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Amphibian conservation in traditional cultural landscapes: the case of Central Romania

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Abstract. Much of the rural landscapes of Central and Western Europe went through drastic changes during the past centuries as a result of rapid socio-economic development. In some Central and Eastern European countries, the geopolitical and institutional instability slowed the pace of the modern economic development, thus many regions are still characterized by less intensive ('traditional') landuse practices. In this study we address the value of traditional landuse practices for amphibians from Southern Transylvania, Romania. The region includes a Natura 2000 Site of Community Importance of 85,000 hectares. We show that the great majority and a high diversity of amphibian ponds were created and maintained by traditional human activities in the studied rural region. These ponds support rich amphibian communities with dense population networks; we documented these for two anurans: the Common Toad (*Bufo bufo*) and the Yellow Bellied Toad (*Bombina variegata*). We conclude that large areas of this region are in favourable conservation status for amphibians and their habitats. The traditional landuse practices are not a free, proactive option for most of the inhabitants of rural regions; therefore, they are vulnerable to change (e.g. agriculture intensification and mechanization). In order to better understand the opportunities and challenges of managing these cultural landscapes for amphibians we propose a social-ecological conservation framework. Such a framework simultaneously considers the main features of the social system (e.g. social and economic aspirations of people, governance structures, knowledge types and attitudes towards the natural and cultural environment), as the landscape features (e.g. topography, landcover types, bioclimatic conditions, vegetation, hydrology) and the ways how these two interact to influence wetland connectivity, pond quality and amphibian population structure. Examples are given on the implications of adopting a social-ecological framework on amphibian conservation in cultural landscapes.

Key words: traditional landuse, Southern Transylvania, biodiversity conservation, Natura 2000, social-ecological systems.

Introduction

Cultural landscapes suffered sharp changes in the past centuries in much of Europe. The major social drivers of the changes are represented by growth of human population, resource exploitation, urbanization, and globalization of the commodity market, the infrastructural, technological and institutional development and the political context (Plieninger & Bieling 2012, Hartel et al. 2014). Rapid socio-economic development was hampered in some regions of Europe, mainly due to socio-political and institutional instability. In these conditions, rural communities still retained many features of the old landuses, biodiversity components and traditional knowledge which largely disappeared from other parts of Europe (Tryjanowski et al. 2011, Oteros-Rozas et al. 2012, Babai & Molnar 2013). As a consequence, the remaining traditional rural regions of Europe have many natural and cultural values worth conserving (e.g. Halada et al. 2011, Wright et al. 2012). The appeal of modern social-economic development in traditional rural communities challenges the natural-cultural heritage conservation efforts (Hartel et al. 2014).

The Natura 2000 network based on the Habitats Directive (for the Sites of Community Importance, SCI) and the Birds Directive (for the Special Protection Areas, SPA) represents one of the most powerful legal instruments for biodiversity conservation in the European Union (EU) (European Commission, http://ec.europa.eu/environment/nature/natura2000/). A mandatory condition to join the EU was the implementation of the Natura 2000 regulations at the country level (Cogălniceanu & Cogălniceanu, 2010). Romania joined the EU in 2007 and currently has 17.9% of its terrestrial surface are SCIs, largely in landscapes with strong traditional cultural character (Iojă et al. 2010). Conservation status of many species and habitats of conservation interest (i.e. listed in the Annexes of the Habitats Directive) relays on the maintenance of the traditional landuse practices. For example, out of 231 habitat types listed on the Annex I of the Habitats Directive, 63 depend on low intensity landuse practices (mostly grazing and mowing), and are vulnerable to agricultural intensification and land abandonment (Halada et al. 2011).

As one of the most vulnerable taxa (Stuart et al., 2004), pond breeding amphibians are often sentinel species for delineating Natura 2000 sites. Pond breeding amphibians have diverse habitat requirements, including aquatic (typically represented by ponds of various sizes and hydroperiods for breeding) and terrestrial habitats for feeding and overwintering. Habitat loss and alteration caused by human activities is considered one of the major drivers of amphibian decline in Europe (Stuart et al., 2004). Recent reviews highlight the crucial importance of man-made ponds as refuges for amphibians in human modified landscapes (Charester & Robson, 2013). Amphibian communities in traditional rural landscapes of Romania are species rich (Hartel et al. 2010, Plăiasu et al. 2012), where species that are in sharp decline in other European countries such as the yellow bellied toad (*Bombina variegata*) are widespread (Cogălniceanu et al. 2013, Hartel & von Wehrden 2013, Popescu et al. 2013).

