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A proposal towards the incorporation of spatial heterogeneity into animal distribution studies in Romanian landscapes

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Abstract. Landscape ecology is a relatively new and continuously developing field of ecology, whose primary focus is the spatial and temporal heterogeneity of the environment and ecological processes. It has been widely adopted by animal ecologists as well. In this paper we present arguments regarding the need of including the landscape ecological approaches in the study of the distribution of organisms in Romania. Based on the recent developments, we present three conceptual landscape models, *the fragmentation model* (the most frequently used), *the variegation model,* and *the continuum model*. We argue that as first step, the fragmentation model should be applied since it allows a relatively quick survey of a larger area. After the main landscape elements influencing the habitat use of the organism in study were identified using this approach, we propose the variegation or the continuum models at smaller scale, depending on the studied organisms, as a complementary tool for the fragmentation model. Whatever the chosen landscape model / approach might be, it is extremely important to clearly *define what is considered to be a landscape* (details about the delimitation of patches and / or some measurable parameters of the spatial heterogeneity) in the study and *what is the spatial scale considered*. The structure of many of our semi-natural landscapes will certainly change in the new, "European Union" era. Without high quality and site-specific data, it will be impossible for engineers and decision makers to incorporate ecological aspects into urban planning and decision making regarding the infrastructural, agricultural or other developements and use of natural resources.

Key-words: landscape ecology, spatial distribution, animals, Romania, conservation

"Biodiversity is not a "set aside" issue that can be physically isolated in few, or even many reserves. All parties to the biodiversity debate –environmentalists and utilitarians- have had this same narrow view and have disagreed only on how much to reserve and where! I think that we need to put reserves and corridors and heroic megafauna in perspective. We must see the larger task – stewardship of all *the species on* all *the landscape with every activity we undertake as human beings – a task without spatial and temporal boundaries"*

(J. F. Franklin, 1993)

Introduction: why landscape ecology?

Landscape ecology is a relatively new and continuously developing field of ecology. Its primary focus is the spatial and temporal heterogeneity of the environment and ecological processes (Forman 1995, Wiens 1992, 2002, Turner 2005). More recently, this approach has also become popular among animal ecologists (see the reviews of Dunning et al. 1992, Mazerolle & Villard 1999, Hunter 2002, Fischer & Lindenmayer 2006). As it was noted by Hanski (1998) "the essence of spatial ecology is that the spatial structure of ecological interactions affects populations as much as do average birth and death rates, competition and predation". The spatial scale at which the landscape is considered by animal ecologists varies greatly, according to the life history, development stage and habitat requirements of the studied organism and from study to study. As Dunning et al. (1992) have noticed, the landscape is a mosaic of habitat patches "intermediate between an organism's normal home range and its regional distribution". According to other animal ecologists (reviewed by Fischer & Lindenmayer 2007) the landscape area may range between 3 – 300 km^2.

The aim of this opinion article is to provide arguments on the necessity of incorporating the spatial heterogeneity in explaining the distribution of animals in Romania. We will focus on three landscape approaches, although we recognize that we are looking at only half of the picture. The meta-population approach may be probably the "arena" where the populations and landscapes are dynamically linked. But as noted by Baguette (2004), metapopulation ecology has a well developed theoretical background without being commonly applied (or applicable) in conservation. The landscape approach for which we call in this opinion article may help identifying the critical habitat/micro-habitat and landscape elements from which the persistence of populations depends. Habitat loss and fragmentation are the most obvious (and until it passes a certain point, the most reversible) causes of the loss of biodiversity and population declines of many animal species in Europe. Human settlements (especially cities and suburban villages) are continuously extending, the infrastructure (especially in transportation) is developing, and the area occupied by agricultural lands is quickly increasing. Many wetlands are impacted mainly by pollution, regulation (rivers), drainage (marshy areas, floodplains, temporary ponds), destruction of the littoral zones (lakes, permanent ponds) and massive introduction of (non-native) organisms (e.g. fish, aquatic plants). These impacts change the quality of habitats, the structure of the landscapes and ultimately affect the animal communities (resulting in the loss of populations at local and/or landscape scale). Because experimental studies regarding the effect of environmental factors on the population dynamics of many species at landscape level is practically impossible, exploratory field studies, combined with theoretical models, can be used to predict the effects of landscape changes. Landscape ecology uses multivariate statistics (regression modeling, principal components analysis and others) to identify important variables (habitat and landscape features) that influence the distribution of a species or community at landscape scale. Without this, scientifically based management plans for populations and communities are hard to be realized. The specific questions that researchers who study the spatial distribution of animals address are:

