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Original Research

Spatial and Temporal Changes in Forest Cover in Turkey's Artvin Forest, 1972-2002

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Abstract

This study analyses the spatial and temporal pattern of land use/forest cover change in the Artvin Forest Planning Unit (AFPU) surrounding the city of Artvin, Turkey. To assess the spatiotemporal changes in forest ecosystem patterns during 1972–2002, we evaluated forest stand maps of 1972, 1985 and 2002 using Geographic Information Systems (GIS). The results showed that the total forested areas decreased from 4617 ha (88.4% of the study area) in 1972 to 4167 ha (79.8%) in 2002, with a considerable net decrease of 450 ha. 198 ha forest openings changed into settlements and agriculture during the first period (1972-1985). 158 ha degraded forest areas changed into settlements and agriculture during the second period (1985-2002). The population of Artvin increased two times over 30 years and high variability in land use/forest cover changes during the study period was reported. In terms of spatial configuration, as a result of unplanned exploitation, settlement, dam and road construction, insect outbreaks on spruce stands, conversion and over utilization, many natural ecosystems were fragmented into small pieces in the AFPU and the total number of forest fragments rapidly increased from 108 to 202. Substantial increase in the number of patches and decrease in the average patch sizes between 1972 and 2002 indicated irregular land use and forest structure, and also suggested that human interventions had produced irregular land cover types.

Keywords: land use/forest cover change, Geographical Information Systems, remote sensing, landscape dynamics, human interventions

Introduction

Forest ecosystems have important functions from economical, environmental and ecological perspectives and provide many goods and services such as biodiversity, water and soil protection, carbon sequestration, tourism and recreation and non-wood forest products. Sustainable management of forest resources is the key objective of ecosystem-based forest ecosystem management, which includes sustainable utilization and conservation of forest ecosystems at local and global scales.

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In recent years, land use and forest cover changes have been an important topic in many countries, especially in developing countries because land use and forest cover changes have played a vital role in sustainable management of forest resources. Generally, changes in land use and forest cover have negative effects on biodiversity, soil and water quality, and world climate when forest ecosystems were disturbed or deteriorated [1-6]. Land use and forest cover was altered drastically with increasing population pressure, agricultural activities and industrialization. The human impacts on those lands are still very great and increasing. Population growth is directly linked to urbanization, which is generally responsible for destroying or

degrading nearby forest ecosystems or agricultural areas. On the other hand, technological, institutional and natural resource policy forces also play an important role in changing land use and forest ecosystem patterns [7-9].

Due to all these reasons, land use and forest cover changes are now a major topic because detection and understanding of historical dynamics of land use and forest cover are necessary for sustainable management of natural resources, specifically forest ecosystems [10, 11]. There are several studies to illustrate spatiotemporal dynamics of land use and forest cover in various countries and regions [11-20]. To date, especially recently, there have been a few studies attempting to document the temporal changes in forest ecosystem patterns in Turkey [9, 21-26]. These studies generally documented the spatial and temporal land use and forest cover changes as well as the factors affecting these processes. GIS and Remote Sensing techniques (RS) were used in these studies because these technologies have provided huge facilities in examining land use and forest cover changes in any region. On the other hand, there is a strong link between land use/forest cover changes and social pressure, meaning urbanization and intensive agriculture. For that reason, complex relationships between environmental, ecological, and socio-economical factors that induce changes and degradations in land use and forest cover should be studied and understood among the first priorities of sustainable development and management of forest resources.

This study is to understand the land use and forest cover changes and to assess the role of various factors affecting these changes, which is especially focused on population growth/urbanization. Within this framework, the objectives of this study are:

1) to detect and document changes in major land use in general and forests in particular in a small forest area in the AFPU surrounding Artvin in 1972, 1985 and 2002, and
2) to analyze patterns of changes in landscape of the study area with special focus on forest fragmentation. The study used RS and GIS technologies to achieve the stated objectives.

Methods

Study Area

The study area is the Artvin Forest Planning Unit surrounding the city of Artvin located in the northeastern Black Sea Region of Turkey (731000-743000 E and 4556000-4570000 N, UTM ED 50 datum Zone 37N). The study region is delineated by the Saçinka Forest Planning Unit in the north, by the Taşlıca Forest Planning Unit in the west, the Ortaköy Forest Planning Unit in the east and the Zeytinlik Forest Planning Unit in the south. AFPU is characterized by dominantly steep and rough terrain with an average slope of 62% and an altitude from 400 to 2,220 m above sea level. Total area is 5221.2 ha. Vegetation of the study area is in the spruce (*Picea orientalis* (L) Link) and beech (*Fagus orientalis* Lipsky) vegetation zone and the balance lies in the fir (*Abies nordmanniana* (Stev.) Spach) zone.

