Possible Scenario for the Vegetation Change in Seyhan River Basin and Role of Land Uses "Anthropozoic Pressures"

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1. Introduction

Becoming a greater concern to scientific era, impacts of climate change have been studied thoroughly in different geographies (Reid et al, 2000, DeLuis et al, 2001, Vilalta, 2002). Mediterranean Basin presents the best example for the human impact on natural structure particularly natural vegetation (Atmaca et al, 2005). But recently climate change is another phenomenon that according to Tamai et al (2005) climate changes, especially precipitation and air temperature in semi-arid areas will likely effect the quality and the quantity of the vegetation.

In this joint work, potential impact of climate change on natural vegetation in Seyhan River Basin (Figure 1) within the framework of the Japanese-Turkish international research project 'Impact of Climate Change on Agricultural System in the Arid Areas' was discussed. Based on expected changes mainly on precipitation and temperature derived by Climate Group of the project, different scenarios on the potential impact of the climate change were indicated in terms of vertical distribution of the vegetation and more emphasis were put particularly on the role of land uses "anthropozoic pressures".

2. Different Scenarios on the Impact of the Climate Change on the Vegetation in Seyhan

Arid regions are expected to undergo significant changes under a scenario of climate warming, but there is considerable variability and uncertainty in these estimates between different scenarios (Lioubimtseva, 2004). Relatively there are THREE main Scenarios that will be adapted by the Vegetation Group. ***The first scenario*** stands on the idea that such differences as 1.87 ^{o}C degree increase in temperature by 2070s would not cause substantial change on the vegetation. To have serious change on vegetation cover, vegetation distribution and plant productivity there is need at least 100-150 years of time. From that point, the 1st scenario formulated on the prediction "No Change o Vegetation" (Table 1).

Here still land use impacts need to be taken into consideration. Because human pressure will remain in the river basin, and so the athropozoic pressures.

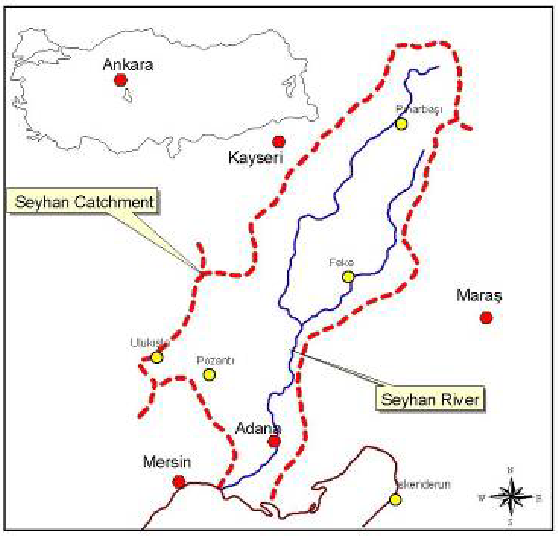

Figure 1. Location of Seyhan River Basin

The second scenario is precise that expected change in climate conditions 1.87 ^{o}C degree increase in temperature and –322.72 mm decrease in precipitation level will have impact particularly on the vertical distribution of the vegetation. Hereby altitude and distribution of different vegetation belts is the basic approach to overlap spatial temperature and precipitation data. According to altitude map nearly 70 % of the research area covers 1000 meters and higher elevations.

Having different study approaches both Turkish and Japanese Vegetation Groups worked on the vegetation on 1000 meters and above. Considering Second scenario we expect that rainfall change around 900-1000mm together with temperature would be effective on the vegetation on the lower basin area. Altitude and precipitation info showed us that rainfall change is happening around 900-1000 meters. Accordingly from sea level (0) to around 1000 meters there will not be concrete change on the vegetation belts but change on some typical species. However possible changes on the typical species and species combination that representing plant formations will be expected. A vertical distribution of present and expected future main vegetation types is given in Table 2. Main vegetation type will be Pinus brutia and macchia between 0-600 meters and Pinus brutia mixed forest between 600-1200 meters. Above Conifer forest mix with deciduous trees and after higher altitudes 1600 meters and above Conifer forest will remain (Table 2).

