SPATIAL AND TEMPORAL ANALYSIS OF FOREST COVERS CHANGE: HUMAN IMPACTS AND NATURAL DISTURBANCES IN BARTIN FORESTS, NW OF TURKEY

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ABSTRACT:

During last two decades, Bartin Forests in northwest of Turkey have been exploited by human impacts. Easy access and the abundance of valuable and large diversity forest products have led to higher population densities with opening new settlement areas via deforestation activities. In this study, interpretation of digital image classification resulted from multi-date Landsat-5 TM images recorded in time frame between 1992s and 2000s was evaluated to produce land cover maps for change detection analysis. The accuracy of the Landsat TM classification and errors inherent to the techniques used were assessed accordingly. The updated digital forest inventory plans, existing different scales topographic maps and aerial photographs was integrated into a GIS database with the generated classification results in order to elaborate a spatially explicit multi-date database on land use/cover change. This spatial model is used for identifying deforestation fronts and biodiversity conservation. As a result, several changes in the test site were observed, including increases in the areas extent of agriculture lands and urbanization with the corresponding decrease in Bartin Forest's wealth.

1. Introduction

Forest areas in the Bartin province and its close vicinity, located at northwestern part of Turkey, with total area of 175,553 ha and 13,578,867 m^3 tree rich are one of the main forest resources of the country. Due to the forests are "natural forests" with high quality and contains extensive species variation, this region becomes one of the important area of the world as well. As species; oak (Quercus sp.), hornbeam (Carpinus betulus), chesnut-tree (Castenae sativa), beech (Fagus orientalis), scotch pine (Pinus sylvestris), crimean pine (Pinus nigra), fir (Abies bornmülleriana), juniper (Juniperus sp.) and yew-tree (Taxus baccata) can mainly be found in the region in addition to the diverse biologic conditions and rich wild life (TMMOB, 1999). Apart from these aspects of the Bartin forests, in last three years, total of 16,589 m^3 dried beech timber has been exported Moreover, constructions have to be added because of the growth in population and extent of the settlement areas. This situation also causes negative influences on forest resources. On the other hand, positively, with the endeavors of local forest directorates, some, but limited new forest areas have been gained in the region. As a result of such activities, there are serious problems in relation to the land use in the region (Hızal et al., 1996, Musaoglu et al., 2002) To show the changes in the forest reserves of Bartin region, remotely sensed images have been evaluated in temporal manner. For this purpose, Landsat-5 TM images acquired on year 1992 and 2000 were classified based on the available spectral information. Comparison of classification results each other and also with the available maps was realized in the GIS environment to show the forest cover changes happened in the interest area. in an increasing manner (Aşcıoğlu, 2001). Such figure shows economical contributions of the forests resources to the sustainable development of the country.

However, Bartin forests are always under attacks of the local people and indirectly by the towns or cities located at close proximity. According to forest directorate data, in forest areas, lands located next to or in the forest faced violations, which are about 400 ha by the purpose of land gain for the last 16 years. Villagers mostly supply living sources from agriculture and animal husbandry, so the products in inconvenient fields remain insufficient to meet with their requirements. Therefore, it is not uncommon that the destruction of forest and their transformation to the agricultural fields, nut grove, settlement areas and other similar usages (Tunay and Atesoglu, 1992).

2. Study Area, Test Materials and Registration

The location of Bartin province and its close vicinity in Turkey's administration map and current Landsat satellite image of the area are shown in Fig. 1. From statistical point of view; 46%, 35%, 7% and 12% of study area amounts to 2,143 km^2 in total are covered by forests, agriculture lands, meadow-pasture and settlement areas respectively (Bartin Tourism Centre, 1996). Furthermore, 31% (Turkey's average ≈ 59%) and 69% (Turkey's average ≈ 41%) of the total population, which is about 186,000 people, lives in city and villages respectively. Nevertheless, approximately 52% of the village population settles in the surroundings of the forest areas (Turkey's average ≈ 20%) (Guvenen, 1992).

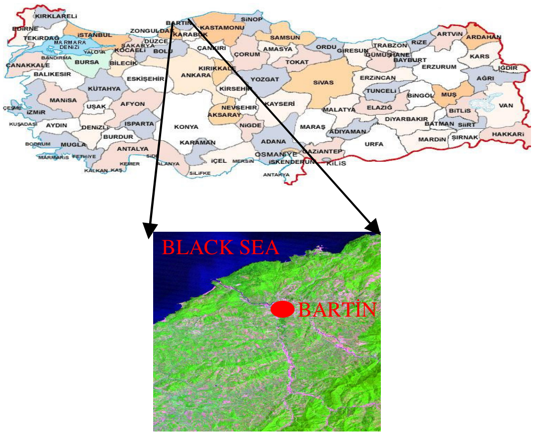

Figure 1. Study area, Bartin and its close vicinity, shown in Turkish administration map and also by Landsat image of the area taken in July 2000.