In this paper we focus on Southern Transylvania (Romania). There are two important characteristics of this rural region: (i) extensive landuse practices, such as hay production using man power, the use of pre-industrial sources of power in agriculture, a low use of chemicals and extensive forestry were still well represented when the study was conducted (Akeroyd & Page 2006, Fischer et al. 2012), creating a heterogeneous landscape with high conservation value; (ii) the traditional social system undergoes dramatic changes, such as the loss of traditions, knowledge types, ethnic and social values, institutional changes, increase of conflicts within the rural communities and the lack of common vision for the future (Fischer et al. 2012, Mikulcak et al. 2013, Hartel et al. 2014). The effects of these changes on biodiversity are already obvious, e.g. through intensification or abandonment of landuse.

The objectives of this paper are: (i) to identify the types of aquatic habitats used by pond-breeding amphibians in Southern Transylvania and their categories (i.e. anthropogenic vs natural), (ii) to estimate the occurrence of pond-breeding amphibians in wetlands, (iii) to estimate the spatial autocorrelation in pond occurrences in two anuran species with contrasting ecology: the common toad (*Bufo bufo*) and the yellow bellied toad (*Bombina variegata*). We will discuss our findings through the social-ecological systems conceptual framework.

Materials and methods

Study area

The study area covers over 3000 km² and is located in Southern Transylvania (Romania) (see Hartel & von Wehrden 2013). The region includes a large recently established Natura 2000 site belonging to the continental biogeographic region (ROSCI Sighişoara-Târnava Mare site, N 46° 8' 4''; E 24° 49' 16''; 85,000 ha). Currently 42% of the study area is covered by broad-leaved forest (dominated by *Quercus robur*, *Q. petraea*, *Fagus sylvatica* and *Carpinus betulus*), 22% by meadows and pastures (including wood-pastures), 20% by arable fields and 3% by urban areas. Wetlands, orchards and other landuse classes add up to 100% (CLC, European Environmental Agency (2011): (http://www.eea.europa.eu/publications/COR0-landcover). Changes in the traditional agricultural practices include: land abandonment and afforestation, clearing of woody vegetation from wood pastures, decrease of cattle and horse grazing and the elimination of buffalo grazing, increase of the number of sheep, increase of the frequency of uncontrolled pasture burnings and the increase of the small sized fishponds (Hartel & von Wehrden 2013, Hartel et al. 2013).

Target species

Bombina variegata is a species of Community importance (European Union Habitats Directive Annex II and IV;

Temple & Cox 2009). It is typically a temporary pond breeder in strong synchronization with rainfall which fills the ponds (Hartel et al. 2007a). In contrast, *Bufo bufo* is a permanent pond breeder (including ponds that support fish), which prefers vegetated ponds surrounded by forested landscapes (Hartel et al. 2007b, 2008). The range of both species was predicted to contract under the future climate change scenarios (Popescu et al. 2013).

Field surveys

A comprehensive survey of wetlands and amphibian species inhabiting them was conducted between 2011-2013. The pond and amphibian survey methods were described in detail in Hartel & von Wehrden (2013). We surveyed 839 ponds and compiled a complete dataset on all amphibian species at 811 ponds. The ponds were classified based on their origin and level of human impact in seven categories (Table 1). Following this survey design we were able to capture the whole range of aquatic habitats and their relative proportion and the potential of this cultural landscape to offer breeding sites for amphibians.

Amphibian surveys were started in the middle of March in both 2011 and 2012 and lasted until the end of August, while in 2013 surveys were made only in May in a subset of 60 ponds, 30 in open pastures and 30 in closed forests (Scheele et al. 2014). We searched for amphibians visually (an efficient method for surveying small sized temporary ponds) and/or with dip netting. When finding at least one life stage in the water and/or close vicinity (i.e. up to two meter distance from the pond edge, especially true for fresh metamorphs) we considered the respective species as present in the pond. As multiple visits at a pond within a season to account for imperfect detection (MacKenzie et al. 2002) were not made, the occurrence represent a naïve estimate of the true occurrence.

