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INDICATORS USED IN ASSESSING THE FRAGMENTATION GENERATED BY THE TRANSPORTATION INFRASTRUCTURE ON THE HABITATS OF A COMMUNITARIAN IMPORTANCE IN ROMANIA

Maria Pătroescu, Laurenţiu Rozylowicz, Ioan Cristian Ioja

Key words*: ecoducts, ecological effects, fragmentation, habitats, transport infrastructure, Romania.*

Résumé: Indicateurs utilisables dans l'évaluation de la fragmentation des habitats communautaires par l'infrastructure de transport.Les effets écologiques déterminés par l'infrastructure feroviaire et routiere sur les sites d'importance communautaires avec des habitats protégés n'ont pas étè évalués jusqu'à présent en Roumanie. En suivant les travaux du Seiler (2003), qui a étudié cing categories des effets du transport sur les habitats, nous avons analisée la rélation habitats-infrastructure de transport au niveaux national, mettant en relation les réseaux de transport et les modalités de connexion des ceux réseaux avec les sites d'importance communitaires contenant des habitats protégés. Après, nous avons hiérarchisés dans le cas de la Roumanie des indicateurs utilisables dans l'évaluation du risque de la fragmentation des habitats ou de la destruction des habitats, mais aussi pour l'évaluation des coûts d'environnement et aménagement régional.

1. Introduction

The simple presence of the infrastructure networks can alter the ecosystems. For example, the roads and the railways can influence the aquatic ecosystems through the contamination with heavy metals, hydrocarbons, salts etc. or can generate changes in the structure, functionality and biological diversity of the terrestrial ecosystems they pass through.

Any development of a network automatically determines the social development of the region, so the negative effects become even more complex, enhancing synergic effects that accumulate from the construction period to the exploitation one. One of the most important effects is the **habitats fragmentation** (Seiler, 2003).

Data on the possible *primary ecological effects* caused on the habitats by the road and railways infrastructure are usually obtained empiricalyl, on a local scale, derived from the observations achieved for a single road or railway thoroughfare, for a small group of ecosystems or habitats. Seiler (2003) groups *the ecological effects* caused by the road infrastructure in five categories (fig. 1):

1. **Habitats loss**: roads and railways construction involves the loss of some surfaces from the habitats they cross. Thus, physical effects appear that in the end contribute to the fragmentation of the habitats crossed by roads and railways.
2. **Perturbation**: roads, railways and traffic determine physical, chemical and biological pollution of the environment, thus reducing habitats favourability for most of the plant and animal species in an area wider than the one occupied by the infrastructure itself.
3. **Corridor effect**: roads and railways margins, especially when they hold shrubs and or trees, represent wildlife refugees, new habitats or passage corridors
4. **Mortality**: traffic causes mortality of many animals that are crossing the transportation routes or using their margins as habitats. The number of collisions increases directly with the motion speed and traffic.
5. **Barriers**: habitats fragmentation is given mainly by the barrier effect produced by the transportation routes on the terrestrial species, especially those that cannot fly.

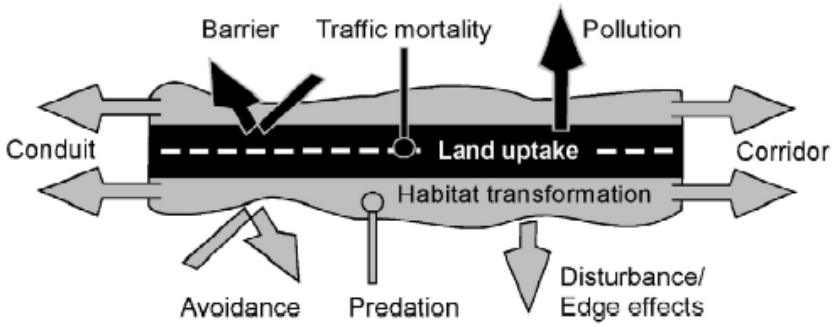

Fig. 1 – Pattern representation of the five primary ecological effects of the infrastructure on the environment: a) habitats loss and transformation; b) perturbation caused by pollution and edge effect; c) barrier and rejection; d) mortality caused by traffic and predation stimulated by the presence of some modified habitats that do not offer protection to the species and the corridor or pipe effects. These effects lead most often to the habitats fragmentation (after Seiler, 2003)

