

PLANNING ECOLOGICAL CORRIDORS ON ARABLE LANDS IN NATURA 2000 SITES: CASE STUDY ROSCI0123 MĂCIN MOUNTAINS, ROMANIA

DENISA LAVINIA BADIU*, FLORIAN BODESCU**, CRISTIAN IOAN IOJĂ***,
MARIA PĂTROESCU***

Key-words: arable lands, ecological corridors, biodiversity, Natura 2000, Măcin Mountains, Romania.

La planification des corridors écologiques sur les terres arables dans le SITES NATURA 2000: étude de cas ROSCI0123 Măcin Montagnes, Roumanie. La planification de l'activité humaine dans les zones protégées est un enjeu important à l'échelle mondiale, due à l'augmentation de la perte de biodiversité. L'étude vise à évaluer si la mise en œuvre des corridors écologiques pourrait être un des outils pour diminuer l'impact environnemental des activités agricoles dans les sites Natura 2000. En utilisant une évaluation multicritère, nous évalué pour Măcin Montagnes Natura 2000 site, la morphologie, le sol et les critères écologiques afin d'identifier les domaines qui pourraient convenir pour les corridors écologiques. Nous avons obtenu 1 432 hectares des zones favorables pour le développement de corridors écologiques, ce qui signifie 62% dans la zone d'étude. Ainsi, les corridors écologiques pourraient être une solution viable à long terme, afin d'intégrer des pratiques agricoles avec des espèces et des besoins de conservation des habitats naturels.

1. INTRODUCTION

Conservation planning represents one of the main tools (Sarkar *et al.*, 2006) that contributes to biodiversity threats control (Margules and Pressey, 2000; Moilanen *et al.*, 2009; Pressey *et al.*, 2007). Among the biodiversity threats, agriculture contributes to the destruction, degradation and fragmentation of natural habitats (Lisec and Pintar, 2005), through habitats conversion, monocultures, chemical uses, aggressiveness of different practices, irrigation and others (Straus *et al.*, 2011; Firbank *et al.*, 2008; Primack *et al.*, 2008).

In the Natura 2000 Network, agriculture has “dual nature, being considered the main risk affecting biodiversity at global level, but also the support of sustaining biological communities” (Ioja *et al.*, 2010). Diminishing the agriculture environmental impact can be obtained through control instruments, which solve most of the short-term problems, or through interventionist measures. One interventionist instrument example is the ecological corridors – “vegetation strips which are different than the adjacent usage” (Hobbs, 1992) and which are contributors to an area's connectivity growth – either between natural habitats (Forman, 2006), or in the context of an agroecosystem (Beier and Noss, 1998).

The ecological corridors differ as structure, wildness, length or purpose, but all of them deliver ecological services, either of a structural order or of a functional one. The ecological corridors that give the structural connectivity can control the water flow, resulted from precipitation or nutrient flow applied on agricultural fields, increase productivity by diminishing the wind actions (Earnshaw, 2004) and allow abiotic process mobility like water, energy or matter (Meiklejohn *et al.*, 2009). Functional, they allow plant and animal species mobility, they can account for support-habitats for avifauna species or dispersion routes for mammal species (Hinsley and Bellamy, 2000; Forman, 2006; Groot *et al.*, 2009).

Nowadays, these limit-plantations are used on the agroecosystems' surface. The ecological corridors incorporated in agroecosystems are improving the structural connectivity level in an area and

* MSc, Faculty of Geography, University of Bucharest, 1 N. Bălcescu Ave., Bucharest, Romania, denisabadiu@gmail.com.

** PhD, Multidimension, 3–4 Tg. Frumos, Bucharest, Romania.

*** Professor, Centre for Environmental Research and Impact Studies (CCMESI), University of Bucharest, 1 N. Bălcescu Ave., Bucharest, Romania, cristi@portiledefier.ro, mpatroescu@yahoo.com.

they have the capacity of improving agricultural productivity and conservation procedures (Hinsley and Bellamy, 2000).

By implementing ecological corridors, an agricultural system can be turned into an agroforestry system with biodiversity benefits and a large number of ecological and economic services (Wehling and Diekmann, 2009).

In the same matter, the European political framework is trying to promote a sustainable agriculture and to protect the environment for future generations, through the Common Agricultural Policy or to avoid actions that can lead to degrading the state of priority habitats (European Council, 1979, 1992; Iojă *et al.*, 2011). A number of objectives set out in the European Biodiversity Strategy are to integrate biodiversity protection objectives in the Common Agricultural Policy instruments by promoting sustainable farm practices to reduce the risk of pollution (European Commission, 2011).

Taking into account that most of the field owners wish for a bigger agricultural production and with the lack of an efficient control system regarding chemical fertilizer application, the ecological corridors can, on one side, help accomplish the conservation purpose in a protected area and on the other to support farmer's activities through European funds assimilation (the European Agricultural Fund for Rural Development, through Measure 112, the Rural Development Program through Measure 221 – First afforestation of agricultural land). So, the necessity of the study comes from the need of developing instruments that can improve the state on the agricultural fields and that can be easily interpreted by the decisional authorities.

