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Evaluation of soil properties and flora under afforestation and natural forest in semi-arid climate of central Anatolia

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Abstract: *Arid and semi-arid climates and antropojen effects have caused rapid deterioration of the natural resources in the watershed. The main objectives of the study were to determine the correlation between soil properties and flora and to examine some soil properties and floristic composition under natural forest and afforestration. The topographical, geological and stand viewing maps of the watershed belong to 1955 and 2006 years were eximaned in the study. According to this study, the 14.5% rate of black pine forest in 1955 increased to 35.8% in 2006. Degraded forest, degraded black pine and agricultural area decreased respectively to 5.7, 1.8 and 15.8% in 51 years. The richest families in the research area were Asteraceae, Fabaceae, Lamiaceae, Poaceae, Brassicaceae, Caryophyllaceae, Scrophulariaceae, Boraginaceae, Apiaceae and Rosaceae. The rate of the richest families was 71.75% in the total species, the remaining 22 families were scattered to 28.25% in proportion of species.*

Key words: *Afforestation, Soil, Flora, Semi-arid climate, Central Anatolia*
PDF of full length paper is available online
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Introduction

Forest can change ecosystem dynamics and have a significant role in the hydrology and global carbon cycle, the biodiversity of species and play crucial role in climate change. From the ecologically viewpoint, silvicultural practices (thinnings and release cuttings) that provide a wide variety of vegetative composition and structure in young stands should help manage the biological diversity across forested landscape (Ozcelik *et al.,* 2008; Ozcelik and Eler, 2009). Biodiversity is perhaps the most important indicator of overall ecosystem health and possibly of function (Everard, 2004). The research on land use, climate change and deforestation various parts of the world has been done (Judex, 2003; Bruinjnzeel, 1990; Jetten, 1995; Spaans *et al*., 1989; Lal, 1981). Especially in arid and semi-arid climate the continuity of natural forest conservation and afforestation to create new forests requires hard work. Between 1938 and 2007 in Turkey, pasture area decreased by approximately 47% from 41 to 12.5 million hectare (Mha), while arable crop land increased by about 80% from 13.3 to 24 Mha (SIS, 2007). Clearance of forests for agricultural production and grazing is widespread, in particular, in highlands of Turkey. Additionally, semi-arid climate and inclined topography prevailing in the central Anatolia render ecosystems vulnerable and unable to recover from incompatible changes in land-use type. Turkey's topographic, climatic and soil properties and erosion are as a result of the wrong land use planning. However, flood, overflow, avalanche, fire, reduction in biological diversity, rural poverty and migration are natural or socio-economic problems. There has been increasing concern in highlands of semi-arid Turkey that conversion of these systems results in excessive soil erosion, ecosystem degradation and loss of sustainable resources. An increasing rate of land use/cover changes especially in semi-arid mountainous areas has resulted in important effects on physical and ecological processes, causing many regions to undergo accelerated environmental degradation in terms of soil erosion, mass movement and reservoir sedimentation (Basaran *et al.,* 2008). Land use is a key parameter in the hydrologic cycle, soil properties and soil organic carbon sequestration (Giertz *et al.,* 2005). Conversion of forest to pasture or cropland or conversion of pasture to cropland is found to decrease soil organig carbon (SOC) stocks, the opposite conversions usually lead to increased SOC stocks (Guo and Gifford, 2002, Lettens *et al*., 2005; Falloon *et al.,* 2006). Besides storage of carbon in the soil, forests store large amounts of carbon in biomass (Freibauer *et al.,* 2004). Within an ecosystem, land use can influence the properties of a soil and flora (Birkeland, 1984). Soils and forest are highly interrelated and none-of them can live without each other. Soil helps secure and renew the forest and forests help secure and renew the soil. On the other hand, forest type can change soil porperties and flora. In arid and semi-arid climate, floristic structure without breaking and create new forests are important issues to improve soil properties. The aim of this study is to analyse the effects of forest stand on soil physical properties and flora in a small watershed in central Anatolia.

Study Area and Methods

All field measurements were performed in the Kartasbagi Steram watershed (20 km^2), which is located in central Anatolia. The region is in the middle of the humid Black sea-arid Central Anatolia zone, which is characterized by terrestrial climate. The mean annual precipitation of the region is 500 mm, while the mean temperature is 10.4°C. According to the Thornthwaite method research area "semi-dry-moist, mesothermal, in excess of water in the dead of winter, the marine climate in the near influence" with a climate that has emerged on the type (Gol, 2002).

