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# Perception and Management of Spatio-Temporal Pasture Heterogeneity by Hungarian Herders

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**Abstract**

The goal of our study was to document traditional steppe herders' perception and management of spatial and temporal heterogeneity of forage availability of their seminatural pastures. Ninety-two herders living in the Hortobágy saline steppe, Hungary, Central Europe were interviewed, and participatory observation was used to understand herding and habitat improvement techniques. The herders recognized 47–66 habitat types (mostly grassland types), and listed at least 90 plant species important for grazing. They have a nuanced knowledge of the intra- and interannual variations of forage quality and quantity. They perform very strong and well-planned herding practices. Daily spatial pattern of grazing is, however, often opportunistic and flexible, but has a more-or-less regular year-round cycle, in which marshes and stubbles provide forage in drought periods. Reciprocal learning and continuous communication between the herder and his driving dogs and livestock strongly influence grazing pattern. Herders manage and improve different habitats of their pastures differently by traditional and, less frequently, modern methods. The main method is grazing supplemented by manuring, burning, and removal of spiny weeds. Traditional knowledge of herders could be effectively used in evidence-based conservation and pasture management of European saline steppes; e.g., the reintroduction of some old herding techniques (opportunistic pasture use, grazing of marshes, and burning). Herders' knowledge could also help the fine-tuning and local adaptation of European agri-environmental regulations (e.g., how to balance subsidies for hay-making and grazing in saline steppes). More research is needed, however, on the ecological effects of different traditional grazing techniques, e.g., rotation, manuring, and burning. In general a more complex socio-ecological understanding of the internal and external factors affecting adaptation of the Hortobágy herders to changing environment, society, and European Union policies is needed.

**Key Words:** fodder availability, grazing distribution, nature conservation management, pastoralists, pasture management, precision herding

## INTRODUCTION

Pasture heterogeneity is one of the key factors that affect grazing besides biology and behavior of domesticated animals and decisions of herders (Coughenour 1991; Scoones 1995; Coppolillo 2000; Dwyer and Istonim 2008). Nomadic, transhumant, and sedentary traditional herders all perceive pasture heterogeneity, and adapt to it by driving their herds to different places at different times (e.g., Bovin 1990; Manger et al. 1996; Fernández-Giménez 2000; Schlecht et al. 2006; Dwyer and Istonim 2008).

The ecological knowledge underlying nomadic and transhumant movements is fairly well documented (Scoones 1995; Fernández-Giménez 2000; Schlecht et al. 2006; Dwyer and Istomin 2008; Roturier and Roué 2009). In contrast, much less is known of the grazing strategies of sedentary herders. Coppolillo (2000) found that distance to water and herd size affected herding radius significantly. Free-ranging cattle switch between a variety of habitats (floodplains, dry land, arable land) during the year, depending on forage availability (Scoones 1995). Herded and herd-release managed livestock are offered more palatable forage and grazes in areas of higher forage availability than free-ranging animals (Turner et al. 2005). Schlecht et al. (2006) documented that herded animals have a longer daily grazing itinerary, but one during which an increased amount of forage is available to grazing livestock. Among sedentary Senegalese Fulani pastoralists both "micro-mobility" and small-scale transhumance were found to be important (Adriansen 2008). In Europe, however, a detailed ecological and ethnoecological documentation of traditional sedentary herding systems is largely lacking.

High-nature-value grasslands are highly threatened across Europe. For better nature conservation management of these grasslands used mainly for pasturing or hay-making, more reliable knowledge is needed (Bunce et al. 2004; Molnár et al. 2008). But where could evidence for the so-called evidence-based conservation management come from? Sutherland et al. (2004) emphasize the role of scientific publications, the knowledge of experts, and the grey literature of reports. However, they do not list among the experts those who have been living in a landscape for a long time, and have been using traditional land-use methods comparable to those in nature conservation management. I argue that these people (peasants and herders) are also experts, and that their knowledge should be taken into consideration in evidence-based management (see also Karl et al. 2012).

