REPORT

Environmental determinants of the old oaks in wood-pastures from a changing traditional social–ecological system of Romania

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Received: 17 June 2015 / Revised: 4 November 2015 / Accepted: 7 December 2015 / Published online: 4 January 2016

Abstract Large, old trees are keystone ecological structures, their decline having disproportional ecological consequences. There is virtually no information available regarding the status and occurrence of old trees in traditional cultural landscapes from Eastern Europe. In this study, we explore the environmental determinants of the old oaks found in wood-pastures from a changing traditional rural landscape from Central Romania. Both the old oaks and the wood-pastures harboring them have exceptional cultural, historical, and ecological values, yet are vulnerable to land-use change. We surveyed 41 wood-pastures from Southern Transylvania and counted the old oaks in them. We then related the number of old oaks from these wood-pastures to a set of local and landscape level variables related to wood-pastures. We found 490 old oaks in 25 wood-pastures. The number of old oaks was positively related to the size of the wood-pasture and the amount of pasture and forest around it (500 m buffer), and negatively related to the proximity of the village. Furthermore, we found a significant interaction between the effects of sheepfolds in the wood-pasture and the size of the wood-pasture on the number of old trees, indicating a negative influence of sheepfolds on the number of old trees in smaller sized wood-pastures. There is an increasing risk for losing old trees in the traditional cultural landscapes due to the lack of formal recognition of these trees. Therefore, while presenting the positive example of local initiatives and citizen science, we argue for an urgent development and implementation of conservation policies along with education strategies targeting the old trees and rural communities from the changing traditional cultural landscapes of Eastern Europe.

Keywords Old trees · Large trees · Rural landscape · Wood-pasture · Conservation · Romania · Transylvania · Citizen involvement

INTRODUCTION

The natural environment is sharply deteriorating in many parts of the world. Drivers include land-use intensification, land conversion, and the lack of recognition and appreciation of certain landscape elements and ecosystem components for their outstanding and multiple ecological and social values. Large old trees are highly vulnerable keystone ecological structures (reviewed by Manning et al. 2006, 2009); the hollowing process and the aging bark are characteristic components of these trees, making them crucial habitats for a large number of associated species, such as saproxylic organisms, as well as for animal species using cavities for breeding or other purposes (e.g., Read 2000; Manning et al. 2006; Cockle et al. 2012; Gruebler et al. 2013; Lonsdale 2013; Müller et al. 2014; Butler 2014; Falk 2014). Large old trees are biological legacies, representing biological and ecological continuity of genetic resources and habitats for a variety of organisms (e.g., Manning et al. 2006, 2009). Large old trees have high historical, cultural, aesthetic, and spiritual values (e.g., Sherren et al. 2012; Blicharska and Mikusiński 2014). People generally associate positive feelings toward large trees, because of their impressive size, shape, and age. A typical example for such a recognition of the social–emotional value of the old trees is the various terms (e.g., ‘veterans’ or ‘working trees’ in UK), names or stories associated with them (e.g., Read 2000; Butler 2014; Sherren et al. 2012). Finally, large, old trees are information bearers about the past climatic and environmental conditions, ecosystem functions, and human management interventions on the tree, such as pollarding, coppicing (Rackham 1986; Babst et al. 2014).

Despite their recognized multiple values, large, old trees are in a global decline (Lindenmayer et al. 2014, but see

Faison 2014), and the urgent need for developing conservation policies to halt their decline was recently addressed (Lindenmayer et al. 2014; Blicharska and Mikusiński 2014).