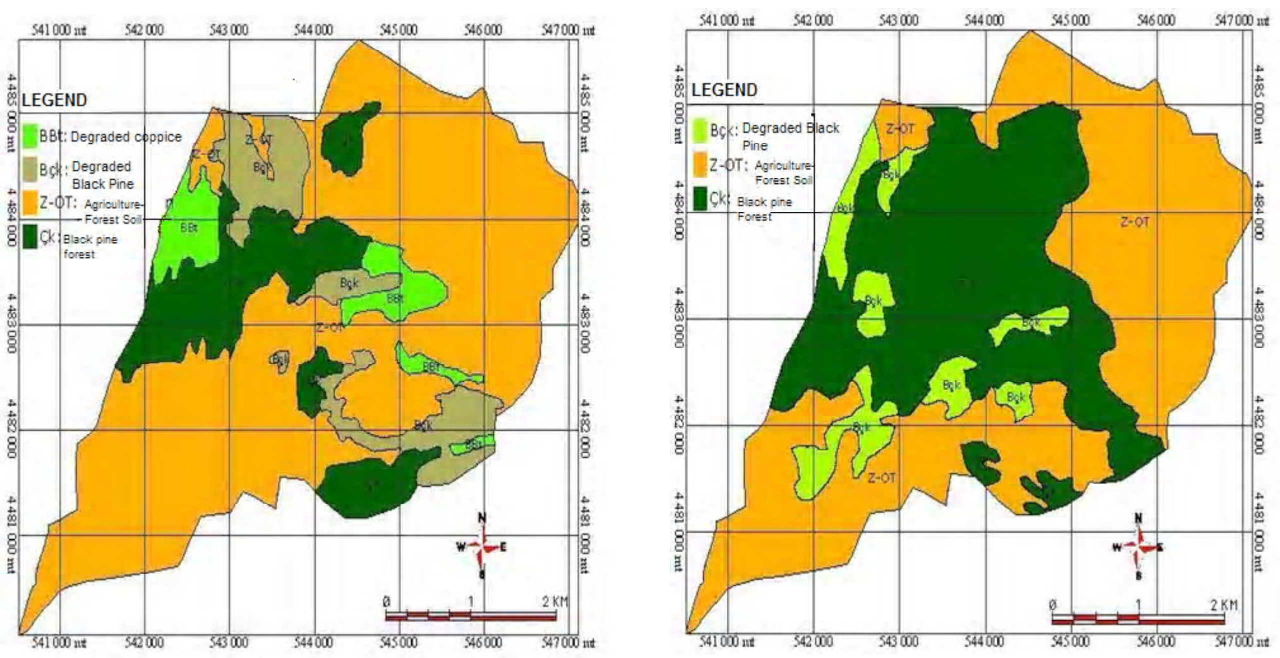
Research area for the 1955 review land use and land cover maps, the watershed in degraded coppice, degraded black pine forest and pasture land, forest and agricultural land were obtained. In 1961, the reclamation work was initiated and the first plantation was started in 1962. Afforestation has been done with the 2 years old bare rooted black pine saplings. Planting space was 2 m. Terraces were spaced by 2 m. Total planting density was 2500 seedling ha^{-1} (Anonymous, 1967).

In 2006 the land use and land cover distribution showed that the degraded black pine (-1.8%), coppice areas (- 5.7%) from the forest and open agricultural land (- 15.8%) decreased, on the contrary, the black pine forest (+ 21.3%) increased (Table 1), (Fig. 1), (Gol and Dengiz, 2007b).

Research areas of the geological formations and Cretase for Neogen comprise metamorphic and volcanic fasies. In the north and south west Cretase Andezit belongs to the limestone and serpentinite in majority. Research areas, belong to the Tertiary series consists of oligo-miosen gypseous (Ketin, 1962). Eldivan Ophiyolite Complex, Central Anatolia, the ocean is the shell material (Anonymous, 1988). Watershed soils were classified as Entisol and Inceptisol according to soil taxonomy (Göl and Dengiz, 2007a).

The active growth period for annuals and perennial geophytes is from early April till late May, and for perennial shrubs and woody plants from April till late October. Research areas of the country's three major areas Irano-Turanian flora in the area, according to Davis's grid is located in A4 frame. Central Anatolia's north, west and south, extending into a wide black pine belt (*Pinus nigra* Arn. subsp. *nigra* var. *caramanica* (Loudon) Rehder) was surrounded. In this forest zone, primary tree species in this stand is *P. nigra* with scattered *Quercus* sp. Forest flora is lower than many of the Iran-Turanian flora and composed of individuals (Atalay, 1983). Forests of *P. nigra* are protected in the mid of the treeless plains and are floristically in very poor conditions in the central Turkey (Akman, 1995). The woodland comprises of black pine (*Pinus nigra* Arn. subsp. *nigra* var. *caramanica* (Loudon) Rehder) and *Oak.* (*Quercus cerris* L., *Q. pubescens* Willd). Principal tree species of the plantation, which was replaced by the original woodland forty eigth years ago, is *Pinus nigra*, which is also principal tree species of the natural forest in the site.

Research in the catchment have been done before Göl and Dengiz (2007b) belong to Digital Elevation Model (DEM) map with topographic maps 1:25.000 scale was examined in the fields of natural and afforestation slopes, maintenance, upgrade features, the two pieces are similar in terms of sample area was determined. First and second examples of areas represent natural forest and the third and fourth sample areas represent afforestation. Sample plots each of which covers $400m^2$ were taken within the study area. Using the Braun-Blanquet method, all the herbaceous and woody plant species in each sample plot were evaluated. Silvicultural measurements of the field maintenance, slopes, elevation, closeness of the canopy, the degree of cover, dominant species, height (m), breast diameter (130 cm above ground), age and the shell thickness have been identified. Example areas evaluation clizimeter, altimeter,



(a) (b)

Fig. 1: The maps of (a)1955 and (b) 2006 of landuse/land cover (Source: Gol and Dengiz 2007b)

Table - 1: Changing pattern of land use / land cover between 1955 and 2006 of research area