Data analysis

We used descriptive statistics to summarize the relative proportion of each pond type and the percent of occurrence of each amphibian species in the various pond types.

We first estimated the spatial extent of the autocorrelations between the recorded pond-presences for each species. The distance among ponds at which significant spatial auto-correlation occurs suggests that amphibian movements within such distances are frequent. We used the results of the autocorrelation analysis to delineate terrestrial buffers around each pond (i.e. centroid of a pond) where the species were present. The length of the buffer radius (m) for each pond separately on species was equal with the maximum distance at which the autocorrelations in species presences was significant. Thus, we considered the clusters of ponds included in the buffers at which auto-correlation was significant as the breeding area of a population which also included the terrestrial habitat necessary for maintaining pond connectivity. The frequent movements between the ponds may unite the breeding aggregates of individual ponds in a demographic unit (Sinsch 1992, Petranka & Holbrook 2006, Hartel 2008).

To assess the spatial autocorrelation of the pond occurrence of *B. variegata* and *B. bufo* we used semivariograms computed using indicator kriging. The indicator kriging is a simple, non-parametric method which can be applied to binary data, in our case represented by presence/absence of the species in ponds. The semivariance ($\gamma(h)$) considers each presence point relative to all the other presence points as well as the distance between these points. The semivariance value is smaller for those points which have spatial dependence (these regularly being closely located to each another) (Wackernagel 2003). The semivariance data between pairs of ponds were averaged by distance using 200 m lag classes. The averaged semivariance values were plotted for each lag class to create a semivariogram. The value of semivariance shows an increase with distance for the points which are spatially autocorrelated, while the asymptote suggests the lack of spatial autocorrelation from the respective distance (Isaaks & Srivastava 2011). The measurement error of the semivariance was calculated for both species. We used the distance at which autocorrelation became negligible (i.e., range) and delineated buffers around the ponds in the study area. We then calculated the area of the regions with overlapping buffers and extracted the CORINE land cover 2006 classes (class and surface area) to evaluate the broad landcover types which should be targeted for management. We used ArcGIS 10.1 (ESRI, Redlands, CA) and Geospatial Modeling Environment 0.7.2.1 (Beyer 2012) for spatial statistics and GIS analyses.

Results

The types and origins of the current ponds in Southern Transylvania

Most of the ponds were located in pastures (57%), forests (25%) and heterogeneous farmlands, other than pastures (15%). The most common pond types were represented by the temporary dirt road- and the pasture ponds (altogether 77% of the inventoried pond categories). Six out of the seven categories of ponds, and 99% of all the pond categories inventoried strongly depended on various types of human activities (Table 1). The only permanent pond types were the fish ponds, also human made. Threats to each type of these ponds are presented in Table 1. Figure 1 presents example pictures for these ponds.

The value of ponds with anthropogenic origins for amphibians

Eight amphibian taxa and a species complex were identified in the surveyed ponds: *Lissotriton vulgaris ampelensis*, *Triturus cristatus*, *Bombina variegata*, *Rana dalmatina*, *R. temporaria*, *Bufo bufo*, *Pelobates fuscus*, *Hyla arborea* and the *Pelophylax esculentus* complex. The first three species are of international interest for designating Natura 2000 sites

Table 1. The ponds classified based on their origin and level of human impact.

