DETECTING HOTSPOTS OF CHANGES IN SPATIAL PATTERNS OF FOREST FRAGMENTATION IN THE ROMANIAN CARPATHIAN MOUNTAINS

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INTRODUCTION
With a total area of about 210,000 km², the Carpathian Mountains represent one of the largest natural regions of the Europe, comprising the most representative forest ecosystems in Europe with about 300,000 ha of natural forests and 20,000 ha of primary beech forests (WFN Report, 2001). The Carpathian mountain range connects 8 Eastern European countries, from Serbia and Romania in the south to Austria, the Czech Republic, Hungary, Poland, Slovakia, and Ukraine in the north (Bojarsen et al., 2009). Romania has about 25% of the entire Carpathian Mts, consisting in the Eastern, Southern, and Western Romanian Carpathian ranges. Landscape fragmentation is the expression of patchiness and spatial heterogeneity of land cover pattern. After the breakdown of the socialist regime in 1989, Romania has undergone significant changes at the levels of political, institutional and socio-economic profile, which determined researchers to consider this country an experimental framework for land and landscape research. The aim of this study is to to detect hotspots of changes of forests landscape fragmentation patterns in the Romanian Carpathian Mountains between 1990 and 2018.

STUDY AREA
The regional-scale study area is the Romanian Carpathians (Figure 1), about 107,000 km² of mountainous terrain with elevations up to 2544 m. It has a temperate-continental climate, with a mean annual temperature of about 7°C and a mean annual rainfall between 750 and 1400 mm (Mihai et al. 2007; Muller et al. 2009). Major soils include podzols in the mountain zone and Cambisols in the foothill zone (FAO, UNESCO, and WRB 1988). In the Romanian Carpathian Mts there were distinguished five vegetation zones: (1) lower mountain zone with pure beech (Fagus sylvatica L.) stands; (2) middle mountains zone with mixture of spruce (Picea abies), silver fir (Abies alba) and beech (Fagus sylvatica) stands; (3) upper mountain zone with pure spruce (Picea abies) stands; (4) subalpine grassland zone; and (5) alpine grassland zone. The dominant tree species in Romanian Carpathian forests are Picea abies, Fagus sylvatica, Abies alba, Pinus sp., Larix decidua. About 65% from total area of Romanian forests are situated in the mountains and, in terms of contribution to the total coverage; the conifers contribute with 30%, broadleaves forests with 50% and mixed forests with 20% (Bădea et al., 2004).

RESULTS AND DISCUSSIONS
Forest fragmentation is scale dependent and observer dependent. In this way, we applied a fragmentation analysis scheme in FAO (Forest Area Density) form at five observations scales using a moving window analysis with square neighborhood areas of length 7, 13, 27, 81, 243 pixels. Finally, the five fragmentation maps are aggregated into a summary map, showing the average FAD value calculated over all 5 observation scales, which is displayed color-coded into the respective fragmentation class, the proportion of forest pixels in each fragmentation class is calculated and summarized in a bar plot showing forest fragmentation over observation scale (Figure 3).

Figure 2. Summary of FAO-APP fragmentation class (transliteration, and color assignment). FAD is a per-pixel classiﬁer while FAO-APP summarizes the average density value per patch.

Figure 3. Appropagh (multi-scale) map of fragmentation classes (left) and bar plot of summary statistics (right) including total amount of forest area, number of forest patches and average patch size (right).

Finally, the presentation, the analysis and the interpretation of the results obtained represented the third phase of the research. In this way, we apply a cartographic approach in order to highlight the spatial and temporal pattern of land use/cover changes occurred at the level of the study area, on the one hand, while a statistical and graphical approach were employed for the presentation of the data strings, on the other hand.

CONCLUSIONS
This study aimed to produce new insights into the mechanisms of forest landscape fragmentation by including maps produced with advance pixel-based image analysis techniques in order to show forest cover changes at a regional scale in an extensive mountain ecosystem. Overall, forest cover in the Romanian Carpathians showed a net increase of 10.551 ha/year in 1990–2006 and a net decrease of 7.148 ha/year in 2006–2018. The study emphasizes the impacts of land use policies and land management practices on the pattern of forest landscape and the usefulness of Guidos Toolbox, a universal digital image object analysis, to detect hotspots of changes at regional scale.

REFERENCES

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