The aim of the study is to identify the favourable areas for ecological corridors on the arable land in the Măcin Mountains Natura 2000 site.

The objectives of the paper are: (a) identifying criteria that allow separating the optimal routes for the ecological corridors and (b) building and applying a multicriteria assessment for an efficient selection of ecological corridors.

2. STUDY AREA

The Măcin Mountains Natura 2000 site (Fig. 1) is located in the Eastern part of Romania, Tulcea County, and has an area of **16 893** hectares (Ministry of Environment, 2011). This area is included in the Steppic biogeographic region, characterized by an arid climate and limited hydrological resources (European Environment Agency, 2006).

In the Măcin Mountains Natura 2000 site, agriculture has the advantage of a favourable climate, with a high number of sunny days in the summer season and some types of fertile soils (Doniță *et al.*, 2007), conditions that determined the development of activities like grazing, vineyards, vegetables and cereal crops.

The Steppe and silvosteppe vegetation is dominating (Pătroescu, 1987) with a high floristic biodiversity given by the presence of rocky, riparian, steppe and forest habitats, endemic species (*Campanula romanica*, *Corydalis dobrogensis*), or by the important species at national or European level (*Moehringia jankae*) (Doniță *et al.*, 2007). Regarding the fauna diversity, the protected area includes endemic vertebrates – *Polia cherrug* or protected species – nationally and internationally significant (invertebrates – *Morinus funereus*, *Cermabix cerdo*, birds – *Falco cherrug*, *Circus macrourus*, mammals – *Spermophilus citellus*), that can be affected by the aggressive agricultural practices (Ministry of Environment and Forests, 2011).

The protected area analysed belongs to the European Nature 2000 network and was designated as a site of community interest because of the presence of habitats and species listed in the Habitats Directive. ROSCI0123 Măcin Mountains tries to preserve the important biodiversity elements at a continental level and also to integrate and help develop the social component, through traditional activities.

The analysis takes into account the surface of the protected area under its limit in 2007 because of the expanded distribution of arable land at that time. Although in 2011 the protected area boundaries

changed and its surface shrank, and much of the arable land is no longer part of a protection zone regime, they remain a threat to biodiversity resulting in true environmental conflicts (Tudor *et al.*, 2014). For that reason, planning the ecological corridors also on the fields nearby the protected area can contribute to a better accomplishment of conservation objectives.

