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Tree Hay as Source of Economic Resilience in Traditional Social-Ecological Systems from Transylvania



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ABSTRACT

Tree farming substantially contributes to the resilience of the farming system. In this paper we bring historical and current arguments about nutritional value of trees and how this contributed to the capacity of the farming societies to navigate environmental challenges. On this basis we highlight the need of reviving the nutritional value of trees and the tree hay related knowledge and practices. Since scattered trees on pastures can simultaneously fulfil several important roles (biodiversity, nutrition source, aesthetic and cultural values) urgent actions are needed both at the level of policies, knowledge and local scales in order to re-connect human societies with trees, for the benefit of the whole social-ecological system.

KEYWORDS

trees, resilience, traditional landscapes, coupled social-ecological systems, conservation policy.

“Is it time to think again? Shouldn’t we be rediscovering the benefits of pollards not only for their essential contribution to sustainable farming and specially healthy and productive soils, but also for being capital assets creating beautiful landscapes, maintaining biodiversity and offsetting carbon to reduce climate change. And secondarily trees provide many products such as timber, fuel, fruits, and shade especially on low productive soils. Surely it’s a win-win to pollard trees to offset growing concerns about how we are going to maintain long term, sustainable agriculture as oil begins to run out and the constant and increasing degradation and depletion of our irreplaceable soils.”

(Ted Green, MBE, Founder President of Ancient Tree Forum, UK. Source of quote: Historic Tree Care)



Introduction

Traditional rural landscapes such as those from Eastern Europe (Romania) are true repositories of heterogeneous native vegetation, traditional ecological knowledge and skills, which makes them highly valuable from both a natural and cultural standpoint (Fischer *et al.* 2012, Molnar 2013, Dorresteyn *et al.* 2015). The large heterogeneity of these farmlands consisting in small arable fields, diverse crops and the existence of scattered trees in hay meadows and pastures also provides several option values for the local communities, e.g. by increasing the diversity and potential of ecosystem





services at local and landscape levels (Baumgärtner 2007). Despite their multiple values, traditional farming landscapes are increasingly under threat due to changes in land use (Plieninger and Bieling 2012; Hartel *et al.* 2016). The homogenization of the farmland resulted from monofunctional management is typically associated with the erosion of the relevant local skills and knowledge types and values related to multifunctional landscape management, this being also a crucial vulnerability factor for the resilience of local social-ecological systems (Plieninger and Bieling 2012).

Trees on farmland are typical examples of vegetation structures which synergistically enhance the multiple values of traditional farmland including aesthetic, cultural, provisioning services and biodiversity values (Plieninger *et al.* 2015). Traditionally scattered trees have had an important role within the farming landscape as they were actively farmed – either for their fruits, their leaves (tree fodder) or timber – and had several other values including shadow for livestock and increasing soil fertility (Rotherham 2013). Scattered trees make a valuable contribution to the farmland ecosystem by providing supporting ecosystem services (i.e. trees create a specific microclimate for the benefit of the grassland and livestock and offer habitats for wildlife) (Manning *et al.* 2006). Furthermore, scattered trees of various species and ages are significant components of the farming landscape identity. However, scattered woody vegetation is typically “traded off” from farming landscapes in modern agriculture because none of the above (or other) values are perceived as being important. Formal agricultural policies also discourage the maintenance and regeneration of trees on farmlands (Beaufoy 2014), as trees are not perceived as vegetation components with high and consistent production yields.

Transitioning rural communities from Eastern Europe, such as those from Romania, are ideal systems to understand

the nature of links between the rural societies and their “treescapes” and how these change in time. This understanding has practical implications for policy because it provides insights on re-connecting rural social-ecological systems (Fischer *et al.* 2012).

Here we provide a glimpse into the importance of farmed trees for the resilience of the rural social-ecological systems in the Saxon biocultural region of Southern Transylvania, Romania. A social-ecological system is considered resilient when it is capable to absorb various shocks while maintaining its identity (Folke 2006). Trees on farmland are ideal structures to address the resilience of traditional rural social-ecological systems because a typical traditional farming landscape contained trees which were either farmed (i.e. trees which were valued for their provisioning ecosystem services) or valued for providing other goods and services (Hartel and Plieninger 2014). Nevertheless certain tree farming practices were beneficial for human societies, trees and tree-related biodiversity (e.g. the coppicing and pollarding) (e.g. Sebek *et al.* 2013).