Apart from vertical distribution, according to more detail vegetation distribution (Table 3) we expect that some characteristic species will move from one elevation to another. With respect to the site aspects and direction, northern aspects are limiting factor of species diversity in the macchia vegetation where shade tolerant species form very thick cover and do not allow many others species survive. Nevertheless long-term changes need to be monitor in detailed level, covering all plant forms in the vegetation. Turkish Vegetation Group set up a constant monitoring parcels' system so far and further researches can easily be integrated about the change on vegetation. Plant analysis that will be carried out on these regular monitoring on these parcels in the future and the comparative studies with project results will supply more precise picture about the future vegetation. Hence constant monitoring parcels' system is an useful contribution, monitoring studies must carried out with certain intervals in the future.

The third scenario will cover both impact on the climate change and impact of anthropozoic pressures and relevantly, scenario for disturbed vegetation in 2070s (Table 1). There are already existing rural land use types of agriculture, stockfarming, forestry, mining, recreation, settlements which will remain in the future. But in terms of severe drought on the lower parts of the river basin would force further land use demands on the upper river basin areas and drastic change on both landscape and the vegetation by the possible conversion from crop fields to pastures or conversion from forest sites to agricultural field.

We expect that ant pressures will be more

Table 1. Three Scenarios adopted by Vegetation Group

1. Scenario	**2. Scenario**	**3. Scenario**
The first scenario is that there will be no change on Climate Conditions and relatively NO CHANGE on the Vegetation	The second scenario is that there will be change On the Climate Condition (1.87 ^{o}C degree increase in temperature and –322.72 mm decrease in precipitation level) and relatively CHANGE on the Vegetation	The third scenario is that there will be change On the Climate Condition (1.87 ^{o}C degree increase in temperature and –322.72 mm decrease in precipitation level) TOGATHER with Human Impact and relatively CHANGE on the Vegetation
As a result Potential Vegetation that present today will be the ***Practical Vegetation in 2070s***	As a result Potential Vegetation that present today will be the ***Potential Vegetation in future*** by 2070s	Impact of the climate change on the Vegetation will be exaggerated by anthropozoic pressures and change on Vegetation will be further in 2070s
	In terms of Climate Conditions, Change in **Temperature and Change in **Precipitation** will be two main driving forces in Vegetation Change by 2070s and onwards	As a result Potential Vegetation that present today will be the ***Disturbed Vegetation in 2070s***

exaggerated by human settlements and agricultural land use demands on the lower part of the basin and rural land use and stockfarming on the upper part, particularly grazing around the timberline which would pull down the forest cover.

*Linear correlation between Plant Productivity and Temperature allows us to assess the Vegetation Change by the change in Average Temperature, which has already been expected to be increasing with 1.87 ^{o}C degree by the year 2070s. Here when the temperature increases so the photosynthesis increases and relatively the plant productivity.

**But relationship between Plant Productivity and Precipitation is rather complex. There is a linear correlation between Plant Productivity and Precipitation with around 400-600 mm, which turns out to be non-linear by 800-1000 mm of rainfall. And there is also a similar linear relationship between Vegetation Cover (%) and Precipitation in some degree of rainfall. Vegetation cover increases in parallel with the rainfall and stands still and does not change with non-linear correlation when the rainfall reaches up to some certain amount. More precisely;

- Average rainfall will be 650-322,72 = 327,28 mm in the lower basin which would create considerable change on the vegetation. It is vague whether macchia and Pinus brutia will survive under this circumstance but there will be clear change on the species within the plant formations. For example it is imprecise if such species as *Oleae europea var. oleaster, Daphne sericea, Laurus nobilis, Cercis siliquastrum, Phillyrea latifolia, Quercus coccifera, Stryrax officinalis* would maintain their woody forms under such amount of rainfall.

- Average rainfall will be 800-1000-322,72 = 477,28 - 677,28 mm in the upper basin. Under this circumstance its is unknown if submediterran deciduous species such *Fraxinus ornus, Ostrya* carpinifolia and deciduous oaks will survive

- Moreover one particular nature of Seyhan River Basin is the severe arid periods. Relatively number and the duration of the arid periods based on climate change for 2070 predicted by Climate Group of the project will be another factor on vegetation change. General expectation is that duration of the arid period will be longer with the sudden showery rains.

