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SPATIAL ANALYSIS OF FORESTED AREA DYNAMICS IN BISTRIŢA VALLEY - SUBCARPATHIAN SECTOR

Dan-Adrian Chelaru[1], Liviu Apostol[1], Adrian Ursu[1]

Key words: forest dynamics, spatial analysis, GIS, Bistrita Subcarpathian Valley

Abstract. The paper is based on diachronic analysis of historical maps from different periods, in order to capture more accurately the evolution of the forest landscape in the subcarpathian sector of Bistriţa Valley. In order to achieve the final purpose, were used large scale cartographic materials covering a period of over two centuries (1788 – 2006), which were processed and interpreted into GIS environment. The results showed a continuous reduction of forest area, which in the first period occupied nearly half of the total study area. The main causes of these changes are of anthropogenic order, gradually replacing forests with pastures, agricultural land or built-up perimeter. During the whole period under review stands some small areas where afforestation works were made but insignificant in relation to the deforested areas.

Introduction

Changes in forest cover and in the way people use forests have become recognized over the last years as an important global environmental issue in their own right (Rudel et al., 2005, Achard et al., 2006). Since the 14th and 15th century, along with the natural ascending numerical population, founding new settlements and extensive development of agriculture in the conditions of feudal economy, the man acted here, as in all Central Europe, consciously or not, more and more destructive to forest which, since the 19th century, became from a prerequisite of development of the human society, to its direct enemy, through multiple negative effects of irrational deforestation (Bojoi & colab., 1996). The study has sought to investigate these changes in the configuration of forested areas from a cartographic point of view, and also the consequences of this dynamics.

Study area

The subcarpathian sector of Bistriţa Valley is a predominantly rural region which „goes from Piatra Neamţ to Racova (...) and from there, Bistriţa is entering into the Moldavian Plateau"(Donisă, 1968). The subcarpathian sector of Bistriţa Valley is situated in the eastern part of Romania, being part of the Moldavian

[1] Phd student "Al. I. Cuza" University of Iasi, chelarudanadrian@yahoo.com

Subcarpathians sector and having as limits the Oriental Carpathians in the west and Siret corridor in the east. Here Bistriţa, together with its tributaries, formed, downstream from Piatra Neamţ, on approximately 50 km long and 20 km wide, a depressionary passage sketched by prolong interfluves descending towards the main river. Its limit in the east, towards the platform sector, is in the locality of Racova (Magdalina, 2004). The large extension of the terraces and pedogeographic favorable conditions led to a significant agricultural use (Chelaru & Apostol, 2012).

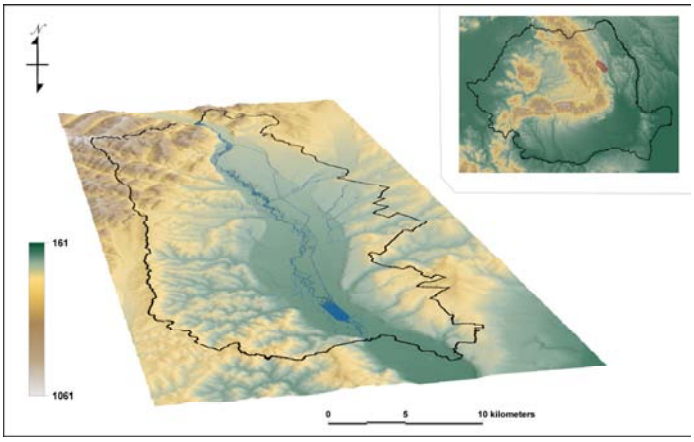

Fig. 1 – The administrative limit of the study area

Materials and methods

In order to achieve the settled objectives, the analysis was conducted through GIS methods using the following cartographic materials: 1:20.000 scale Austrian maps of von Otzellowitz made in 1788/1790, (obtained from the Romanian Academy Library, Bucharest), old maps from the Romanian Atlas at 1:50.000 scale made in 1896, old military survey maps at 1:20.000 scale(1912-1957), 1:5.000 topographic plans, 1975/1976 edition, 1:10.000 cadastral plans, 1986 edition and 2005/2006 ortophotomaps obtained from ANCPI.