Although “tree haymaking” is no longer a practice in this region of Transylvania, it used to be one of the several value types which were associated to trees (whether on farmland or woodland). Similarly to fruits (mast, acorn and other) tree hay was typically a temporary, yet very important livestock nutrient resource to the local farming communities. Therefore our goal is not to overstate the fodder (hay) value of the trees; rather, our study should be interpreted within the context of multifunctional values of scattered trees, among which tree hay was one important value besides many other types of values (actively recognized or potential). A short overview of the importance and context of tree hay use in Europe is provided by Annex 1. While discussing our results we emphasize the (i) importance of reviving tree hay related knowledge and skills at

regional level, which could serve as a safe and effective knowledge source for the rural communities at village level during times of livestock nutrient shortage and (ii) the urgent need of formal policies and regulations for the re-introduction of tree hay making in these communities while recognizing the multiple (social, cultural, economic and ecological) values of this practice.

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Study area and methods

This study was conducted in the Southern part of Transylvania, in the Saxon historical region. The region is dominated by hills (up to 400-500 m a.s.l.) with a relatively equal proportion of forest, grassland and arable land cover. The study region was presented already in previous works (e.g. Hartel *et al.* 2013; Hartel *et al.* 2014). The field surveys conducted in this area evidenced the existence of a large number of old pollarded trees, especially hornbeam. The specific shape of these trees is due to the management interventions applied on the

branches (i.e. periodical removal either for firewood or for leaves) (Figure 1). Although we observed such trees very often, we never saw the practice of pollarding on these trees. Based on ring counts on branches, we roughly estimated that the oldest trees may have been pollarded *ca* 40-60 years ago.

This study is part of a broader assessment on wood-pasture preferences and use by the traditional rural communities from southern Transylvania. The semi-structured interviews were carried out in 2013 in six villages with 22 pilot interviews (in three villages) and then 92 interviews with the following themes: (i) the local names attributed to pastures with scattered trees, (ii) the most common trees on pastures, (iii) the values of scattered trees on pasture, (iv) the values of large, old trees and (v) the large, old, hollowing trees. The issue of “tree hay” was raised during the pilot interviews when two interviewees remembered the use of the tree leaves for feeding livestock in the past years in dry seasons. Because of this we explicitly asked about tree hay in the final interviews while discussing about the values of trees on wood-pastures with the following question: “What about the use of

tree hay and acorn? I heard that in the past people used dried tree leaves as fodder for livestock?” We allowed interviewees to express their knowledge and experience related to this topic.

The interviewees were approached in their homes or while they conducted farming activities. Each interview was conducted with one to four persons, the overall number of persons participating at the 92 interviews being 142. All interviews were recorded

and transcribed. The transcripts were then analysed using an open coding technique; each narrative was unpacked using codes, i.e. succinct summaries (consisting of one



Fig. 1. Old hornbeam pollard from Southern Transylvania. Pollarding is an intervention consisting of cutting the tree branches in various cycles as part of a harvesting activity (firewood and/ or leaves). The tree shown has 500 cm trunk circumference and it is the largest hornbeam we know of in Transylvania. Photo credits: Lucian Holban and Árpád Szapanyos.



or few words) of broad topics addressed under each theme. Examples of such codes included the mentioning of tree species used as source of fodder (e.g. “oak”, “hornbeam”, “beech”), the livestock type (e.g. “sheep”, “cattle”), the nature of experience with tree hay (no knowledge, no direct experience, direct experience), the time (e.g. year when they made tree hay), and context when they produced tree hay. Furthermore, in some cases information was provided about the ways of collecting and storing the tree hay and its nutritional value. We recorded the ethnic group, gender, age, main occupation, and origin of every interviewee. When more than one interviewee was present (usually the partner for married couples), we elicited the above information from the main interviewee and considered it as one interview.