Plant growth and productivity are increasing when the amount of rainfall increases. But when the precipitation reaches at and above 1000 mm there will be no consequent change in either plant growth or productivity. Therefore draft estimation was carried out for the lower parts of the Seyhan River Basin based on both the prediction of Climate Group, which has already been expected to be decreasing by – 322.72 mm. Considering that average amount of annual rainfall in the area is around 750 – 950 mm, such decrease by -322.72 mm will be a strong impact on the vegetation.

Vegetation Change on the Lower Seyhan River Basin

The Vegetation of Lower Seyhan River Basin is evaluated in different zones starting from sea level rising up to 800-1200 meters. Here we took account increasing temperatures and decreasing rainfalls. Lower Seyhan River basin is more characterized by *Pinus brutia* and macchia species. Between sea level and 100 meters *Pinus halepensis*, limited locations in Çamlık, Pinus brutia and macchia, where we can find sand dunes, marshland and reed beds in Çukurova Delta, on the lower basin. Because of intensive agricultural activities natural vegetation in this part of the basin almost disappeared. And remaining islets of natural vegetation is under heavy human impact. Up to 700 meters macchia cover either in primer or seconder form, has wider distribution mixed *Pinus brutia* (Table 2).

Above 700 meters submediterran species become apparent due to increasing amount of rainfall and decreasing temperatures. Here *Pinus brutia* is the dominant species with extensive distribution between 1200-1300m and forming close stands on the upper parts. Within humid valleys and particularly northern slopes typical submediterran species such *Quercus infectoria ssp. boisseri*, *Q. Cerris, Q, pubescens* deciduous trees with *Ostrya carpinifolis, Fraxinus ornus* and *Carpinus orientalis* are found. Then *Pinus brutia* leaves its place to macchia in some locations with *Pistacia terebinthus, Arbutus andrachne, Fountanesia phillyroides, Styrax officinalis, Laurus nobilis, Cercis siliquastrum* (Table 2). However general vegetation distribution along this altitude is not expected to change much but the species composition will change moving either to higher elevation or disappearing.

3. Role of Land Uses “Anthropozoic Pressures”

Vegetation in the eastern Mediterranean severely disturbed by anthropozoic pressure and it is very hard to estimate vegetation in the past (Tamai et al, 2005). But learning from the past, land use pattern will keep its critical role in terms of change of the vegetation.

Table 2. Present and expected future main vegetation types with characteristic species in eastern Mediterranean