For the temporal analysis of forest cover changes, Landsat-5 TM images covering the test site and taken on 19.05.1992 and 12.07.2000 have been utilised. At the processing phase, only spectral channels 1, 4 and 7 of Landsat sensor were available for the experimental purposes. Reference datasets employed during the classification procedures of Landsat-5 TM images includes the management plans, stand and age class maps, topographic maps, aerial photographs and personal knowledge about the area. Another map used as a data belonging 1984 which has 1:25000 scales and showing degree of canopy was obtained from local Forest Directorate. Classification procedure has been carried out using the related module of PCI Geomatica V8.2 software package (www.pcigeomatics.com). For GIS analysis, ArcMap V8.3 software was used.

However, before the image classification processes, geometric correction of Landsat images was completed. For this purpose, 21 uniformly distributed GCPs digitized from the 1:25,000 scales topographic maps of the interest area were used. Planimetric accuracy of these GCPs can be expected in the range of 7.5m. On Landsat images, linear features appeared sharp enough, so GCPs are mainly selected from road crossings and bridges. Digital image coordinates for GCPs were measured manually using the GCPWorks module of PCI system with the sub-pixel point determination. Then, affine transformation was applied between the GCPs's image and ground coordinates. Root means square errors for X and Y directions were found to be 0.69 pixels (20.7m) and 0.67 pixels (20.1m) respectively. After producing transformation function, for image registration, bilinear resembling method was used to determine the pixel values to fill into the output matrix from the original image matrix.

3. Image Classification Procedure

The overall objective of image classification procedures is to automatically categorize all pixels in an image into land cover classes or themes. Normally, multispectral data are used to perform the classification and, indeed, the spectral pattern present within the data for each pixel is used as the numerical basis for categorization. That is, different feature types manifest different combinations of DNs based on their inherent spectral reflectance and emittance properties. In this light, a spectral "pattern" is not at all geometric in character. Rather, the term pattern refers to the set of radiance measurements obtained in the various wavelength bands for each pixel. Spectral pattern recognition refers to the family of classification procedures that utilizes this pixel-by-pixel spectral information as the basis for automated land cover classification.

One way of discriminating changes between two dates of imaging is to employ post classification comparison. In this approach, two dates of imagery are independently classified and registered. Then an algorithm can be employed to determine those pixels with a change in classification between dates. In addition, statistics (and change maps) can be compiled to express the specific nature of the changes between the dates of imagery. Obviously, the accuracy of such procedures depends upon the accuracy of each of the independent classifications used in the analysis. The errors present in each of the initial classifications are compounded in the change detection procedures (Lillesand and Kiefer, 1994).

In a view of approach given above, image for each year was analyzed with supervised classification method since the authors have many reference materials and personal knowledge about the region. As a classification procedure, maximum likelihood method was selected for more reliability percentage. Table 1 is an error matrix that prepared to determine how well a classification has categorized a representative subset of pixels used in the training process of a supervised classification. This matrix stems from classifying the sampled training set pixels and listing the known cover types used for training (columns) versus the pixels actually classified into each land cover category by the classifier (rows). Furthermore, classification results for each year are shown in Figure 2 with the respective colors. In this phase, main training sites are assigned as forest, sea, agricultural and idle areas, settlement areas, sandy-stony-rocky area and also cloud available in one image as an additional class.

Table 1. Confusion matrix and accuracy figures resulted from the classification of 1992 image

Error (Confusion) Matrix for Landsat 5 TM (19.05.1992)

Classified Data	*Reference Data*						
	Settlement	*Sea*	*Forest*	*Sandy-Rocky.. Areas*	*Agricultural and Idle Areas*	*Cloud*	*Totals*
Settlement	**8**	0	0	0	0	0	8
Sea	1	**31**	0	0	0	0	32
Forest	2	0	**55**	0	20	0	77
Sandy-Rocky.. Areas	2	0	0	**2**	0	0	4
Agricultural and Idle Areas	1	0	11	2	**65**	0	79
Cloud	0	0	0	0	0	**0**	0
Totals	14	31	66	4	85	0	**200**

Accuracy Statistics for Landsat 5 TM (19.05.1992)