2. Habitat diversity and their relation with the transport infrastructure in Romania

It is impossible to evaluate the ecological effects without considering the type of landscape that the infrastructure is crossing. Also, the roads and the railways belong to a network, the effects of a sector being synergic with those of the entire structure. *Fragmentation is defined as being the splitting of a larger area into small fragments by breaking the functional connections that exist between these fragments.* The fragments can have dimensions that cannot maintain the habitats functions that they are part of. Assessing the fragmentation degree can be achieved very simply through *the density of the communication routes on the habitats type,* to which you can add information related *to traffic numbers, speed, category of route, the type of landscape crossed.* The areas without any communication routes are considered ecological security areas, with a very important biodiversity from the conservation policies point of view.

About 90 types of natural habitats of a communitarian importance are found in Romania (Doniță et al. 2005), for which reason they have been declared Natura 2000 sites. The simple presence of the infrastructure networks in Romania can alter the health state of the habitats and species.

Most often, in different moments of their existence (construction, maintenance, closure etc) they lead to the *habitats fragmentation*. The territorial transportation existing in Romania induces direct and indirect impacts in the environment, with different effects from aspects like the area of action and unbalances intensity they generate into natural habitats.

Studies on the relationships *density – roads – species* have been accomplished at a global level for several species. Thus, Mladenoff et al. (1999) cited by Primack (2006) observed that the wolves packs did not established territories in Minnesota, where the roads density is higher than 0,45 km/km^2. Other important species are also affected by the fragmentation the routes determine, species like the lynx avoiding to establish territories even in areas with county roads only. The fragmentation can be reduced by a series of measures out of which the construction of *ecoducts* is to be mentioned.

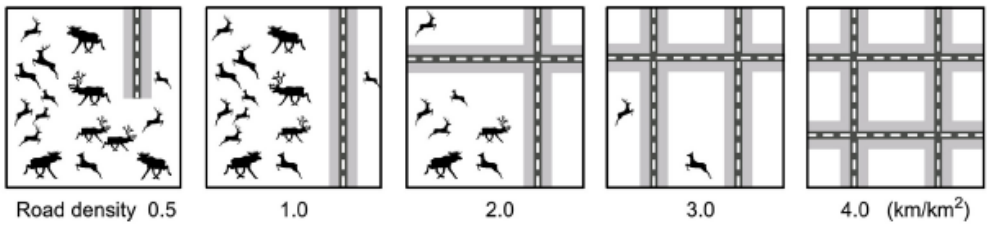

Fig. 2 – The pattern of habitats loss as a consequence of the increased density of transportation infrastructure (after Seiler 2003).

