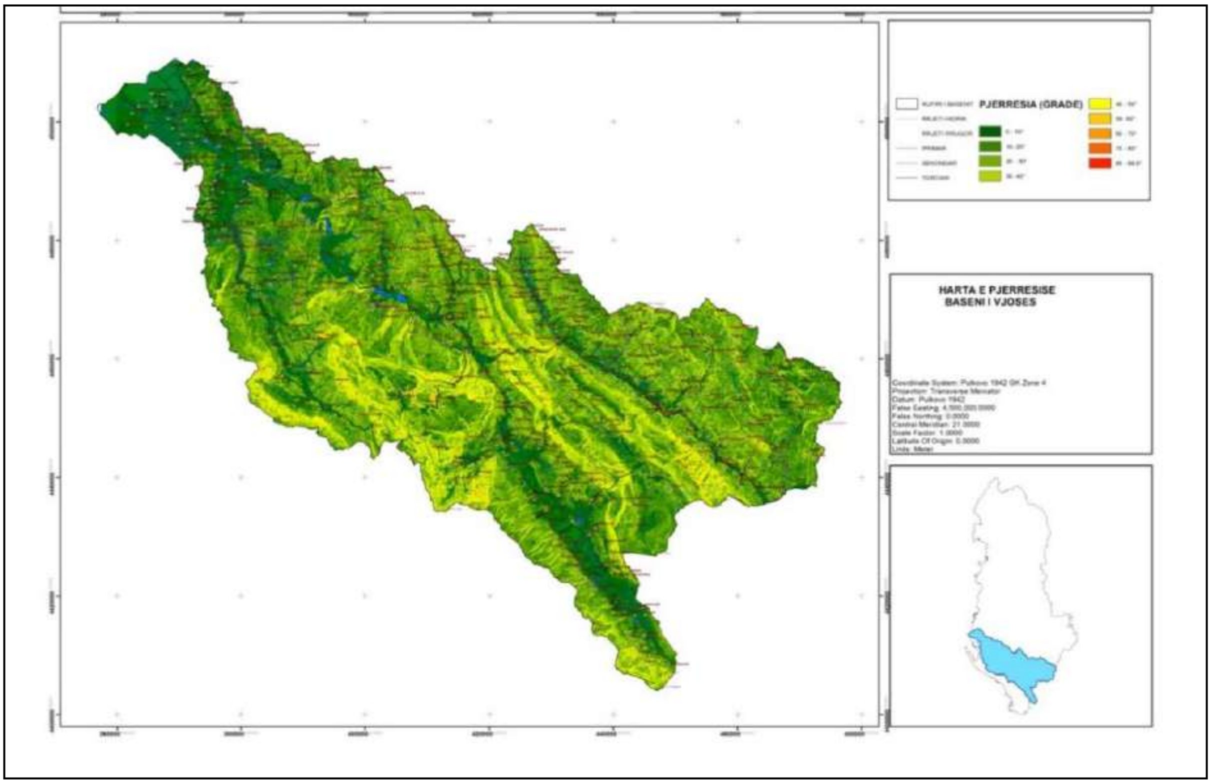

Figure 3. Slope classes in the Vjosa river basin based on DEM

1.3. Climate in the Vjosa river basin

The Vjosa valley is part of the south-eastern hilly climate zone. The Vjosa valley plays an important role in the region's climate, affecting the temperatures and rainfall. The climate of the Vjosa basin can be characterized as Mediterranean, with dry and hot summers and mild and wet winters. The western part of the Vjosa basin is warmer versus the eastern part due to the lower altitude and proximity to the sea. The mean temperature values vary from 10.7 to 17.5 °C along the river valley and from 6 to 10 °C in the mountainous areas. The mean maximum temperatures in the upper, middle, and lower parts of the catchment area ranges between 26.9 and 35.8 °C.

The hottest months are June, July, and August with daily mean temperatures between 20 and 24 °C. The highest mean maximum values are between 26 and 36 °C, and the observed absolute maximum values are 41.6 °C at Fier (July 6, 1988) and 43.5 °C at Selenice (July 18, 1973). The coldest months are during December to February, with daily mean temperatures of less than 5 °C. The average annual rainfall in the river basin ranges from 950 to 1600 mm, while the long-term annual rainfall reaches 1076.2 mm, of which about 66% rains in autumn and winter. The minimum precipitation typically occurs in the summer months (June, July, and August) while the maximum rain is evident in November and December. The number of rainy days ranges from 85 to 100 days a year. Climate data in the area was obtained from Climate

Explorer (http://climexp.knmi.nl/data/icru4_pre_20.33E_40.05N_n.dat) (Trouet abd Oldenborgh 2013).

Table 2. Climatic data from weather stations along the Vjosa valley

Location	Coordinates		Elevation m (a.s.l)	T mean (ºC)	T min (ºC)	T max (ºC)	Precipitation (mm)
	N	E					
Permet	40º 14'	20º 21'	240	17.5	2.4	35.8	1267.2
Kelcyre	40º 19'	19 º 20'	182	14.1	2.1	34.2	1218.3
Frasher	40º 21'	20º 25'	1031	10.7	-1.4	26.9	1283.3

1.4. Geology and soils

1.4.1. Vjosa river basin

The geology of the Vjosa Basin in Albania is dominated by alluvial sand and gravel deposits in the river valley. These alluvial deposits are formed by Neocene deposits composed of sandstone, siltstone, conglomerate, and partly marlstone, flysch deposits, karstic limestone deposits and ultrabasic rocks. The Vjosa is characterized by a wide braided sand-gravel layer and strong river dynamics. The course and cross-section of the river changes rapidly over the years. The main soil types identified in the Vjosa river basin are Humic Cambisol (Bh), Calcaro chromic Cambisol (Bcc), Orthic Luvisol (Lo), Eutric Fluvisoil (Je), Fluvi-Gelyic Solonachak (Zgf), and Haplic Phaeozem (Hh). Differences between soils are related not only to the natural conditions of formation and evolution, but also to human interventions in ecosystems.

1.4.2. Soils in oak forests in Vjosa valley

Soils in oak forests in the Vjosa valley are mainly formed on sedimentary rocks; a few are formed on gneiss. Their formation is strongly influenced by the presence of xerophytic oak forests. These forests are mainly subject to erosion on steep slopes and this phenomenon is severe in the degraded forest stands. In terms of climate, such soils have an average air temperature of 17°C and are dry soils at lower altitudes. The drought period lasts 1 to 2 months and 85% of the precipitation falls in winter from October to March. Most of the time during winter, such soils experience extensive leaching and due to the humidity and temperature conditions, weathering is intense, resulting in montmorillonite clay formation. The maximum soil depth is usually 100 to 150 cm.

1.4.3. Soils in the Mediterranean shrub in Vjosa valley

The soils of the Mediterranean shrubs are formed under particular types of vegetation and are strongly influenced by climate and relief. The main species of Mediterranean shrubs in the valley are *Arbutus unedo, Fraxinus ornus, Juniperus oxycedrus, Quercus coccifera, Carpinus orientalis*, etc. Trees in the area include *Populus nigra, Populus alba, Platanus orientalis, Ulmus campestre,* and *Salix spp.* The main soil types in this vegetation are gray cinnamon soils and are found on slopes ranging from 12% to 25%. Thea are formed on limestones and conglomerates and are rich in CaCO3.

1.4.4. Soils in lowland part of Vjosa valley

Meadow gray soils are found in the flat areas with a slope of 3% to 8%. Such soils are medium to heavy in texture and have an angular block structure. They have a neutral to slightly alkaline pH with values between 6.5 and 7.5 and a medium humus content (in the upper layer the humus content varies between 1.1% and 3.3%). Intensive cultivation reduces the humus content in such soils, combined with lower soil fertility.

1.5. Potential Natural Vegetation

The potential natural vegetation (PNV), also known as Kuchler potential vegetation, is the vegetation that will develop through natural succession after the last glacier period only driven by environmental conditions (climate, geomorphology, geology) and without any human interventions. It is the result of physiological amplitude of species indicating its theoretical distribution according to the inherited genetic potential and the so-called socio-ecological amplitude indicating the competition among different species for a given place to grow. With other words, the PNV represents the dominating species or species composition of forest succession for a given forest site without any human interferences. Within forest management is considered as a reference ecosystem since the degree of divergence to an existing ecosystem is an indicator of management impacts and degradation effects.

The Vjosa river basin has gone under severe and heavy management impacts by overcutting and livestock farming resulting in large devastated forest areas. In addition, little is known about the distribution of the potential natural vegetation coverage. Thus, we obtained European natural vegetation map (scale 1: 250,000) provided by Bundesamt für Naturschutz (2003). The results are shown in Figure 4.

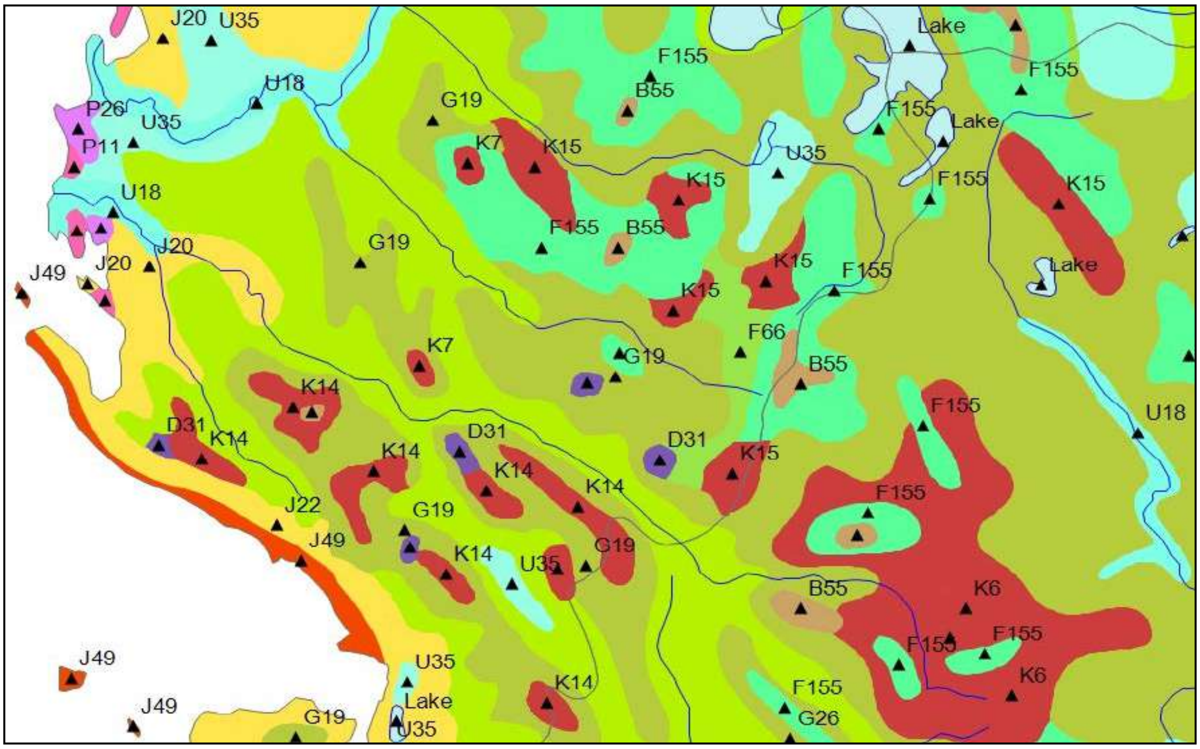

Figure 4. Main Potential Natural Vegetation (PNV) in the Vjosa river basin (Bohn et al. 2003)

As shown in Figure 4, the PNV of the study area includes zonal and azonal vegetation. Zonal vegetation primarily (climatically conditioned) includes the following formations:

B55 - B-Arctic tundra and alpine vegetation. This formation lies in coastal lowland and high mountainous locations of Europe. In the case of the Vjosa river basin, it is represented by unit B55 -Iberian, Apennine, Illyrian-Dinaric and Balkan alpine vegetation on carbonate and silicate rock. Their occurrence is restricted to peak areas of the Vjosa river basin and the vegetation on carbonate rock (B55) is characterized above all by grasslands with endemic *Festuca* and *Sesleria* species, but this is outside the border of the Vjosa national park.

D31 - D-Mesophytic and hygromesophytic coniferous and mixed broad-leaved-coniferous forests, where the main unit from this formation is D31. In southern Albania the spruce forests are formed almost exclusively on limestone between 1200 and 1600 m and consist of *Abies borisii-regis* (an intermediate form between *Abies alba* and *Abies cephalonica*-D31). Only in some places do *Fagus sylvatica* (in the north-east), *Pinus nigra* or *Fraxinus ornus* (in the south) exist as admixtures. With *Abies borisii-regis*, the Albanian endemic *Hypericum haplophylloides*, the basiphilous shrub and herb layer (*Sorbus graeca*, *Daphne mezereum*, *Sesleria coerulans*, *Brachypodium pinetum*, and *Galium lucidum* agg.) and xerothermic oak forests as adjacent communities, this unit is clearly different from the one found in Central Europe.

F155 - F-Mesophytic deciduous broadleaved and mixed coniferous-broadleaved forests, where the most representative units from this formation are Hellenic beech and fir-beech forests (F155). This formation mainly encompasses deciduous forest communities, but does not include thermophilus deciduous forests dominated by summer-green oak species that occur in the warm temperate climate. This formation covers deciduous forest communities but does not include thermophilus deciduous forests dominated by summer-green oak species that occur in the warm temperate climate. Hellenic beech and fir-beech forests are mainly represented by fir and beech forests, where the entire edaphic spectrum from acidic to calcareous beech forest is represented. This unit stretches from south-eastern Albania and southern Macedonia via north-western Greece (Pindos mountains). It inhabits mesotrophic to eutrophic soils over flysch.

