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Project: Development of a Common Protocol to Assess the Impact of Forest Management Practices on Climate Change

Common Management Guidelines to Increase Carbon Sequestration in Forests

Deliverable 4.5

IMPACT
FOREST MANAGEMENT
&
CLIMATE CHANGE

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1. SCOPE

The forest sector is a net primary source of Renewable Energy Sources (RES) and also the greater carbon pool after the oceans. Therefore, increasing forest cover through afforestation and reforestation is expected to play a strategic and twofold role in the new low carbon economy by contributing to the targets of 2050 as a RES provider on one hand and as a major carbon pool on the other. Moreover, decision 529/2013/EU, on accounting rules regarding Greenhouse Gas (GHG) emissions and removals stipulates that all land use should be considered in a holistic manner and Land Use, Land Use Change and Forestry (LULUCF) should be addressed within the Union's climate policy. EU Regulation 2018/841 amended EU Regulation No 525/2013 and decision No 592/2013/EU, on the inclusion of greenhouse gas emissions and removals from LULUCF in the EU 2030 climate and energy framework. According to this regulation Member States should submit national forestry accounting plans to the Commission, including forest reference levels.

Forest management represents about 70% of the LULUCF sector and EU has recognized that increased sustainable use of harvested wood products can not only enhance removals of GHG from the atmosphere but also substantially limit emissions. Therefore, sustainable forest management has the potential to play an important role in the reduction of EU emissions in the atmosphere. The LULUCF sector in the EU is a net sink that can offset a significant share of the total Union's GHG emissions.

In order for measures targeted at increasing carbon sequestration to be effective, the long-term stability and adaptability of carbon pools is essential. Sustainable management practices maintain the productivity, regeneration capacity and vitality of the LULUCF sector and are therefore important in promoting economic and social development, while reducing the carbon and ecological footprint of that sector (EU Commission 2018).

The current document constitutes a guide to all interested parties of the forestry sector in Turkey that are willing to pursue ways of improving carbon sequestration through forest management. The present guidelines are a result of an analysis that was based on data from a field survey in the management units of Vakfıkebir, Tonya and Düzköy of Trabzon, Turkey in the context of the Action 'Development of a common protocol to assess the impact of forest management practices on climate change'. The project focused on planted oriental beech forests with maximum stand age of 34 years. However, the methodology applied in this context may be used for other forest species elsewhere with the aim to assess and validate forest management practices and measures, aiming to improve the CO2 removal/sequestration balance.

The rationale behind the present guidelines is firstly to obtain knowledge about carbon stocks in planted forests in order to set a baseline and be able to monitor their changes and secondly to provide insight into the impact of different management practices on the carbon stock of planted forests.

2. LITERATURE REVIEW

2.1 Introduction

Forest functions traditionally included wood production, protection and forest recreation. However, a fourth category was added concerning environmental impacts, after realizing the magnitude of environmental issues worldwide in relation to climate change (Galatsidas, 2012).The twofold role of forests as both sources and sinks of greenhouse gases (GHG) makes their influence on the climate extremely significant (SFC, 2010).

This fact has led to climate change adaptation and mitigation being set as a current priority in forest management. However, there are trade-offs between stand-level strategies aimed at climate-change mitigation and those aimed at adaptation (D'Amato et al., 2011; Sharma et al., 2016). The Action focuses on the mitigation of climate change impact through increasing the size of the carbon pool in forests, which is a worldwide recommended mitigation measure (FAO, 2010; D'Amato et al., 2011; Jandl et al., 2015; Behera et al., 2016).

Maintaining the carbon stock and enhancing carbon sequestration of forests in Europe contributes to the implementation of the UNFCCC and the Kyoto Protocol. It is also one of the commitments of the Signatory States of the Ministerial Conference on the Protection of Forests in Europe and the European Community (Forest Europe, 2015). Mitigation is achieved either through the creation of new forest areas or through sustainable forest management. Both approaches provide carbon sequestration and storage in forest biomass and soils, as well as in harvested forest products. Therefore, carbon stock and carbon stock changes need to be incorporated in sustainable forest management by supporting research and analysis on these topics (MCPFE, 2003).

Over the period 1991–2015, planted forest, representing 7% of the total forest area, accounted for a global average carbon sink that was comparable to the sink of natural forest (-1.08 vs. -1.44 Gt CO_2 yr-1), driven by continuous increases in total area (Federici et al., 2015). In Turkey, planted forests increased by more than 50% after 2010 due to the implementation of the Afforestation and Erosion Control Mobilization Action Plan (2008–2012) and due to the Combating Erosion Action Plan (2013-2017) (FAO, 2014).

Towards the same direction, the Intended Nationally Determined Contribution (INDC) of the Republic of Turkey for the period 2021-2030, which aims to achieve the ultimate objective of the UN Framework Convention on Climate Change, proposes, amongst others, specific actions for increasing forest sink areas and a National Afforestation Campaign. The contribution of those actions is mainly achieved by new forest plantations.

Sustainable forest management contributes to climate change mitigation by preserving and expanding carbon stocks in the forests (including above- and below-ground biomass, deadwood, litter, and soil) (SFC, 2010). In view of this fact, the project aims to foster transnational cooperation to investigate alternative management practices in order to identify the most efficient in terms of carbon sequestration and storage in planted forests. Planted forests represent approximately 30% of the forests in Turkey, covering 3,386,000 hectares according to FAO (2015).

2.2 Forest management and climate change: EU legislation and policies

Recently EU strengthened its climate change strategy by increasing the 20-20-20 targets to 40-27-27 till the year 2030.The corresponding roadmap for a low carbon economy towards 2050 regards the development of Renewable Energy Sources (RES) and the storage of CO_2 as key elements for reducing GHG emission by 80% compared to 1990 levels. The forest sector is a net primary source of RES and also the greater carbon pool after the oceans. Therefore, appropriate adaptation of forest management is expected to play a strategic and twofold role in the new low carbon economy: on one hand by contributing to the targets of 2050 as RES provider and on the other hand as a major carbon pool. Forest conservation (or prevention of deforestation) has been officially recognized in COP16 (2010) as one of the most important options to the post-Kyoto climate policies for combating climate change though stabilizing Greenhouse Gas (GHG) emissions (Ding *et al.*, 2016).

Moreover, decision 529/2013/EU, on accounting rules regarding GHG emissions and removals stipulates that all land use should be considered in a holistic manner and land use, land-use change and forestry (LULUCF) should be addressed within the Union's climate policy. Therefore, Member States have to prepare and maintain accounts that accurately reflect all emissions and removals resulting from forest management. Carbon stock changes need to be estimated in an unbiased, transparent, and consistent manner to allow for uncertainties to be determined and reduced over time, as prescribed in the IPCC Good Practice Guidance for LULUCF activities (IPCC, 2003; Beets *et al.*, 2011). According to Federici et al. (2015), enhanced country data to cover carbon stock gains and carbon stock losses separately, and disaggregated by forest type (primary forest, other naturally regenerated forest, and planted forest) would significantly improve the 2020 Forest

Resources Assessment (FRA) made available by the Food and Agriculture Organization of the United Nations.

The incorporation of adaptation and mitigation aspects of climate change in sustainable forest management is necessary in order to fully utilize its potential. However, a broad range of policy measures is still required to support this task (e.g. incentives for afforestation and reforestation, taxation, public procurement rules to promote the use of wood, national and regional legislation to enhance the use of timber in the construction sector, proper technical and biological forest education) (SFC, 2010).

2.3 Forest management practices to address climate change

The development of forest management strategies for addressing climate change has become an increasingly important issue around the globe. Currently, management approaches are being proposed that intend to mitigate climate change by enhancing forest carbon stores (D'Amato *et al.*, 2011). While sustainable management, planting and rehabilitation of forests are efficient ways to conserve or even increase forest carbon stocks, it should be noted that deforestation, degradation and poor forest management do reduce carbon stocks (UNFCCC, 2016).

In this scope, mitigation activities include conserving forests with large stocks of biomass from deforestation and degradation, avoiding significant carbon emissions to the atmosphere and sustainably managing forests in order to restore their carbon sequestration potential (Keith *et al.*, 2009).

Incorporating carbon sequestration and storage in forest management raises a lot of questions regarding age, rotation period, stand structure and mixture, as well as management practices. Different analyses of national or local forest systems reveal that cessation of forest management in productive forests would yield much lower mitigation effects than those provided by the substitution effect of the currently harvested wood (SFC, 2010).

Carbon stocks can be maintained and increased through the use of extended rotation periods. This recommendation is supported by widely documented positive relationships between aboveground carbon stores and stand age (D'Amato *et al*., 2011, Yavuz *et al*., 2010). The net carbon balance in forests between 15 and 80 years of age (including the soil), is usually positive and old-growth forests seem to continue to accumulate carbon (Luyssaert *et al.*, 2008). However, young forests have high carbon sequestration rates which decline as they age. Mature forests eventually reach equilibrium in which no or little further sequestration takes place, leading to limited mitigation potential and carbon storage capacity in time (SFC, 2010). Moreover, the resilience of forests to climate change impacts is often decreased with increasing stand age and basal area (Seidl *et al.*, 2017).

The critical question to consider is when should the carbon stock of the living biomass, the forest floor carbon and the soil carbon be replaced. Carbon pools and fluxes are strongly determined by the applied rotation lengths, the thinning intensity, and the resulting age–class distribution of the forests. While short rotation length increases the carbon sequestration rate, it accounts for lower average carbon stock in the biomass and other conflicts e.g. regarding nature conservation (SFC, 2010).

Regeneration methods and thinning treatments that retain a large proportion of mature trees are more efficient in maintaining carbon stores compared to more intensive removals, even in cases when off-site storage is considered (D'Amato et al., 2011). Furthermore, the soil temperature may go up in open spaces created after intensive thinning which may lead to increased decomposition of soil organic matter. However, moderate thinning in young stands does not seem to give a net flux of CO2 to the atmosphere (SFC, 2010). Therefore, multi-aged stands are proposed as an effective means to strengthen forest resilience against disturbances (Kuuluvainen et al., 2012; Lafond et al., 2014; Seidl et al., 2017).

Uneven-aged management creates overall more complex stand structure (Stand Structural Diversity) and maintains a steady flow of yields and aboveground carbon stocks (Sharma et al., 2016). Selection cuttings maintain late-successional forest characteristics and species assemblages better than even-aged stands at least at the stand scale and in the short term (Kuuluvainen et al., 2012). Both even- and uneven-aged management options have the potential to improve production and carbon storage and are a substantial improvement over no action (Sharma et al., 2016).

There are still many uncertainties regarding the impacts of climate change on forests, despite the significant body of existing research. As a result, climate change may impact forests in ways that are partly opposing and therefore can require adaptation activities that are difficult to design and to plan (Lindner et al., 2014). Carbon sequestration should only be one of the goals that drive forest management decisions in relation to climate change. Optimal achievement of multiple benefits across the landscape may require maintaining an assortment of management strategies to enhance ecosystem resilience while improving production and carbon storage (Lindner et al., 2014; Sharma et al., 2016).

Another management practice that needs to be considered is favouring species mixture. The effects of mixed stands on growth and forest production can vary from no effect to productivity increases up to 50 % when species make different use of available resources, either in space or in time. Mixed stands are more resilient to disturbances and are therefore a favourable practice for adaptation (SFC, 2010).

2.4 Forest management practices and climate change in the project area - Historical development of Forest Management Planning in Turkey

There are several studies on the history of forest management in Turkey. The most important of these are Eraslan (1982), Mısır (2001), Mısır (2013) and Zengin et al. (2013). Due to the fact that these works are newer as of the year they were published, the history of Forestry Management planning in Turkey according to these studies is as follows:

The first contemporary management plan was prepared in 1918 (General Directorate of Forestry, 2007) by a team composed of Turkish and Austrian foresters. This was also the first application of the age classes' method for regulating even-aged forests. Some have characterized this process as German-led neoclassical area control management (Zengin et al. 2013). By comparison, Hufnagl's method of managing diameter classes (Roth, 1914) was used to calculate the allowable cut from uneven-aged high forests. A 1973 forest regulation defined the main and auxiliary management methods for forests, which were based on stand form (Asan, 1992).

Today about 96% of the forests in Turkey are even-aged. In the last four decades, a portion of the even-aged forests have been managed using a single-tree selection system, which did not consider the biological characteristics of forests. In its implementation in Turkey, many irregular and unusual forest structures occurred through the use of these treatments, and these forests are still the subject of debate among forest managers (Zengin et al., 2013). Concern over how to transition even-aged forests to an uneven-aged structure and how to maintain shade-intolerant tree species through uneven-aged management is not unique to Turkey and can be accomplished under the right conditions (Malcolm et al., 2001; Nyland, 2003).

From 1918 through the mid-1980s timber production was viewed as the most important forest function and thus was the main objective of many forest plans. As a result, forest plans were monotypic, and the same management approach was used everywhere without consideration of the diverse forest characteristics of the country. Plans prepared using these conventional methods were therefore called conventional forest management planning models. The plans were revised on a 10-year cycle, and in them the annual allowable cut was based on sustainable wood production principles.

However, the plans did not pay attention to the improvement of relationships between forest enterprises and the forest villagers living within the planning units. About 43% of the forests in Turkey continue to be managed with plans developed using this process. In the 1970s, Mediterranean region planning models were introduced and applied to forests in this region (Asan, 1989). They were developed by special planning groups to introduce new planning approaches and concepts for forests along the Mediterranean coast. These regional plans were a major step toward the sustainability of forest functions and benefits were also used to sustain timber production in Turkey. However, these plans did not involve nor incorporate the management of livestock and rangeland resources, important issues that needed to be addressed to ensure the sustainable management of Turkish forests.

These management plans also proposed an intensive forestry direction that used an area control method for determining the allowable cut. They were prepared for the whole area of a Forest Enterprise, despite the previous conventional plans that were prepared for planning units. Some minimum rotation age principles were continued, but others were adjusted. For example, in 1977 the minimum rotation age for *Pinus brutia* was decreased from 60 to 40 years. Furthermore, a longer planning horizon was assumed (100 years) to determine whether modelled forest policies were sustainable in the long-term and whether forest resources were sustainable as a supply for the integrated manufacturing facilities of each region (Zengin et al., 2013).

In the 1990s, Western Black Sea region planning models were introduced. Also known as Turkish-German collaborative projects (individual plan), Western Black Sea region planning models were prepared to address a regeneration problem that occurred in forests along the Black Sea as a result of the application of management techniques (regeneration period, rotation ages, and others) that did not consider site conditions and tree species requirements. These plans addressed stand-level silvicultural direction more than the attainment of forest-wide goals and thus focused on natural sustainability of deciduous forests through stand-level decisions.

These regional plans were different from conventional plans through the use of longer rotations and regeneration periods and the use of continuous cover forestry concepts (uneven-aged concepts) (Asan, 1995). Although these three types of management planning processes had been used either universally or regionally to develop forest plans, a fourth process is now used throughout Turkey (Asan, 2005). The main concept of forest management planning in Turkey today is to manage forests in such a way as to maintain biological diversity, productivity, regenerative capacity, and vitality and to fulfil relevant ecological, economic, and social functions (Eeronheimo et al., 1997). This philosophy encourages the development and maintenance of both ecosystem processes and multiple uses. Therefore, this fourth type of planning process is considered an ecosystem-based functional planning approach (Zengin et al., 2013).

In essence, the process can be perceived as either a segregation or an integration method, as this is determined based on the function(s) an area within a forest is assumed to accommodate. These functional areas need to be separated when the functions conflict with each other. If there is no major conflict among forest functions, a forest area is managed based on the dominant function, with some modifications used to recognize other functions. The perceived flexibility of the current planning process seems to have increased its applicability and acceptability among forest planners and managers. The planning process proposes treatments suitable for the function that the forests serve. In this endeavour, the planning process must use the forest structure created under the older management planning processes; therefore, the treatments applied may need to be designed in a manner to adjust structural components so that different societal goals can be met. In addition, some aspects of the process involve fairly complex assessments, which can include, for example, the determination of carbon sequestered; oxygen produced, and dust filtered (Asan, 2010).

The ecosystem-based functional planning process consists of several phases. These phases are similar to planning processes used on public land in the United States (Bettinger et al., 2009). There are a few minor differences; for example, in Turkey, public input is gathered near the end of the process rather than at the beginning. After current and future conditions of forests are estimated and after plan alternatives have been developed, the outcomes obtained by the management planning groups are presented to stakeholders before preparation of the management plan report. In this participatory process, management objectives primarily relate to the maximization of wood production, resolution of social conflicts, facilitation of recreational and aesthetic goals, improvement of social welfare, water production and soil protection.

In a way, the management of forests in Turkey can be viewed as the management of the people who are interested in forestry. By determining functional areas and by using a participatory approach, along with technical analyses and the application of forestry techniques based on forest functions, conflicts between stakeholders should decrease. Although initially there were social reactions to the application of this planning process, people now generally support forestry activities because of the information they receive during the public participation in the process.

However, the sustainability of forest resources tends to take precedence over the alleviation of social issues such as poverty (Güneş and Coşkun, 2008).The pursuit of ecosystem-based functional planning can be viewed as a way to introduce modern forestry organization to a country with a long forestry history. Modern land allocation methods, participatory planning processes, and the emphasis on both ecosystem function and multiple uses illustrate this evolution. One main drawback is the generally limited use of operations research methods, yet this was a distinct drawback of the conventional forest management planning model and Western Black Sea region planning model processes as well.

On a positive note, the ecosystem-based functional planning process does not disregard experience gained through the implementation of previous planning processes. Even with this perceived evolution in thought and philosophy, there are people who believe ecosystem-based management is too utopic and that it can never be successfully applied, given a lack of certain basic data necessary for modelling multiple forest functions. However, the planning process used tends to recognize these shortcomings, and attempts are being made to integrate modern planning techniques with analytical models. To add knowledge and to inform the process, studies concerning the development of appropriate criteria and indicators for local planning units have been undertaken.

As an example of the extent to which ecosystem-based approaches are used, two management plans were elaborated in 2009 for the Artvin-Yusufeli Forest Directorate (Yusufeli and Altıparmak Forest regions) within the framework of an international project titled “Sustainable Forest Use and Protection Project for Kaçkar Mountains.” Further, 14 management plans were developed in 2011 and 2012 for the urban forests belonging to the Istanbul Metropolitan Municipality. In addition, three management plans were developed by the management planning groups in 2011 for the Bahçeköy, Kanlıca, and Demirköy Forest Directorates of Istanbul, and plans are being developed for Vize and Demirköy Forest Directorates. In 2013 these planning groups have finished four more management plans using the ecosystem-based functional planning model approach. Formal planning groups working in various parts of the country are also continuing to apply the new process.

Although the ecosystem-based functional planning model approach to forest planning is the only type of process used to develop plans today in Turkey, only 57% of the forest area is currently managed under ecosystem-based plans. When the conventional plan time horizon ends for a forest area, an ecosystem-based plan will be developed. The various planning processes that have been used can be compared according to how timber and non-timber products, social concerns, and economic values were recognized and assessed. Interestingly, modern quantitative decision-making techniques have only been used in the development of Mediterranean region planning models. Despite simulation models developed by Soykan (1978), Mısır (2001) and others in recent years, these types of processes have not generally been put into practice. Therefore, from the standpoint of recognizing the various quantitative functional relationships that exist between competing uses of the land, none of the approaches are considered better than the others along these lines. In the plans developed through conventional forest management planning models, Western Black Sea region planning models and ecosystem-based functional planning models, the sustainable allowable cut was determined, in general, for one planning period.

However, because Western Black Sea region planning model plans used silvicultural considerations in the determination of the allowable cut amount and various other planning methods for the regulation of yields, it was usually impossible to guarantee equal wood production levels during sequential planning periods. Equal wood volume production was desired to meet wood production demands, rather than local village demands for fuelwood.

In contrast, plans developed through Mediterranean region planning models determined an allowable cut over a 100-year planning horizon. The forest planning techniques used in forest planning only addressed timber production; therefore, it was nearly impossible to achieve multiple objectives by means of the conventional or the Mediterranean model plans. With a continuous forest approach, the ecosystem-based functional planning models and Western Blacksea region planning models were better along these lines. From an economic perspective, the Western Black Sea region model plans were the most expensive to develop because of more intense data collection and assessment procedures.

If conventional forest management planning models were the basis of comparison, it has been expressed that the Western Blacksea region model plans were twice as expensive for each plan, the Mediterranean region model plans were about 80% more expensive, and the ecosystem-based functional planning model cost is about 70% more expensive. Whereas the ecosystem-based functional planning models recognize that changes in tree species, landscape condition, and forest function require different silvicultural techniques in different parts of the country, none of plans that have been prepared for Turkish forests have acknowledged regional peculiarities in marketing circumstances, transportation facilities, and managerial intensities. The value of timber and other forest benefits is not equal and vary across the country. Therefore, the content and detail of management plans should change as managerial intensity and the economic importance of the planning unit changes. Furthermore, the social benefits of forest resources change with the expectations of people living in or near the forests. Conflicts cannot be mitigated unless the opinions and desires of all people can be incorporated into management plans.

Currently, the implementation of forest plans in Turkey faces many challenges. Centralized planning is necessary because of a lack of skilled personnel and qualified decision-makers at the local level. Compounding this issue of institutional capacity are ineffective forest protection programs, occasional poor communication with local residents, and social conflicts, and these have limited the implementation of forest plans, even though the planning process has evolved. Local villagers have employment rights for certain forestry activities and access rights to forests for recreational purposes and for non-timber forest product collection (Güneş and Coşkun, 2008).

However, fuelwood and construction-grade lumber are necessary resources for many people, and access to these resources is critical. Lumber needed for the development of new buildings or the repair of older ones is generally available to local villagers at a cost that reflects the stumpage price of the wood and some transportation and stacking costs. Fuelwood is also made available using a variable cost and volume schedule that depends on the number of people living in a house. As an example, villagers who live in a house containing up to six people and who cut the fuelwood themselves can acquire about five cords of wood at a cost equivalent to the stumpage price of the wood. The impact of these wood product demands on the allowable cut for each working circle will vary due to the timing of local needs and the existing supply of goods (Zengin et al., 2013).