By understanding traditional European herders' ecological perceptions and how they make their herding decisions, we

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may better understand the resource management and the importance in this of traditional ecological knowledge in grazed landscapes (cf. Fernández-Giménez 1993, Roturier and Roué 2009). Identifying the factors that affect grazing patterns may also help us recognize the rationale behind heterogeneous resource use, and may provide a deeper insight into the role of the long-term factors shaping current landscapes. All this information could be used effectively to improve our management in European pasture lands (Council Directive 1992; Bunce et al. 2004; Fernández-Giménez and Estaque 2012).

In this paper, the traditional ecological knowledge and herding practices of sedentary herders of the Hortobágy steppe is introduced. By traditional I refer (sensu Johnson and Hunn 2010) to social and economic systems that are historically deep, relatively independent of global markets, and composed of people whose livelihoods still depend on the local biomass of the landscape to a substantial degree, and who are thus more directly tied to their natural surroundings than city dwellers. By modern I refer to more industrialized agriculture, utilizing machinery, monocultures, and high levels of fertilizers, pesticides, and herbicides.

It is not easy to define traditional ecological knowledge in Europe, as nontraditional urban people have lived in close vicinity to rural people for centuries, and Western science could have had a profound effect on many areas of rural ways of life. I define traditional ecological knowledge as follows: tradional ecological knowledge in Europe is a practical knowledge based upon decades of personal experience with the landscape, and usually contains many centuries' old, communally stored knowledge and experiences, which are inherently connected to many rituals of the everyday social life.

The study primarily focused on the following questions: How do traditional herders perceive spatial heterogeneity and temporal variation of their pastures, and what do they know of quantitative and qualitative changes of the key fodder plants? Details of traditional and modern pasture management, and the herding methods used by herders is provided.

## STUDY AREA AND METHODS

### The Landscape

The Hortobágy steppe (ca. 100 000 ha, central coordinates: lat 47°30′N, long 21°06′E) lies within the Carpathian Basin in Central Europe (Fig. S1; available online at http://dx.doi.org/10.2111/REM-D-13-00082.s1). The Hortobágy National Park was founded in 1973, and the study area lies within the boundaries of the park. Originally, the area was a floodplain that gradually dried out and became saline (Sümegi et al. 2000). Water from melting snow and summer rains covers approximately one-third of its area for weeks and months, usually in the period between October and April. The average yearly precipitation is 550 mm, whereas the mean annual temperature is 10°C (Pécsi 1989). The shallow groundwater is sodic.

The vegetation is a multiscaled mosaic of habitats along an elevation gradient of ca. 1.7–2.3 m. Vegetation is determined mostly by soil type (Molnár and Borhidi 2003). Habitats at higher elevations have chernozem soils and a deep groundwater table. Habitats in the middle section of the edaphic gradient have a high groundwater table and are highly saline. Habitats in the depressions are usually waterlogged for most of the year. For the last few millennia, vegetation has been fairly stable (no woodland invasion, no big changes in hydrology), but during the 19th and 20th centuries, river channelization and drainage works dried out many marshes (Molnár and Borhidi 2003). The area has been used for extensive grazing for millennia. The vegetation (and also the flora) of the area is well documented (e.g., Szujkó-Lacza 1981; Molnár and Borhidi 2003). Latin names of plant communities and plants follow Borhidi (2003) and Király (2009), respectively.

Landscape elements have a diverse terminology in the literature of traditional ecological knowledge: ecotope, habitat, kind of place, biotope (Johnson and Hunn 2010). I chose to use the term habitat, since in Europe this is the most widespread term that includes all living creatures on a piece of land with its soil, bedrock, and hydrology. Herders distinguished and described habitats on their pastures based mainly on these environmental features (see below).