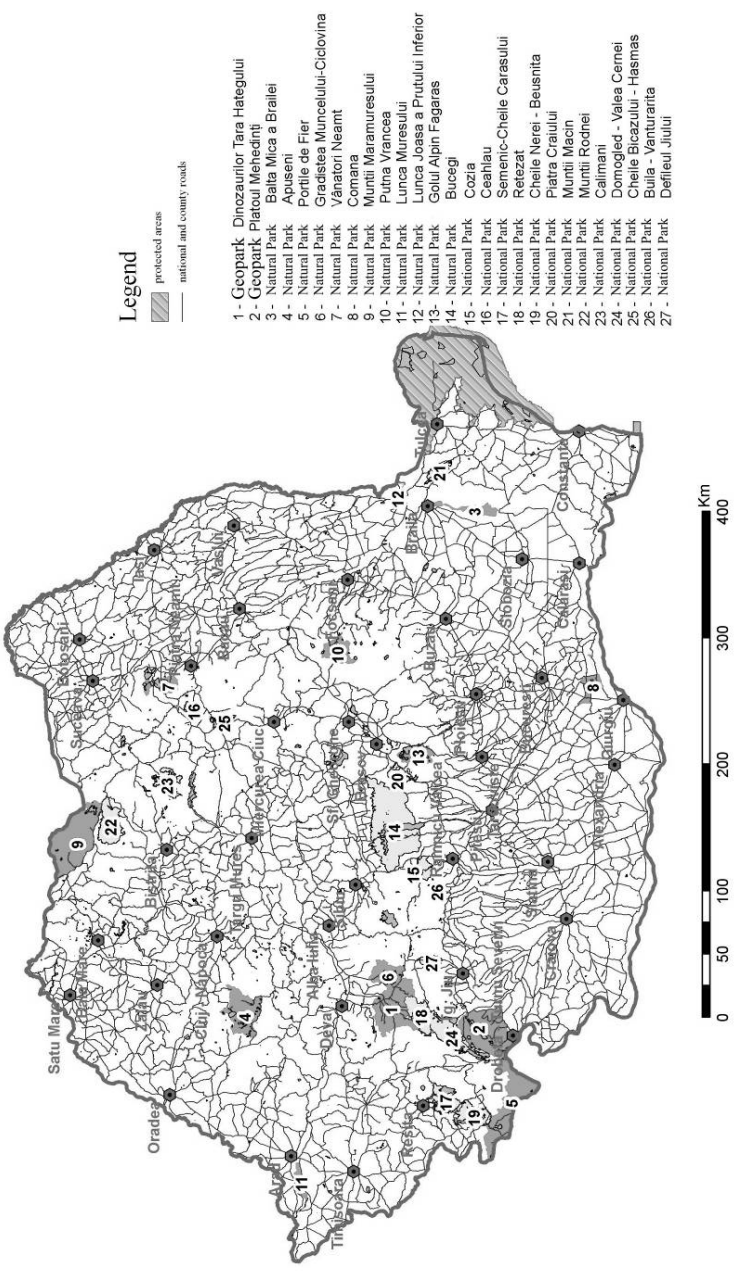

Fig. 2 – Spatial distribution of national and county roads in Romania in relation with protected areas

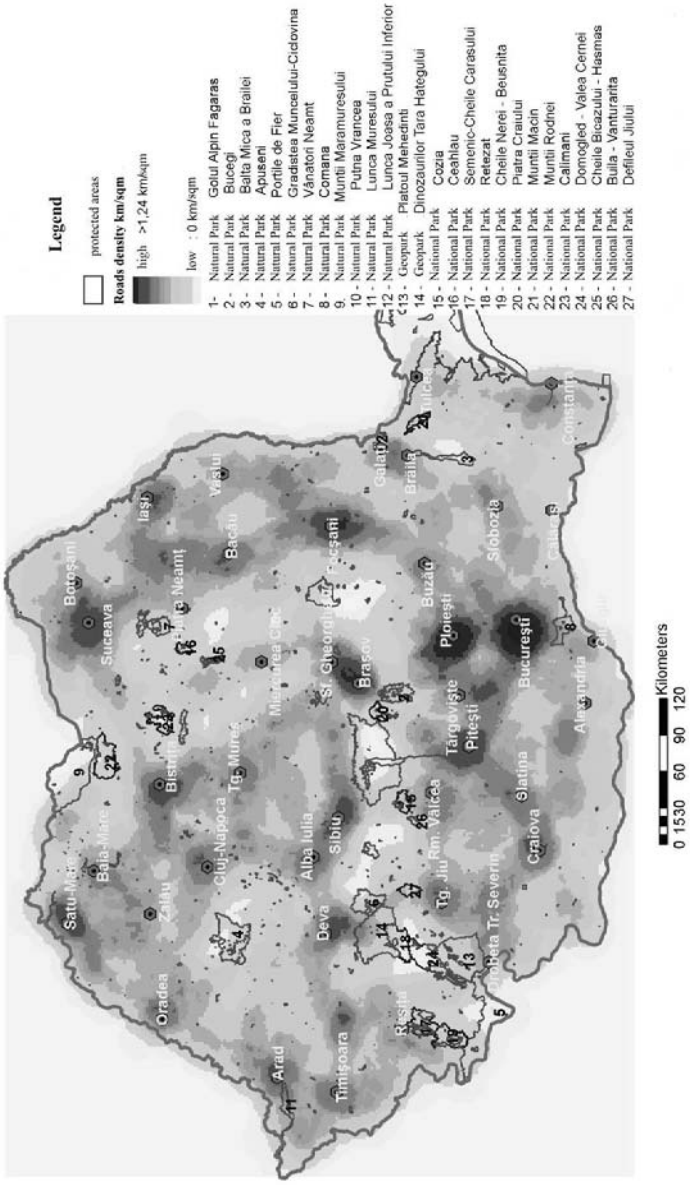

Fig. 3 – Infrastructure connectivity nodes a in relation with protected areas

Table no. 1

Possible indicators to be used in assessing the habitats fragmentation due to transportation infrastructure at national, regional and local level (EEA, 2000)

