ALTERFOR

Deliverable 1.1 – FMM descriptions (in report form)

Project Title	Alternatives models and robust decision-making for future forest management
Project Acronym	ALTERFOR
Project Coordinator	Ljusk Ola Eriksson, Swedish University of Agricultural Sciences (SLU)
Scientific Coordinator	Vilis Brukas, Swedish University of Agricultural Sciences (SLU)
Project Administrator	Giulia Attocchi, Swedish University of Agricultural Sciences (SLU)
Project Duration	1 April 2016 – 30 September 2020
Project Duration in months	54
Authors, organizations (short name)	Main authors: Eric Agestam and Urban Nilsson, SLU Co-authors: local case coordinators
WP No., WPL(s)	WP1, Urban Nilsson and Eric Agestam
Date of delivery by Coordinator	07 June 2017
Date of delivery according to DoA	31 May 2017
Reviewed by	
Project coordinator, scientific coordinator, administrative coordinator	
Type of Deliverable	
Report	X
Demonstration	
Websites, patents, fillings, etc.	
Dissemination level	
Public	X
Confidential, only members of the consortium (including the Commission Services)	
Other	

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 676754.

I. Forest Management Models (FMMs) description

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10. Turkey

10.1. Background and forest history

The planning process has slowly evolved over time and noticeably changed over the last few decades in Turkey. From the first management plan, prepared in 1917, to the late 1990's, forests were man-aged for principally commodity production as maximizing timber production according to classical planning approach. Although some attempts were experienced in some regions as pilot projects such as Mediterranean forest use project (1970s and 1980s), Turkish-German collaborative model (1990s) Forest Resource Information System (FRIS) (late 1990s) and Global Environment Facility Fund (GEF II) (2000s) to replace the negative effects of the classical approach, multiple-use planning has become the Turkish forestry agenda in the last two decades.

By 1960s, forests were managed mostly with a single-tree selection silvicultural system regardless of the biological characteristics of existing commercial trees. For instance, uneven-aged management practices were applied to forests composed solely of light demanding trees (e.g., pine forests) even though those forests reflect single-layered even-aged stand structures. Unregulated and anomalous forest structures were created across the country leaving the forest managers with great dilemma. Realizing the detrimental consequences of inappropriate management actions of the time, even-aged management practices were introduced immediately after 1963. However, foresters were seen only to meet the allowable cut levels, and applied various forms of clear-cut management action. The practitioners unwittingly neglected the renewal of the harvested areas due to heavy administrational duties, short supply of seedlings in nurseries, ill-equipped technical foresters and lack of a control mechanism. As a result, many clear-cut areas were left untreated, exposing them to harsh natural disturbances such as weed competition, soil erosion, and wind blow-down. Thus, the idea of regeneration by either natural succession or plantation was virtually overlooked.

It was after 1971 that both uneven-aged management methods for tolerant trees dominated forests and even-aged for the rest of the forests were implemented across the country. On the other hand, neo-classic area-control or wood production oriented management of forest resources carried important shortcomings besides unresolved ownership, no spatial database established, forest stratification not carried; site, biodiversity, health and capacity inventory not conducted with GIS and RS, conservation of various forest values was not accommodated, decision making process with operations research techniques not conducted, and participation was not materialized. Therefore, modern management initiatives were undertaken later in the late 1990s. Various forms of multiple-use forest planning approaches were used in some forest districts. Since 2008, the planning process in Turkey has completely turned to an ecosystem based forest management concept accommodating biodiversity conservation, participation, multiple uses, and information technologies.

The planning process is centralized, with the planning teams formed each year by the forestry head-quarters and assigned to prepare a management plan for a planning unit. The plans are

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prepared for every 10 years based on management guidelines. Area, increment, and growing stocks of each stand type (identified by species mix, development stage, and crown closure) are measured in forest inventory. The production capacity is determined according to age and dominant height of stands. The current age or size class distribution is determined based on the forest inventory and the future forest structure is determined by the empirical yield tables. Using the area/ size regulation method, a harvest schedule is determined to maximize wood production in a single period, leaving other periods unplanned until the rotation period (Başkent and others 2005b).

Forest cover

In Turkey, forest lands cover 22.3 million ha, or 28 % of the national territory. Almost half of these forest resources are degraded; the other half is productive. High forests account for 88 % of total forest land, and coppice forests for 12 %. High forests contain 97 % of Turkey's standing tree volume, and coppice forests only 3 %. Turkish forests have rich and diverse biodiversity and nature protection values. The productivity of forest resources measured in terms of annual increments averages about 2.0 m^3/ha.

Ownership

The main stakeholders in forest resources are the public along with local communities, few private investors and forest owners. More than 99 % of forest resources are owned by the State, with the remainder owned by public or private entities. While, the first organization of forestry extends back to 1839, during rule of Ottoman Empire, the development of the forest legislation gained momentum after the Forest Law No. 3116 enacted in 1937 made first legal definition of forest and introduced the first set of forest policies. After the experience with private national and foreign contractors of forests for management, all forests were nationalized in 1945. This year marks as one of the important benchmarks of forestry history. Since the beginning, all forestry activities were carried out by single organization, The General Directorate of Forestry (GDF). Some of the functions of forests, such as national parks, protected areas, wild-life and game, have been taken to the responsibility of the "Nature Conservation and National Parks". Protected areas are cover nearly 10% of the forested lands.

Stakeholders' main rights to forest resources are access, exclusion, resources withdrawal, and alienation, with the exception of State forests, which cannot be alienated. In general, forest resources are planned by State authorities, with only very limited participation from other stakeholders. Forest resources management is implemented by the GDF as sustainably as possible, with some activities carried out by local people and private investors, such as afforestation and collection of NWFPs by private investors, and harvesting activities by forest villagers and forest village development co-operatives, according to relevant laws.

10.2. The case study area

The Gölcük study area is located in the Marmara region having broadleaved (generally mixed) productive forests when compared to other regions of Turkey. Climatic condition is very convenient for continuity and viability of forests and forestry activities such as regeneration or planting. Gölcük state forest enterprise owns nearly 91% of the total forest area which is much more when compared to other parts of Turkey. This characteristic is prominent when compared with other

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regions of Tur-key. However, forest owners are not willing to produce timber and private forests managed for other forest values such as aesthetics, recreation and chestnut fruit as a non-wood forest product. Forests having dense, medium and loose crown closure (>10%) comprises nearly 93%, which is quite higher than the Turkish average (nearly 53%). All forests within the CSA managed for even-aged forest management model/system. The annual increment is also nearly 4.7 m3/ha within the CSA, which is two times higher than country average (2 m3/ha).

In Turkey, indirect method is used for the determination of site quality considering the height growth of dominant, free growing trees in the upper forest canopy. There are some studies that accommodate the edaphic, climatic and typographic properties as well, but could not extend throughout the country and also in the case study area. Therefore, there is no information about the soil moisture content of the study area. In addition, nearly 3256 ha of the degraded forest land has no site information. Site index of the degraded stands could not be determined because of the selected method itself (indirect method). Conducted inventory method does not include distribution of productivity to the site. On the other hand, according to designed stand tables; the site productivity ranges from 5 to 7.5 m^3 ha^{-1} yr^{-1} in high site, from 2.5 to 5 m^3 ha^{-1} yr^{-1} in medium site and < 2.5 in low site.

Table 56. Distribution of forest area in high, middle and low production sites and estimate of production (right).