- How does the spatial heterogeneity affect their distribution?
- What spatial (landscape) elements are important and at what spatial scales?
- Are there species-specific differences in the sensitivity to the different spatial (habitat and landscape) elements?
- Is there a threshold at which a change in the configuration of a landscape that creates spatial heterogeneity (that may increase the biodiversity at the landscape level) becomes fragmentation (that may decrease biodiversity)?
- How do the different (sympatric) species perceive the landscape and its modifications?
- How much does a particular habitat contribute to the maintenance of populations at landscape scale?
- Which landscape elements represent corridors (migration, dispersal) for different species?
- How the source-sink habitats are distributed and how important are they for the maintenance of species at landscape scale?

Further and more complicated questions are related to the effect of habitat and landscape features on the inter- (i.e. predation, competition) and intraspecific (reproduction, competition) relationships between organisms. Dunning et al. (1992) provide many examples on how the different landscape processes affect such relationships within and between different animal groups.

There may be a “landscape effect” on the results gathered for a particular species: the same problem (hypothesis or question) and methodology may provide different results for a given species in different landscapes due to possible local adaptations and differences between landscapes. This possibility highlights the importance, of carrying out studies in landscapes that have different structures and are poorly known, even if the species explored are well studied in Western Europe.

Also, landscape studies are important in prioritizing conservation activities. Human development cannot be stopped, but ecologists and landscape planners can make development proposals more sustainable if they incorporate landscape ecology into the planning and decision making processes. This will maintain vital ecosystem services for humans (climate stabilization, increased welfare etc.) and habitats for wildlife (Fischer et al. 2006).

Applying three landscape conceptual models in Romania

The cultural and natural landscapes of Romania (and other Central and Eastern European countries) represent an ideal target for landscape-scale approaches, and management for conservation would become more efficient with such studies. Romania has five biogeographycal regions (EEA 2001) with many natural and seminatural ecosystems supporting highly diverse animal communities. The traditional land use practices in this part of Europe maintained over centuries created small–scale perturbations/patchiness in the landscape, increasing landscape heterogeneity and ultimately leading to a high level of biodiversity (Palang et al. 2006). This spatial heterogeneity and the (animal) biodiversity linked to it are still not adequately explored. Moreover, landscape elements that dissappeared from many parts of Europe are still well represented in Romania, including species rich meadows and pastures, extensive semi-natural woodlands, traditionally maintained orchards, wood pastures and wetlands. Europe lacks information about the biodiversity and / or its status in Romanian landscapes, as demonstrated by many recent "pan-European" and even Central and Eastern European reviews from which data on the Romanian landscapes are missing (i.e. Palang et al. 2006 for the rural landscapes, Billeter et al. 2008 for biodiversity, Houlahan et al. 2000 for amphibians, Mikusinski 1995 for the black woodpecker) or the data are said to be largely absent (for example Green et al. 1997 for the corncrake).

The adoption of the EU land use practices in Romania, as a result of agricultural policies that favor intensification and abandonment, will probably result in an unprecedented, massive elimination of native wildlife populations and species (Cremene et al. 2005, Schmitt & Rákosy 2007). Animal ecologists from Romania need the methods and resources that would enable them to quantify the present situation in a way that will enable further changes in the landscapes, communities and populations to be tracked.

There are many new developments in population/metapopulation theory, island biogeography and landscape ecology that represent useful modern insights about how hypotheses should be formulated, data gathered, analysed and interpreted for landscape ecological studies (Sandersen et al. 2002, Wiens 2002, Fischer et al. 2004, Fischer et al. 2006, Girvetz & Greco 2007, Fischer & Lindenmayer 2007, Lindenmayer et al. 2007, Cumming 2007). It would be worth trying to adopt locally the range of different conceptual models currently used and proposed for the exploration of the factors influencing the spatial distribution of animals. Fischer et al. (*in press*) defined the conceptual landscape model as a theoretical framework that provides the terminology needed to communicate and analyze the way of how organisms are distributed through space. A conceptual landscape model also can be used to visualize landscape pattern (Fischer et al. *in press*). Below we will summarize three conceptual models, wit notes on their aplicability in the landscapes from Romania.