### Herders and Herding

There are ca. 300 active herders in the Hortobágy, herding mostly sheep and cattle. All herders are Hungarians speaking Hungarian. Most of their families settled in the landscape before the 18th century. In the Hortobágy region, nomadic, seminomadic transhumant, and sedentary grazing systems existed often in parallel throughout history (Bellon 1996), utilizing also the Tisza River floodplain to the west, and the sand forest steppes to the east. Longer-distance transhumance collapsed after World War II, but a much more restricted, transhumant-like system survived even afterwards. Animals are kept in barns in the villages surrounding the Hortobágy steppe in winter, and are driven to spring-to-autumn pastures on the inner parts of the steppe. Today, the extensive steppe is parceled out into separate pastures (ca. 90–150 ha for sheep, and 500–800 ha for cattle) that are used by one herd. Usually 500–800 sheep or 250–300 cattle form a herd. Animals are usually herded with herder dogs. Paddock systems, restricted to small areas, existed only during the socialist period, mostly in the 1970s and 1980s. Herders rent pastures from the Hortobágy National Park, or are employed by a state-owned company. Some herders herd the animals of the villagers, while some have their own animals.

All interviewed herders have a deep root in herding, and all were born in the region. Herders spend ca. 110–200 $d \cdot yr^{-1}$ on the steppe. Herding skills and related knowledge were exclusively learnt in informal ways, i.e., in the family, from the early childhood. They argue that they have learned nothing in school or from books on herding and pasture vegetation.

### Data Collection and Analysis

Ninety-two herders were interviewed (age minimum, 29; maximum, 86; average, 67). The 27 most knowledgeable ones (those who knew more than 70 plant species and distinguished at least 30 habitat types, and were regarded as outstanding herders by their colleagues) were interviewed several times. First, knowledge of wild plant species and pasture habitats were collected, then knowledge of herding and pasture management. Indoor interviews (1.5–2.5 h each in the home

**Table 1.** Questions asked to elicit traditional herding practices and the related traditional ecological knowledge.

| Questions during indoor interviews and outdoor participatory field work |
|---|
| Could you describe the activities on your pasture from January to December? |
| Could you describe a day on your pasture in spring/summer/autumn/winter? |
| Could you list the parts of your pasture (from the viewpoint of grazing)? |
| Could you describe in detail what X looks like? (X is a locally elicited habitat name.) |
| What plant species occur on your pasture/in X-type places? (X is a locally elicited habitat name.) |
| What should we know about species Y? (Y is a salient plant species of the local pastures.) |
| What places does species Y prefer? |
| What is the season and forage quality of species Y? |
| What are the key plant species for your animals in spring/summer/autumn/winter? |
| Do your sheep/cattle prefer or not species Y/X-type places? (X is a locally elicited habitat name.) |
| How can you maintain/improve the grass quality of your pasture? |
| How do you perform activity Z? (Z is an activity previously elicited from local herders.) |
| Have you heard of any other maintenance/improvement method? |

of the herder) were followed by outdoor interviews. Interviews were recorded by a Dictaphone. Ethical guidelines suggested by the International Society of Ethnobiology were followed. During the 86 field days, free and semistructured interviews and free listings were applied. Field visits and participatory observation were made as often as possible (45 d). During herdings, thorough observations and photo documentation and walking interviews were made in order to get a deeper understanding of the herders' practices and the related ecological knowledge. Qualitative botanical assessments (species and habitat identifications) were done parallel to the interviews.

I explored herders' knowledge regarding the main activities on the pastures, their knowledge about the habitats of the landscape they are active within through the year, the typical plant species occurring in various parts of the landscape, and the livestock preferences toward various plants (Table 1). Items (plant species and habitats) were selected based on our previous experiences (see Molnár 2012).