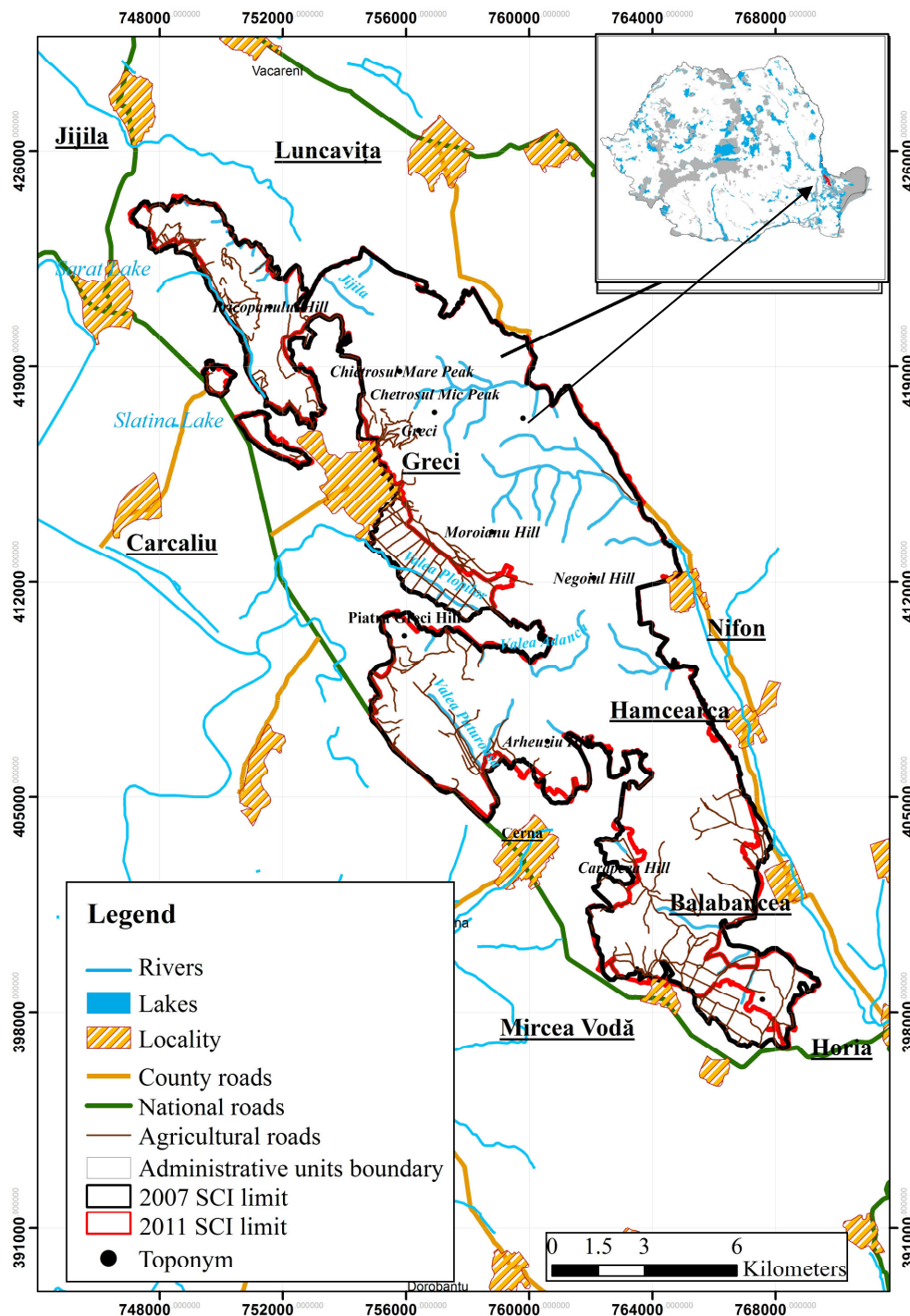


Fig. 1 – Study area ROSCI0123 Măcin Mountains.

3. DATA AND METHODS

For this study we used cartographic materials: the soil map at a scale of 1:200 000 (Geological Institute, 1971, updated in 2005), the topographic map at a scale of 1:25 000 (1980), orthophotoplans at a scale of 1:5 000 (2008), and the Digital Elevation Model with the resolution of 30 m – all used for elaborating the geodatabase and the Model Builder application used for the analysis.

Table 1

Reclassifying criteria according to their favourability for ecological corridors planning

No.	Spatial criteria	Criteria importance (from 1=low to 5=high)	Justification	Reclassifying and recoding the criteria	
				Code	Correspondence
1.	Patch surface	4	High favourability degree for patches with surfaces larger than 3 hectares since this area is established as favourable, relative to the ecological corridor width of 20 m (Earnshaw, 2004)	10	Patch < 3 hectares
				100	Patch > 3 hectares
2.	Flow accumulation areas	2	Higher values for those areas where water derived from rainfall could accumulate in the biologically active surface and could wash out farmland nitrogen chemical compounds and lead to diffuse pollution. These areas may be considered for ecological corridor implementing on one side to capture rich nutrients and to redistribute them on other arable lands and also to reduce surface runoff (Kovar <i>et al.</i> , 2011)	10	High flow accumulation
				20	
				30	
				40	
				50	Medium flow accumulation
				60	
				70	
				80	Low flow accumulation
				90	
				100	
3.	Soil texture	3	Soil texture was classified according to its ability to retain water and can lead to areas of stagnation. A clay texture causes high water stagnation compared to the sandy texture. These areas show favourable conditions for implementation because of their capacity to retain water rich in nutrients (Burel and Baudry, 2005)	10	Varied texture
				20	Clay and sandy texture
				30	Clay and sandy texture, clay texture
				40	Clay texture
				50	Clay texture, Clay and argyle texture
				60	Clay and argyle texture
4.	Land-use	5	Areas occupied by arable land present the highest favourability given the need to diminish the anthropic impact on the structural connectivity (Groot <i>et al.</i> , 2009)	500	Arable land
				400	Rivers, lakes, roads
				300	Pastures, orchards
				200	Construction sites, Unproductive land, Mining area
				100	Forest
5.	Roadside spaces	2	Proximity to roads is a significant criterion because of the existence of uncultivated land in their immediate neighbourhood. We considered a distance of 30 meters from the road as favourable (Earnshaw, 2004)	100	0-30 m
				0	>30 m
6.	Riverside spaces	4	An important criterion in identifying favourable areas for ecological corridor implementation was proximity to rivers in order to create a hydrographic network protection and reduce the possibility of eutrophication by nutrients effect from agricultural lands. We considered a distance of 30 m from the river as favourable (Earnshaw, 2004)	100	0-30 m
				0	>30 m

To separate the favourable areas for ecological corridors, we identify criteria with spatial distribution. Using ArcGIS 10.1, we obtained layers about: (a) land use and cover, vectored on the ortophotoplans (2008); (b) the hydrographical network vectored on the base of the topographic map; (c) soil texture distribution, using the soil map and (d) the road network). Using geoprocessing instruments from ArcMap and with the Model Builder application (ESRI, 2011) we delineated favourable areas for ecological corridor implementation. The criteria considered for our study are presented and justified in.