Major forest tree species include fir, spruce, pine, beech, oak and hornbeam. Winters are mild and wet, and summers are relatively cool and dry. Mean annual temperature of the study area is 11.9ºC, and mean annual precipitation is 719.7 mm. Main soil types are sandy clay loam, clay loam and sandy loam. There is also an important recreation area in the study area, named Kafkasör, which covers approximately 5 ha. The area, which is close to the city center is a popular recreation spot.

Database Development

The spatial database, developed as part of this study, consisted of forest stand type maps derived from remote Sensing data (aerial photographs and satellite images) and field survey. Aerial photographs of the study area were obtained from the General Directorate of Forestry (GDF), for the years 1972 (scale 1:22,000 and panchromatic aerial photographs), 1985 (1:15,000 panchromatic aerial photographs) and 2002 (1:15,000 color infrared aerial photographs and a meter resolution IKONOS). Forest stand maps, generated through aerial photographs and field survey data in 1972 and 1985 were also gathered from the GDF database. The 2002 forest stand map was derived from interpreting aerial photographs, high-resolution satellite images and field survey. The paper maps were digitized and processed using a Geographic Information System (ArcGIS 8.3) with a maximum root mean square (RMS) error under 10 m. The associated attribute data were entered into the computer to create a spatial database of the area [27].

In order to study forest fragmentation processes, the land use/forest cover maps for 1972, 1985 and 2002 were used to determine the number of forest patches, their perimeters and their areas, from which the minimum, maximum, and average areas were determined. In this study, case study area was investigated from the point of view of both land use (agriculture, settlements and forest) and forest cover (conifer forest, broadleaf forest, degraded forest). Therefore, generally "land use and forest cover" was preferred. Forest patches are represented as stand types, which is characterized according to tree species, crown closure, stand age and development stages. Non-forested areas have also been found in forest cover type maps and represented in the form of polygons. A shape complexity index (SCI) was calculated by dividing the perimeter by the area, which is an indication of the degree of irregularity of land use plots [8, 13]. This is,

$$SCI = \frac{b}{d}$$

where SCI is shape complexity index (m/ha), b is average perimeter (m) and d is average area of the patches (ha).

To determine socio-economic factors and management interventions influencing land use changes, a number of documents such as forest management plan, silvicultural prescriptions, harvesting activities, demographic change, economic conditions and living standard of people in the study area were obtained and evaluated. Furthermore, historical information about natural resource management for the last 30 years was obtained to provide a context from which to analyze their impact on land use in the region.

Results

Changes in Land Use/Forest Cover Types

The land use/forest cover maps for 1972, 1985 and 2002 are presented in Fig. 1 and the area for each land use/cover class during the three periods is shown in Table 1. According to data from maps, the total forested area decreased from 4,617ha (88.4% of the study area) in 1972