Habitat type	Character	Description, origin	Dependence on human activities and human related threats from the perspective of amphibians.	Proportion from all pond types (%)
1. Dirt road pond	Temporary	Formed along the unpaved roads after activities with horse carts and/or a low intensity of heavy machineries. Their surface is typically 2-30 m² and has duration of up to 7 weeks after filling. Hydroperiod dependent on rain.	Strong dependence on low intensity activity and the maintenance of bare grounds. *Main threats*: asphaltation and/or filling and the intensification of the landuse surrounding them.	43
2. Ponds in pastures	Temporary	Typically formed as a result of the traditional cattle and buffalo grazing. Their surface is usually 4-200 m² and their duration is up to 15 weeks and depends on rain and the amount of vegetation.	Strongly dependent on low intensity cattle and buffalo grazing. *Main threats*: abandonment of the traditional grazing with cattle and buffalo which result in the development of vegetation (most commonly *Juncus* sp.) and the shortenance of their hydroperiod. This happens even if the traditional grazing is replaced with sheep grazing. The conversion of the pastures into arable fields is also a major threat especially in the flat landscapes.	34, out of which: 61 have mostly open character 39 are overgrown by vegetation
3. Fishponds	Permanent	These ponds were created by and are populated by fish. Their number is increasing recently. Their size is mostly small (typically around 1 ha) and are situated along the springs in the valleys.	Strong. *Main threat*: the high densities of introduced predatory fish coupled with the removal of vegetation. Commonly introduce fish species includes *Carassius auratus*, *Cyprinus carpio*, *Esox lucius*, *Silurus glanis*, *Stizostedion lucioperca*, *Perca fluviatilis* as well as alien species such as *Pseudorasbora parva*, *Lepomis gibbosus*, *Clarias glariepinus*.	5
4. Ditches	Temporary	These are created mostly in agricultural fields to drain the water. They are temporary but with potentially long (sometimes year round) hydroperiod. These ditches typically do not contain fish.	Strong. *Main threat*: lack of traditional maintenance and / or improvement with concrete.	6
5. Livestock drinking thoughts	Temporary with long duration	Created on pastures for watering the livestock, usually in close vicinity of a spring. They are made by concrete, sometimes also from metal or wood.	Strong. *Main threats*: the replacement of the concrete thoughts with metal thoughts, as well as their complete elimination.	4
6. Ponds with other human origins	Mostly temporary	They result from other types of human activities such as gas extraction, clay extraction, and constructions. These are small ponds, of similar size than the pasture ponds (see above).	Strong. *Main threat*: refilling and drainage.	7
7. Ponds with unknown origins	Mostly temporary	The human origins of these ponds are not obvious. We suspect that wildlife or other natural processes were more important in their creation and maintenance than in the case of the previously mentioned pond types. These are small sized wetlands (same size category as the types 1 and 2 above) except the marshy areas in the centre of the study region.	Relatively weak. *Main threat*: Desiccation (especially for the marches from the central part of the study region).	1

Figure 1. Typical examples of the common pond types in the studied landscape. Temporary ponds maintained by buffalo and cattle activity (a), dirt road ponds (b), permanent (fish)ponds (c), livestock drinking troughs (d).

(Annex II of the Habitats Directive). The value of the livestock drinking (watering) troughs, the dirt road ponds, open pasture ponds, ditches and the ponds with other anthropogenic origins was high for *B. variegata*, this species being present in at least 67-88% of these ponds (Fig. 2). The value of the dirt road ponds and drinking troughs was surprisingly small for the other amphibian species, compared to *B. variegata* (Fig. 2). The amphibian occurrence in fish ponds was highest for *B. bufo* (100%), *R. dalmatina* (65%) and the *P. esculentus* complex (81%). The overgrown pasture ponds had overall low value for all amphibian species (Fig. 2).