The need for inventory, description, and conservation of old trees for their huge aesthetic, historical, and cultural value was emphasized long time ago in Eastern Europe (e.g., Szívós 1904 for Hungary). However, we are not aware about studies addressing the environmental determinants of the occurrence and number of the old trees in Central and Eastern Europe, although citizen-based old tree inventory initiatives exist (see e.g., György Pósfai, Hungary's Largest Trees: <http://dendromania.hu/index.php>). With this study we aim to start filling this gap, by presenting the environmental factors affecting the number of old oaks in wood-pastures from a changing traditional cultural landscape from Central Romania. We selected wood-pastures because these landscape elements typically contain larger number of old trees than other managed ecosystems from the same region (Hartel et al. 2013; Butler 2014; Kirby and Perry 2014; Kirby 2015). Moreover, while wood-pastures, ancient wood-pastures in particular, went through sharp decline in most of Europe (Bergmeier et al. 2010; Hartel and Plieninger 2014; Plieninger et al. 2015), they are still well represented in the traditional landscapes from our region (Hartel et al. 2013). Ancient wood-pastures are considered the closest analogues of some pre-human lowland landscapes of Europe, being important components of the European ecological and cultural identity (Vera 2000; Plieninger et al. 2015). We selected oak trees because of their crucial economic and cultural importance for the traditional rural communities (Dorner 1910; Oroszi 2004) and because they are among the most dominant tree species in wood-pastures in our study region (Hartel et al. 2013). Moreover, oak trees can have considerable sizes and ages; old oaks from wood-pastures being the largest living organisms from our study region (Hartel and Moga 2010; Hartel et al. 2013, see also Kirby 2015 for Britain). Large, old oaks are in decline due to secondary forest succession (being sensitive to low light conditions), uncontrolled pasture burnings, and direct cutting (Bergmeier et al. 2010; Hartel et al. 2013; Öllerer 2013, 2014).

In this explorative study, we related the number of old oak trees in the traditional wood-pastures to variables describing the management of wood-pastures, distance from settlements (i.e., village), and surrounding landscape structures. The approach adopted by us is commonly used in landscape ecological studies exploring the relationship between organismal occurrence and abundance and the habitat- and landscape features (e.g., amphibians—Ficetola et al. 2009, birds—Dorresteijn et al. 2013, plants and butterflies—Loos et al. 2014, 2015). All these variables can be considered as proxies for human impact in cultural landscapes, like the historical landscapes from Southern

Transylvania (see below). Therefore, we discuss our findings in the context of landscape and land-use history from our region, which influenced the emergence and persistence of the current wood-pastures.

MATERIALS AND METHODS

Study area

The study area is situated in southern Transylvania, Romania, and it covers roughly 3000 km² (center point coordinates: Latitude: 46.153969°, Longitude: 24.788233°, and see Appendix 1 in Hartel et al. 2013 for satellite maps of wood-pastures from this region). The study area encompasses the Natura 2000 site 'ROSCI0227 Sighișoara-Târnava Mare'. The study region is ethnographically distinct and was historically inhabited by Transylvanian Saxons. They benefited of administrative and religious autonomy from the 12th up to the eighteenth century. Although their influence decreased drastically ever since, and their majority has immigrated to Germany in the Twentieth century (Gündisch 1998), their cultural legacy is still reflected by the characteristic traditional land-use practices and landscapes which are still well represented, making the entire region of High Nature Value. The levels of infrastructural and urban development are low. The region belongs to the woodland ecozone characterized by mixed forests with oaks (*Quercus robur*, *Q. petraea*) and other tree species characteristic of low hills (e.g., *Fagus sylvatica* and *Carpinus betulus*) (Donita et al. 2005). Broad-leaved forests cover ca 30 %, pastures ca 26 %, heterogeneous agricultural areas (including agro-forestry areas) ca 15 % and arable fields ca 14 % of the area. Other social and ecological features of the study region are presented in Hartel et al. (2014a).

Field surveys and variables

Field surveys were carried out primarily in 2009 and 2010 and then in 2013–2015, within a series of projects aiming to provide the first comprehensive step toward understanding the distribution, status, and ecological value of wood-pastures from Southern Transylvania (see e.g., Hartel et al. 2013, 2014b; Öllerer 2014; Roellig et al. 2014). Wood-pastures were identified using the satellite images provided by Google Earth, orthophotos, and our personal experiences in the region (four of the authors have in-depth knowledge of this cultural region). We surveyed 42 oak-dominated wood-pastures. One wood-pasture (i.e., the Breite ancient oak wood-pasture, near Sighișoara, 133 ha) was deliberately excluded from the data analysis because of its very high number of old oaks (i.e., over 300 trees), due to its protection status since the 1970's. This wood-pasture is excluded from

the characteristic rural management since over 30 years, and the ancient trees are protected.

