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LAND USE CHANGES IN POST-SOCIALIST ROMANIA. CASE STUDY: BISTRIȚA VALLEY, NEAMȚ COUNTY

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ABSTRACT. – Land Use Changes in Post-Socialist Romania. Case Study: Bistriţa Valley, Neamţ County. Land use and vegetation density are by far a major feature of post-socialist Romania. Free access to Landsat imagery archive makes it possible to track these changes in time and link them to their causes and other factors that facilitated the changing process, like political shifts, social trends and economic decisions. After 1989, the Romanian forests entered the restitution period marked by three laws (1991, 2000 and 2005) which has inevitably led to major changes in land usage by modifying the ownership and power of decision. Using tools like vegetation indexes and supervised classifications, the analysis is focused on highlighting the link between socio-political decisions and their impact on land use by analyzing the rural area of Bistriţa Valley, Neamţ County through the years of 1985-2017. Therefore, the study demonstrates the connection of institutional decisions to the natural environment, it explains the reasons behind land use changes and also formulates future perspectives for forest recovery process in this area.

Keywords: *land use change, forest disturbances, Landsat, image classification, land ownership*.

1. INTRODUCTION

1.1. Background

From the perspective of ecosystem services and their role in human settlements and well-being, forest has a great impact especially in the populated areas. This impact can be either positive, when the presence of forests is consistent enough to participate in climate regulation, watershed protection, having also recreational purposes (GLP, 2005; Millennium Ecosystem Assessment, M.A.,

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2005), or, on the other hand, the absence of forest-cover lands results in low carbon sequestration, deterioration of biodiversity and landslides (IPCC, 2000). Therefore, analyzing the changes in the percent of the surfaces covered by forests is not only beneficial, but also essential for a better management of the environment that can lead to a better decision making process advantageous for both human beings and ecosystems. Once human settlements have interfered with natural areas, every decision made in any of the political, economic, social spheres has a direct or indirect impact on the environment. Being aware of this indestructible link makes it possible for governments to better manage and protect the impact they should have or not have on natural surroundings.

The change in land use as an effect of forest restitution in post-socialist Romania between 1985 and 2010 was analyzed by Patrick Griffiths et al. (2011) for the Transylvanian Basin and the Southern Carpathians. Processing and analyzing the annual time series of Landsat images, the authors concluded that with each of the three restitution laws (1991, 2000, 2005) the percent of forest disturbances increased by more than 30%. Therefore, the study demonstrated a direct natural consequence of the radical changes of the political regime.

Another study of the forest changes in the Carpathian ecoregion in 1985-2010 was conducted by Patrick Griffiths et al. (2013), focusing this time on the Eastern Europe forest recovery. The results indicate a great dynamism of the forests cover (especially affecting coniferous and mixed forests) during the institutional and socio-economic changes caused by the fall of socialism in Poland, the Czech Republic and Romania.

The recovery of forest-cover lands in 1985-2012 is mentioned by P. V. Potapov et al. (2014). Their study, besides showing the increasing loss of forest in Eastern Europe after the 1980s, it also reveals how many of these areas entered a recovery stage. The process has been demonstrated to be rather fast and only "12% of the areas of forest loss prior to 1995 had not yet recovered by 2012".

Frequently used in the analysis of change detection, John G. Lyon et al. (1998) mention the vegetation indices. Thus, studying the State of Chiapas, Mexico, the authors managed to group the indices in three categories, but more importantly demonstrated that the frequently used NDVI is least affected by topographic factors, showing its utility and cataloguing it by giving the best vegetation change detection results.

1.2. Objectives

Regarding Romania, the link between political shifts and forest ownership and management became even more obvious with the fall of socialism. If prior to 1948, most forests were managed by communities and forms of communal

ownership (50%), and the rest were either owned by the state (28%) or were private lands (23%) (Ioraş and Abrudan, 2006), between 1948 and 1989 most of the lands covered by forests were directly owned by the state. With the fall of socialism, the decision was to start the restitution process through three laws: in 1991, 2000 and 2005. After all the three laws have passed, the Romanian forests would be 70% owned by non-state forest owners (Ioraş and Abrudan, 2006; Lawrence, 2009; Lawrence and Szabo, 2005).

Consequently, the political and economic decisions resulted in new rates of the spatial patterns of forest cover. Moreover, the political shift alongside with the APIA grants (Agency for Payments and Intervention for Agriculture) for farmers and meadow owners led to a major land use change in the rural areas of Romania.