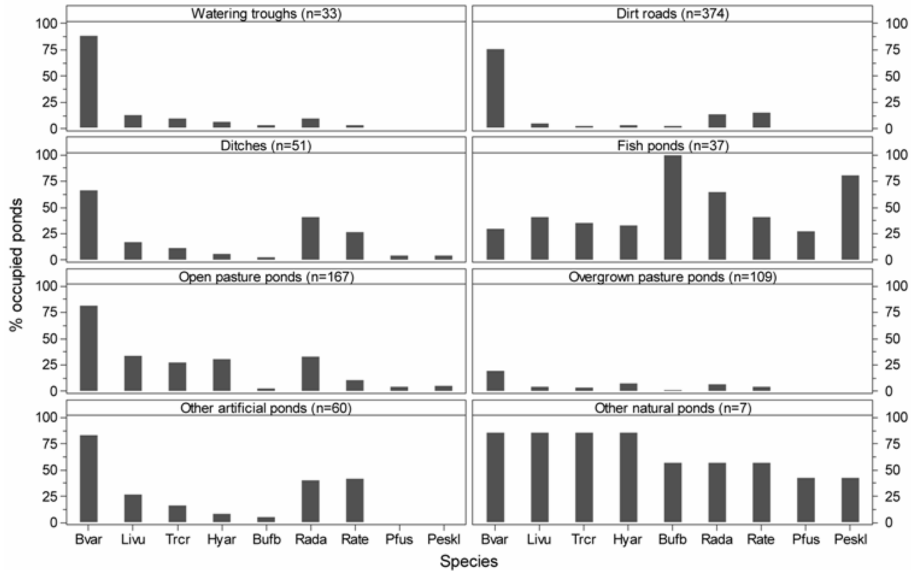

Figure 2. The occurrence of amphibians in the various pond categories (Bvar = *Bombina variegata*, Livu = *Lissotriton vulgaris ampelensis*, Trcr = *Triturus cristatus*, Hyar = *Hyla arborea*, Bufb = *Bufo bufo*, Rada = *Rana dalmatina*, Rate = *Rana temporaria*, Pfus = *Pelobates fuscus*, Pekl = *Pelophylax esculentus* complex)

Spatial autocorrelation in pond occurrences for *Bombina variegata* and *Bufo bufo*

Bombina variegata occurred at 572 ponds (70%), while *B. bufo* at 56 ponds (7%), these being the minimum naïve estimates of their true occurrence. The spatial autocorrelation in pond occurrence for *B. variegata* was significant until a threshold range of 1308 m (semivariance error: 0.14) and for *B. bufo* at 3548 m (semivariance error: 0.02) (Fig. 3).

The overlapping buffers based on the autocorrelation distances for the two species encompassed much of the Natura 2000 site (Fig. 4). For *B. variegata* 26 areas could be delineated based on the overlapping buffers, covering an area of *ca* 73,000 ha (min-max: 533 ha for buffer no. 6 – 36,000 ha for buffer no. 26, Fig. 4) with 16 out of the 44 landcover categories. The best represented categories of landcover in these buffers were those representing native vegetation such as the broad leaved forests (CLC 311 with 29,515 ha, 41%) and pastures (CLC 231 with 16,797 ha, 23%). Moreover, lands principally occupied by agriculture with significant areas of natural vegetation (CLC 243 with 9408 ha, 13%) and the non irrigated arable land (CLC 211 with 6287 ha, 9%) were less represented, while most of the remaining landcover classes covered each less than 1000 ha in these buffers.

For *B. bufo* there were six areas were delineated based on the overlapping buffers, representing 152,466 ha of land (min-max: 3,873 ha for buffer no. 3 – 26,253 ha for buffer no. 2, Fig. 4) with 15 landcover categories. Landcover classes representing native vegetation were again the best represented: the broad leaved forests (64,866 ha, 43%) and the pastures (29,631 ha, 19%). Other well represented land cover classes were the lands principally occupied by agriculture with significant areas of natural vegetation (21,107 ha, 14%) and the non irrigated arable land (12,854 ha, 8%).

Discussion

Our study showed that virtually all amphibian ponds in the traditional rural landscapes from Southern Transylvania resulted from diverse human activities. These ponds in combination with the wide cover of native, seminatural vegetation (managed forests and grasslands) support a spatially extent amphibian populations. Our findings have a high relevance for landscape scale amphibian conservation initia- tives.

Extensive human activities generate many suitable ponds for amphibians because of their overall low intensity and a strong seasonality (Hartel and von Wehrden 2013). As the industrial activity is very low, local communities largely rely on ecosystem services for their everyday life, and