Creating a GIS with this data, needed an intermediary process that transformed the data from analog to digital by scanning operation. Then they were imported into GIS software used, and georeferenced by the coordinates displayed on maps or by correspondence method. The ground control points for georeferencing are map elements that can be recognized in both data records, and that supposedly cannot change their position over a long period of time, leaving their intersections relatively intact over a long period of time. All materials were

re-georeferenced and brought in Stereo 70 projection system so as to have a cartographic base reunited at the end (Chelaru & Apostol, 2012).

Necessary spatial data were extracted both by direct digitization, through ON SCREEN method, or by semiautomatic vectorization methods, depending on the quality of the cartographic documents. We obtained in the end a set of spatial data in a easy to process and analyze format. The good overlapping of the maps allowed us to compare the forest dynamics between 1788 and 2006, both from a quantitative and qualitative point of view.

All these processes and the resulted maps were made using the professional softwares TNT Mips Microimages 7.2 and ArcGIS 10.1.

Results and discussions

By the analysis of the years 1788/1790 is noted that forests occupied about half of the total area of the study area, largely distributed on the right side of Bistriţa river, in areas with higher elevation. On the left side of Bistriţa, the largest forest areas are found close to Racova and Buhuşi whose built-up perimeters were constituted at that time of small cores of settlements.

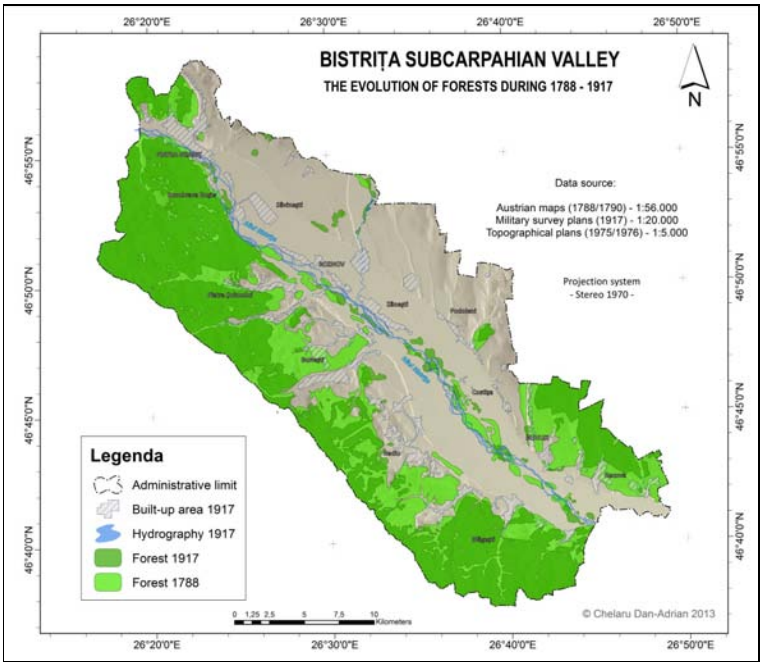

Fig. 2 – The evolution of forests during 1788 - 1917

Following the forest evolution map in the 1788 – 1917 period (fig. 2) can be observed a major decrease of forestry areas of about 10.000 ha, from 31.967 ha to 21.640 ha. This decrease was due to increased human pressure as a result of expanding the built-up area. From the vast forest areas that have almost completely been deforested at the present remain only traces of local toponimia (eg. Dumbrava Roşie).

One can also observe the forests in the proximity of riverbed which, during this period has extended its surfaces, not being affected by the anthropogenic factor mainly due to high flooding of the area.

The causes of these massive deforestation can be explained by political decisions taken at national level whose provisions have directly affected forestry areas. According to Giurescu (1976), the most important historical event which affected directly the forests occurred, unfortunately, after the economic independence of the Romanian Principalities, respectively after the Peace of Adrianopole (1829) when they have gained the right to do foreign trade, mainly with grain, which favored massive deforestation for agricultural purposes, wheat export being particularly advantageous for large landowners.

Then followed the great reform of monastic estates secularization (1863), performed by Alexandru Ioan Cuza after the unification of Moldova with Ţara Românească (1859) which, although it was beneficial in social terms, had negative effects on forests. Becoming new forest owners and eager to fast enrichment, the peasants quickly deforested the land with the purpose of timber trade and especially to expand agricultural activity.