Land cover and land use	Stand Map (1955)		Stand Map (2006)		Change (%)
	(ha)	(%)	(ha)	(%)	
Degraded coppice (Btt)	118.6	5.7	-	-	-5.7
Degraded black pine (Bçk)	203.4	9.8	166.8	8.0	-1.8
Black pine (Çk)	301.3	14.5	743.4	35.8	+ 21.3
Agriculture-forest soil (Z-OT)	1455.4	70.0	1168.5	56.2	-15.8
Total	2078.7	100.0	2078.7	100.0	

(Source : Gol and Dengiz, 2007b)

Table - 2: Site characteristics of natural forest in The Karataþbagi River watershed

Habitat	Sample plot 1	Sample plot 2
1. Location, site and coordinates		
A- Location	Eldivan, Bülbül Pinari	Eldivan, Bulbul Pinari
B- Coordinates	542 941 N, 4 483 338 E	542 985 N, 4 483 747 E
C- Altitude (m)	1240	1202
D- Terrestrial conformation	Mid-mountaineous, sub-side	Mid-mountaineous, sub-side
E- Side	West	West
F- Slope (%)	30	60
2. Forest constitution and species		
A- Stand canopy	80-90%	80-100%
B- Stand constitution	Storied constitution	Storied constitution

3. Tree, shrub and herbaceous plants	Layers canopy									
	A1	A2	A3	Shrub	Herb. plants	A1	A2	A3	Shrub	Herb. plants
Black pine	3	2	1	+	+	3	2	1	1	
Oak				1	+		2	1	1	1
Juniper				1					1	
Azarole				+					+	
Popper				1					1	
Rose hip				1					1	

Habitat	Sample plot 1	Sample plot 2
4. Litter and soil properties		
A- Litter layer (cm)	4	5.5
Leaf layer (cm)	2	3
Rot layer (cm)	1	1.5
Mould layer (cm)	1	1
B- Mould type	Dry-rot-mull	Dry-rot-mull
C- Physiological depth (cm)	130+	60+
D- Plenary depth (cm)	80	25
E- Soil stony (cm)	0-30 cm: 30%, 30-60 cm: 20%	0-30 cm: 30%, 30-60 cm: 60%
F- Soil horizons	**Ah 0-4 cm:** chocolate brown, granule, weak humid, permeable, scattered thin roots **Ael 4-22 cm:** tawny, granule, weak humid, rare roots **AB 22-33 cm:** grey swarty, half cornered block, humid, fine permeabilty, rich roots **Bst 33-46 cm:** grey swarty, half cornered block, rich and thin roots **BC 46-62 cm:** reddish brown, half cornered block, weak humid, fine permeabilty rare and thin roots **BC 62-80 cm:** reddish brown, half cornered block, weak humid, fine permeabilty rare and thin roots C1 80+ cm: reddish brown, unique grain, weak humid, fine permeabilty rich roots	**Ah 0-5 cm:** chocolate brown, granule, weak humid, permeable, thin roots **Ael 5-17 cm:** tawny, granule, weak humid, fine permeablity, mezzo roots **AC 17-25 cm:** tawny, granule, weak humid, fine permeabilty, mezzo roots **C1 25+cm:** tawny, massive, weak humid, fine permeabilty, fat roots

Note: A1: Top tree storied, A2: Middle tree storied, A3: Bottom tree storied, 3: 71-100%, 2: 41-70%, 1: 11-40%, 0 (+): 0–10%

to measure the diameter, height meter, and calipers use auger increment (Ozalp, 1989; Kantarci, 2000). Results for assessment of natural forest area were taken from the 1st and 2nd sample areas and for afforesttation areas were taken for 3rd and 4th sample areas. In the final stage of natural forest and afforestation properties were assessed on a mutual basis. Plant materials from the region of 2008-year period of vegetation growth (bloom, the fruit, seeds) were gathered as a result of working in the field. Collected plants in accordance with the rules of modern systematic herbarium material has been made. For each plant at least 2 samples were prepared. A soil pit was opened in each instance. Soil in the pit outside the territorial state, absolute and physiological depth, drainage condition, the skeleton, root distribution, humidity, structure, stoniness and the carbonate were evaluated according to Cepel (1998) and Kantarci (2000).

Particle size distribution was determined by the hydrometer method (Bouyoucous, 1951). A wet sieving method was used to determine the coarse fragments (Kemper and Rosenau, 1986). Bulk density (BD) and saturated hydraulic conductivity (K_{sat}) were determined by the core method (Cassel and Nielsen, 1986). Soil reaction (pH), electrical conductivity (EC) and salinity were measured by a pH/conductivity meter (Rhoades, 1996). Total nitrogen (TN) was determined by Kjeldahl (Bremner, 1996) method. Carbonate ($CaCO_3$) was determined by pressure calcimeter method (Richard and Donald, 1996). The concentration of soil organic matter (SOM) was determined by Walkley-Black method (Nelson and Sommer, 1996).