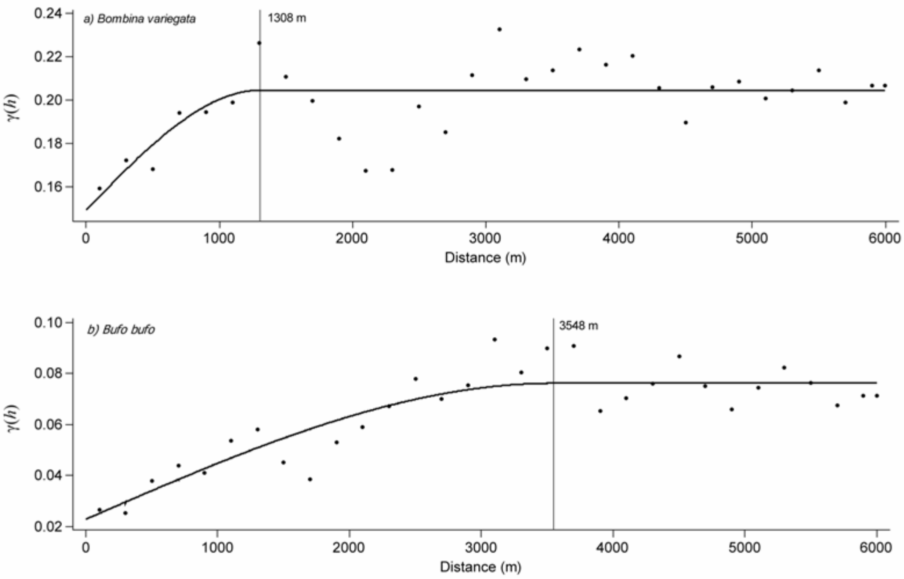

Figure 3. The results of the spatial autocorrelation analysis for *B. variegata* and *B. bufo*.

they use still largely traditional management methods to extract these services (Fischer et al. 2012). The permanent ponds were created to provide water for livestock and occasional recreation (Hartel & von Wehrden 2013). Our study showed the value of small, open water bodies such as the drinking troughs, open pasture ponds and dirt road ponds is high for *B. variegata* while the value of fishponds is high for *B. bufo*, *R. dalmatina* and *P. esculentus* complex. The case of the open pasture ponds is especially important as they were maintained by traditional extensive grazing with cattle and buffalo, showing that this economic activity contributes to crucial habitats for protected amphibians. Contrary, the overgrown pasture ponds were of low value for all amphibian species (see also Hartel & von Wehrden 2013). The hydroperiod of the temporary ponds overgrown with vegetation may be shorter because of the increased evapotranspiration through the vegetation, especially in the summer months (July, August) when the amount of precipitation is the lowest and the temperatures are high. The permanent ponds, even if they contain fish can harbour rich amphibian communities if they contain aquatic vegetation, because vegetation increases habitat complexity, allowing co-existence between amphibians and certain fish species (Hartel et al. 2007).

Our study showed that presences in the neighbouring ponds were autocorrelated at distances of ca 1300 m for *B. variegata* and ca 3500 m for *B. bufo*. Inter-pond movements are possible at these distances for both species (Glandt 1986, Sinsch 1990, Smith & Green 2005, Hartel 2008, Kovar et al. 2009). Hartel & Öllerer (2009) found that the number of temporary ponds in the landscape (buffers with 800 m radius) was significantly related to the persistence of five amphibian species in permanent ponds, including *B. bufo*. These findings highlight the importance of maintaining multiple ponds at landscape scale for conserving amphibian populations.

There are many socio-economic and ecological changes in the region that already impacted the ponds and amphibians (summarized in Table 1). Some of these changes affects many ponds simultaneously over larger areas. For example, the dirt road ponds are disappearing both due to land abandonment (becoming over-vegetated) and due to paving, and intensification of human activities. The abandonment of grazing with buffalo and cattle will affect all ponds from the pastures, resulting in vegetation overgrow. The traditional grazing with these livestock types was rather the norm than the exception in the past, while currently this management is largely abandoned and replaced with sheep grazing (Hartel et al. 2013). The abandonment of the traditional grazing in the whole region results in landscape scale deterioration of these ponds. Fish ponds tend to be farmed inten-