Indicators	Scale	Utility	Frequency for determination
Density of infrastructure	National Regional Local	Evaluation of habitat fragmentation, especially forests	once, periodic
Area between infrastructure	Regional National	Description of habitat fragmentation	once, periodic
Fragmentation index – length of infrastructure/surface of habitat occupied by ungulates	National	Evaluation of ungulates populations	once, periodic
Indicators	**Scale**	**Utility**	**Frequency for determination**
Distance by constructions	National	Monitoring habitats at national level	Annual
Number of intersections with regional bio-corridors	National Regional	Evaluation of habitat permeability	once, periodic
Length of over posing of infrastructure and protected areas	Regional	Evaluation of losing of natural protected areas and evaluation of development strategies	once, periodic
Length of over posing of infrastructure and protected areas without ecological works (safety works for wildlife)	National	Evaluation of development strategies	Annual
Number of habitat patches with and without infrastructure	National, European	Description of habitat fragmentation	once, annual
Ratio between of habitat patches with and without infrastructure	National European	Description of habitat fragmentation	once, periodic
Affected surface of bio-corridors	National Regional	Evaluation of bio-corridor health status	once, periodic
Density of infrastructures related with traffic intensity	Regional National	Elaboration of scenarios for environmental changes	Periodic
Average distance between area with same land use category or similar habitats	Regional National	Monitoring the species and habitat isolation fenomena	Periodic
Average number of habitat units who is neighbour with habitat with high biodiversity	Regional, national	Quantification of spatial context	Periodic
Length of communication routes parallels (at a maximum 1 km distance)	Regional National	Measuring the multiplied fragmentation	Periodic
Land percent occupied by infrastructure from country	National	Description of habitat fragmentation	once, periodic
Area of protected areas with infrastructure at least at 5 km by centre of protected area	European	Evaluation of development strategies	periodic
Number of protected areas with infrastructure at least at 5 km by centre of protected area	European	Evaluation of development strategies	periodic

In Romania, the analysis of the habitats-infrastructure relationship permitted to obtain information on the habitats fragmentation and degradation degree, on categories of environments. The *mountainous* and *Sub-Carpathian environments* hold a wide diversity of habitats, most of them of a communitarian importance, included in protected areas of different categories (Fig. 2). Generally, it is possible to notice that the areas with high density of transportation infrastructure are located at a large distance from the protected areas so they cannot affect directly the habitats of a communitarian importance (Fig. 3). Due to the cumulative impact of the anthropogenic activities, the plain and plateau environments have lost parts of their biodiversity and also most of their initial habitats. An example for this category of environment is the one of the halophyle and gypsum continental steppes communities that are the most diverse but also the ones with the highest exposure to degradation due to the high density of the road thoroughfares (highways, European, national, county, agricultural roads) and railways.

3. Possible indicators to be used in assessing the habitats fragmentation

The use of Geographical Information Systems as a tool for the habitats fragmentation modelling is not the only method to analyse this process. The most complete information is provided by the indicators that can quantify the existing information or can be used for the future dynamics forecast.

The indicators used for the habitats fragmentation due to infrastructure are relatively less used, the studies being still pretty rare (Table no 1). From EU contries, only in the Netherlands these indicators are adopted by the official authorities.

4.Conclusions

Infrastructure increasing diversity and density enforces the need for calculating the indicators that are usually used in assessing the habitats fragmentation both at a national and a regional level.

The indicators values shall be used in assessing the risk of losing habitats of a communitarian importance and in establishing the priorities of action that aim at reducing the losses at national and regional level.

The stage of habitat fragmentation determined by the road and railway routes should be quantified and used in forecasting the restoration costs of the environment and the rehabilitation costs of the transportation infrastructure during its entire existence.

The corridor effect of the transportation infrastructure should be monitorised using the Geographical Information Systems.

The categories of quantified indicators should be the starting point of the projects focusing on regional and national territorial planning and development.

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