The fragmentation model (the „patchy landscape" approach)

The classical theory of *island biogeography* developed by MacArthur & Wilson (1967) explain the distribution pattern of species richness in the oceanic islands considering their size (area) and distance from mainland (isolation from the source populations). In this model the islands are the habitable patches that are surrounded by the sea, that is unhabitable for given organisms. This theory was later adopted to terrestrial habitats (Usher 1984, Haila 2002) by considering the landscape as the totality of *patches* (islands) of different type, size and arrangement (fig. 1).

As in the island biogeography theory, patches are the landscape elements that can be distinguished from their surroundings and relatively easily visualized on maps and / or identified by eye in the field (and thus are primarily human defined elements) (Fischer et al. 2004). From the perspective of the studied organism those landscape elements that are not hospitable are called the *matrix*, whereas the habitable patches are considered as *habitats* (Dunning et al. 1992, Forman 1995, Mazerolle & Villard 1999). The matrix may be *permeable* and thus may represent „green connecting corridors" between the habitat patches or *impermeable*, when the mortality rate is high when the organisms cross them, contributiong to fragmentation. A corridor may or not contribute to natality (Forman 1995). Girvetz & Greco (2007) emphasized that the structure otf the patches in the landscape and the contrast between a patch and the surrounding matrix will be always dependent on the perceptual abilities and behavioral responses of the studied organism.

Classical metapopulation theory also views the landscape consisting of local populations in suitable habitat patches (Levins 1970) (later, parameters regarding the size, quality, isolation were also included in the models), every patch being inhabited by a population, with a certain probability of extinction and (re)colonization via dispersal of individuals through the matrix (Hanski 1998).

According to the spatial arrangement and the total cover of these patches /landscape elements, animal ecologists usually distinguish the following aspects of the landscape structure: (i) *landscape composition* - the type, number of patches and their spatial extent in the landscape, and (ii) *landscape configuration* - the spatial arrangement of the patches relative to each other (Turner 1989, 2005) (fig. 1). As Figure 1 shows, the negative impact of infrastructural and agricultural developements on the animal

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populations may be reduced if the spatial arrangement of the landscape is not disturbed by these interventions. A similar fragmentation situation that the one presented in the Figure 1.a. will appear if the highway that is planned to cross the Saxon area of Transylvania will be constructed (Photo 1).