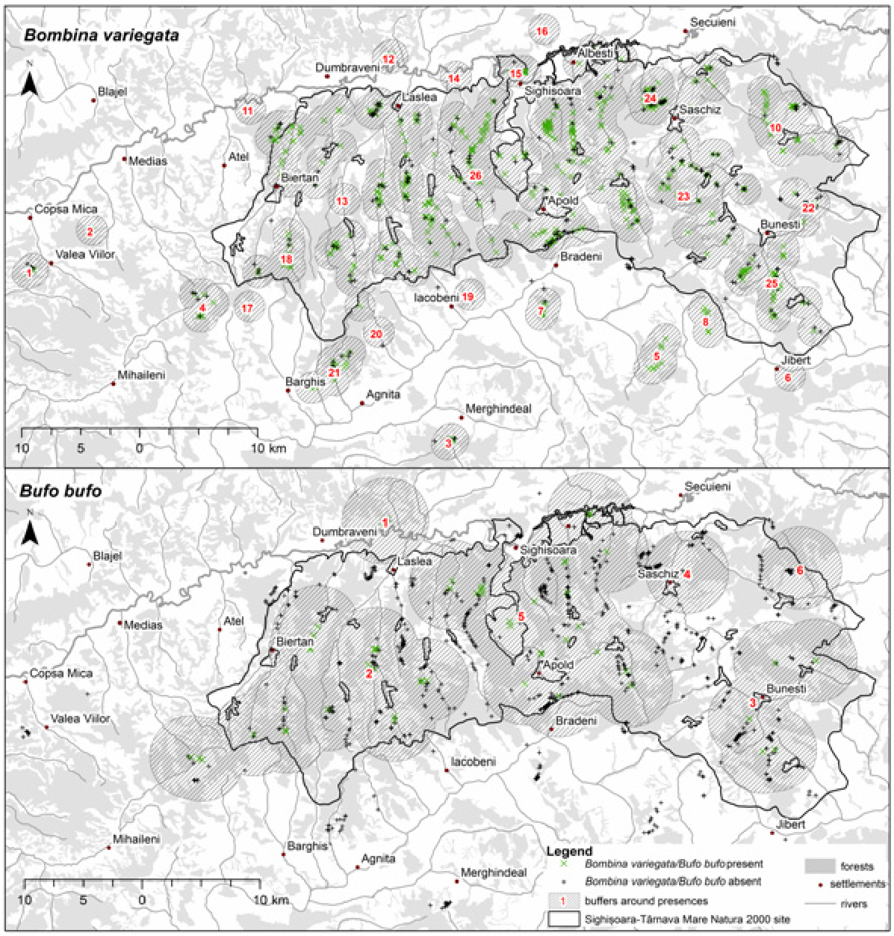

Figure 4. The distribution of *B. variegata* and *B. bufo* with the delineated buffers around the presences in ponds. The radius of the buffer coincides with the maximum distances at which the autocorrelation was found to be significant (see Figure 3).

sively making them economically viable but unsuitable for amphibians. This includes introduction of both native and non-native predatory fish and removal of aquatic vegetation. This will likely have detrimental effects on many amphibian species (e.g. newts, tree frogs), while others may profit from them (Hartel et al. 2007). We showed that the extent of the native vegetation cover (forests and grasslands) is high within the buffers delineated for both amphibians (64 and 63% for *B. variegata* and *B. bufo* respectively) to which an important amount of agricultural land with significant native vegetation is added (13 and 14% respectively). This is of crucial importance for amphibians because native vegetation pose low resistance to toad movements, allowing safe dispersal and migration and pond colonization (Stevens & Baguette 2008, Janin et al. 2009). Repeated surveys in our study region suggest that new ponds are quickly colonized by amphibians (i.e. within up to three years after their creation) (Hartel & Sos personal observations), including by *B. bufo* and *B. variegata*. These suggest high conservation and restoration potential of wetlands and the landscape for amphibians.

The main caveat for delineating the breeding clusters is that such circular buffers assume a homogenous terrestrial habitat quality, which could be unlikely in natural systems: for example, the humid terrestrial environments facilitate amphibian movement compared to well-drained ones (Joly & Miaud 1993, Dall`Antonia & Sinsch 2001).