Each wood-pasture was surveyed comprehensively by six persons, and the circumference of the tree stems was measured at ca 130–150 cm height. When a bifurcation (fork) or a node was present at that height, we measured the trunk size below (bifurcation) or above the node. We arbitrarily set ≥ 400 cm trunk circumference (diameter at breast height = 127 cm) for considering an oak ‘old’ (see Read 2000). At this trunk size, the majority of oaks have ≥ 200 years, and the hollowing process tends to be well represented (Authors, *personal, unpublished data*, see also Ranius et al. 2009). The stumps of the trees were not counted due to the following reasons: (i) The difficulty of assessing the size of the trunk at the stump level. As the height of the stumps is in average ca 25–30 cm, at this level, the circumference is usually much larger (can be up to 1 m) than at the breast height where the measurements were made for this study (see above). Furthermore, (ii) the number of stumps may not be a reliable indicator of the number of recently cut trees, since we do not know how many stumps were cleared from the wood-pasture after cutting, as it is common to chop up stumps with an axe (Fig. 1b). In this study, we focus only on the species *Q. robur* and *Q. petraea*, because these oaks reach typically large sizes and old ages and are the characteristically dominant trees in the wood-pastures from this region (Hartel et al. 2013). The dominant oak species (with ca 90 % prevalence) is *Q. robur* (Hartel and Moga 2010).

We considered the following explanatory variables to explore the number of ancient trees in wood-pastures: (i) The size of the wood-pasture (ha). The delineation of wood-pastures in forested landscapes was relatively easy because the forest margins represented the border of the wood-pasture. In the case of those wood-pastures which were surrounded by open landscapes, the exact delineation was more subjective; we delineated areas encompassing continuous areas of scattered trees (these being typical physiognomies for Transylvanian wood-pastures). (ii) The distance of the nearby village (calculated in meters, from the margin of the wood-pasture to the margin of the village) was a variable denoting the potential importance of the proximity of human communities. Written documents (e.g., Dorner 1910; Oroszi 2004) as well as our personal experience (see below) suggest that the ‘eye of the village’ was an important factor in informally protecting landscape elements such as large trees. (iii) The number of sheepfolds in the wood-pasture, based on the presence of characteristic shacks and fences, was considered as proxy for the direct human impact through management on wood-pastures and their old trees. Sheep are typically guarded by shepherds in this region and are kept in the wood-pastures often throughout the whole year (Öllerer 2014). Several direct observations from this and other regions of Transylvania suggest that shepherds often burn and cut the hollowing trees, which justifies the consideration of this variable in our analysis. (iv) The

percentage of the forest, pasture and arable fields within the 500 m radius around the margin of wood-pastures were also used as proxies for human access and impact. If the landscape surrounding the wood-pasture was dominated by forest, we assumed a relatively low human access and impact (Hartel et al. 2013). If the landscape surrounding the wood-pasture was dominated by pasture, we assumed a smaller extent of land cover and land-use change, while if the landscape was dominated by arable fields, we assumed a drastic landcover change around wood-pasture and possibly high human impact on wood-pastures. We considered the forest cover also because the great majority of the wood-pastures from this study region originate from grazed woodlands (Oroszi 2004).

We extracted the Corine Land Cover (CLC2006, European Environment Agency, 2012) classes using a model designed with Model Builder in ArcGIS Desktop 10.3 (ESRI 2015).

Three of the authors (CM, KÖ, TH) were directly involved in 2009 and 2010 in a large-scale educational project targeting the study region (‘Find the Oldest Tree’: <http://www.rezervatia-breite.ro/node/29>). We consider this project important from the perspective of the goals of the present paper, because it shows a potentially good local example for involving local communities in identifying and protecting ancient trees (Box 1).

Box 1. Finding the largest living oak from Transylvania with a citizen educational project

In 2009, the Mihai Eminescu Trust (MET) initiated a citizen-based project entitled ‘Find the oldest tree’, which involved primarily schools from over 20 villages from Southern Transylvania. Every pupil was asked to provide basic informations about the trees including the trunk circumference, species, location, the existence of hollows and a picture about the tree (<http://www.rezervatia-breite.ro/node/29>). The large trees were verified by the personnel of the MET.