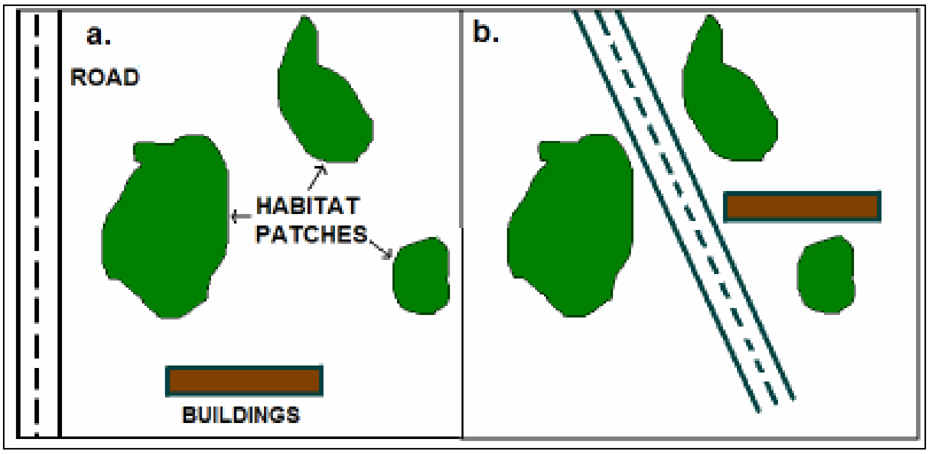

Figure 1. The presentation of a landscape using the *fragmentation* approach. The green spots represent those landscape elements that are used as *habitats* by a certain group of animals. The road and building represent the *impermeable matrix* (see text). The *landscape composition* is the same in both landscapes (i.e. both „a" and „b" landscapes have the same types of patches in the same amount and size) but the *landscape configuration* (i.e. the the spatial arrangement of pathes) differs. The „a" landscape is more "friendly" because it allows interpatch migrations and dispersal for the organisms, whereas the configuration of the „b" landscape represents a case of fragmentation, not allowing movements between the habitats (thus having an isolation effect on local populations).

The Saxon area of Transylvania is extremely rich in species and currently represents unfragmented habitat for many large carnivores (*Canis lupus*, *Ursus arctos*) (Photo 1). Due to these values, an area of 85 374 ha was recently proposed as a Natura 2000 Site of Community Importance (Ministerial Order 776/2007). The route of the highway, according to the current plans, will dissect the "core" of the Natura 2000 Site, not taking in consideration its biodiversity and population densities of large carnivores (Photo 1). There are possible solutions for this problem (similar to those presented in fig.1). We hope that the proposed protection status of the area, the scientific team working for its acceptance and nevertheless the international recognition of this area will make the decision makers reconsider their actual plans and to find other, more environmental friendly ways through which the catastrophic impact of the proposed highway on biodiversity can be avoided.

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Photo 1. The infrastructural developement may lead to catastrophic consequences on the natural systems of Romania if the recommendations of wildlife ecology scientists are ignored. The above photo shows a landscape in the Saxon area of Transylvania that will be severely impacted if the currently planned highway will be constructed here. In this landscape many footprints of bears and an active den of wolves were identified by TH and CM. Picture taken in Stejăreni Valley, where the highway is planned to be constructed, in 2006 (T. Hartel).

Landscape complementation refers to the situation when the resources of organisms are distributed in more than one patch because the resource requirements of these organisms apply for more than one patch. High landscape complementation occurs when the organisms find these patches close to each other (Dunning et al. 1992, Turner 1989, 2005) (fig. 2, Photo 2).

A typical example of organisms whose spatial distribution and density can be predicted by the landscape complementation are raptors. For these birds, the carrying capacity of any habitat is set by two main resources, feeding and nesting sites: whichever is most restricted is likely to limit breeding density (Newton 2002). Our personal data (Moga & Hartel and Demeter *unpublished*) shows that the density of common buzzards (*Buteo buteo*) can be well predicted by landscape complementation. Their density is high in the landscapes from Târnava Mare (Saxon area of Transylvania), where the landscape is a mosaic of alternating forests and open lands with a high diversity of land use patterns (Photo 2a, b – this corresponding to the situation presented in fig.2a) whereas in the Ciuc Basin (Eastern Transylvania), the buzzards are restricted to the marginal areas between the basin and the forest – open land ecotones (Photo 2b, c, - corresponding to the situation presented in fig.2b).