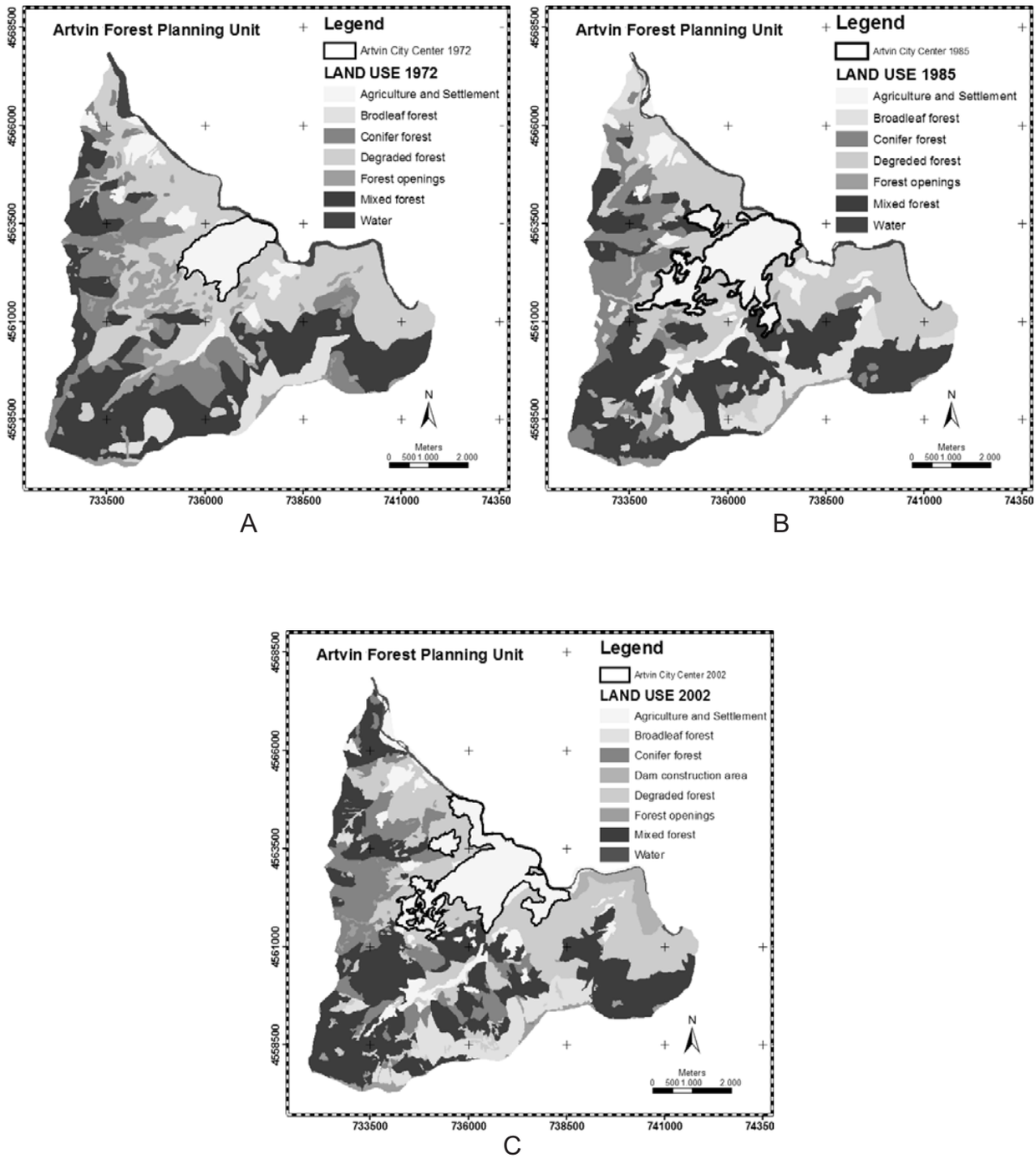

Fig. 1. Land use and forest cover map of Artvin Forest Planning Unit in A) 1972, B) 1985, and C) 2002.

Table 1. Evolution of selected landscape variables in the study area from 1972 to 2002.

Year	1972		1985		2002	
Land use/Forest cover	ha	%	ha	%	ha	%
Degraded forest*	1607.8	30.8	1583.3	30.3	1385.7	26.5
Mixed forest	1558.9	29.9	1556.4	29.8	1664.7	31.9
Forest openings**	414.7	7.9	98.7	1.9	114.4	2.2
Broadleaf forest***	240.9	4.6	424.5	8.1	351.4	6.7
Conifer forest***	794.3	15.2	640.1	12.3	650.3	12.5
Water	126.5	2.4	95.5	1.8	59.5	1.1
Settlement and Agriculture	478.1	9.2	822.6	15.8	887.3	17.0
Dam	-	-	-	-	107.8	2.1
Total	5221.2	100	5221.2	100	5221.2	100

* Degraded forest consists of stands whose crown closure is smaller than 10%. Productive forests also consist of stands whose crown closure is higher than 10% **Forest openings are defined as treeless open areas accepted as forest areas. ***Conifer forests and broadleaf forests mainly consist of *Picea orientalis* (*partly Abies nordmanniana*) and *Fagus orientlis* forest stands, respectively.

to 4,167 ha (79.8%) in 2002 with a considerable net decrease of 450 ha. However, productive forest areas (forest areas whose stand crown closure is greater than 10%) increased 72 ha (2.7%). There was a net decline of 300 ha in forest openings (treeless and open areas which are being accepted as forest area in Turkey) as opposed to a net increase of 409 ha in settlement and agricultural areas during 1972-2002 (Table 1). Broadleaf forest increased 111 ha, conifer forest decreased 144 ha, degraded forest decreased 222 ha, and mixed forest increased 106 ha. Furthermore, a lot of dams have been built up since 2000 on the Çoruh River. One of them is the Deriner Dam near Artvin Forest Planning Unit. Because of the dam construction, water area in planning unit decreased 67 ha while dam area increased 108 ha.