Productivity/soil moisture	Dry	Mesic	Moist	Wet	Productivity
High	15.6 %				5 – 7.5 m^3 ha^{-1} yr^{-1}
Medium	63.7 %				2.5 - 5 m^3 ha^{-1} yr^{-1}
Low	20.7 %				<2.5 m^3 ha^{-1} yr^{-1}

10.2.1. Land area and forest cover

Table 57. Total land area, forest area, standing volumes, productivity and ownership in CSA Turkey.

	CSA Gölcük	Turkey
Total area	81 808.5 ha	78 004 644 ha
Forest land	40 493.5 ha	22 342 935 ha
Proportion of forest land	49.5%	28.6%
High forests	40 126.5 ha	19 619 718 ha (88%)
Coppice	367 ha	2 723 217 ha (12%)
Growing stock	5 022 955 m^3	1 611 774 193 m^3
Productive forests (crown closure <10%)	37 237.5 ha (92.8%)	12 704 148 ha (57%)
Degraded forests (crown closure <10%)	3 256.0 ha (7.2%)	9 638 787 ha (33%)
Increment (m3)	189 858 (m^3)	45 904 083 (m^3)
Allowable cut (m3)	84 866 (m^3)	18 314 621 (m^3)
Forests managed for economical value	27 422.8 (67.7%)	50%
Forests managed for ecological value	10 574.2 (26.1%)	42%
Forests managed for socio-cultural value	3 659.1 (6.2%)	8%
Even-aged management	100%	98%
Uneven-aged management	-	2%
Pure stands	13 966.1 (34.4%)	62%

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Mixed stands	26 527.4 (65.9%)	38%
Forests under state ownership	40 493.5 ha (90.8%)	99%
Private forests	4 109.9 ha (9.2%)	1%
Protected areas	10.7%	7%

10.2.2. Tree species

Beech, *Fagus orientalis* is the by far most important tree species in the CSA. But there is a number of species important for forestry (Table 58).

Table 58. Tree species, proportion of total forest area.

	CSA Gölcük	Region	Country
Species (Latin name)	Proportion (% total volume)	Proportion (% of area as main sp.)	Proportion (% of area as main species)
Fagus orientalis	62.9	36.9	8.5
Castanea sativa	15.2	3.6	0.4
Carpinus betulus	7.3	5.4	0.2
Quercus petraea	3.4	24.8 (Quercus sp.	26.3 (Quercus sp.)
Quercus robur	3.3		
Pinus nigra Crimean pine	1.8	8.6	19.0
Abies nordmanniana	1.7	2.2	2.6 (*Abies* sp.)
Tilia (spp)	1.4	-	0.06
Pinus brutia Turkish pine)	0.7	6.6	25.1
Quercus frainetto	0.6	-	-
Other oaks (*Q. infectoria, Q. cerris, Q. hartwissiana*)	0.6		
Acer spp.	0.4	-	0.01
Exotic species (*Robinia pseudoacacia, Pinus pinaster, Cypress, Pseudotsuga menziesii)*	0.3	2.4	0.01
Other (*Platanus orientalis, Pinus sylvestris*)	0.4	1.5	6.8

Note: The proportion of the total volume refers to all tree species in the forest stands, however the proportion of area refers to the main tree species in the stands. The statistics were taken from forest management plans of the case study area renewed in 2015 and forestry statistics published by General Directorate of Forestry. The volume or area statistics is available for all oak species for the study area. However, region or country level statistics available for the whole Quercus species.

10.3. FMMs in the country and in the CSA Gölcük

Shelter-wood method is the dominant forest management method represented in the CSA Gölcük. Beech is the dominant species and shelter-wood system is applied in the regeneration of beech forests in Turkey. Forests having ES such as soil conservation, water conservation or aesthetics will not fully be regenerated and yet will have certain amount of allowable cut determined with a

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different management models, i.e., small area removal system and were evaluated in the "nature conservation with management". Extended rotation ages are sometimes applied in the conservation forests using shelterwood method. Nature conservation areas include legally declared protected areas such as nature parks, national parks or recreation areas and any forestry activities such as regeneration or thinning is prohibited within the CSA. Four decades ago, 1/3 of Turkish forests were managed with coppice system. Coppice forests have been converted to high forests and some oak forests are subject to this implementation, as the CSA has different kinds of oak species (nearly 8%).

10.4. Alternative FMMs

The silvicultural needs of the tree species presented substantial difference between the CSA and the entire country. The dominant tree species in the study area is beech. The ecological requests of this species necessitate the regeneration method as shelter-wood method. Shrubs, especially such as Rhododendron and cherries cause absence of light and as a result death. On the other hand, Turkish red pine (Pinus brutia) covers 25% of the Turkish forest area and those forests are regenerated via clearcutting. Legally declared nature conservation areas such as national parks, nature parks, national monuments or recreational areas cover larger areas in Turkey than in the CSA.

10.5. FMMs used in the CSA Gölcük

Shelterwood models dominate forest management in the CSA. More than half of the area is managed with such models. Management for conservation is used on 24% of the area. Other forest man-agement models used includes clearcutting and coppice systems, Table 59.

Table 59. The major forest management models (FMMs) used in CSA Gölcük, and the use in the CSA and in Turkey.

FMM, Domestic name in English	**Corresponding silviculture system**	**Coverage *CSA* Gölcük (% forestland)**	**Coverage Turkey (% forestland)**
1 Shelter-wood method	Uniform shelter-wood system	56.4	24.0
2 Shelter-wood method, long rotation	Uniform shelter-wood system	7.1	1.0
3 Nature conservation with management	None	24.4	28.0
4 Nature conservation	No intervention	3.9	20.0
5 Conversion of coppice	None	3.3	0.5
6 Medium rotation coppice	Coppice system	3.1	9.4
7 Short rotation coppice	Coppice system	0.9	0.1
8 Clear cutting	Clear cutting system	0.9	15.0

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Eco system services

Table 60. Ecosystem services connected to the four FMMs in CSA Gölcük. Ranking of important ES within each FMM. No ranking between FMM.

Forest manage model (FMM)	Ecosystem services in order, ranking from most (1) to least (5) important				
	1	2	3	4	5
1 Big area long shelter-wood method	Timber production				
2 Big area very long helter-wood method	Soil conservation	Water conservation			
3 Nature conservation with management	Soil conservation	Water conservation	Non-wood products	Aesthetics	
4 Nature conservation	Nature conservation	Nature parks	Recreation	tourism	Seed stands
5 Conversion of coppice (ES when converted to high forest)	None Timber products	Soil conservation	Water conservation	Non-wood products	Aesthetics
6 Medium rotation coppice	Timber products				
7 Short rotation coppice	Timber products				
8 Clear cutting	Timber products				

Introduced species

Forestry in CSA Gölcük is based on species as *Fagus orientalis, Castanea sativa,* Oak *spp. (Quercus petraea, Quercus robur, Quercus frainetto, Quercus infectoria, Quercus cerris,* and *Quercus hart-wissiana), Pinus nigra, Pseudotsuga menziesii*. There only exists 26 ha (among 2974 ha) Pseudotsuga menziesii stands planted nearly 50 years ago. Those stands were established for a test to investigate the availability of extending this species to large areas for timber production. However, there is no attempt to enlarge this species to the region or countrywide now. Besides, silvicultural guideline (Technical principles of silvicultural applications, No: 298) is suggested native species. However, guaranteed resuming the same tree species after regeneration in existing stands.