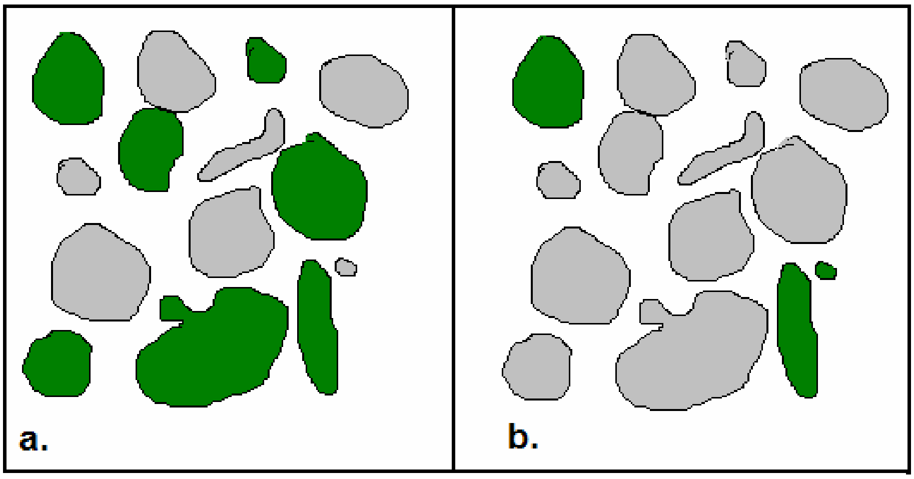

Figure 2. The visualization of *landscape complementation* with two resources (showed here with gray and green spots). Many organisms depend on more resources that may be patchily distributed in the landscape. When these resources are in high density and close to each other (the landscape having a high complementation), larger populations may establish (a). When one of the resources is lacking or is poorly represented, this may limit the number of individuals using the landscape (b). This model suggests that the conservation of organisms having complex habitat and resource requirements may not be possible through conserving only one habitat (resource). The drawing was inspired from Dunning et al. (1992).

Pond breeding amphibians also requires a high landscape complementation for their persistence because they depend both on the quality and availability of breeding, feeding and overwintering (the last two being usually terrestrial habitats) habitats (see for example Hartel 2008a, b). The *fragmentation model* was and still is the most frequently used in the analysis of the spatial distribution of animals (reviewed by Fischer et al. 2004), and due to its conceptual simplicity is the most accessible for Romanian researchers. Patches frequently used in this approach are the major land cover types (i.e. forest cover, pasture cover, arable land cover, human settlement cover, wetland cover, road cover etc.). The fragmentation approach is widely usable in many parts of Western Europe, where the human impact on landscapes created clearly distinguishable patches; moreover, the intensive land use practices make the binary view of the landscape (i.e.

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habitat *versus* matrix) easier to apply in those landscapes. It is highly probable that in the intensively used landscapes, the different patches (for example the forest patches) are used as refugia by different organisms whereas others are avoided (crops or intensively used grasslands). Moreover, this model can be applied to organisms that depend on patchily distributed resources that are easily delimited by the human perspective.