The main goal of this study is to analyze the land use changes and their impact on forests in the rural areas of the mountain sector of Bistriţa Valley in Neamţ County, Romania. Thanks to the Landsat imagery archive, a temporal analysis is possible and also makes it easier to track the consequences of the three forest restitution laws. Aiming to help the local and national administration, the results can have a great impact on forest management and land use systems, if the following research questions are being answered:

-What is the impact and the consequences of the three restitution laws on forests in Bistriţa Valley?

-Are there some main reasons for land use changes in this area?

-What are the future perspectives for this rural area from a social and natural point of view?

2. STUDY AREA AND DATA

The study area for this study is located in the Eastern Carpathians, along Bistriţa Valley, from the border of Neamţ and Suceava Counties down to Izvoru Muntelui (Bicaz) Reservoir. This area includes over 30 villages, the protected area of Ceahlău Massif and the man-made Bicaz Reservoir. The presence of Stânişoara and Bistriţa Mountains (peaking at 1530m and 1791m respectively) makes it possible for the area to be covered by extensive surfaces of forests. Also, being a rural area, the main source of profit for the local population comes out from logging trees, agriculture and farming by exploting the meadows. Consequently, these main occupations of the locals imply high physical capacities that, since the migration of the youths to urban centers and the aging of the remaining population, have been reduced drastically.

Regarding the analyzed data, the Landsat images have been downloaded from the Earth Explorer United States Geological Survey (USGS) portal. The study is based on imagery archive from 1985 to 2017 of Landsat 1-3 MSS (path/row/197-198/207), Landsat 4-5 TM (path/row/183/027) and Landsat 7 ETM+ (path/row/183-184/207). The images have been selected from August-September to show the greatest extension of vegetation covered areas, but due to the extensive presence of clouds, some images were replaced with others from springtime.

3. METHODOLOGY

3.1. Pre-processing and image compositing

Once the images were downloaded, each of them has been reprojected to the Stereo70 projection. The SLC-off error was corrected though Focal Analysis for the Landsat 7 ETM+ images from after 2003. Adjustments for the contrast and haze reduction have also been made to better illustrate the differences between vegetation covered lands and those with other types of land use. The initial analysis was applied on the 5-4-2 band combination which best illustrated the above mentioned.

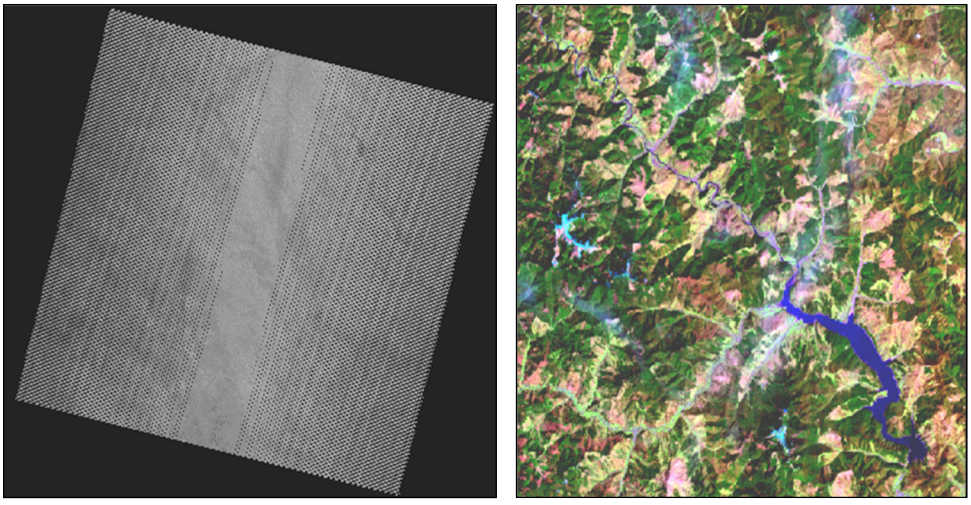
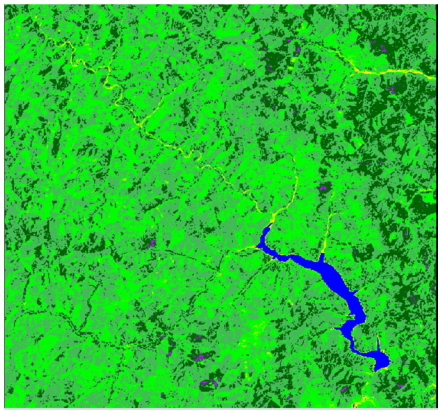
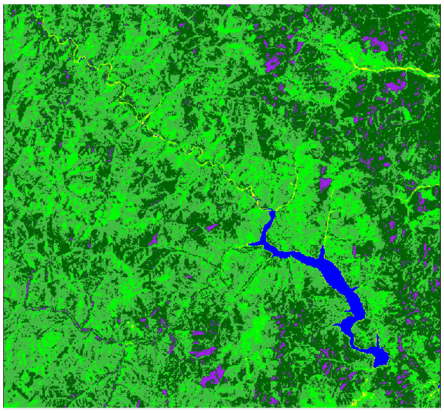