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Results and discussions

Experiencing tree hay

The average age of those persons who had directly experienced tree hay was significantly higher (age 66, SD=13, n=31) than that of those who had only heard about it (47, SD=13, n=37) and of those who had had no direct or indirect experience with tree hay (43, SD=12, n=20), while the average age does not differ significantly between the last two groups (ANOVA test, $F_{[2,89]}=26.39$, $P<0.001$). These results indicate a sharp erosion of the tree hay related knowledge in the rural societies from Southern Transylvania in the younger generations. There are multiple correlated reasons for this knowledge erosion. First, the formal institutions (e.g. forestry) which prohibited the removal of tree branches (that is, pollarding) pushed traditional tree hay making in the threshold of illegality (increasingly since the nineteenth century). Although we did not specifically asked about the legal background of tree hay making, one interviewee mentioned that:

We cut branches of trees with leaves for livestock because we did not have enough hay for winter in the 50s. We were aware about the fact that it was not entirely a legal activity, but the weather gave us no option. We had more animals not like now, and we needed to feed them through the winter (Male, age 80, Hungarian).

Second, the less frequent shortage in grass hay which would keep the tree hay related skills and knowledge alive. While this may stand for certain regions, historical records suggest that in some cultural regions tree hay was made more frequently than in other regions, even if grass was available (Wessely 1864; Paládi-Kovács 1983) suggesting that tree hay making was also related to cultural habits (see also Annex 1). Finally, technology allowed for the production of other nutrient resources which could be more attractive (e.g. efficient, cheap) than tree hay during grass hay shortages. For example, in the nineteenth century, the technology allowed for the industrial processing of sugar beet in the Saxon region of Transylvania (as well as in other parts of Europe). Therefore Saxons produced sugar beet in high quantity on arable lands, which was then provided for feeding the livestock (Dorner 1910). The emergence of new, alternative and easily accessible fodder sources on the market may also contribute to the overall abandonment of tree hay and the related knowledge and skills. From a social-ecological systems perspective, the abandonment of tree hay represents one example of the erosion traditional of links between the farming society and the trees. Similar phenomena or other uses of the farmland trees such as acorn, pear and timber values were observed in the Saxon region of Transylvania (Hartel *et al.*, *unpublished manuscript*), resulting in a sharp decrease of trees on farmlands, which in turn threatens cultural landscapes with outstanding sociocultural and ecological values such as the wood-pastures (Hartel *et al.* 2013).



Trees used for hay

Tree species were specified 42 times in the interviews. 38% of those interviewees who had heard about tree hay mentioned tree species, while 52 % of those who had directly experienced tree hay making mentioned specific trees in their responses. The most commonly mentioned tree was the “oak” (62% of the 42 tree names provided), followed by “hornbeam” (21%). The other trees (“ash”, “beech”, “black locust”, “alder”, “birch”, “poplar”, “willow”) were less frequently mentioned (2-5%). Ash (*Fraxinus* sp.) which is commonly recognized for its fodder value (e.g. Wessely 1864) but occurs very scarcely in our region; this may be the reason of its less frequent mentioning by interviewees. Few interviewees also mentioned the reed as nutrient source for livestock (and nettle for pigs). Two interviewees also mentioned that the length of the branches should be up to 60 cm. According to the interviewees, the green (but dried) leaves are the most suitable for tree hay. Ash which is recognized for its fodder value in different parts of Europe (Rotherham 2013) was not mentioned at all by our interviewees probably because the regional availability of this tree is scarce. The overall preparation of tree hay detailed by the interviewees coincided with the written sources (see Annex 1).

The tree species used for tree hay making are likely dependent on the bioclimatic context (influencing the abundance of native trees) in interaction with local preferences and their palatability (Annex 1). In our region, the oak and hornbeam are the most common tree species on the wood-pastures and in forests, while the beech is also well represented (Hartel *et al.* 2013). The high percentage of interviewees mentioning oak as source of tree hay is interesting because the leaves of this tree were generally little used as fodder in Europe. Rather, the value of the oak was related mainly to their role as shade for livestock (Varga and Molnar

2014) and source of acorn for pannage (pig fattening) (Szabó 2013).