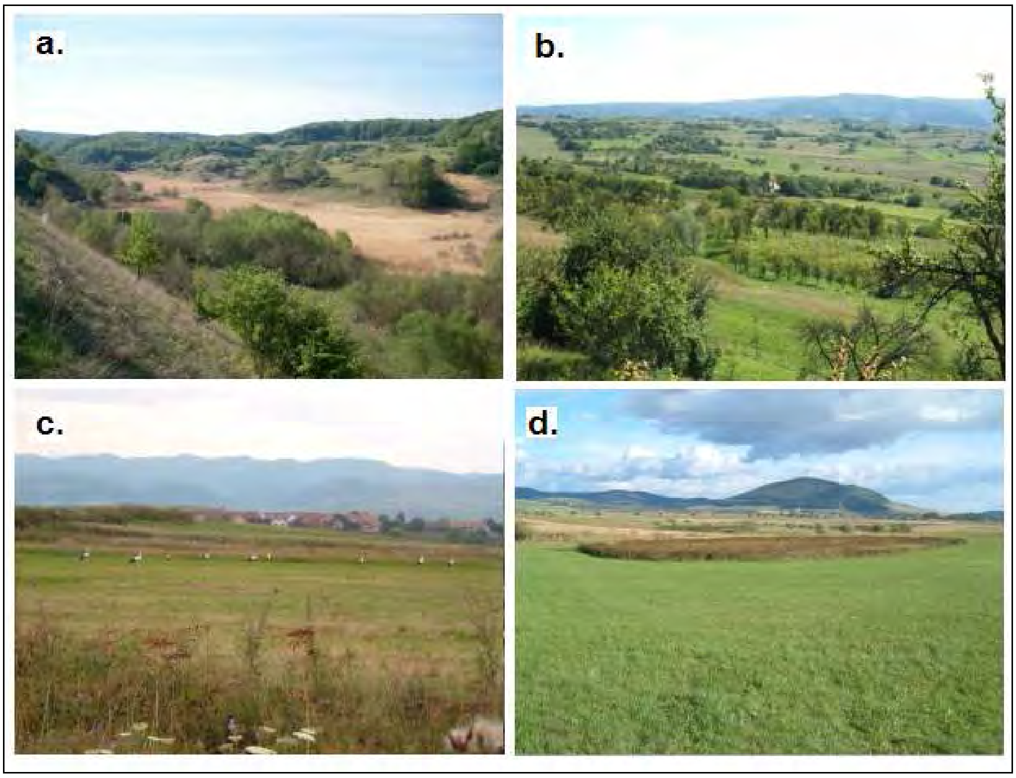

Photo 2. Landscapes from the Saxon area of Transylvania (a, b) and the Ciuc Basin – Eastern Carpathians (c, d) are very different in their structure, geomorphology, climate and history of human impact. The Saxon landscapes have large amouts of forest cover, narrow valleys, are very complex in their structure, the traditional land use patterns created a high spatial heterogeneity. The landscapes of Ciuc are wide, open and relatively flat, lack forests in the lowest area of the basin but the area has a rich hydrography wich increases local biodiversity. Both landscapes harbor their particular and unique biodiversity. Species/groups well represented in Târnava are scarcely represented in Ciuc (many anurans, woodland birds) but others are better represented in Ciuc (large branchiopods, some anurans, white stork). Other species (i.e. corncrake) are equally well represented. In terms of landscape complementation from the perspective of the birds of prey (i.e. *Buteo buteo*) the Saxon landscapes have higher complementation than the landscapes from Ciuc. Pictures taken by C. I. Moga, T. Hartel (Saxon landscapes) and L. Demeter (Ciuc basin).

Although it has many weak points (see below), this is the approach that we recommend to be adopted as a first step in landscape-scale analysis in Romania because it can be applied relatively easily at larger scales (in the condition when we have no data at all for the distribution of the majority of animal species and groups) and may help in formulating further hypotheses regarding the ecological factors influencing animal distribution and population processes (thus, further conceptual models can be applied in this base). The fragmentation approach was first used in Romania in the middle section of the Târnava Mare River and the Ciuc Basin to investigate the relationships between the habitat and landscape structure and the pond use by amphibians (Demeter et al. 2006, Hartel et al. 2006, 2007, Hartel et al. 2008a). These exploratory studies showed that the fragmentation approach may provide information about species specific differences on the habitat and landscape elements for different amphibians in the Saxon area of Transylvania and the Ciuc basin.

The variegation model

McIntyre & Barrett (1992) recognized that the fragmentation approach is too simplistic to be applied in all areas. For example there may be gradual changes in *vegetation cover* types i.e. different types of grasslands and grassland-woodland „transitions" (ecotones), making the delineation of patches (*sensu* those used in the fragmentation model) difficult. Lindenmayer et al. (2003) used data on birds in southeastern Australia to illustrate that a wide range of bird responses to habitat modification may be overlooked if the fragmentation model is used. A similar situation was found in the cultural landscapes of the Saxon region of Transylvania (Târnava Tableland) (Moga *unpublished*) (Photo 3a, b). The area currently is a mozaic of forested- and open habitats. In the adjacent valleys of the Târnava Mare River, the area between the forest edges is usually a gradation between the grassland and forest, so the clear delineation of these two landscape elements (though applying the fragmentation approach) is difficult (Photo 3a, b). These transition zones may contain trees and/or shrubs that may be grouped or scattered (woodpastures), hedgerows and riparian forests. These transitional landscape elements often harbor a mixture of species of these two habitats (i.e. grassland and forested areas). Many typical forest bird species are relatively uniformly distributed across this transitional areas (Moga *unpublished results*). The studies that aim to explore the extent, dynamic and species richness of these transitional landscape elements are very scarce in Romania. This is an unfortunate situation because these areas are likely to be among the first to dissapear when land use intensification occurs.