If in subcarpathian territory the massive deforestation was carried out mainly due to the increasing anthropic pressure, in mountainous area drained by Bistriţa river the forest exploitation remain the priority regarding the economic activity. Bistriţa subcarpathian Valley was an important part of the transportation network of wood coming from upstream. The rafting was the primary means of transporting timber on Bistriţa, continuing the route on Siret, to the Danube ports.

The intensification of deforestation in this period can be attributed to excessive mechanization of forest exploitation and wood processing. The appearance of mechanical or steam mills and factories of wood processing led to the ratio disturbance between cutting trees capacity and the forests natural restoring (Bojoi & colab., 1996).

During the 2nd period under observation (1917 – 1986, fig. 3) can be seen major changes in forestry areas distribution throughout the territory. As a result of the regularization works along Bistriţa river that started in 1960, materialized in the construction of accumulation lakes and especially the deviation channel over a length of 30 km, floods were no longer causing problems, resulting in built-up perimeter increasing. This growth imposed changes in land use, emphasizing

almost completely disappearance of forests located along the riverbed and other areas favorable for housing or agricultural activities.

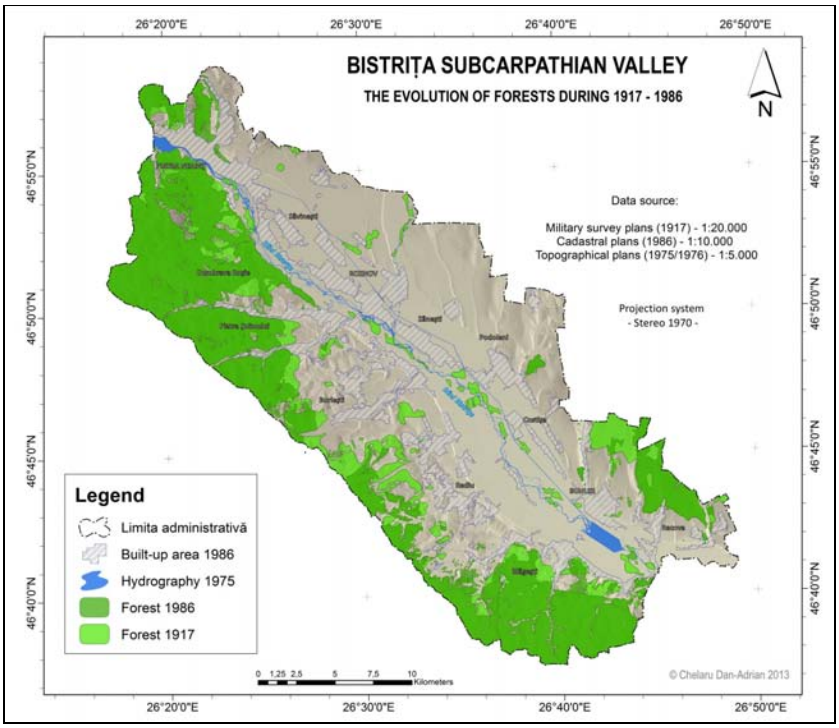

Fig. 3 - The evolution of forests during 1917 – 1986

Current configuration of forest distribution in the study area has changed considerably observing its involution as a result of the massive expansion of built-up perimeter, even in areas less favorable for housing (fig. 4).

The general view of the deforestations that affected for over two centuries the subcarpathian sector of Bistriţa Valley shows a significant reduction of forest areas, the analysis of the historical maps highlighting a number of different stages depending on the degree of anthropogenic intervention. Can be observed the disappearance of almost all forests on the widely terraces on the left of Bistriţa river, favorable to agriculture, pointing out in the perimeter of Podoleni the Făget forest, which, although has halved its total area, remains the only forest on a large radius. At west of this forest area stands Mălăişte hillside which, because of its

predisposition to landslides, has been afforested with a plantation of alohtone tree species: acacia, which are suitable for the local soil surface.