Results and Discussion

Silvicultural properties: Some silvicultural features and site charecteristics of the natural forest are shown in Table 2. The elevations of the sample areas are between 1200 and 1250 m. First and second sample areas are at the bottom of the hillside of the west and middle mountainous terrain. Stand density of these sampling areas has been defined as fully closed (80-100%). Dominant tree species in natural forests is the black pine. Oak trees are also included in the second tree storied. In the bush storied, oak (*Quercus cerris* L., *Q. pubescens* Willd), azarole (*Crataegus monogyna* Jacq.) popper (*Colutea cilicica* Boiss.) and rose hip (Rosa canina L.) were added to mixture.

The closeness of A1 storied trees is 90-100%, A2 storied is 80% and A3 storied trees is 10%. The closeness of bush storied and grass storied was estimated respectively at 10-30% and 10%. Stand density was deteriorated because of the reasons like rapine, felled and drying of trees. The areas where slope was very high the closeness of A2 and A3 storieds decreased.

Human activities (recreation, production and hunting) affected homogeneous distribution of dead cover in the area. It was measured mull type dead cover with 4 cm thickness in the first sample area and 5.5 cm thickness in the second sample area. The amount of stone was determined low in the top soil and high in the sub-soil.

A total of 32 trees were counted in the first sample area (400 m^2). Whole of the stand consists of black pine trees. The highest tree height was 26 m, the largest tree diameter ($d_{1.30}$) was 55 cm and the oldest tree was 79 years. In the same area the lowest tree height was 10 m, the smallest diameter ($d_{1.30}$) was 13 cm and the minimum age was 25 years.

A total of 66 trees were counted in the second sample area. The main tree species are black pine in the A1 storied, although the mixture of oak (50%) also encounterred. The highest black pine height was 15 m, the largest tree diameter was ($d_{1.30}$) 32 cm and the oldest tree was 70 years. The highest oak tree was 7 m, the largest tree diameter was ($d_{1.30}$) 8 cm and the oldest age was 36. Oaks could not make sufficient growth. Due to the erosion and slope, the deepness of the soil was unsufficient in the area. For that reason black pine trees also could not make sufficient root growth (Table 3).

The third and the fourth sample areas were chosen in the afforestation areas at an altitudes of 1105 m and 1285 m in the west. At the afforestation studies, the slopes were chosen different from each other in order to see the effect of the depth of the soil and the slope. Slope of the third sample area is 45% and slope of the fourth sample area is 0-5%. The saplings of black pine aged 2 years were used for afforesttation. Stand density on the above-tree storied was 80-100% in both areas. Moreover, it was seen that the forest started to regenerate in the below-tree storied and in the bush storied. The stand density of the A1 storied was 70-80%, the canopy of the A2 storied was 70-80% and the canopy of the below-tree storied was estimated at 10-20%. In the third sample area, the slope is high and the erosion is strong. Because the stand canopy didn't occur entirely in this sample area, the canopy in the bush and grass floor was valued as high (60-70%). In the bush storied, lots of species of oaks, azarole, (*Colutea cilicica* Boiss. Et Bal.), rose hip, juniper, plum, filixmas and *Astragalus angustifolius* Lam. subsp. *pungens* (Willd.) Hayek were encountered. The sample area was separated by gullies, and it was seen that the stream rehabilitation study was done with dry wall benches during the watershed rehabilitation studies. The A1 storied canopy was valued as 90-100%, A2 storied was valued as 70-80%, in the fourth sample area the slope is low. Stand canopy was valued as 60-70% due to the oaks that join the mixture at a rate of 50% in the A3 storied. The species similar to grass that were encountered in the third sample area were also seen in the bush storied. Thirty-two trees were counted in the third sample area (400 m^2). Although 2500 saplings were planted, it was seen that there were 800 trees in a hectare. The highest tree height is 19 m, the largest diameter is 29 cm ($d_{1.30}$) and the oldest tree is 42 year. The main species of the A1 storied was the black pine in the fourth sample area. Thirty-five trees were counted totally. Although the slope was low in this sample area, the depth of the soil was low affecting the development of the height and the width of the trees badly. In this sampling area, the highest is 12 m, the largest is 24 cm ($d_{1.30}$) and the oldest is 41 in the A1 storied (Gol *et al*., 2008).

Table - 3: Site characteristics of afforestation in The Karatasbagi river watershed

Habitat	Sample plot 3	Sample plot 4
1. Location, site and coordinates:		
A- Location	Eldivan, Golez Plantation	Eldivan, Bulbul Pinari
B- Coordinates	543 539 N, 4 484 863 E	542 985 N, 4 483 747 E
C- Altitude (m)	1105	1202
D- Terrestrial conformation	Mid-mountaineous, sub-side	Mid-mountaineous, up-side
E- Side	West	West
F- Slope (%)	45	60
2. Forest constitution and species:		
A- Stand canopy	80-90%	90-100%
B- Stand constitution	Storied constitution	Storied constitution

3. Tree, shrub and herbaceous plants	**Layers canopy**									
	A1	**A2**	**A3**	**Shrub**	**Herb. plants**	**A1**	**A2**	**A3**	**Shrub**	**Herb. plants**
Black pine	2	2	+	+		3	2	+		
Oak				+	+		2	+	2	+
Juniper				+					+	1
Azarole				+	+				+	
Popper				+	+				+	
Rose hip					+				+	