The continuum conceptual models

Fischer et al. (2004) and Fischer & Lindenmayer (2006) recognized the need for „a conceptual model that creates an explicit link between ecological processes and species distribution patterns" and outlined the importance of the *continuum model* (*contour model*) in faunal studies. They noticed that this model can complete the fragmentation model by highlighting potential additional ecological factors that affect the distribution of animals in the landscape. The *continuum model* proposes a focus on the spatial distribution of four key resource and environmental gradients: (i) food, (ii) shelter, (iii) space and (iv) climate. The spatial distribution of the studied organism may be linked to the gradual distribution of these four variables. This model also recognizes that every species has its own sensitivity to these variables (although a certain overlapping is possible). Moreover, it comes close to the *niche theory*. In our opinion, since this model is pending on knowledge of the habitat preferences of the studied organism (and this may require further exploratory studies before the continuum model can be applied) and a larger effort, it should be applied at a small landscape scale and only after the basic conclusions from the larger scale explorative studies (using habitat fragmentation approach) have been formulated. If the chosen landscape is representative for a wider region, it may represent a useful complement-tool to the fragmentation model. The *Continua and Umwelt model* (Manning et al. 2004) also recognizes that: (i) the habitat is a species-specific term and (ii) the spatio-temporal distribution of animals in the landscape may not follow the rules of the fragmentation model, rather, there are „peaks and troughs" (Fischer et al. 2004) in their spatial distribution.

The *contour model* would be the most useful to understand the distribution through the landscape of the organisms that are very sensitive to the soil microclimate, such are the postmetamorphic amphibians. The dispersion of postmetamorphic common toad (*Bufo bufo*) through a human modified landscape in the middle section of the Târnava Mare Basin (fig. 3) was studied in two years (Hartel *unpublished results*). This study showed that the soil humidity gradients rather then the patches (grass, arable land, forest) in the landscape are important culoars for the toadlets. The toadlets use the humid patches after the desiccation of temporary ponds and springs (that may be not identified by the researcher in this stage) also as refuge habitats in dry summers. The juvenile toads grow and disperse faster along these corridors and patches, even when they reach the forest. The attainance of a good body condition in the first year may decrease the probability of death during the overwintering period. Since the juveniles are the dispersal stage for the great majority of amphibians, the results of this study suggest that the drainage activities of which consequence is the decrease of the soil humidity may hamper the recolonization of the empty habitats (metapopulation perspective). The loss of amphibian reproductive success due to the changes in the wetland hydroperiods caused by drainage ditches is the main reason of the reproductive failure of amphibians in the *Breite Reserve* near Sighişoara. These ditches moreover, severly impact the soil humidity, causing its overall desiccation, this being observable in the changes of vegetation structure. The restoration of the wetland hydroperiod and soil humidity in this landscape is considered to be a priority in the management interventions (Hartel et al. 2008b). The hystorical modification of the hydrological regime of the soils after drainage was suspected to negatively affect amphibians in the Australia (Hazell et al. 2003).

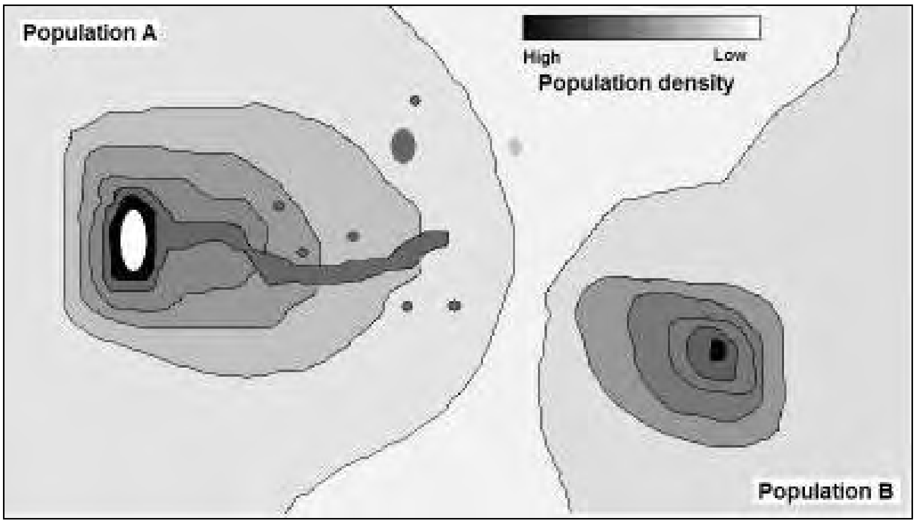

Figure 3. An example of the distribution of two populations in a human altered landscape, modelled by the *contour map* approach. ″Population A″ represents the situation found in the case of postmetamorphic common toads in June-August (2001 and 2002) (Hartel *unpublished results*). The density of the active toadlets in hot summers was higher in the humid patches than in the surroundings. The ″Population B″ is a hypothetical population. The drawing was inspired from Fischer et al. (2004).