To our knowledge, there are no historical descriptions of tree hay making by Southern Transylvanian Saxons. Assuming that we did not omit a significant number of written resources, we think that the main reason for the overall scarcity of written records related to tree hay is that these writings focused on the modern technologies, the traditional practices such as pollarding for tree fodder being omitted or largely neglected (see e.g. Dorner 1910; Giurescu 1975; Oroszi 2004). Traditional agricultural and forestry practices were often treated with irony even within the traditional Saxon society, calling these technologies old fashioned and economically costly (Dorner 1910; Oroszi 2004). Demetrescu (1942), an expert forester even referred to pollarding as a traditional method characteristic to regions of Romania marked by “extreme poverty”. However, even if largely overlooked by written sources (at least those available for us), the still common occurrence of old pollarded trees (see Figure 1 for a large, old hornbeam pollard) in Southern Transylvania suggests that this activity was once a more common practice in this region. This highlights the extraordinary historical and cultural heritage values of the old pollards, in addition to their ecological values. These trees should be formally recognized and protected. The project “Remarkable Trees of Romania” (*Arborii Remarcabili din România*) identified 55 large hornbeam trees the great majority of them being pollarded (<http://arboriremarcabili.ro/en/>). The potential number of such large trees is much larger in the studied cultural region of Transylvania.

Livestock fed with tree hay

Livestock was mentioned most of the times only generally (i.e. “animals”). Mention of specific livestock occurred in 22 interviews (14 of them with direct experience in tree hay making and 8 with

indirect experience), the overall number of occurrences being 27. The most frequently mentioned livestock was sheep (mentioned 11 times) and cattle (mentioned 10 times), other livestock being: goat (4 times), horse (1), and pig (1). Based on our interviews and written references goats and sheep seem to be less particular about the tree species they eat than cattle and horses, experience with tree hay for different livestock being therefore an important factor. Wessely (1864) for example claimed that livestock which is initially reluctant about eating tree hay may get accustomed to it and then even prefer it. Overall, re-discovering and learning the tree species preferences of livestock would be advisable in tree hay reviving strategies (Wessely 1864).

The context of tree hay making

Every interviewee admitted that tree hay in Southern Transylvania was typically made in periods of extreme dry summers when there was a shortage of grass hay. Twenty three interviewees (34% of those who had direct or indirect experience with tree hay) also mentioned specific years when the summer was very warm and dry. These years were: 1937 (mentioned once), 1942 (once), 1944 (three interviewees from one village), 1946-1947 (13 interviewees from all villages), 1956 (once), and 1987 (once). Two interviewees mentioned generally the '40s-'50s and one the '60s-'70s. Vivid memory accounts of the interviewees about tree hay making are exemplified by the next two quotes.

After the war, in 1946 and 1947, it was a terrible drought, so terrible, that there was no water. People said that God took revenge for Hitler's war. And I know that my aunt and I had two oxen, Bandi and Viktor, and we took the cart and put a short ladder in it, we took the sickles and we went out to these large oaks with their drooping branches and cut the thin branches with leaf. We made sheaves as you do with wheat usually. We took home

one-two carts of such fodder and we fed the oxen with that. They ate the timber too... they had something to eat! There was no grass because of the drought. We say: "If God takes something away from you, He will give you something else in return." You see, last year there was a drought, but there was also a lot of acorn. So, He gave us acorn. (Female, age 77, Saxon)

Yes, we made tree fodder for the animals. I gathered it myself, when I was a child and there was a very serious drought. My father, may he rest in peace, and I would go up to the large oak forest near the village, up on the hill, and with my brother in law, the husband of my aunt, sister of my father, in autumn, I remember that we would climb the oak and wouldn't cut the thick branches, only the thin ones not wider than my finger. We brought them home with the carts and cattle and we gave them to sheep in autumn and winter when there was a drought and we didn't have any hay. (Male, age 50, Romanian)