G19/G26 - G-Thermophilous mixed deciduous broad-leaved forests, also known as xerothermic mixed oak forests, where one of the units is Pannonian-Danubian-Balkan lowland to submontane Balkan oak-bitter oak forests (G19). This unit is represented by *Quercus cerris* – *Quercus frainetto* forests, with a species-rich flora of woody plants and south and east Balkan colline to montane (mixed) Balkan oak forests (G26). Pannonian-Danubian-Balkan lowland to submontane Balkan oak-bitter oak forests (G19) represented by *Quercus cerris-Quercus frainetto* forests with a species-rich flora of woody plants. The forests are medium- to tall-growing with two- to three-layers and *Quercus cerris* and *Quercus frainetto* dominating the upper tree layer. Depending on the location, it is mixed with *Carpinus orientalis*, *Fraxinus ornus*, *Sorbus torminalis*, *Acer campestre*, *Ulmus minor*. The shrub layer mainly consists of *Crataegus monogyna*, *Cornus mas*, *Ruscus acuelatus*, *Euonymus verrucosa* etc. In the herb layer, thermophilus species are predominant, including *Potentilla micrantha*, *Helleborus odorus*, *Lithospermum purpurocaeruleum*, *Polygonatum hirtum, Lathyros laxiflorus, Brachypodium sylvaticum, Stellaria holostea, Festuca heterophylla, Anemone ramunculoides*.

The G26 unit includes Balkan oak forests with dominant *Quercus frainetto*. The two-to-three layered forests are mostly medium, rarely tall growing. *Quercus frainetto* is the dominant species in the upper tree layer, with varying admixture of *Quercus cerris* and *Quercus pubescens*. In the lower tree layer, *Carpinus orientalis, Fraxinus ornus, Ostrya carpinifolia* also appear. The shrub layer contains common species such as *Juniperus oxycedrus, Paliurus spina-christi,Phillyrea media* etc**.** The herb layer contains numerous thermophilus species, including *Lathyrus niger, Potentilla micrantha, Lathyru laxiflorus, Silene coronaria,* and *Helleborus odorus, Galium pseudo-aristatum*.

J20 - J-Mediterranean sclerophyllous forests and scrub includes communities of xeromorphic evergreen tree and shrub species, especially the genera Quercus, Pinus, Juniperus, and Pistacia. In the Vjosa river basin, the J20 unit can be found. Sclerophyllous forests and scrubs occur on all slopes and expositions and most evergreen, broadleaved forest species can grow as trees or shrubs, depending on external influences. The holm oak (*Quercus ilex*) is the most competitive species in dry locations and, in some locations, is mixed with kermes oak (*Quercus coccifera*) and *Quercus cerris, Quercus frainetto, Fraxinus ornus,* and *Carpinus orientalis*. In some cases, grazed oak forests are replaced by a very dense evergreen shrub layer, which can me composed of Erica *arborea, Arbutus unedo,* and *Arbutus andrachne, Myrtus communis, Phillyrea media* etc. In some sites *Pinus halepensis* artificial forest stands were established and in many areas the understory is represented by the common shrub of the thermo-Mediterranean sclerophyllous shrub formations. Due to tough bark and high regenerative capacity through seed production, *Pinus halepensis* forest stands tolerate fire more than other tree species and for that reason they may dominate or suppress oak as the main tree species. J20 extends further into the colline inland. The south of Albania is climatically much more favorable and the East Mediterranean character in the evergreen sclerophyllous vegetation is more present, since *Arbutus andrachne* appears in the shrub vegetation.

K7/K14 - K-Xerophytic coniferous forests and scrub consists of conifer-dominated communities of dry sites on shallow soils, with no groundwater access. Stands are mainly formed by Pinus. Their stand structure is shaped by edaphic and climatic factors, but is often altered by human interventions. In some cases, this can result in open stands where the spacing between trees is large. Due to a shallow rooting system and steep slopes, many *Pinus halepensis* trees have fallen (for instance in forest stands across the street of the Uji Trebeshina water plant). The main units in the Vjosa river basin are K7 and K14. The K7 unit is mainly located in mountainous regions of the Vjosa river basin, where *Abies borisii-regis* and *Pinus heldreichii* forests are situated. Logging and grazing are widespread forms of disturbance. K14-Meso to Mediterranean pine forests (*Pinus halepensis*) are widespread in the Vjosa river basin and are formed by artificial planting. They were planted due to its resistance to harsh site conditions, as a pioneer species in reforestation of bare lands. They occur on shallow soils of limestone or serpentine sites, forming mostly pure stands

U – Azonal vegetation sites

In the Vjosa river basin, azonal vegetation determined by specific soil properties and water regimes, covers vegetation resulting from flood plains, estuaries and freshwater polders as well as other damp or wet (U) sites. This formation of riverine biocenosis and intermittently moist to wet lowlands is represented by deciduous lowland forests and scrubs, often combined with tall reeds, grasslands, herbaceous perennials, and annual vegetation. Shrubs determine the structure of floodplain vegetation with Salix, Poplar, Platanus, Ulmus, and Alnus. These species are adapted to mechanical loads from water currents, as well as sharp fluctuations in water levels with frequent changes from flooding with floods in winter and in autumn. This vegetation can survive such events without damage and if damaged regenerating occurs quickly. In the Vjosa river basin, there are mainly coniferous alluvial forests (*Salix alba, Populus nigra,* and *Populus alba*) and humid lowland forests of larger river valleys (U18).

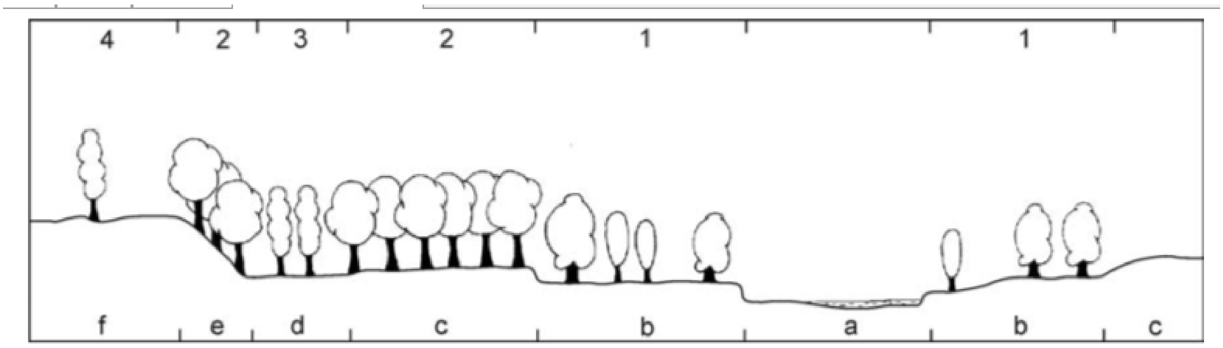

Figure 5. Vjosa river alluvial forests profile.

1-*Populetum albae*;	a-riverbed at low water
2-*Rubio-Carpinetum betuli*;	b & d- Area affected by floods
3-*Carici remotae-Fraxinetum spp*;	c-Terrace bank
4-Single tree of *Fraxinus angustrifolia*;	f-Terrace

Softwood riparian forests are associated with young riverine sediments and an area extending from the mean waterline to 3/4 to 1 m above it. Due to the frequent flooding, these areas are hardly used for forestry purposes. Sometimes, these species are mixed with hardwood riparian forest species such as elm.

1.6. Land use change from 2000 to 2020

One of the most important issues in the Vjosa river basin is the long-lasting historic land use impact resulting in a severe change of the Potential Natural Vegetation (PNV) and enormous degradation effects. The main reasons are the need for wood and livestock farming with cows but especially with goats and sheep. The result is low forest coverage, a loss in soil productivity and erosion problems.

Figure 6: Livestock farming near the creek boarder. Large herds of sheep and goats impact the vegetation and especially natural regeneration.

The recent forest area development can be summarized as follows:

Between 2000 to 2020 the forest area declined by 9 % from 110.305 ha to 99.834 ha (see Figure 6 and Table 3). Compared to the total land area of the Vjosa catchment, the forest area decreased by 2%, from 24% to 22%. The most affected forest type was the broad-leaved forest, which diminished by 13%. Both mixed and coniferous forest types increased from 2000 to 2020 (2% and 1% of the total forest area, respectively). Mixed forests grew by 40%. At the same time the pasture area increased by 169% from 6039 ha to 17542 ha.

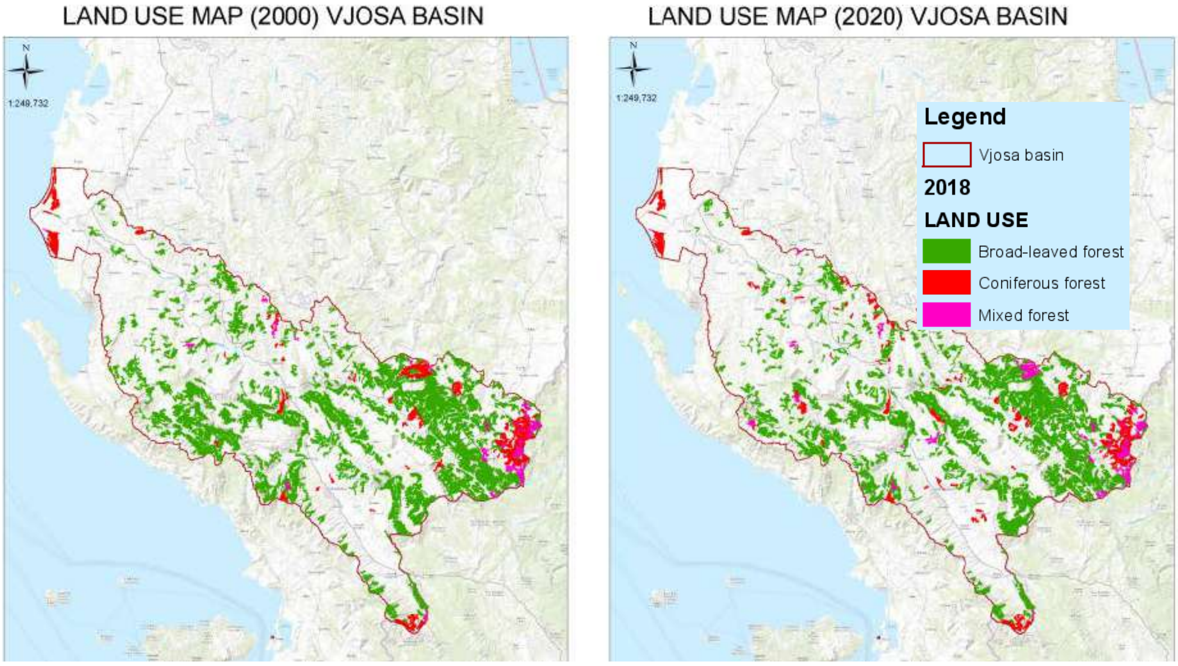

Figure 7. Changes in forest land use from 2000 to 2020.

Table 3. Changes in forest land use from 2000 to 2020. Delta shows the changes in total numbers and in percentage between 2000 and 2020.

Type	**area 2020 (ha)**	**In % of forest area**	**area 2000 (ha)**	**In % of forest area**	**Delta (ha)**	**Delta in %**
Broad-leaved forest	82990.97	83%	95011.55	86%	-12020.57	-13%
Coniferous forest	11810.67	12%	11702.88	11%	107.79	1%
Mixed forest	5033.15	5%	3590.93	3%	1442.21	40%
Total forest area	**99834.79**		**110305.36**		**-10470.57**	
		In % of total land area		**In % of total land area**		
Total forest area	99834.79	22%	110305.36	24%	-10470.57	-9%
Total land area	**460687.80**		**460687.80**			

2. Identification of typical forest ecosystems using selected stands as examples (“Reference Stand Concept”)

2.1. Identifying potential vegetation types

Based on a field survey (April 19. to 21. 2022), we identified four typical forest vegetation types covering the Vjosa river basin. For each vegetation type, a limited number of stands is selected and as “reference stands” to provide an insight in the ecological, historical, economic challenges and the future management options by forest vegetation type. The following vegetation types were identified:

1. Floodplain Forests Representing the typical ecosystem along the river

Figure 8. Floodplain forests along the Vjosa river

2. Oak forests the ecosystem relatively close to the Potential Natural Vegetation

Figure 9: Oak forest near the Greek boarder.

3. Mediterranean evergreen shrub forests (Macchia) the ecosystem which resulted in long lasting historic forest management and livestock farming impacts. Macchia is the most important forest ecosystem in the area.

Figure 10. Typical Macchia sites

4. Pine forests: Planting started after the second worl war in response to the loss of fuel wood but also to protect soils from eroseion an secure infrastructure.

Figure 11. Pinus halepensis stands

For each of the 4 vegetation type we selected typical stands for further assessment:

- Flood Plain - riparian forests at three different locations (Tepelena, chapter 3.1.1., Cakran, chapter 3.1.2., and Pocem, chapter 3.1.3.) along the Vjosa
- Oak forest (chapter 3.2.)
- Macchia Mediterranean evergreen shrub forests represented by three different sites:
    - shrub with oak (chapter 3.3.3.)
    - degraded shrub forests (chapter 3.3.2.)

- o typical shrub forests but no oak (chapter 3.3.1.)
- Three mediterranean pine forest stratified by age and forest stand characteristics:
  - o Young pine stand (chapter 3.4.1.)
  - o Middle pine stand (chapter 3.4.2.)
  - o Old pine stand (chapter 3.4.3.)