The largest oak (*Q. robur*) from this region, with a trunk circumference of 920 cm, was reported during this project by two pupils from the pasture nearby Mercheaşa village. The tree was highly popularized, including by local, regional, and national TV Channels, newspapers, and internet forums. The tree received a name, ‘The Old of Carpathians’. Later, a local NGO (the Association Carpaterra) further documented the health and age of the tree, developing the formal documents to declare this oak ‘Natural Monument’. The Romanian Academy and the local authorities approved this request, currently the oak being formally protected. The oak and the spectacular wood-pasture where it is situated can be ‘virtually visited’ on Google Map using the ‘Bătrânul Carpatilor’ keywords in the ‘Search’ menu, showing that this monument was quickly updated on widely available satellite images. The tree also has a ‘Facebook’ page (‘Bătrânul Carpaţilor’) and was nominated for the ‘European Tree of the Year’ international competition.

The ‘Old of the Carpathians’ is currently the second largest known living oak from Romania. It is a wonderful example about the value of collaborative initiatives between local civil societies, communities and conservation scientists in building and complementing each other in order to achieve the recognition and protection of old trees.

Fig. 1 Examples of remarkable oak wood-pastures from our study region. **a** Mercheasa, **b** Ticusu, **c** Rupea. Stumps in various stages of degradation and a burned out trunk are visible in **b**

Table 1 Descriptive statistics of the variables describing the studied wood-pastures from southern Transylvania. Average values are given. *SD* Standard deviation, *CV* coefficient of variation

Variables	Average	SD	CV
Size of wood-pasture (ha)	171.47	279.75	1.63
Distance to the village	1216.90	812.47	0.67
Number of sheepfolds in the wood-pasture	0.59	0.74	1.27
Proportion of forest in 500 m buffer (%)	55.68	20.93	0.38
Proportion of pasture in 500 m buffer (%)	23.32	17.03	0.73
Proportion of arable land in 500 m buffer (%)	10.10	11.82	1.17
Number of old oaks	19.32	24.66	1.27
Density of old oaks (trees/hectare)	0.13	0.24	1.90

Data analysis

Statistical analyses were conducted on 41 wood-pastures (see above for the reasons of excluding one wood-pasture). The descriptive statistics for each variable are presented in Table 1. Pairwise correlations were calculated among variables to evaluate the presence of multicollinearity. No strong pairwise correlations were found between variables ($|r| < 0.78$), indicating low multicollinearity (Berry and Feldman 1985). Because of many zeros in the dataset caused by the lack of old oaks in 16 wood-pastures, the count data of the old oaks were related to environmental variables with zero-inflated Poisson (ZIP) models (Zuur et al. 2009) in the R statistical software (R Core Team 2014), applied with the ‘pscl’ package (Jackman et al. 2011). The ZIP models are used to model count data for which the proportion of zero counts is greater than expected on the basis of the mean of the non-zero counts. The ZIP models have two parts: (i) a Poisson count model and (ii) a zero inflation model. Therefore, they provide results as count model coefficients and zero inflation model coefficients. Thirteen apriori zero-inflated Poisson (ZIP) models were created, and their relative performance was evaluated using the Akaike’s Information Criterion corrected for small sample (AICc) (Mazerolle 2006). Comparisons were carried out between the ZIP models and the ordinary Poisson regression model using the Vuong test. The ZIP models were chosen because the Vuong test indicated that the ZIP models are superior to the standard Poisson models. We tested the interaction between the size of the wood-pasture and the number of sheepfolds in wood-pastures because we assumed that the negative influence of sheepfolds on the old trees is higher in smaller wood-pastures than in large ones.

RESULTS

We identified 490 old oaks in 25 of the surveyed 41 wood-pastures. The descriptive characteristics of these wood-pastures are presented in Table 1 and examples of the

largest wood-pastures with ancient trees are shown in Fig. 1. The oaks between 400 and 500 cm trunk circumference were best represented, while five oaks had over 700 cm trunk circumferences (Fig. 2). The largest oak from Transylvania and the second largest known living oak from Romania were identified in Southern Transylvania through a citizen-based educational project (Box 1). The average density of the old oaks was 0.13 trees per hectare (Table 1), and only one wood-pasture had a density of old trees higher than one tree per hectare. Eight wood-pastures had at least 35 large oaks.