Non-European species are used very limited. In areas managed with clearfelling, approx. 1% of the total area of the CSA, Caribean pine (*Pinus pinaster*) are used.

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Natural regeneration is a very common method of regeneration and very local seeds are then used.

Genetically improved or modified seedlings

Mostly seed and seedlings originate from areas within 100 km from the CSA are used, except for Pinus pinaster that is introduced to Europe. Seed and seedlings origination from selected trees are used and in that way genetics are improved. No genetically modified seed/seedlings are used in Tur-key.

No tree hybrids are used in Turkish forestry.

Herbicides and chemicals used and fertilization

Herbicides and chemicals are not used in the CSA, however, pesticides are applied at nurseries for the fungus to prevent damping of in Pinus brutia and Pinus pinaster.

Fertilization is not used in the CSA, one reason is the cost and limited time and labour.

10.6. Shelterwood systems with long and very long rotation period

In the CSA two shelter wood systems or models are used. The difference between them are the length of rotation periods. Shelterwoods is the most used forest model in the CSA and Turkey, in the CSA they cover 63% of the area and about 25% on national level.

This shelterwood models is based on retention of overstory trees to act as seed-source and buffer the detrimental effects of a wide range of factors. The shelterwood models is used with almost all species except Pinus brutia in Turkey. Besides, high forests allocated for all values except for timber production are potentially managed with shelterwoods in even-aged forestry. Stands composed of especially beech, oak, chestnut and hornbeam species are covered by a great deal of different under-story species such as Rhododendron, smilax or berries in Turkey. In case of regeneration of those stands via clearcutting method, saplings are faced with lack of light and nutrient deficiency.

Rotation age is typical up to 140 years. There are also some standards to integrate nature protection in the stand-level management such as dead wood thresholds.

The shelterwood method and a longer rotation period is separated from the model described above only because of the length of the rotation. Long rotation periods are used in forests allocated for ecological or social values of ecosystem services with Beech. Conservation forests serving for soil and water conservation are also subject to this management model in the CSA.

Tree species used and tree species composition

The most common species with the shelterwood model are *Fagus orientalis*, *Castanea sativa*, and Oak spp. (*Quercus petraea, Quercus robur, Quercus frainetto, Quercus infectoria, Quercus cerris, Quercus hartwissiana*)

With shelterwood and long rotation most important are *Fagus orientalis, Pinus nigra*, and *Pseudotsuga menziesii*.

Nearly all of the tree species occur natural within the CSA, only 0.3% is exotic species, Pseudotsuga menziesii and Pinus pinaster. According to Technical Principles of Silvicultural Applications Act (No:

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298), all natural forests should maintain the same species mixture after regeneration. If the technical foresters or forest practitioners want to change the main species or species mixture, a report should be prepared and they should obtain permission from General Directorate of Forestry. Therefore, natural (which is actual) structure should be maintained.

Rotation periods

Site index of the regenerating stands should be considered in determining rotation periods. Beech stands reach the requested diameter for timber processing factories at nearly 100 years on good site and 120 years on poor site. Moreover, cavities or holes occur after certain years. On the other hand, foresters responsible for technical forestry activities such as silviculture, planting, forest protection etc. are generally manage large forest areas and leads reducing rotation age as a result of area control method. If the number of foresters increases, the rotation age would be decreased by 40 years. Today the rotation age is determined as 140 years for timber production in the CSA (note that dominant species is oriental beech in those stands).

Today the rotation age is the same in all site classes. If the rotation age is decreased, than the regen-eration area to be harvested will be increased according to “area control method”. The planning units (there are six planning units meaning six foresters responsible for technical forestry activities) cover nearly 5000 ha of forest lands each and one forest engineer or silvicultural expert is responsible for the regeneration, maintenance, forest protection, cadastral survey and supervision of all forest lands within the planning unit. Therefore, longer rotation ages are preferred to reduce the area of harvesting for regeneration. In this case, site index is not important since, the desired round wood is reached to that time for all sites.

In the model with shelterwood and long rotation the rotation period today is about 200 years. Two centuries is too long for the sustainability of those forests and rotation age should be shortened. For beech and Crimean pine, 140 years should be enough for soil or water conservation under this management model. Those conservation forests also need regeneration to sustain forest values after collapsing. The determined rotation age is high for healthy regeneration when considering seed source possibilities. In CSA Gölcük, there are limited stands reaching to 200 years although almost all of the stands are natural forests. Forest planners generally give higher rotation ages to avoid giving large regeneration areas allocated to those forest values. However, storms, insects or fungi dam-ages stands and those stands generally collapse before 200 years. For the conservation forests, 140 years seems to be ideal for the CSA.

Size of clearcuts

The size of the regeneration areas calculated via “area control method” for each forest management unit. This formula uses planning parameters as total forest area, rotation age and planning period. Although there is no restriction about harvesting area at one time point. The harvesting areas are distributed into the management unit and are avoided to regenerate adjacent compartments.

There is large variation in the size of the harvested areas in the CSA, the smallest are 1,4 ha, average 9 and largest 46 ha for shelterwood method and for shelterwood and long rotation 9,6, 41,4 and 88ha respectively.

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Forest regeneration

Considering the tree species in this FMM, 100% are natural regeneration. *Fagus orientalis, Castanea sativa* and Oak secies are growing with a high number of different understorey species such as Rhododendron, smilax or berries. In case of regeneration of those stands via clearcutting method, saplings are faced with lack of light and nutrient deficiency.

Site preparation, scarification, is needed and is done on all regenerated areas to get densities for high quality timber production. It is also important to increase the likelihood of regeneration in both models. Browsing and fencing

All areas in CSA Gölcü, also this the two models with shelter wood is fenced to avoid browsing. Browsing originated from game is negligible, however browsing from livestock, belongs to local people, has effects on the regeneration.

Stand management

Pre-commercial thinning

The Shelterwood model have timber production as a management goal. To get target diameters earlier pre-commercial thinning (PCT) is recommended at all stands at least once. By reducing the intensity of competition and to increase the accessibility in future thinning operations as well as for the purpose of quality selection, it is a good idea to perform pre-commercial thinning. In practice about half of the stands PCT are done. One technical forester is responsible for all forestry activities such as regeneration, thinning, protection, management within the planning unit. Therefore, the number of technical staff limits the target. Also forests, far from the roads and with high wood extraction costs could not be thinned. The price of the obtained material is not high enough as expected for application.

Not all but 70-80% of stands managed with shelterwood and long rotation are pre-commercially thinned. Soil and/or water conservation is set as a management goal in this management model. Therefore, the primary aim is not for wood production. However, to get resistant trees for diseases, wind effects or snow break, it is a good idea to perform pre-commercial thinning.

Commercial thinning

Thinning is required in all stands to achieve good diameter growth and get trees with good stability. The obtained material also find buyers from near timber factories. Not all forest, but about 80% are thinned, forest far from the roads and with high wood extraction cost could not be thinned.

Commercial thinning is recommended to be done in 70% of the stands where long rotation period is used. Forest far from roads and with high extraction cost is not thinned.

Pruning

Pruning is not done in any of the two shelterwood models

Harvest, transport and logging residues

Harvesters are not used at all. Chain saw is used for felling operations. Wood is extracted by forest tractor (60%) and my animal power and man power (40%). In very steep conditions small or middle

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size cranes or sledge-yarders are also used. Forest residues are not extracted, but they are generally collected by local people.