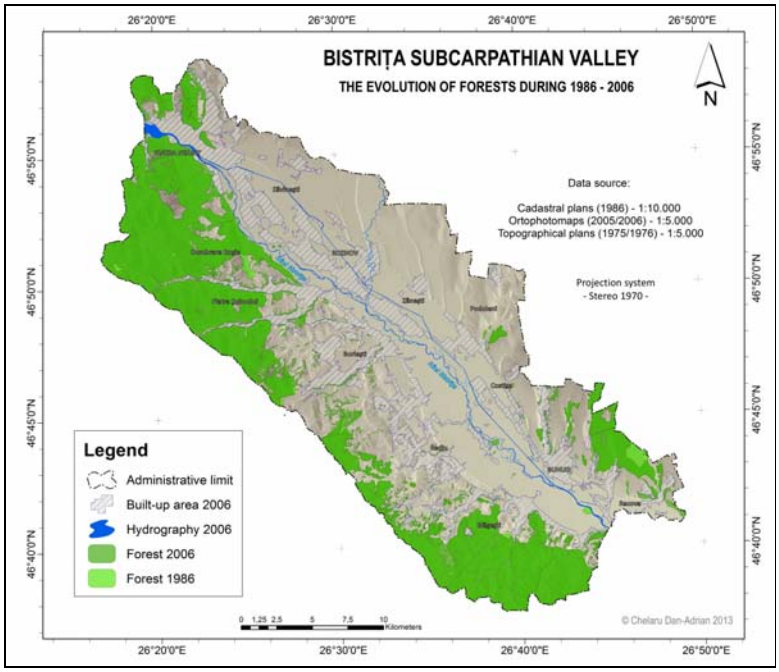

Fig. 4 - The evolution of forests during 1986 - 2006

Destruction of river meadow forests increased the capacity of lateral erosion of the river, which has set a large process of meanders migration, which had the effect of reducing the areas of highest levels of meadow or even some terraces. At the same time was favored the onset of gravitational mass movement processes especially in the thicker colluvial slopes belonging to deforested slopes by activation or reactivation of landslides. The effect of these morphological processes resulted in decreasing the cultivated areas with direct consequences on local rural economy (Ungureanu & colab., 1998).

If wooded areas covered in 1788 more than half of the administrative territory of Buhuşi and Racova settlements (4266 ha), the human factor has dramatically reduced the area, reaching 1423 ha in 2006.

Very interesting is the gradual migration of the forest limit towards the western mountainous area concomitantly with a massive expansion of built-up area. The old forests gave way to buildings, pastures or arable land.