Habitat	Sample plot 3	Sample plot 4
4. Litter and soil properties		
A- Litter layer (cm)	3	5.5
Leaf layer (cm)	2	3
Rot layer (cm)	0.5	1.5
Mould layer (cm)	0.5	1
B- Mould type	Dry-rot-mull	Dry-rot-mull
C- Physiological depth (cm)	130+	60+
D- Plenary depth (cm)	40	25
E- Soil stony (cm)	0-30 cm: 15% , 30-60 cm: 50%	0-30 cm: 30% , 30-60 cm: 60%
F- Soil horizons	**Ael 0-10 cm:** tawny, unique grain, weak humid, rare roots **Bst 10-26 cm:** tawny, half cornered block, weak humid, fine permeabilty, rich and thin roots **BC 26-40 cm:** grey swarty, unique grain, weak humid, fine permeabilty, rare and mezzo roots **C1 40-63 cm:** tawny, unique grain, weak humid, fine permeabilty, rare and thin roots **C2 63+ cm:** tawny, massive, weak humid, fine permeabilty, scattered roots	**Ah 0-2 cm:** chocolate brown, granule, weak humid, thin and rare roots **Ael 2-20 cm:** chocolate Brown, half cornered block, weak humid, fine permeabilty, scattered roots **Bst 20-36 cm:** tawny, half cornered block, weak humid, fine permeabilty, rich and fat roots **BC 36-52 cm:** tawny, massive, weak humid, fine permeabilty, rich- thin and fat roots **Cv 52+ cm:** tawny, massive, weak humid, fine permeabilty, scattered

Floristic composition: According to the P.H. Davis's Grid systems, the research area is in A4 frame. During April to September, approximately 500 plant samples were collected which includes 123 species belonging to 32 families and 177 takson (the number and types of species, including six taxon) was determined (Table 4). In the research area, the richest families are *Asteraceae*, *Fabaceae*, *Lamiaceae*, *Poaceae*, *Brassicaceae*, *Caryophyllaceae*, *Scrophulariaceae*, *Boraginaceae*, *Apiaceae* and *Rosaceae*. The richest of 10 families in the total species rate is 71.75%, the remaining 22 families are scattered to 28.25% in proportion of species. The identification of the plants was done by using the Flora of Turkey (Davis, 1965-1985; Davis *et al.,* 1988) and other floras (Boisser, 1867-1888; Komarov and Shiskin, 1933-1964; Rechinger, 1998) checked from The Herbarium of Ankara university (ANK).

Soil properties of different land covers: Table 5 shows some soil properties of different land covers. Analysis results of natural and plantation forest soils are given in Table 3. The sandy clay soil and sand ting shows the structure features. In the afforestation area, dead cover could not be sufficiently accumulated. The amount of coarse fragments is high in natural forest soils. Very mild acid soil reaction (pH 6.1), mild acid (pH 6.7) with strong alkali (pH 8.1) showed the change. Lime and soil organic matter of soil coverage are directly affecting the soil reaction. The amount of organic matter was high in the top soil so in this soil pH was low. The amount of lime was high in the sub-soil so that pH was measured high in this soil. In

Table - 4: Floristic composition of research area

Family	Genus	NF	A	G
Ranunculaceae	*Ceratocephalus falcatus* L. PERS.			x
	Clematis vitalba L.	x		
	Consolida orientalis (Gay) Schröd.		x	
	Ranunculus arvensis L.			
Berberidaceae	*Berberis crataegina* DC.	x	x	x
	B. vulgaris L.			x
Papaveraceae	*Fumaria asepala* Boiss.	x		x
	F. parviflora Lam.	x		
	Papaver dubium L.			x
Brassicaceae	*Aethionema arabicum* (L.) Andrz. ex DC.			x
	Alyssum desertorum Stapf. var. *desertorum* Stapf.		x	
	A. minutum Schlecht. ex DC.		x	
	A. minus (L.) Rothm. var. *micranthum* (Meyer) Dudley	x		
	A. murale Waldst. and Kit. var. *murale* Waldst. and Kit.		x	
	A. pateri Nyar. subsp. *pateri* Nyar.			x
	Arabis caucasica Willd. subsp. *caucasica* Willd.			x
	Camelina rumelica Velen.	x		x
	Cardaria draba (L.) Desv. subsp. *chalepensis* (L.) O. E. Schulz	x	x	
	Erysimum crassipes Fisch. and Mey.	x		
	Fibigia clypeata (L.) Medik.	x		
	Thlaspi perfoliatum L.			x
Resedaceae	*Reseda lutea* L. var. *lutea* L.	x	x	
Cistaceae	*Helianthemum nummularium* subsp. *lycaonicum* Coode and Cullen	x	x	
	H. nummularium subsp. *ovatum* (Viv.) Schinz and Thellung		x	
Polygalaceae	*Polygala anatolica* Boiss. and Heldr		x	
	P. supina Schreb.		x	
Caryophyllaceae	*Arenaria serpyllifolia* L.	x		
	Cerastium brachypetalum Pers. subsp. *roeseri* (Boiss. & Heldr.) Nyman	x		
	Saponaria prostrata Willd. subsp. *prostrata* Willd.	x		
	Silene alba (Miller) Krause subsp. *eriocalycina* (Boiss.) Walters	x	x	x
	S. chlorifolia Sm.			x
	S. italica (L.) Pers.			x
	S. vulgaris (Moench) Garcke var. *vulgaris* (Moench) Garcke		x	
	Stellaria holostea L.			x
Illecebraceae	*Herniaria incana* Lam.	x		x
Polygonaceae	*Rumex acetosella* L.			x
	R. crispus L.			
Chenopodiaceae	*Chenopodium album* L. subsp. *album* L. var. *album* L.	x		
	C. botrys L.	x		
Clusiaceae	*Hypericum linarioides* Bosse		x	x
	H. lydium Boiss.			x
	H. origanifolium Willd.			
	H. perforatum L.	x		x
Malvaceae	*Alcea pallida* Waldst. and Kit.			x
	Malva neglecta Wallr			x
Linaceae	*Linum tenuifolium* L.			x
Geraniaceae	*Geranium asphodeloides* subsp. asphodeloides Burm. Fil.		x	
Fabaceae	*Astragalus angustifolius* Lam. subsp. *pungens* (Willd.) Hayek	x		
	A. anthylloides Lam.	x	x	
	A. dipsaceus Bunge	x		
	A. karamasicus Boiss. and Bal.	x	x	
	A. lycius Boiss.	x		
	A. sigmoideus Bunge			x
	Colutea cilicica Boiss. and Bal.	x	x	
	Coronilla orientalis Miller var. *orientalis* Miller	x		
Fabaceae	*C. varia* L. subsp. varia L.	x		
	Dorycnium graecum (L.) Ser.			x