Nature protection

Silvicultural guidelines (Technical Principles of silvicultural Applications, No: 298) require some stand level targets towards dead wood management on the field. For instance, in economically designated areas for wood production, 1-3 dead wood trees per ha is to be retained in all managed are-as. When available, small areas of islands (<3ha) is promoted or left out for “aging islands”.

All deadwoods in the areas 50-80 meters away from the top of the timber line is strictly left un-touched in ecologically designated areas. Any silvicultural implementations should target up to 15 deadwood trees per ha, with ecological corridors. Small open lands in the forests should be left to nature and should not be regenerated. Thinning activities should be moderate in stands with a 25-50 m strip adjacent to narrow-based streams and in stands with a 50-100 m strip adjacent to broad-based streams. Besides, regeneration is prohibited in water conservation forest far from 300 m to stream.

10.7. Nature conservation with and without management

Nearly 25% of the forest area in the CSA is managed for nature conservation and another 4% is set aside for nature conservation. A model for forests having values other than timber, such as soil conservation, non-wood forest products, water conservation and aesthetics are predominant in this FMM. Final felling or harvesting is not currently applied, however, a certain lower amount of allow-able cut is taken from stands according to prominent forest values. The amount of allowable cut changes depends on the different conditions such as volume, increment, stocking, as well as forest values. *Fagus orientalis, Quercus petraea, Castanea sativa, Quercus robur, Pinus brutia and Quercus frainetto* are the dominated tree species in the CSA. Rotation age is determined extremely high between 180-200 years for beech and between 120-180 years for chestnut stands to have very small area for final harvest/felling and regeneration according to area control strategy, which is the pre-dominant forest regulation system. In fact, those stands should be regenerated earlier to sustain most of other forest values. Therefore some areas need to be more actively managed and the area managed with the model “nature conservation for nature consideration” is suggested to be reduced to 15% and the area for nature values without any management reduced from 4 to 2%.

Tree species used and tree species composition

Stands with *Fagus orientalis, Quercus petraea, Castanea sativa, Quercus robur, Pinus brutia, Quercus frainetto* included in the model for nature conservation with management and stands without any management are dominated by *Fagus orientalis, Castanea sativa, Quercus robur*.

Stands are typically mixed stands. All kind of mixtures are found.

Rotation periods

Rotation period is determined considering both forest values and rotation ages. For beech, oak and Crimean pine, 140 years is enough and besides for Turkish pine, chestnut and hornbeam 100 years is enough to sustain forest values after collapsing of the stands when considering seed source possibilities. In practice, rotation period is determined as 180 years for soil protection, 180 years for

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water protection, 180 years for aesthetics and 120 years for non-wood forest products. However, currently, there is no stands reaching those ages and there is no regeneration area in nature conservation stands. In this FMM, includes protection forest values such as soil conservation, water conservation and aesthetics, forest authority is not willing to apply regeneration activities and only maintenance activities such as thinning or pruning is carried out. Therefore, extremely high rotation years are determined to avoid regeneration.

In the core zone of the protected areas where no management is done, or in recreation sites, there is no need to determine rotation ages. On the other hand, nature conservation with management should be applied in other parts of the protected areas or recreation areas according to prominent forest value and tree species. In brief, considering the CSA, there is no need to determine a rotation period for the core zone of the protected areas and recreation sites. For beech, oak and Crimean pine, 140 years is enough, besides, for Turkish pine, hornbeam and chestnut, 100 years is enough to sustain forest values after collapsing of the stands when considering seed source possibilities.

In practice, rotation period determined as 180 years for recreation areas and 200 years for nature parks. However, there is no stands reaching those ages and there is no regeneration area for this FMM in the CSA. In this FMM, includes protected areas and recreation sites, forest authority is not willing to apply any forestry activities in terms of both maintenance and regeneration. Therefore, extremely high rotation years are determined.

Size of clearcuts

There are harvest and no regeneration activities in this model and therefor no clear-cut areas.

Forest regeneration

No activities to perform regeneration is performed.

Browsing and fencing

No regeneration and therefor no need for fencing

Stand management

Pre-commercial thinning

Nature conservation with management includes pre-commercial thinning. About 70% of the area is recommended to pre-commercially thinned. Stands in this FMM are allocated for soil conservation, water conservation, non-wood forest products, and aesthetics. Pre-commercial thinning is not suggested for aesthetics. However, stands allocated to other values needs pre-commercial thinning to get resistant stands to external risks and reach stands according to desired structure. Today 50-60% of the stands are pre-commercially thinned.

Commercial thinning

Nature conservation with management includes also commercial thinning. About 70% of the area is recommended to commercially thinned. Commercial thinning is not suggested for aesthetics. However, stands allocated to other values needs commercial thinning to get resistant stands to

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external risks and reach stands according to desired structure. Today 50-60% of the stands are pre-commercially thinned. The areas thinned is limited by lack of foresters.

Pruning

Pruning is not recommended and is not done.

Harvest transport and logging residues

Harvesters are not used at all. The topography and getting harvester cost is not suitable. Chain-saw is used for all precommercial thinning or thinning operations.

Nature protection

Nature protection is not only integrated, it is the objective of the management with this two FMM-. Most typical, silvicultural guidelines (Technical Principles of Silvicultural Applications, No: 298) require that all deadwoods in the areas 50-80 meters away from the top of the timber line are strictly left untouched in ecologically designated areas. Any silvicultural implementations should target up to 15 deadwood trees per ha, with ecological corridors. Small open lands in the forests should be left to nature and should not be regenerated. Thinning activities should be moderate in stands with a 25-50 m strip adjacent to narrow-based streams and in stands with a 50-100 m strip adjacent to broad-based streams.

10.8. Two models for coppice

On a minor part of the area in CSA Gölcük coppice systems are used, one system with a rotation of about 20 years and one with a much shorter rotation, 4 years. The two systems differ only in length of the rotation. The models is not applied over 60% terrain slope.

On 3% of the area coppice with medium rotation period are grown. Pole-wood demand is met via coppice method with rotation period of 20 years. The size of the area is sufficient to meet the demand.

The management method is based on clearing all shoots after reaching 20 years and providing new shoots. Timber production (pole woods or construction board) is set as management goal. The model is suitable for oak species and chestnut, however, chestnut is preferred in the CSA but it is not applied over 60% terrain slope.

Four year shoots of the chestnuts is used in the production of hand-craft chairs. Therefore a certain amount of flexible young shoot wood is demanded by the local tradesman. The 1% of the land in the CSA is managed with this model. This management model is based on cutting the shoots after reaching 4 years and providing new shoots. The shoots of the chestnuts is used in the production of hand-made chairs. Therefore a certain amount of flexible young shoot is supplied by the forest service. The model is suitable for oak species and chestnut, however, flexible young chestnut shoots is preferred.

Tree species used and tree species composition

The specie used is chestnut (*Castanea sativa*). The stands are monocultures.

Rotation periods

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 676754.

Most common is rotation period of 20 years. The desired round wood will be used for pole production and fire wood and the time period is enough for the desired wood material.

Wood for chair production as furniture is available in 4 years. Therefore, rotation period should be four years for some stands of chestnut.

Size of clear-cuts

There are no regulation of size of logging areas, the average size is 14 and 46 ha for stand with 20 year and 4 year rotations are used, maximum 55 and minimum 6,5 ha.

Regeneration

All new shoots/trees originate from shoots/coppice.

To fill gaps in stands and replace the old stumps scarification is needed at a certain rate.

Browsing and fencing

Trees are originated from shoots. Young shoots are fast growing and recover from deleterious effects of browsing originated from livestock. (Browsing by game is not important). Therefore fencing is not done.