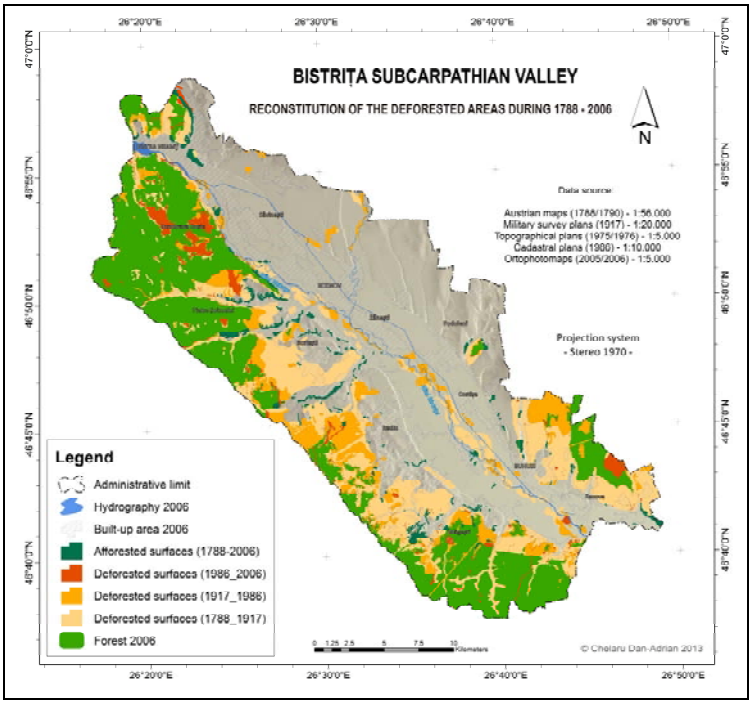

Fig. 5 – Reconstitution of the deforested surfaces during 1788 – 2006

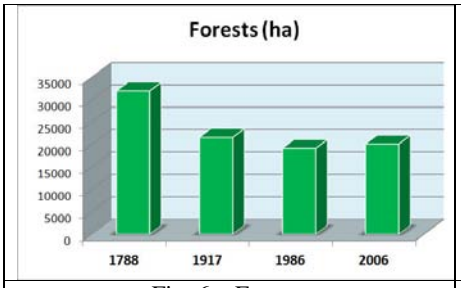

Fig. 6 – Forests

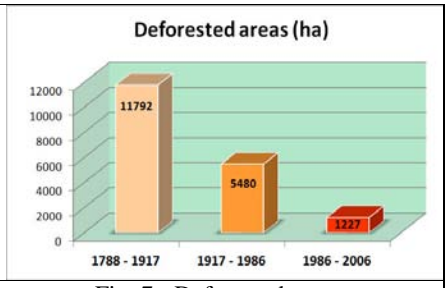

Fig. 7 - Deforested areas

Analysing the chart that expresses the values of forestry areas in the four periods can be clearly seen their involution, although the studied intervals are not

equal, decreasing by about 35%, and finally the trend to grow relatively slowly in the last time interval due to local afforestation works (fig. 6).

The graph which represents deforested areas (fig. 7) shows that the deforestation phenomenon has grown during the first period analysed spanning a period of over a century, having mainly anthropogenic causes: built-up area expansion, wood exploitation, forests replacement with pastures (for livestock) or arable land (with the purpose of providing food for a growing number of inhabitants). The second period (69 years) also shows a high rate of deforestation caused mainly by built-up area expansion. The last period under observation examines only 20 years, and although the rate of deforestation is obviously lower, because of the continuous decrease of the forestry area until that time, can be seen some areas completely deforested.

In the last decades have been taken measures to limit the action of these processes through reforestation of certain areas and setting up the torrential formations. All these interventions were much mitigated or even stopped after 1989 when the forest plots were redistributed to the former owners along with limiting the government funding for this purpose (Ungureanu & colab., 1998). Overall, can be observed in the studied area a number of areas in which were carried out reforestation work as a result of local government action or of changing the land use category from shrubs to forests (as can be seen from the land use change maps). Such areas are found disseminated over the territory especially in Piatra Şoimului, Borleşti, Buhuşi or Blăgeşti.

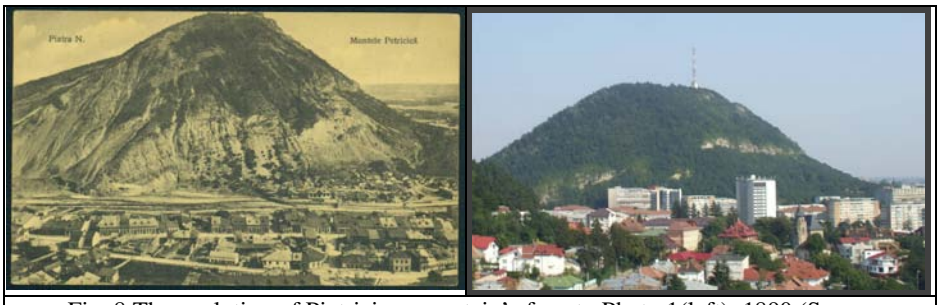

Fig. 8 The evolution of Pietricica mountain's forest. Photo 1(left): 1890 (Source: Romanian Academy Library), Photo 2 (right): 2009.

The most representative examples of these afforested areas stands at Piatra Neamţ on the Pietricica(fig. 8) and Cozla mountains, with 38, respectively 195 hectares. First afforestation works over these areas have been realized during 1901-1904, due to the fact that some of the south-west slope of Mount Cozla slipped after long rains. Local authorities have stabilized the slope by planting conifers.

Thus it was created the ”Cozla Park”, which later became the favorite promenade of the city residents and numerous visitors in the country, attracted by the beauty of places.