As described above, there are 4 forest management scenarios applied in Turkey. A brief description of each one is provided along with their impact on carbon storage. The first two scenarios are those widely applied whereas scenarios 3 and 4 are only pilot implemented or as part of research projects.

I. Conventional (Sustainable wood production) - German-led neoclassical area control management

Even-aged management, characterized by short rotation length, large clear-cut blocks, no vegetation control on clear-cut areas, high grading, clear cutting on steep slopes, and over-harvesting the accessible sites. Forest characteristics were not taken into account.

+ high C sequestration rate during the establishment of new stands after clear cuts

- low average carbon stock, decomposition of soil organic matter, soil erosion and degradation, increased CO_2 emissions due to deforestation, endangerment of biodiversity, difficult or non-existing natural succession or artificial regeneration

II. Mediterranean region planning model (Sustainability of forest functions and benefits)

Even-aged management, intensive forestry direction characterized by shorter rotation length for some species but longer planning horizon and no clearcuts.

+ high C sequestration rate during the establishment of new stands after intensive harvesting
- low average carbon stock, difficult or non-existing natural succession or artificial regeneration

III. Western Black Sea region planning (Turkish – German collaboration)

Stand-level silvicultural direction focusing on natural sustainability of deciduous forests through stand-level decisions. Longer rotation and regeneration periods and the use of continuous cover forestry concepts (uneven-aged concepts)

+ high average carbon stock by increasing and sustaining constant forest cover, soil protection, biodiversity conservation
- low C sequestration rate, especially for beech forests. However, while generally fast growing species accumulate carbon more rapidly (Behera *et al.*, 2016), slow growing species have advantages for long-term carbon storage in the forest advantages (SFC, 2010).

IV. Ecosystem-based functional planning

Aiming to maintain biological diversity, productivity, regenerative capacity, and vitality and to fulfil relevant ecological, economic, and social functions. Flexible, integrated, oriented towards the dominant function of the forest.

Incorporate carbon storage in the forest management plan: baseline, monitoring and reporting process.

+ high average carbon stock by increasing and sustaining constant forest cover, soil protection, conservation of biodiversity, productivity, regenerative capacity, and vitality

- low C sequestration rate.

2.5 Comparison of forest management practices related to climate change in Turkey and Greece.

Nowadays, a single type of planning process is used for forest management in Turkey, which takes into account ecological and environmental conditions, multiple uses of the landscape and social concerns but still focuses on wood production. Although management and planning are evolving, the planning concept needs to be steered towards holistic management with the integration of various forest values based on ecosystem sustainability (Zengin et al., 2013).

Similar is also the situation in Greece, with forest management and planning still targeted mainly to wood production, although the need for a comprehensive management of all forest functions has been recognized (Galatsidas, 2012). No steps have been taken towards the estimation of existing carbon stock in forests or the adaptation of management to incorporate climate change.

The management of forests in Greece has been based on the same principles since the 1950s , with minor modifications regarding the management goals. Initially, wood production was the main forest function considered and other products and functions, which could pose limitations to wood production, were determined as secondary benefits (Regulations 1959 & 1965). Forest recreation and other uses of forests gained significance in the ‘80s and suggestions to manage forests for multiple uses were made (Gatzojannis, 1984, 1988). Models to incorporate protective functions of forests into management plans have also been proposed in the decades that followed (Gatzojannis et al., 1997; Kalabokidis et al., 2002; Galatsidas 2001; Gatzojannis 2002; Galatsidas et al., 2015a,b), but wood production still remains the main planning goal of the forest practice and other forest functions have not been practically included in the management plans.

In general, forest management planning in Greece follows an ecosystem-based functional planning model, similar to the one applied in Turkey. However, the dominant function is determined for the entire forest administrative unit, which is often delineated using natural break lines (rivers or ridges) and administrative boundaries (municipalities, prefectures, etc.).

The basic functions of the nowadays managed Greek forests are sustainable wood production, soil protection, recreation and other uses (i.e. conservation of biodiversity).

Management is based on 10 year management plans. The minimum planning and management unit in Greek forestry is the sub-section, which covers an area of few hectares and is defined by natural topographical break lines in most cases, so that it is easily recognized in the field.

The management practices are based on species specific silvicultural treatments that favour natural regeneration and sustainable wood production. The main productive species are located on medium and high altitudes, whereas forests at lower altitudes are generally degraded (Oak coppice forests and pine reforestations) or cover areas where wood production is not the main forest function but protective functions (of soil, water and biodiversity) prevail.

Table 1. Comparison of forest management practices in the two countries

Management practices information	Turkey	Greece
Planning method	Ecosystem-based functional planning	Ecosystem-based functional planning
Dominant function area	Functional area	Forest administrative entity (related to municipal boundaries)
Minimum planning unit	Functional area	Management unit (sub-section)
Planning period of forest management plans	10-year	10-year

Biodiversity conservation needs in Greece have led to the establishment of an extended network of protected areas. In 1937, Greece started to identify natural areas of specific ecological importance (forests, wetlands etc.) and place them under special protection. While in the early stages of this special protection, all human activities were prohibited later on, this concept was abandoned and a new approach was followed, that of associating nature protection with the sustainable use of its resources (GBWC, 2017).

The protection status of the areas may be at national, European or international level. In many cases the same area is listed in both national legislation and international conventions or international or/and European initiatives. The NATURA 2000 network of protected sites in Europe is an important initiative for the conservation of natural habitats and species of wild fauna and flora of Community interest. The management of protected forests incorporates considerations regarding biodiversity conservation.

The management practices applied in Greece until today have resulted in intertemporal reduced wood production and increased biomass in forests (therefore increased carbon storage). Efforts are being made at research level, to upgrade the forest management planning procedures and include all potential forest ecosystem services. Climate change impacts on forests and vice versa is an issue that needs to be addressed in contemporary forest management plans. Carbon storage potential, carbon sequestration rates in forests, as well as carbon accounting and reporting are required according to decision 529/2013/EU on accounting rules on removals resulting from activities relating forestry.

2.6 Project area description and management history

The study area is located in the Trabzon Central State Forest Enterprise which covers part of Trabzon Province located in the eastern Black Sea region of Turkey (Fig.1). The 58810.9 ha study area consists of three planning units and contains a forested area of 30082.35 ha. The altitude ranges from 400 to 2,280 m above the sea level and average slope is about 57 %.

The Black Sea climate is characterized by mild winters and cool summers and is rainy during all four seasons. The average annual temperature is 12.2 °C, reaching a maximum of 20.2 °C in summer, a minimum of 4.5 °C in winter and with an average annual precipitation of 640.9 mm. Forest vegetation is typical and the dominant tree species include oriental spruce (*Picea orientalis* (L.) Link), oriental beech (*Fagus orientalis* Lipsky), scots pine (*Pinus sylvestris* L.), Nordmann's fir (*Abies nordmanniana* (Stev.) Spach subsp. *nordmanniana*), , oriental hornbeam (*Carpinus orientalis* Mill.), and alder (*Alnus glutinosa* (L.) Gaertner).

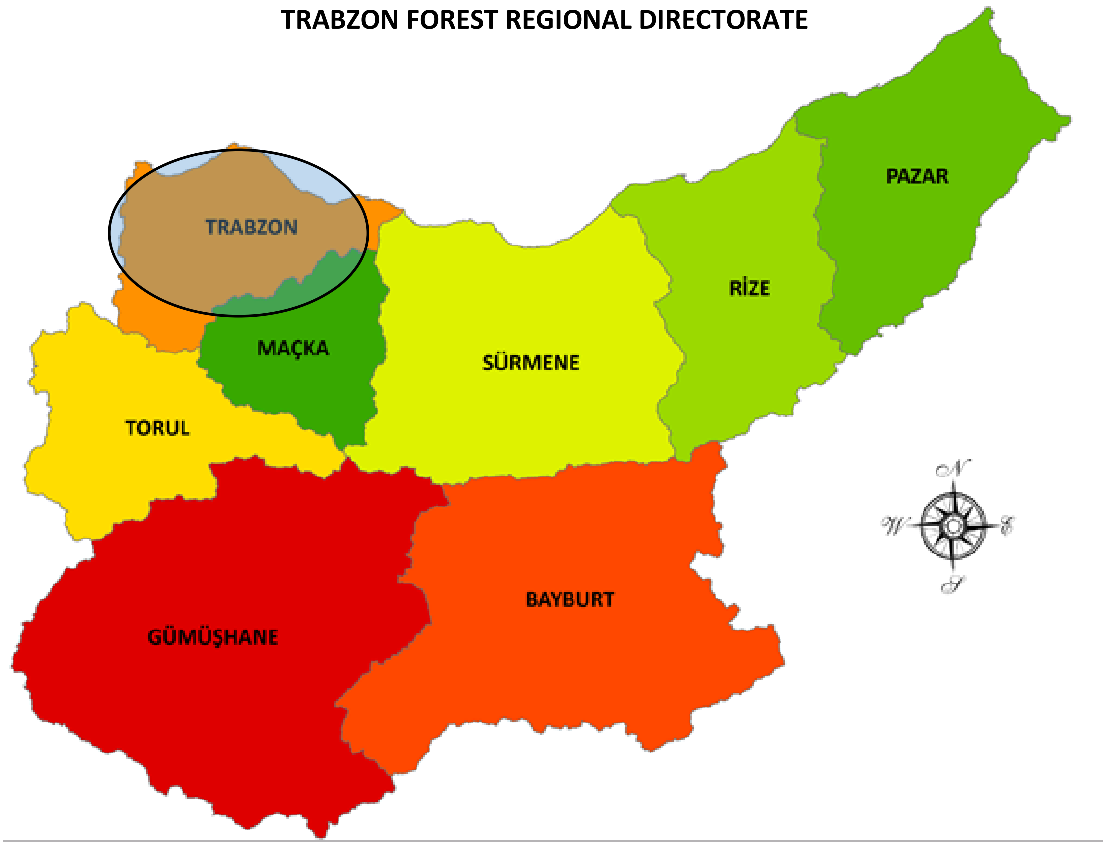

Figure 1. Location of the study area

Natural stands dominate the study area. However, there are also planted beech forests under three Forest Management Chiefs of the Trabzon Central State Forest Enterprise; Vakfıkebir, Tonya and Düzköy.

The oriental beech plantations are being established in the study area since 1983. This was because the regeneration success of the beech species in this region was lower than that of other species (e.g. oriental spruce) and also due to the extreme destruction of beech stands (social pressure, etc.). During the application of the final allowable cut, afforestation was carried out in order to prevent the area from becoming damaged due to the inability of the natural beech seedlings to reach the area. This process started in 1983 and no such method had been applied before. Oriental beech planting has been continued almost every year since then. In this way, approximately 80 ha in the Vakfıkebir planning unit, 50 ha in the Düzköy planning unit and 70 ha in the Tonya planning unit are present.

2.7 History of management practices applied & Current management practice

Until the early 1970s the Trabzon Forest district Directorate forests were managed under national defence policies in Turkey. With this management policy, harvested areas were not regenerated properly nor were appropriate forest composition and structure created, leaving sustainable timber production in jeopardy resulting in a decrease in standing timber volume. It was after 1973 when tree species that were semi-tolerant and intolerant to climatic conditions in Turkey were planted using an even-aged management method. Since adequate knowledge for implementing a new management approach was not available at that time, clear-cut harvesting was implemented haphazardly in larger areas and the cut areas failed to regenerate to forest quickly. Stands in the forest landscape were all designated as having timber production as the prime management objective. As a result, forest structure was created messily, especially in oriental spruce forest. Because trees were planted prior to 1984 which could not tolerate local climatic conditions, all the management plans in Eastern Black Sea region were revised in 1984. In the new plans, optimal target forest structure was determined using newly established yield tables and well defined age classes were designated (Misir, 2013). In 2002 a new planning method was adopted, called the Turkish-German collaborate model plan (individual plan), which is still in effect until today.

Even though the current management method is based on sustainability principles, it remains oriented towards wood production. This is a significant improvement in relation to the previous management practices, which is documented by the 48% increase in forest carbon stock in Northern Turkey between 1973 and 2006 (Misir, 2013). The estimation of carbon stock only includes live above-ground tree biomass. Carbon sequestration in standing dead trees, lying dead wood, shrubs and litter has not been included in the overall carbon stock of the forests.

3. SAMPLING PLAN

The purpose of the stand inventory is to obtain knowledge about carbon Sources, Sinks or Reservoirs (SSRs) in order to set a baseline and monitor any changes. SSRs are defined by IPCC (2001) as follows:

Source: *Any process, activity, or mechanism that releases a GHG*[1]*, an aerosol, or a precursor of a greenhouse gas or aerosol into the atmosphere*

Sink: *Any process, activity or mechanism that removes a GHG, an aerosol, or a precursor of a greenhouse gas or aerosol from the atmosphere*

Reservoir: *A component of the climate system, other than the atmosphere, which has the capacity to store, accumulate, or release a substance of concern (e.g., carbon, a GHG, or a precursor).*

The main 'carbon pools' or reservoirs which can be included in a forest carbon sampling program are five, according to the Intergovernmental Panel on Climate Change (IPCC, 2006):

1. Aboveground biomass, which can be divided into tree and non-tree pools (e.g. shrubs etc)
2. Belowground biomass (live tree roots)
3. Dead wood (including debris such as fallen branches and logging residues)
4. Litter (i.e. fallen leaves)
5. Soil organic matter

According to UK Forest Research (2018) carbon levels in forestry are accounted for through:

- periodic, direct measurements of carbon in forestry stock
- inventory-based carbon accounting models
- direct carbon flux measurements

The method presented in the current document involves inventory-based carbon accounting models. The inventory was based on a sampling plan that included the following activities:

- Identification of SSRs to be measured/assessed
- Planning for SSRs measurement/assessment (carbon stock sampling, GHG sources measurement, etc.)

[1] In this case CO_2

- Measurement/assessment of SSRs
- Data analysis and interpretation
- Development/use of growth models to predict biomass and carbon stocks

3.1. Identification of SSRs

Carbon Sources, Sinks and Reservoirs are related or affected by the forest management practices applied. Therefore, it is necessary to identify them beforehand and set a baseline in order to assess future changes due to the implementation of different management scenarios.

Only the ‘key categories’ should be included within the project in order to make the most efficient use of available resources. ‘Key categories’ refer to the carbon SSRs that have the greatest contribution to the carbon stock and GHG emissions. The SSRs that are related to the Action have been identified and are described in Table 2. Depending on their contribution as either a source or a reservoir they have been included or excluded from the sampling and analysis process.

Greenhouse gas emissions are linked to the use of fossil fuels in industry (2/3) and 1/3 is due to land use change and agricultural activities. Therefore, the emissions from forest management (establishment, treatment, harvesting) are not considered significant and are excluded. The carbon pools that will be included in the Action are aboveground and belowground biomass, dead wood and litter, in accordance with the accounting rules for all afforestation and reforestation project activities under the Clean Development Mechanism (UNFCCC, 2015). The first two pools are mandatory (above- and below-ground biomass), whereas deadwood and litter are optional.

Table 2. Carbon Sources, Sinks and Reservoirs in planted forests (adapted from Tree Canada, 2015)

Stage	Identified SSR	Description	Include/ Exclude	Justification for Exclusion
Production of planting material/ Establishment of plantation	1a. Fossil fuel combustion – seedling production, labour and materials transport	Fossil fuel used (for heat or electricity production) in seedling production and for transport of planting stock, labour and equipment to project site for the establishment of planted forests	Exclude	The emissions from fossil fuel that is combusted to heat the greenhouses where the seedlings are produced is not considered significant.
	2. Fertilizer use	Non-CO_2 GHG emissions (CH_3 and N_2O)	Exclude	The emissions from fertilizer used to produce the tree seedlings is not considered to be significant.
	1b. Fossil fuel combustion — labour and materials transport	In vehicles and equipment used for site preparation and plantation establishment	Exclude	The emission from fossil fuel that is combusted to transport labour and materials to the project site is not considered significant.
Onsite forest SSR	**3. Above-ground C reservoir**	Biomass in live trees, including branches and foliage	**Include: live trees and shrubs**	Live tree, above-ground biomass must be considered in the baseline, as well as the project. Live aboveground shrub biomass must also be included where the shrubs have a diameter of at least 2 cm at a stem height of 10 cm. The amount of live herbaceous biomass will also be measured.
	4. Below-ground C reservoir	Live tree root biomass	**Include (estimation)**	No measurements can be carried out during the project implementation period due to the weather conditions
	5. Standing Dead Wood	**Biomass in standing dead wood**	**Include**	Dead wood must be quantified at the project start, and forecast in both the baseline and the project.

Stage	Identified SSR	Description	Include/ Exclude	Justification for Exclusion
	6. Lying Dead Wood	**Biomass in lying dead wood**	**Include**	Dead wood must be quantified at the project start, and forecast in both the baseline and the project.
	7. Litter C reservoir	**Biomass in litter**	**Include**	Project is likely to increase the amount of litter
	8. Soil Organic C reservoir	Organic C, dead root and live fine root content of soil	Exclude	Project impacts are likely to be positive over the project period. Any changes will not be significant.
Management activities/ Harvesting	1c. Fossil fuel combustion	In vehicles and equipment used for plantation maintenance, monitoring and any harvesting activities.	Exclude	Not significant and exclusion results in more conservative estimate
Transport to facility/ Production of wood products	1d. Fossil fuel combustion — transport of harvested biomass	Transport of any harvested biomass to processing facility	Exclude	Emissions from combusting fossil fuel to transport harvested wood /agricultural products to a processing facility are judged to be not significant since the amount of harvesting permitted in a project is limited.
	9. Processing facility	Process emissions at wood product or biomass energy facility. Emissions related to energy used in processing of crops /food products	Exclude	Exclude, for reasons analogous to those for excluding emissions associated with transport of product to mill.
	10: Harvested wood products	Wood from thinning or partial harvests may be converted into wood products. A proportion of the products remains for some time in the products pool and can be considered as offsets.	Exclude	Exclude, since the scale of the projects is very small relative to the regional landbase and supply capacity.

Carbon stock in the belowground biomass will be estimated as a fixed percentage of the carbon stock in the aboveground biomass (root:shoot ratio). Generally, belowground C stock is lower in broadleaved species than in coniferous forests (Dar and Sundarapandian, 2015; Tufekcioglu *et al.*, 2004).

3.2. Planning for measuring/ assessing Carbon Sink & Reservoir

The project site (Maçka forest) covers 21471.6 ha overall, with approximately 200 ha of scattered planted areas of beech (Fagus orientalis), up to 34 years old (Image 1). Past management was based on previous management plans (1973, 1984, 2006 & 2016), with different priorities.

Field measurements will be applied to estimate the aboveground live tree volume, using allometric equations (Misir et al., 2013). Field measurements will also be applied to estimate the aboveground live tree biomass in branches and foliage, as well as the shrub volume. Other measurements will provide data for standing dead wood, lying dead wood and litter. The parameters to be measured/assessed are included in the Inventory sheet (Annex I).

The beech plantations were stratified into 10-year age classes (4 age classes overall) and 3 types of site quality in the forest (good, medium, poor). In order to efficiently estimate the carbon stock, random stratified sampling will be applied. Stratification minimizes the variation within each stratum therefore providing a more precise estimate, with less effort and cost. Effort has been made to equally allocate at least three sample plots to each age classes. For each age class, effort was also made to include the full range of site conditions (from poorest to best). Sampling will therefore be carried out in 3 plots for each age class – site quality combination (stratum) which sums up to 32 plots overall (Table 3).

The selection of the size and shape of the plots was based on capturing the variation of the stand at each sampling. The plot size will vary between 400 to 800 m2 depending on the age class and site quality (smaller area for trees of smaller dimensions). Each plot will include at least 30 trees, which exceeds the 10–20 trees set as a rule of thumb in order to obtain a representative sample (ForestWorks ISC, 2014). The number and area of the plots per stratum is shown in Table 3.

Table 3. Number of sample plot per stratum

Site Quality	Age class			
	I	II	III	IV
	0 - 10	10 - 20	20 - 30	30 - 40
Good (A)	3	3	3	3
Medium (B)	3	3	3	3
Poor (C)	2	2	2	2

A design of nested quadrats of different sizes will be implemented in order to measure vegetation of different sizes and strata, and for collecting litter to estimate carbon stock (Figure 2). The 1m X 1m quadrat will be used for small shrubs biomass (< 2cm DBH), herbaceous species and litter.

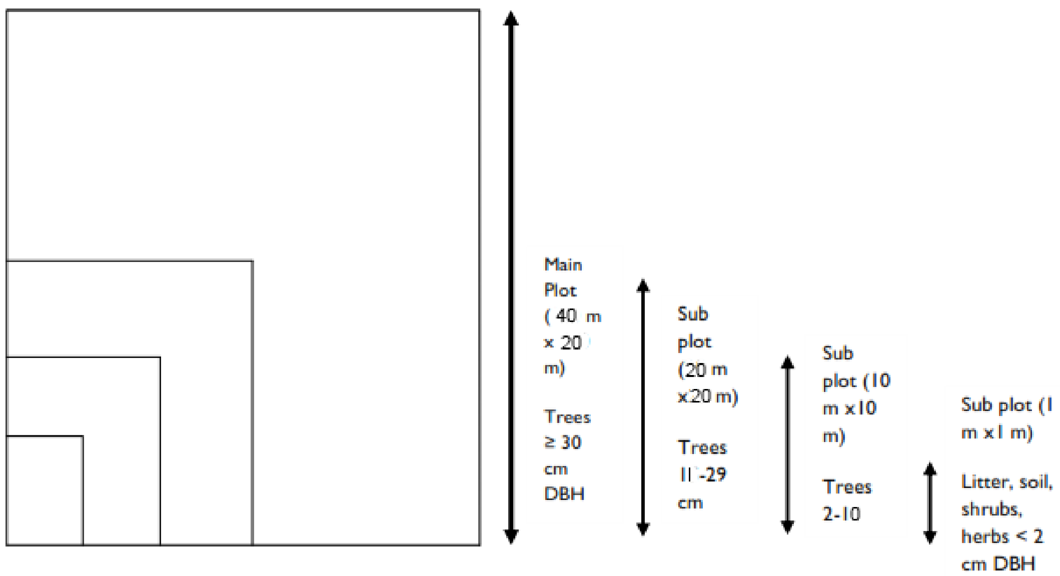

Figure 2. Nested plot design for sampling various carbon pools in homogeneous stratum (adapted from Assefa et al., 2013)

The 10m X 10m quadrat will be used for sampling above ground live trees with 2-10 cm DBH and dead wood. The second quadrat will be used for trees with DBH between 11 – 29 cm. Trees with DBH ≥ 30 cm should be counted in the entire sample plots. The size of the sampling plots will depend on the stratum (age class and site quality).