Table 2

Data and geoprocessing instruments used by the model in order to locate the favourable areas for ecological corridors implementation

No.	Input data	Geoprocessing instruments	Output data
1.	Land-use and cover type in Măcin Mountains Natura 2000 site	Polygon to Raster	Patch surface classification Land-use type classification
2.	Soil texture distribution in Măcin Mountains Natura 2000 site	Polygon to Raster	Soil permeability classification
3.	Hydrographic network	Euclidean Distance Reclassify	Distance to rivers classification
4.	Road network	Euclidean Distance Reclassify	Distance to roads classification
5.	Digital Elevation Model	Flow Direction Flow Accumulation Reclassify	Flow accumulation areas
6.	Output data 1–5	Weighted Sum	Potential areas with high favourability for ecological corridors application

4. RESULTS

The development and application of this model led to identifying the favourable fields for implementing ecological corridors. The selected criteria and their spatial distribution allowed a better visualisation of each type of corridor.

Within ROSCI0123 Măcin Mountains there resulted various spaces with a high level of favourability for implementing ecological corridors. This is based on the high number of criteria and the extensive distribution of each favourable class (Table 3). The extensive distribution of clay and argyle soil texture within the area, along with the large surfaces of arable land, a developed road network and a large number of patches with surfaces larger than 3 hectares projected a connected system of ecological corridors. The criteria with a low weight in the model – the distance to the hydrographical network and the flow accumulation areas – are explained by the reduced density of the hydrographical system and the low variability of altitudinal classes. Even with a poor spatial distribution of these criteria, the model considered them in the process because of their importance to conservation – the hydrological network that can be affected by the chemical fertilizer layer or areas where sediments rich in nutrients can be stored.

Table 3

Values obtained for each favourable class of the criterion in the model

No.	Criterion	The surface of the favourable class of the criterion within the study area hectares	The weight of the favourable class of the criterion within the study area (%)
1.	Distance to rivers	311	2
2.	Distance to roads	2,362	12
3.	Patch surface	3,460	18
4.	Flow accumulation areas	20	0.1
5.	Soil texture	1,083	6
6.	Land-use types	2,302	12

The spatial distribution of each favourable class of each criterion resulted in the following values: *Distance to rivers* criterion resulted in 2% of the total area of the study, *Distance to roads* approximately 12%, *Patch surface* 18%, *Flow accumulation areas* 0.1%, *Soil texture* 6% and *Land use type* 12% (Figs. 2, 3, 4, 5, 6, 7).

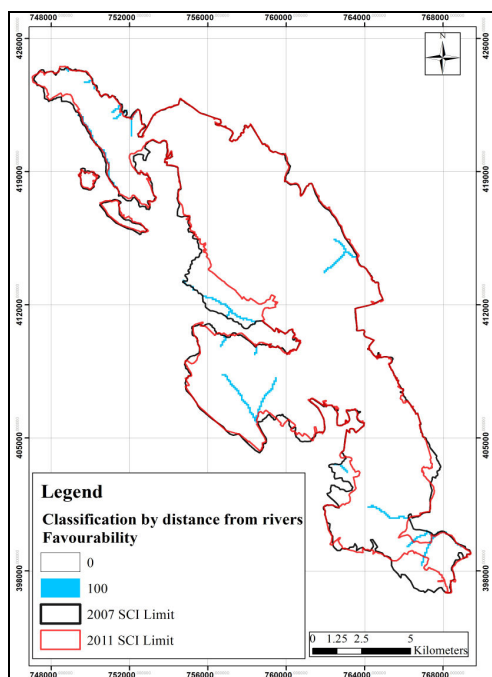


Fig. 2 – Distance to the hydrographical network.

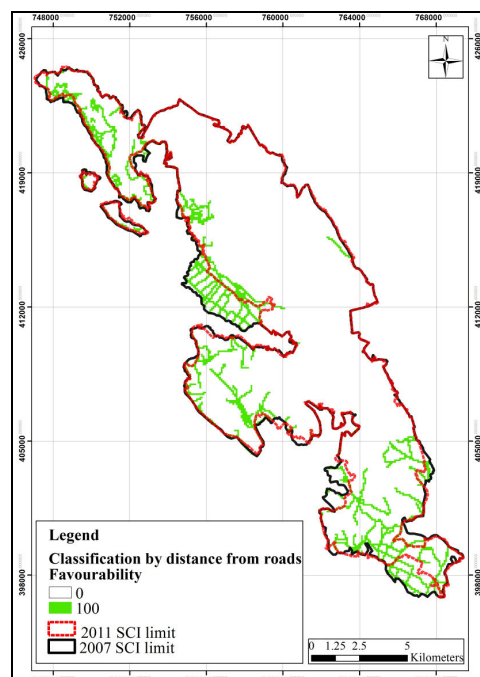


Fig. 3 – Distance to roads.