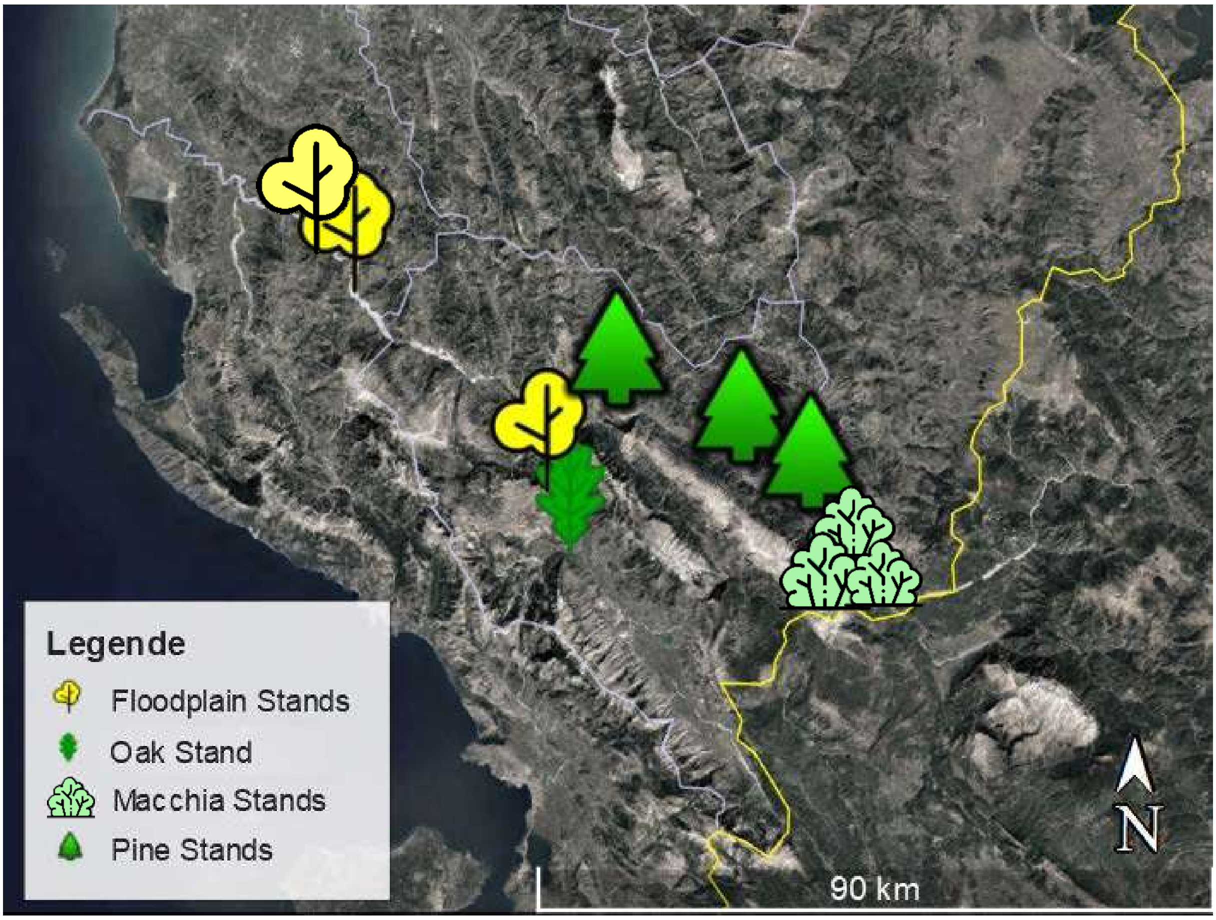

Figure 12: overview of the 10 selected forest stands for the 4 identified major vegetation zones in the Vjosa catchment. Note that a detailed description for each forest stand is given in the following chapters.

2.1.1. Methods of the field survey

The methodology used for data collection is based on the idea of the "Reference Stand Concept". After choosing the location of the stands, an inventory-based approach is used. Four circular and concentric fixed area plots were placed 50 meters north, east, south, and west of the plot center.

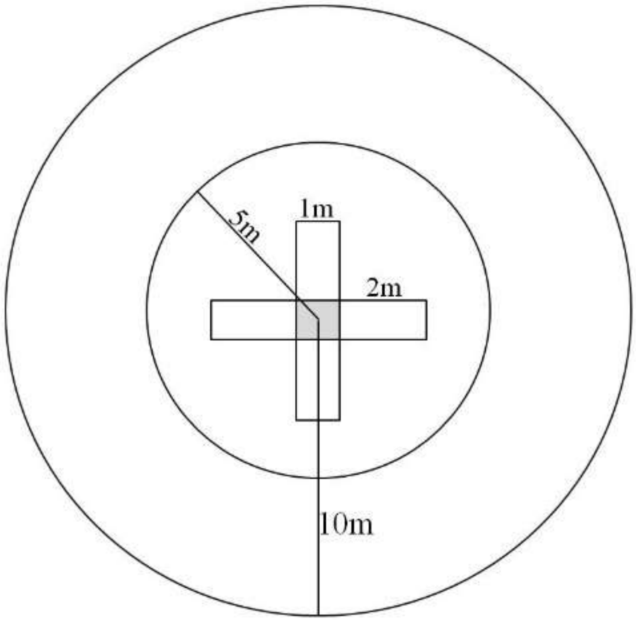

Figure 13.

Figure 13: On the area with a radius of 10 m all trees with a DBH > 10 cm were recorded, on the sub plot area with a radius of 5 m, trees with a DBH below 10 cm were measured. The subplot also included shrubs. On the 4 satellite 1 m by 2 m plots the regeneration of trees were recorded.

For each plot a GPS measure exists and the plot center was marked with an iron stick. The slope to correct the radius and the orientation of the sample area was identified and possible effects of grazing, cutting etc. were collected. Measurements were started from the closest tree and continued clockwise. Each tree was numbered within the sample area, and the azimuth, distance from the center of the sample area, DBH, identified species, as well as canopy size in four directions was recorded. The mean average tree corresponding to the 60th percentile of the DBH distribution by species was identified and its height, height to the live crown base and incremental cores were taken to analyze radial growth in our laboratory. Regen4ration defined as trees < 1.3 m in height were recorded by the number of seedlings for each species.

2.1.2. Simulations

Using the recorded tree data, a visualization and simulation of the stands is possible using the distance-dependent, single-tree-growth simulator MOSES (see Hasenauer 2000, Thurnher et al. 2017). Stand indices were estimated and yield tables were fitted to match the data from the points. In the Figures 14 and 15 examples are shown for a natural 25-year development of a *Pinus halepensis* stand (Permet, West) and a *Quercus cerris* coppice stand (Mesare, East) with hornbeam (green grid) and oak (green) regeneration. Red trees are trees that died due to competition during the last 5-year growth period. Pink trees are regenerated trees. Using MOSES 3.0 (see Hasenauer et al. 2006), we were also able to apply cuttings and plantings of trees. We used the stand view options 2D for the pine stand and the option 3D for the oak stand.

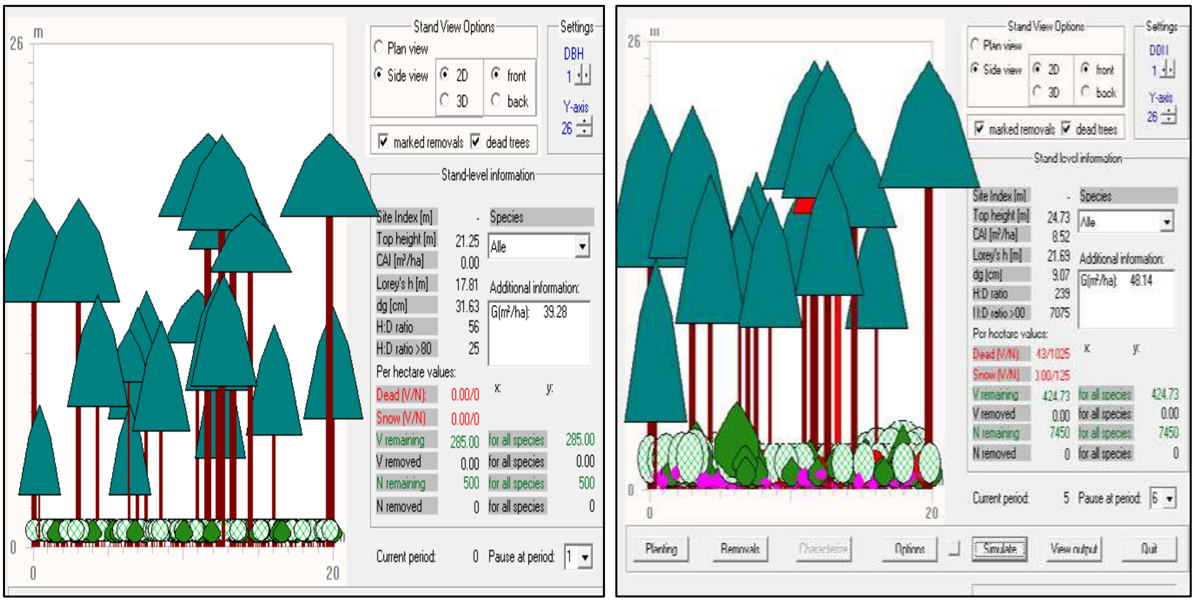

Figure 14. Pine stand in 2022 (top) and 2047 (bottom).

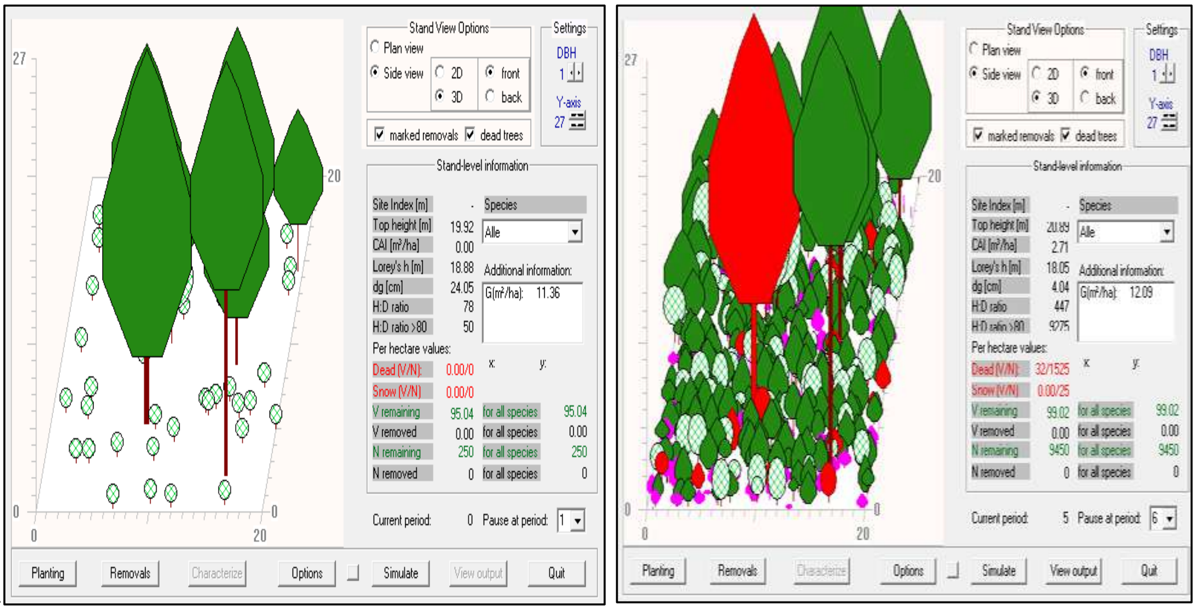

Figure 15. Oak stand in 2022 (top) and 2047 (bottom).

3.1.1. Floodplain forest - Tepelena

Location and general information

The forest site is located south of the city Tepelena, next to Vjosa river (see Figure 16). Currently the area covers approximately 51 ha, is flat and was until two years ago the largest remaining alluvial floodplain forest area along the entire Vjosa. The north-eastern edge of the area is located at 40°17' 28.05 N, 20° 1'32.60"E. The site was visited and assessed on April 20th, 2022 and evaluated for site conditions and species presented. The climate of the site can be characterized as Hilly Mediterranean, with dry and hot summers, and mild and wet winters. The vegetation found in the site is typical alluvial represented by poplar, platanus, and *Salix* trees. The landscape of the area is typical flat floodplain shaped during the Quaternary Period and the soil is dominated by sand and gravel alluvial deposits induced by Vjosa river. The alluvial deposits are formed by: Neocene's deposits composed by sand stone and silt stone. The site has been affected by the dynamic change of the Vjosa river flow and the area size has changed over the years due to frequent flooded affecting the vegetation composition and development.

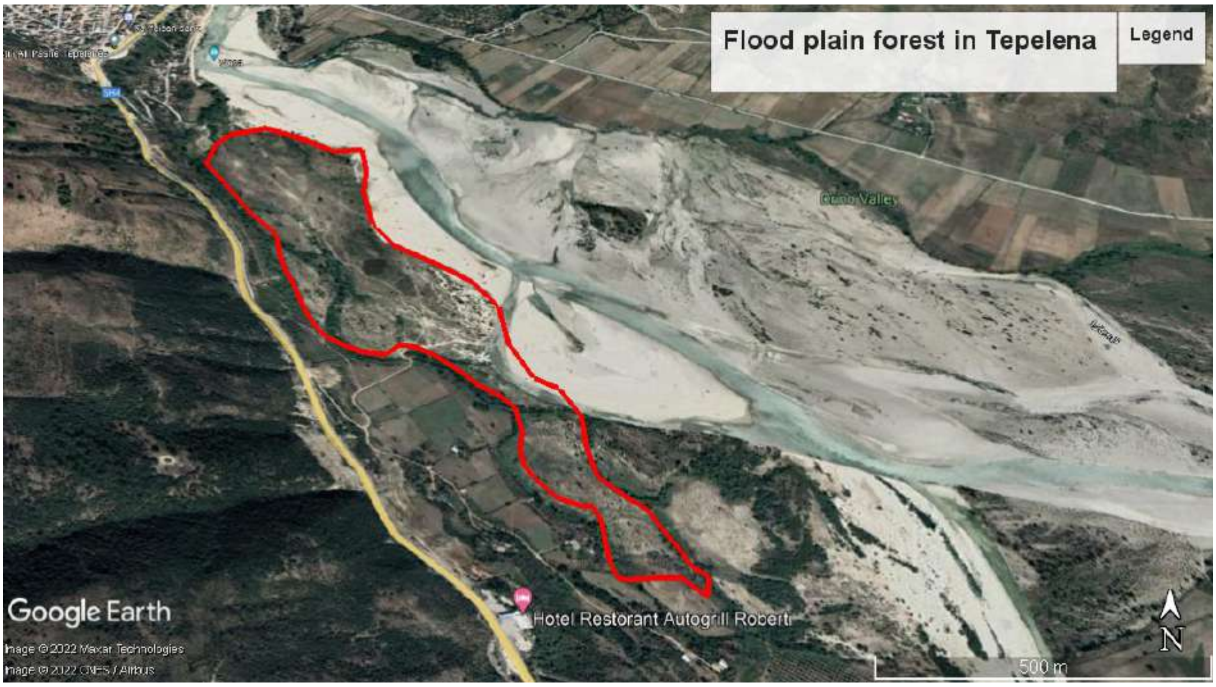

Figure 16. Position of the reference stand

The area has been covered by *Polpar*, *Salix*, *Platanus,* but due to some health problems and dieback signs especially for *Platanus* and *Poplar,* the forest staff at Tepelena municipality decided to clear cut and replanted it with hybrid poplar seedlings a non-native tree species in the area. From the field survey it became clear that clear cutting was not the best solution and will cause major future problems for the ecosystem in the area.