Management

Pre-commercial thinning

No pre-commercial thinning is done today. But when rotation is longer, (20 years) all stand are recommended to be pre-commercial thinned. Fire wood production is set as one of management goal in this management model. To get maximum wood material, it might be a good idea to perform pre-commercial thinning to remove weak shoots and to increase the accessibility in future thinning operations. But this is not done due limiting number of foresters.

There is no need for pre-commercial thinning when rotation is short, four years. Stand could not reach pre-commercial stands in four years.

Commercial thinning

With a rotation period of four or 20 years there is no need for thinning, the stands are cut and re-generated again when they reach commercial dimensions.

Pruning

Pruning is not recommended and is not done.

Harvest transport and logging residues

Chainsaw is used. For extraction forest tractor is the leading method as nearly 80%. Besides, animal power and man power are used in very steep conditions.

With short rotation there are no residue branches to collect. In coppice stands with 20 year rotation age, there is limited forest residue as branches > 5cm. However, available forest residues are generally collected by local people.

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10.9. Conversion of coppice to high forest

In the past nearly 30 % of the Turkish forest land was managed with the coppice system. However, from the beginning of the 2000s, those forest lands have been converted to high forests. Those areas are now generally young and in pre-commercial stage. In the future, after conversion to high forests, those areas should be turned to uniform shelterwood system Today the nearly 3% of the forest area is under conversion from coppice to high forest.

Tree species used and tree species composition

The specie are oak species, (*Quercus petraea, Quercus robur, Quercus frainetto*) while the more valuable coppice specie chestnut (*Castanea sativa*) still is used for coppice (see Table 58).

The stands are monocultures but in the future some admixture is recommended, species like horn-beam, maple or chestnut.

Rotation periods

Regeneration is not permitted until the conversion of high forests is fulfilled. However, thinning for the maintenance of stands is applicable. Therefore, a nominal rotation period is determined as 80 years for this planning period. After conversion, a realistic or practical rotation period will be determined according to target ecosystem service.

Regeneration

The aim is conversing coppice stands to high forests, therefore this can be regarded as a temporary process rather than a model. After conversion of coppice to high forest the purpose of the method will be completed. Regeneration is also not permitted until the conversion of high forests. The trees growing, the new high forest is established as coppice.

Stand management

Pre-commercial thinning

Although the management goal is not defined for this method and the only aim is conversion of coppice, it is important to make maintenance applications to reach high forest. Pre-commercial thinning is one of the tools while conversion of coppice to high forests and should be done in all stands. Today only 60-65% of the stand is pre-commercially thinned due to lacking forest technicians.

Commercial thinning

Thinning is another tool while conversion of coppice to high forests. It is also important to get trees with good stability. The obtained material is also used by near timber factories. 75-80% of the stands are thinned. Forest far from roads and where extraction cost is high is not thinned.

Pruning

Pruning is not done, as it is not suggested for broadleaves.

Harvest transport and logging residues

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 676754.

The topography is not suitable for harvesters and the cost is high. Chain-saw is used for all maintenance operations. For extraction forest tractor is the most common method. Besides, animal power and man power are used. In very steep conditions small and middle size cable cranes or sledge yarders are also used

Forest residues are not extracted; however they are generally collected by local people.

Nature protection

Converting from coppice stand to high forest is a way to increase nature values. Forest value such as wood production, water conservation or soil conservation will be determined after conversion. Forest values are very efficient or determinative in integration of nature protection in the stand-level management.

10.10. Clear cutting model

Nearly 1% of the forest area is managed with a clearcutting system. The dominant tree species are Turkish pine (*Pinus brutia*) and maritime pine, (*Pinus pinaster*).

Tree species used and tree species composition

Turkish pine (*Pinus brutia*) and maritime pine, (*Pinus pinaster*) (exotic) should be used. Those species are fast growing and appropriate for the wood production.

More or less pure stands with Turkish pine as main specie and in most cases maximum 25 % admixture of maritime pine.

Rotation periods

Rotation age is regulated and in practice determined as 60 years regardless of the site index. However, on best sites, lower rotation age, as 50 years, is recommended to use. There is no need to wait extra 10 years in good site.

Size of clear-cuts

The size of the regeneration areas is calculated via “area control method” for each forest management unit. This formula uses planning parameters as total forest area, rotation age and planning period. Second, there is a “25 ha” size restriction about harvesting area at one time point. The maximum clearfelled are is 25 ha, the smallest 7 ha and the average 18 ha.

Regeneration

90 % of the seedlings reaching pole stage are planted, 10 % are natural regeneration. The management goal is maximum timber production and dominating species Turkish pine and maritime pine are both eligible for artificial regeneration and there is no problem for growing young stands.

Scarification is important to increase the success of establishment and are done in all clear-cuts. It results in an increased initial growth of the seedlings through better nutritional status and reduced mortality.

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Browsing and fencing

Browsing originated from game is negligible, however browsing from livestock, belongs to local people, has effects on the regeneration therefore all regeneration areas after clearfelling is fenced.

Stand Management

Pre-commercial thinning

Turkish pine and maritime pine are fast growing pioneers. To get target diameters earlier by reducing the intensity of competition and to increase the accessibility in future thinning operations as well as for the purpose of quality selection, it is a good idea to perform pre-commercial thinning. It is also important for reducing the fire risk in pine stands.

About 50-60% of the stands are pre-commercially thinned. Lack of forest technicians limit the areas pre-commercially thinned.

Commercial thinning

Thinning is required to achieve good diameter growth and trees with good stability. The obtained material can also be sold to buyers from near timber processing firms. It is also important for reducing the fire risk in Turkish pine and maritime pine stands. 80-90% of the stands are thinned. Forests, far from the roads and with high wood extraction costs could not be thinned.

Pruning

Pruning is not as it is not suggested.

Harvest transport and logging residues

The topography and harvester cost is not suitable. Chain-saw is used for all maintenance operations. For extraction forest tractor is the leading method as nearly 60%. Besides, animal power and man power are used. In very steep conditions small size cable cranes, middle size cable cranes or sledge yarders are also used

Forest residues are not extracted; however they are generally collected by local people.

Nature protection

Silvicultural guidelines (Technical Principles of Silvicultural Applications, No: 298) require some stand level targets towards dead wood management on the field. For instance, in economically designated areas for wood production, 1-3 dead wood trees per ha is to be retained in all managed are-as. When available, small areas of islands (<3ha) is promoted or left out for “aging islands”.

10.11. References

Persons involved:

Dr. Uzay KARAHALİL, Researcher and Assistant Professor at Karadeniz Technical University, Field of Study; Forest Management

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 676754.

Prof. Emin Zeki BAŞKENT, LCC and Professor at Karadeniz Technical University, Field of Study; Forest Management

Prof. İbrahim TURNA, Karadeniz Technical University, Field of study is silviculture, nursery and seed technology.

Prof. Ertuğrul BİLGİLİ, Karadeniz Technical University, Field of study is wild fires.

Murat VARLIBAŞ, Branch manager of silvicultural plans at Turkish General Directorate of Forestry

Ünal AYGÜL, Vice director of the Sakarya forest nursery.

Cemil KURU, Forest officer responsible for Gölcük Forest Management Planning Unit.

Sabiha DİLSİZ, Forest officer responsible for Kadırga Forest Management Planning Unit.

Mustafa LEVENT, Forest officer responsible for Karamürsel Forest Management Planning Unit.