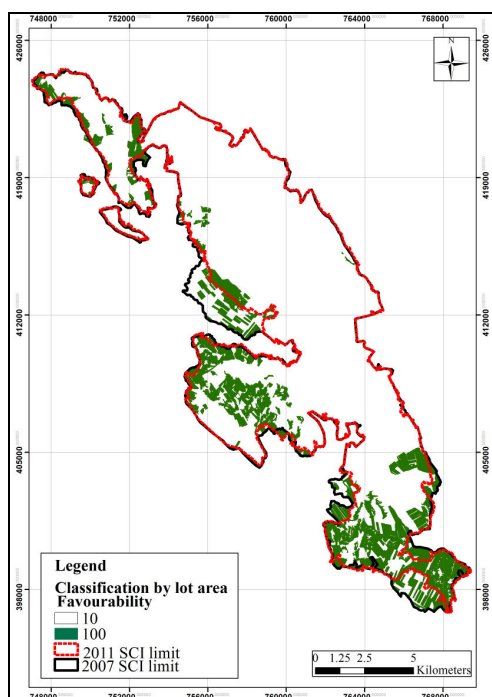


Fig. 4 – Patch surface.

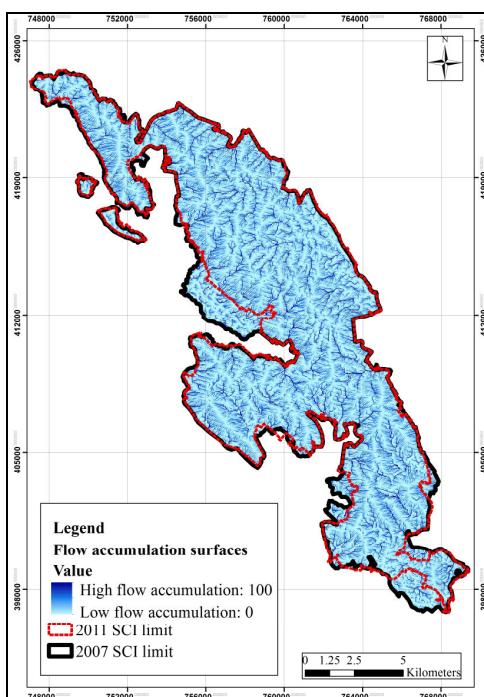


Fig. 5 – Flow accumulation areas.

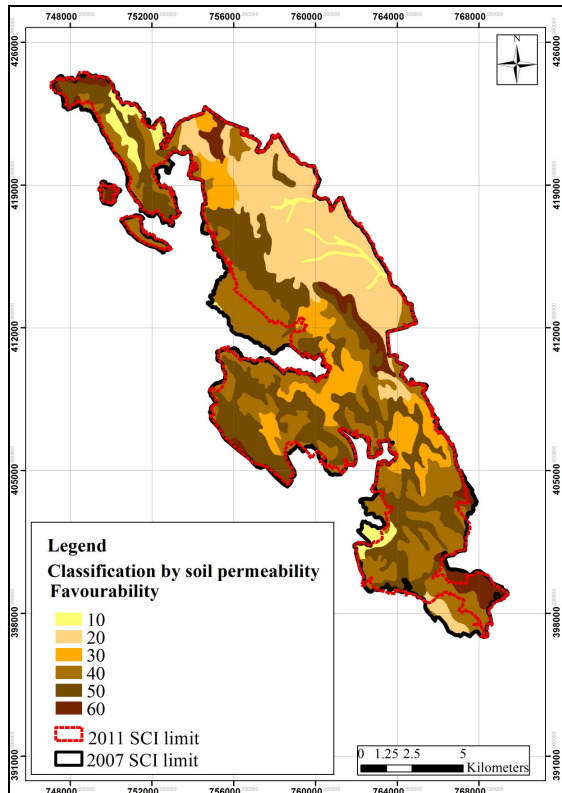


Fig. 6 – Soil texture.

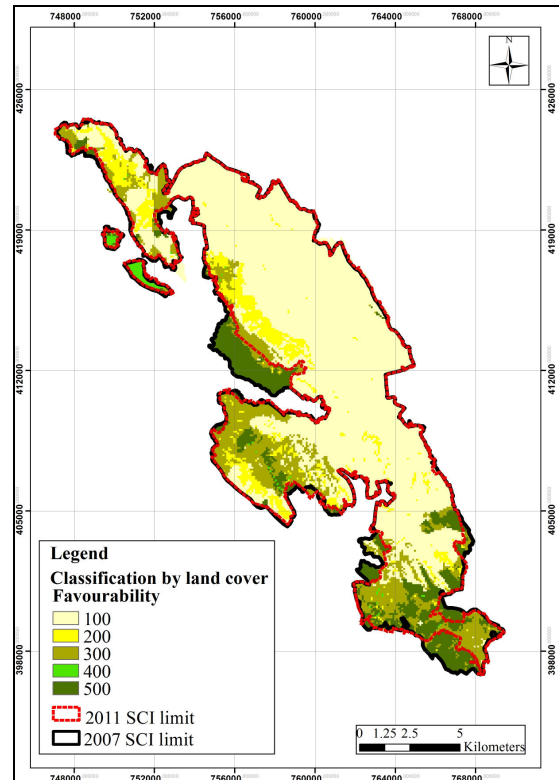


Fig. 7 – Land-use types.

All these criteria were overlapped and analysed within the model and reduced to a single class that represents the favourable areas for ecological corridors implementation.