Potential Natural Vegetation

The Vjosa river basin vegetation consists of deciduous lowland forests and shrubs, often combined with tall reeds and grasslands. Figure 17 shows an example of the forest conditions prior to the cuttings. Flood plain forests consist mainly of *Salix spp., Populus spp., Platanus spp. Ulmus spp*., and *Alnus spp*., which are adapted to mechanical loads from water currents as well as fluctuations in water levels with frequent changes due to floods in autumn and winter (see Figure 18). This vegetation can survive such events without long lasting damage and the flooding is part in maintaining the ecosystem and initiates natural regeneration.

Figure 17: The Flood plain forest near Tepelena prior to the cutting.

Figure 18. Typical flood of the Tepelena forest area during autumn/winter after heavy rain fall. The photo shows the situation prior to the clear cut of the forest area and demonstrates why a forest in this area is important to avoid erosion.

Historical Development

Floodplain forests are very dynamic ecosystems strongly driven by flooding and intermediate dry periods. Important for such ecosystems is that due to their deep root system they provide access to ground waters, which explains its fast growth even during dry periods. A comparison using satellite imagery at different time scales (Figure 19 and 22) revealed the highly dynamic changes of the area since 2007.

Important for the development of these sites is the high presence of livestock impact. Grazing by cows, sheep and goats limit the natural regeneration. Thus, the forest structure prior to the cuttings consisted of a forest canopy layer of tall trees with bushes in the second layer and small meadows. Almost no natural regeneration was evident and the livestock pressure is one of the main reasons.

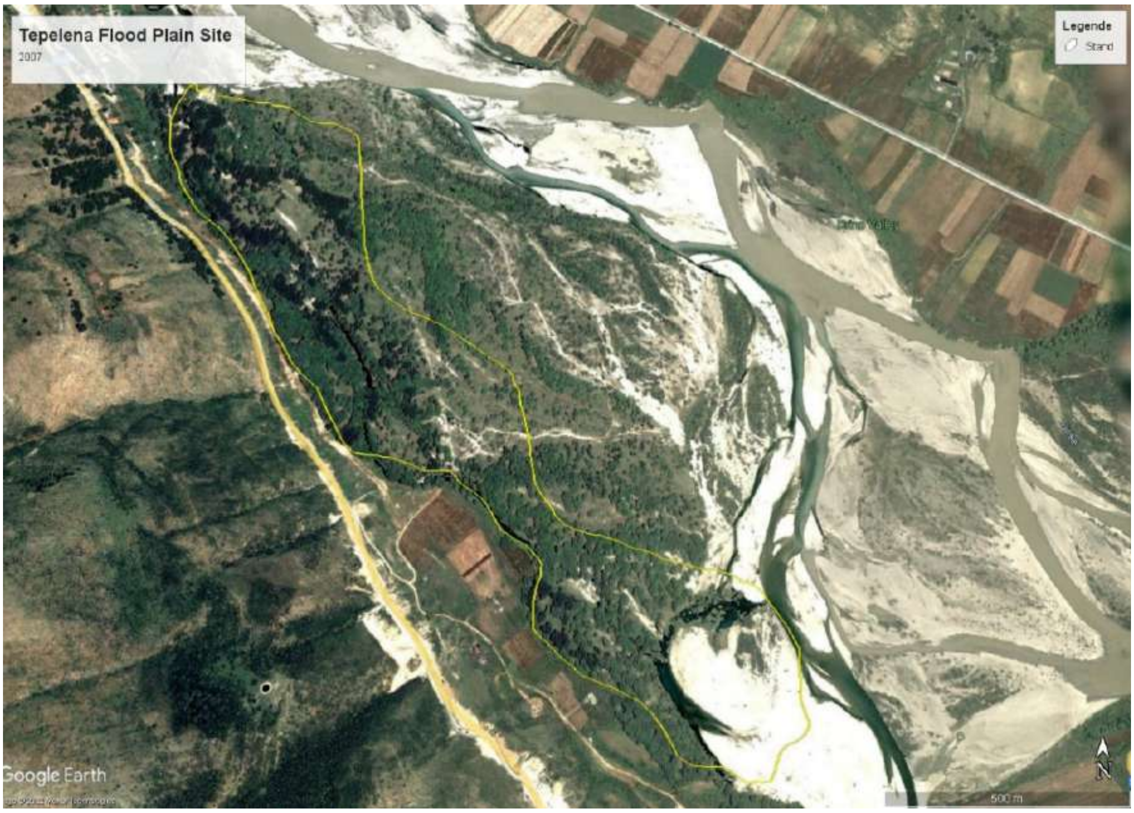

Figure 19. In 2007 the forest stand area was roughly 100 ha, about double the size of today (51 ha).The southern part of the area used to be a sand bank.

Figure 20. Between 2007 to 2014 the forest area expanded because trees regnerated also in the southern part of the area.

Figure 21. Between 2014 and 2019 clear cuts took place and large parts of the forest was harvested, resulting in a rapid extension of the river sand bank.

Figure 22. Between 2019 and 2022 the remaining Populus nigra trees covering the northern part were harvested resulting in a further loss of forest area. The yellow line shows the remaining current forest coverage after clear cut in 2022.

Between 2007 and 2022, the Tepelena flood plain forest (Figures 19 to227) went through a severe loss in area from nearly 100 ha to about 50 ha. Although it is common that rivers show a dynamic behavior, the uncontrolled clear cuttings have induced a dramatic expansion of the sedimentation process on former forest land since the speed of the water flow increased. If the replanting process of the remaining area fails, it is expected that the ongoing sedimentation process will even lead to further decline of the forest area.

Current situation

The floodplain forest of the site dominated by poplar trees with an age over 40 years old was clear cut because some dieback signs were noted affecting the trunk and the tree crown. These health problems were caused by Armillaria root rot which attack the root system of the poplar and weakened the tree vigor. The fungus can spread from one tree to another by rhizomorphs that grow through the soil until they contact and infect a root of another tree. Mycelium of the fungus then spreads through the root system of that tree, causing root rot and eventually butt rot.

The typical autochthonous *Populus* and *Salix* flood plain forest mixed with some human induced Hybrid poplar trees were harvested. This has strongly affected the nature conservation perspective of the site. It is also an economic failure because enormous financial efforts must be taken to reforest the area. Figure 23 provides an example for the ongoing sedimentation process and the related consequences. It is expected that this sedimentation will continuous and further reduce the forest area of the site.

The lack of trees increases the speed of water movement during flooding which in turn increases the transport of sediments. In forested areas the water flow is reduced and the sedimentation process especially for heavy gravel, takes place near the river banks outside the forested areas.

Figure 23. Current stand situation. The flood plain forest consists of some remaining P. nigra trees and planted Hybrid popular (P. xcanadensis).

For replanting the area an excavator was used to create holes for planting the hybrid popular heister. This resulted in additional problems such as soil compaction of the sensitive flood plain humus and soil layer, and even more erosion problem (see Figures below). Furthermore, Hybrid popular is non-native to the area and thus from a nature conservation perspective this species should not be planted.

Figure 24. Site preparation efforts for planting.

Figure 25. Soil compaction from heavy machinery.

Figure 26. Example for an eroding patch. Fertile humus is gone and gravel and/or sedimentation remains. A replanting of eroded areas is difficult, very expansive or even impossible.

Due to this anthropogenic impact, the current forest situation differs from the potential natural vegetation. The original stand used to be closed to the potential natural vegetation before most of *P. nigra* was harvested (see Figures 17 and 18).

The planted, *Populus x canadensis* Moench using excavators has led to further damage because

(i) Soil compaction with heavy machinery for planting reduces the water holding capacity of the soil
(ii) The panting system with the excavator leads to further openings of the humus and soil layer and this induces leaching problems of fertile soils during flooding periods of the Vjosa
(iii) From a nature conservation perspective, the planting of non-native Hybrid popular is unsuitable.

The management applied to this largest flood plain forest along the Vjosa was unsuitable both from a nature conservation but also from an economic management perspective. The clear cuts were too large in size and in very short time intervals without ensuring that the previous cleared forest area is reforested and safe. Additionally, no actions were taken to avoid browsing during the regeneration/planting phase. This severe damage to the ecosystem requires enormous investments for planting and maintenance to avoid further erosion but also a successful reforestation of the area.

Future Management Recommendations

Since the Vjose region will be soon a National park the management recommendations for this site have to focus on nature conservation goals. This includes no further cuttings on the site, taking actions to restore the potential natural forest vegetation or at least a forest which is close to it and it will restrict and/or reduce the browsing impact due to live stock farming. According to the recent management history (see previous chapter), the following suggestions are proposed:

On the edge of the planted area close to Vjosa river we suggest to plant *Salix* spp. and *Ulmus* as well as *Platanus* in between rows of poplar seedlings in order to establish a mix forest stand which is more climate-compatible and more resilient to extreme weather events and provide more potential benefits including greater biodiversity, log-term economic efficiency and stability. Considering the fact that planted seedlings were provided from nurseries located far from the site it is suggested to establish a nursery in the area to produce seedlings from native genetic resources and use it for reforestation purposes along the Vjosa river basin in other locations.

- Replanting of the area with autochthones tree species covering Salix spp. and Elm. as well as Platanus in between the rows of the planted Hybrid popular to establish a mixed stand which eventually allows the removal or the planted Hybrids A specific reforestation concept is needed which covers the planting density by species, mixtures as well as spatial distribution of species and mixtures depending on the distance from the river banks. For example, near the main river bank Salix sp. in higher densities may be planted to reduce the speed of the water flow and thus further sedimentation in the forest are.
- No heavy machinery for planting to avoid soil compaction and further erosion.
- Parts of the area were replanted with non-native Hybrid popular with rather low density. The Hybrid popular should be maintained but in between Platanus should

be planted to establish a mixed stand which eventually allows the removal or the planted Hybrids. The Hybridpopular should insure some forest coverage and a protection of the site which is than systematically replaced by introducing native species.

- Live-stock farming in the area needs to be controlled to avoid further damage to the sensitive humus and soil layer as well as to induce natural regeneration which is currently destroyed or damaged by browsing. The following protection measure may be considered:
  - Rigorous restriction of livestock grazing in the whole area
  - Separation of grazing areas from forest areas which may require fencing measures. It is important that during the flooding periods such fences need to be removed sine they will not withstand the water flow.
  - Planting of young trees larger in size with individual protection (individual fences, etc.) to avoid browsing.
  - The impact of live-stock browsing needs to be assessed by installing small fenced areas (2 m x 2m or 3 m x 3 m) to compare forest development with and without browsing

Summary: For the area a detailed replanting plan which covers (i) species selection, panting density and mixtures, (ii) managing of non-native Hybrid popular plantations, (iii) potential actions to reduce browsing and (iv) establishing a monitoring system to record the success of the defined management strategies is needed.

3.1.2. Floodplain Forest – Cakran

Location and general information

This flood plain forest is located south of the Cakran, next to Vjosa river (Figure 27). Currently the area covers approximately 44 ha, is flat and was until two years ago on of the large remaining alluvial floodplain forest area along the Vjosa river. The north-eastern edge of the area is located at 40°32'42.61"N, 19°39'46.93"E. The site was visited and assessed on April 21th, 2022 and evaluated for site conditions and species presented. The climate of the site can be characterized as Hilly Mediterranean, with dry and hot summers, and mild and wet winters.

Figure 27. overview of the flood plain forest area Cakran.

Potential Natural Vegetation

Similar to the Tepelena flood plain area the typical vegetation would consist of a deciduous lowland forests and shrubs mainly *Salix spp., Populus spp., Platanus spp. Ulmus spp*., and *Alnus spp*. these species are adapted to mechanical loads from water currents as well as fluctuations in water levels with frequent changes due to floods in autumn and winter.

Historical Development

The area was covered with *Polpar*, *Salix*, *Platanus* but has been harvested contiously during the recedt years with the result that only very view Poplar and Salix trees remainedt. From 2015 to 2016 *Paulownia tomentosa* was planted, but almost the entire plantations died mainly due to the high ground water level (see Figures below).

Figure 28 Overview of the flood plain forest near Cakran

Figure 29. Meadow next to the flood plain area with the remaining trees of the former forest.

Figure 30. Stand situation after the large cuttings with the remaining individuals.

Current situation

The typical flood plain forest was harvested during the recent years and a large Paulonia plantation was established (see Figures below). However, Paulonia, a species native in central and western China, grows well on semi dry and semi rich soils on warm as well as sonny sites. The plantation at the flood plain forest near Cakran is a good example for an unsuitable site of Paulonia plantations because

- the site exhibits a ground water level up to the surface
- is very nutrient rich and
- due to the high ground water level the soil is cold.

Thus, it is no surprise that most of the Paulonia plantations died after planting. The only exception is a Paulonia stand planted near the edge of the flood plain and the nearby hills – this site exhibits a lower ground water level and has a higher sand content (see Figure 32)

Figure 31. Series of photos of the Paulonia plantation which died due to the unsuitable site conditions for the species. Note the species needs semi-dry and semi-nutrient rich and warm soils. Thus, flood plain sites are unsuitable for Paulonia plantations.

Figure 32. The only Paulonia stand that survived since it was located higher up on dryer site with warmer soil conditions.

Future Management Recommendations

The Paulonia plantations should be replaced by a flood plain forest planation of the following species composition (see also Tepelena site):

On the edge of the planted area close to Vjosa river *Salix* spp. and *Ulmus* as well as *Platanus* should be planted to establish a mix forest stand which is more climate-compatible and more resilient to extreme weather events and provide more potential benefits including greater biodiversity, log-term economic efficiency and stability. It needs to be ensured that planted seedlings are suitable for the area, which may require the establishment of a local nursery.