The AIC allowed an unambiguous evaluation of the best model. The difference between the best and the second best model was 66.69 AIC units (Table 2). The best model in the count part showed that the number of old oaks in wood-pastures was negatively related to the village distance and positively related to the size of the wood-pastures and the proportion of forest and pasture around the wood-pastures (Table 3). Two variables (the size of the wood-pasture and the number of sheepfolds in the wood-pasture) when considered separately had positive influences on the number of old oaks but their interaction negatively influenced the number of old trees (Table 3). The zero-inflated part of the ZIP models did not contain significant relationships for any of the variables. The ZIP models confirm that the ordinary Poisson models should be applied with caution for count data that have an excess of zero counts.

DISCUSSION

The main results of our study can be summarized as follows: (i) Wood-pastures with old oaks are still well represented in the traditional rural social–ecological systems of central Romania. (ii) Wood-pastures with larger areas and surrounded by larger amount of pastures and forests tend to have more old oaks. (iii) The proximity of the village had a positive influence on the old trees, and (iv)

Fig. 2 The tree size distribution of the measured oaks based on the trunk circumference at breast height

The number of sheepfolds negatively affected the number of old oaks, in interaction with the wood-pasture size.

Our results revealed a high number of old oaks in the Saxon region of Southern Transylvania. However, 16 of the surveyed wood-pastures had no old trees, and the old oak density of the other 25 wood-pastures was relatively low. There are no official accounts of the number of old trees in Central and Eastern European countries, and therefore, we relied on online databases and informal communications in order to comparatively assess the value of the traditional cultural landscapes studied by us from the perspective of old oaks. A database presenting the largest trees from Hungary (country area ca 93 000 km²) shows that the number of oaks with trunk circumference above 500 cm exceeds 455, and 156 of these oaks are found in 50 wood-pastures (*personal communication* of György Pósfai, and see ‘Hungary’s Largest Trees’: <http://dendromania.hu/index.php>). The ancient tree hunt (ATH) database from UK contains 525 Pedunculate oak, Sessile oak and their

hybrids in wood-pastures, having at least 400 cm trunk circumference for England (source: ATH database, <http://www.old-tree-hunt.org.uk/discoveries/TreeSearch>, for October, 2015). Although the above data may underestimate the real number of large oaks to an unknown degree, as a rough comparison, our results suggest that the traditional cultural landscapes from Southern Transylvania have relatively high value in terms of old trees, specifically oaks. Our personal surveys carried out on oak wood-pastures from other parts of Transylvania (e.g. the region of Cluj, Hartel and Réti, *unpublished data*) show that the high number of oak trees is indeed a specific characteristic of the Southern part of this region.

The maintenance of the traditional farming practices due to the lack of opportunities for intensification, together with the demographic instability in the villages (Hartel et al. 2014a, b), was beneficial not only for the old oaks, but also for other important habitats types (such as small, temporary ponds, Hartel and von Wehrden 2013) and many species and habitats of conservation interest (e.g., amphibians—Hartel et al. 2010; corncrake—Dorresteijn et al. 2015; butterflies—Loos et al. 2015, brown bear—Roellig et al. 2014, large carnivores—Dorresteijn et al. 2014). Based on our results, we suggest that the high number of ancient trees is also a specific feature of the social–ecological systems in Southern Transylvania, besides the above-mentioned other natural values. Old trees are negatively affected by social–ecological changes and they persist in higher number in regions where such changes were less dramatic (Andersson and Östlund 2004; Butler 2014; Jørgensen and Quelch 2014). The importance of the marginal,

Table 2 Model selection results. *LL* Log-likelihood, *K* number of parameters, *AICc* corrected akaike information criterion value, *Delta AICc* difference between lowest *AICc* model and model *AICc*. *S* Size of the wood-pasture, *DTV* distance to village (m), *SF* the number of sheepfolds in the wood-pasture, *P_500* = proportion of pasture within the 500 m radius around the wood-pasture, *A_500* = proportion of arable lands within the 500 m radius around the wood-pasture, *F_500* = proportion of forest within the 500 m radius around wood-pasture “+” = the additive effect, “*” = the interaction effect