Relevant information from the interviews was extracted and grouped into the following groups in a database: plant species (334 species; 5 149 records of species identification and 1 772 records of habitat requirements and dynamics of plant species), habitats (66 habitat types; 1 543 records), landscape changes (general landscape, main habitat categories, species specific information, century-scale changes, decade-scale changes, yearly fluctuations; 236 records), pasturing and management activities (the grass of the pasture, grazing in general, grazing in different seasons, grazing techniques, hay-making, pasture improvements, cooperatives, National Park, learning processes, world view; 1 183 records of pasturing activities and 945 records of pasture management), and other data. In an Excel database the codes, the original quotations, and the name of herders were recorded.

## RESULTS

### Herders' Perception and Knowledge of Spatial and Temporal Heterogeneity of Their Pasture Habitats

Herders evaluated habitats in their pastures based on productivity, salinity, wetness, dominant plant species, soil color, relative elevation, geomorphology, patchiness, land use, density (of tall herbs and bushes), and litter cover (Fig. 1; Table 2). Three main groups were distinguished: *partos* (most important and stable pastures on higher elevation, mostly tall- and short-grass steppes), *szíkes* (saline areas with highly variable water cover and vegetation height and density), and *lapos* (wetlands with intra- and interannually highly fluctuating water levels, and high and dense vegetation). Mosaics at different scales were also named.

Herders regarded *telek* habitats (places around sheds and wells) with a high quantity and quality of biomass as most suitable for grazing. *Festuca pseudovina* dominated habitats; though having less biomass, it provides high quality forage throughout the year. Saline and wet habitats were valued less, though some saline patches provide nutritious forage in late summer, but only in small quantities. Herders don't appreciate abandoned pastures, as spiny species (e.g., *Cirsium* and *Carduus* species) tend to spread, or litter tends to accumulate on these (they "became wild"). Road verges and ditch sides were valued for their diverse and nutritious hay.

### Distribution and Dynamics of Key Forage Species

Herders listed ca. 90 plant taxa as important for grazing. An additional ca. 90 taxa had lower importance or were regarded as pasture weeds. The most salient and typical 35 folk taxa are described in Table 3.

According to herders, almost all plants have a patchy distribution, though most species occur on each pasture. Some were characterized as being specific to certain habitats (e.g., "*Camphorosma annua* likes the most saline places, it grows only there"). According to herders, some species provide larger quantity and nutritious forage (e.g., *Festuca pseudovina, Lolium perenne*), whereas some others provide a large quantity but low-quality forage (e.g., *Alopecurus pratensis*). Some plants were regarded as having low biomass, but being nutritious (e.g., *Camphorosma annua, Puccinellia limosa, Polygonum aviculare*). Flowers of *Podospermum canum* seemed to be a dessert for sheep and pigs ("they run after it"). Herders distinguished "short" (*Festuca pseudovina*) and "long" grasses (*Alopecurus pratensis*). Herders often made a clear distinction between soft and tough grasses: "After eating soft grasses, animals do not drink and do not fatten."

Herders were well aware that most species show intra- and interannual variability in abundance. They used a phrase for species (e.g., *Trifolium* spp., *Lotus* spp., *Geranium* spp.) that have highly fluctuating interannual dynamics: *felfordult tőle a mező*—literally "it turned up the grass," meaning that the usual structure of the vegetation was disturbed by the species.

Intra-annual availability of species was also seen as highly variable. The abundance of annual species fluctuates the most within and between years, e.g., "*Trifolium* depends on the weather; in good weather it is abundant." Herders also have a special phrase for such years: *bodorkajárás* (literally, "when