Fig. 1. Example of Landsat ETM+ image with SLC-off corrected and contrast adjustments (5-4-2 band combination)

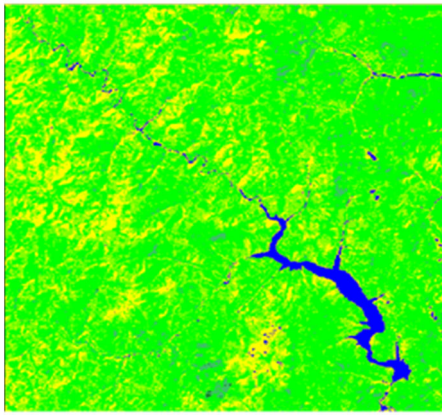
L4-5 TM 1985



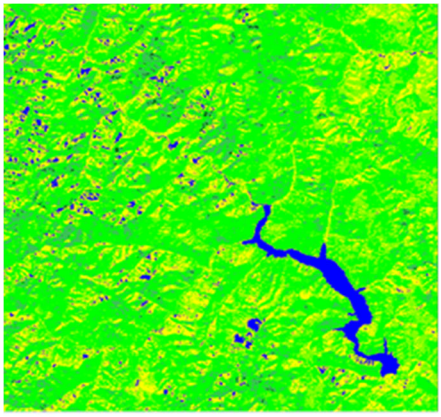
L4-5 TM 1993



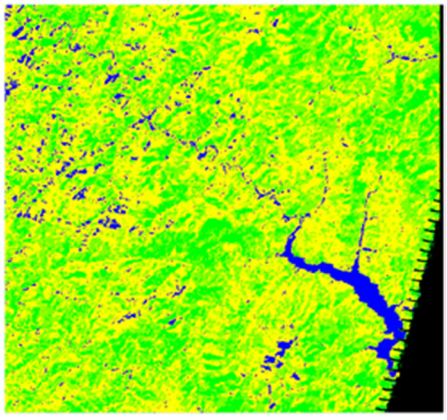
L7 ETM+ 2005

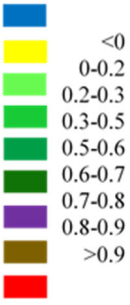


L4-5 TM 2010



L7 ETM+ 2017





After all the corrections have been made, the Normalized Difference Vegetation Index (NDVI) has been applied and the images classified based on the values obtained, resulting 9 classes: below 0 for the absence of vegetation, 0-0.2, 0.2-0.3, 0.3-0.5, for different states of incipient vegetation, 0.5-0.6, 0.6-0.7 for moderate vegetation density and 0.7-0.8, 0.8-0.9 and higher than 0.9 for high vegetation density levels.

At a first glance, it is easy to say there is an obvious decrease in vegetation density, especially after 1993, mostly in the values higher than 0.5 of the NDVI processing. However, there is a slight increase of the values higher than 0.8 between 1985 and 1993. This can be exxplained by the transition period that came with the fall of socialism in 1989 and the beginning of the restitution process in 1991. Due to the political changes, the forests were less exploited belonging neither to the state nor to private owners.

To better illustrate this diminution of high vegetation density values, three areas have been selected as samples. The selected areas are either close to the villages, or easily accessible for the local population in order to exemplify the degree of human intervation in forest cover change. Since the higher density values are those that dropped the most, the samples were taken from the post NDVI processing images with values higher than 0.5. The results below demonstrate the negative impact the local community had on high density vegetation levels mostly through their economic activities involving forests and meadows.