3.3. Measurement/ assessment of Carbon Stock (Sinks & Reservoirs)

3.3.1 Determination of Living Tree Biomass and Carbon Storage

Above-ground live biomass: Includes all live vegetative biomass above the soil including stem, stump, branches, bark, seeds and foliage. The biomass contained in the trees is the primary source of carbon stocks. For each tree the diameter is measured at 1.3 m above the soil surface, except where trunk irregularities at that height occur (plank woods, tapping or other wounds) and necessitate measurement at a greater height (Hairiah et al., 2001).

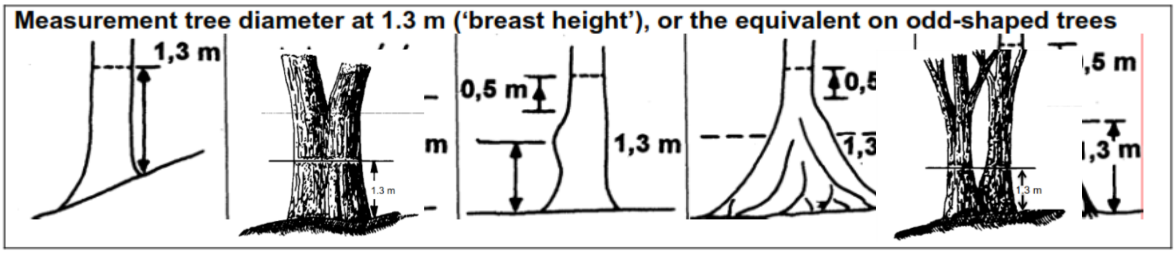

Figure 3. Tree measurement at breast height diameter (Hairiah *et al.*, 2001; Climate Action Reserve, 2017)

The aboveground biomass measurement will include all trees and shrubs within each plot that are greater than 2 cm diameter at breast height (DBH), and also their branches and foliage. The living tree biomass and carbon storage capacity of beech plantations will be determined using the biomass and carbon storage models developed by Misir et al. (2013) for tree and tree components. In other words, whole tree biomass and carbon storage capacity will be estimated from DBH for oriental beech using allometric biomass equations proposed by Mısır (2013).

Since the diameter at breast height and total height of each tree in the sample plot are measured, they are used to fill in the corresponding places for diameter and height in the biomass and carbon storage models. Stem, branch, bark, leaves, and tree biomass and the amount of carbon stored in the tree biomass will be estimated. By correlating with the size of the sample area, stem, branch, bark, leaf, tree biomass and the amount of carbon stored in these biomass will be found in the hectare.

General information (aspect, slope, elevation) and stand characteristics will also be recorded during the samplings (structure, cover, etc.). The cover within the sample area of the shrubs or herbaceous species will also be determined. After that, it will be cut from the soil ground with motorized saws and scissors, and the leaves, shrubs and herbaceous layer will be weighed individually in the field. Each component will then be subjected to sub-sampling and transported to laboratories for biomass measurements and carbon analysis. In addition, all of the fine woody debris and coarse woody materials will be collected and weighed from the sample plots; sub-samples will be taken and brought to the laboratory for further analysis.

3.3.2 Determination of Belowground Biomass and Stored Carbon

The belowground biomass will be estimated using the root to shoot ratio, which is based on the relationship between biomass in shoot and roots for a tree of a given species as well as for a given forest or plantation type.

According to (Cairns et al., 1997) the average below-ground (root) biomass to average above-ground (shoot) biomass ratio for tropical, temperate and boreal areas is 0.26.

3.3.3 Determination of Standing Dead Tree, Lying Dead Wood and Shrubs Biomass and Stored Carbon

Dead woody materials with a diameter of 1-10 cm will be categorized as fine and those larger than 10 cm will be categorized as coarse woody material and their biomass will be determined. Each sample will be pulverized by grinding in a grinding mill and three sub-samples will be taken from this powder mixture. Their carbon content will be determined with COSTECH's elemental analysis device. Thus, the amount of carbon stored in each sample will be found and converted into tons per hectare.

3.3.4 Determination of Litter Biomass and Stored Carbon

Litter: Material that is too small to be considered lying dead wood is classed as litter. This includes branches, stumps, leaves and duff.

In order to determine the amount of litter on the forest floor, the litter organic matter of 25 x 25 cm size in 4 points which are not destroyed in sample areas and determined by random sampling will be collected up to mineral soil and transported to laboratories. Thus, for each sample plot, the amount of litter (litter biomass) in the unit area and the amount of carbon stored in the litter will be determined. Litter samples will be kept in a drying oven at 65 ± 3 °C for 48 hours and when they reach constant weight, their dry weights will be measured (sensitivity 0.01 g). Utilizing the biomass of this sample, several transformations will be found on the hectare of litter biomass. In addition, samples are grinded in a grinding mill and analysed by COSTECH's Elemental Analyser to determine the amount of carbon stored.

3.4. Equipment and supplies

The following list includes the basic equipment and supplies that will be required for the carbon sampling field crew:

- GPS, for navigation to plot locations and Maps
- Diameter tape for measuring Diameter at Breast Height at 1.3 m
- Laser rangefinder/distance measuring device, for measuring tree height (if required).
- Measuring tape, for laying out plots
- Corner posts/stakes
- Metal sampling frame (for litter measurements)
- Satellite phone, two way radio or mobile phone (if there is reception)
- Data recording device (i.e. waterproof paper-based sheets, or electronic data logger, pens/pencils)
- Flagging tape
- Motorized saws and scissors
- Camera
- Safety equipment such as a first aid kit, hard hat, sun protection, high visibility vest, etc.

Work health and safety, environmental and organizational requirements that apply to any forest operation in Turkey will be taken into account when carrying out the carbon stock sampling.

4. FIELD SAMPLING

The Action incorporates sample plots and sample trees data. The results of sample plots include stand type, stand diameter (two type: mean diameter and quadratic mean diameter), stand height, basal area, number of trees, herbaceous biomass, shrub biomass, litter biomass, lying dead wood biomass, herbaceous carbon amount, shrub carbon amount, litter carbon amount and lying dead wood carbon amount. The Sample trees results include diameter at breast height, tree height, stem biomass, branch biomass, foliage biomass, stem carbon amount, branch carbon amount and foliage carbon amount.

The project site (Vakfıkebir forest) has approximately 200 ha of scattered planted areas of beech (*Fagus orientalis*), up to 34 years old (Figure 1). Past management was based on previous management plans (1973, 1984, 2006 & 2016), with different priorities.

Field measurements were applied to estimate the aboveground live tree volume, using allometric equations developed in this project. Field measurements were also applied to estimate the aboveground live tree biomass in branches and foliage, as well as the shrub/herbaceous volume. Other measurements provided data for standing dead wood, lying dead wood and litter. The parameters to be measured/assessed were included in the Inventory sheet.

The beech plantations were stratified into 10-year age classes (4 age classes overall) and 3 types of site quality in the forest (good, medium, poor). In order to efficiently estimate the carbon stock, random stratified sampling will be applied. Stratification minimizes the variation within each stratum therefore providing a more precise estimate, with less effort and cost. Effort has been made to equally allocate at least three sample plots to each age classes. For each age class, effort was also made to include the full range of site conditions (from poorest to best). Sampling therefore was carried out in 3 plots for each age class – site quality combination (stratum) which sums up to 32 plots overall (Table 4).

The selection of the size and shape of the plots was based on capturing the variation of the stand at each sampling. The plot size will vary between 100 to 600 m^2 depending on the age class and site quality (smaller area for trees of smaller dimensions). Each plot included at least 30 trees, which exceeds the 10–20 trees set as a rule of thumb in order to obtain a representative sample (ForestWorks ISC, 2014). The distribution of site quality and age classes the sample plots is shown in Table 4.

Table 4. Distribution of site quality and age classes of sample plots

Site Quality	Age class (number of sample plots)			
	I	II	III	IV
	0 - 10	10 - 20	20 - 30	30 - 40
Good (A)	9 10 16	11 20 21	5 19 26	2 17 25
Medium (B)	8 12 14	4 7 18	22 27 32	6 28 29
Poor (C)	13 15	23 31	3 30	1 24

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This project is co-financed by the European Union and the Republic of Tukey

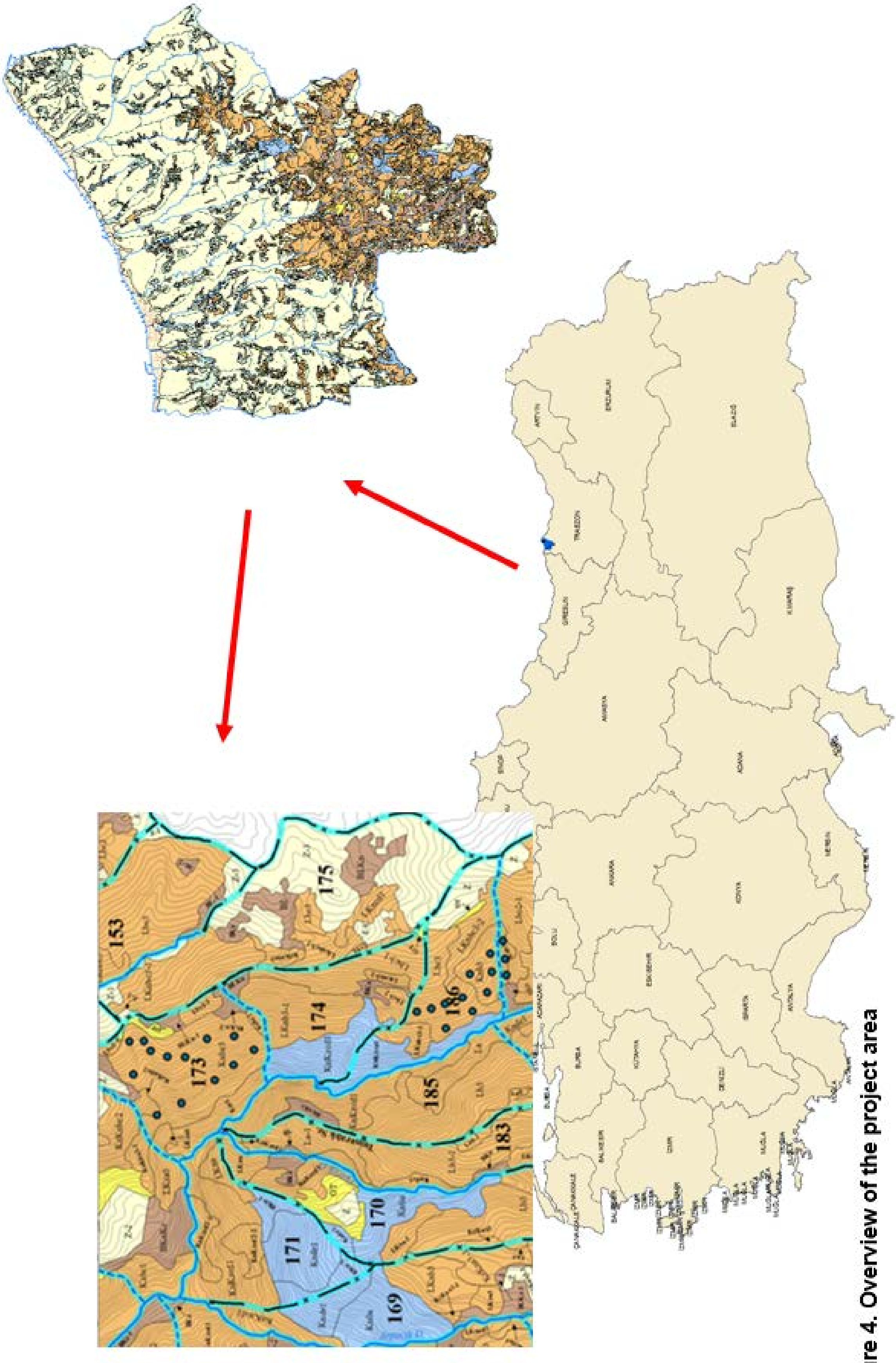


Figure 4. Overview of the project area

The sampling plots were allocated between planning units of the Vakfıkebir State Forest (Figure 4 and Figure 5) as follows:

- Vakfıkebir planning unit: 13 sampling plots
- Tonya planning unit: 10 sampling plots
- Düzköy planning unit: 9 sampling plots

Figure 5. Project Area

A design of nested quadrats of different sizes was implemented in order to measure vegetation of different sizes and strata, and for collecting litter to estimate carbon stock, as described in the Sampling plan. The 1m X 1m quadrat will be used for small shrubs biomass (< 2cm DBH), herbaceous species and litter.

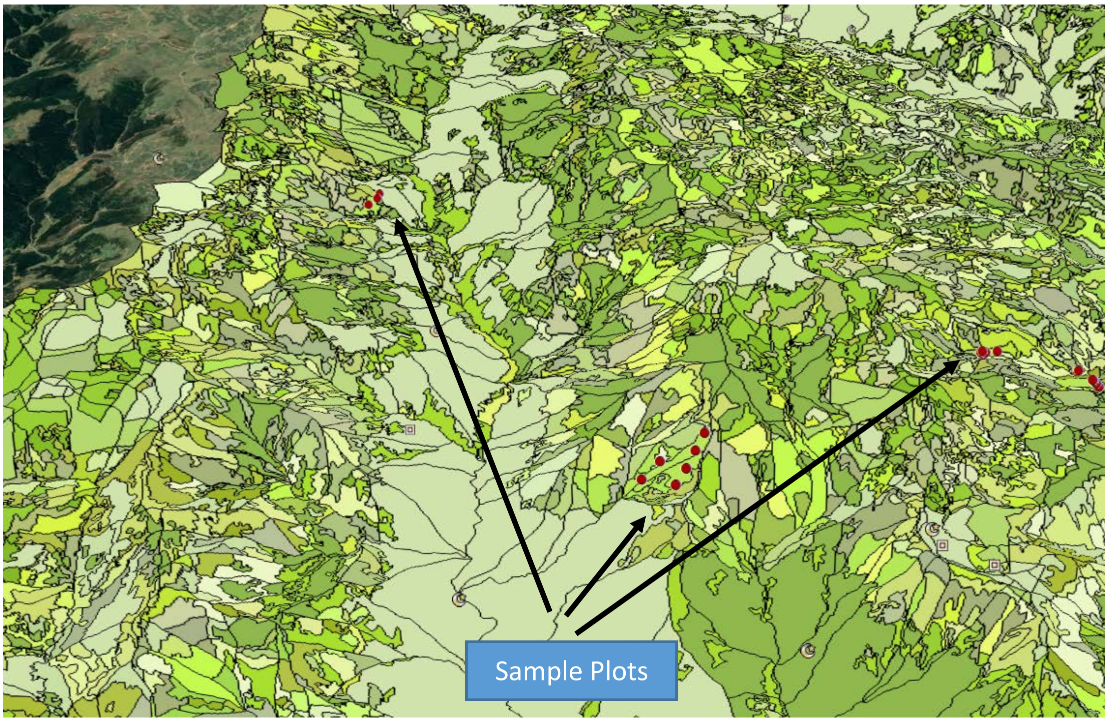


Figure 6. Sampling Plots

Implementing field sampling to derive the baseline situation of the forest stands of the project area

Figure 7. Field Stusies

Figure 8. Field Stusies

Figure 9. Laboratory Studies

The results obtained from the measurements performed in the sample plots are presented in Tables 5 & 6.

Table 5. **Sampling plots – General information**

Sample Plot No	Mean diameter (cm)	Age class	Site class	Basal area m^2/ha	Number of trees
1	17.0	IV	Poor	19.4	800
2	10.8	IV	Good	44.7	4000
3	13.2	III	Poor	36.1	2000
4	9.3	II	Medium	37.2	4100
5	12.8	III	Good	53.0	3400
6	14.3	IV	Medium	29.9	1550
7	9.7	II	Medium	33.1	3700
8	5.5	I	Medium	25.5	9600
9	5.7	I	Good	29.9	6700
10	6.8	I	Good	36.1	8000
11	7.8	II	Good	20.7	3400
12	0.8	I	Medium	0.1	867
13	1.3	I	Poor	0.4	2500
14	1.1	I	Medium	0.7	5200
15	0.9	I	Poor	0.2	3067
16	6.7	I	Good	17.4	3800
17	13.3	IV	Good	37.1	2200
18	11.5	II	Medium	39.1	2867
19	12.6	III	Good	26.8	1645
20	11.4	II	Good	52.2	4300
21	10.8	II	Good	43.1	4000
22	13.5	III	Medium	49.0	2900
23	11.6	II	Poor	32.9	2534
24	22.7	IV	Poor	40.9	925
25	15.9	IV	Good	33.0	1500
26	14.7	III	Good	26.6	1425
27	15.0	III	Medium	24.0	1200
28	16.9	IV	Medium	27.1	1050
29	15.8	IV	Medium	38.1	1700
30	13.1	III	Poor	20.2	1325
31	12.4	II	Poor	19.6	1475
32	13.7	III	medium	19.2	1225

Table 6. Understorey biomass of the sample plots

Sample Plot	Biomass (kg)			
	Herbaceous	Shrub	Litter	Lying dead wood
1	0	1830	7200	0
2	0	4950	12000	3375
3	38	750	3200	1080
4	0	4980	26400	2370
5	129	3870	14200	3270
6	76	3020	19580	2280
7	23	57.5	10800	200
8	125	750	23000	6030
9	30	0	30200	480
10	58	345	8200	2490
11	75	150	8600	2030
12	975	163	5867	303
13	2610	6525	2000	5925
14	260	0	2600	0
15	1280	80	8600	345
16	700	4200	14000	3480
17	0	1245	10600	6990
18	0	1890	10200	1960
19	23	1125	11600	2175
20	40	2370	17200	1140
21	21	735	13600	1698
22	26	1820	8800	1540
23	52	3090	10400	1710
24	0	500	6000	500
25	10	1000	10000	1701
26	20	1200	8000	3252
27	15	950	9008	4000
28	0	1200	7040	3270
29	0	750	3040	1050
30	0	57	10560	201
31	0	0	2720	0
32	0	0	3200	1080

The results obtained from measurements made of sample trees are presented in Table 7.

Table 7. Biomass and characteristics of sample trees

Sample tree no	Dbh (cm)	Tree Height (m)	Stem biomass (kg)	Branch biomass (kg)	Foliage Biomass (kg)
1	11.70	11.55	37	2.25	0.01
2	8.80	10.80	16	0.24	0.01
3	7.00	11.90	16	0.47	0
4	5.30	7.15	4	0.21	0.05
5	15.50	12.20	43	4.83	0
6	6.20	8.60	4	4.62	0
7	15.50	13.10	58	20.10	0.68
8	12.80	15.20	50	5.49	0.76
9	14.20	13.10	49	14.10	0.54
10	8.00	7.90	10	2.13	0.08
11	7.50	10.25	17	3.19	0.37
12	10.50	11.90	21	4.03	0.34
13	16.40	14.80	79	20.52	1.71
14	6.90	10.65	14	2.60	0.26
15	0.30	1.60	0	0.02	0.02
16	1.40	1.25	0	0.04	0.01
17	1.20	1.45	0	0.03	0.02
18	1.20	1.33	0	0.03	0.03
19	8.20	11.60	19	1.30	0.13
20	4.90	10.70	6	0.70	0.08
21	24.8	18.40	165	124.40	10.9

During the Action, samples were collected from specific carbon pools in the forests to estimate the amount of carbon in each one, through laboratory analysis which resulted in the following allometric equations for the calculation of biomass and carbon storage in tree stems, branches and foliage for oriental beech in the Trabzon region, for maximum stand age of 40 years:

$$Stem\ Biomass\ (Kg, inside\ bark) = 0.927 - 0.611 \times d + 0.289 \times d^2, R^2 = 0.977, S_{y.x} = 6.2\ kg$$

$$Branch\ Biomass\ (Kg) = 0.05036 \times 1.43373^d, R^2 = 0.82, S_{y.x} = 1.02\ kg$$

$$Leaf\ Biomass\ (kg) = 0.01627 \times 1.31125^d, R^2 = 0.925,\ S_{y.x} = 0.5\ kg$$

$$Stem\ Carbon\ (kg) = 0.06373 - 0.13234 \times d + 0.22919 \times d^2, R^2 = 0.976, S_{y.x} = 2.7kg$$

$$Branch\ carbon\ (kg) = 0.02378 \times 0.14339^d, R^2 = 0.82, S_{y.x} = 1.0\ kg$$

$$Leaf\ carbon\ (kg) = 0.00742 \times 1.3123^d, R^2 = 0.927, S_{y.x} = 1.5\ kg$$

NOTE: All models are statistically significant with $P < 0.001$.

Moreover, carbon storage in shrubs, herbaceous vegetation and deadwood was estimated as shown in Figure 6. This analysis provides insight into the allocation of carbon stocks in the sampling plots.