Ali BAL, Forest officer responsible for Suadiye Forest Management Planning Unit.

Emrah YAŞA, Forest officer responsible for Kartepe Forest Management Planning Unit.

İlker Mete DAŞDEMİR, Forest officer responsible for Yuvacık Forest Management Planning Unit.

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 676754.

ALTERFOR

II. Ranking of Ecosystem Services (ES)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 676754.

2.9. Turkey

2.9.1. Assessments of FMM in terms of Biodiversity at stand level

Clearcutting with intermediate rotation – Calabrian pine.

This FMM is based on clearcutting and then planting of Pinus brutia, because other species generally have understorey problems and covered by a great deal of different species such as Rhododendron, smilax or berries that prevent regeneration. This FMM is applied in timber production not in other forest values such as soil conservation, water conservation or aesthetics. Rotation age was used to be 60 years. Maximum regeneration areas are restricted with 25 ha. There are also some standards to contribute to the nature protection in the stand-level management such as dead wood thresholds. In clear CC FMM all other individual native trees or plants not threatening the natural regenerations are recommended to leave over. For these reasons Calabrian pine stands have some aspects that are both potentially consistent and inconsistent with biodiversity goals addressing forest structures.

Clearcutting with short rotation – Maritime pine.

Maritime pine is a fast growing exotic tree in the region, its regeneration is based on clearcutting and then planting. This FMM is applied in timber production not in other forest values such as soil conservation, water conservation or aesthetics. Rotation age was used to be around 50 years. As in Calabrian pine stands, maximum regeneration areas are restricted with 25 ha and other native trees or plants not threatening the natural regenerations are left over. However there are not many other species in the site. For these reasons Maritime pine stands have very little aspects that would both contribute to the biodiversity goals. Thus the score was low.

Big area/uniform shelter-wood method (Very Long Rotation) – Oriental beech, Anatolian pine and Oak spp.

This FMM is based on retention of overstory trees as seed-source and buffer the detrimental effects of a wide range of factors. Forests classified for ecological and socio-cultural values are potentially subject to this FMM in even-aged management systems. Stands composed of especially beech, oak, chestnut and hornbeam species are covered by a great deal of different understorey species such as Rhododendron, smilax or berries in Turkey. This FMM prevents direct sun light and assists saplings. Big area shelterwood system is applied to forests with Fagus orientalis, Castanea sativa, Quercus spp., Pinus nigra, Pinus sylvestris, etc. species. Conservation forests focusing on soil and water conservation are subject to this FMM in the CSA. The rotation age is around 200 years. There are also some standards to integrate nature protection in the stand-level management such as dead wood thresholds. Thus, this FMM ranks quite higher than clearcutting FMM.

Uniform/long rotation shelter-wood method (Long rotation) – Oriental beech, Anatolian pine and Oak spp.

Similar to very-long rotation shelterwood method. Stands composed of especially beech, oak, chestnut and hornbeam species are covered by a great deal of different understorey species such as Rhododendron, smilax or berries in Turkey. The rotation age is around 140 years. The contribution to the amount of deadwood is a bit lower than the very long rotation shelterwood system. Thus this FMM has a bit lower score.

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NS – nature conservation with management

The nature conservation with management may provide higher biodiversity values than many of the production forest alternatives due to the fact that conservation is the dominant/main purpose of this FMM

Nature conservation / NS without management

The nature conservation without management is expected to provide much higher biodiversity values than many of the other FMMs due to the fact that conservation is the solo purpose of this FMM

Conversion of coppice

None of the above FMMs resembles this FMM. Regeneration is not permitted until the conversion of high forests in this FMM. However, thinning for the maintenance of stands is applicable. Currently, a nominal rotation period is determined as 80 years. This FMM is based on all Oak species In Turkey. Thus, there is a certain biodiversity value as the coppicing is abandoning and is expected that in the future the FMM will provide better value for biodiversity.

Medium rotation coppice

FMM is based on clearing all shoots after reaching 20 years and providing new shoots. Timber production (pole woods or construction board) is set as management goal in this FMM. This FMM is suitable for oak species and chestnut, however, chestnut is preferred in the CSA. Thus, there is a low level of biodiversity value as the coppicing is the main actions of this FMM.

Short rotation coppice

This FMM is based on cutting the shoots after reaching 4 years and providing new shoots. Four-year shoots of the chestnuts is used in the production of hand-made chairs. This FMM is suitable for oak species and chestnut, however, chestnut is preferred in the CSA. Thus, there is a very low level of biodiversity value as the intensive coppicing is the main actions of this FMM.

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Table 47. Eight Turkish FMMs and associated subcategories ranked in terms of their relative capacity to close the gap between the habitat provided in production forests and the habitat requirements of forest dependent flora and fauna.

FMM	FMM subcategory	Tree species composition (Native trees, broadleaf trees, tree species diversity)	Forest structures (older / larger trees coarse woody debris)	Disturbance regime (emulate natural disturbance regimes spatially and temporally	Rank out of 7
Uniform shelter-wood method (FMM1)	Fagus orientalis. Pinus nigra, Oak spp. shelterwood	5	4	5	4.66
Big area/uniform shelter-wood method (long rotation) (FMM2)	Fagus orientalis, Pinus nigra, Oak spp. shelterwood	6	5	6	5.66
NS - Nature conservation with management (FMM3)	Mix of tree specie; mostly beech, oak, chestnut broadleafs and the pines	6	6	7	6.33
Nature Conservation (FMM4)	Mix of all native tree species existing in the area	7	7	7	7.00
Conversion of coppice (FMM5)	All Oak species	5	4	4	4.3
Medium rotation coppice (FMM6)	All Oak and chestnut species	4	2	2	2.66
Short rotation coppice (FMM7)	All Oak species	3	1	1	1.66
Clear cuttings systems (FMM8)	Calabrian pine (>70% basal area)	3	3	3	3
	Maritime pine (>70% basal area)	2	3	3	2.66

Reference list

The information is based on the view and interpretation of wildlife biologists and the literature of

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 676754.

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2.9.2. Stand level assessment of Carbon sequestration value of Turkey's stand level FMMs

The stand level assessment is conducted at a stand level using a simple spreadsheet programme for C stock in forest and HWP as well as the substitution. A quick assessment is based on the same stand input in order to make a comparison possible. The relative ranking of FMM is dependent on the fact that they are based on the same conditions. The site conditions is assumed to be average conditions in the Gölcük CSA.

The FMM descriptions below are brief descriptions of Carbon stock and flow.

FMM1: Uniform shelterwood system (Oriental beech)

The assumption here is that management is relatively intensive and follows more or less a clear cut kind of management with slow clearance of final felling. The simulation is based on beech which is the dominant species in this kind of FMM.

FMM2: Uniform/long rotation shelter-wood method (Long rotation) – Oriental beech)

/similar expectations with FMM1/

FMM3 – nature conservation with management

The assumption here is that management is relatively less intensive and follows more or less a continuous cover forest kind of management.

FMM4: Nature conservation

This FMM assumes no intervention at all. As pointed out above, the growth tends to slow down over time. The figures showed something like a stabilization in the last decades over the simulation. The stand is a Beech dominated stand.

FMM5: Conversion of coppice

We do not have much info about the conversion. Thus, it is left out

FMM6: Medium rotation coppice

/similar to FMM7/

FMM7: Short rotation coppice

This is similar to CC yet with a short rotation of Oak stands

FMM8: Clearcutting with intermediate rotation – Calabrian pine.