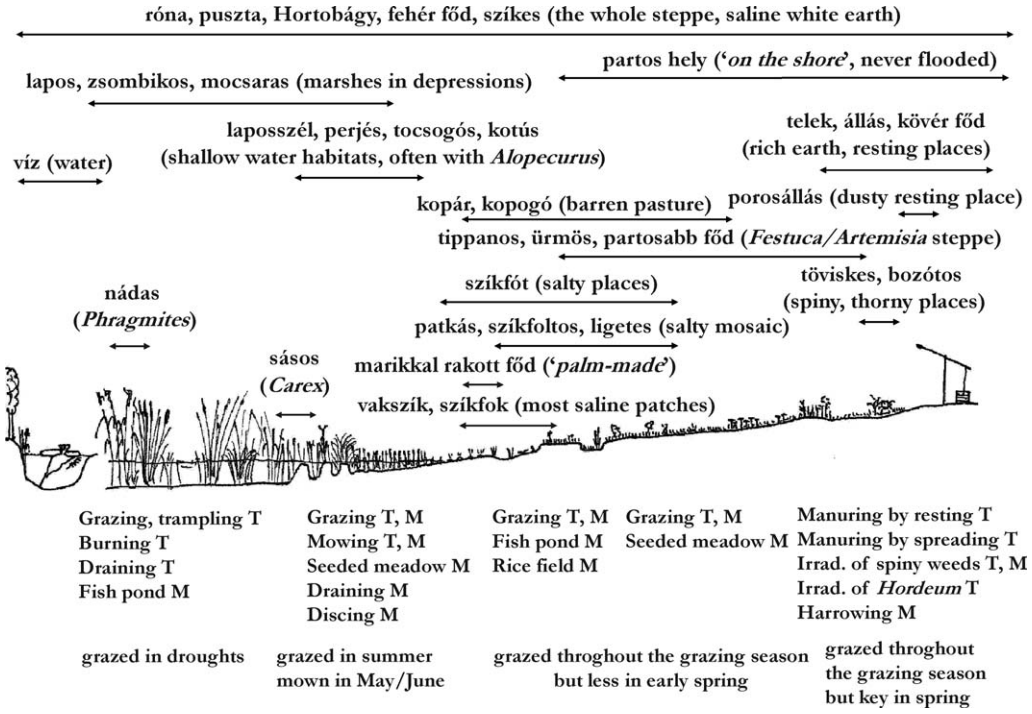


**Figure 1.** Habitats recognized by herders and traditional (T) and modern (M) habitat use along the habitat gradient in the Hortobágy salt steppe. Arrows indicate which part of the gradient certain habitats refer to. For descriptions and meanings of folk habitat names see Table 2. Electronic supplement: Map of the study area: Hortobágy saline steppe, Hungary (available online at http://dx.doi.org/10.2111/REM-D-13-00082.1.s1).

*Trifolium* comes"). Herders mentioned some (invasive) species that did not grow here when they were young (e.g., *Amorpha fruticosa, Elaeagnus angustifolia*).

As herders like to forecast pasture conditions, some species with fluctuating populations became indicators. One of these is *Erophila verna*, which grows in large quantities on saline patches in dry springs. Its abundance is used to forecast summer pasture conditions: "if it flowers [in large quantities], we will have a bad year."

## Spatio-Temporal Patterns of Pasturing

The Hortobágy is divided up into pastures (without fences!) among herds. As individual pastures are relatively small, movements are spatially highly restricted. This resulted in a well-structured grazing system adapted to the spatially and temporally heterogeneous forage availability.

Herders are proud of their herding skills: "It does matter, who leans on the [herding] stick!" Good herders know well their animals' grazing habits and social behavior individually. Herders say, "You have to force the animals to eat; they do not eat with their legs [meaning if they just run]. You have to go in front of them." Herders are interested in calm grazing, as fattening and milk production depend on intake efficiency. Driving or turning animals by dogs is thus limited to the minimum amount needed. If the livestock is trained properly, it behaves as the herder planned, and dogs are used only as a "threatening agent." Herders organize the daily grazing route as an ordered sequence of offered grazing patches. Their goal is to constantly revive the animals' motivation for grazing ("they must eat as much as possible"). Travelling time of animals is adjusted to the carrying capacity of the patch, the place of the patch in the rotation pattern, and the nutritional needs of animals. Where annual *Trifolium* spp. are abundant, herders slow down the speed of travel to prevent selective grazing. Otherwise animals could bloat up and die. Herders use bells tied on the necks of the animals. Their function is to inform animals in which direction and at what speed the herd is travelling. Leading animals (always moving with the front group) have different bells than animals that like to stay back.