Elevation (meter)	Present Vegetation Characteristic species	Main Vegetation TYPE	Expected Change	Main Vegetation TYPE	Expected Future Vegetation Characteristic Species
0 – 100	Pinus halepensis (limited location in Çamlık) Pinus brutia, Quercus coccifera, Olea europea, Pistacia lentiscus, Phillyrea media, Myrtus communis, Cistus creticus and other macchia species	***Pinus halepensis, P. brutia*** **forest + Macchia**	*1.87 °C temperature **increase** + *–322.72 mm precipitation **decrease**	***Pinus halepensis P. brutia*** **+ Macchia**	Pinus halepensis, (limited) Pinus brutia, Quercus coccifera, Calycotome villosa, Paliurus spina-cristi, Olea europea var. oleaster, Phillyrea latifolia, Myrtus communis, Cistus creticus
100 – 400	Pinus brutia mixed Macchia species; Quercus coccifera, Olea europea, Pistacia lentiscus, Pistacia terebinhus, Laurus nobilis, Phillyrea latifolia, Daphne sericea, Myrtus communis Ceratonia siliqua, Cercis siliquastrum	***Pinus brutia*** **forest + Macchia**		***Pinus brutia*** **forest + Macchia**	Pinus brutia and macchia species; Quercus coccifera, Olea europea var. oleaster, Pistacia lentiscus, Pistacia terebinhus, Phillyrea latifolia, Ceratonia siliqua, Rhamnus alaternus, Calicotome villosa, Myrtus communis
400 – 700	Pinus brutia, Quercus coccifera, Quercus infectoria ssp. boisseri, Pistacia terebinhus, Laurus nobilis, Arbutus andrachne, Fontanesia phillyrioides, Ostrya carpinifolia, Styrax officinalis, Cotinus coggyria, Daphne gnidium, Cercis siliquastrum	***Pinus brutia*** **forest, decisuos species + Macchia**		***Pinus brutia*** **forest + Macchia**	Pinus brutia; Quercus coccifera, Quercus infectoria ssp. boisseri, Pistacia terebinhus, Phillyrea latifolia, Myrtus communis, Ostrya carpinifolia, Cotinus coggyria, Daphne gnidium
700 – 900	Pinus brutia, Pinus nigra, Juniperus oxycedrus, Quercus infectoria ssp. boisseri, Quercus cerris, Quercus pubescens, Pistacia terebinhus, Arbatus andrachne, Fontanesia phillyrioides, Ostrya carpinifolia, Styrax officinalis, Carpinus orientalis, Laurus nobilis, cercis siliquastrum	***Pinus brutia*** **mixed forest**		***Pinus brutia*** **mixed forest + Macchia**	Pinus brutia, Quercus infectoria ssp. boisseri, Quercus cerris, Pistacia terebinthus, Myrtus coomunis, Phillyrea latifolia Arbatus andrachne, Fontanesia phillyrioides, Ostrya carpinifolia, Styrax officinalis
900 – 1200	Pinus brutia, Pinus nigra ssp. pallasiana, Juniperus oxycedrus, Juniperus exelsa, Ostrya carpinifolia, Quercus cerris, Quercus pubescens, Carpinus orientalis	***Pinus brutia*** **mixed forest**		***Pinus brutia*** **mixed forest + Macchia**	Pinus brutia, Juniperus oxycedrus, Ostrya carpinifolia, Quercus cerris, Quercus infectoria ssp. boisseri
1200 – 1600 ↓ > 1600	Pinus brutia, Pinus nigra ssp. pallasiana, Cedrus libani, Abies cilicica, Juniperus oxycedrus, Juniperus exelsa, Juniperus durupacea. + Decidous trees; Ostrya carpinifolia, Carpinus orientalis, Quercus cerris, Quercus pubescens	**Conifer forest Mixed deciduous Trees** **Conifer Forests**		**Conifer forest Mixed deciduous Trees** **Conifer Forests**	Pinus brutia, Pinus nigra ssp. pallasiana, Cedrus libani, Abies cilicica, Juniperus oxycedrus, Juniperus exelsa, Juniperus durupacea; Ostrya carpinifolia, Quercus cerris, Quercus pubescens, Quercus infectoria ssp. boisseri (Likely escalation of timber line)

Occupation of the Area: Occupation of the area traces back as earlier as to neolitic periods and Hittites in 1000s BC and the use of natural forest as earlier as antic times to Phoenician, Egyptians, and Romans. They used *Pinus nigra* forest to build ships. The forest itself was very dense and productive one and known with its high quality. After Hittites, Romans and Byzantines, Turks came from Asia and settled in Anatolia around 12th Century (Ener, 1990). Around 1930s there were 7 villages in and around Aladağ (Yalgın,1950). Today there are 26 villages with direct impacts on forests, nomadic and semi-nomadic lifestyle has been continuing on the upper basin Agriculture: Most of the agricultural fields in the area stand on the slope lands. They are usually stony and have boulder surfaces and poor. Availability of the flat field for agriculture is quite limited which is likely lead to surface erosion (Picture 1). Using fallow fields for grazing, meeting the need for animal forage and also preventing surface erosion, forage cultivation is supported by the government. Relatively the size of the cultivation area was extended. Yards and gardening practices are more based on Cherry production which is an important income for farmers. Impact of agriculture on the natural environment becomes more apparent that dense agricultural practices on the slopes damage the soil surfaces.

Picture 1. Agricultural land use patterns in Posyağbasan Village (Deneri, 2006)

Stock farming: Stock farming is carried out in the area in two terms; nomadic way of stock farming and sedentary stockfarming. Nomadic way has been the oldest traditional type that people take their animals to Taurus Mountains for grazing for at least one season starting from very early spring to late autumn. Moving from one location to another nomadic life style shapes the land use patterns (Picture 2). In terms of environmental effects goat herding is the major concern in stock farming nearly in 65 %.