Our results suggest that the tree hay was typically made as response in case of extreme droughts. Recent interviews carried out in the mountainous regions of the Eastern Carpathians as well as in the Transylvanian lowlands (Hartel, *unpublished material*) show that traditional farming societies navigated extreme drought periods (some interviewees explicitly mentioning the droughts from 1945-47) by making tree hay. A quick Google search using the words "seceta din 1946" (i.e. drought from 1946, this year occurring most frequently in the interviewees' accounts) provided several grey literature accounts on the extent of the economic and social misery caused by this climatic event in Romania. Ioniță *et al.* (2016) identified seven more periods with extreme drought in the past half century, namely 1965-1966, 1974, 1986, 2000, 2002, 2003 and 2011 – these had all negative consequences on Romanian agriculture at regional scale. Annex 2 provides a detailed example on the 1893 extreme drought (in France) and the quick (and reactive) response of the government and society



to mitigate its negative effects. Tree fodder was an important resource to navigate this extreme year and it was applied as a quick response to the (unexpected) drought. Annex 2 also highlights the situation from Hungary (1866) where the extreme drought had severe consequences on livestock and Wessely (1867) highlighted that the situation could have been mitigated if tree fodder had been known, appreciated and used as a resource at that time. Observations on the use of tree fodder in extreme summer droughts by farmers in UK was reported by Ted Green:

In the “great summer heats” like 1976 when all the meadows had burned off, especially improved grassland, I watched farmers in Brittany cutting the only remaining greenery to feed their animals – branches with leaves. However, this is now the exception as pollarding for fodder across the European continent appears to be in steep decline. In parts of the Lake District, ash pollards are still cut in the winter months to give the bark and buds to the sheep. Otherwise it is increasingly confined to a few small areas in remote regions, in poorer countries or in mountainous areas where the animals are housed for long periods during the winter months. In the UK and other fertile lowland areas it may have died out with the coming of turnips. (source: Treework Environmental Practice, <http://www.treeworks.co.uk/>).

The above examples show that trees had crucial importance for the traditional rural societies in the Saxon region of Transylvania and elsewhere in Europe (see also Annex 1 and 2). Tree hay became disproportionately valuable for farmers during extreme drought spells by contributing to the capacity of the household economy (which was largely determined by livestock and their products) to navigate these extreme periods without significant loss of capital. Therefore tree hay was a significant source of resilience for farming communities.

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Conclusions

In this paper we showed that trees contributed to the resilience of traditional farming systems in periods of drought. We furthermore showed that the direct experience with tree hay is restricted to elderly persons while the young farmer generations have no knowledge of this resource. Consequently, tree hay is an important example of quickly changing links between farmer communities and treescapes and the complete abandonment of formerly important ecosystem services of trees. We listed three possible reasons which could lead to this abandonment: less frequent grass hay shortages in the past decades, institutional prohibition, and the less direct reliance on trees as sources of fodder with the more efficient and easier available fodder resources accessible on the market. While we acknowledge the importance of technological development in co-producing ecosystem services, we also call for the regional maintenance of specific traditional knowledge and skill types because of their learning and inspiration value and also because they are part of the regional historical, cultural and landscape identity. Similarly to biodiversity (e.g. Baumgärtner 2007), our tree hay example shows that the diversity of knowledge types and skills related to the management of natural resources (in our case, farmed trees) can also be a source of resilience for local communities. The maintenance of local tree hay related knowledge and skill types could therefore represent easily available knowledge and inspiration for the local community. Furthermore tree hay making can also contribute to the maintenance of a traditional practice, adding extra heritage value to local communities while increasing the habitat value of trees (Sebek *et al.* 2013).

Currently there is a sharp decline of scattered trees from farmland. Although our study did not explicitly showed that only



trees on farmland were valued as fodder, the economic and ecological potential of these trees are enormous. Trees scattered on farmland should therefore not be quickly removed just because society perceives no direct and tangible benefit at a given moment of time from these trees or because currently there is no formal policy to support these trees. Rather, scattered trees in grazed landscapes have huge value potential and could provide societies (rural and urban) with an opportunity to (re)discover the old and new values of trees. For example, scattered old trees on wood-pastures in Transylvania were subjected to a photo exhibition project in three large cities of Romania, where arts, social and environmental sciences were brought together to communicate the several values of these trees for urban communities (Project “Old Trees”, run by Florin Ghenade at Galeria Posibilă, see e.g. <http://www.natgeo.ro/romania/locuri-oameni-ro/10341-arbori-batrani>). This project clearly demonstrated that there is a societal demand for old trees for their aesthetic, historical, cultural and ecological values. Villages which still have traditional wood-pastures will be more advantaged from a cultural perspective because these aesthetically, historically, culturally and ecologically valuable systems and could provide extra options for social