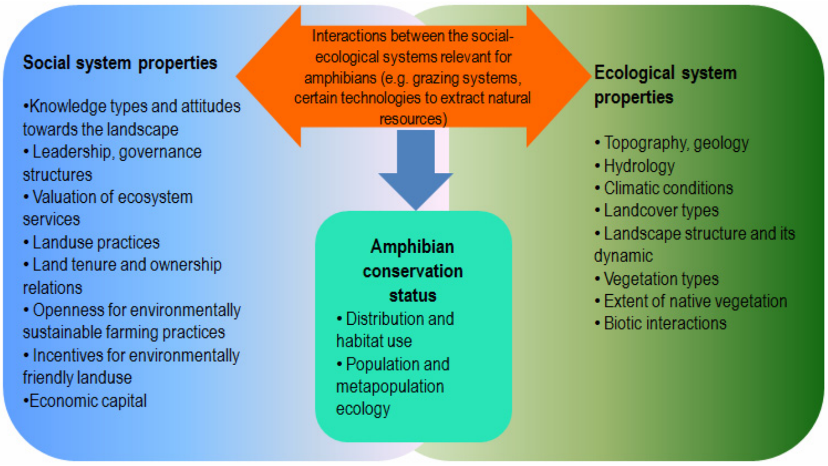

Figure 5. A social-ecological framework to address amphibian conservation in traditional cultural landscapes. This framework recognizes (i) the strong links and interdependences between the social and ecological systems and (ii) many valuable habitats for amphibians result from the interactions between the two systems, ultimately resulting in the 'cultural amplification' of species, including those of conservation interest. In order to maintain viable amphibian populations in traditional cultural landscapes a whole set of issues must be addressed related to the broad properties of the social and ecological systems.

Hence, even within the same distance category the occurrence of some species in ponds can be more interdependent than in others because of the potential variation of landscape resistance to toad migration (e.g., Janin et al. 2009). Furthermore, the pond occurrences are not indicative of their quality: presence in certain ponds may indicate continuous breeding and large populations (source habitats) while presences in other ponds may not indicate this because of the potential high reproductive failures and smaller populations (sink habitats) (Hartel et al. 2011).

A social-ecological perspective on amphibian conservation in historic landscapes

In this paper we showed that there are strong links between the diversity of amphibian ponds and the human activities in Southern Transylvania rural landscape. We suggest that a social-ecological approach tailored to the specific social, ecological and cultural context of our study area is needed for conserving amphibians in traditional cultural landscapes (Fig. 5).

The social-ecological approach recognizes the interdependence of the social and ecological systems: humans influence the ecological systems through resource extraction activities (including ecosystem services). In the same time, the ecological systems influence the social systems through their various properties, such as the bioclimatic and morphological conditions and the natural resources (e.g. Folke 2006). Since the low intensity human activities contribute to the maintenance of highly diverse landscapes (e.g. Halada et al. 2010) and ecosystem services (Bugalho et al. 2011), it was recently suggested to address the ecosystem services of the traditional rural landscapes as 'social-ecological services' (Huntsinger and Oviedo 2014) that is, ecosystem services are co-produced by the social and the ecological systems.

Amphibian distribution, habitat use and the spatio-temporal dynamic of the populations and metapopulations are strongly influenced by properties of the social and ecological systems and the ways these systems interact with each other (Fig. 5). For example the traditional grazing with buffalo, cattle and horse, combined with extensive forestry applied over large areas, and by many rural communities, were important drivers for the creation of suitable habitats for the yellow bellied toad (Hartel & von Wehrden 2013). The maintenance of these traditional practices in order to conserve amphibians will depend on the interest of locals to continue traditional grazing systems, to maintain the hay meadows and the use of the animals for various works (e.g. horses and horse carts). These will further depend on the social capital, governance structures around the use of the communal pastures and forests, the openness for environmentally friendly landuse practices (Fig. 5). On the other hand, the broad properties of the ecological systems (i.e. landscape, native vegetation cover) also influence amphibian conservation status, through the above mentioned social-ecological interactions. For example flat and open areas may be more attractive for intensive agricultural practices, and more forests were converted into agricultural lands historically in such regions. Currently such areas have a lower suitability for amphibian ponds (Hartel & von Wehrden 2013).

In conclusion, amphibian conservation initiatives in traditional cultural landscapes must consider the broad features of the social-ecological systems and the specific nature of their interactions in order to be grounded in the social and ecological realities of the region. This is achievable only through inter- and transdisciplinary teams, which addresses simultaneously the many aspects of the social-ecological system (Fischer et al. 2014). As the traditional rural societies are rapidly changing, there is an urgent need to find solutions for promoting landuse practices that maintain the high conservation potential of these landscapes.

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