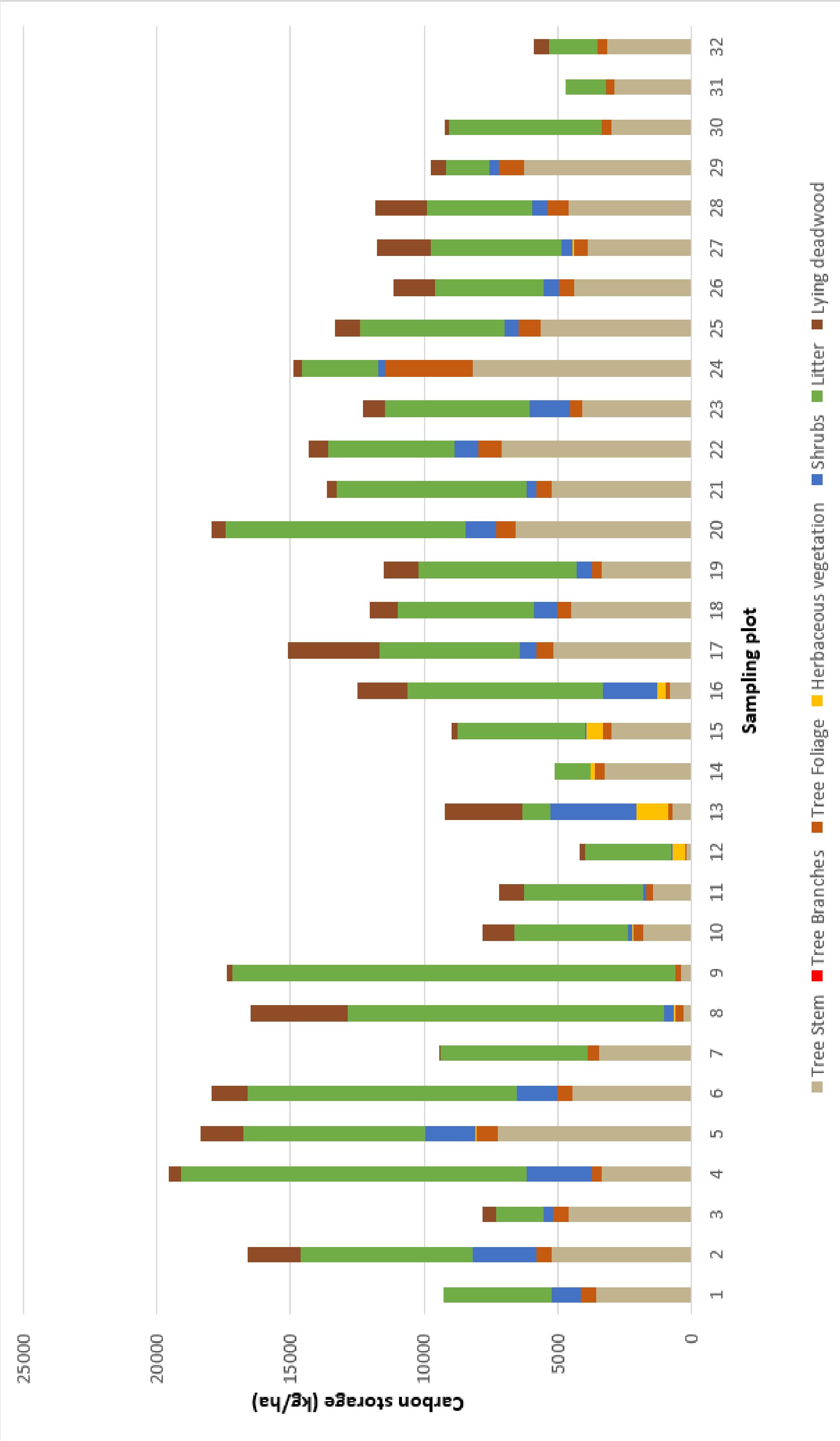


Figure10. Allocation of carbon storage in various forest stand carbon pools

Field sampling carried out during WP2 has resulted in the following findings regarding the planted *Fagus orientalis* forests within the management units of Vakfıkebir, Tonya and Düzköy:

- Canopy closure affects the balance between tree stem and litter carbon pools within the plots. Higher canopy closure is inversely proportional to the carbon storage in tree stems (Figure 7).

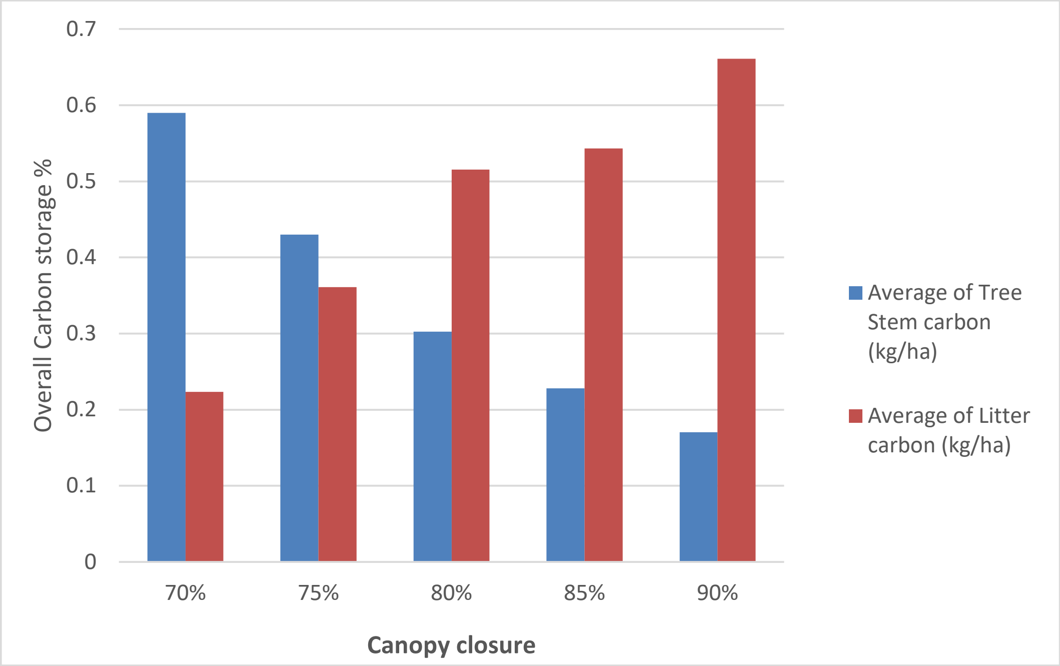


Figure 11. Effect of canopy closure on tree stem & litter carbon pools

- Tree stem biomass and litter account for more than 70% of the carbon storage (Figure 2)
- Carbon storage in tree branches is insignificant, whereas the third larger carbon pool in the study area is lying deadwood, followed by shrubs and tree foliage (Figure 2)

The accumulation of large amounts of litter in forest stands inhibits the soil enrichment with nutrients and reduces the soil carbon storage. Therefore, the most important carbon pool, which adapted forest management targets, is tree stem.

The models developed in WP2 revealed a significant correlation between breast height diameters, biomass and carbon storage in oriental beech forests.

Tree stem biomass and litter account for more than 70% of the carbon storage in the Trabzon region. Also, carbon storage in tree branches is insignificant, whereas the third larger carbon pool in the study area is lying deadwood, followed by shrubs and tree foliage. This information may provide useful directions towards understanding the carbon stock dynamics at stand level. This is necessary in order to follow the appropriate management practices that would keep carbon pools high, such as thinning to create more open stands in case of excessive litter accumulation and therefore a well-developed understory.

5. FOREST MANAGEMENT PRACTICES AND MEASURES TO IMPROVE THE CARBON REMOVAL/SEQUESTRATION

Forests, which are the main component of the so-called ‘‘land sinks,’’ play a vital role in the global carbon cycle through the absorption of 2.9 ± 0.8 Pg of carbon (C) per year (in the period 2004–2013), thus mitigating climate change related to the increase of anthropogenic carbon dioxide (CO2) in the atmosphere (Le Quéré et al. 2014). The total carbon stock in Turkey’s forests was calculated as 2251.26 Tg C in 2004 and 2648.5 Tg C in 2015 (Mısır et al., 2017). The carbon stock in the living biomass was calculated as 479.87 Tg C. The 92.20% of carbon stock in the living biomass was attributed to productive forests, while the remaining 7.80% to degraded forests (Tolunay, 2011). Using the gain-loss method, Turkey’s forests have approximately absorbed 13.68 Tg C year-1 from the atmosphere in 2004. The majority of that amount, 12.63 Tg C year-1, belonged to the productive forests, while the remaining 1.05 Tg C year-1 portion belonged to the degraded forests (Tolunay, 2011).

Forest carbon storage is controlled by a number of factors. Initially, the climatic conditions in general and climate change. As Karjalainen et al. (2003) have reported carbon densities in northern and southern European forests are lower than those of central European forests, due to northern Europe’s cold climate and drought in southern Europe. Furthermore, natural disturbance (e.g., fire, pests, hurricanes), human management (i.e., what to do with harvest), and policies on a national or global scale affect carbon accumulation and storage.

To determine the accumulation of carbon in Turkey’s forests, there is a need to adapt the carbon management approach to forest management. The principal aim of carbon management is to increase the amount of carbon accumulated in the forest ecosystems. Reduction of deforestation, forest fires, illegal cuttings, and afforesting are the main measures for increasing the carbon accumulation. In particular, the degraded forests, making up half of Turkey’s forests, have to be rehabilitated. The carbon stocks may also be increased by taking various silvicultural measures (Tolunay, 2011).

In other words, forests become substantial carbon sinks depending on how they are managed. In Turkey, carbon accumulated in the forests due to volume increment, however, is removed from the forests through the fuelwood and industrial roundwood production – as the management plans suggest. According to Tolunay (2011), during 1990-2005, an average cutting amount of 7.26 million m^3 /year was done for industrial roundwood production, while an average amount of 6.86 million m^3 /year was done for fuelwood production. Additionally, a volume of 18.69 million m^3 /year is removed from the volume increment, which reached 36.28 million m^3 /year by logging in Turkey's forest in 2004.

On the other hand, conversion of coppices to high forest, rehabilitation of degraded forests, and an increase of plantations lead to an increase in carbon sequestration (Tolunay, 2011).

In the long run, the carbon accumulated in the growing stock will be released through respiration, death, and the decay of litter and humus, and oxidation of wood products. The delay between the accumulation and release represents the sequestration, which is a temporary stock by definition. In this respect, forests and wood products can provide only temporary carbon stocks compensating for the human induced carbon releases. These stocks can be, however, long lasting ones and they can be affected by management.

The aim of the present common Protocol is to assess and validate forest management practices and measures to improve the carbon removal/sequestration balance. In this chapter, a number of forest management practices are outlined that are commonly used towards increasing carbon storage in the forest sector.

Key issue to promote forest carbon storage is the recovery of the ecological efficiency of forests, which in many cases have been overexploited for thousands of years (Chiriaco et al. 2013). In this perspective, forest management policies should aim at:

(1) restoring forest stands degraded by past intensive logging (Corona et al. 1997);

(2) promoting a gradual increase of forest growing stock and, possibly, the adoption of longer rotation cycles in old/healthy forests that are at low risk from pests or environmental disturbances (Fares et al. 2015);

(3) converting coppice forest into high forest stands, where technically and economically viable, thus bringing positive effects on above- and belowground biomass accumulation (Ciancio et al. 2006).

Forest management practices for conserving and sequestering carbon can be grouped into four major categories (Dixon et al., 1994):

1. the maintenance of existing carbon pools (slow deforestation and forest degradation)

2. the expansion of existing carbon sinks and pools through forest management

3. the creation of new carbon sinks and pools by expanding tree and forest cover

4. the substitution of fossil fuels and fossil fuel-based product with renewable wood-based fuels and products.

In line with the above, as already proposed by the Climate Action Reserve (2012), carbon stock may be enhanced by the following sustainable forestry management activities:

- increasing the overall age of the forest by extending the rotation period;
- increasing the forest productivity by thinning diseased and suppressed trees,
- managing competing brush and short-lived forest species, and
- maintaining stocks at a high level (Bourque *et al.*, 2007).

Furthermore, forest management involves decision-making that may have a significant impact on the level and time of carbon sequestered either in forests or in the wood products generated from these forests (Matthews, 1996; Meng et al., 2003). For example, forests with fast growing, short-rotation aged stands have a high rate of carbon uptake (Metting et al., 2001; Ney et al., 2002).

Generally, the changes in biomass stock or annual volume increment are used in determining the change in biomass carbon stocks in forests. However, determining the forest biomass appears to be an important problem because the forest inventories are not generally designed to determine the carbon budget, but are focused mostly on determining the stem volume (Van Camp et al. 2004; Jalkanen et al. 2005).

Changes in soil properties due to different forest management and silvicultural methods also affect soil C pools and the carbon budget of the atmosphere (McPherson et al. 1993; Bayramzadeh, 2014).

However, the time over which the carbon is stored is relatively short, especially if burned or converted into paper. Short-lived products like paper, wood chips, sawdust, and hog fuel enter the waste stream quickly and decompose fairly rapidly (Hoen and Solberg, 1994; Bhatti *et al.*, 2003).

IPCC provides the following default half-life values for the most common forest products:

(a) 2 years for paper;

(b) 25 years for wood panels;

(c) 35 years for sawn wood.

The carbon stored in short-lived products returns to the atmosphere and re-enters the carbon cycle in just a few years, whereas investing in other products may secure its storage for more than 30 years.

In order to increase the amount and time of carbon storage specific management practices need to be applied. A brief summary of these practices is presented below to investigate ways that they can potentially be incorporated in the forest management currently applied in the project area. The objective of the management is not only to increase carbon storage but also to improve stand stability and adaptation potential to climate change.

A wide range of forest management practices to improve carbon sequestration are available in the literature, however the following practices are further outlined because stand density, rotation age and species mixture are considered the most important for both Turkey and Greece.

✓ Adapted Stand Management

The density of forest stands during their life cycle needs to be actively modified by forest managers in order to improve stand conditions, reduce competition-induced tree mortality and to avoid natural disturbances such as storm damage and insects' infestation. Stand thinning has a long history in practical forest management. However, in the context of carbon sequestration, thinning removes amounts of carbon sequestered in biomass and dead organic matter for the sake of sustainability, improved stand stability and longevity.

The amount of carbon stored in a forest stand depends on its age and productivity. Uneven-aged management creates overall more complex stand structure and maintains a steady flow of yields and aboveground carbon stocks through time (Sharma et al., 2016). Selection cuttings maintain late-successional forest characteristics and species assemblages better than even-aged stands (Kuuluvainen et al., 2012). Both even- and uneven-aged management options have the potential to improve production and carbon storage and are a substantial improvement over no action (Sharma et al., 2016).

Thinned stands contain fewer trees with larger diameters and therefore higher value and potential to provide long-lived wood products. Thinning not only removes biomass but also stimulates microbial soil processes by exposing the forest floor to solar radiation and precipitation. Therefore, stands that have undergone thinning never hold the maximum amount of carbon (Vesterdal et al, 1995; Skovsgaard et al., 2006), but are less vulnerable to disturbances and thus create more stable carbon pools than unmanaged forests (Jandl et al., 2007).

In planted forests it is common practice to have frequent and intense thinning, due to the fact that these forests are usually managed for wood production. This is the case also in the Trabzon region where frequent thinning are performed in the oriental beech forests, every 5-7 years. Comparing the impact of this practice on carbon storage to exploitation scenarios of less frequent and less intense thinning showed that the current practice contributes the least to carbon storage:

Frequent, intensive thinning (5 – 7 years, up to 45%) < Frequent, less intensive thinning (5 – 7 years, up to 35%) < Less frequent thinning (15 years, up to 45%) < Less frequent & less intensive thinning (15 years, up to 35%).

The results of the scenarios analysis are in agreement with the international literature reviewed for the current deliverable on forest management practices and measures to improve carbon sequestration. In particular, management scenarios of this project suggest that biomass and stocked carbon amount increase through forestry management practices that involve adapted stand management which includes thinnings and selection cuttings to improve stand structure.

✓ Extending the Rotation Period

Biomass and carbon sequestration increase with stand age. Therefore postponing harvesting to the age of biological maturity may seem as the only logical step to forming a large carbon sink. Carbon stocks can be maintained and increased through the use of extended rotation periods. This recommendation is supported by widely documented positive relationships between aboveground carbon stores and stand age (D' Amato *et al.,* 2011; Yavuz *et al.*, 2010).

Very high carbon stocks have been recorded in mature forest ecosystems, where the sum of carbon in the biomass and the soil peaks (Knohl *et al.,* 2003; Harmon *et al.*, 1990). The net carbon balance in forests between 15 and 80 years of age (including the soil), is usually positive and old-growth forests seem to continue to accumulate carbon (Luyssaert *et al.*, 2008).

Old forests have a high carbon density whereas young stands have a large carbon sink capacity. Young forests have high carbon sequestration rates which decline as they age. Mature forests eventually reach equilibrium in which no or little further sequestration takes place, leading to limited mitigation potential and carbon storage capacity in time (SFC, 2010). Moreover, the resilience of forests to climate change impacts is often decreased with increasing stand age and basal area (Seidl *et al.*, 2017).

Short rotation lengths maximize aboveground carbon sequestration, but not carbon storage in the forest or in the wood products. On the other hand, mature forests represent a large, but saturated carbon pool that has little potential for future additional carbon sequestration.

Apart from ecological considerations, the question remains whether forests fulfil their climate change mitigation potential best by storing a large quantity of carbon (either in situ or as long-lived wood products) or by providing short-lived wood products that substitute goods produced from non-renewable resources.

✓ Increasing species mixture

Tree species composition, which can be altered by silvicultural methods, affects soil carbon storage by direct and indirect effects on the quality and quantity of litter fall, throughfall and stemflow, soil properties, rooting patterns, soil respiration and consequently the nutrient availability in forest stands (Berger et al. 2002; Bayramzadeh, 2014).

Favoring species mixture is a management practice that needs to be considered towards increasing carbon stocks in a forest. The effects of mixed stands on growth and forest production may vary from no effect to productivity increase up to 50 % when species make different use of available resources, either in space or in time. Mixed stands are more resilient to disturbances and are therefore a favorable practice for adaptation (SFC, 2010).

The choice of tree species is relevant for the terrestrial carbon pool for the following reasons:

- ✓ different growth patterns over time
- ✓ specific achievable stand density;
- ✓ different rooting depths and rooting patterns;
- ✓ different effect on soil carbon pool;
- ✓ specific wood densities;
- ✓ different life spans;
- ✓ different vulnerability to disturbance

Forest stands with mixed species are often seen as a remedy for the establishment of stable forests. The benefits of single tree species can be utilized and the production risk of the entire forest can be minimized. Mixed species are superior to single species stands when the individual species exploit different resources at the same site but can also lead to a competition that reduces the overall productivity of a stand (Pretzsch, 2005; Resh et al, 2002).

According to Jandl et al. (2007), in a comparison between beech and spruce, spruce is more productive than beech in terms of stem volume production. When the higher density of beech wood is taken into account, the difference is almost compensated. This particular species comparison is especially important, because spruce is a dominant tree species in central

Europe but is believed to have negative effects on the site quality because of the slow decomposition rate of spruce litter and the species' shallow rooting depth. For carbon sequestration, both the volume productivity and the weight of the produced wood needs to be taken into account. For example, broad-leaved trees usually have a higher wood density than coniferous trees (Binkley and Menyailo, 2005).

According to the rules of the Kyoto Protocol and of the UN Framework Convention on Climate Change, forestry can generate a sink for GHG that can contribute to meeting the commitments to emissions reductions (Jandl et al., 2007). Managing mountain forests is also very important for society generally and especially for communities in densely populated mountain regions (Frehner et al., 2007).

Adapted management of existing forests may have a less obvious or slower effect on the terrestrial carbon pool. After analyzing the effects of harvesting, rotation length, thinning, fertilizer application and tree-species selection it has been concluded that these have an impact on the forest productivity and consequently on carbon sequestration in the ecosystem. Many forest treatments are already an integral part of sustainable forestry practice. In the context of carbon sequestration and its accounting in national greenhouse-gas budgets, ecosystem stability is highly rated. Forests that are robust against disturbances up to a certain degree of severity are better suited for national carbon pools than stands of maximum productivity with a high risk of damages (Jandl et al., 2007).

Different analyses of national or local forest systems reveal that cessation of forest management in productive forests would yield much lower mitigation effects than those provided by the substitution effect of the currently harvested wood (SFC, 2010).

6. ANALYSIS OF MANAGEMENT SCENARIOS

Carbon storage under different management practices was calculated through scenarios analysis, by testing their efficiency as proposed adaptations to the current management practice. In order to evaluate the impact of different management practices in beech forests of the Trabzon area the following four (4) alternative scenarios were investigated:

1. Current management practice
2. Less frequent thinning
3. Less intensive thinning
4. Increase of the rotation age

For each of these scenarios the overall carbon stored per age class and site quality was estimated. Diameter increment was calculated based on the average diameter for oriental beech determined by KTU. Carbon storage was then calculated using the equations developed:

$$Stem\ Carbon\ (kg) = 0.06373 - 0.13234 \times d + 0.22919 \times d^2, R^2 = 0.976, S_{y.x} = 2.7kg$$

$$Branch\ carbon\ (kg) = 0.02378 \times 0.14339^d, R^2 = 0.82, S_{y.x} = 1.0\ kg$$

$$Leaf\ carbon\ (kg) = 0.00742 \times 1.3123^d, R^2 = 0.927, S_{y.x} = 1.5\ kg$$

The scenarios focus on tree stem carbon, since this is the main carbon pool in the beech forests within the project area, as the sampling results have shown. The models used to calculate future stand development and consecutive carbon storage have been elaborated in the frame of this project, using data from the pilot areas. Therefore, the results presented in this report are based on the data and equations developed for the pilot area and they reflect tendencies induced by each management scenario. Their generalization should be done with cautiousness and only after proper testing and scientific justification through further research.

Data from very young stands, with diameter 0.8 – 1.3 cm (sampling plots 12 – 15) have not been included in the analysis due to the following reasons:

- The amount of carbon stored in saplings is very low and no models have been developed to efficiently assess it in the project area

- At the stage of saplings no treatment is recommended due to very early growth stage which poses limitations regarding tree diameter growth, survival rate, etc.