Model	LL	K	AICc	Delta AICc
S* SF + DTV + F_500 + P_500 + A_500	−419.96	16	893.68	0
S + DTV + SF + F_500 + P_500 + A_500	−458.41	14	960.37	66.69
F_500 + P_500	−708.91	6	1432.23	538.55
F_500 + P_500 + A_500	−708.66	8	1437.69	544.01
S + SF	−762.1	6	1538.59	644.91
P_500	−800.25	4	1609.58	715.9
S + DTV	−799.51	6	1613.43	719.74
S	−809.04	4	1627.16	733.48
DTV + SF	−843.36	4	1695.81	802.13
A_500	−856.57	6	1727.54	833.86
DTV	−861.97	4	1733.03	839.35
SF	−871.19	4	1751.46	857.77
F_500	−893.77	4	1796.61	902.93

Table 3 Results of the zero-inflated models relating the proportion of veteran trees with wood-pasture characteristics and land use

	Estimate	SE	Z	P
Count model coefficients (Poisson models with a log link)				
Intercept	2.696	0.068	39.539	<0.001
S	0.176	0.057	3.108	<0.001
DTV	−1.186	0.067	−17.591	<0.001
SF	0.593	0.052	11.487	<0.01
F_500	1.261	0.101	12.499	<0.001
P_500	0.845	0.096	8.835	<0.001
A_500	−0.031	0.096	−0.319	0.749
SF*S	−0.327	0.038	−8.708	<0.001
Zero-inflated models coefficients (binomial models with a logit link)				
Intercept	−0.956	0.544	−1.758	0.079
DTV	−0.160	0.563	−0.284	0.777
SF	−1.934	1.405	−1.377	0.169
S	0.130	0.417	0.312	0.755
F_500	0.539	0.783	0.688	0.492
P_500	0.923	0.794	1.163	0.245
A_500	0.367	0.552	0.665	0.506
SF*S	−0.042	0.989	−0.042	0.967

stable habitats for the large, old trees was also highlighted by Szívós (1904) and Orłowski and Nowak (2007).

We found that the sheepfolds negatively affect the old trees in wood-pastures, and their negative effect is more pronounced in smaller wood-pastures than in the larger ones. The clearance of the old, hollowing trees from pastures by shepherds is a widely known phenomenon in Transylvania. A typical quote illustrating this comes from a traditional farmer from the village Archita (the Eastern part of our study region): ‘I found many old oaks with hollows in them which were burned out by shepherds and they fell afterwards. Shepherds use these trees as firewood when they are out with the sheep in winter. These trees are available for them, as they need firewood every day’ (Man, 55 years, Hartel, *unpublished interview results*).

The number of sheepfolds dramatically increased in the wood-pastures after the year 2000, while the stocking rates of water buffalo and cattle (the traditional livestock for this region) remained relatively low since the collapse of the Romanian communism (National Institute of Statistics 2015). In this period, the uncontrolled pasture fires also intensified, with many ancient oaks being burned (Hartel et al. 2013). Sheep are favored by the recent subsidiary payments within the Common Agricultural Policy of the European Union, which, on the other hand, indirectly disadvantage cattle and water buffalo due to increasing severeness in the dairy products regulations. This increase in the number of sheep and the number of immigrating shepherds was already seen as a damaging factor in this region even at its very beginning (Dorner 1910), and is still

perceived as such by many locals, due to their clear effects on the management of pastures and hay meadows (Öllerer 2014).

Our study shows that the number of old oaks trees on wood-pastures was negatively related to the distance from the village and positively related to the proportion of forest cover in the landscape. We believe that the proximity of the village influenced the number of old oaks in two ways. First, the pastures more closely situated to the villages are assumingly older than the pastures situated far from the village. Historical records show that the settled rural communities first converted the closest woodlands into more open, wood-pastures, while the more distant woodlands were converted later as the demand for agricultural products (milk, meat) grew (Dorner 1910, Oroszi 2004). Indeed, the largest oaks in most of the wood-pastures are closely situated to the settlements, and the old historical maps (e.g., the Josephine maps of the Habsburg Empire, eighteenth century and afterwards) clearly show those landscapes where the current largest trees are, as open (the Mercheaşa (Fig. 1a), Ticuşu (Fig. 1b), and Dăișoara wood-pastures as typical examples). In many cases, the large oak trees are visible from the village (Fig. 1). Second, local communities generally show a positive attitude toward large, old trees. In several cases, locals name these trees, create stories around them or even protect large trees (e.g., the ‘Old of the Carpathians’, a 900 years old oak near Mercheaşa Braşov county (Box 1), the ‘Oak of Banciu’ from Alma Vii, Sibiu county, the ‘Beautiful Tree’, an oak from Dăișoara, Braşov county, the ‘Rounded Tree’, a field

maple from Tibod, Harghita county). A high number of locals expressed their concerns about the loss of old trees and the inability of the local authorities to stop these phenomena (Hartel, *unpublished results of 120 interviews from this region*). These calls for the urgent need for implementing local initiatives to increase the awareness about the values and threats related to these trees (see Box 1 for a successful local example), as well as to strengthen the social capital in order to protect these trees and other values.