3.2. Supervised classifications

Regarding the supervised classifications, seven classes have been identified, consisting of: hydrography, settlements, agricultural fields, meadows, rockery, coniferous forests and deciduous forests. Therefore, the first step of the supervised classification was to assign the image pixels to one of the seven classes. Of course, another 2-3 steps of corrections were needed, based on the personal knowledge of the area. The resulting images demonstrate the link between forest covered land and meadows and agricultural lands. The connection is given by the replacement of forest with meadows and lucerne crops especially after 2000. Before that, there is an expansion of agricultural lands in 1985-1993, which where slowly replaced by lucerne crops.

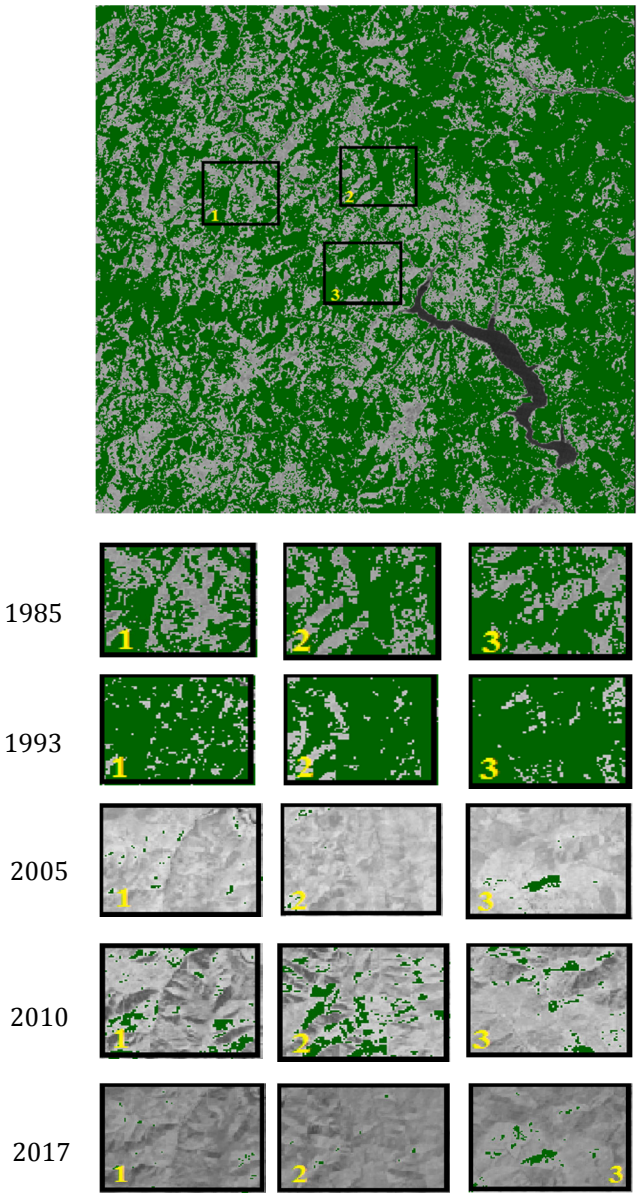
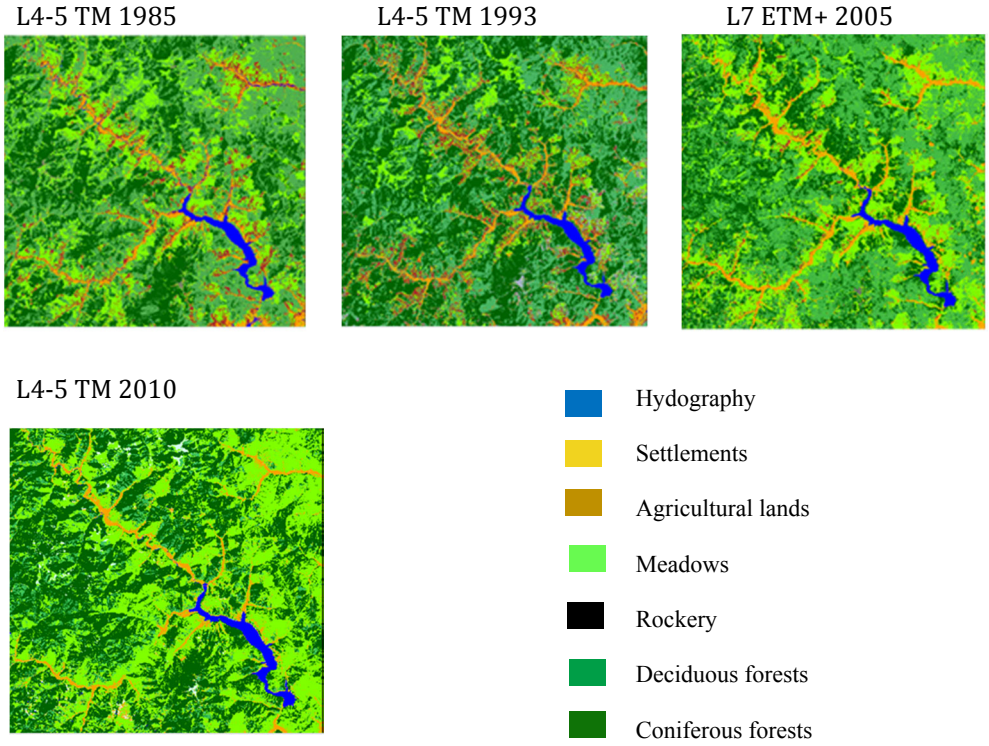