It is suggested to use part of this area for the establishment of a flood plain seedling nursery.

A typical replanting scheme of may be as follows:

- No heavy machinery for planting to avoid soil compaction and further erosion.
- Removal of the whole Paulonia trees in the area to avoid future seed contamination.
- No Hybrid popular plantations
- Live-stock farming in the area needs to be controlled to avoid further damage to the sensitive humus and soil layer as well as to induce natural regeneration which is currently destroyed or damaged by browsing.
- Planting of native tree species (Salix, Platanus, Popular, etc.) coming from regional seed sources.
- Rigorous restriction of livestock grazing and/or browsing protection in the whole flood plain area.

3.1.3. Floodplain forest – Pocem

Location and general information

The forest site is located next to the Vjosa river (Figure 1). The area is flat (no slope or expsition) and one of the largest remaining alluvial floodplain forest area along the entire Vjosa. The sample plot is located at N 40º 31' 22.5", E 19º 44' 2.1" and elevation is 36 m above sea level. The site was visited and assessed on May 1st 2022.

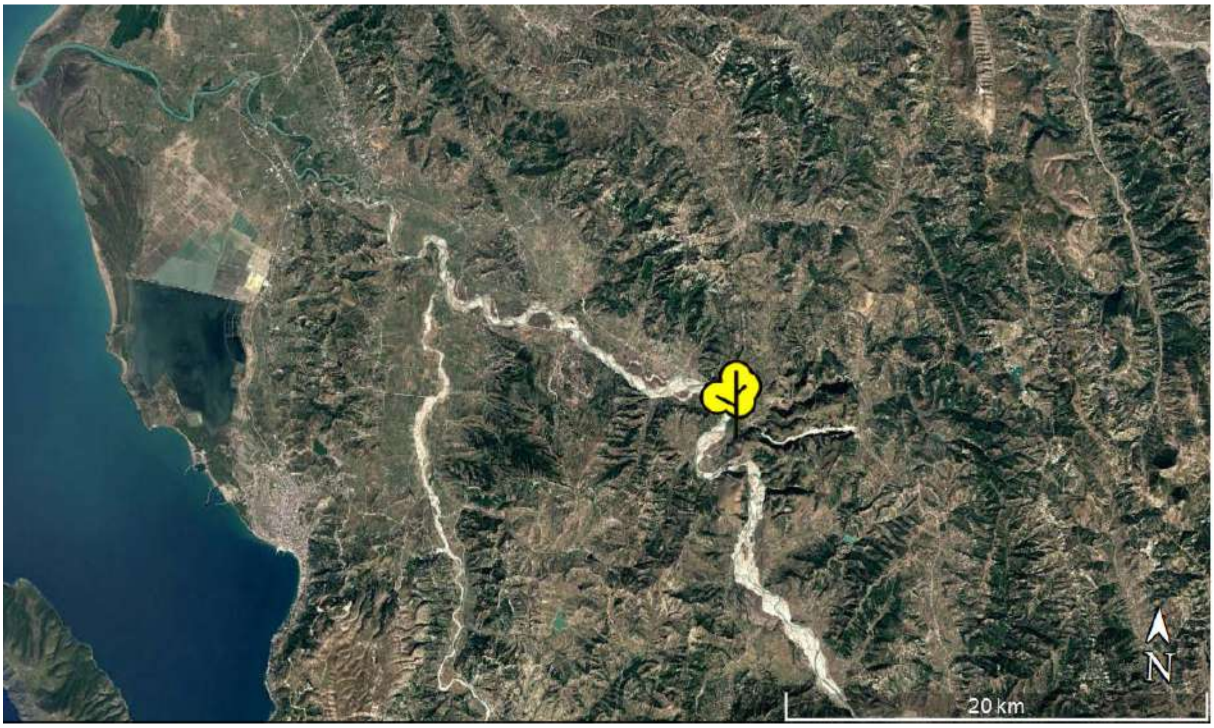

Figure 33. Position of the reference stand.

Potential Natural Vegetation

The Vjosa river basin vegetation consists of deciduous lowland forests and shrubs, often combined with tall reeds and grasslands. Flood plain forests consist mainly of Salix spp., Populus spp., Platanus spp. Ulmus spp., and Alnus spp., which are adapted to mechanical loads from water currents, as well as fluctuations in water levels with frequent changes due to floods in autumn and winter. This vegetation can survive such events without long lasting damage. The flooding is part in maintaining the ecosystem and initiates natural regeneration. This floodplain forest is unique because of its periodic flooding and regular river disturbances, which cause deposits of silt and sand along the river bank. These help to create the typical communities of plants that tolerate flooding and require nutrient-rich soils. This forest stand provides many ecological services, such as water retention, filtration of pollutants to prevent them from entering to river, improving the water quality, controlling river banks in the case of erosion, carbon sequestration etc. as well as being an important habitat for wildlife.

Historical Development

Floodplain forests are very dynamic ecosystems, strongly driven by flooding and intermediate dry periods. Important for such ecosystems is that they have access to ground water, which explains their fast growth, even during dry periods. The following figures show the dynamic changes of the area since 2005, using publicly available information. Important for the development of these sites is the impact of humans and livestock on their progress. Grazing by cows, sheep and goats limit the natural regeneration, while humans impact the forests by illegal logging or wildfires, changing their density and composition. Due to these drivers, the forest structure changed from a very dense forest canopy layer of poplar trees to a less dense forest stand with bushes in the second layer and grass land.

Figure 34. In 2011 the floodplain forest area was roughly 35 ha, compared to todays 28 ha.

Figure 35. Between 2011 and 2016 a 7 ha in the norther parts of the stands erroded into the river.The yellow lines marks the stand border from 2011.

Between 2011 and 2016, the Pocem flood plain forest went through a severe loss in area (Figures 2 to 3). Although it is common that rivers show a dynamic behavior, the uncontrolled cuttings and wildfires have induced a dramatic expansion of the sedimentation process on former forest land, as the speed of the water flow increased. The sparse, remaining vegetation managed to keep the whole site from eroding.

Current situation

Due to these anthropogenic impacts, the current forest situation differs from the potential natural vegetation. The original stand used to be closed to the potential natural vegetation before most of Populus nigra trees were harvested (see Figure 2). The management applied to this flood plain forest was less disastrous than on the Tepelena site, but still impacted the forest situation negatively. The logging in the northern parts of the stand were too extensive and in very short time intervals without ensuring that the previously cleared forest area is reforested and safe. For the ecosystem to recover, investment for planting and maintenance to avoid further erosion is needed. This should be done by regenerating the stand with native floodplain species.

Figure 36. Series of photos to get an impression of the current stand situation

Stand Description

The forest stand is dominated by old-growth *Populus nigra, associated by Platanus orientalis,* while the understory is represented by *Rosa canina*, *Crataegus monoggyna*, *Rubus ulmifolium*, and *Spartum junceum.*

Table 4: Measurements from the P. nigra tree at the 60th percentile of the diameter at breast height (DBH) distribution at the four sampling plots. DBH is the Diameter at Breast height, Height is the VERTEX-measured height.

	North	**East**	**South**	**West**
Main Species	*P. nigra*	*P.nigra*	*P. nigra*	*P.nigra*
DBH (cm)	50	86	83	59
Height (*m*)	16.9	24.5	24.2	21.7
Number of trees on plot	8	3	3	2

Current Management and Future Development

Current management of the floodplain forest was driven by negative human interventions, including logging and wildfires. Our measurements showed that few trees were growing in the area, but no measure was taken to improve this situation by the responsible authorities. If the situation does not change, then the floodplain forest is very likely to end up like the Tepelena stand. Natural regeneration in the area was missing and this is partly due to flooding and partly due to wildfires. Young trees that are completely inundated by water cannot survive more than a few days with their leaves underwater. For this reason, new plantings are especially at risk. This being said, the frequent burning of young saplings in the area also left its damage. Therefore, forest establishment on the floodplain can be accomplished by natural regeneration, in an artificial manner, or by combining the two. Regardless of which approach is used, the main goal should be to achieve crown closure as quickly as possible. Careful planning is necessary to ensure the proper species mixture, appropriate for the site conditions and soil type. In the area, selective logging aiming to remove poor developed trees or burned trees should be applied. Considering the importance of the floodplain forest, multifunctional floodplain management can be seen as a solution to ensure the sustainable use of this area. Multifunctional floodplain management should be considered as a management approach that aims at a balanced provision of multiple ecosystem services and meets the needs of local residents. The restoration efforts of this floodplain forest should consider a combination of multiple-species, aiming at restoring natural hydrological dynamics. A single-species approach should focus on the conservation status of individual species and this should be done in accordance with the EU Water Framework Directive and the Birds and Habitat Directives, as well as local legislation.

Future Management Recommendations

Since the Vjosa region will be soon a national park, the management recommendations for this site have to focus on nature conservation goals. This includes no further cuttings on the site, taking action to restore the potential natural forest vegetation or at least a forest which is close to it, and restriction and/or reduction of the browsing impact due to livestock farming. According to the recent management history (see previous chapter), the following suggestions are proposed:

- Implementation of planting operations with autochthone tree species covering *Salix spp., Popular spp.*, etc. A specific reforestation concept is needed, which covers the planting density by species, mixtures as well as spatial distribution of species and mixtures depending on the distance from the riverbanks. For example, near the main river bank *Salix spp*. in higher densities may be planted to reduce the speed of the water flow and thus further sedimentation in the forest area.
- No heavy machinery for planting to avoid soil compaction and further erosion.
- Once a dense regeneration is established, single old trees can be harvested
- Livestock farming in the area needs to be controlled to avoid further damage to the sensitive humus and soil layer as well as to induce natural regeneration which is currently destroyed or damaged by browsing. The following protection measure may be considered:
    - Rigorous restriction of livestock grazing in the whole area

- Separation of grazing areas from forest areas which may require area fencing. It is important that such fences are removed during the flooding periods, since they will not withstand the water flow.
- Planting of young trees larger in size with individual protection (individual fences, etc.) to avoid browsing.
- The impact of livestock browsing needs to be assessed by installing small, fenced areas (2m x 2m or 3m x 3m) to compare forest development with and without browsing.

Identified potential experimental sites

Additionally, we identified potential areas that could be used to install showcase stands for best-practice floodplain forest management. Information on these candidate sites and satellite images are provided below:

Table 5. Location of potential experimental sites

No	Location Name	Geographic coordinates		Elevation m (asl)	Area (ha)	Species
		X	Y			
1	Memaliaj	40 º 19'44.19"	20 º 0'11.29"	119	4.1	Poplar, Platanus, Salix, elm
2	Qesarat	40 º 23'12.01"	19 º 52'03.00"	85	0.52	Poplar, Platanus, Salix, elm

High resolution images can be found at:

https://drive.boku.ac.at/d/6eb3060fb8444408a9c1/

3.2. Oak Forest

General Information

Large parts of the Vjosa catchment areas would be covered with thermophilus mixed deciduous broad-leaved forests, also known as xerothermic mixed oak forests, if no human impact would have been taken place in the area (see chapter Potential Natural vegetation). This human influence has resulted in a severe land use change - forests converted in agricultural land. In the remaining forested areas intensive life stock farming is evident creating the typical Macchia and bushland secondary vegetation in the area. Thus, only in very few forested areas the tree species composition is somehow similar to the potential vegetation even if some management has taken place. These areas are located in the upper Vjosa catchment area next to the Greek boarder (see examples).

A typical example which is selected as reference oak stand is located in the western part of the Drinos river catchment outside of Tepelena. The yellow pin in Figure 1 and 2 marks the center of the four plots recorded in this area. The points are located at an altitude of 206 m to 306 m above sea level facing east, the slope varies from 47% to 51%. The data were collected on June 16th, 2022.

Figure 37. Position of the reference stand

Figure 38. 3D Position of the reference stand

Potential Natural Vegetation (PNV)

The potential natural vegetation in this area consists of thermophilous mixed deciduous broad-leaved forests, also known as xerothermic mixed oak forests. The two-to-three layered forests are mostly medium, rarely tall growing. *Quercus frainetto* Ten. is the dominant species in the upper tree layer, with varying admixture of *Quercus cerris* L. and *Quercus pubescens* Willd. In the lower tree layer, *Carpinus orientalis* Mill., *Fraxinus ornus*L., and *Ostrya carpinifolia* Scop. are growing.

The species mixture of the selected forest is one of the few sites which is close to PNV in the area. The forest grows on Chromic Cambisol influenced by the hilly Mediterranean climate. The annual rainfall is about 130 mm / year with distinct seasonal pattern. About 84% of the rain is recorded between October to May with November, the month with the highest rainfall of 150 mm. In July with about 18 to 27 mm the lowest rainfall is recorded.

Current forest situation

Although these forests cover native species the anthropogenic impact is evident. The presence of the hornbeam and very little natural regeneration is a clear indication of the livestock pressure. The stands are influenced by livestock grazing and the resulting erosion problems due to livestock trails from sheep and goat trails.

The past and current forest management consists of coppicing. No thinning or tending operations are applied. The coppice management regime in combination with strong live-stock impact is an important problem in maintaining the species mixture and regeneration of the forest. However, the forest is a good example that if the live-stock farming and the management regime (no coppice management) is changed the area has the potential to develop towards the PNV.

Figure 39. Typical oak stands with forest management and grazing impact but a high potential towards the site specific Potential Natural Vegetation. These sites have experienced forest management impacts and grazing but still maintain some oak trees.

Figure 40. typical Oak forest stands managed in coppice with standard forest management system near the Greek boarder. The forests may be considered as one of the closest forests to the Potential Natural Vegetation in the area and haver relatively little (compared to the other sites) grazing impact. With proper management they can be directed towards the PNV.

Stand description

The main upper story tree species are *Q. frainetto*. and *Quercus trojana* Webb. These are old grown trees while in the understory mostly *Cotinus coggygria* Scop., *Carpinus.orientalis*, *Fraxinus ornus*, *Ruscus acuelatus* and *Quercus trojana regeneration* are growing. The naturally regenerating tree species are *Quercus spp.and Acone of the pp.* Figure 4 provides the visualization of one of the plots the current stand situation with the tree modeling software MOSES 3.0. The modeling software could be applied rot assess future stand development under different management regimes. The tree age derived from increment cores ranged from 38 to 65 years and the mean annual radial increment over the last ten years ranged from 0.24 cm to 0.70 cm per year as in Table 1.