According to the model results, within the total area of the study of **18,546** hectares and **2,302** hectares of arable land (National Institute of Statistics, 2012) we identified approximately **1,432** hectares with high favourability for ecological corridors planning (Fig. 8). Considering the whole number of criteria in the model and overlapping them we were able to establish a connected network with multiple functions, an aspect that would have been overlooked in case the parameters were treated separately.

5. DISCUSSIONS

The arable land-use in the Măcin Mountains Natura 2000 site shows a high favourability for planning and implementing ecological corridors. Feasibility consists in the existence of various criteria of spatial distribution (Hobbs *et al.*, 1992; Forman, 2006).

The high number of patches of arable land of over **3** hectares allows the implementation of an ecological corridor approximately 20 meters wide which can also be economically efficient. This criterion, alongside surfaces with flow accumulation, the distribution of soils with clay and argyle texture and empty land near roads and rivers completed the model and helped develop a network that, in the end, through an active management can sustain species of community interest (Beier and Noss, 1998; Hinsley and Bellamy, 2000) and diminish the negative impact of agricultural practices (Groot *et al.*, 2009).

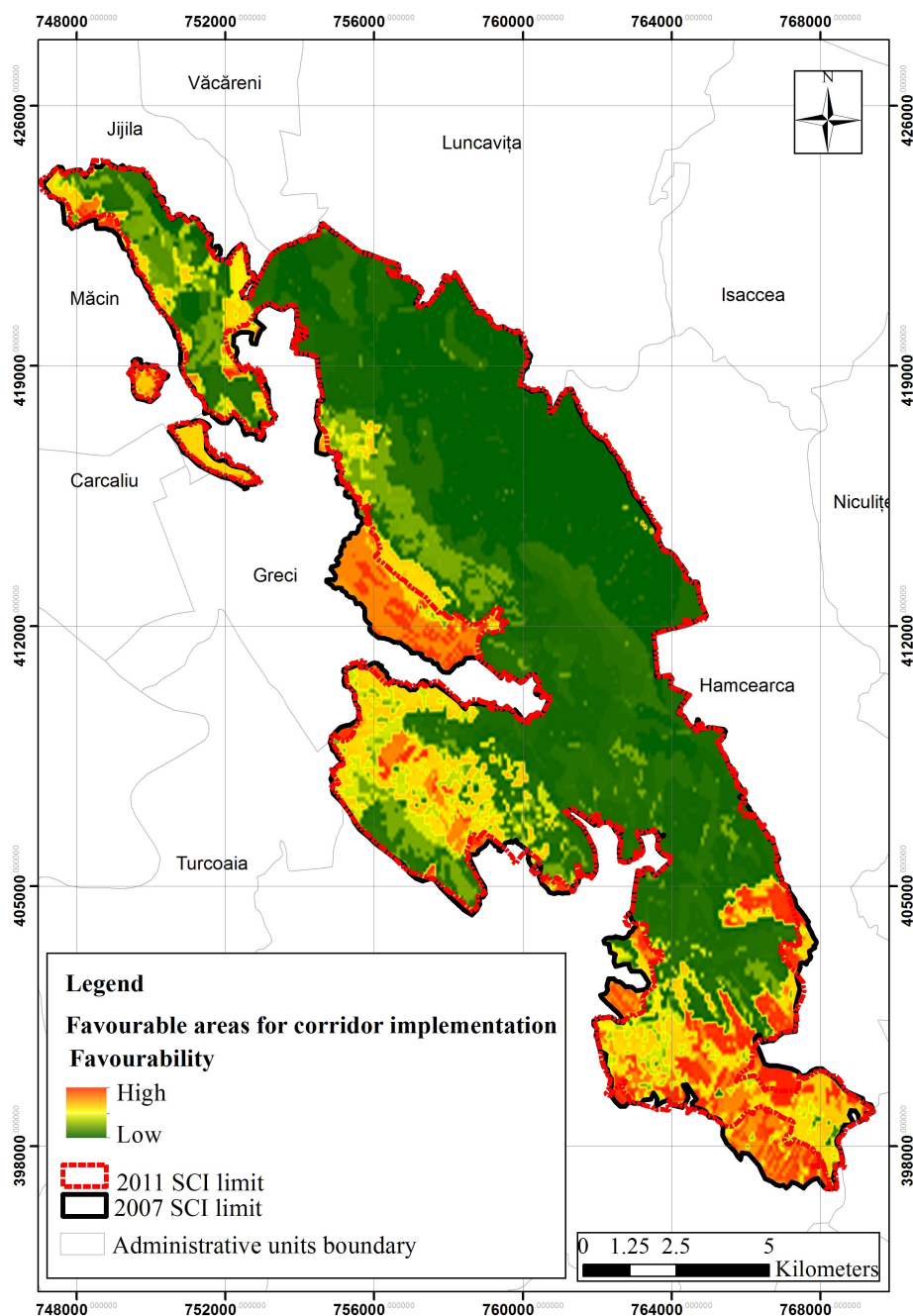


Fig. 8 – Spatial distribution of favourable areas for ecological corridor implementation in ROSCI0123 Măcin Mountains.