When applying a particular landscape model we should be aware that its outcome will also depend on the populations dynamics of individual species, including events that take place more or less independently of the landscape parameters, for example density-dependent sinchronous or asynchronous population fluctuations (Hanski 1998).

Although most landscape studies were carried out in terrestrial areas (this having „traditional reasons", as landscape ecology was from the outset centered on human activities on land, see Turner 2005), there have been many proposals suggesting how landscape ecology approaches can be applied to rivers (Schlosser 1991, Fausch et al. 2002, Wiens 2002) and ponds. In these habitats the vegetation cover, its distribution and density creates alternative and refuge habitats for the many aquatic species that are pursued by predators) (i.e. Werner et al. 1983, and the references in Hartel et al. 2007). As the important landscape elements influencing habitat use (spatial distribution) and population sizes of species are identified, long term scenarios can be made to assess the outcomes of alternative policies and landscape designs on animal populations and communities (Cumming 2007).

Further thoughts

As mentioned above, there are many ways to study a landscape, and it is likely that there is no "one perfect" landscape approach. Researchers should use their best knowledge, creativity, resources (financial, logistical, personnel) when deciding for the (number of) species studied and the level of population detail (just presence/absence data or population size estimations?) the "trade off" between the size of the area surveyed (scale of the study), the number of habitats sampled and the number of searches per habitat. Whatever the choosen landscape model / approach, it is extremely important to clearly *define what is considered to be a landscape* (i.e. to provide details about the delimitation of patches and / or some measurable parameters of the spatial heterogeneity) in the study and *what is the spatial scale considered*. We should recognize that the habitat(s) and microhabitats are the target of many management proposals for conserving species and communities and therefore we should be able to generally predict what are and will be the consequences of the different modifications at the habitat and landscape scale on the studied organisms. Descriptive statistics about the habitat parameters would allow the use of data for meta-analysis. A recent review on the distribution and conservation status of the moor frog (*Rana arvalis*) in Romania (Sas et al. *in press*) shows how difficult it is to reach conclusions about these aspects when the data regarding the habitats are lacking.

Our personal experience shows that many interesting ideas arise during discussions with researchers working in different fields of ecology (animal- and/or plant/vegetation ecology). These discussions (about the potential interactions between the studied species / groups of species and other plant and animal species/ groups) highlight the differencess between how different species perceive the habitats and landscapes. Western European scientists that have a more developed theoretical background in landscape ecology and are more experienced in these approaches are open to discussions regarding such potential research plans (even "outside" of official collaborations) and may kindly provide many relevant papers on the topic. We strongly suggest that investigators should be familiar with the past and present scientific literature and models used in the landscape analysis of the taxonomic/functional group (or related groups) studied. Studies should also offer as much information as possible about the exact location of the *habitat*(*s*) studied (i.e. by using *Global Positioning System*).

We are aware that our proposal is simplistic (and short) in this form and requires some knowledge of theories and case studies in landscape ecology and other related fields of ecology, such as island biogeography, metapopulation theory, source-sink systems, umbrella species, etc. Each theory has its own range and limits of applicability with positive aspects and weaknesses. For example there may be animal groups, such are the large carnivores (*Canis lupus, Ursus arctos*) that are still relatively abundant in Romania, and their distribution can be hardly predicted using the models described in this paper. These species use large areas that are ecologically diverse and thus are good candidates for the "landscape species" category (*sensu* that described in Sanderson et al. 2002). We believe, nevertheless, that adoption of the models described in this opinion paper is worth trying, because the researcher may both discover interesting and new scientific challenges and will realize the enormous benefits of these approaches in management and conservation. The structure of many of our semi-natural landscapes will change considerably in the new, „European Union" era. Without high quality data, it will not be possible to present realistic proposals to engineers and decision makers in order to incorporate them into development planning and conservation efforts that aim to reduce the impact of urban, infrastructural, agricultural or other developments on natural resources. Moreover there will be no reference data for further restoration projects.

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