Calabrian pine is the only species allowed for CC FMM. The Calabrian pine stands are natural stands intensively managed, structurally-simplified, single-species dominated, and thus relatively homogenous production forest alternatives.

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Table 48 Stock and flow of C for different FMM (all figures per ha; the same colour = the same C impact).

FMM	FMM subcategory	Rotation length (y)	Stock (tC)	Substitution (tC/y)	Rank out of 7 (stock/subst)
Uniform shelter-wood method (FMM1)	Fagus orientalis, Pinus nigra, Oak spp. shelterwood	120	204	0,1611	5/4
Big area/uniform shelter-wood method (long rotation) (FMM2)	Fagus orientalis, Pinus nigra, Oak spp. shelterwood				
NS - Nature conservation with management (FMM3)	Mix of tree specie; mostly beech, oak, chestnut broadleafs and the pines	240	240	0,27	6/5
Nature Conservation (FMM4)	Mix of all native tree species existing in the area	240	244	0,00	7/1
Conversion of coppice (FMM5)	All Oak species				
Medium rotation coppice (FMM6)	All Oak and chestnut species				
Short rotation coppice (FMM7)	All Oak species	20	15,89	0,014	1 / 2
Clear cuttings systems (FMM8)	Calabrian pine (>70% basal area)	60	93,43	0.05713	4/3
	Maritime pine (>70% basal area)				

The BAU global strategy was used to relatively compare some FMM with respect to C stock and substitution. It appears that forest conservation with a relatively longer rotation gives the largest stocks at the expense of no substation (Table 49). The common use of shelterwood programme seems as a good alternative due to its growth and usability. Clear cut management model with Pine stands produces relatively enough amount of carbon stock with a medium level of substitution. The short rotation of Oak used in coppice FMM provides the lowest amount of carbon stock as expected.

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Table 49 Stock and flow of C for different FMM under BAU scenario (all figures per ha).

FMM	Beech Shelterwood	Pine ClearCut	Oak Coppice	Conservation	
Stock (tC)	204	93,43	15,89	244	
Substitution (tC/y)	0,161	0.057	0.014	0.000	

2.9.3. Cultural

Ranking of FMM 1-8 in terms of cultural values shows that FMM 5-8 have lower ranking than FMM1-4, in all attributes except visual scale, Figure 39 Cultural Services FMM 1- 8, Turkey. FMM5 to 7 are characterised by coppice, conversion of coppice, medium rotation and short rotation coppice respectively and FMM8 is clearfelling model.

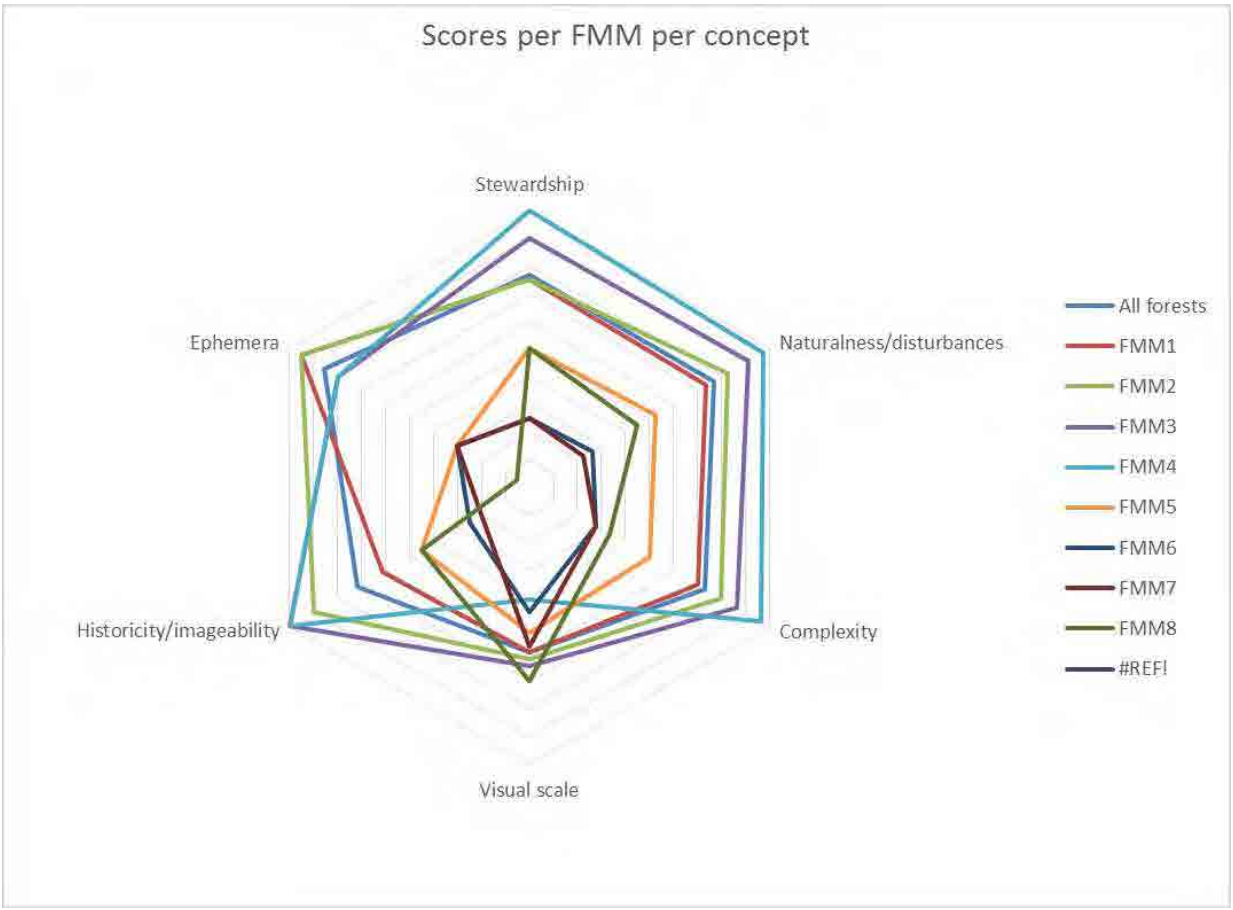

Figure 39 Cultural Services FMM 1- 8, Turkey

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2.9.4. Assessment of the contribution of FMMs to mitigate impacts of catastrophic events Gölcük CSA

We will prepare a non-model based forest fire vulnerability assessment of GÖLCÜK CSA. The vulnerability classes will be characterized according to a number of stand based **biometric and spatial** metrics. These include species type, basal area, number of trees, development stages, age, topography and shape of patches. The scale of the Fire Sensitivity Index (FSI) is between 0, no fire danger, and 10, extremely sensitive to fire. Here is the list of dendrometric and topographic criteria and their associated fire sensitivity indices.

Basal area (m2/ha)

Number of trees (n/ha).

Quadratic mean diameter (cm)

Dominant height (m)

Understory biomass (Mg/ha)

Age (years) in the case of even-aged stands

Distribution of tree sizes (% of Vol/ha of each size class)

Species composition (% of Vol of each species/ha)

Table 50 Fire Sensitivity Index (FSI) for some combinations, age and tree species (top), age and mixture (second), basal area (third), no of trees per ha (fourth), slope (second from bottom) and patch figuration (bottom).