The consequences of forest landscape changes

In order to highlight the consequences of deforestation on the landscape system we have realized based on the same succession of cartographic materials the evolution of naturality degree. According to Osaci-Costache (2010), the index

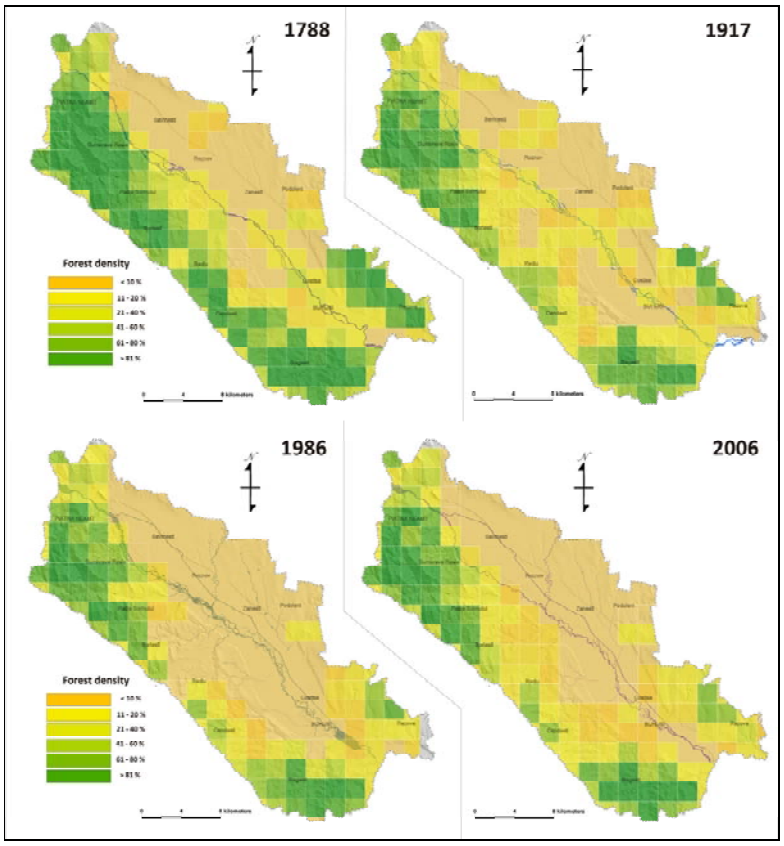

Fig. 9 – The evolution of Naturality degree computed on the historical cartographic documents

is directly proportional with the degree of forest cover. The diminishing of wooded lands determined a continuous lowering of the naturality degree, expressed as percentage of the forest in the total area (Ionescu et al., 1989). It must be

mentioned, however, that we have computed the index relying on the information provided by historical maps, while being aware of the fact that man was not entirely responsible for the recession of wooded areas (Osaci-Costache, 2010).

The next step was dividing the study area into equal sized squares having an area of 400 hectares each, following the comparative analysis of each map.

F**rom the analysis of the four rows of maps one can clearly observe a significant** reduction in the degree of naturality, the most affected localities being Borleşti, Rediu, Cândeşti, Buhuşi or Racova. The deforestations affected primarily the large terraces on the left side of Bistriţa river because of the high favorability for constructions and agricultural activity, the naturality index having in 2006 values less than 10 %. If in 1788 the average value of the naturality index was over than 60% (reaching often 100 % on the right side on Bistriţa), in 2006 the average value decreased considerably reaching 36 %. As stated previously, the decrease of forested areas was done in favor of arable land or built-up area due to the increase in the population number leading to the overall lowering of the naturality index of the study area.

The continuous decrease of forest areas in the subcarpathian sector of Bistriţa Valley has determined a series of events with severe consequences on the local natural conditions and the life in the region. Deforestation on some slopes with high tilt and friable lithologic substrate favored the installation of depth and surface erosion developing torrential formations that have evolved over time from gullies and ravines to complex torrential assemblies such as torrents (Ungureanu & colab., 1998).

Not to be neglected is the fact that the lack of forest determines inevitable changes with negative effects on the climatic conditions (air moisture and precipitation reduction, air temperature regime change by increasing the average temperature, wind speed increase which leads to increased evapotranspiration, decreased nebulosity) (Bojoi & colab., 1997).