Class Name	*Producer's Accuracy*	*User's Accuracy*
Settlement	57.143%	100.000%
Sea	100.000%	96.875%
Forest	83.333%	71.429%
Sandy-Rocky.. Areas	50.000%	50.000%
Agricultural An Idle Areas	76.471%	82.278%
Cloud	0.000%	0.000%

Overall Accuracy: 80.500%

Error (Confusion) Matrix for Landsat 5 TM (12.07.2000)

Classified Data	*Reference Data*					
	Settlement	*Sea*	*Forest*	*Sandy-Rocky.. Areas*	*Agricultural and Idle Areas*	*Totals*
Settlement	**6**	0	0	0	0	6
Sea	0	**31**	0	0	0	31
Forest	0	0	**60**	0	2	62
Sandy-Rocky.. Areas	0	1	0	**1**	0	2
Agricultural and Idle Areas	5	0	15	1	**78**	99
Totals	11	32	75	2	80	**200**

Accuracy Statistics for Landsat 5 TM (12.07.2000)

Class Name	*Producer's Accuracy*	*User's Accuracy*
Settlement	54.545%	100.000%
Sea	96.875%	100.000%
Forest	80.000%	96.774%
Sandy-Rocky.. Areas	50.000%	50.000%
Agricultural An Idle Areas	97.500%	78.788%

Overall Accuracy: 88.000%

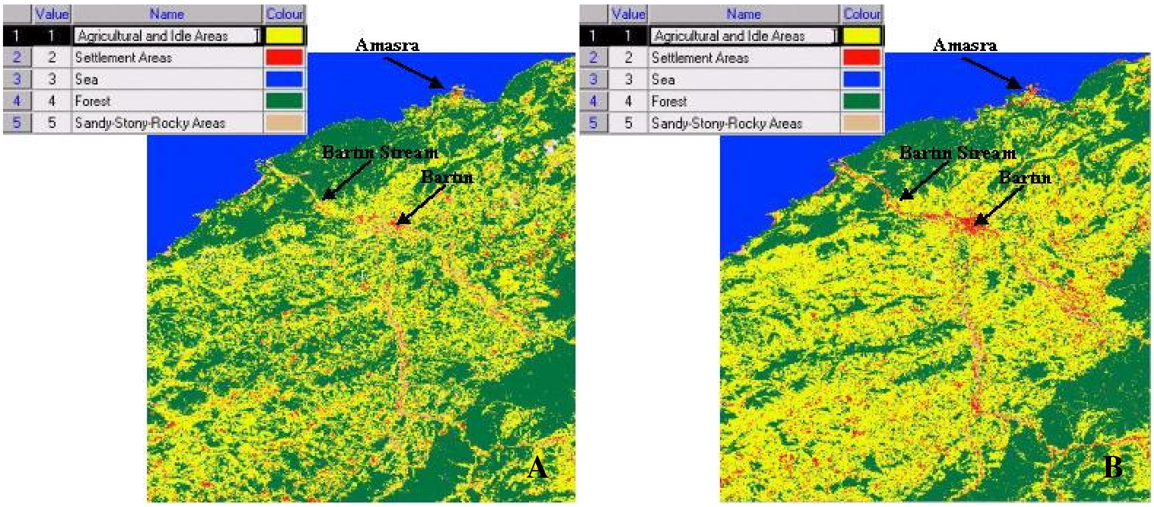

Figure 2. Visualization of classification results from 1992 image (A) and from 2000 image (B).

4. Results and Discussion

Both images contain same number of pixels (1,364,200). The dispersion (as percentage) of total pixels that constitute the field of study according to the terrain types determined for each year is shown in Table 2. The change in forest areas belonging to each year is negative (-5.6%). This percentage is 6.31% for agricultural and idle areas. Considering these results, the change in Bartin province and its vicinity is the transformation of the land into agricultural areas. Furthermore, the increase in residential areas (0.3%) is the result of construction activities in recent years. The decrease in the amount of sandy-stony-rocky areas (0.46%) is the result of dense industrialization and construction activities in these types of areas. İn Bartin forests, there are three different forest management units; high forest, unproductive high forest, unproductive coppice (Table 3). According to the investigations made on crime files, which were documented by Bartın Forest Directorate, most of the crimes were observed in areas belonging coppice management unit. The reason of high forests being more damaged than unproductive high forest is that high forest occupies 3.2 times more area than the unproductive high forest. Also, the reason of having the most damage on coppice area is not to provide enough revenue and not to take care of forest by forest directorates. In order to keep coppice areas safe which are damaged by forest villages continuously, these forest areas must be rehabilitated and converted to high forest. Nevertheless, in this case protection measures will be increased and this forest will face less negative effects. When looking at the illegal activities stem from forest villagers to the forested areas in terms of the canopy and management unit, it was observed that coppice having 10%-40% canopy degree has been experienced the most severe damage. High forests having 41%-100% canopy degree had no damage at all. Another reason of attack in these forest areas is being near to agricultural or settlement areas. Social-economic structure of the people in those areas brings such a result.