Therefore, the following results refer to tree stands over 10 years old (age class II). Age classes are defined as follows for the project area:

Age class	Age (years)
II	10 - 20
III	20 - 30
IV	30 - 40
V	40 - 50
VI	50 – 60

a. Scenario 1. Current management practice

The current management practice includes frequent thinning, every 5 – 7 years, until the age of 40 (Table 8). The first thinning takes place during age class II, whereas until the stand reaches age class III, three additional thinning have been applied. Currently, the beech forests in the Trabzon area provide short-lived wood products and low carbon pools. The mean DBH rarely exceeds 20 cm, as shown by the sampling results mentioned above.

Table 8. Thinning plan of Scenario 1

Stand Age	Thinning intensity per Site class		
	Good	Medium	Poor
15 yrs	20%	15%	10%
22 yrs	30%	25%	20%
27 yrs	40%	30%	25%
30 yrs	40%	30%	25%
35 yrs	45%	35%	27%
40 yrs	45%	35%	30%

The current management practice (Scenario 1) results in minor variations between carbon storage in sites of good and medium quality. Carbon storage ranges from 1.7 to 2.5 tonnes/ha in good quality sites and declines with age. Due to the high intensity thinning trees with larger diameters are removed thus reducing the carbon stock. The carbon storage in medium site classes is approximately 3 tonnes/ha ± 0.3, whereas the larger quantities of carbon are stored in poor sites. Most likely, due to less intense thinning, carbon storage is increasing with age, even though the sites are less productive (Figure 8).

Figure 12. Scenario 1 carbon sequestration per age class & site quality

b. Scenario 2. Less frequent thinning

This scenario involves reducing the thinnings by half, from six (6) that are currently applied to three (3), maintaining the same intensity (Table 9). The first thinning takes place during age class II and is followed by two consecutive thinnings at the age of 30 (Class III) and 40 (Class IV).

Table 9. Thinning plan of Scenario 2

Stand Age	Thinning intensity per Site class		
	Good	Medium	Poor
15 yrs	20%	15%	10%
30 yrs	40%	30%	25%
40 yrs	45%	35%	30%

Scenario 2 results in higher carbon storage than scenario 1, which consistently increases with age. However, carbon stocks seem to be inversely correlated with site quality with higher values found in poor sites (Figure 13).

Figure 13. Scenario 2 carbon sequestration per age class & site quality

c. Scenario 3. Less intensive thinning

This scenario involves reducing the intensity of the thinning, at least by 5%, in all age classes and site qualities (Table 10). The stand age of each thinning remains the same as in Scenario 1.

Table 10. Thinning plan of Scenario 3

Stand Age	Thinning intensity per Site class		
	Good	Medium	Poor
15 yrs	15%	10%	5%
22 yrs	25%	20%	10%
27 yrs	30%	25%	10%
30 yrs	30%	25%	10%
35 yrs	35%	27%	10%
40 yrs	35%	30%	10%

Scenario 3 results in higher carbon storage as stand age increases in sites of medium and poor quality. In good quality sites carbon storage peaks at age class III but decreases over time after that point (Figure 14).

Figure 14. Scenario 3 carbon sequestration per age class & site quality

d. Scenario 4. Increase of the rotation age

This scenario includes increasing the rotation age, reducing the number of thinning by half and reducing the intensity of the thinning (Table 11). The thinning are reduced to three (3), same as in scenario 2 and are less intense, same as in Scenario 3. The first thinning takes place during age class II and is followed by two consecutive thinning at the age of 30 (Class III) and 60 (Class IV).

Table 11. Thinning plan of Scenario 4

Stand Age	Thinning intensity per Site class		
	Good	Medium	Poor
15 yrs	15%	10%	5%
30 yrs	30%	25%	10%
60 yrs	35%	30%	10%

Scenario 4 results in higher carbon storage in all site qualities, which is increasing over time (Figure 15). Carbon stocks double from age class II to age class III and exceed 10 tonnes/ha in age class IV. The increase of the rotation age by 20 years significantly boosts carbon storage in age class VI, regardless of the site quality.

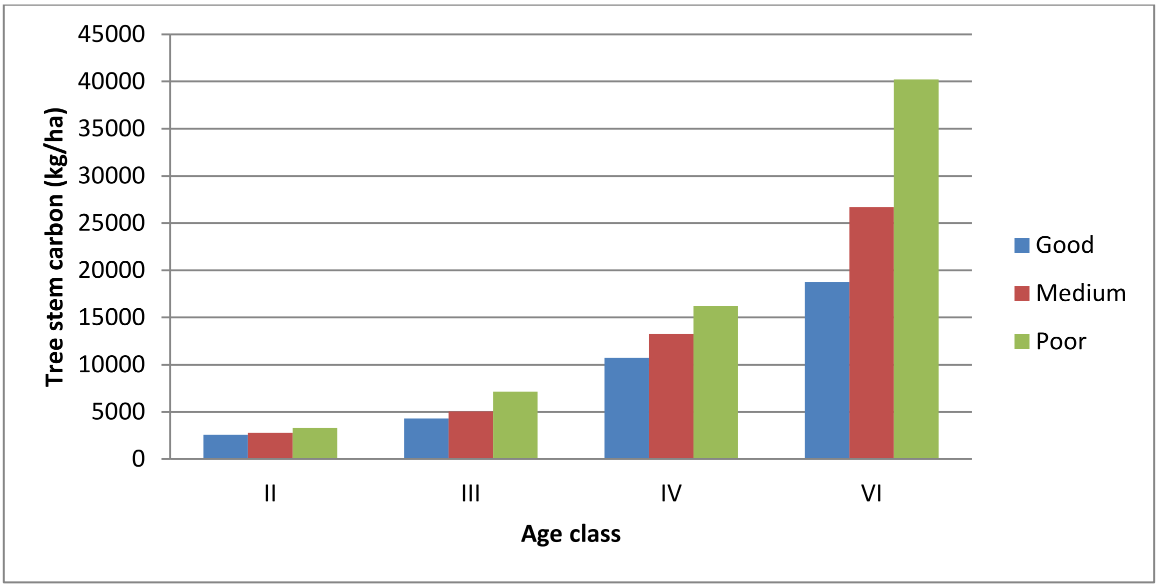


Figure 15. Scenario 4 carbon sequestration per age class & site quality

e. Comparison of different scenarios

The management scenarios investigated have shown that short rotation periods do not favor carbon storage (Figure 16). However, even slight modifications in the current management, such as those presented in Scenarios 2 and 3, can increase the carbon pool in the project area.

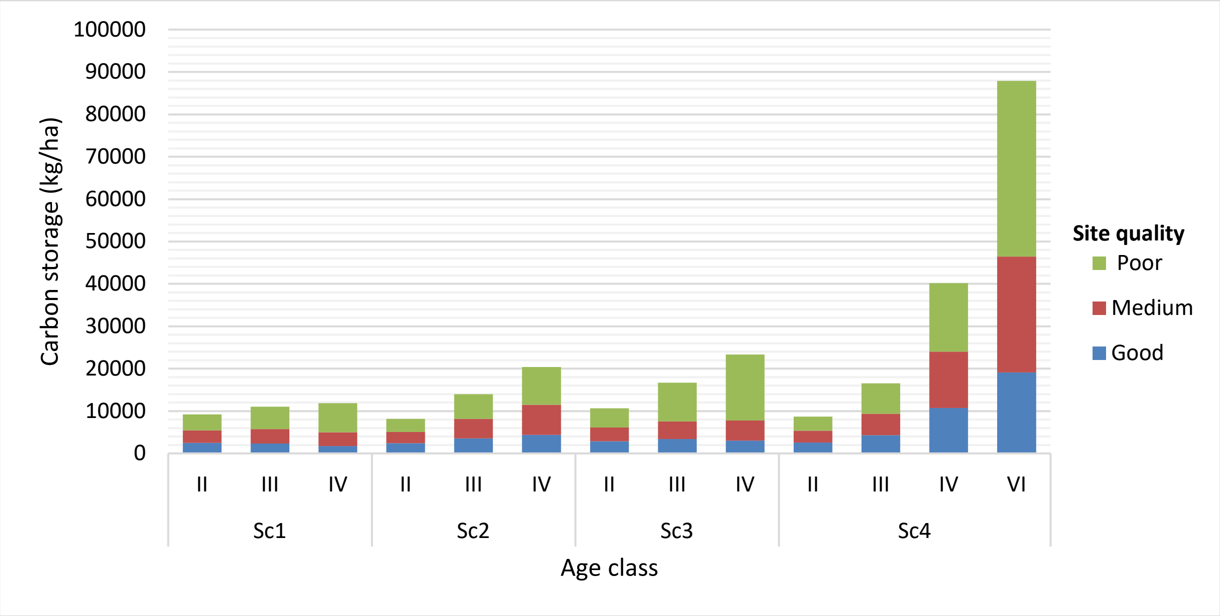
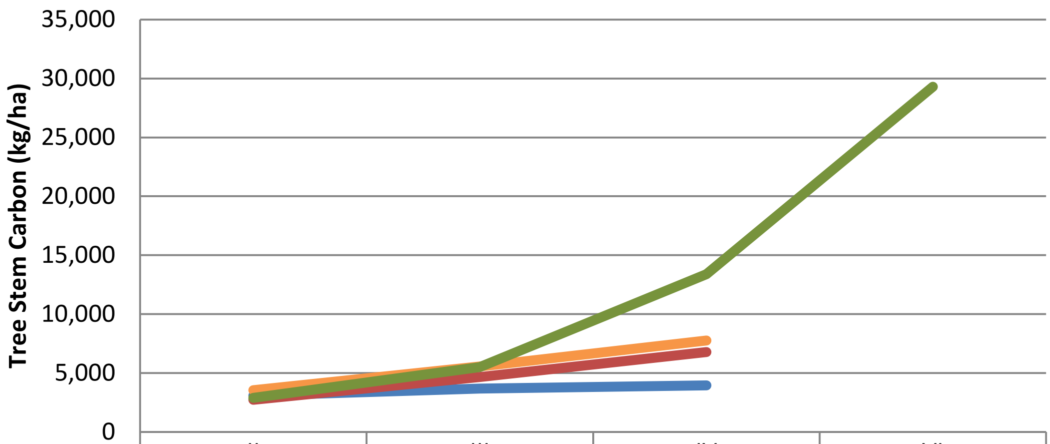


Figure 16. Overall carbon storage per age class, site quality category and management scenario

Less frequent thinning (Scenario 2) lead to slightly less carbon storage in young stands (age class II), by up to 20%. The benefits of extending the time interval between thinning are evident as the stand grows (age classes III & IV), when carbon storage increases by 25 – 60% (Figure 17). On the other hand, less intense thinning (Scenario 3), compared to the currently applied practice (Scenario 1), generally increase carbon storage by approximately 12% in age class II to over 55% in age class IV (Figure 17). The combination of extending the rotation period and decreasing the intensity of the thinning (Scenario 4) is by far the optional practice to increase carbon storage in the project area as seen in Figures 16 and 17.



	II	III	IV	VI
Sc1	3,077.03	3,680.54	3,945.97	
Sc2	2,726.26	4,660.36	6,793.42	
Sc3	3,555.65	5,566.18	7,777.68	
Sc4	2,885.68	5,510.84	13,390.20	29,290.46

Age class

Figure 17. Average tree stem carbon storage per site class and management scenario

Reducing both the intensity and frequency of thinning (Scenario 4) leads to lower carbon stocks in age class II which is compensated as the stand grows. Carbon stocks in age class III under scenario 4 exceed the corresponding amounts of scenario 1 by 25 - 45%. This percentage increases even more in age class IV to over 80%. The extension of the rotation age by 20 years substantially increases forest carbon stocks, almost doubling them between the ages of 40 and 60 the carbon stock

When assessing management scenarios in favor of climate change, however, there are more aspects to consider than carbon storage solely. These include less GHG emissions from forest works, less disturbance in the forest, frequency of financial revenues and wood products with larger dimensions, which potentially will be transformed to wood products with longer half-life values. These aspects have been considered, together with carbon storage, in the scoreboard presented in Table 12.

Table 12. Scenarios scoreboard

Benefits	**Sc1**	**Sc2**	**Sc3**	**Sc4**
Less GHG emissions from forest works		1		1
Less disturbance in the forest		1		1
Frequent financial revenue	1		1	
Wood products with larger dimensions				1
Carbon storage (1 point for the minimum value tonnes of carbon stored/ha[2])	1	1.7	2	3.4
Overall score	**2**	**3.7**	**3**	**6.4**

For the last benefit (carbon storage) 1 point is attributed to the lowest carbon stock value (Scenario 1 →4 tons/ha → 1 point) and the remaining scores are calculated proportionately for Scenario 2 (7 tons/ha → 1.8 points), Scenario 3 (8 tons/ha → 2 points) and for Scenario 4 (13.4 tons/ha → 3.4 points).

By reducing the number of thinning in the forest GHG emissions decrease and disturbances due to forest works are also less frequent. Moreover, extending the rotation period provides wood products of larger dimensions that keep carbon stored for longer periods of time compared to firewood or paper. These benefits come with the price of reduced financial revenue for prolonged periods of time which range from 15 to 30 years, based on the proposed scenarios.

The results of the scenarios analysis are in agreement with the international literature reviewed for the current deliverable on forest management practices and measures to improve carbon sequestration. In particular, management scenarios of this project suggest that biomass and stocked carbon amount increase through forestry management practices that involve extending rotation periods and adapted stand management which includes thinning and selection cuttings to improve stand structure (Figure 14).

[2] Based on the maximum storage value at age class IV

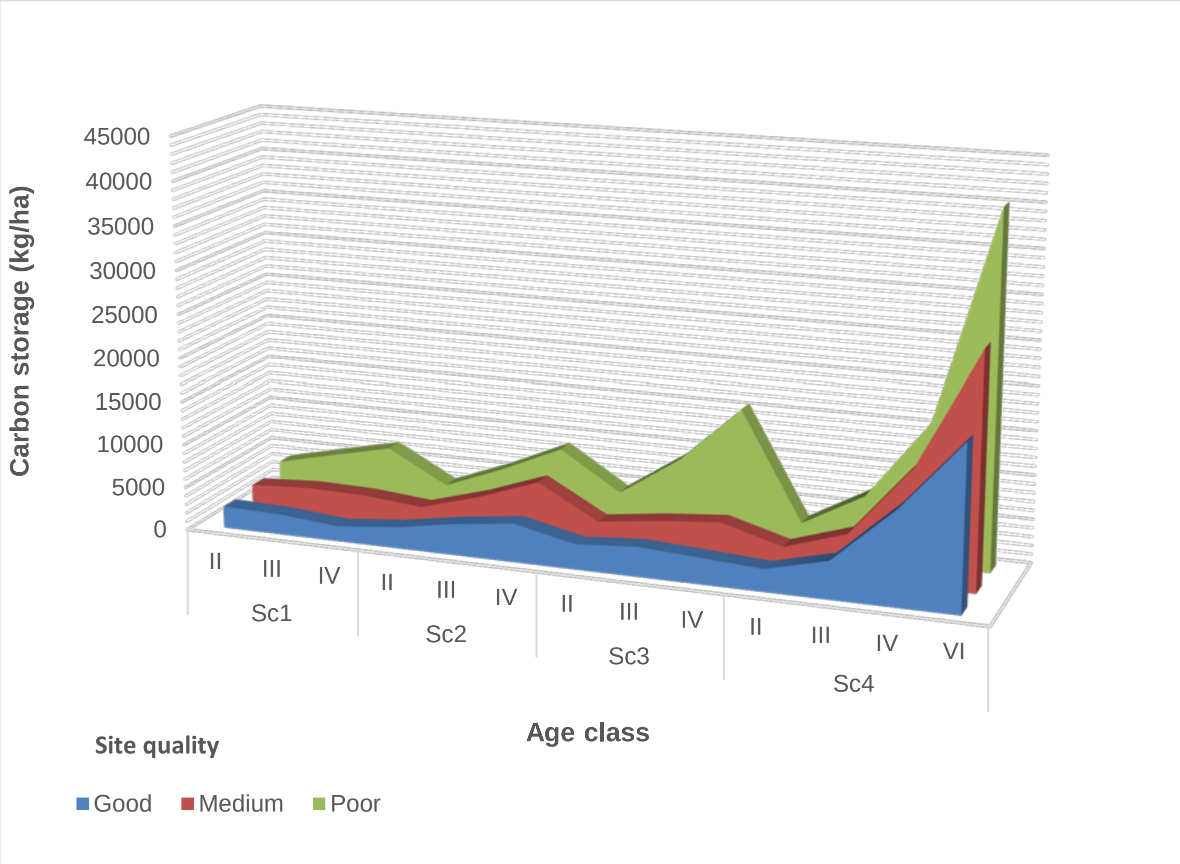


Figure 18. Carbon storage in tree stem biomass per age class, site quality category and management scenario

Stands of poor site quality have shown potential to act as the most important carbon sinks of the forests of the project area. Field measurements and scenarios analysis both point at the same conclusion. Carbon storage is consistently increasing in poor sites under all management practices examined. The small growth rates in these sites induce low efficiency in wood production but high carbon storage values, indicating that these stands may be utilized as carbon pools. This process may also gradually improve the site conditions and productivity of the stands.

Regardless of site quality, the scenarios' analysis (Figure 1) has shown that less frequent thinning (Scenario 2) lead to less carbon storage in young stands (age class II[3]), by 10% to

[3] Ten-year age classes (II:10-20, III: 20-30, IV: 30-40; VI: 50-60)

30% compared to the current practice. However, as the stand grows the benefits of extending the time interval between thinning are evident in age classes III & IV, when carbon storage increases by 35 – 55%. On the other hand, less intense thinning (Scenario 3), compared to the currently applied practice (Scenario 1), generally increase carbon storage by approximately 10% in age class II to over 35% in age class IV. The combination of extending the rotation period and decreasing the intensity of the thinning (Scenario 4) is by far the optional practice to increase carbon storage in the project area.

7. CARBON STOCK QUANTIFICATION AND MONITORING GUIDELINES

The rate of build-up of CO_2 in the atmosphere can be reduced by taking advantage of the fact that atmospheric CO_2 can be accumulated as carbon into vegetation and soils in terrestrial ecosystems (UNFCCC, 2015). The overall CO_2 sequestered or released through forest management can be calculated taking into account that 1 ton of stored carbon corresponds to the removal of 3.67 tons carbon dioxide (t CO_2) from the atmosphere.

However, due to the dynamic nature of carbon sinks, assessing their current state offers only limited insight into their role. Carbon balance needs to be monitored and assessed consistently in order to provide substantial results. The logical framework required for this process is outlined in Figure 15. Each of the steps presented in Figure 15 is described below, based on literature review and the results of the current Action for the Trabzon area.

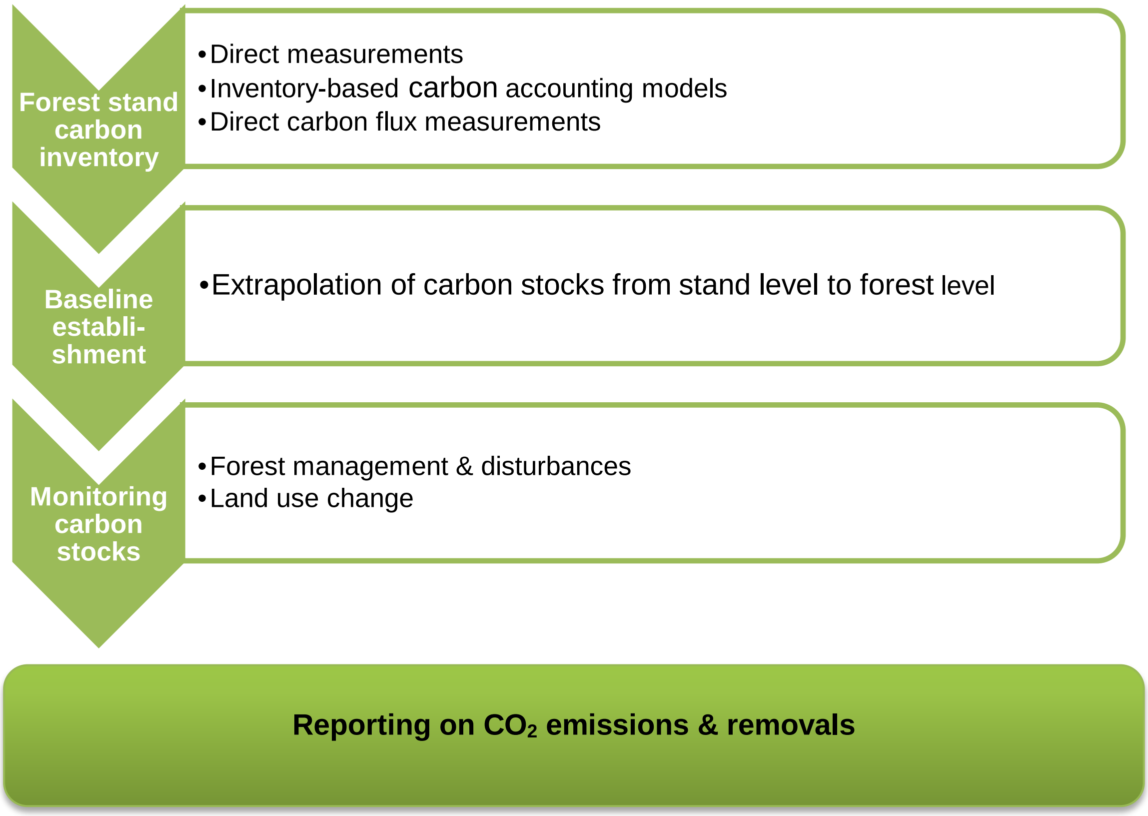


Figure 19. Logical framework for carbon stock assessment, monitoring and reporting

a. Carbon stock baseline establishment

According to EU Regulation 2018/841, removals from managed forest land should be accounted against a forward-looking forest reference level. The projected future removals by carbon pools should be based on an extrapolation of forest management practices and their intensity compared to the baseline.