The economic component, the financial and legislative instruments of implementation (Bonnin, 2006) together with the social one – through the field owners' availability to develop these ecological corridors on their land – are elements that can dictate the ecological corridors' network complexity (Earnshaw, 2004). The existence of real financial resources, in the implementation and management process, together with possible compensations for farm owners can sustain the conservation objectives in the Măcin Mountains Natura 2000 site (Ioja *et al.*, 2010).

The presented method has the advantage of being applied to other areas and can be improved by adding more criteria, specific to each area. Also, by using this specific method we obtain quantitative results that can be easily interpreted by decisional authorities.

The importance of the study consists in its relevance during the administration process of the protected area, but also for the management of agricultural activities within the sit (Firbank *et al.*, 2008). From a conservation point of view, these ecological corridors can create habitats (Burel and Baudry, 2005; Wehling and Diekmann, 2009) and feeding spaces for species of community interest (Michel *et al.*, 2007), food resources for predators and can enhance the landscape's structural connectivity (Meiklejohn *et al.*, 2009).

The study shows the possibility of a landscape's structural connectivity improvement in a space of high conservative value, threatened by more and more aggressive agricultural practices (Primack *et al.*, 2008). Implementing the ecological corridors will lead to an improvement of arable fields state, through a careful management and by decreasing the negative effect of acidification or diffuse pollution on the soil's fertility level (European Commission, 2011). All of these outcomes can have a positive result on the biodiversity component of the SCI Măcin Mountains (Dallimer *et al.*, 2010; Ioja *et al.*, 2011).

6. CONCLUSION

The implementation of ecological corridors can be considered a proper instrument for conservation planning (Sarkar *et al.*, 2006) and the management of biodiversity threats caused by agricultural practices (Bayne and Hobson, 1998; Firbank *et al.*, 2008). The developed model is applicable to any study area with similar needs and characteristics if the data are available.

The landscape's structural connectivity is often ignored when we discuss the conversion from natural habitats to agroecosystems and it can lead to imbalances of physical and biological processes at an ecosystem level (Taylor *et al.*, 1993).

By developing a method that can locate an ecological corridor network the structural connectivity of an area can be restored, leading the way to improve the functional connectivity species' dispersion and mobility. Applying the method also demonstrates the feasibility of the area for ecological corridors, that take into consideration various criteria and has the advantage of performing numerous functions. The developed tool is applicable to any study area with similar needs and characteristics if the data are available.

For ROSCI0124 Măcin Mountains, creating a system with financial and legislative support that can ease the development of an ecological corridor network can lead to a balanced integration of human activities and conservation objectives of the protected area.

Acknowledgements

The results of this study were obtained during the ongoing of the SOP Environment research project "Studies for the development of the integrated management plan for Măcin Mountains National Park by reviewing and integrating management prescriptions for Natura 2000 sites (ROSPA0073 Măcin – Niculițel and ROSCI0123 Măcin Mountains), including Măcin Mountains National Park".

REFERENCES

- Bayne, E. M., Hobson, K.A. (1998), *The effects of habitat fragmentation by forestry and agriculture on the abundance of small mammals in the southern boreal mixed wood forest*, Canadian Journal of Zoology, **76**, pp. 62–69.
- Beier, P., Noss, R.F. (1998), *Do Habitat Corridors Provide Connectivity?* Biological Conservation, **12**, pp. 1241–1252.
- Bonnin, M. (2006), *Les corridors, vecteurs d'un aménagement durable de l'espace favorable à la protection des espèces*, Natures Sciences Sociétés, **14**, pp. 67–69.