Transitions among Land Use/Forest Cover

The magnitude and the direction of changes in land use and forest cover are the most important factors relating to landscape evolution [28]. Besides analyzing the changes in the amount of land use and forest cover types, the temporal transitions among land use/forest cover types were also documented and evaluated to see the intertemporal dynamics of land use and forest cover types. The transitions were evaluated using periodic results of historical forest stand type maps for forest planning units.

More details of transitions of major land use/forest cover types among 1972, 1985 and 2002 maps are given in Table 2. Some apparent forest cover type transitions between 1972 and 1985 could be illustrated as: degraded forest to settlement and agriculture 142 ha, forest openings to settlement and agriculture 198 ha., from degraded forest to mixed forest 109 ha, from mixed forest to degraded forest 157 ha, from mixed forest to conifer forest 247 ha. In addition, transition results between 1972 and 1985 similarity with transition result between 1985 and 2002. During 1985-2002, some apparent land use transitions could be illustrated as: from water area to dam 11 ha, from degraded forest to dam 97 ha, from degraded forest to settlement and agriculture 158 ha, from forest openings to settlement and agriculture 6 ha, from water area to settlement and agriculture 44 ha. General analysis showed that there were apparent dynamics of land use and forest cover, some of which issue from either urbanization and social pressure on forests or mismanagement of the area and uncontrolled forest protection.

Changes in Landscape Patterns

Besides non-spatial compositions, the spatial structure of landscapes is important as it has implications for the design and management of forest resources [29]. Thus, the spatial dynamics of the forest landscape refers to the temporal change in the size, number, shape, adjacency and the proximity of patches in a landscape. In this study we used the Shape Complexity Index (SCI=b/d), which could be useful indicator (especially in forested areas). Besides, the most important indicators of fragmentation are the number of patches and the increase in the number of smaller patches [13, 19, 30].

To assess the shape complexity of the land use cover types in the AFPU, the ratio of average perimeter to the average area of land use patches was used to derive an SCI. Because the higher SCI ratios indicate more irregular patch forms than lower ratios, the analysis conducted in this study showed an increase in the SCI of AFPU forest patches (Table 3). The number of patches decreased from 108 in

Table 2. Land use/Forest cover changes 1972-2002 in Artvin Forest Planning Unit (ha).

changed from	changed to	change during	
		1972-1985	1985-2002
Degraded forest	Degraded forest	1234.5	924.1
	Dam	0.0	96.6
	Mixed forest	109.1	268.9
	Forest openings	12.8	13.7
	Broadleaf forest	46.9	26.2
	Conifer forest	63.4	82.3
	Water	7.9	8.8
	Settlement and Agriculture	141.7	158.2
Mixed forest	Degraded forest	157.0	192.1
	Mixed forest	948.1	979.2
	Forest openings	7.7	21.1
	Broadleaf forest	181.1	104.7
	Conifer forest	246.6	237.9
	Settlement and Agriculture	18.1	21.4
Forest openings	Degraded forest	61.1	10.1
	Mixed forest	54.7	15.7
	Forest openings	60.8	52.9
	Broadleaf forest	8.1	10.1
	Conifer forest	31.9	4.4
	Settlement and Agriculture	198.1	5.5
Broadleaf forest	Degraded forest	1.3	53.1
	Mixed forest	46.5	147.4
	Forest openings	14.6	2.7
	Broadleaf forest	177.7	205.9
	Conifer forest	0.8	13.9
	Settlement and Agriculture	0.0	1.5
Conifer forest	Degraded forest	77.2	96.4
	Mixed forest	386.1	214.1
	Forest openings	2.8	15.4
	Broadleaf forest	10.8	4.5
	Conifer forest	293.5	298.2
	Settlement and Agriculture	16.0	11.5
Water	Degraded forest	8.8	0.0
	Dam	0.0	11.2
	Water	90.6	45.1
	Settlement and Agriculture	26.8	43.7
Settlement and Agriculture	Degraded forest	38.9	109.8
	Mixed forest	12.1	39.6
	Forest openings	0.0	8.6
	Broadleaf forest	0.0	0.0
	Conifer forest	3.6	13.6
	Water	1.6	5.6
	Settlement and Agriculture	421.9	645.5
Total Area		5221.2	5221.2