The forest reference level should be set with regard to dynamic age-related forest characteristics, using the best available data. In order to establish the carbon stock baseline allometric equations are required to convert the data from the forest stand inventory to carbon inventory. During the Action, samples were collected from all the carbon pools in the forests to estimate the amount of carbon in each one, through laboratory analysis performed by KTU.

The field data and analysis results were then used to develop allometric equations for the calculation of biomass and carbon storage in tree stems, branches and foliage for oriental beech in the project area, as mentioned in previous chapters.

Moreover, carbon storage was estimated also for the shrub and herbaceous understories, dead wood and litter.

b. Forest management & Disturbance monitoring

Forest management and natural disturbances, such as forest fires and severe insect outbreaks influence the carbon stocks in forest ecosystems (NRCAN, 2016). Forests sequester carbon by capturing carbon dioxide from the atmosphere and transforming it into biomass through photosynthesis. Sequestered carbon is then accumulated in the form of biomass, deadwood, litter and in forest soils (UNECE, 2006).

Forest ecosystems release carbon through natural processes (respiration and oxidation) as well as a deliberate or unintended result of human activities (i.e. harvesting, fires, deforestation). A decrease in a pool relative to the reference level should be accounted for as emissions. Specific national circumstances and practices, such as lower harvest intensity than usual or ageing forests during the reference period, should also be taken into account (European Commission, 2018).

Monitoring forest management is necessary to acquire data on carbon removals through carbon storage and also on carbon emissions through management practices (thinning). In cases of natural disturbances carbon emissions should also be quantified based on the area affected and the amount of carbon stored. The contribution of forests to carbon cycles has to be evaluated taking also into account the use of harvested wood, e.g. wood products storing carbon for a certain period of time, or energy generation releasing carbon in the atmosphere (UNECE, 2006).

Therefore, monitoring is required to record carbon net balance from stand level, to forest level up to national level annually in order to provide up to date information at all times.

c. Tracking land-use change

The European accounting rules specify that the mere existence of large terrestrial carbon pools in forest ecosystems represents no advantage for countries. Only changes in the terrestrial carbon pool are relevant for the mitigation of climate change. Countries are required to maintain their forest cover and the increase in the carbon pool by specific forms of forest management (Jandl et al., 2007). A review of the forest cover of the project area must be conducted on an annual basis to determine changes in forest cover.

To facilitate data collection and methodology improvement, land use should be inventoried and reported using geographical tracking of each land area, corresponding to national data collection systems. The best use should be made of existing land use change tracking programs and surveys. Data management, including sharing of data for reporting, reuse and dissemination, should conform to the requirements provided for in Directive 2007/2/EC (European Commission, 2018).

d. Reporting on CO_2 emissions & removals

Reporting on emissions and removals should be done for each calendar year (IPCC, 2006). Therefore, the monitoring results of forest management and disturbance monitoring, as well as land-use change data described above should refer to this time period.

In cases where the net balance of carbon emissions by forests is negative, i.e. carbon sequestration prevails, forests contribute to mitigating carbon emissions by acting as both a carbon reservoir and a tool to sequester additional carbon. In cases when the net balance of carbon emissions is positive, forests contribute to enhancing greenhouse effect and climate change (UNECE, 2006).

8. ABBREVIATIONS AND ACRONYMS

DBH	Diameter at breast height (1.3m)
FAO	Food and Agriculture Organization of the United Nations
FRA	Forest Resources Assessment
GHG	Greenhouse gases
INDC	Nationally Determined Contribution of the Republic of Turkey
IPCC	Intergovernmental Panel on Climate Change
LULUCF	Land Use, Land Use Change of Forestry
MCPFE	Ministerial Conference on the Protection of Forests in Europe
NRCAN	National Resources Canada
RES	Renewable Energy Sources
SSR	Sources Sinks or Reservoirs
UN	United Nations
UNECE	United Nations Economic Commission for Europe
UNFCCC	United Nations Framework Convention on Climate Change
WBCSD	World Business Council for Sustainable Development
WRI	World Resources Institute

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ANNEX I. SAMPLE FIELD INVENTORY SHEETS

GENERAL INFORMATION

Forest Management Unit	
Stand	
Location	

Plot No/ Area (m^2)		
Date		
Inventory Personnel		

Aspect (°)	
Slope (%)	
Elevation (m)	

Plot coordinates (left bottom point of quadrat 1x1m)	
Longitude	
Latitude	

B. STAND CHARACTERISTICS (overall plot area)

Canopy closure (%)				
Main wood species				
Stand structure	Even-aged ☐ Uneven-aged groups ☐ Uneven-aged individuals ☐			
Maturity stage	Saplings☐ (d<7 cm)	Poles ☐ (DBH 7 - 20 cm)	Mature trees ☐ (DBH 20 - 35 cm)	Mature trees ☐ (DBH>35 cm)
Number of stems per diameter class (percentage %)	<25cm: 95 25-50cm: 5 >50cm:			
Stand storeys	One-storey ☐ Two-storey ☐ Multi-storey ☐			
Mean overstorey height (m)	13.0			
Mean height of 2nd storey (m)	-			
Forest edge – Ecotone	Yes ☐ No ☐			
Water locations	Yes ☐ No ☐			

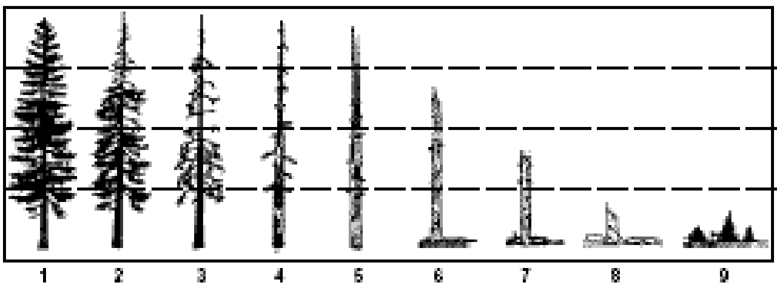
C. TIMBER CRUISING

No	Type (LT, DST, BT)[4]	Branched (Y or N)?	Species	DBH (cm)	Total height (m)	Time of necrosis (for DST)[5]
1						A ☐ B ☐ C ☐
2						A ☐ B ☐ C ☐
3						A ☐ B ☐ C ☐
4						A ☐ B ☐ C ☐
5						A ☐ B ☐ C ☐
6						A ☐ B ☐ C ☐
7						A ☐ B ☐ C ☐
8						A ☐ B ☐ C ☐
9						A ☐ B ☐ C ☐
10						A ☐ B ☐ C ☐
11						A ☐ B ☐ C ☐
12						A ☐ B ☐ C ☐
13						A ☐ B ☐ C ☐
14						A ☐ B ☐ C ☐
15						A ☐ B ☐ C ☐
16						A ☐ B ☐ C ☐
17						A ☐ B ☐ C ☐
18						A ☐ B ☐ C ☐
19						A ☐ B ☐ C ☐
20						A ☐ B ☐ C ☐
21						A ☐ B ☐ C ☐
22						A ☐ B ☐ C ☐
23						A ☐ B ☐ C ☐
24						A ☐ B ☐ C ☐
25						A ☐ B ☐ C ☐
26						A ☐ B ☐ C ☐

[4] Live tree (LT), Dead standing tree (DST), Big tree with diameter over 30 cm (BT)

[5]

A: recently (1, 2), **B**: a few years ago (3, 4), **C**: a lot of years ago (5 – 9).



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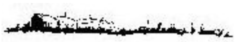
D. UNDERSTOREY: LYING DEAD WOOD & SHRUBS (10 X 10 m Quadrat)

LYING DEAD TREES				
No	**Species**	**Average diameter (cm)**	**Length (m)**	**Stage of Decaying**
1				A ☐ B ☐ C ☐
2				A ☐ B ☐ C ☐
3				A ☐ B ☐ C ☐
4				A ☐ B ☐ C ☐
		A. Early stages 	**B. Middle stages:** 	**C.Final stages:** 

UNDERSTOREY	
Shrub understorey	**Yes** ☐ **No** ☐
Dominant species	
Cover (%)	
Mean height (m)	
Herbaceous understorey	**Yes** ☐ **No** ☐
Cover (%)	
Mean height (cm)	

ANNEX II. FIELD INVENTORY SHEETS OF SAMPLE PLOTS

GENERAL INFORMATION

Forest Management Unit	VAKFIKEBİR
Stand	Knb3
Location	173

Plot No/ Area (m^2)	1	400
Date	27/04/2018	
Inventory Personnel	M.MISIR	

Aspect (°)	241
Slope (%)	15
Elevation (m)	1353

Plot coordinates (left bottom point of quadrat 1x1m)	
Longitude	532748
Latitude	4535326

B. STAND CHARACTERISTICS (overall plot area)

Canopy closure (%)	50			
Main wood species	Fagus orientalis			
Stand structure	**Even-aged** ☒ **Uneven-aged groups** ☐ **Uneven-aged individuals** ☐			
Maturity stage	**Saplings**☐ **(d<7 cm)**	**Poles** ☒ **(DBH 7 - 20 cm)**	**Mature trees** ☐ **(DBH 20 - 35 cm)**	**Mature trees** ☐ **(DBH>35 cm)**
Number of stems per diameter class (percentage %)	**<25cm: 95 25-50cm: 5 >50cm:**			
Stand storeys	**One-storey** ☒ **Two-storey** ☐ **Multi-storey** ☐			
Mean overstorey height (m)	**13.0**			
Mean height of 2nd storey (m)	-			
Forest edge – Ecotone	**Yes** ☐ **No** ☒			
Water locations	**Yes** ☐ **No** ☒			

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A. GENERAL INFORMATION

Forest Management Unit	VAKFIKEBİR
Stand	Knb3
Location	173

Plot No/ Area (m^2)	2	100
Date	27/04/2018	
Inventory Personnel	M.MISIR	

Aspect (°)	267
Slope (%)	45
Elevation (m)	1339

Plot coordinates (left bottom point of quadrat 1x1m)	
Longitude	532675
Latitude	4535268

B. STAND CHARACTERISTICS (overall plot area)

Canopy closure (%)	80			
Main wood species	Fagus orientalis			
Stand structure	**Even-aged** ☒ **Uneven-aged groups** ☐ **Uneven-aged individuals** ☐			
Maturity stage	**Saplings**☐ **(d<7 cm)**	**Poles** ☒ **(DBH 7 - 20 cm)**	**Mature trees** ☐ **(DBH 20 - 35 cm)**	**Mature trees** ☐ **(DBH>35 cm)**
Number of stems per diameter class (percentage %)	**<25cm: 100 25-50cm: >50cm:**			
Stand storeys	**One-storey** ☒ **Two-storey** ☐ **Multi-storey** ☐			
Mean overstorey height (m)	**17.8**			
Mean height of 2nd storey (m)	-			
Forest edge – Ecotone	**Yes** ☐ **No** ☒			
Water locations	**Yes** ☐ **No** ☒			

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A. GENERAL INFORMATION

Forest Management Unit	VAKFIKEBİR
Stand	Knb2
Location	173

Plot No/ Area (m²)	3	100
Date	27/04/2018	
Inventory Personnel	N.MISIR	

Aspect (°)	295
Slope (%)	55
Elevation (m)	1313

Plot coordinates (left bottom point of quadrat 1x1m)	
Longitude	532612
Latitude	4535216

B. STAND CHARACTERISTICS (overall plot area)

Canopy closure (%)	70			
Main wood species	Fagus orientalis			
Stand structure	**Even-aged** ☒ **Uneven-aged groups** ☐ **Uneven-aged individuals** ☐			
Maturity stage	**Saplings** ☐ **(d<7 cm)**	**Poles** ☒ **(DBH 7 - 20 cm)**	**Mature trees** ☐ **(DBH 20 - 35 cm)**	**Mature trees** ☐ **(DBH>35 cm)**
Number of stems per diameter class (percentage %)	**<25cm: 90 25-50cm: 10 >50cm:**			
Stand storeys	**One-storey** ☒ **Two-storey** ☐ **Multi-storey** ☐			
Mean overstorey height (m)	**11.4**			
Mean height of 2nd storey (m)	-			
Forest edge – Ecotone	**Yes** ☐ **No** ☒			
Water locations	**Yes** ☐ **No** ☒			

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A. GENERAL INFORMATION

Forest Management Unit	VAKFIKEBİR
Stand	Knab3
Location	173

Plot No/ Area (m²)	4	100
Date	27/04/2018	
Inventory Personnel	N.MISIR	

Aspect (°)	286
Slope (%)	100
Elevation (m)	1310

Plot coordinates (left bottom point of quadrat 1x1m)	
Longitude	532595
Latitude	4535197

B. STAND CHARACTERISTICS (overall plot area)

Canopy closure (%)	90			
Main wood species	Fagus orientalis			
Stand structure	**Even-aged** ☒ **Uneven-aged groups** ☐ **Uneven-aged individuals** ☐			
Maturity stage	**Saplings**☐ **(d<7 cm)**	**Poles** ☒ **(DBH 7 - 20 cm)**	**Mature trees** ☐ **(DBH 20 - 35 cm)**	**Mature trees** ☐ **(DBH>35 cm)**
Number of stems per diameter class (percentage %)	**<25cm: 95 25-50cm: 5 >50cm:**			
Stand storeys	**One-storey** ☒ **Two-storey** ☐ **Multi-storey** ☐			
Mean overstorey height (m)	**11.0**			
Mean height of 2nd storey (m)	-			
Forest edge – Ecotone	**Yes** ☐ **No** ☒			
Water locations	**Yes** ☐ **No** ☒			

A. GENERAL INFORMATION

Forest Management Unit	VAKFIKEBİR
Stand	Knbc3
Location	173

Plot No/ Area (m^2)	5	400
Date	03/05/2018	
Inventory Personnel	M.MISIR	

Aspect (°)	256
Slope (%)	110
Elevation (m)	1290

Plot coordinates (left bottom point of quadrat 1x1m)	
Longitude	532276
Latitude	4534922

B. STAND CHARACTERISTICS (overall plot area)

Canopy closure (%)	80			
Main wood species	Fagus orientalis			
Stand structure	**Even-aged** ☒ **Uneven-aged groups** ☐ **Uneven-aged individuals** ☐			
Maturity stage	**Saplings**☐ **(d<7 cm)**	**Poles** ☒ **(DBH 7 - 20 cm)**	**Mature trees** ☐ **(DBH 20 - 35 cm)**	**Mature trees** ☐ **(DBH>35 cm)**
Number of stems per diameter class (percentage %)	**<25cm: 100 25-50cm: >50cm:**			
Stand storeys	**One-storey** ☒ **Two-storey** ☐ **Multi-storey** ☐			
Mean overstorey height (m)	**13.1**			
Mean height of 2nd storey (m)	-			
Forest edge – Ecotone	**Yes** ☐ **No** ☒			
Water locations	**Yes** ☐ **No** ☒			

A. GENERAL INFORMATION

Forest Management Unit	VAKFIKEBİR
Stand	Knbc3
Location	173

Plot No/ Area (m^2)	6	200
Date	03/05/2018	
Inventory Personnel	N.MISIR	

Aspect (°)	257
Slope (%)	100
Elevation (m)	1220

Plot coordinates (left bottom point of quadrat 1x1m)	
Longitude	532218
Latitude	4534933

B. STAND CHARACTERISTICS (overall plot area)

Canopy closure (%)	80			
Main wood species	Fagus orientalis			
Stand structure	**Even-aged** ☒ **Uneven-aged groups** ☐ **Uneven-aged individuals** ☐			
Maturity stage	**Saplings**☐ (d<7 cm)	**Poles** ☒ (DBH 7 - 20 cm)	**Mature trees** ☐ (DBH 20 - 35 cm)	**Mature trees** ☐ (DBH>35 cm)
Number of stems per diameter class (percentage %)	**<25cm: 95** **25-50cm: 5** **>50cm:**			
Stand storeys	**One-storey** ☒ **Two-storey** ☐ **Multi-storey** ☐			
Mean overstorey height (m)	**14.5**			
Mean height of 2nd storey (m)	-			
Forest edge – Ecotone	**Yes** ☐ **No** ☒			
Water locations	**Yes** ☐ **No** ☒			

A. GENERAL INFORMATION

Forest Management Unit	TONYA
Stand	Knb3
Location	201

Plot No/ Area (m^2)	7	100
Date	04/05/2018	
Inventory Personnel	M.MISIR	

Aspect (°)	341
Slope (%)	80
Elevation (m)	1280

Plot coordinates (left bottom point of quadrat 1x1m)	
Longitude	523906
Latitude	4514774

B. STAND CHARACTERISTICS (overall plot area)

Canopy closure (%)	80			
Main wood species	Fagus orientalis			
Stand structure	**Even-aged** ☒ **Uneven-aged groups** ☐ **Uneven-aged individuals** ☐			
Maturity stage	**Saplings**☐ **(d<7 cm)**	**Poles** ☒ **(DBH 7 - 20 cm)**	**Mature trees** ☐ **(DBH 20 - 35 cm)**	**Mature trees** ☐ **(DBH>35 cm)**
Number of stems per diameter class (percentage %)	**<25cm: 100**	**25-50cm:**	**>50cm:**	
Stand storeys	**One-storey** ☒ **Two-storey** ☐ **Multi-storey** ☐			
Mean overstorey height (m)	**10.5**			
Mean height of 2nd storey (m)	-			
Forest edge – Ecotone	**Yes** ☐ **No** ☒			
Water locations	**Yes** ☐ **No** ☒			

A. GENERAL INFORMATION

Forest Management Unit	TONYA
Stand	KnAb3
Location	201

Plot No/ Area (m^2)	8	50
Date	04/05/2018	
Inventory Personnel	N.MISIR	

Aspect (°)	327
Slope (%)	90
Elevation (m)	1320

Plot coordinates (left bottom point of quadrat 1x1m)	
Longitude	523925
Latitude	4514755

B. STAND CHARACTERISTICS (overall plot area)

Canopy closure (%)	80			
Main wood species	Fagus orientalis			
Stand structure	**Even-aged** ☒ **Uneven-aged groups** ☐ **Uneven-aged individuals** ☐			
Maturity stage	**Saplings**☒ **(d<7 cm)**	**Poles** ☐ **(DBH 7 - 20 cm)**	**Mature trees** ☐ **(DBH 20 - 35 cm)**	**Mature trees** ☐ **(DBH>35 cm)**
Number of stems per diameter class (percentage %)	**<25cm: 100** **25-50cm:** **>50cm:**			
Stand storeys	**One-storey** ☒ **Two-storey** ☐ **Multi-storey** ☐			
Mean overstorey height (m)	**9.2**			
Mean height of 2nd storey (m)	-			
Forest edge – Ecotone	**Yes** ☐ **No** ☒			
Water locations	**Yes** ☐ **No** ☒			

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A. GENERAL INFORMATION

Forest Management Unit	TONYA
Stand	Knab3
Location	201

Plot No/ Area (m^2)	9	100
Date	04/05/2018	
Inventory Personnel	N.MISIR	

Aspect (°)	296
Slope (%)	60
Elevation (m)	1280

Plot coordinates (left bottom point of quadrat 1x1m)	
Longitude	524006
Latitude	4514910

B. STAND CHARACTERISTICS (overall plot area)

Canopy closure (%)	80			
Main wood species	Fagus orientalis			
Stand structure	**Even-aged** ☒ **Uneven-aged groups** ☐ **Uneven-aged individuals** ☐			
Maturity stage	**Saplings**☒ **(d<7 cm)**	**Poles** ☐ **(DBH 7 - 20 cm)**	**Mature trees** ☐ **(DBH 20 - 35 cm)**	**Mature trees** ☐ **(DBH>35 cm)**
Number of stems per diameter class (percentage %)	**<25cm: 100** **25-50cm:** **>50cm:**			
Stand storeys	**One-storey** ☒ **Two-storey** ☐ **Multi-storey** ☐			
Mean overstorey height (m)	**10.6**			
Mean height of 2nd storey (m)	-			
Forest edge – Ecotone	**Yes** ☐ **No** ☒			
Water locations	**Yes** ☐ **No** ☒			

A. GENERAL INFORMATION

Forest Management Unit	TONYA
Stand	Knab3
Location	201

Plot No/ Area (m^2)	10	50
Date	04/05/2018	
Inventory Personnel	N.MISIR	

Aspect (°)	305
Slope (%)	50
Elevation (m)	1290

Plot coordinates (left bottom point of quadrat 1x1m)	
Longitude	524124
Latitude	4515348

B. STAND CHARACTERISTICS (overall plot area)

Canopy closure (%)	85			
Main wood species	Fagus orientalis			
Stand structure	**Even-aged** ☒ **Uneven-aged groups** ☐ **Uneven-aged individuals** ☐			
Maturity stage	**Saplings**☒ (d<7 cm)	**Poles** ☐ (DBH 7 - 20 cm)	**Mature trees** ☐ (DBH 20 - 35 cm)	**Mature trees** ☐ (DBH>35 cm)
Number of stems per diameter class (percentage %)	**<25cm: 100 25-50cm: >50cm:**			
Stand storeys	**One-storey** ☒ **Two-storey** ☐ **Multi-storey** ☐			
Mean overstorey height (m)	**10.4**			
Mean height of 2nd storey (m)	-			
Forest edge – Ecotone	**Yes** ☐ **No** ☒			
Water locations	**Yes** ☐ **No** ☒			

A. GENERAL INFORMATION

Forest Management Unit	TONYA
Stand	Knab3
Location	201

Plot No/ Area (m^2)	11	100
Date	04/05/2018	
Inventory Personnel	M.MISIR	

Aspect (°)	325
Slope (%)	80
Elevation (m)	1310

Plot coordinates (left bottom point of quadrat 1x1m)	
Longitude	524129
Latitude	4515269