Contd. ......

	Genista lydia Boiss. var. *lydia* Griseb.			x
	Lathyrus tukhtensis Czecz.			x
	Lotus aegaeus (Gris.) Boiss.		x	
	Medicago falcata L.		x	
	Medicago lupulina L.		x	
	M. minima (L.) Bart. var. *minima* (L.) Bart.	x		
	Melilotus alba Desr.			x
	M. officinalis (L.) Desr.			x
	Onobrychis armena Boiss. and Huet		x	
	Ononis spinosa L. subsp. *leiosperma* (Boiss.) Sirj.		x	
	Trifolium caudatum Boiss.			x
	T. medium L. var. *medium* L.			x
	T. pannonicum Jacq. subsp. *elongatom* (Willd.) Zoh.			x
	T. repens L. var. *repens* L.			x
	Trigonella fischeriana Ser.	x		
	Vicia cracca L. subsp. *cracca* L.		x	
	V. cracca L. subsp. *stenophylla* Vel.		x	
Rosaceae	*Alchemilla mollis* (Buser) Rothm			x
	Geum urbanum L.			x
	Potentilla recta L.			x
	Rosa canina L.	x	x	
	Sanguisorba minor Scop. subsp. *muricata* (Spach) Brip.			x
Apiaceae	*Bifora radians* Bieb.			x
	Bunium microcarpum subsp. *bourgaei* (Boiss.) Hedge and Lamond			x
	Caucalis platycarpos L.	x		
	Echinophora tenuifolia L. subsp. *sibthorpiana* (Guss.) Tutin		x	
	Laserpitium hispidum Bieb.		x	
	Turgenia latifolia (L.) Hoffmann			x
	Zosima absinthifolia (Vent.) Link			x
Rubiaceae	*Cruciata taurica* (Pallas ex Willd.) Ehrend.			x
	Galium incanum Sm. subsp. *elatius* (Boiss.) Ehrend.			x
Morinaceae	*Morina persica* L. var. *persica* L.			x
Dipsacaceae	*Scabiosa argentea* L.		x	
Asteraceae	*Achillea biebersteinii* Afan.			x
	Acroptilon repens (L.) DC.		x	
	Anthemis tinctoria L. var. *pallida* DC.			x
	A. triumfettii (L.) All.		x	
	Carduus nutans sensu lato			x
	Centaurea depressa Bieb.			x
	C. virgata Lam.		x	
	Chondrilla juncea L. var. *juncea* L.			x
	Cichorium intybus L.			x
	Cirsium arvense subsp. *vestitum* (Wimmer and Grab.) Petrak			x
	Crepis foetida L. subsp. *rhoeadifolia* (Bieb.) Celak	x	x	
	Crupina vulgaris Cass.		x	
	Doronicum orientale Hoffmann			x
	Inula montbretiana DC.			x
	Jurinea pontica Hausskn. and Freyn ex Hausskn.		x	x
	Pilosella piloselloides subsp. *piloselloides* (Vill.) Sojak			x
	Senecio vernalis Waldst. and Kit			x
	Tanacetum vulgare L.			x
	Taraxacum macrolepium Schischkin		x	
	T. serotinum (Waldst. and Kit.) Poriet	x	x	x
Campanulaceae	*Asyneuma amplexicaule* subsp. *amplexicaule* var. *amplexicaule* (Willd.) Hand.-Mazz.			x
	Campanula glomerata L. subsp. *hispida* (Witasek) Hayek			x
	C. rapunculoides L. subsp. *rapunculoides* L			
Primulaceae	*Androsace maxima* L.			x
Boraginaceae	*Alkanna orientalis* (L.) Boiss. var. *orientalis* (L.) Boiss.	x	x	
	Anchusa azurea Miller var. *azurea* Miller	x		
	A. leptophylla subsp. *incana* (Ledeb.) Chamb.	x	x	x

Contd. ......