Table 6. Measurements from the Quercus. spp. trees at the 60 percentile of the diameter at breast height (DBH) distribution on the 4 plots recorded. MAI 10 is the 10 year mean annual increment with the standard deviation.

	North	East	South	West
Main Species	*Q. trojana*	*Q. frainetto*	*Q. trojana*	*Q. trojana*
Age in years	41	44	65	38
DBH in cm	17	17	31	24
MAI 10 (mm/year)	2.43 ± 1.2	3.6 ±1.5	2.53 ±0.6	2.41 ± 0.7

Future development and management options

Development under current management

Due to shrub layer and impacts of the live-stock farming, natural regeneration only establishes slowly. Oak seedlings have difficulties to regenerate. Oak as a thermophilous species which needs light. The high density resulting from the coppice management limits the light penetration and thus the growth of seedlings in the regeneration. Under current management (i) severe live-stock farming impact and (ii) some coppice management, the forest conditions are likely to degrade since natural regeneration is limited.

Potential management options

The fact that this forest is an example where with some changes in management a show case for promoting the stand succession toward the Potential Natural Vegetation (PNV) can be initiated the following management options are suggested:

- Regardless of the management option, the livestock farming impact needs to be substantially reduced or even abounded to avoid further soil compaction and the browsing of natural regeneration. This will require fencing at least for part of the area A further increase in livestock will destroy the forest and transform the area in the typical regional Macchia.

- **Management option 1: Coppice with Standard:** The change from coppice forest to coppice with standards will meet the demand of the local population for firewood and high-quality timber. The upper layer will consist of well-formed and vital *Quercus spp*., while the lower layer provides the fuelwood and may consist of *C. orientalis* and *Quercus spp*. This continuous forest cover management system needs regular interventions to decrease the competition for nutrients, light and water caused by the shrub vegetation. The decrease of the shrub layer would also lead to an increase in natural regeneration for the light demanding *Quercus spp*.

- **Management option 2: High forest:** Coppice forest management promotes species with a good sprouting potential and mainly focuses on fuel wood production. A typical high forest system focused on high quality timber using the native tree species. Again, especially in the transformation phase tending is needed to promote the typical natural species in the area. The typical frost management concept would be an open shelter wood which allows natural regeneration.
- **Management option 3 – Establishment of the PNV:** Considering that only very few areas in the Vjosa region have the potential to develop with the next decades toward a forest which somehow similar to the Potential vegetation sites like this could be seen as show case to demonstrate how a forest might look like without any human i9mpact. For this purpose, in the transformation phase management is required to promote the natural species, reduce the competition by secondary vegetation and mover y important to avoid a lives-stock impact by fencing areas. The management would have to focus on bringing in native tree species promote generative regeneration avoid sprouting or coppicing and create openings with soil preparation for natural regeneration.

3.3. Macchia Forests

General Information

Macchia is an anthropogenic secondary ever-green hard wood bush vegetation, which covers large Mediterranean areas. The climate is typical Mediterranean, with dry and hot summers and mild and wet winters. The western part of the Vjosa basin, due to lower elevation and the proximity to the sea, is warmer than the eastern part.

The Macchia vegetation is composed of broad-leaved evergreen shrubs, bushes, and small trees, usually shorter than 2.5 meters. This vegetation shows a number of adaptations to drought, grazing, and wildfires. Typical Macchia sites were originally covered with broadleaved Oak species. Intensive livestock farming combined with forest fires, followed by land degradation effects resulted in the typical hardwood bush vegetation found today. Since different stages of site degradation are evident in the Vjosa region, we selected three Macchia demonstration sites, which covers all stand situations in the catchment:

- **Example 1 - Heavy degraded Macchia Site,** with intensive livestock farming
- **Example 2 - Typical Macchia Site,** with moderate livestock farming impact
- **Example 3 - Less degraded Macchia Site,** with low livestock farming impact

General information on macchia stands

The three Macchia stands are located at N 40º 8' 41.8" E 20º 30' 18" (degraded stand), N 40º 8' 7.6" E 20º 30' 27.4" (middle stage stands) and N 40º 7' 44.7" E 20º 31' 43.6" (undegraded stand) at 388 m, 422 m, and 391 m above sea level. All stands are located close to the main road connecting Permeti with Greek border (Tre Urat)

Potential natural vegetation and the impact of grazing

Mediterranean sclerophyllous forests and shrubs include communities of xeromorphic evergreen tree and shrub species, especially of the genera *Quercus*, *Pinus*, *Juniperus*, and *Pistacia.* Sclerophyllous forests and scrubs occur on all slopes and expositions and most evergreen, broadleaved forest species can grow as trees or shrubs, depending on external influences. The holm oak (*Quercus ilex*) is the most competitive species in dry locations and, in some locations, is mixed with kermes oak (*Quercus coccifera*) and *Quercus cerris, Quercus frainetto, Fraxinus ornus,* and *Carpinus orientalis*. These species communities represent the potential natural vegetation on this Macchia sites. The sclerophyllous vegetation that characterizes many of the perennial trees and shrubs on these sites is able to conserve water and prevent nutrient loss due to small leaves.

With the increasing impact of livestock farming, oak forests are replaced by a very dense evergreen shrub layer composed of *Erica arborea, Arbutus unedo,* and *Arbutus andrachne, Myrtus communis, Phillyrea media* etc. On some sites, *Pinus halepensis* secondary forest stands were established and in many areas the understory is represented by the common shrub of the thermo-Mediterranean sclerophyllous shrub formations. Due to tough bark and high regenerative capacity through seed production, *Pinus halepensis* forest stands tolerate fire more than other tree species and for that reason, they may dominate or suppress oak as the main tree species. The south of Albania is climatically much more favorable and the East Mediterranean character in the evergreen sclerophyllous vegetation is more present since *Arbutus andrachne* appears in the shrub vegetation.

Figure 41. Positions of the stands. From north to south: degraded stand, middle stage stand, and undegraded stand. The yellow line is the Permeti-Tre Urat road.

3.3.1. Heavily degraded Macchia

Historical and current stand situation

The former oak stands have been cut for fuelwood and the landscape has been shaped by livestock, mainly sheep and goats. The oak stands did not regenerate and as a result, severe degradation took place, leading to soil erosion. The grazing impact has led to a secondary bush vegetation and a recovery of the PNV (mainly *Quercus spp*.) is impossible. In some areas, the erosion was so severe that most of the soil and humus layers is gone.

Figure 42. Example of an extremely degraded site induced by grazing

Management and future Development

Figure 41. Positions of the stands. From north to south: degraded stand, middle stage stand, and undegraded stand. The yellow line is the Permeti-Tre Urat road.

Currently, the stand appears to be unmanaged. Without any active replanting activity, the erosion will continue (as seen in Figure 2). Thus, the re-establishment of vegetation is essential to improve the site conditions and to avoid gully erosion. Vegetation protects the soil and helps to avoid erosion by their root system and surface water flow. However, on such sites, livestock farming must be abounded because any planting activity will be destroyed if livestock farming takes place. Thus, a separation of grazing land from forest land is required. Once bush or forest land is established, minor forest management for fuel wood production is possible. This will also ensure stand stability and promote natural regeneration with species such as *Quercus spp*. or *C. orientalis* representing the PNV. Regeneration of vegetation and replanting of degraded areas must be associated with engineering measures, such as the construction of check dams or establishment of double green fences in the areas with clear signs of gully erosion.

Risks

Grazing and browsing may hinder natural regeneration. Poor management of Macchia stands and lack of silvicultural interventions and tending may lead to unstable stands. Erosion (see Figure 3) may be a threat to local infrastructure such as roads, settlements and water reservoirs.

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Figure 43. Results of an erosion event at the site

3.3.2. Typical Macchia Site

Historical and current stand situation

Due to cutting as well as livestock farming, a secondary bush vegetation has developed. The degradation is not as severe and a recovery of the PNV (mainly *Quercus spp*.) could be possible. There is a rare presence of native trees of *Q. trojana* and *Q. cerris*, but the shrubs dominate the stand. The main species present in the stand were *Arbutus unedo*, *Cotinus coggygria*, *Phillyrea media*, *Arbutus andrachne*, *Juniperus oxycedrus* and *Erica arborea.*The tree density varies from 3400 to 7600 trees per hectare, with a diameter at breast height from 2 to 4.5 cm and height of up to 3.5 m.

Figure 13. Typical Macchia Site

Figure 44. Typical Macchia Site with some small Oak trees.

Management and future Development

The stand is unmanaged and moderate livestock farming hinders the progression towards the PNV. However (i) if farming on these sites can be avoided or substantially reduced and (ii) management is implemented to promote the typical tree species of PNV, we may be able to support the natural progession to restore a forest vegetation. We can expect that stand regeneration is initiated and upper layer should consist of *Quercus* spp., while in the lower layer *C. orientalis* and *Quercus* spp. will grow.

Risks

Grazing and browsing may hinder natural regeneration. Poor management of Macchia stands and lack of silvicultural interventions and tending led to unstable stands. Erosion of exposed soil poses a threat for the local roads.

3.3.3. Less degraded Macchia

History and Current Stand Situation

These sites have experienced the typical historic management of the region (cuttings combined with livestock grazing). Since it was not as severe, the forest stand conditions are in an intermediate stage between Macchia and oak forest stands. Patches with the typical Macchia bush vegetation, but also young to middle aged patches with trees near the PNV were present. The vegetation is very dense (see Figure 6) and their density varies from 9600 to 16800 individuals per hectare. The shrub layer consists mostly of *A. unedo, C. coggygria, Ph. media, J.oxycedrus and F.angustifolia*. The tree layer is multi-layered, with tree species below the 10-cm-DBH-threshold in the lower layers, such as *Q. frainneto*, *Q. cerris*, *Q. illex*, and *C. orientalis* reaching up to 7 m in height and *Q. cerris* in the upper-layer with a height of up to 9 m.

Figure 45. Site with low degradation impact

Management and Future Development

Currently, no regular management takes place and the stand is very dense. This protects the soil from erosion but also hinders the natural progression and growth towards the Potential Vegetation. Management such as tending and thinning will promote this transformation. The native tree species can be promoted and the Macchia patches will be reduced. The top layer should consist of well-formed and vital *Quercus spp*., while the lower layer should consist of *C. orientalis* and shrub species. The decrease of the shrub layer would also lead to an increase in natural regeneration for the light demanding *Quercus spp*.

Regular forest management would also provide fuel wood. Livestock farming has to be abounded or at least substantially reduced. The site is a typical case for how the degraded Macchia sites can be transformed into a typical forest for the region.

Risks

The risks are intensified grazing impacts and forest fires.

Summary

The selected Macchia sites represent the main forest cover type of the Vjosa region and range from very degraded sites to typical Macchia sites to areas where we see a transformation process from Macchia to forests typical for the Vjosa river basin.

3.4. Pinus halepensis: 3 Forest Stands

General Information

With the enormous land use change to meet the societal demands (large forest areas were converted into agricultural land) the forest area in the Vjosa catchment was substantially reduced during the last centuries. This has resulted in a loss of available timber, but also in severe erosion problems and thus a threat for the infrastructure since the protection function of the forest was no longer secured. As a result of this development, afforestation programs with Pinus halepensis were initiated after the 1970s in Albania. Although the species in not native to the area, it grows well on dry degraded sites, provides timber as well as fuel wood and improves water infiltration on hilly slopes. It is used for soil protection from erosion and protects the infrastructure and villages in the area. In the middle part of the Vjosa catchment, these forests are one of the major forest types. For our study, we selected three demo sites covering the age range and the associated management challenges.

- **Example 1 - Young Pine Stand** in Kaluth, about 364 m above sea level
- **Example 2 - Middle aged Pine Stand** in Kelcyre, about 260 m above sea level
- **Example 3 – Old Pine Stand** in Permet, atown about 400 m above sea level

Figure 46. Location of the three selected Pine stands. From north to south: young stand, old stand, and middle-stage stand.

Potential Natural Vegetation

Pinus halepensis was planted on sites where the potential natural vegetation includes Xerophytic coniferous and Mediterranean sclerophyllous forest types:

(i) Xerophytic coniferous forests and scrubs of conifer-dominated communities growing on dry sites with shallow soils with low ground water access. On these sites, the PNV is mainly formed by coniferous *Pinus* and their stand structure is shaped by edaphic and climatic factors. The natural vegetation would consist of *Abies borisi reggis* and *Pinus heldreichii*.

(ii) Mediterranean sclerophyllous forests, which include communities of xeromorphic evergreen tree and shrub species, especially from genera *Quercus*, *Pinus*, *Juniperus*, as well as *Pistacia.* In the Vjosa river basin, the J20 unit can be found. Sclerophyllous forests and scrubs occur on all slopes and expositions and most evergreen, broadleaved forest species can grow as trees or shrubs, depending on external influences like grazing, logging or wildfires. The holm oak (*Quercus ilex*) is the most competitive species in dry locations and, in some locations, is mixed with kermes oak (*Quercus coccifera*) and *Quercus cerris, Quercus frainetto, Fraxinus ornus,* and *Carpinus orientalis*.

In some cases, grazed oak forests are replaced by a very dense evergreen shrub layer, which can be composed of *Erica arborea, Arbutus unedo,* and *Arbutus andrachne, Myrtus communis, Phillyrea media* etc.

On these sites, pure, even-aged *Pinus halepensis* forests were planted. The understory often consists of thermo-Mediterranean sclerophyllous shrub formations. Due to the tough bark and the high regeneration capacity through seed production, *Pinus halepensis* forests tolerate fire more than other tree species. As a consequence, they may dominate or suppress oak as the main tree species. Although *Pinus halepensis* stands are planted on sites with low productivity, a field survey showed that this species has not improved the soil conditions. In the case of it being planted very densely, forest soils appear to be more acid and ground vegetation is rare.