Although the decrease on nomadic stock farming comparing to past, local people still take their animals to the plateaus for grazing between May to September. In sedentary way, locals stay in the villages and use forest around the village for grazing. Which are subjected to high grazing pressure with the degradation on natural vegetation. During the winter time with heavy snowfall when the villagers are not able to take their animals to grazing, they cut the young branches of old trees providing food for stocks (Picture 3). Consequently typical forms of particularly fir (*Abies cilicica*) and cedar (*Cedrus libani*) and juniper (*Juniperus oxycedrus, J., exelsa*) disappear, productivity and vitality of trees decreases.

Picture 2. Way and the impact of grazing in the area (Deneri, 2006)

Picture 3. Tree cutting for stockfarming (Deneri, 2006)

Forestry: Natural forest in the area called "Pos", which comes from the local identification of black pine (*Pinus nigra*). Old documents indicate that the area was covered by dense vegetation of Red pine (*Pinus brutia*), Black pine (*Pinus nigra*), Juniper (*Juniperus oxycedrus, J. exelsa*) and Oaks (Yalgın, 1950). According the forest classification, timber productivity and quality is valued rather than diversity, and 23 % of the forest described as distorted forest. Tree plantation, forest regeneration and seedling is carried our by forestry service. But afforestation works have been rather based on certain species; Pinus brutia in lower areas and Pinus brutia, Pinus nigra and Cedrus libani in upper parts of the Seyhan River Basin which is rather monoculture and would restrain the species diversity in the vegetation.

Mining: Mining activity has a long history in the area. There are very old mine spots where people took the material out and basically used the natural forest and timber to work on mines for useful production. The wood from the natural forest was the basic source to produce items from the mines (Picture 4). Mining activity is based on chrome, plumbic (lead) and iron (Akyel, 2004). Authority of the mines belongs to Forestry Service as all mines are in forest sites, which can provide control and limits environmental impacts.

Picture 4. Impact of mining in the area

4. Discussions

Climate is the main farce on the distribution of vegetation. DelBarrio et al, (2006) indicated two general conclusions that despite the uncertainties; climate change involves the development of transient conditions and fragmentation within the core of species distributions. According to the scenarios on the vegetation change adapted by ICCAP Vegetation Groups main vegetation types along altitude is not expected to be changed by 1.87 ^{o}C temperature increase and –322.72 mm precipitation decrease. But some characteristic species (core species) would move into higher elevations or would not appear.

- *Pinus brutia* forest on the lower part of Seyhan River Basin will survive. However there will be potential risk for the existence of *Pinus brutia* forest in case of unfavourable environmental condition such as thin layer of soil, poor water holding capacity and sloppy-rocky south aspects

- macchia vegetation generally will remain and will move higher elevation by temperature increase and rainfall decrease. Species composition of macchia is expected to change towards humid tolerant species.

In this joint work, Japanese and Turkish vegetation groups developed there main scenario about the vegetation change based on the potential impact of climate change the 2070s and onwards. According to the first scenario there will not be a substantial change on the climate and so the vegetation (Figure 2).

According to the second scenario that expected change in climate conditions will be 1.87 ^{o}C degree increase in temperature and –322.72 mm decrease in precipitation level so we don not expect a substantial change on vertical distribution of the vegetation, but upwards movement in some vegetation belts such *Pinus brutia* mix forest, Conifer forest mixed deciduous trees as well as conifer forest by changing so characteristic species (Figure 3).

Apart from climate based environmental conditions there will be continuing human land uses and anthropozoic pressure on the vegetation, which need to be taken into account along with the climate change. Altan (2000) informed that forest degradation in Turkey basically stands on forest fires, grazing in the in the forest sites, land reclamations for agricultural lands and over use of forest resources. An exemplifying process on degradation levels of Mediterranean Vegetation is given in Figure 4.

The third scenario of the vegetation group is the potential impact of the climate change and impact of anthropozoic pressures (human use) on the natural vegetation. We expect that existing rural land use types of agriculture, stockfarming, forestry, mining, recreation, settlement developments will remain in the future. Güney et al (2006) suggested that bush and scrublands are densely used in the mountainous areas with the rising numbers of stocks. In terms of severe aridity, it would be possible to see such land conversion from forests to agricultural fields or pastures in the basin.