CONCLUSIONS AND IMPLICATIONS FOR AWARENESS RAISING AND POLICY

We showed that the number of old oaks in the wood-pastures from our study region is high, which further increases the exceptional ecological and socio-cultural value of the rural social–ecological systems from Southern Transylvania. The old trees found in wood-pastures are, however, vulnerable to several human-related factors, from which direct cutting and burning (this study) and uncontrolled pasture fires (Hartel et al. 2013) are dominant. Indeed, yearly several tens of old oaks are irreversibly damaged or completely removed. The contradiction between the human-caused loss of old trees from pastures (see above) and positive attitude of a significant part of the local communities toward (individual) old trees (see results of this study and Box 1) is only apparent and highlights the need for deeper understanding of the value systems linking people to old trees and the importance of local and national policy regulation mechanisms shaping these links. For example, the weak and often corrupt local institutions (Mikulcak et al. 2013; Hartel et al. 2014a, b) can result in a disproportionally high negative effect of few people (e.g., shepherds) on old trees, despite the fact that local communities disagree with such behaviors.

The Common Agricultural Policy (CAP) could contribute to the conservation of old trees in Transylvania. For example the cross compliance rules (i.e. the Good Agricultural and Environmental Condition (GAEC) and Statutory Management Requirements (SMR) standards) for direct payments includes also the maintenance of the habitat value of the farmland (Agency of Payments and Interventions for Agriculture (APIA), Romania, 2015). The SMR no. 3 recognizes the habitat value of the trees on pastures, their removal being forbidden. The GAEC no. 7 protects trees on pastures (Farmers Guide for Eco-Conditionality, APIA, 2015). The hollowing, dying or dead trees, however, are not protected, their removal being possible with permits from the forestry authority (GAEC 7 in Farmers Guide for Eco-Conditionality, APIA, 2015). This is unfortunate because the habitat value of the trees

increases with the increase of hollowing and dead elements on the tree. The explicit and urgent recognition of value of old trees within the CAP regulation would be especially important for our study region, because of the high number of old trees and their fast decline due to human activities. Wood-pastures with large, old trees could be explicitly recognized and promoted within the Rural Development Program of the CAP. These trees are often older than many old buildings from the villages, which are considered cultural heritage elements. The long term sustainability of the old trees should be in the hearth of the farmland biodiversity conservation policies (Kirby 2015).

Complementary to the above-mentioned policy-related actions, there is an urgent need for initiating citizen science-based activities in order to inventory and describe large trees and to increase the social awareness of the many values of the old trees. The great attention received by the two recent projects involving citizens in identifying old trees in Romania, namely ‘Find the oldest tree’ (initiated by the Mihai Eminescu Trust) and the recently launched project ‘Remarkable Trees of Romania’ (initiated by a consortium of non-governmental organizations <http://arboriremarcabili.ro/en>, with over 2500 followers on its Facebook page and over 300 old tree records), show that such initiatives can raise major societal interest.

Acknowledgments The field research for this study was partly supported by the Mihai Eminescu Trust through the project ‘Conservation of wood-pastures with ancient oaks through the involvement of local communities’ funded by a Financiar Mechanism of the European Economic Area (EEA) grant (2009–2010). The research of TH was supported by an Alexander von Humboldt fellowship (2012–2013). We are grateful for Andra Pop, Árpád Szapanyos, Luminița Holban, Lucian Holban, Minodora Holban, Alexandru Goța, Kuno Martini and Denise Bobeș for their dedication in inventorying ancient trees in the Saxon region of Transylvania. This research has received funding from the European Community’s Seventh Framework Programme under Grant Agreement No. 613520 (Project AGFORWARD), through TH and LR.

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