Conclusions

The study indicates that the use of GIS techniques for the spatial analysis and evaluation of forest landscape change proves to be adequate, having the advantage of allowing us to monitor long time intervals, depending on the available cartographic documents.

The large-scale historical maps made in the last two centuries have proved to be the best witnesses of the landscape features. Their analysis and comparison have highlighted a landscape profoundly altered by man. Over the time, the human intervention has had various intensities, but it has particularly influenced the Subcarpathian area and the contact strip between the Subcarpathians and the Carpathians (Osaci-Costache, 2010).

Concerning our analysis, some remarkable changes have been recorded, not only over the entire investigated period, but also between the individual time horizons. The balance of these actions of afforestation-deforestation in the Bistriţa subcarpathian Valley during 1788 – 2006 has a negative value which resulted in significant diminish of forested areas leading to the ratio disturbance between cutting trees capacity and the natural of forests restoring, with strong negative implications on the analysed landscape system. Anthropic pressure lead to changes in land use, forests losing importand areas in favor of agricultural land, pastures, and especially the built-up area. These phenomena resulted over time in lowering the degree of naturality of the territory.

Acknowledgements

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References

Achard F., Mollicone D., Stibig H-J., Aksenov D., Laestadius L., Li Z., Popatov P., Yaroshenko A., (2006) - *Areas of rapid forest-cover change in boreal Eurasia*, Forest Ecology and Management 237, pp. 322–334.

Bojoi, I. & colab. (1996) - *Dinamica peisajului geografic din Podişul Bîrladului*, în „Cercetări asupra dinamicii peisajului geografic din Moldova extracarpatică pentru stabilirea categoriilor de favorabilitate economică şi de protecţie a mediului", Univ."Al.I.Cuza" Iaşi -Facultatea de Geografie şi Geologie (grant CNCSIS), 224 p.

Bojoi I & colab., (1997) - *Dinamica peisajului geografic din Câmpia Moldovei*, în „Cercetări asupra dinamicii peisajului geografic din Moldova extracarpatică pentru stabilirea categoriilor de favorabilitate economică şi de protecţie a mediului", Univ."Al.I.Cuza" Iaşi -Facultatea de Geografie şi Geologie (grant CNCSIS), 256 p.

Chelaru D.-A. & Apostol L. (2012) - *Using Gis To Analyse Land Use Change In Bistrita Subcarpathian Valley*, Present Environment & Sustainable Development, Vol. 6, No. 2, pp. 315 – 325.

Donisă I., (1968) – *Geo-morfologia Văii Bistriţei*, Edit. Academiei RSR, Bucureşti, 285 p.

Giurescu C., (1976) - *Istoria pădurilor româneşti din cele mai vechi timpuri până astăzi,* Eit. Ceres, Bucureşti, pp. 394.

Ionescu Al., Săhleanu V., Bîndiu C. (1989) - *Protecţia mediului înconjurător şi educaţia ecologică*, Editura Ceres, Bucureşti.

Magdalina Elena Simona, (2004) - *Clima şi calitatea aerului în culoarul subcarpatic al Bistriţei* - ed. Alma Mater, Bacău.

Osaci-Costache Gabriela & Ene M., (2010) – *The analysis of forest dynamics within the Carpathians – The Subcarpathians contact area by using the historical cartography approach and open source GIS software. Case study: The Limpedea catchment (Romania),* Forum Geografic. Studii şi cercetări de geografie şi protecţia mediului, No. 9, pp. 115-124.

Rudel, T.K., Coomes, O.T., Moran, E., Achard, F., Angelsen, A., Xu, J., Lambin, E., (2005) - *Forest transitions: towards a global understanding of land use change*. Global Environmental Change 15, pp. 23–31.

Ungureanu Irina & colab., (1998) - *Dinamica peisajului geografic din Pod. Sucevei*, în „Cercetări asupra dinamicii peisajului geografic din Moldova extracarpatică pentru stabilirea categoriilor de favorabilitate economică şi de protecţie a mediului", Univ."Al.I.Cuza" Iaşi -Facultatea de Geografie şi Geologie (grant CNCSIS), 223 p.