According to third scenario, we expect some changes with the main vegetation zones. For example timber line zone can be reduced by the nomadic land use in the plateaus, more by grazing on the upper parts and by the change in air temperature on the lower parts. In some cases second house developments and recreation would be another driving force on the declining timber line (Figure 5).

Whatever the change on the vegetation will be

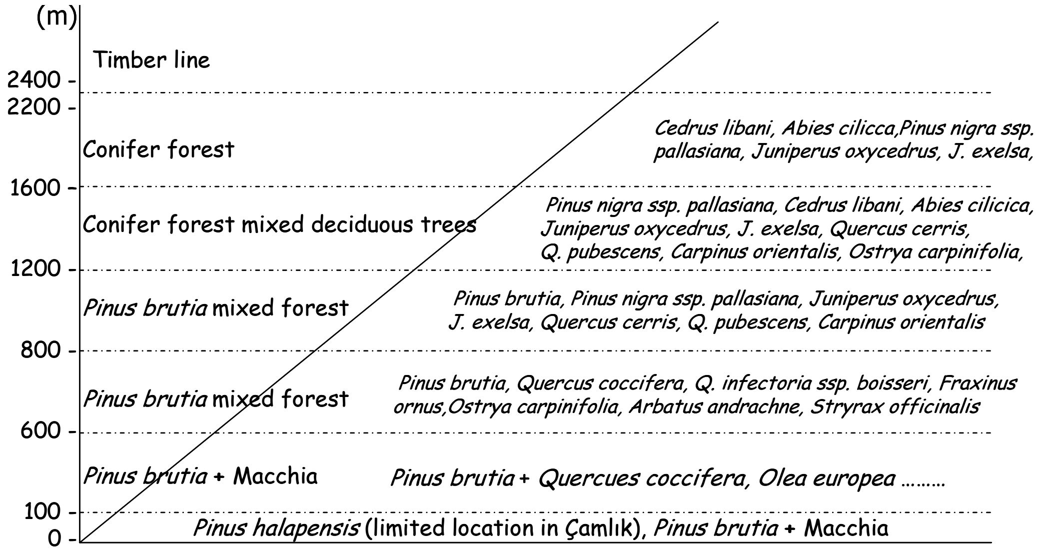

Figure 2. Expected change on vertical distribution of vegetation according to first scenario

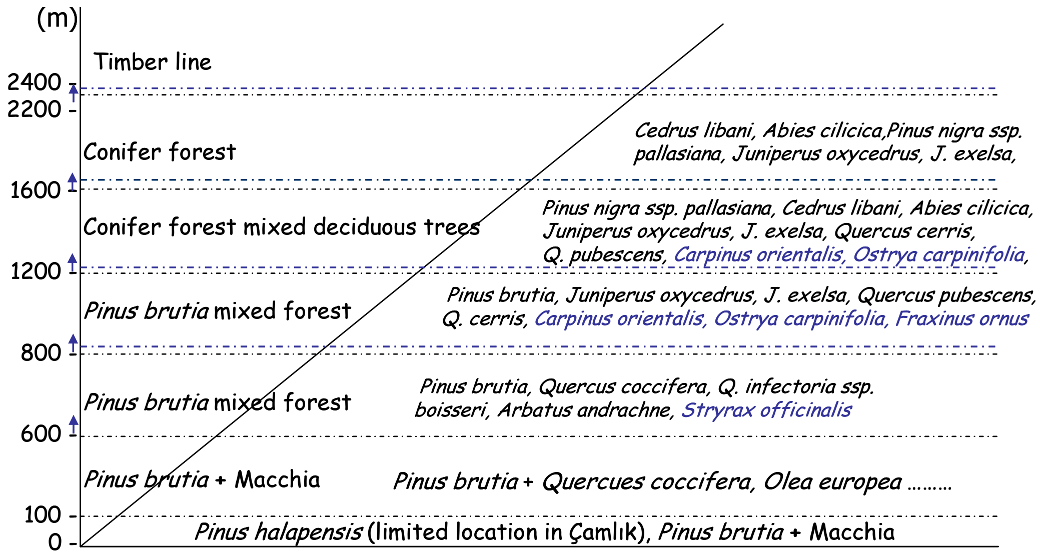

Figure 3. Expected change on vertical distribution of vegetation according to second scenario

in the future based on either climate change on land use demands, long-term monitoring on site will be needed for the exact change that the area will experience. Such changes can be monitor in used and un-used areas to see the impact of climate of its own and, impacts of anthropogenic pressures on the vegetation. Constant monitoring Parcels' System set up by Turkish vegetation group in Seyhan River Base can be used for farther studies. Plant analysis that will be carried out on these regular monitoring on these parcels in the future will provide precise information about the vegetation change by 2070s and onwards.