1972 to 103 in 1985, while they increased from 103 in 1985 to 202 in 2002 and there was an increase in the SCI. Average patch area for land use cover types decreased from 1972 to 2002. The significant change in the number of patches and average patch area suggested that human-based interventions had produced irregular land use and forest cover types. There are a number of possible reasons for increased fragmentation: expansion of settlement and agricultural areas, road and dam construction, and other infrastructural development. Other causes are mismanagement activities, heavy grazing of pastureland adjacent to forest areas, illegal use of forest resources and insect attacks on the forest ecosystem.

Demographic Development

Demographic dynamics of Artvin have varied considerably due to the wave of immigration between 1970 and 2000 as shown in Fig. 2 [31], which shows that the population of Artvin has increased two times over 30 years. Urbanization has increased because of population increase as a result of immigrants from rural areas to city center in Artvin. Employed people in Artvin have studied in agriculture, industry and service sectors (72%, 9% and 19%, respectively). In Artvin, agricultural areas are very small and unproductive. Education and healthcare services are limited. Unemployment rates are high. As a result, migration from

Table 3. Changes in patchiness of the different land use areas as an indicator for landscape fragmentation between 1972 and 2002 in the Artvin Forest Planning Unit, Turkey.

Year	Land Use	Number of Patches[a] (n)	Area (ha)			Average Perimeter[b] (m)	Shape Complexity Index[c] (m/ha)
			Average[d]	Maximum	Minimum		
1972	Degraded forest	7	229.7	860.7	3.4	16460.6	71.7
	Mixed forest	8	194.9	1176.1	10.1	11703.6	60.0
	Forest openings	65	6.4	126.1	0.3	1290.7	201.7
	Broadleaf forest	3	80.3	167.7	10.2	5359.2	66.7
	Conifer forest	15	53.0	308.5	1.5	5110.2	96.4
	Water	1	126.5	126.5	126.5	26715.9	211.2
	Settlement and Agriculture	9	53.1	275.6	6.5	3514.6	66.2
	Total	108					
1985	Degraded forest	22	72.0	606.4	1.6	5585.6	77.6
	Mixed forest	12	129.7	800.1	6.2	8423.7	64.9
	Forest openings	14	7.0	28.9	1.1	1620.9	231.6
	Broadleaf forest	6	70.7	267.9	10.8	5523.9	78.1
	Conifer forest	14	45.7	235.1	3.5	4528.2	99.1
	Water	1	95.5	95.5	95.5	31358.7	328.4
	Settlement and Agriculture	34	24.2	477.5	0.3	2354.0	97.3
	Total	103					
2002	Degraded forest	45	30.8	651.4	0.3	3146.2	102.1
	Mixed forest	16	104.0	583.3	1.3	8587.5	82.6
	Forest openings	63	1.8	21.8	0.1	738.9	410.5
	Broadleaf forest	7	50.2	291.5	2.1	4965.0	98.9
	Conifer forest	24	27.1	258.4	0.3	3161.2	116.6
	Water	2	29.8	55.2	4.3	13405.3	449.8
	Settlement and Agriculture	44	20.2	556.5	0.3	2525.7	125.0
	Dam	1	107.8	107.8	107.8	8474.3	78.6
	Total	202					

[a] Number of patches of different land use, [b] Average perimeter of the patches, [c] Shape complexity index (SCI) is the ratio of average perimeter to average area of patches, [d] Average area of patches.

rural areas to the city has inreased to escape poverty and to get better education, healthcare and welfare services. This reduces the pressures on the forests in rural areas, yet the pressures on the forests near urban areas have increased. It is understood that rural people in the surrounding areas are also primarily dependent on arable agriculture and livestock for their livelihood. Both demographic and socio-economic considerations have been playing an important role in the land use and forest dynamics of the study area.

Discussion and Conclusions

The amount, rate and intensity of land use/forest cover change are very high in many countries, especially developing countries like Turkey. And social pressure on natural resources is still very great and increasing. During the last centuries, land use and forest cover were altered drastically with increasing population pressure and urbanization, agricultural activities and industrial wood material extraction activities. For these reasons, land use and forest cover type changes have been a major topic in sustainable management of natural resources [3, 7, 8].