3.4.1. Young Pine Stand

Historical Development

The PNV of sites where Pinus halepensis is planted is typical for Quercus spp., but this vegetation has changed over time as result of grazing and harvesting in the past and transformed into a degraded area with low soil productivity. The Pinus halepensis forest stands were established in the early 1980s by the state forest service, using seedlings produced in local nurseries allocated close to the planted sites. As a pioneer species, P. halepensis was often used to reforest bare lands in the Vjosa river basin, as well as other areas in the country. This was due to its resistance to harsh site conditions. The planting density varies, depending on site conditions and slope. The common density of planting was 2 x 2 m (2500 seedlings /ha) and the planting manner varies from terraces (60 cm - 80 cm width) in steep parts to holes in gentle slopes or flat parts.

Current Situation

The *Pinus halepensis* stand is artificial, established on a hill having a slope ranging from 40% to 62% close to Kaluth village in the Permeti area. The elevation of the hill varies from 339 m to 364 m above sea level and the dominant aspect is southeast. *P.halepensis* is the dominant species of the forest stand, while the understory is represented by *Quercus trojana, Quercus cerris Juniperus oxycedrus, Phillyrea media, Cotinus soggygria, Erica arborea,* and *Arbutus unedo.* During the field measurements, we noticed the presence of illegal logging and, in some parts, livestock grazing.

Stand Description

The forest stand consists of P. halapensis, established by the state forest service since the 1980s. The standing trees had a diameter at breast height ranging from 13.1 to 30.5 cm and height of up to 11.8 m.

Table 7. Measurements from the P. halapensis trees at the 60th percentile of the diameter at breast height (DBH) distribution. DBH is the Diameter at Breast height, MAI the mean annual radial increment for the last ten ears derived from increment cores, Height is the VERTEX-measured height.

	Kaluth- Young	**Kelcyre- Middle**	**Permet- Old**
Main Species	***P. halepensis***	***P. halepensis***	***P. halepensis***
Age in years	35 to 45	38 to 52	45 to 66
DBH (cm)	13.1 to 30.5	12 to 38.5	13.5 to 62.5
Radial MAI (mm)	2.3 to 2.6	0.5 to 1.2	1.6 to 2.3
Height (m)	8.3 to 11.8	13.5 to 16.5	8.1 to 15.6

The stem density varied in the stand, ranging from 287 to 605 trees per hectare. Natural regeneration is present in the site and, from our measurements, it has resulted in a young seedling number per hectare ranging from 400 to 2189. The understory vegetation and the pine regeneration depend strongly on the density of the main dominant trees in the stand. The forest stand crown density varies from 0.7 to 0.9. The timber quality of the dominant trees in the forest stand is very low, with curved trunks and trees having branches as low as 0.5 m from the ground.

Figure 47. Examples of young pine stands

Current Management and Future Development

The forest stand is managed as a high forest. From the field survey and the information gathered by the forest staff at the Permeti municipality, we found that no management has been applied in this young Pinus halepensis forest stand since its establishment. The current state of the forest stand was not good and sometimes grazing and illegal logging was present on the site. The quality of the timber and tree height indicate that site index and forest stand productivity is low. In order to improve the current situation, we suggest to control grazing in some parts of the forest stands and to carry out some tending operations, including branch removing up to 2 m from the ground to reduce the wildfire risk on the site. In some parts of the stand, there is clear evidence of rill erosion and some measures to prevent soil erosion should be considered.

Suggested Management Goals for the Site

Implementation of tending activities in this Pinus halepensis forest stands, including thinning, branch cleaning up to 2 m from the ground to avoid crown wildfires. A separation of grazing land from forest land is needed to meet the demands. Minor forest management for fuel wood production is possible in combination with ensuring stand regeneration.

Risks

Grazing and browsing may hinder natural regeneration. Poor management of Mediterranean coniferous forests and lack of silvicultural interventions and tending leads to unstable stands. Man-made fires pose additional threats for the stands.

3.4.2. Middle-aged Pine stand

Historical Development

The former stands probably consisted of Quercus spp., or A. reggis and P.heldreichii and have been harvested in the past. The area has been used for grazing. The forest stands were regenerated around 1970 using Pinus halepensis. The pioneer species P. halepensis was often used to reforest bare lands, due to its resistance to harsh site conditions. They occur on shallow soils of limestone, forming pure stands. This results in sparse, sometimes unstable, stands. As seen in Figure 2, the canopy of the stand was much denser in 2005 than it is in 2022, as seen in Figure 3.

Figure 48. Pine stand conditions in 2022

Current Situation

The *Pinus halepensis* forest stand situation situated in the front of Uji Trebeshina near Kelcyra municipality, was characterized by fallen-over trees, broken trees and damages causes by fire on some trees. The trees falling over is a result of the shallow rooting systems of P. halepensis. The bad conditions of the stand were further worsened by illegal logging and livestock grazing.

Figure 49. Several *P.halepensis* stands near Kelcyre. It is a typical middle-aged pine forest which urgently needs some thinning to enhance the stand stability.

Stand Description

The forest stand consists only of P. halapensis and has been established by the state forest service since the 1980s. The site has a slope ranging from 25% to 55%, a southern aspect and an elevation of 223 m to 260 m above sea level. The crown density is 0.6 and the tree number per hectare is 653 and varies from 382 (sample plot 1) to 987 (sample plot 4) trees/ha. The tree diameter at breast height (Dbh) ranges from 12 to 38 cm and the mean quadratic diameter is 26.2 cm. The standing trees have a height ranging from 8.1 to 15.6 m. Natural regeneration is missing in the site and ground vegetation is very rare. The timber quality of the dominant trees in the forest stand is bad, with curved trunks and branches reaching the ground and many felled and broken trees on the ground. At the bottom of the forest stand, there is clear evidence of livestock presence; this area is heavily grazed.

Current Management and Future Development

The present situation of the Pinus halepensis forest stand is an indicator of the lack of proper management. Since planting, no management has been implemented on the site.The only interventions are from local people that logged many trees illegaly and thereby decreased the crown density of the forest stand. These interventions negatively affected the remaining trees associated with their felling or breakage. These negative phenomenons are also favored by strong winds and shallow the root system of aleppo pine trees.The presence of many fallen trees indicates that timber exraction is missing and this poses more evidence for the mismanagement of the forest stand. In the future, we suggest timber estraction of the fallen trees and selling timber on the market and, at the same time, removing the branches of the standing trees to reduce the wildfire risk. In the open spaces of the forest stand, we suggest to interevene with reforestation, but by using other pine trees to establish a mixed forest stand or by using broadleaved species like oaks. Another measure is grazing prevention. For that reason we suggest fencing of the area along the main road and in some other parts.

Suggested Management Goals for the Site

Sites where P. halapensis has been proven to be unstable due to the nature of the tree species should slowly be transformed into the better adapted Potential Natural Vegetation.

Reestablishment and/or promoting the Potential Natural Vegetation by reducing the livestock impact and promoting management practices, which initiate natural regeneration of tree species representing the Potential Natural Vegetation.

Implementation of tending activities in Pinus halepensis forest stands, including thinning, dead wood removal, branch cleaning up to 2 m from ground to avoid crown wildfires.

A separation of grazing land from forest land is needed to meet the demands. Minor forest management for fuel wood production is possible in combination with ensured stand regeneration.

Risks

Grazing and browsing may hinder natural regeneration. Poor management of Mediterranean coniferous forests and lack of silvicultural interventions and tending lead to unstable stands. Man-made fires pose additional threats for the stands.

3.4.3. Old Pine stand

Historical Development

The former stands probably consisted of Quercus spp., or A. reggis and P.heldreichii and have been harvested in the past. The area has been used for grazing. The forest stands were regenerated using Pinus halepensis around 1955 close to the city of Permet (see Figure 5). The pioneer species P. halepensis was often used to reforest bare lands, due to its resistance to harsh site conditions. They occur on shallow soils of limestone, forming pure stands. The results are sparse, sometimes unstable, stands.

Stand Description

This forest stand consists of *P. halapensis* and has been established by the state forest service since the 1980s. The site has a slope of 30% to 48%, an eastern aspect and an elevation ranging from 325 m to 337 m above sea level. The crown density is 0.5 and the tree number per hectare is 350 and varies from 255 (sample plot 3) to 510 (sample plot 4) trees/ha. The tree diameter at breast height (Dbh) ranges from 13.5 to 62.5 cm and the mean quadratic diameter is 35.1 cm. The standing trees have a height ranging from 13.5 to 16.5 cm and most of them are leaning, due to the slope and strong winds. Natural regeneration is missing on the site and ground vegetation is represented by *Juniperus oxycedrus, Cotinus coggygria, Cercis siliquastrum, Phillyrea media, Pistacia terebinthos* and *Calutea arborescens*. In the forest stand*, Phlomis fruticosa, Paliurus spina christi,* and *Rosa canina* were present. These species are indicator species for livestock grazing. The state of the ground vegetation indicates that this site is heavily grazed. The timber quality of the dominant trees in the forest stand is poor and sometimes branched near to the ground.

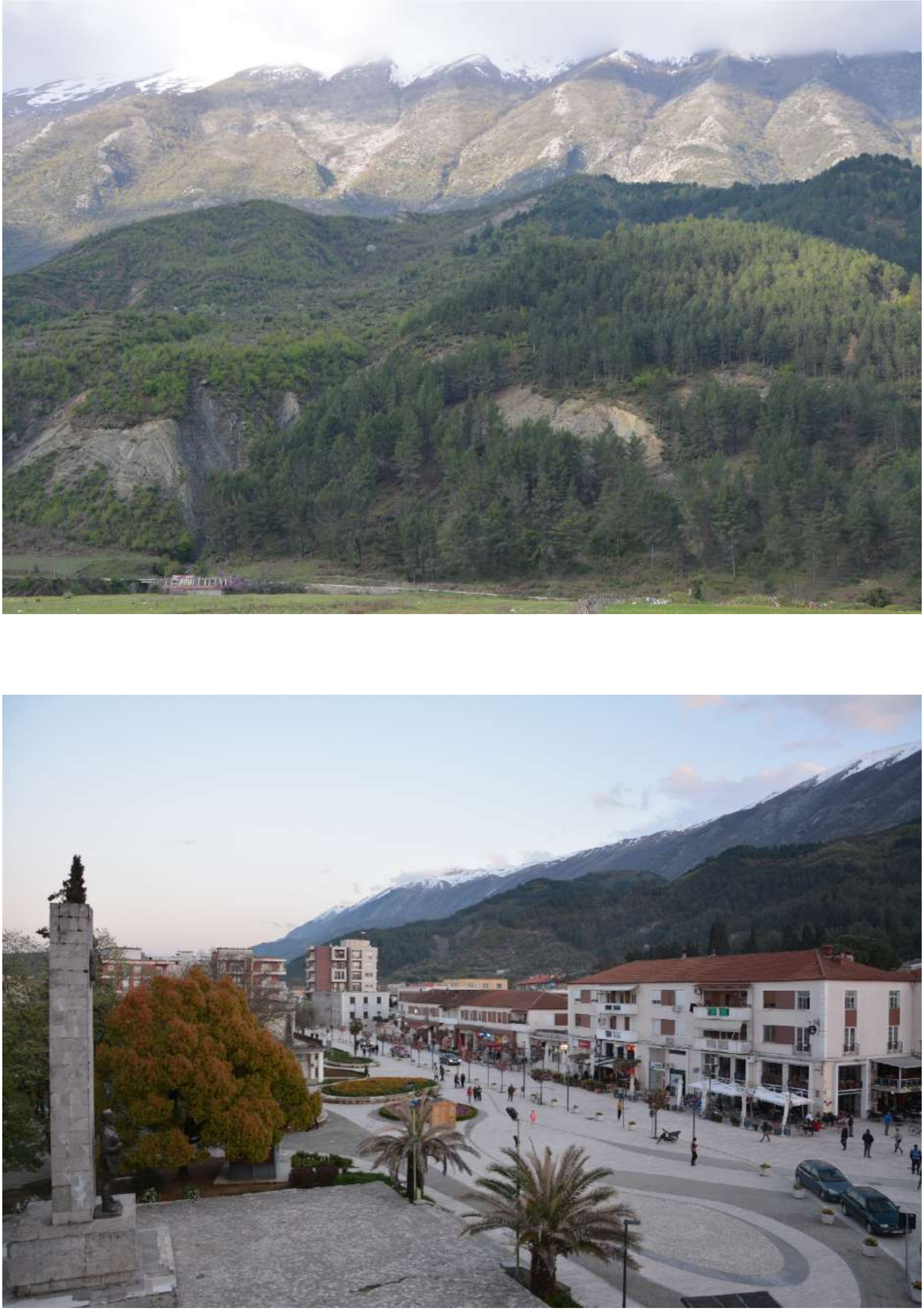

Figure 50. Old pine stands near Permet planted after the second world war. The forest fulfill a protection function for the soil as well as the infrastructure and provide fuel wood and timber for the local population.

Figure 51. Within stand situation of such old pine stands. Some regeneration of pine but also other species is evident. Forest management for further initiating regeneration is needed.

Current Management and future Development

The current situation of the forest stand indicates a lack of management. The main problem in the area is grazing and the forest service at municipality has not been paying attention. The low density of the forest stand favored the development of the understory, which in some parts is very dense and poses a risk for wildfires. In the case of wildfires starting from the understory, the fire can easily reach the pine crowns. Therefore, cleaning the branches in some pine trees is suggested. In addition, planting with Pinus pinea is suggested in open parts of the forest stand, with the aim to create a mixed pine stand.

Suggested Management Goals for the Site

In this Pinus halepensis stand, harvesting can slowly be initiated. Since there is no natural regeneration, the stand is in proximity to Permet and other forest functions may outweigh the economical one, a reestablishment of the potential natural vegetation could be initiated. A separation of grazing land from forest land is needed to meet the demands. Minor forest management for fuel wood production is possible in combination with ensured stand regeneration.

Risks

Grazing and browsing may hinder natural regeneration. Poor management of Mediterranean coniferous forests and lack of silvicultural interventions and tending leads to unstable stands. Man-made fires pose additional threats to the stands.

Closing remark

This pilot study provides an overview of the forest situation in the Vjosa region by

- Assessing the area covered with forests
- Define the major vegetation types
- Provide show cases or typical stands to demonstrate the historic management impact, the current situation and the potential future development of such ecosystems.