Table 2. Total pixels dispersion that constitute the field of study according to the land-cover types determined for each year.

Land-Cover type	***1992 (%)***	***2000 (%)***	***Change (%)***
Forest	37.11%	31.51%	**-5.6%**
Agricultural and Idle Areas	38.54%	44.85%	**6.31%**
Settlement Areas	3.74%	4.04%	**0.3%**
Sandy-Stoney-Rocky Areas	1.37%	0.91%	**-0.46%**
Sea	18.69%	18.69%	**0.00%**
Cloud	0.55%	-	**-**

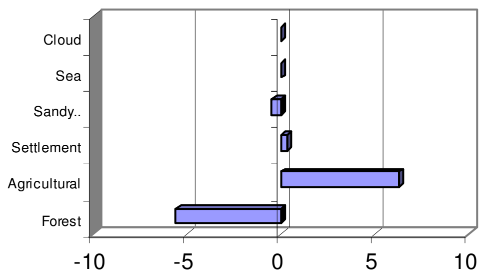

Figure 3. Estimated net change (%) in land-cover area between 1992 and 2000 in the study area.

Table 3 Distributions of forest crimes according to forest management units.

Forest Management units	Field (m^2)	%
High Forest	224774	21
Unproductive High Forest	169561	16
Unproductive Coppice	686469	63
Total	1080804	100

Observations based on Landsat images indicate that in coppice located north-northwest sections of study area (10%-40% canopy degree), attacks were observed. The results in Table 2 verify that the change between the years of 1992-2000 corresponds to the change between the agriculture and forest areas. In order to observe the illegal activities in the study area, Landsat 5 TM image in raster format of the year 2000 has been converted to the vector format. In a similar way, the map showing the canopy and management units in the study area in 1984 have been digitized (Figure 4). When the transparent image of this map has been superimposed onto the Landsat 5 TM image, it has been shown that what kind of management units have been converted to what kind of land use classes between 1984-2000 (Figure 5A/B).