Land use and land cover change is generally known to be directly or indirectly affected by human-induced activities and population [7], socio-economic factors [32], forestry expansion [15], urbanization [23] and patterns of agricultural activities [33, 34]. Urbanization is an inevitable process as well as a significant problem in many countries in the world, especially in developing countries such as Turkey. Turkey is one of the most important and the richest countries from a natural resources viewpoint, especially biodiversity and forest resources in the world. During the last decades, urbanization has increased because of population increase as a result of immigrants from rural areas to urban areas. Increased population and urbanization have caused irregular land use/land cover changes in recent times. Thus, population increase and urbanization have been an important issue of land use/land cover changes in Turkey.

This study was to assess the influences of human-based activities and population increase/urbanization on changes in land use and forest cover from 1972 to recent times in the Artvin Forest Planning Unit in Turkey. The dynamics of land use types and forest cover type structure have been detected by the digitized stand type maps from periodically renewed forest management plans from 1972, 1985 to 2002. The quantitative evidences of land use dynamics presented here showed that almost all factors mentioned above have affected land use and forest cover type changes. The possible reasons for decreased forested areas and increased fragmentation of AFPU could relate urbanization, road construction, insect attacks on spruce stands, recreational uses of forest, illegal harvesting activities for firewood, the failure of resforestation activities and silvicultural treatments.

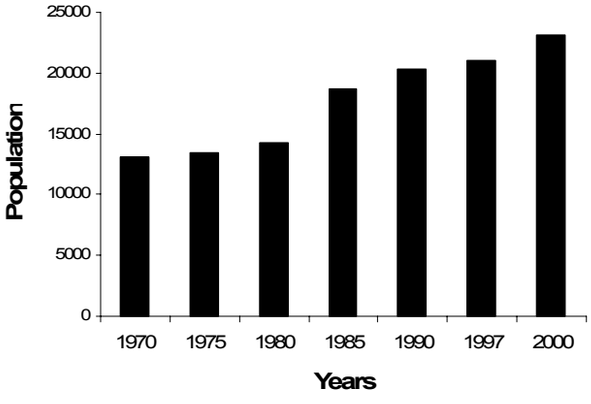

Fig. 2. Demographic change in Artvin Forest Planning Unit.

As an overall change, there was a net decrease of 450 ha in total forested areas, especially because of expansion of settlement and agricultural areas from 478 ha in 1972 to 887 ha in 2002. While mixed and broadleaf forest area increased during the study period, conifer forest area decreased by 144 ha because of insect outbreaks. Annual deforestation rates for 1972-1985 and 1985-2002 are 0.5% (24 ha/year) and 0.19% (8 ha/year], respectively. The deforestation rate for the overall study period is 0.33% (15 ha/year). Forest loss or deforestation has been recognized as a major threat to ecosystems in the world [35-37]. The deforestation process may have negative effects on biodiversity, global climate, water and soil resources, and the maintenance of a range of ecosystem functions. Deforestation has led to the fragmentation of natural ecosystems. Forest cover changes are the most common cause of the loss of biological diversity [38, 39]. In this study area, forest area decreased due especially to population increase and expanding of settlements area. As a result of this process, fragmentation increased and biodiversity is affected negatively in the study area.

The most important indicators of fragmentation are the number of patches and the increase in the number of smaller patches [13, 19, 30]. The changes in each of the land use types were reflected at the landscape level by an increase in the total number of patches and a decrease in the average patch area. Substantial increase in the number of patches and increase in the landscape level SCI of patches between 1972 and 2002 indicated irregular land use and forest structure. Increase in patch numbers during the last three decades is because of harvesting, insects, road construction, and especially expansion of settlement and agricultural areas. While total road length in the Forest Planning Unit was 68 km in 1972, it was 130 km in 2002 with an increase of 62 km. This fragmentation led to an increased evenness of several land uses. Increase in the number of forest patches between 1972 and 2002 and a decrease in average patch area showed that the landscape has gone into a more fragmented structure. Furthermore, the changes in crown closures of forest stands between 1972 and 2002 in the planning unit were examined by Keleş et al. [40]. Their results showed that fully covered areas were changed in favor of less covered areas. Some forest stand development stages were left to grow older development stages while some of them changed to lower development stages as a result of

either unusual/illegal harvesting activities or possible harvesting of larger trees in pre-commercial thinning legally. Increases in the population have led to increased forest clearing to the extent and irregular land use cover types that additional residents were especially involved in agricultural production. Such a trend shows a danger for the sustainability of forest ecosystems because forest cover changes, forest fragmentation, habitat loss, and urbanization due to forest cover change are the most common cause of biodiversity loss [13, 19, 30, 38, 39].