Fig. 2. Piles of tree hay drying, made in Valea Zălanului (Zălânpatak) in 2016, as part of a tree hay revival project. Trees were selected according to local knowledge (e.g. Mr. Farkas József, age 82, forester) and consisted of grey willow, hornbeam and oak.
Photo credits: Kinga Olga Réti.

and economic capital building. Tree hay as a currently unusual but traditionally widespread resource could be an important central component in such projects. The existence of tree hay related knowledge and skills in the local memory could be an important source of learning for reviving this practice in the local communities (Figure 2).

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Annex 1. Short overview of tree hay in Europe

Extent of tree hay use. Tree haymaking is an ancient tree farming method in Europe (e.g. Simmonds, 1986). Historical reports show that the practice of tree hay making was widespread in Europe, including UK, Slovakia, Germany, Switzerland, Belgium, France, Hungary, Mediterranean region, Scandinavian countries, Czech Republic. In Romania, it was reported in all geographical regions (Paládi-Kovács 1983; Austad 1988; Robinson 1986; Anamaria Iuga *personal communication*).

The trees used for tree hay. The trees used for tree haymaking varied largely geographically being also determined by the local experience (culture) and livestock type fed with this resource and the active chemical content (e.g. tannin, pharmaceutically active substances) of the trees. A general pattern emerging from the written references is that tree hay is a valuable complementary nutrient for livestock in addition to grass hay, and the frequency of its use varied by regions, climatic conditions and the availability of other resources. The most often used trees for livestock feeding mentioned by various references were the ash (*Fraxinus* sp.), birch (*Betula* sp.), maple (*Acer* sp.), oak (*Quercus* sp.), alder (*Alnus* sp.), hornbeam (*Carpinus* sp.), willow (*Salix* sp.), lime (*Tilia* sp.), peanut (*Corylus* sp.), elm (*Ulmus* sp.), poplar (*Populus* sp.), beech (*Fagus* sp.), pear (*Pyrus* sp.), black locust (*Robinia* sp.), heather (*Calluna* sp.), holly (*Ilex* sp.), spruce (*Picea* sp.) (Wessely 1864; Paládi-Kovács 1983; Robinson 1986, A.I. *personal communication*). Wessely (1864) provides a detailed, experience-based overview for the value of 22 tree and shrub species and genera as fodder for livestock. His overall conclusion was that while sheep and goat have more broad preferences for various species of trees, cattle will provide good milk when fed with ash, elm and willow. The young leaves of black locust, maple and

beech provide also good nutrients for cattle, but the oak, lime, poplar and hornbeam are less preferred by cattle. Finally, Wessely concluded that tree hay can compete with grass hay in its nutritional values. The general view of Wessely is supported by many similar (“grey literature”) sources. Other authors take a more technical-engineered approach, classifying the woody vegetation simply as having virtually no nutritional value *and* being harmful for the herbaceous vegetation and pasture, without highlighting the importance of multiple values which trees can have on farmlands in various contexts and densities (Marusca *et al.* 2011). Tree fodder has high recognized nutritional value for wild herbivores, examples of trees including black locust, poplar, birch, ash, maple, elm and lime (Georgescu and Georgescu 2014). Tree hay was generally made in the summer (June, August and September – in periods without rain) and fed to livestock during winter time (Paládi-Kovács 1983). Leaves should be dried in the shade (so that they remain green), and stored in sheaves (called *snopi* in Romanian and *kéve* in Hungarian). When tree hay was produced more intensively, the tree branches were cut in three-four year cycles (Paládi-Kovács 1983). Special equipment to climb on the tree and cut the branches existed and their use was sometimes regulated.

Context. In some regions tree hay was used every winter while in other regions it was used only when the extreme summers “burned out” the pastures and hay meadows (Wessely 1867, Code for good practices for farms, 2015).