Species (Fuel Type)	Fir Spruce			All Hardwood Trees			Pine (Calabrian pine, Anatolian pine)			Pine (others)		
Age	<4	80	>80	<40	80	>80	<30	50	>50	<30	50	>50
FSI	1	2	3	1	3	2	10	7	5	9	5	4

Species (Fuel Type)	Coppice	Mixed (Hardwood+Softwood)			Mixed (Softwood+Hardwood)		
Age	<40	<40	80	>80	<	50	>50
FSI	1	3	4	3	7	5	4

Basal Area	80	70	60	50	40	30	20	10	0
FSI	1	2	3	4	5	6	7	2	0

#trees	>50	400	300	200	100	500	250	50	20
FSI	4	8	10	7	5	3	2	1	0

Slope		**Aspect**		**Elevation**		**Canopy**		**Development stages**	
%	**FSI**		**FSI**	**M**	**FSI**	**%**	**FSI**	**DBH class**	**FSI**
<5	2	N	2	<200	10	<10	1	a (0-19,9cm)	4
15	4	NE	4	500	7	10	2	b (20-	10

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Slope		Aspect		Elevation		Canopy		Development stages	
30	6	E	4	1000	5	40	5	c 36-	6
50	8	SE	6	>1000	3	70	8	d (>52cm)	2
>50	10	S	10			>70	10		
		SW	8						
		W	4						
		NW	2						

Patch Config	Near Circle			Regular			Irregular			Meandering		
$\frac{(2\sqrt{\pi}\sqrt{Area})}{Perimeter}$	1	0,9	0,8	0,7	0,6	0,5	0,4	0,3	0,2	0,1		
FSI	10	9	8	7	6	5	4	3	2	1		

When producing the fire vulnerability map of the CSA we will use the ***combined value*** of the various parameters of forest fires listed above. Then, we will slice the area into five major vulnerability categories-VU **(5 - very high vulnerability, 4- high vulnerability, 3 - average vulnerability, 2- low vulnerability and 1 - very low or no vulnerability)** in terms of ***combined*** VU classes. We caution that the combined values are literally/quantitatively used here, no qualitative differences were sought for the sake of clarity and simplicity.

The following sample table shows the simple implementation of above indicators for a 40 year old Calibrian pine stand with 20m2 basal area, 500 trees, 30%slope, SE aspect, 1000m elevation, 30% canopy, 30cm dbh and Irregular shape. This stand is scored to be ***"average vulnerability***" for both FMM4 and FMM8 (other FMMs are not applicable for this stand). However, as the stand changes over time with respect to the FMM, thus some of the parameters such as basal area, age, #of trees will change, than the effects of different FMMs will emerge.

Table 51 implementation of above indicators for a 40 year old Calibrian pine stand

FMMs	Age - Species composition	Basal area	# of trees	Slope	Aspect	Elevation	Canopy	Development stages	Patch Config	Score out of 5 (VU)
Uniform shelter-wood method (FMM1)	N/A									
Big area/uniform shelter-wood method (long rotation) (FMM2)	N/A N/A									
NS - Nature conservation with management (FMM3)	N/A									
Nature Conservation (FMM4)	7	7	3	6	6	5	2	10	3	2.7 (Average)

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FMMs	Age - Species composition	Basal area	# of trees	Slope	Aspect	Elevation	Canopy	Development stages	Patch Config	Score out of 5 (VU)
Conversion of coppice (FMM5)	N/A									
Medium rotation coppice (FMM6)	N/A									
Short rotation coppice (FMM7)	N/A									
Clear cuttings systems (FMM8)	7	7	3	6	6	5	2	10	3	2.7 (Average)

2.9.5. Evaluation of water related ecosystem services – CSA Gölcük

In Gölcük case study area, water yield (ground run-off water) and erosion control are the most relevant ES to evaluate changes. As the topography is not harsh, heavy erosion and landslides do not prevail in the CSA. Besides, chemical conditions of the area is unknown.

Soil loss and amount of ground run-off water (not water quality) are estimated by our DSS based on a typical regression models using basal area, developed in similar other forest conditions.

Our DSS ETÇAP does not estimate all outputs listed inof the guideline document, see appendix. Our DSS provides information regarding forest cover type, area distribution, treatment areas, treatment period, amount of estimated ground run-off water yield and amount of soil loss in each planning period and yet we have no model nor expert knowledge to estimate and evaluate the development of other water related indicators (run-off time, water distribution, chemical conditions and water quality) either at the stand and the landscape-scale (Table 52, Table 53). Additional effort may be done with GIS routines to compute road and stream crossing. Nevertheless, again we have no models or expert knowledge that might link those variables to the rest of the quantified water related ES. Thus, regarding the basic level**,** changes in several variables (Table 52, possible related DSS Output) can be **identified** through our DSS. On the other hand, we are not able to model the three advanced level of ES evaluation suggested in your water services guidelines as no data is available for that purpose.

Stand-scale: Basic level

At the basic level, our CSA can report the variation of the raw DSS outputs (Table 52), but the net contribution to the indicators is not provided as no model or expert knowledge is available for that purpose.

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Table 52 Basic Stand-level – indicators related with ETÇAP DSS outputs

ES	Indicators	Possible Related SADfLOR Output
water yield	Total supply of water per forest area	Harvesting (%) – harvested or not harvested stand in each planning period Age – stand age Species – type of forest specie evergreen or deciduous Amount of water yield: The amount of ground run-off water for each stand per period
Flood protection	Runnoff time	Harvesting (%) - harvesting or not harvesting in each planning period
Water flow maintenance	Water distribution along the year – flow regime	Harvesting (%) - harvesting or not harvesting in each planning period Change of water: The development of run-off water over time
Erosion control	Erosion protection	Harvesting (%) – harvesting or not harvesting in susceptible area. Additional GIS routine to overlay stand clear cuts in steep areas Soil loss: The amount of soil lost over time
Chemical conditions	Water quality	Harvesting (%) - harvesting in each planning period Species – Type of forest specie broadleaves or conifers Age – stand age

Landscape-scale

At the landscape-scale, our CSA can report the variation of the raw DSS outputs (Table 53), but the net contribution to the indicators is not provided as no model or expert knowledge is available for that purpose (except run-off water and soil loss)

Table 53. Landscape scale – indicators related with ETÇAP outputs

ES	Indicators	Possible Related SADfLOR Output
1. Water yield	Total supply of water per forest area	**Harvesting (% of cover removed)** – sum of areas of harvested stands in each planning period **Stand age distribution –** stand age distribution in each planning period **Species** – Distribution of forest species per area in each planning period (evergreen or deciduous) **Amount of water yield:** The total amount of ground run-off water per period

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ES	Indicators	Possible Related SADfLOR Output
2. Flood protection	Runnoff time	**Harvesting (% of cover removed) -** sum of areas of harvested stands in each planning period **Road density** (density) - additional GIS routine to compute road and stream crossing
3. Water flow maintenance	Water distribution along the year – flow regime	**Harvesting** (% of cover removed) - sum of areas of harvested stands in each planning period
4. Erosion control	Erosion protection	**Harvesting** (% of cover removed) **in susceptible area**. Additional GIS routine to overlay clear cuts in steep areas. **Road density** (density) - additional GIS routine may be needed to compute road and stream crossing through the entire study area **Soil loss:** The total amount of soil lost over time
5. Chemical conditions	Water quality	**Harvesting** (% of cover removed) sum of areas of harvested stands in each planning period **Species** – Distribution of type of forest species (broadleaves or conifers) per area in each planning period **Stand age distribution –** % and area of various developmental stages (regen, young, mature, over mature) across the entire area

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