Fragmentation may affect isolation of habitats, endangered species' population dynamics and species richness. The composition and the configuration of forest resources are considerably changed in the study area. While the forest area increased during a 30-year period, number of patch, smaller patch and patch increased resulting in fragmentation of the landscape.The forest ecosystem was positively affected regarding quantity of forest area, but forest configuration became more fragmented which might negatively affect biodiversity and forest values. The major factors contributing to the decline of several biological populations and often cause extensive changes in plant species richness and composition are habitat loss and the resulting fragmentation [41], introduced species [42], over-grazing [43], agriculture and livestock, mining, industry, transportation and communication and urbanization [44]. Successful biological conservation efforts require ecologists and urban planners to simultaneously understand patterns and processes of landscape change, such as habitat loss and fragmentation [45].

These results are quite comparable to similar research results. Our results show similarities to Kadıoğulları and Başkent [46], who presented a net decline of 2,271 ha in forest areas as opposed to a net increase of 1,796 ha in settlement areas. In other words, there was a net decrease of 0.54% in total forested areas in Gümüşhane, Turkey. Keleş et al. [47] documented the forest area decrease from 244,543 ha (46.2% of the study area) in 1975 to 220,128 ha (41.6%) in 2000. Both productive and degraded forest areas decreased from 1975 to 2000 in Trabzon, Turkey. However, Status et al. [48] showed that forested areas decreased nearly 4.7%, with an annual rate of forest disturbance of only 0.53% and 0.57% and yet forest fragmentation increased. In the eastern US, Hall et al. [49] reported annual conifer forest disturbances of 1.8% in northern Minnesota and Luque et al. [50] found annual pine–oak forest declines in the Pine Barrens region of New Jersey to be 2.2%. In the Sikhote-alinskiy Biosphere Reserve region of the Russian Far East, Cushman and Wallin [51] showed 18.3% reduction in conifer forest cover between 1972 and 1992 and 7.4% reduction in hardwood forests. In a portion of the Central Oregon Cascades, Spies et al. [52] reported annual forest disturbance rates of 1.2% on public, non-wilderness lands, 3.9% on private lands, and 0.2% in wilderness. For western Oregon annual forest disturbance rates due to clear-cutting between 1972 and 1995 ranged from 0.5 – 1.2% overall with nearly a 20% total forest impact [53]. The Tillamook Bay watershed of the midcoastal Oregon showed an annual forest disturbance rate of 1.0% [54]. Rao and Pant [8] noted that natural forest area decreased while agriculture areas, which include settlements, pasture, and shrubs area, increased in Himalaya, India. Doygun and Alphan [23] showed the total urban areas increased from 500.7 ha in 1972 to 1260.8 ha in 2002, a net increase of 760.1 ha urban areas in İskenderun city, Turkey. Echeverria et al. [19] reported the total forest areas decreased from 16541 ha in 1975 to 4800 ha in 2000 in Chilean temperate forest.

Forest ecosystems provide many goods and services to the public, such as water, soil protection, carbon sequestration, recreation, and the biodiversity other than timber production. However, all forest ecosystem functions are extremely connected to forest ecosystem structures like species, stand crown closure and development stages. For example, as stand density increases water production and soil erosion decrease [55, 56]. Thus, land-use/land cover changes, especially in forest cover, may have important consequences for all forest functions. Our study area was selected because it surrounds Artvin, calling for the importance of carbon and oxygen production in addition to timber production to the people living in the city. Forest absorbs carbon dioxide from the atmosphere through the process of photosynthesis. This means that forest ecosystems store carbon and produce oxygen, especially for urban areas. Also, a number of hydroelectric power stations have been established within the area that also necessitates the multi-purpose planning of the area. Forest area of 97 ha has been lost owing to dam construction. Forest ecosystems surrounding Artvin are the major source of the city's freshwater resources. As such, forests play an important role in the quantity and quality of surface and ground water systems. Several characteristics of forests aid in the production of clean water that is critical to the sustenance of human life. Shortages of fresh water and the increasing pollution of water bodies are becoming limiting factors in maintenance of economic productivity, social well being and lifestyle and the maintenance of nature and ecosystem services of many countries. Under these conditions, assessing and managing water resources are vital. In this context, population increase and urbanization have been an important issue of land use and forest cover changes in Turkey.