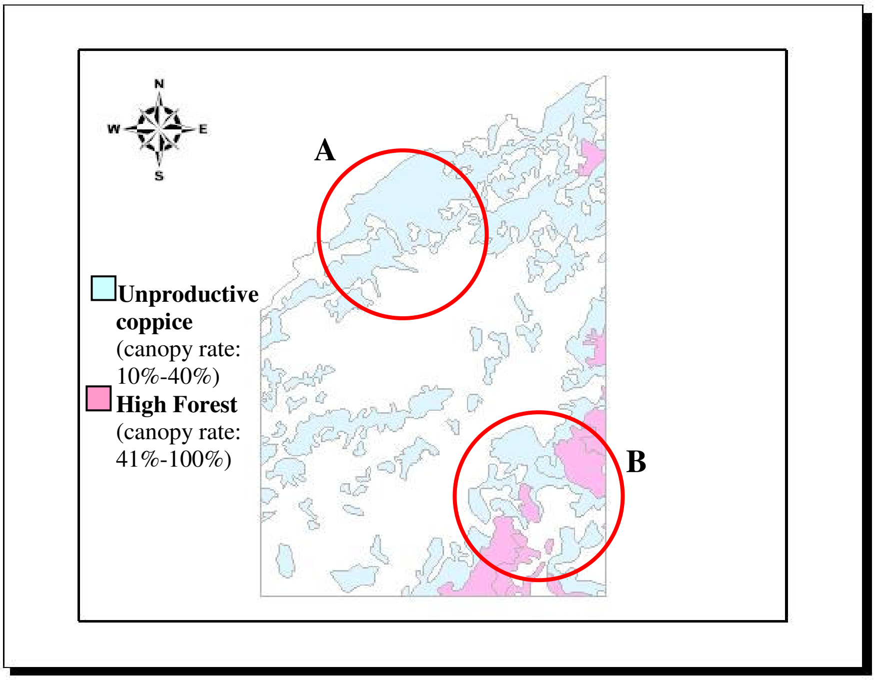

Figure 4. Management units map in the study area

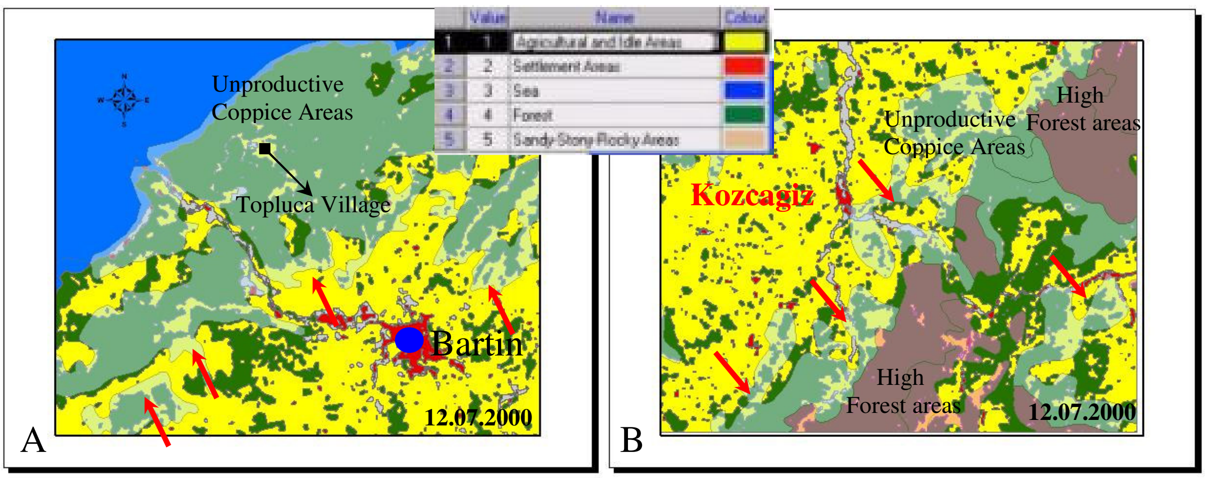

Figure 5. Comparison of canopy & management units map and classification image in 2000: (A) Topluca village and its vicinity. (B) Kozcagiz district and its vicinity

In Topluca Village and its surrounding, highest amount of damage was observed and illustrated in Figure 5/A. In order to prevent these attacks, the conservation made by means of cadastral activities of forest directorate since 1992 must immediately be stopped. When the damages were examined in Kozcagız vicinity located South-Southeast section of study area (Figure 5/B), damages were observed mostly on coppice having %10-40 degree of canopy. On the contrary, high forest having %41-100 degree of canopy had no damage. Another reason behind this result is that high forests have disturbed the topography structure and it is impossible for the villagers to convert these areas to another land use.

5. Conclusions

It has been determined that there are some serious difficulties about land use in the interest area of Bartin and its vicinity. In this proximity, it can be seen that there is "traditional" land use which is not suitable for land use class. **I**n this study area, forest lands have been damaged by converting them to agricultural areas, hazelnut areas and settlements etc. Agricultural activities which are done without necessary soil conservation measures cause the forest areas near to settlement areas to face recession and consequently causing damages to existing natural equipoise. In the forested areas, it can be seen that there are open and intensive clearing made to obtain agricultural and settlement areas. For this reason, species composition has been modified; degree of canopy and density has been decreased. According to measurements from satellite images, the total amount of deforestation in the area in 1992-2000 was 775.65 ha/yr. In order to prevent these illegal activitie,s following suggestions should be taken into account:

- To prevent the damages to forest areas legal measures must be applied without any compensation. Moreover, studies on increasing legal sanction must be speeded up; intensive control mechanisms against clearing must be applied. It has been known that occupation and clearing crimes against forest areas, which cadastral registration has been applied, has been decreased significantly. For this reason, completing the forest cadastre as soon as possible is an important issue.
- Another reason of damaging forests is the economical and educational level of forest villagers. The people living in villages' represent the poorest people of this part. Government should give enough attention to development of forest villages. They should be encourage to get benefits such as agriculture, stock farming, forestry etc.. Also all technical, economical, social and cultural measures should be included in regional development plans.
- The forests which have lost their density and canopy can not fulfill their hydrologic and soil conservation functions. These places should be rehabilitated without damaging of natural structure. Thus flooding and land sliding can be prevented.
- Very high damaging of coppice areas has pointed to the fact that the care and importance given to the other management units could not be observed the coppice areas. Unproductive coppice areas which are constantly damaged by forest villagers should be converted to high forest as soon as possible. To increase the conservation measures in the forests belonging to all management units guarantees the submission of the existing forests to the next generations.

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