B. STAND CHARACTERISTICS (overall plot area)

Canopy closure (%)	75			
Main wood species	Fagus orientalis			
Stand structure	**Even-aged** ☒ **Uneven-aged groups** ☐ **Uneven-aged individuals** ☐			
Maturity stage	**Saplings**☐ **(d<7 cm)**	**Poles** ☒ **(DBH 7 - 20 cm)**	**Mature trees** ☐ **(DBH 20 - 35 cm)**	**Mature trees** ☐ **(DBH>35 cm)**
Number of stems per diameter class (percentage %)	**<25cm: 100 25-50cm: >50cm:**			
Stand storeys	**One-storey** ☒ **Two-storey** ☐ **Multi-storey** ☐			
Mean overstorey height (m)	**11.3**			
Mean height of 2^{nd} storey (m)	-			
Forest edge – Ecotone	**Yes** ☐ **No** ☒			
Water locations	**Yes** ☐ **No** ☒			

A. GENERAL INFORMATION

Forest Management Unit	TONYA
Stand	Kna0
Location	200

Plot No/ Area (m²)	12	150
Date	15/05/2018	
Inventory Personnel	N.MISIR	

Aspect (°)	350
Slope (%)	50
Elevation (m)	1579

Plot coordinates (left bottom point of quadrat 1x1m)	
Longitude	524049
Latitude	4514327

B. STAND CHARACTERISTICS (overall plot area)

Canopy closure (%)	0			
Main wood species	Fagus orientalis			
Stand structure	**Even-aged** ☒ **Uneven-aged groups** ☐ **Uneven-aged individuals** ☐			
Maturity stage	**Saplings**☒ **(d<7 cm)**	**Poles** ☐ **(DBH 7 - 20 cm)**	**Mature trees** ☐ **(DBH 20 - 35 cm)**	**Mature trees** ☐ **(DBH>35 cm)**
Number of stems per diameter class (percentage %)	**<25cm: 100 25-50cm: >50cm:**			
Stand storeys	**One-storey** ☒ **Two-storey** ☐ **Multi-storey** ☐			
Mean overstorey height (m)	**1.4**			
Mean height of 2nd storey (m)	-			
Forest edge – Ecotone	**Yes** ☐ **No** ☒			
Water locations	**Yes** ☐ **No** ☒			

A. GENERAL INFORMATION

Forest Management Unit	TONYA
Stand	Kna0
Location	200

Plot No/ Area (m^2)	13	300
Date	15/05/2018	
Inventory Personnel	M.MISIR	

Aspect (°)	320
Slope (%)	60
Elevation (m)	1588

Plot coordinates (left bottom point of quadrat 1x1m)	
Longitude	524221
Latitude	4514354

B. STAND CHARACTERISTICS (overall plot area)

Canopy closure (%)	0			
Main wood species	Fagus orientalis			
Stand structure	**Even-aged** ☒ **Uneven-aged groups** ☐ **Uneven-aged individuals** ☐			
Maturity stage	**Saplings**☒ **(d<7 cm)**	**Poles** ☐ **(DBH 7 - 20 cm)**	**Mature trees** ☐ **(DBH 20 - 35 cm)**	**Mature trees** ☐ **(DBH>35 cm)**
Number of stems per diameter class (percentage %)	**<25cm: 100 25-50cm: >50cm:**			
Stand storeys	**One-storey** ☒ **Two-storey** ☐ **Multi-storey** ☐			
Mean overstorey height (m)	**0.9**			
Mean height of 2nd storey (m)	-			
Forest edge – Ecotone	**Yes** ☐ **No** ☒			
Water locations	**Yes** ☐ **No** ☒			

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A. GENERAL INFORMATION

Forest Management Unit	TONYA
Stand	Kna0
Location	200

Plot No/ Area (m^2)	14	100
Date	15/05/2018	
Inventory Personnel	N.MISIR	

Aspect (°)	357
Slope (%)	60
Elevation (m)	1571

Plot coordinates (left bottom point of quadrat 1x1m)	
Longitude	524108
Latitude	4514302

B. STAND CHARACTERISTICS (overall plot area)

Canopy closure (%)	0			
Main wood species	Fagus orientalis			
Stand structure	**Even-aged ☒ Uneven-aged groups ☐ Uneven-aged individuals ☐**			
Maturity stage	**Saplings☒** **(d<7 cm)**	**Poles ☐** **(DBH 7 - 20 cm)**	**Mature trees ☐** **(DBH 20 - 35 cm)**	**Mature trees ☐** **(DBH>35 cm)**
Number of stems per diameter class (percentage %)	**<25cm: 100 25-50cm: >50cm:**			
Stand storeys	**One-storey ☒ Two-storey ☐ Multi-storey ☐**			
Mean overstorey height (m)	**1.3**			
Mean height of 2nd storey (m)	-			
Forest edge – Ecotone	**Yes ☐ No ☒**			
Water locations	**Yes ☐ No ☒**			

A. GENERAL INFORMATION

Forest Management Unit	TONYA
Stand	Kna0
Location	200

Plot No/ Area (m²)	15	150
Date	15/05/2018	
Inventory Personnel	M.MISIR	

Aspect (°)	312
Slope (%)	60
Elevation (m)	1541

Plot coordinates (left bottom point of quadrat 1x1m)	
Longitude	524215
Latitude	4514430

B. STAND CHARACTERISTICS (overall plot area)

Canopy closure (%)	0			
Main wood species	Fagus orientalis			
Stand structure	**Even-aged** ☒ **Uneven-aged groups** ☐ **Uneven-aged individuals** ☐			
Maturity stage	**Saplings**☒ (d<7 cm)	**Poles** ☐ (DBH 7 - 20 cm)	**Mature trees** ☐ (DBH 20 - 35 cm)	**Mature trees** ☐ (DBH>35 cm)
Number of stems per diameter class (percentage %)	**<25cm: 100** **25-50cm:** **>50cm:**			
Stand storeys	**One-storey** ☒ **Two-storey** ☐ **Multi-storey** ☐			
Mean overstorey height (m)	**1.0**			
Mean height of 2nd storey (m)	-			
Forest edge – Ecotone	**Yes** ☐ **No** ☒			
Water locations	**Yes** ☐ **No** ☒			

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A. GENERAL INFORMATION

Forest Management Unit	TONYA
Stand	Knb3
Location	201

Plot No/ Area (m²)	16	100
Date	15/05/2018	
Inventory Personnel	M.MISIR	

Aspect (°)	289
Slope (%)	80
Elevation (m)	1340

Plot coordinates (left bottom point of quadrat 1x1m)	
Longitude	523905
Latitude	4514865

B. STAND CHARACTERISTICS (overall plot area)

Canopy closure (%)	80			
Main wood species	Fagus orientalis			
Stand structure	**Even-aged** ☒ **Uneven-aged groups** ☐ **Uneven-aged individuals** ☐			
Maturity stage	**Saplings**☒ **(d<7 cm)**	**Poles** ☐ **(DBH 7 - 20 cm)**	**Mature trees** ☐ **(DBH 20 - 35 cm)**	**Mature trees** ☐ **(DBH>35 cm)**
Number of stems per diameter class (percentage %)	**<25cm: 100 25-50cm: >50cm:**			
Stand storeys	**One-storey** ☒ **Two-storey** ☐ **Multi-storey** ☐			
Mean overstorey height (m)	**8.6**			
Mean height of 2nd storey (m)	-			
Forest edge – Ecotone	**Yes** ☐ **No** ☒			
Water locations	**Yes** ☐ **No** ☒			

A. GENERAL INFORMATION

Forest Management Unit	VAKFIKEBİR
Stand	Knb3
Location	186

Plot No/ Area (m^2)	17	100
Date	29/05/2018	
Inventory Personnel	N.MISIR-D.VLACHAKI	

Aspect (°)	205
Slope (%)	44
Elevation (m)	1335

Plot coordinates (left bottom point of quadrat 1x1m)	
Longitude	532890
Latitude	4533466

B. STAND CHARACTERISTICS (overall plot area)

Canopy closure (%)	90			
Main wood species	Fagus orientalis			
Stand structure	**Even-aged** ☒ **Uneven-aged groups** ☐ **Uneven-aged individuals** ☐			
Maturity stage	**Saplings**☐ **(d<7 cm)**	**Poles** ☒ **(DBH 7 - 20 cm)**	**Mature trees** ☐ **(DBH 20 - 35 cm)**	**Mature trees** ☐ **(DBH>35 cm)**
Number of stems per diameter class (percentage %)	**<25cm: 100 25-50cm: >50cm:**			
Stand storeys	**One-storey** ☒ **Two-storey** ☐ **Multi-storey** ☐			
Mean overstorey height (m)	**18.4**			
Mean height of 2nd storey (m)	-			
Forest edge – Ecotone	**Yes** ☐ **No** ☒			
Water locations	**Yes** ☐ **No** ☒			

A. GENERAL INFORMATION

Forest Management Unit	VAKFIKEBİR
Stand	Knb2
Location	186

Plot No/ Area (m^2)	18	150
Date	31/05/2018	
Inventory Personnel	N.MISIR	

Aspect (°)	211
Slope (%)	53
Elevation (m)	1370

Plot coordinates (left bottom point of quadrat 1x1m)	
Longitude	532931
Latitude	4533505

B. STAND CHARACTERISTICS (overall plot area)

Canopy closure (%)	80			
Main wood species	Fagus orientalis			
Stand structure	**Even-aged** ☒ **Uneven-aged groups** ☐ **Uneven-aged individuals** ☐			
Maturity stage	**Saplings**☐ **(d<7 cm)**	**Poles** ☒ **(DBH 7 - 20 cm)**	**Mature trees** ☐ **(DBH 20 - 35 cm)**	**Mature trees** ☐ **(DBH>35 cm)**
Number of stems per diameter class (percentage %)	**<25cm: 94 25-50cm: 6 >50cm:**			
Stand storeys	**One-storey** ☒ **Two-storey** ☐ **Multi-storey** ☐			
Mean overstorey height (m)	**11.9**			
Mean height of 2nd storey (m)	-			
Forest edge – Ecotone	**Yes** ☐ **No** ☒			
Water locations	**Yes** ☐ **No** ☒			

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A. GENERAL INFORMATION

Forest Management Unit	VAKFIKEBİR
Stand	Knb3
Location	186

Plot No/ Area (m²)	19	225
Date	31/05/2018	
Inventory Personnel	M.MISIR	

Aspect (°)	204
Slope (%)	60
Elevation (m)	1385

Plot coordinates (left bottom point of quadrat 1x1m)	
Longitude	532696
Latitude	4533674

B. STAND CHARACTERISTICS (overall plot area)

Canopy closure (%)	80			
Main wood species	Fagus orientalis			
Stand structure	**Even-aged** ☒ **Uneven-aged groups** ☐ **Uneven-aged individuals** ☐			
Maturity stage	**Saplings**☐ (d<7 cm)	**Poles** ☒ (DBH 7 - 20 cm)	**Mature trees** ☐ (DBH 20 - 35 cm)	**Mature trees** ☐ (DBH>35 cm)
Number of stems per diameter class (percentage %)	**<25cm: 95 25-50cm: 5 >50cm:**			
Stand storeys	**One-storey** ☒ **Two-storey** ☐ **Multi-storey** ☐			
Mean overstorey height (m)	**13.5**			
Mean height of 2nd storey (m)	-			
Forest edge – Ecotone	**Yes** ☐ **No** ☒			
Water locations	**Yes** ☐ **No** ☒			

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A. GENERAL INFORMATION

Forest Management Unit	VAKFIKEBİR
Stand	Knb3
Location	186

Plot No/ Area (m^2)	20	100
Date	31/05/2018	
Inventory Personnel	N.MISIR	

Aspect (°)	197
Slope (%)	64
Elevation (m)	1420

Plot coordinates (left bottom point of quadrat 1x1m)	
Longitude	532819
Latitude	4533465

B. STAND CHARACTERISTICS (overall plot area)

Canopy closure (%)	80			
Main wood species	Fagus orientalis			
Stand structure	**Even-aged** ☒ **Uneven-aged groups** ☐ **Uneven-aged individuals** ☐			
Maturity stage	**Saplings**☐ **(d<7 cm)**	**Poles** ☒ **(DBH 7 - 20 cm)**	**Mature trees** ☐ **(DBH 20 - 35 cm)**	**Mature trees** ☐ **(DBH>35 cm)**
Number of stems per diameter class (percentage %)	**<25cm: 100** **25-50cm:** **>50cm:**			
Stand storeys	**One-storey** ☒ **Two-storey** ☐ **Multi-storey** ☐			
Mean overstorey height (m)	**12.3**			
Mean height of 2nd storey (m)	-			
Forest edge – Ecotone	**Yes** ☐ **No** ☒			
Water locations	**Yes** ☐ **No** ☒			

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A. GENERAL INFORMATION

Forest Management Unit	VAKFIKEBİR
Stand	Knb3
Location	186

Plot No/ Area (m^2)	21	100
Date	31/05/2018	
Inventory Personnel	M.MISIR	

Aspect (°)	225
Slope (%)	55
Elevation (m)	1430

Plot coordinates (left bottom point of quadrat 1x1m)	
Longitude	532817
Latitude	4533517

B. STAND CHARACTERISTICS (overall plot area)

Canopy closure (%)	80			
Main wood species	Fagus orientalis			
Stand structure	**Even-aged** ☒ **Uneven-aged groups** ☐ **Uneven-aged individuals** ☐			
Maturity stage	**Saplings**☐ **(d<7 cm)**	**Poles** ☒ **(DBH 7 - 20 cm)**	**Mature trees** ☐ **(DBH 20 - 35 cm)**	**Mature trees** ☐ **(DBH>35 cm)**
Number of stems per diameter class (percentage %)	**<25cm: 100 25-50cm: >50cm:**			
Stand storeys	**One-storey** ☒ **Two-storey** ☐ **Multi-storey** ☐			
Mean overstorey height (m)	**14.4**			
Mean height of 2nd storey (m)	-			
Forest edge – Ecotone	**Yes** ☐ **No** ☒			
Water locations	**Yes** ☐ **No** ☒			

A. GENERAL INFORMATION

Forest Management Unit	VAKFIKEBİR
Stand	Knb3
Location	186

Plot No/ Area (m^2)	22	100
Date	31/05/2018	
Inventory Personnel	N.MISIR	

Aspect (°)	241
Slope (%)	46
Elevation (m)	1370

Plot coordinates (left bottom point of quadrat 1x1m)	
Longitude	532865
Latitude	4533448

B. STAND CHARACTERISTICS (overall plot area)

Canopy closure (%)	80			
Main wood species	Fagus orientalis			
Stand structure	**Even-aged** ☒ **Uneven-aged groups** ☐ **Uneven-aged individuals** ☐			
Maturity stage	**Saplings**☐ **(d<7 cm)**	**Poles** ☒ **(DBH 7 - 20 cm)**	**Mature trees** ☐ **(DBH 20 - 35 cm)**	**Mature trees** ☐ **(DBH>35 cm)**
Number of stems per diameter class (percentage %)	**<25cm:** **100** **25-50cm:** **>50cm:**			
Stand storeys	**One-storey** ☒ **Two-storey** ☐ **Multi-storey** ☐			
Mean overstorey height (m)	**12.9**			
Mean height of 2nd storey (m)	-			
Forest edge – Ecotone	**Yes** ☐ **No** ☒			
Water locations	**Yes** ☐ **No** ☒			

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A. GENERAL INFORMATION

Forest Management Unit	VAKFIKEBİR
Stand	Knb3
Location	186

Plot No/ Area (m^2)	23	150
Date	31/05/2018	
Inventory Personnel	N.MISIR	

Aspect (°)	247
Slope (%)	45
Elevation (m)	1360

Plot coordinates (left bottom point of quadrat 1x1m)	
Longitude	532877
Latitude	4533455

B. STAND CHARACTERISTICS (overall plot area)

Canopy closure (%)	80			
Main wood species	Fagus orientalis			
Stand structure	**Even-aged** ☒ **Uneven-aged groups** ☐ **Uneven-aged individuals** ☐			
Maturity stage	**Saplings**☐ **(d<7 cm)**	**Poles** ☒ **(DBH 7 - 20 cm)**	**Mature trees** ☐ **(DBH 20 - 35 cm)**	**Mature trees** ☐ **(DBH>35 cm)**
Number of stems per diameter class (percentage %)	**<25cm: 100 25-50cm: 0 >50cm:**			
Stand storeys	**One-storey** ☒ **Two-storey** ☐ **Multi-storey** ☐			
Mean overstorey height (m)	**10.5**			
Mean height of 2nd storey (m)	-			
Forest edge – Ecotone	**Yes** ☐ **No** ☒			
Water locations	**Yes** ☐ **No** ☒			

A. GENERAL INFORMATION

Forest Management Unit	DÜZKÖY
Stand	Knc3
Location	16

Plot No/ Area (m^2)	24	400
Date	01/03/2018	
Inventory Personnel	M.MISIR	

Aspect (°)	197
Slope (%)	80
Elevation (m)	1022

Plot coordinates (left bottom point of quadrat 1x1m)	
Longitude	537296
Latitude	4530279

B. STAND CHARACTERISTICS (overall plot area)

Canopy closure (%)	75			
Main wood species	Fagus orientalis			
Stand structure	**Even-aged** ☒ **Uneven-aged groups** ☐ **Uneven-aged individuals** ☐			
Maturity stage	**Saplings**☐ **(d<7 cm)**	**Poles** ☐ **(DBH 7 - 20 cm)**	**Mature trees** ☒ **(DBH 20 - 35 cm)**	**Mature trees** ☐ **(DBH>35 cm)**
Number of stems per diameter class (percentage %)	**<25cm: 68 25-50cm: 32 >50cm:**			
Stand storeys	**One-storey** ☒ **Two-storey** ☐ **Multi-storey** ☐			
Mean overstorey height (m)	**13.9**			
Mean height of 2nd storey (m)	-			
Forest edge – Ecotone	**Yes** ☐ **No** ☒			
Water locations	**Yes** ☐ **No** ☒			

A. GENERAL INFORMATION

Forest Management Unit	DÜZKÖY
Stand	Knbc3
Location	16

Plot No/ Area (m^2)	25	400
Date	14/03/2018	
Inventory Personnel	M.MISIR	

Aspect (°)	93
Slope (%)	60
Elevation (m)	855

Plot coordinates (left bottom point of quadrat 1x1m)	
Longitude	537313
Latitude	4529700

B. STAND CHARACTERISTICS (overall plot area)

Canopy closure (%)	75			
Main wood species	Fagus orientalis			
Stand structure	**Even-aged** ☒ **Uneven-aged groups** ☐ **Uneven-aged individuals** ☐			
Maturity stage	**Saplings**☐ **(d<7 cm)**	**Poles** ☒ **(DBH 7 - 20 cm)**	**Mature trees** ☐ **(DBH 20 - 35 cm)**	**Mature trees** ☐ **(DBH>35 cm)**
Number of stems per diameter class (percentage %)	**<25cm: 95 25-50cm: 5 >50cm:**			
Stand storeys	**One-storey** ☒ **Two-storey** ☐ **Multi-storey** ☐			
Mean overstorey height (m)	**17.0**			
Mean height of 2nd storey (m)	-			
Forest edge – Ecotone	**Yes** ☐ **No** ☒			
Water locations	**Yes** ☐ **No** ☒			

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A. GENERAL INFORMATION

Forest Management Unit	DÜZKÖY
Stand	Knbc3
Location	15

Plot No/ Area (m²)	26	400
Date	14/03/2018	
Inventory Personnel	M.MISIR	

Aspect (°)	182
Slope (%)	93
Elevation (m)	947

Plot coordinates (left bottom point of quadrat 1x1m)	
Longitude	536953
Latitude	4529823

B. STAND CHARACTERISTICS (overall plot area)

Canopy closure (%)	75			
Main wood species	Fagus orientalis			
Stand structure	**Even-aged ☒ Uneven-aged groups ☐ Uneven-aged individuals ☐**			
Maturity stage	**Saplings☐ (d<7 cm)**	**Poles ☒ (DBH 7 - 20 cm)**	**Mature trees ☐ (DBH 20 - 35 cm)**	**Mature trees ☐ (DBH>35 cm)**
Number of stems per diameter class (percentage %)	**<25cm: 100 25-50cm: >50cm:**			
Stand storeys	**One-storey ☒ Two-storey ☐ Multi-storey ☐**			
Mean overstorey height (m)	**14.3**			
Mean height of 2nd storey (m)	-			
Forest edge – Ecotone	**Yes ☐ No ☒**			
Water locations	**Yes ☐ No ☒**			

A. GENERAL INFORMATION

Forest Management Unit	DÜZKÖY
Stand	Knbc3
Location	15

Plot No/ Area (m²)	27	400
Date	30/03/2018	
Inventory Personnel	M.MISIR	

Aspect (°)	240
Slope (%)	62
Elevation (m)	1335

Plot coordinates (left bottom point of quadrat 1x1m)	
Longitude	536400
Latitude	4530300

B. STAND CHARACTERISTICS (overall plot area)

Canopy closure (%)	75			
Main wood species	Fagus orientalis			
Stand structure	**Even-aged ☒ Uneven-aged groups ☐ Uneven-aged individuals ☐**			
Maturity stage	**Saplings☐ (d<7 cm)**	**Poles ☒ (DBH 7 - 20 cm)**	**Mature trees ☐ (DBH 20 - 35 cm)**	**Mature trees ☐ (DBH>35 cm)**
Number of stems per diameter class (percentage %)	**<25cm: 95 25-50cm: 5 >50cm:**			
Stand storeys	**One-storey ☒ Two-storey ☐ Multi-storey ☐**			
Mean overstorey height (m)	**12.1**			
Mean height of 2nd storey (m)	-			
Forest edge – Ecotone	**Yes ☐ No ☒**			
Water locations	**Yes ☐ No ☒**			

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A. GENERAL INFORMATION

Forest Management Unit	DÜZKÖY
Stand	Knbc3
Location	16

Plot No/ Area (m^2)	28	400
Date	09/03/2018	
Inventory Personnel	M.MISIR	

Aspect (°)	124
Slope (%)	61
Elevation (m)	1240

Plot coordinates (left bottom point of quadrat 1x1m)	
Longitude	536700
Latitude	4530300