The Artvin Forest Planning Unit is located in a region that is stable for natural fire. But no forest fire have occurred since forming the forest ecosystem and, thus, land use and forest cover type changes have not been affected by fire. One of the key reasons for land use and forest cover type changes in the AFPU is insect attacks on spruce (*Picea orientalis*) stands. 55% of whole forest area in the planning unit is spruce. The first insect attacks started in 1966, and originated from nearby Georgia. The most destructive insects are *Ips typographus*, *Ips sexdentatus* and *Dendroctonus micans* [57]. Mechanical control against these insects was performed up to 1985. Diseased trees were generally eliminated from the area. However, these struggles did not stop the insect outbreaks and, therefore, biological control started in 1985. For these reasons, some activities relating to insect outbreaks as well as forest harvesting were made in the planning area. In Artvin Forest

Planning Unit, forest harvesting studies with maximum wood production aim were made up to 1980. After that, they were interrupted in these forests near the city because of social pressure on forests. However, some harvesting studies have continued since 1990 because of insect outbreaks.

In most cases, urbanization pressures and industrialization remove the natural vegetation and replace it with pavement, buildings, agriculture, grass, and introduced shrubs and trees [58, 59]. In examining three periods in the planning unit, some important changes in land use and forest cover type structure occurred. The most important change between 1972 and 1985 was to extend the city boundary in a northerly direction. That enlargement continued up to 2004. The most important reason in this city expansion was rural migration to Artvin from 1970 to 2000. The population of Artvin increased two times over 30 years. In conversion of forested areas to non forest areas, urbanization and population growth as well as illegal human interventions like harvesting had been effective. Immigration of many rural people in forest willages to Artvin city have caused radical changes in demographic structure. The rapid urbanization process and increasing population growth cause various problems such as the exploitation of forest resources around the city. There is a growing pressure on forest lands from urbanized cities living in or nearby urban areas. Recreational uses of forests in Kafkasör cause changes in forest landscape structure, forest degradation, and some ecosystem functions like erosion and poor water quality. Furthermore, forest villagers have low income levels compared to the national level, and this situation has caused some problems like illegal wood cutting, over-grazing and clearing forest areas for agricultural fields, houses and official or industrial buildings.

Consequently, detecting and understanding the results arising from population growth/urbanization is vital, especially in areas near or next to city areas. Moreover, understanding the interactions between population and land use/forest cover types is increasingly important in sustainable development and management of natural resources. This study has provided important insights into the dynamics of forest ecosystems that occurred in forested areas and other major land uses of the AFPU between 1972 and 2002. The work carried out in a typical forested area in Turkey showed that land use and forest ecosystem structure were drastically affected by population growth and urbanization. To understand forest dynamics and successfully manage forest ecosystems, forest managers need to understand spatial and temporal configuration of the forest landscape. Within the concept, management actions should be based on a sound understanding of ecological principles and of the goals established for a forest. Any forest management actions or regulations will change the status of forest ecosystems, including forest biodiversity thus designing appropriate management actions (i.e., silvicultural prescriptions) to protect and monitor biodiversity is crucial. To harmonize the balance between conservation and wood-based production is a challenge and must be pursued on a sustainable basis. Here, Ecosystem-Based Multiple Use Forest Management is an alternative approach designed to integrate primarily the biodiversity conservation into forest management plans. The planning approach focuses on the maintenance of biodiversity, productivity, regeneration capacity, vitality and their potential to satisfy ecological, economic and socio-cultural values without jeopardizing the long-term stability of forest ecosystems. The economic conditions of rural forest users should be improved. Effective education, training and awareness programs for ecotourism plans and activities to encourage and improve ecotourism should be carried out especially in Kafkasör. Mechanical and biological fights against insects, which are *Ips typographus, Ips sexdentatus* and *Dendroctonus micans*, should be carried out strictly by the General Directorate of Forestry. Reforestration activities should be carried out in this study area. These reforestation or afforestation strategies, especially in highly urbanized cities, will improve the forest landscape structure and ecosystem functions such as biodiversity conservation, gas regulation and water production.

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