The next steps would be the development of a full forest management plan of the whole area which must include and/or address

- All the available local historical forest information
- A systematic forest inventory with a strong nature conservation focus
- A concept for establishing a nursery to promote local seed sources and local tree species
- The establishment of long-term research sites to study forest ecosystem succession
- A program how to deal with non-native tree species in the region considering the fact that this will become a national park.
- A management concept for live-stock farming. Note animals are the main threat to tees in the area. Nature conservation with no management of live-stock will be very difficult or even impossible.
- A monitoring system (in combination with the inventory and the long term research sites) to assess the anthropogenic impact

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Appendix 1:

Species composition by management units in Vjosa river basin

Management Units	Species composition by Management form		
	Shrubs	Coppice	High forests
Petran-Carshove	Pure forests of A.unedo	Forest dominated by Q.cerris mixed with Q.frainetto	Forests dominated by P.halepensis mixed with Q.trojana
	Pure forests of C.betulus	Forest dominated by Q.frainetto mixed with Q.cerris	Pure Platanus orientalis forests
	Forests dominated by A.unedo,mixed with Ph.media & C.coggygria	Pure Q.frainetto forests	Pure Abies borisii-regis forests
	Forests dominated by A.unedo mixed with Ph.media	Pure O.carpinifolia forests	Pure Pinus nigra forests
	Forests dominated by A.unedo mixed with E.arborea & Ph.media	Forests dominated by Q.trojana mixed with Q.frainetto	
	Forests dominated by A.unedo mixed with E.arborea	Forest dominated by Q.frainetto mixed with Q.trojana	
	Forests dominated by A.unedo mixed with C.orientalis & Ph.media	Pure Q.trojana forests	

	Forests dominated by A.unedo mixed with C.betulus & Ph.media		
	Forests dominated by C.betulus mixed with Ph.media		
	Forests dominated by A.unedo mixed with C.orientalis & J.oxycedrus		
	Forests dominated by C.betulus mixed with O.carpinifolia & C.avellana		
	Forests dominated by C.betulus mixed with J.oxycedrus		
	Pure C.betulus forest stand		
	Forests dominated by C.betulus mixed with Ph.media		
	Forests dominated by C.betulus mixed with O.carpinifolia		
	Forests dominated by C.betulus mixed with A.unedo		
	Forests dominated by A,unedo mixed with C.betulus		

	Forests dominated by A,unedo mixed with C.betulus &O.carpinifolia		
	Forests dominated by A.unedo mixed with C.coggygria		
	Forests dominated by C.betulus mixed with A.unedo & O.carpinifolia		
	Forests dominated by Ph.media mixed with C.orientalis & J.oxycedrus		
	Forests dominated by C.betulus mixed with A.unedo & Ph.media		
	Forests dominated by J.oxycedrus mixed with Ph.media & C.orientalis		
	Forests dominated by A.unedo mixed with O.carpinifolia		
Deshnice	Pure forests of Phillyrea media	Forests dominated by Acer sp mixed with Fraxinus ornus	Pure Forest with P.pinaster
	Pure forests of C.betulus	Forests of Acer mixed with Q.trojana & Fr.ornus	Pure Forests with P.halepensis
	Pure forests of C.orientalis	Forests dominated by Q.trojana mixed with Fr.ornus, Acer spp & C.orinetalis	

	Pure forests of J.communis	Forests dominated by Q.trojana mixed with Pinus pinea & Acer spp	
	Forests dominated by Phillyrea media mixed with Q.ilex	Forests dominated by Q.cerris mixed with Q.frainetto	
	Forests dominated by C.orientalis mixed with C.coggygria	Forests dominated by Q.frainetto mixed with Q.cerris	
	Forests dominated by C.orientalis mixed with O.carpinifolia	Forests dominated by Q.frainetto mixed with Q.pubescens and Q.cerris	
	Forests dominated by C.orientalis mixed with O.carpinifolia & Fr.ornus	Forests dominated by Q.cerris mixed with Q.pubescens	
	Forests dominated by C.orientalis mixed with Acer spp & O.carpinifolia	Forests of Q.petraea	
	Forests dominated by C.orientalis mixed with Acer spp	Forests dominated by Q.pubescens mixed with Q.cerris	
	Forests dominated by C.orientalis mixed with C.coggygria & J.communis	Forests dominated by Q.cerris,mixed with Q.frainetto and Fr.ornus	
Lomnice	Pure forests of A.unedo	Pure forests with Q.frainetto	Pure forests of A.borisii-regis
	Forests dominated by A.unedo mixed with Ph.media	Pure forests of Q.cerris	Forests dominated by F.sylvativa mixed with

			Q.frainetto & Acer pseudoplatanus
	Forests dominated by A.unedo mixed with Ph.media & O.carpinifolia	Forests dominated by Q.cerris mixed with Q.frainetto	Pure forests of P.halepensis
	Forests dominated by A.unedo and C.orientalis	Forests of Q.cerris and Q.frainetto	Forests dominated by P.halepensis mixed with R. pseudoaccacia
	Forests dominated by A.unedo mixed Ph media with C.orientalis	Pure forests with Q.trojana	Forests dominated by P.halepensis mixed with P.nigra
	Pure forests with C.orientalis	Forests dominated by Q.frainetto mixed with Q.cerris	
	Forests dominated by C.orientalis mixed with O.carpinifolia	Forests of Q.cerris mixed with Q.trojana	
	Forests dominated by C.orientalis mixed with A.unedo and Ph.media	Forests dominated by Q.cerris mixed with Q.frainetto & Acer	
	Forests dominated by A.unedo mixed with C.orientalis	Forests dominated by Q.cerris mixed with C.orientalis	
	Forests dominated by A.unedo mixed with Q.trojana	Forests dominated by Q.cerris mixed with Acer	

		Forests dominated by Q.cerris mixed with F.sylvatica	
Nemercke	Forests dominated by C.orientalis mixed with C.coggygria and J.communis	Pure forests of O.carpinifolia	Forests dominated by A.borisii-regis mixed with F.sylvatica
	Forests dominated by C.orientalis mixed with C.coggygria	Forests dominated by O.carpinifolia mixed with Acer and Fr.ornus	Forests dominated by A.borisii-regis mixed with F.sylvatica and Acer
	Forests dominated by C.betulus mixed with J.communis	Forests dominated by Q.cerris mixed with Bungbute	Forests of F.sylvatica with O.carpinifolia
	Forests dominated by C.betulus mixed with J.communis and C.coggygria	Forests dominated by Q.cerris mixed with Q.trojana	Forests of F.sylvatica with A.borisii-regis
	Forests dominated by C.betulus mixed with A.unedo and Shqopa	Forests dominated by O.carpinifolia mixed with C.orinetalis	Forests dominated by F.sylvatica with A.pseudoplatanus
	Forests dominated by J.communis mixed with C.betulus	Pure forests of Q.cerris	Forests dominated by A.borisii-regis mixed with O.carpinifolia
		Forests dominated by Q.frainetto mixed with Q.cerris and Q.trojana	Forests dominated by O.carpinifolia mixed with F.sylvatica and A.pseudoplatanus

		Forests dominated by O.carpinifolia mixed with Bungbute,Acer and Fr.ornus	Forests dominated by A.borisii-regis mixed with A.pseudoplatanus and Tilia sp
		Forests dominated by Q.frainetto mixed with Q.cerris	Forests dominated by P.nigra mixed with C.sativa and J.regia
		Forests of Bungbute and Q.cerris	Forests dominated by A.borisii-regis mixed with O.carpinifolia
		Forests dominated by Bungbute amixed with Acer sp	Forests dominated by A.borisii-regis mixed with Acer pseudoplatanus
		Forests dominated by Q.cerris mixed with Q.frainetto	Forests dominated by A.pseudoplatanus mixed with A. borisii-regis
		Forests dominated by Q.trojana mixed with Q.cerris	Pure forests of P.orientalis
		Pure forests of Q.trojana	Forests with P.halepensis
		Forests dominated by Q.cerris mixed with Pl .orientalis	Forests dominated by P.halepensis mixed with P.pinea
		Forests of Q.frainetto and Q.trojana	Forests dominated by P.halepensis mixed with P.nigra
		Forests dominated by Bungbute amixed with O.carpinifolia	Forests dominated by P.nigra mixed with P.halepensis

		Forests dominated by C.orinetalis mixed with Fr.ornus	
		Forests of Q.cerris and Acer spp.	
		Forests dominated by Q.trojana mixed with Bungbute	
Petran-Zavalan	Forest dominated by A.unedo mixed with Ph.media & C.coggygria	Pure forests of Q.trojana	Pure forests of P.nigra
	Forest dominated by A.unedo mixed with Ph.media	Pure forests of Q.cerris	Pure forests of F.sylvatica
	Pure forest with A.unedo	Pure forests with Q.frainetto	
	Forest dominated by A.unedo mixed with Q.ilex	Forest dominated by Q.trojana mixed with C.orientalis	
	Forest dominated by A.unedo mixed with Ph.media & Q.ilex	Forest dominated by Q.cerris mixed with Q.frainetto	
	Forest dominated by A.unedo mixed with C.orientalis	Forest dominated by Q.frainetto mixed with Q.cerris	
	Forest dominated by A.unedo mixed with Ph.media & Q.trojana	Forest dominated by Q.trojana mixed with Q.cerris & Q.frainetto	
	Forest dominated by A.unedo mixed with Ph.media & C.orientalis	Forest of Q.cerris mixed with Q.trojana	

	Forest dominated by A.unedo mixed with Ph.media,C.orientalis & O.carpinifolia	Forest dominated by Q.trojana mixed with Q.frainetto	
	Forest dominated by A.unedo mixed with Q.ilex,Ph.media & A.andrachne	Forest dominated by Q.frainetto mixed with Q.trojana & Q.cerris	
	Forest dominated by A.unedo mixed with A.andrachne	Forest dominated by Q.frainetto mixed with Q.trojana	
	Forest dominated by A.unedo mixed with Q.trojana & A.andrachne		
	Forest dominated by A.unedo mixed with Q.trojana & O.carpinifolia		
	Forest dominated by A.unedo mixed with O.carpinifolia		
	Forest dominated by A.unedo mixed with C.orientalis & O.carpinifolia		
	Forests dominated by C.orientalis mixed with Ph.media		
	Forest with C.orientalis		

	Forests dominated by C.orientalis mixed with O.carpinifolia		
	Forests dominated by C.orientalis mixed with A.unedo & Ph.media		
	Forests dominated by O.carpinifolia mixed with A.unedo		
	Forests with C. avellana		
	Forests dominated by C. avellana mixed with C.orientalis		
	Forests dominated by C.orientalis mixed with C. avellana.		
	Forests dominated by C.orientalis mixed with O.carpinifolia & C.avellana		
	Forests dominated by C. avellana mixed with O.carpinifolia		
Dangelli	Pure forests of C.orientalis	Pure forests of Q.cerris	Pure forests of F.sylvatica
	Forests dominated by C.orientalis mixed with C.avellana	Forests dominated by Q.cerris mixed with Q.trojana	Forests of F.sylvatica mixed with Q.cerris
	Forests dominated by C.betulus mixed with O.carpinifolia		Forests dominated by F.sylvatica mixed with P.nigra

	Forests dominated by C.betulus mixed with C.avellana		Pure forests of P.nigra
	Forests of C.avellana and C.orientalis		Forests dominated by P.nigra mixed with F.sylvatica
	Forests dominated by C.orientalis mixed with O.carpinifolia		Pure forests of A.borisii-regis
	Forests dominated by C.avellana mixed with O.carpinifolia		
	Forests of C.betulus and O.carpinifolia		
Dhembel-Kala	Forests dominated by C.orientalis mixed with C.coggygria	Pure forests of Q.cerris	Pure forests with A.borisi-reggis
	Forests dominated by Ph.media mixed with C.orientalis	Forests dominated by O.carpinifolia mixed with Acer spp & Q.petraea	Forests dominated by A.pseudoplatanus mixed with O.carpinifolia & Q.pubescens
	Forests dominated by C.orientalis mixed with Ph.media	Forests dominated by Q.cerris mixed with Q.frainetto	Forests dominated by A.borisi-reggis mixed with A.pseudoplatanus
	Forests dominated by C.orientalis mixed with O.carpinifolia	Forests dominated by Q.pubescens mixed with Q.cerris & Q.frainetto	Forests dominated by A.pseudoplatanus mixed with O.carpinifolia & Tilia spp

	Forests dominated by C.orientalis mixed with C.mass	Forests dominated by Q.frainetto mixed with Q.cerris & Q.pubescens	Forests dominated by Tilia spp.mixed with O.carpinifolia & F.ornus
	Forests dominated by O.carpinifolia mixed with Fr.ornus & Acer spp	Forests dominated by Q.frainetto mixed with Q.cerris	Forests dominated by P.nigra mixed with R.pseudoaccacia
	Forest of C.orientalis and O.carpinifolia	Forests dominated by Q.frainetto mixed with Q.cerris & O.carpinifolia	Forests dominated by P.nigra mixed with P.pinaster
	Forests dominated by C.orientalis mixed with Q.trojana & O.carpinifolia	Forests dominated by Q.cerris mixed with Q.frainetto & Q.pubescens	Pure forest with P.pinaster
	Forests dominated by C.orientalis mixed with Ph.media & J.oxycedrus	Forests dominated by O.carpinifolia mixed with C.orientalis & Acer spp	
	Forests dominated by Ph.media mixed with Q.trojana	Forests dominated by O.carpinifolia mixed with C.orientalis & Fr.ornus	
	Forests dominated by C.orientalis mixed with O.carpinifolia & Fr.ornus		
	Pure forests of Ph.media		
	Forests dominated by A.unedo mixed with Ph.media		
	Pure forests of C.orientalis		

	Pure forests of A.unedo		
	Forests dominated by Ph.media and A.unedo mixed with C.orientalis		
	Forests dominated by A.unedo mixed with C.orientalis		
	Forests dominated by C.orientalis mixed with A.unedo		
	Forests of Ph.media & C.orientalis		
	Forests dominated by C.orientalis mixed with A.unedo & C.coggygria		
	Forests dominated by C.orientalis mixed with O.carpinifolia,Acer spp & Fr.ornus		
	Forests dominated by C.orientalis mixed with J.oxycedrus & C.mas		