Fig. 2. Samples taken for the higher than 0.5 NDVI values (1985)



This stage of the analysis is excluding the year of 2017 because, after several attempts to classify the pixels, the results were not conclusive, based on the personal knowledge of the area. The results of the analyzed four years show an increse of the locals' interest towards agriculture (corn fields, production of potatoes and other vegetables) between 1985 and 1993, followed by a sudden switch to lucerne crops and exploitation of meadows located in higher areas, replacing the forests. The entire process can be explained by the increse in APIA grants for the maintenance of the meadows.

3.3. Change detection

Due to the drastical changes over the years, a simple analysis of the resulting images has already led to some conclusions. However, the database analysis by making a connection between the number of pixels and the area they cover are the best argument for highlighting the decrease in high vegetation density over the years.

First of all, the analysis was based on extracting the areas covered by the pixels belonging to the classes that resulted after the NDVI processing. The resulting database in table 1 illustrated in the graph below (fig. 3) better shows the decrease of forest covered lands. This chart makes it easier to see that there is a mirrored evolution between 1985 and 2017. It also demonstrates the statements made above about the slight increase in vegetation density between 1985 and 1993, and the abrupt decrease after that.

Table 1. NDVI change detection database (pixels/surfaces)

Year	NDVI	1985		1993		2005		2010		2017	
Value		No. Pixels	Area (km²)	No. Pixels	Area (km²)	No. Pixels	Area (km²)	No. Pixels	Area (km²)	No. Pixels	Area (km²)
1	<0	20639	18.57	23802	21.42	35889	32.3	88003	79.20	88439	79.59
2	0-0.2	7213	6.49	4572	4.11	164018	147.61	184162	165.74	622872	560.58
3	0.2-0.3	12160	10.94	4878	4.39	429570	386.61	301491	271.34	571689	514.52
4	0.3-0.5	538844	484.95	304562	274.1	617754	555.97	837138	753.42	283774	255.39
5	0.5-0.6	672534	605.28	621485	559.33	314487	283.03	133670	120.30	82	0.07
6	0.6-0.7	303968	273.57	548385	493.54	468	0.42	14801	13.32	0	0.00
7	0.7-0.8	10474	9.42	57378	51.64	0	0.00	13	0.01	0	0.00
8	0.8-0.9	7	0.006	0	0.00	0	0.00	0	0.00	0	0.00
9	>9	5	0.004	0	0.00	0	0.00	0	0.00	0	0.00