Status, policies, regulations. With the increase of the timber value of the trees, regulations emerged to prohibit tree hay making because this activity was perceived as damaging to the trees. Such regulations appeared back in the eighteenth century (for private forests) while nowadays it is forbidden everywhere. Tree hay was also abandoned in large areas of Europe as more efficient fodder types became



available (Robinson 1986). Paládi-Kovács (1983) noted that tree hay was common in Hungary up to the end of the nineteenth century “but in the twentieth century even its memory had become blurred” from large regions of this country. Currently there is great divergence of opinion regarding the value of trees for fodder (and generally on farmland, see above).

Annex 2. Adaptive responses of farmers to the 1883 extreme drought: a case from France

Written historical records can be important sources of knowledge about how societies navigated environmental shocks such as extreme climatic variations. In this annex we present the case of France during the 1883 extreme drought that caused severe loss in the agricultural sector. We will emphasize the nature and extent of damages, the most vulnerable social groups, and the (reactive) ways in which the government tried to cope with the drought. Trees as nutrient sources were important components of the nation-level adaptation strategies, but were not built in a coherent “crisis strategy”. All information are extracted from Csillag (1894) who wrote the paper for the Hungarian scientific community with the special goal of warning about the need to prepare for such periods.

The drought. The winter of 1892-1893 was usual and no one suspected that an extreme drought will follow later on in 1893. March however was 3°C warmer than usual and the precipitation was much below the normal values for that period (9.6 mm, while the normal value would be ca 25 mm – as measured in Paris). The vegetation including fruit trees started to green in March. The extreme drought from March continued in April (1.2 mm), being associated also with extreme heat: 13.8°C (i.e. 4.6°C warmer than the average, similar high values being recorded 100 years ago). In the southern part of France there were 49 mm in March and 38 mm in April.

The consequences of the drought. The meadows and pastures were “burned down” in April. Several crops seeded in March were compromised by the drought and heat from April, while other economically valuable plants – beet – which were seeded later were also affected. The damages caused by insect pests were high. “In order to feed their animals, people deprived the trees of their leaves; as a consequence, the birds which would destroy the insects left the region” (Csillag 1894: 270). The hay was very expensive (“The best meadows which provided 18-20 tons of hay yearly now provided only 750 kg.”) leading to the loss of many livestock animals (Csillag 1894: 271). The price of livestock dropped to unprecedented levels.

Reactive measures to overcome the consequences of the drought. The French government ordered the county-level chief financial officers to promote the seeding of more crops and to try new fodder resources (May 3 and afterwards). Csillag highlighted the extraordinary cooperation between farmers and formal institutions to quickly spread important information and seeds in the society to overcome economic loss. After several failed attempts, the government resorted to a traditional method to help people survive the extreme period of drought, by allowing forest grazing in state-owned forests. This was applied also in 1875 when the Royal Agricultural Society allowed forest grazing in response to hay shortage caused by drought. Some trees (e.g. black locust, poplar, birch, some coniferous trees) may provide good fodder while others are less palatable, even poisonous. “The leaves are therefore excellent nutrients and the forest is a hanging pasture” (Csillag 1894: 271). Although relying only on tree leaves was not beneficial for cattle, they at least survived the hard period although they caused damages to forests. After other complementary – but failed – attempts, the government allowed the expenditure of 5 million francs to help the farmers most affected by drought. “Although they were



not efficient in halting economic losses of farmers in this crisis period, the measures being applied equitably, they alleviated their misery, especially for the poor farmers" (Csillag 1894: 273). A call was made by the government to create formal institutional structures in order to prepare for future similar extreme crises.

Conclusions. The above example shows that French society was able to mobilize a wide diversity of resources (including different types of knowledge) in order to navigate the crisis period caused by drought. Testing new crops, traditional knowledge types, efficient spreading of information, quick decisions and fair distribution of resources

were important components of these measures. Tree fodder was an important source of resilience for the farmers in this period. Although Csillag does not mention the 1866 extreme drought in Hungary, Wessely (1867) provides a description of the economic loss of Hungarian farmers in this year, while suggesting that the knowledge and availability of tree fodder could have contributed significantly to the mitigation of economic losses. The economic crisis caused by the drought in Hungary (1866) was basically the result of the lack of knowledge on how to mobilize important complementary resources in a quick and effective way.

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