- Burel, F., Baudry, J. (2005), *Habitat quality and connectivity in agricultural landscapes: The role of land use systems at various scales in time*, Ecological Indicators, **5**, pp. 305–313.
- Dallimer, M., Gaston, K.J., Skinner, A.M.J., Hanley, N.A.S., Armsworth, P.R. (2010), *Field-level bird abundances are enhanced by landscape-scale agrienvironment scheme uptake*, Biology Letters, **6**, pp. 643–646.
- Doniță, N., Popescu, A., Băjenaru, B. (2007), *Cercetări asupra vegetației Parcului Național Munții Măcinului*, GEF (UNDP) Project, România.
- Earnshaw, S. (2004), *Hedgerows for California Agriculture, A Resource Guide*, California, USA.
- ESRI (2011), *Geoprocessing with ModelBuilder*, ArcGIS Resource Center.
- European Commission (2011), *European Union Biodiversity Strategy to 2020*, European Union Publication Office, Brussels.
- European Council (1979), *Council Directive 79/409/EEC of 2 April 1979 on the conservation of wild birds*, European Union Publication Office, Brussels.
- European Council (1992), *Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora*, European Union Publication Office, Brussels.
- European Environment Agency (2006), *Europe's biodiversity – biogeographical regions and seas, Biogeographical regions in Europe The Steppic Region – the plains of Europe*, ZooBoTech HB, Sweden, Linus Svensson, **15**.
- Firbank, L. G., Petit, S., Smart, S., Blain, A., Fuller, R.J. (2008), *Assessing the impacts of agricultural intensification on biodiversity: a British perspective*, Philosophical Transactions of the Royal Society (Biological Sciences), pp. 777–787.
- Forman, R.T.T. (2006), *Land Mosaics, The ecology of landscapes and regions*, Cambridge, United Kingdom: Cambridge University Press.
- Groot, J., Jellema, A., Rossing, W. (2009), *Designing a hedgerow network in a multifunctional agricultural landscape: Balancing trade-offs among ecological quality, landscape character and implementation costs*, European Journal of Agronomy, pp. 112–119.
- Hinsley, S. A., Bellamy, P. A. (2000), *The influence of hedge structure, management and landscape context on the value of hedgerows to birds*, Journal of Environmental Management, **60**, pp. 33–49.
- Hobbs, R. (1992), *The Role of Corridors in Conservation: Solution or Bandwagon?* Tree, **7**, pp. 389–392.
- Iojă, C., Pătroescu, M., Rozyłowicz, L., Popescu, V.D., Verghet, M., Zotta, M., Felciuc, M. (2010) *The efficacy of Romania's protected areas network in conserving biodiversity*, Biological Conservation, **143**, pp. 2468–2476.
- Iojă, C., Rozyłowicz, L., Pătroescu, M., Niță, M.R., Onose, D., (2011), *Agriculture and Conservation in the Natura 2000 Network. A Sustainable Development Approach of the European Union*. In I. Global (Ed.), *Agricultural and Environmental Informatics, Governance and Management: Emerging Research Applications*, pp. 339–358.
- Kovar, P., Vassova, D., Hrabalíkova, M. (2011), *Mitigation of Surface Runoff and Erosion Impacts on Catchment by Stone Hedgerows*, Soil & Water Resources, **6**, pp. 5–16.
- Lisec, A., Pintar, M. (2005), *Conservation of natural ecosystems by land consolidation in the rural landscape*, Acta Agriculturae Slovenica, **85**, pp. 73–82.
- Margules, C.R., Pressey, R.L. (2000), *Systematic conservation planning*. Nature, **405**, pp. 243–253.
- Meiklejohn, K., Ament, R., Tabor, G. (2009), *Habitat Corridors & Landscape Connectivity: Clarifying the Terminology*, Center For Large Landscape Conservation.
- Michel, N., Burel, F., Legendre, P., Butet, A. (2007), *Role of habitat and landscape in structuring small mammal assemblages in hedgerow networks of contrasted farming landscapes in Brittany, France*. Landscape Ecology, **22**, pp. 1241–1253.
- Ministry of Environment (2011), *Natura 2000 Standard Dataform. ROSCI0123 Factsheet*, Bucharest.
- Moilanen, A., Wilson, A.K., Possingham H.P. (2009), *Spatial Conservation Prioritization. Quantitative Methods and Computational Tools*, Oxford University Press.
- Pătroescu, M. (1987), *Succesiunea zonelor și etajelor de vegetație din R. S. România*. Sinteze geografice, pp. 191–198.
- Pressey, L.P., Cabeza, M., Watts, M.E., Cowling, R.M., Wilson, K.A. (2007), *Conservation planning in a changing world*, Trends in Ecology and Evolution, **22**, pp. 583–592.
- Primack, R., Pătroescu, M., Rozyłowicz, L., Iojă, C. (2008), *Fundamentele conservării diversității biologice*, București, Edit. AGIR.
- Sarkar, S., Pressey, R.L., Faith, D.P., Margules, C., Fuller, T., Stoms, D.M., Moffett, A., Wilson, K.A., Williams, K.J., Williams, P.H., Andelman, S. (2006), *Biodiversity conservation planning tools: Present Status and Challenges for the Future*, Annual Reviews Environmental Resources, **31**, pp. 123–159.
- Statistics National Institute (2012), *2010 General Agricultural Census – Macroregions North-East and South-East*, Statistics National Institute Publication Office, Bucharest.
- Straus, S., Bavec, F., Bavec, M. (2011), *Organic farming as a potential for the development of protected areas*, Acta Geographica Slovenica, **51**, pp. 52–160.
- Taylor, P. D., Fahrig, L., Henein, K., Merriam, G. (1993), *Connectivity is a vital element of landscape structure*, Oikos, **68**, pp. 571–573.
- Tudor, A. C., Iojă, C.I., Pătru-Stupariu, I., Niță, M.R., Hersperger A.M. (2014), *How successful is the resolution of land-use conflicts? A comparison of cases from Switzerland and Romania*, Applied Geography, **47**, pp. 125–136.
- Wehling, S., Diekmann, M. (2009), *Importance of hedgerows as habitat corridors for forest plants in agricultural landscapes*, Biological Conservation, **142**.

Received January 28, 2015