	A. leptophylla subsp. *leptophylla* Roemer and Schultes			x
	Onosma isauricum Boiss. and Heldr.		x	
	O. stenolobum Hausskn. ex H. Riedl		x	x
Scrophulariaceae	*Linaria corifolia* Desf.			x
	L. simplex (Willd.) DC.	x		
	Odontites verna subsp. *serotina* (Dumort.) Corb.	x		
	Scrophularia canina L. subsp. *bicolor* (Sm.) Greuter			x
	Verbascum cheiranthifolium var. *asperulum* (Boiss.) Murb.			x
	V. cheiranthifolium Boiss. var. *cheiranthifolium* Boiss			x
	V. lasianthum Boiss. ex Bentham			x
	Veronica multifida L.	x	x	
	V. officinalis L.	x		
	V. triphyllos L.	x		
Lamiaceae	*Acinos rotundifolius* Pers.		x	x
	Ajuga chamaepitys subsp. *chia* var. *chia* (Schreber) Arcangeli			x
	A. orientalis L.			x
	Lamium purpureum L. var. *purpureum* L.			x
	Marrubium astracanicum Jacq. subsp. *astracanicum* Jacq.		x	
	Mentha longifolia (L.) Hudson subsp. *longifolia* (L.) Hudson		x	
	Phlomis armeniaca Willd.			x
	P. pungens Willd. var. *pungens* Willd.			
	Salvia candidissima Vahl subsp. *candidissima* Vahl	x	x	
	S. dichroantha Stapf		x	x
	Scutellaria orientalis L. subsp. *pinnatifida* Edmondson			x
	S. salviifolia Bentham			x
	Sideritis montana L. subsp. *montana* L.		x	
	Stachys annua subsp. *annua* var. *lycaonica* Bhattacharjee	x	x	
	Teucrium chamaedrys L. subsp. *chamaedrys* L.			x
	Thymus longicaulis subsp. *longicaulis* var. *longicaulis* C. Presl	x	x	
	T. longicaulis subsp. *longicaulis* var. *subisophyllus* (Borbas) Jalas	x	x	
	T. sipyleus subsp. *sipyleus* Boiss. var. *sipyleus* Boiss			x
Euphorbiaceae	*Euphorbia macroclada* Boiss.	x	x	x
	E. myrsinites L.			x
	E. stricta L.			x
Fagaceae	*Quercus petraea* subsp. *iberica* (Steven ex Bieb.) Krassiln	x	x	
	Quercus pubescens Willd.	x	x	
Liliaceae	*Allium. scorodoprasum* L. subsp. *rotundum* (L.) Stearn			x
	Muscari armeniacum Leichtl. ex Baker	x	x	
	M. neglectum Guss.	x	x	x
	Ornithogalum oligophyllum E. D. Clarke			x
Iridaceae	*Crocus ancyrensis* (Herbert) Maw	x	x	x
Poaceae	*Aegilops umbellulata* subsp. *umbellulata* Zhukovsky	x	x	
	Agrostis stolonifera L.			x
	Alopecurus arundinaceus Poiret			x
	Bromus danthoniae Trin.			x
	B. japonicus Thunb. subsp. *japonicus* Thunb.			x
	B. squarrosus L.	x	x	x
	B. tectorum L. subsp. *tectorum* L.	x	x	x
	Dactylis glomerata L. subsp. *hispanica* (Roth) Nyman	x	x	x
	Festuca valesiaca Schleich. ex Gaudin		x	
	Poa bulbosa L.	x	x	x
	Stipa joannis Celak.		x	x

Note: NF = Natural forest, A = Afforestation, G = Grassland, x = Land used internal species

the third sample area, the amount of lime for field sampling of soil decreased with depth. The low pH were measured in the third sample soils. This region has a low amount of lime in the soil. 1st, 2nd and 3rd sampling area has been identified as salt-free or very little salt. 4th sample area soils were determined as very salty or too much salt. Electrical conductivity is 6.81 dS/m in this soils. The diametter and height of trees was negatively affected from soil deepness and salt in the fourth sample area. The upper soils of natural forest were rich and very rich in organic matter. The upper soils of afforestation sites were also rich in organic matter.