B. STAND CHARACTERISTICS (overall plot area)

Canopy closure (%)	75			
Main wood species	Fagus orientalis			
Stand structure	**Even-aged** ☒ **Uneven-aged groups** ☐ **Uneven-aged individuals** ☐			
Maturity stage	**Saplings**☐ (d<7 cm)	**Poles** ☒ (DBH 7 - 20 cm)	**Mature trees** ☐ (DBH 20 - 35 cm)	**Mature trees** ☐ (DBH>35 cm)
Number of stems per diameter class (percentage %)	**<25cm: 90 25-50cm: 10 >50cm:**			
Stand storeys	**One-storey** ☒ **Two-storey** ☐ **Multi-storey** ☐			
Mean overstorey height (m)	**15.3**			
Mean height of 2nd storey (m)	-			
Forest edge – Ecotone	**Yes** ☐ **No** ☒			
Water locations	**Yes** ☐ **No** ☒			

A. GENERAL INFORMATION

Forest Management Unit	DÜZKÖY
Stand	Knbc3
Location	16

Plot No/ Area (m^2)	29	400
Date	07/03/2018	
Inventory Personnel	M.MISIR	

Aspect (°)	136
Slope (%)	60
Elevation (m)	1135

Plot coordinates (left bottom point of quadrat 1x1m)	
Longitude	537000
Latitude	4530300

B. STAND CHARACTERISTICS (overall plot area)

Canopy closure (%)	75			
Main wood species	Fagus orientalis			
Stand structure	**Even-aged** ☒ **Uneven-aged groups** ☐ **Uneven-aged individuals** ☐			
Maturity stage	**Saplings** ☐ **(d<7 cm)**	**Poles** ☒ **(DBH 7 - 20 cm)**	**Mature trees** ☐ **(DBH 20 - 35 cm)**	**Mature trees** ☐ **(DBH>35 cm)**
Number of stems per diameter class (percentage %)	**<25cm: 97** **25-50cm: 3** **>50cm:**			
Stand storeys	**One-storey** ☒ **Two-storey** ☐ **Multi-storey** ☐			
Mean overstorey height (m)	**15.0**			
Mean height of 2nd storey (m)	-			
Forest edge – Ecotone	**Yes** ☐ **No** ☒			
Water locations	**Yes** ☐ **No** ☒			

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A. GENERAL INFORMATION

Forest Management Unit	DÜZKÖY
Stand	Knc3
Location	129

Plot No/ Area (m^2)	30	400
Date	15/05/2018	
Inventory Personnel	M.MISIR	

Aspect (°)	320
Slope (%)	64
Elevation (m)	1025

Plot coordinates (left bottom point of quadrat 1x1m)	
Longitude	533825
Latitude	4522255

B. STAND CHARACTERISTICS (overall plot area)

Canopy closure (%)	70			
Main wood species	Fagus orientalis			
Stand structure	**Even-aged ☒ Uneven-aged groups ☐ Uneven-aged individuals ☐**			
Maturity stage	**Saplings☐ (d<7 cm)**	**Poles ☒ (DBH 7 - 20 cm)**	**Mature trees ☐ (DBH 20 - 35 cm)**	**Mature trees ☐ (DBH>35 cm)**
Number of stems per diameter class (percentage %)	**<25cm: 100 25-50cm: >50cm:**			
Stand storeys	**One-storey ☒ Two-storey ☐ Multi-storey ☐**			
Mean overstorey height (m)	**9.5**			
Mean height of 2nd storey (m)	-			
Forest edge – Ecotone	**Yes ☐ No ☒**			
Water locations	**Yes ☐ No ☒**			

A. GENERAL INFORMATION

Forest Management Unit	DÜZKÖY
Stand	Knbc3
Location	130

Plot No/ Area (m^2)	31	400
Date	04/05/2018	
Inventory Personnel	M.MISIR	

Aspect (°)	7
Slope (%)	35
Elevation (m)	1022

Plot coordinates (left bottom point of quadrat 1x1m)	
Longitude	533952
Latitude	4522300

B. STAND CHARACTERISTICS (overall plot area)

Canopy closure (%)	75			
Main wood species	Fagus orientalis			
Stand structure	**Even-aged** ☒ **Uneven-aged groups** ☐ **Uneven-aged individuals** ☐			
Maturity stage	**Saplings**☐ (d<7 cm)	**Poles** ☒ (DBH 7 - 20 cm)	**Mature trees** ☐ (DBH 20 - 35 cm)	**Mature trees** ☐ (DBH>35 cm)
Number of stems per diameter class (percentage %)	**<25cm: 100 25-50cm: >50cm:**			
Stand storeys	**One-storey** ☒ **Two-storey** ☐ **Multi-storey** ☐			
Mean overstorey height (m)	**11.6**			
Mean height of 2nd storey (m)	-			
Forest edge – Ecotone	**Yes** ☐ **No** ☒			
Water locations	**Yes** ☐ **No** ☒			

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A. GENERAL INFORMATION

Forest Management Unit	DÜZKÖY
Stand	Knbc3
Location	130

Plot No/ Area (m^2)	32	400
Date	14/05/2018	
Inventory Personnel	N.MISIR	

Aspect (°)	38
Slope (%)	60
Elevation (m)	995

Plot coordinates (left bottom point of quadrat 1x1m)	
Longitude	534157
Latitude	4522250

B. STAND CHARACTERISTICS (overall plot area)

Canopy closure (%)	80			
Main wood species	Fagus orientalis			
Stand structure	**Even-aged** ☒ **Uneven-aged groups** ☐ **Uneven-aged individuals** ☐			
Maturity stage	**Saplings**☐ **(d<7 cm)**	**Poles** ☒ **(DBH 7 - 20 cm)**	**Mature trees** ☐ **(DBH 20 - 35 cm)**	**Mature trees** ☐ **(DBH>35 cm)**
Number of stems per diameter class (percentage %)	**<25cm: 100 25-50cm: >50cm:**			
Stand storeys	**One-storey** ☒ **Two-storey** ☐ **Multi-storey** ☐			
Mean overstorey height (m)	**12.8**			
Mean height of 2nd storey (m)	-			
Forest edge – Ecotone	**Yes** ☐ **No** ☒			
Water locations	**Yes** ☐ **No** ☒			

ANNEX III. FIELD INVENTORY PHOTOS OF SAMPLE PLOTS

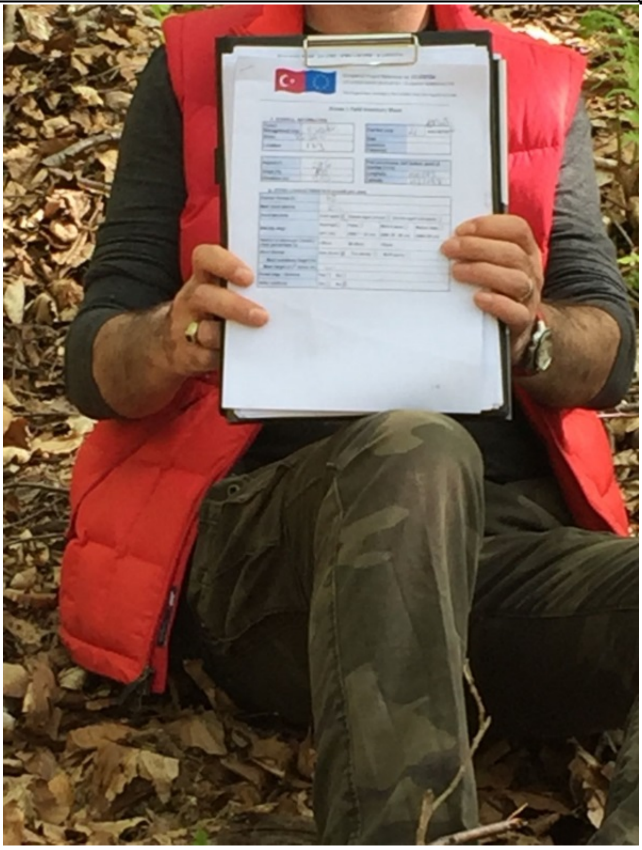
Plot No	1




Plot No	2

Plot No	3

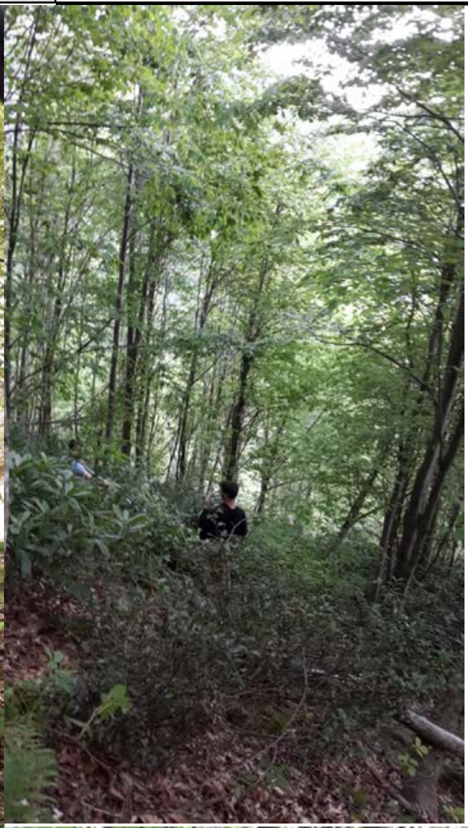
Plot No	4



Plot No	5




Plot No	6

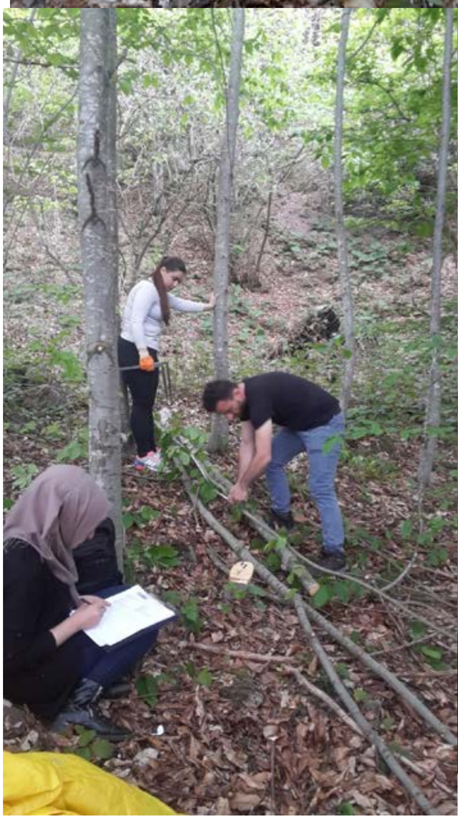
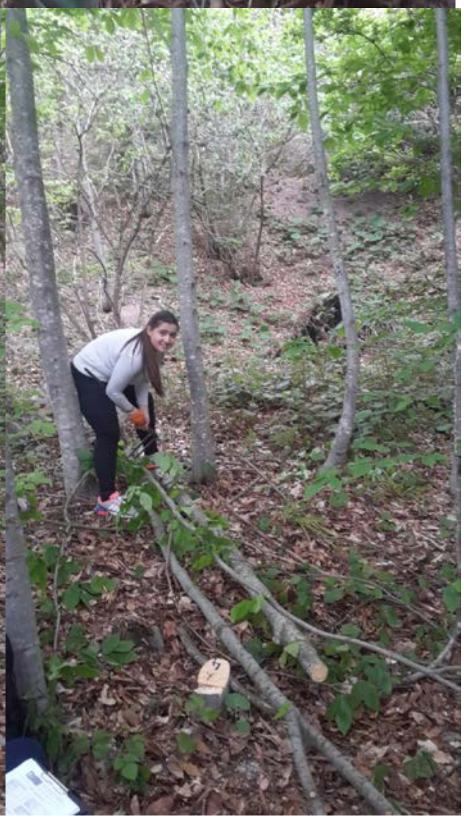
Plot No	7

Plot No	8




Plot No	9



Plot No	10

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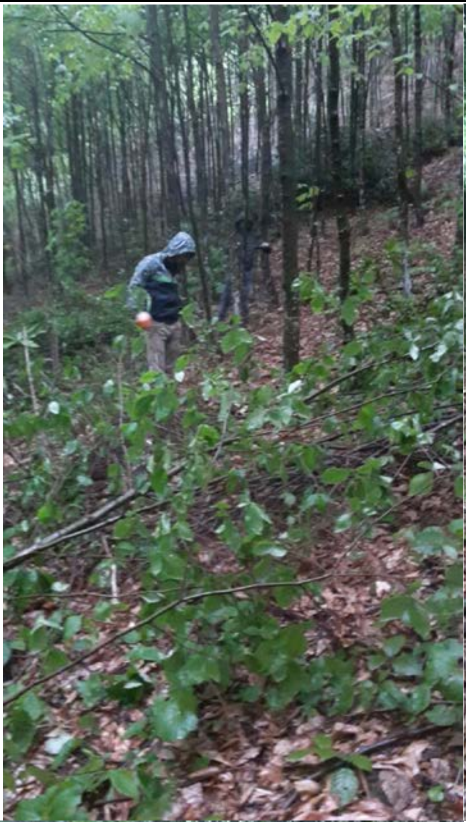
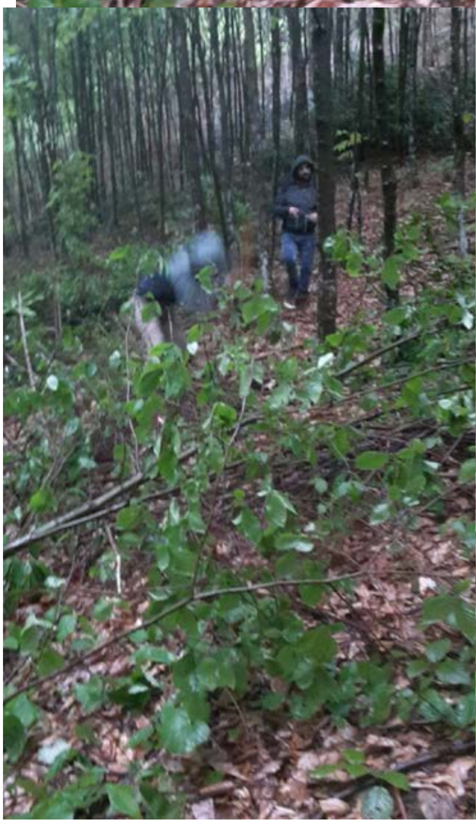
Plot No	11





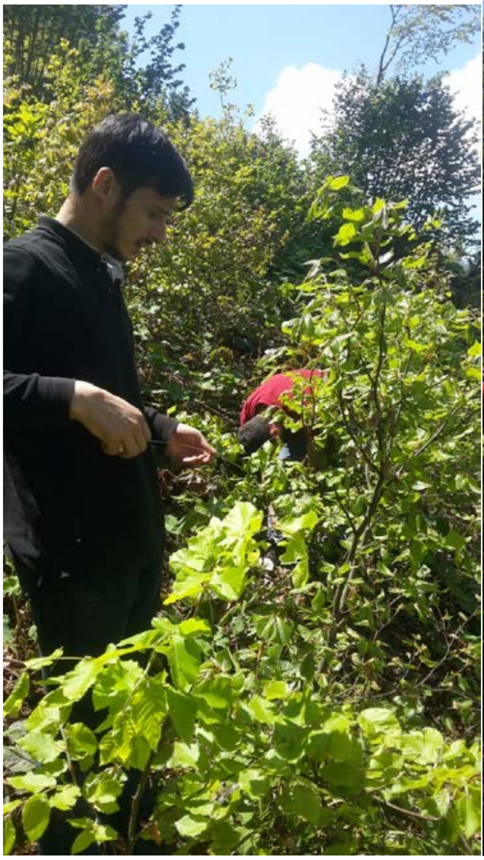

Plot No	12




Plot No	13




Plot No	14

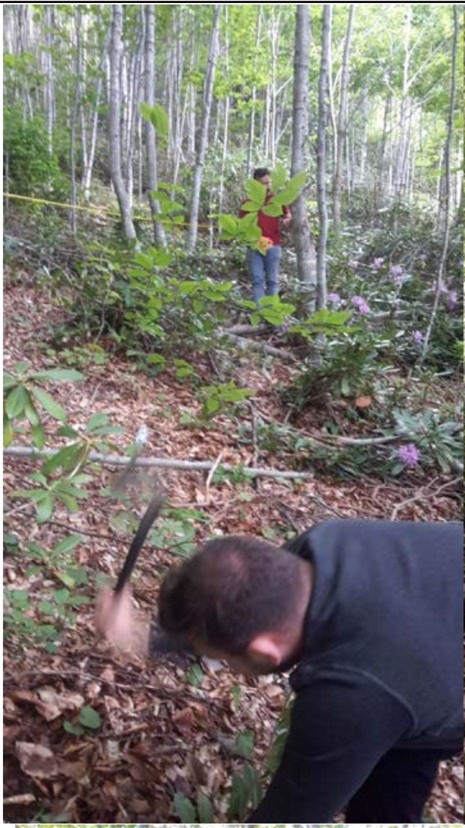



Plot No	15

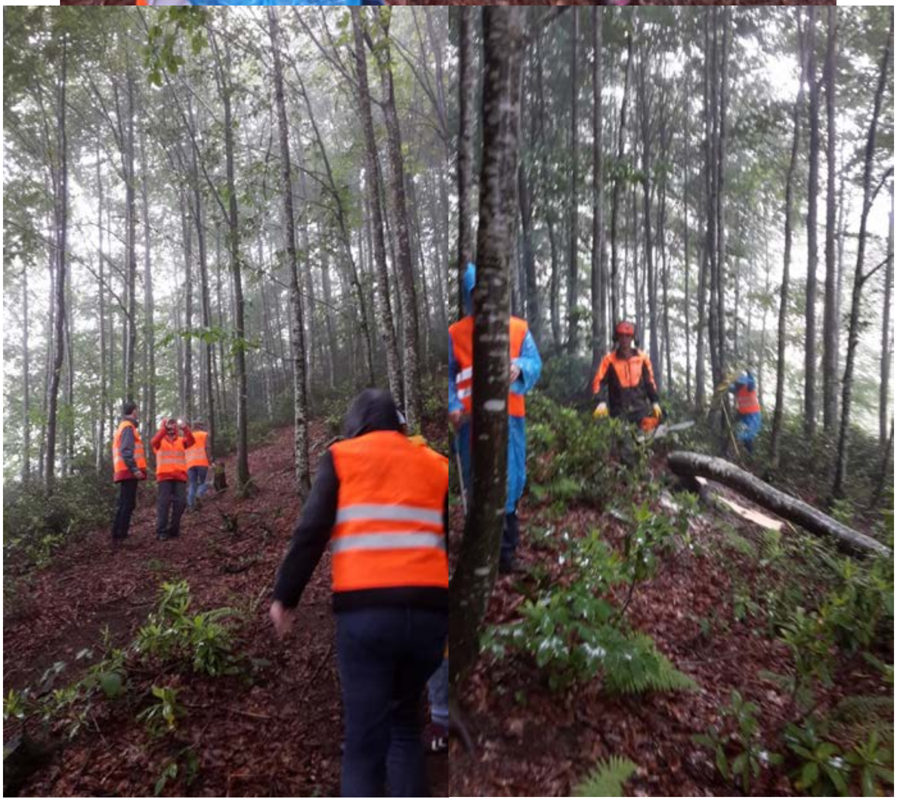




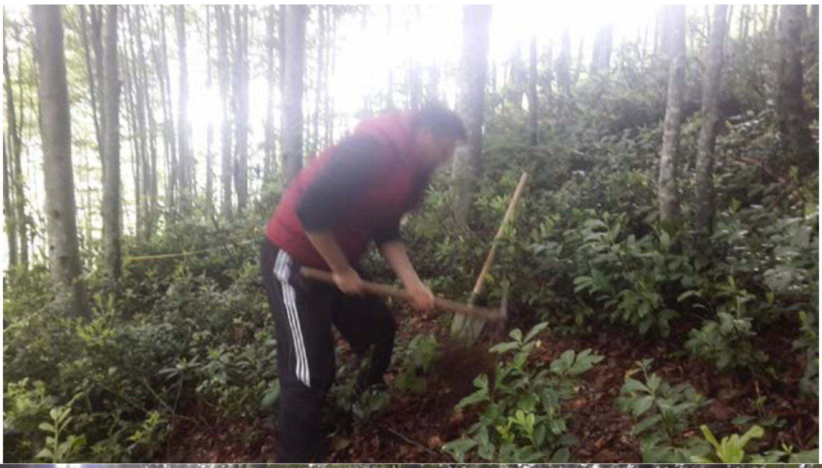
Plot No	16




Plot No	17



Plot No	18

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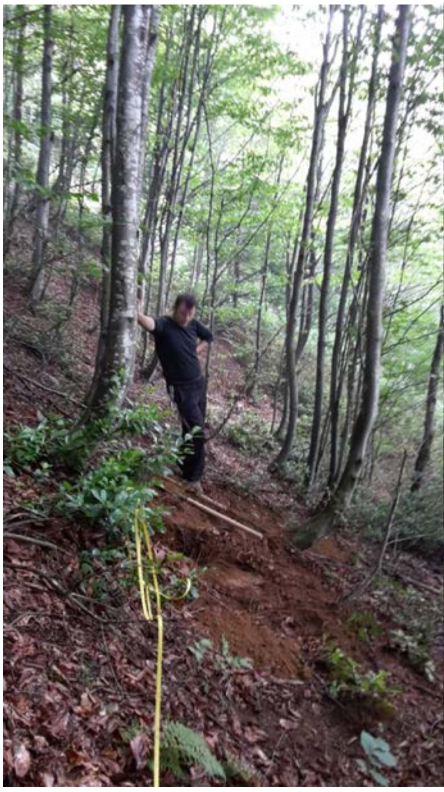
Plot No	19




Plot No	20



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Plot No	21




Plot No	22



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Plot No	**23**




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Plot No	24

Plot No	25

Plot No	**26**

Plot No	27

Plot No	**28**

Plot No	**29**

Plot No	**30**

Plot No	31


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Plot No	32

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