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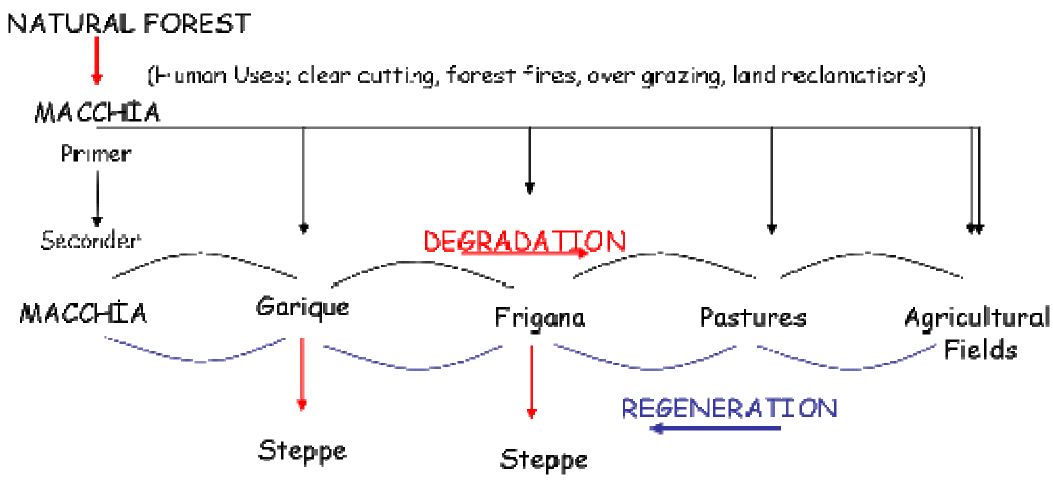

Figure 4. Degradation Levels of Mediterranean Vegetation (Altan, 2000)

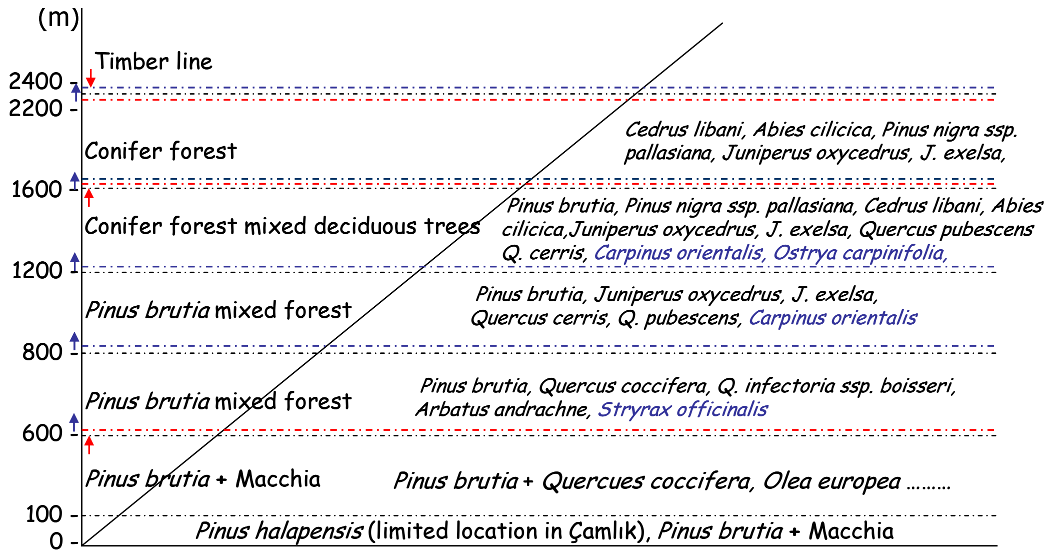

Figure 5. Expected change on vertical distribution of vegetation according to third scenario

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