Table - 5: Physical and chemical properties of soil from study area

Forest constitution	Coordinates	Horizon	Depth (cm)	Texture(%) Clay	Silt	Sand	Soil Type	CF	pH 1/5DIW	Saturation (%)	Salinity (%)	EC (dSm^{-1})	Lime ($CaCO_3$) (%)	BD	K_{sat}	SOM (%)	TN (%)
		Ah	0-4	31	23	46	SCL	55	7.1	80	0.12	2.69	7	0.98	89.16	7.04	0.36
		Ael	4-22	19	33	48	SL	41	6.7	64	0.12	2.61	17	1.03	72.93	5.54	0.32
	542 941 N	AB	22-33	30	23	47	SCL	46	7.7	56	0.11	2.38	27	1.11	42.11	3.14	0.15
Natural forest		Bst	33-46	29	21	50	SCL	25	7.5	52	0.13	2.90	25	1.22	13.16	2.02	0.10
	4 483 338 E	BC	46-62	28	25	47	SCL	71	7.6	52	0.08	2.00	21	1.27	21.78	1.89	0.09
		Cv_1	62-80	27	26	47	SCL	81	7.7	44	0.09	2.08	27	1.30	—	0.88	0.04
		Cv_2	80+	27	27	46	SCL	75	7.7	47	0.07	1.64	24	1.32	—	0.77	0.03
	542 985 N	Ah	0-5	22	20	58	SCL	43	7.1	65	0.11	2.35	17	0.88	102.34	5.29	0.26
Natural forest		Ael	5-17	14	36	50	SL	52	7.6	50	0.09	2.05	24	1.08	82.65	3.89	0.19
	4 483 747 E	AC	17-25	13	27	60	SL	52	7.5	47	0.09	2.03	22	1.27	27.16	2.02	0.10
		Cv	25+	34	31	35	SCL	55	7.7	41	0.07	1.62	26	1.25	—	0.88	0.04
		Ael	0-10	33	32	35	SCL	44	7.7	47	0.09	2.22	21	1.00	63.49	2.39	0.11
		Bst	10-26	28	38	34	SCL	44	7.7	42	0.11	2.41	22	1.09	34.76	2.77	0.13
Plantation	543 539 N	BC	26-40	34	29	37	SCL	49	7.8	43	0.13	2.81	16	1.17	16.62	0.90	0.04
forest	4 484 863 E	Cv_1	40-63	20	31	49	SCL	58	7.9	39	0.07	1.70	19	1.24	—	0.63	0.03
		Cv_2	63-78	32	29	39	SCL	66	7.9	43	0.07	1.67	18	1.30	—	0.63	0.03
		Cv_3	78+	22	23	55	SCL	52	8.1	35	0.06	1.41	5	1.30	—	0.51	0.02
		Ah	0-2	35	23	42	SCL	13	6.7	70	0.07	1.71	2	0.98	81.29	5.67	0.32
Plantation	543 812 N	Ael	2-20	34	38	28	SCL	17	6.5	51	0.19	4.08	2	1.10	78.36	3.89	0.19
forest	4 484 263 E	Bst	20-36	34	23	43	SCL	38	6.2	62	0.26	5.61	1	1.17	9.32	2.02	0.10
		BC	36-52	14	16	70	SL	32	7.0	50	0.14	3.11	2	1.18	—	1.40	0.07
		Cv	52+	28	21	51	SCL	25	6.2	58	0.33	6.81	2	1.23	—	1.01	0.05

CF = Coarse fragments, DIW = Deionize water, EC = Electrcal conductivity, BD = Bulk density, K_{sat} = Satureted hydraulic conductivity, SOM = Soil organic matter, TN = Total nitrogen, N = North, E = East, Ah = Organic horizon, Ael = Mineral horizon, AB-Bst-BC = Mineral Horizon, CV_1-CV_2 = Parent material horizon, SCL = Sandy clay loam, SL = Sandy loam

This research will help to clarify how land cover affects soil properties and resulting hydrologic and carbon cycle dynamics. The SOM, K_{sat} and BD of soil are strongly correlated with land use management practices. Our research focuses on assessing the impact of land cover change (primary natural forest and afforestation) on soil properties (SOM and subsurface K_{sat}).

46 years of afforestation led to changes in some of the physical, chemical and hydro physical properties of soils. Soil characteristics affirmatively affected by afforestation are SOM, WSA, $K_{sat,}$ and BD.

Results have shown that significantly higher values of saturated hydraulic conductivity (K_{sat}) in natural forest top soil (102.34-89.16cm^3 h^{-1}) compared to afforestation soil (83.49-63.49cm^3 h^{-1}) (Table 5). Forests are generally known for a high soil infiltration capacity and hydraulic conductivity, enhancing base flow (Buytaert, 2007). In watershed scale thus, forest areas may positively influence from relevant hydrological functions like infiltration, percolation, and base flow that subsequently affect the water regime. Hydraulic conductivity correlated significantly with bulk density and clay content. Soils under afforestation have higher bulk density (1.1 g cm^{-3}) than the soils under natural forests (0.7 g cm^{-3}).

The above results indicate converting grassland or farmland to secondry forest, restorate soil properties. The other benefit of afforestation is decrease in soil erosion and increase of yield. The effect of land cover change on soil physical and chemical properties should be accounted in order to examine accurately and simulate ecosystem dynamic in the high land mountain ecosystems on the Central Anatolia.

Catchment reclamation project was began in 1955. According to this project, the rate (14.5%) of black pine forest in 1955 increased to 35.8% in 2006. Degraded forest, degraded black pine, and agricultural area decreased respectively to 5.7%-1.8% and 15.8% in 51 years.

Dense forestry activities and that people support the project increase the success in the catchment where the drought is the biggest problem. As a result of this success, Bulbulpinari zone of the catchment has been opened to be used as recreation. Consequently, when determining the targets in the catchment rehabilitation studies, economical and ecological criteria must be evaluated together.

Semi-arid climatic regions of the catchment, the balance between soil-climate-vegetation of the catchment hydrologic characteristics of the building and afforestation work in improving care in the jungle after planting as very important. The other important point is always to place the appropriate species for afforestation work should be used. Biological diversity provides information about ecosystem health. As a result of working in the field of afforestation, some species leave the area and some new species have been observed to occur. 51 years as a result of afforestation work, despite all the negative features of afforestation land, natural forest land that has been approached to feature.

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