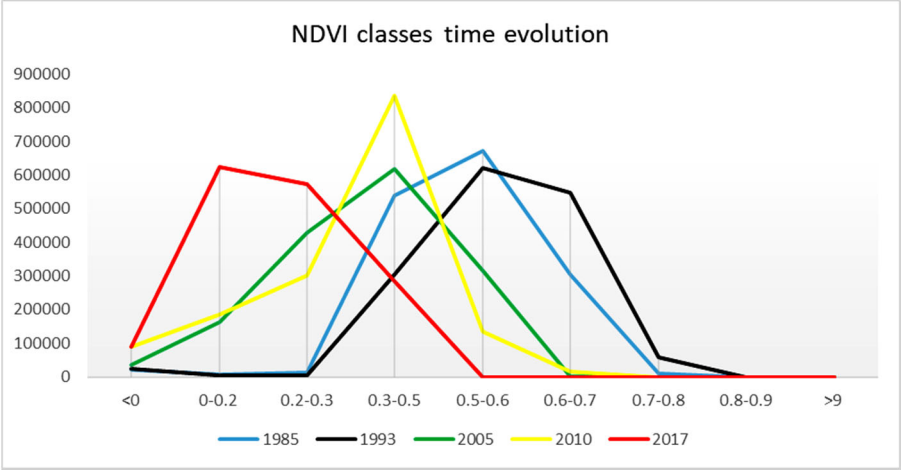


Fig. 3. NDVI change detection chart

The same analysis methodology was applied to the supervised classification resulting images. Therefore, as shown in the chart below (fig. 4), there is a slight increase in the class of settlements and a normal stagnation of hydrography and rockery classes. Regarding vegetation, the class of coniferous forests registrates the biggest oscillations, with an increase in 1993 and a decrease that comes after. The interesting fact is that after 2005, the coniferous forests have become denser which, by anticipating the conclusions, demonstrates the lack of interest in the higher areas for local population who tend to transfer their meadows closer to their settlements, and therefore the forest enters a process of slow natural regeneration. On the other hand, the deciduous forests have registered a constantly slow decrease due to logging and exploitational activities.

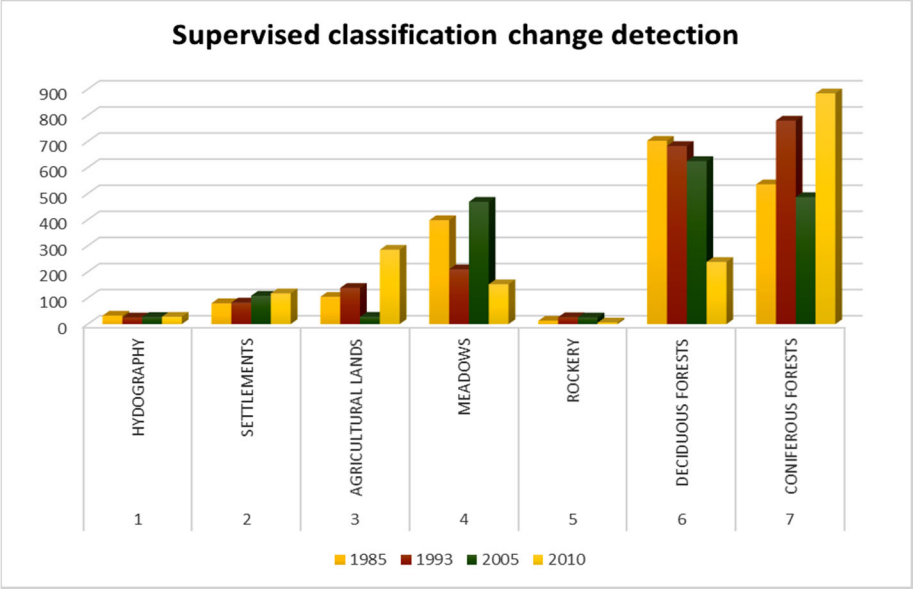


Fig. 4. Supervised classification change detection chart

Table 2. Supervised classification change detection database (pixels/surface)

Year	CLASSES	1985		1993		2005		2010	
Value		No. Pixels	Area (km²)	No. Pixels	Area (km²)	No. Pixels	Area (km²)	No. Pixels	Area (km²)
1	HYDOGRAPHY	36213	32.59	28325	25.49	30402	27.36	31409	28.26
2	SETTLEMENTS	88949	80.05	154069	82.6	120650	108.58	131008	117.90
3	AGRICULTURAL LANDS	116373	104.73	91778	138.66	31523	28.37	31687	285.12

Year	CLASSES	1985		1993		2005		2010	
Value		No. Pixels	Area (km²)	No. Pixels	Area (km²)	No. Pixels	Area (km²)	No. Pixels	Area (km²)
4	MEADOWS	442642	398.37	29383	209.96	520709	468.63	169616	152.65
5	ROCKERY	14256	12.83	233289	26.44	28605	25.74	6910	6.21
6	DECIDUOUS FORESTS	780741	702.66	758285	682.45	693931	624.538	2644607	238.14
7	CONIFEROUS FORESTS	595110	535.59	866539	779.88	541030	486.92	982357	884.12

Both the table and the chart above suggest a strong link between the evolution of meadows and that of the agricultural lands. Accordingly, for the year of 2005, if there is a decrease in the column of agricultural lands, in the same year the meadows extended. On the other side, regarding the year of 2010, the connection between the two remains, but it is inverted. Therefore, while the meadows covered less surface, the agricultural lands extended.

3.4. Field validation results

The analysis is validated comparing the database results that suggest the replacement of forests with meadows in the proximity of settlements to the reality in the field. In fig. 5 there are a few examples of this tendency. The process of aging of the local population forces them to leave the higher areas in the mountains, and move their meadows closer to their settlements. It is easy to anticipate that, thanks to this transition from higher to lower areas, makes it possible for the natural forest recovery process to step in and eventually lead towards a growth in forest covered lands.

The results and their motives can be a little fuzzy without a timeline of the events. First, the aging process of the local population is triggered by the youths moving to urban areas. Therefore, the level of energy to continue the work of maintenance and exploitation of meadows and forests deacreses. The natural consequence is for the locals to retreat from the areas situated at a higher altitude and replace them with those located near their settlements. That is why currently the lands at higher altitudes enter a slow regenerating state.

Secondly, for a while, the APIA grants given to farmers and agricultural workers for maintaining their meadows were profitable enough to put in the work of keeping the lands clean. Together with the aging population and the decreasing energy levels, these grants were no longer profitable enough. Local families reduced their properties and farms, and chose to buy more and produce less. The direct consequence is the same: the beginning of the natural reforestation process.

Thirdly, since 1989 and the fall of socialism, three laws have been implemented regarding property restitution, in 1991, 2000 and 2005. The first law explains the growth in vegetation density between 1985 and 1993 shown in fig. 5. Since this was a period of transition for forest covered lands from state owenership to private owners, the logging and exploitation stagnated a few years. The second and third laws (2000 and 2005) were followed by a massive decrease in vegetation density due to the fact that forest exploitation has become and still is one of the main sources of profit for the local population.

Lastly, the timeline has been drawn: the young population left this rural area, the workforce got lower and lower, the meadows were transferred near the settlements, the market prices for vegetables made their production unprofitable, the agricultural lands were replaced by lucerne crops by giving up a big part of the meadows, so these lands are no longer under maintenance and the natural process of vegetation recovery has space to evolve.

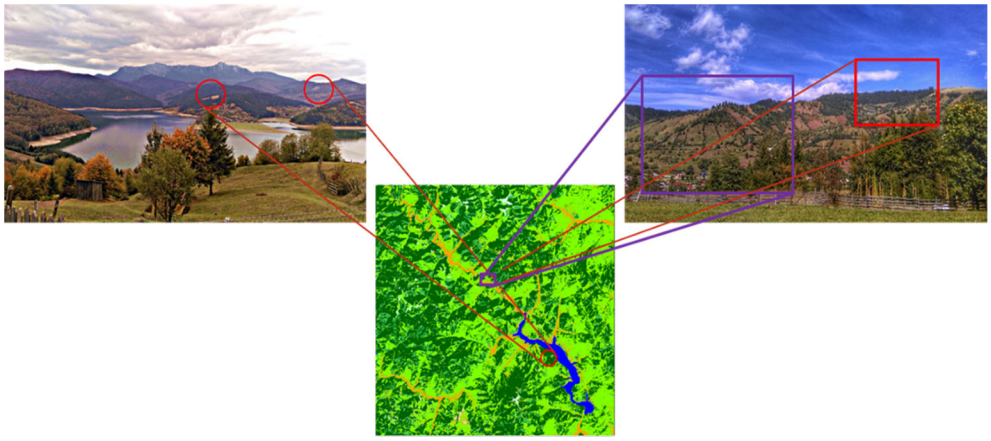


Fig. 5. Field validation of the resulting database

4. CONCLUSIONS

The high utility of open source Landsat imagery archives has been proved once again by making it possible to draw a distinct and certain link between political decisions and social shifts, and the fluctuations of vegetation density, change detection of land use and forest covered lands. Along Bistriţa Valley in Neamţ County, Romania, the local population is still characterized by a high average age, depopulation, making it impossible to put in the same amount of work and energy into properly maintain or exploit the meadows and

forests. However, if one was to ask a local their opinion on deforestation in the area, the answer would be: "There is more forest today than in my childhood" (local 49 years old man).

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