The year-round cycle of grazing (Table 4) is determined by several factors. Winter grazing was rare, and occurred only when needed ("you had profit on your sheep if it overwinters in boots, old people said"—i.e., it is grazed in winter and not fed on hay). Animals are usually kept in barns, and fed on hay and additional fodder. Early spring grazing is regarded as harmful to the regeneration of the grass, but also to the development of animals, as grass is "too weak." In March and April, animals are driven to the pasture. Reciprocal learning starts: herders teach the animals the boundaries of the pasture and select the areas for grazing, while learning the behavior of their herds. The habitats grazed first are the ones on chernozem soil, followed by saline habitats, and from June, by meadows and later marshes. Herders argued that "you have to catch the sudden growth in May; animals like short grass better." Herders often portion the pasture, otherwise animals would trample ungrazed grass. Stubble fields with crop residues and arable weeds become available in midsummer (July). When grass is scarce, herders are not reluctant to graze in otherwise prohibited areas ("we went where grass was good. . ."). During the 1970s and 1980s, herding in the Hortobágy was partly replaced by fenced paddocks (6.3% of the pastures). However, the establishment of the national park prevented their spread, and now all are abandoned.

**Table 2.** Most salient and typical habitats and habitat groups of the habitat mosaic of the Hortobágy steppe and their vegetation, ecology, and usage for herding, according to herders. Vernacular names are in italics.

| No. | Habitats[1] | English equivalents | Salient features for herders[2] |
|---|---|---|---|
| 1 | *Víz* (105) | Open water | Deep water, lasts long, it is unsuitable for grazing |
| 2 | *Lapos* (455), *zsombikos* (84), *mocsár* (49) | Marshes with tall vegetation, often with mud tussocks | Water stays for long; high quantity of fodder, but not nutritious, poor pasture or hay, animals do not enter these habitats, only if forced, better horse or cattle; grass is eaten up in dry years but is untouched in wet years |
| 3 | *Laposszél* (57), *perjés* (30) | Meadows and edges of marshy depressions with shallow water | Large quantity of hay, though quality is often low; ungrazed litter often rots, becomes wild, smelly, animals avoid it; in wet years mowing has to be delayed, in dry years biomass can be very low |
| 4 | *Tocsogó* (41), *locsogó* (64) | Meadows with shallow, semiopen water surfaces | Horses like it, if dries up, sweet grass grows |
| 5 | *Szikfót* (68), *szikfok* (65), *vakszik* (66), *(szik)ér* (21) | The most saline patches, wet in spring, dry in summer, often without vegetation | Water-covered in spring and after rains, very salty, salt kills the plants, vegetation is sparse, only fescue and chamomile grow, and that small plant that only lives here (*Camphorosma annua*); it is barren in summer, sheep bite, cattle lick the salt, we grazed it in late summer |
| 6 | *Marikkal rakott főd* (79), *bibicbasztafőd* (59) | Saline habitats with sparse cover of *Festuca pseudovina* | Only scattered fescue tussocks, nothing else; after water dries up nothing is left; very poor salty land, animals avoid it |
| 7 | *Kopár* (44), *kopogó* (46) | barren overgrazed pastures (often saline) | Animals ate up all the grass, the pasture is barren; it develops mostly in dry years |
| 8 | *Tippanos* (107), *ürmös* (23), *partosabb főd* (36) | Short-grass steppes dominated by *Festuca pseudovina* and either *Artemisia santonicum* or *Achillea* spp. | Good pasture with fescue, at higher places, not water-covered, grass is diverse; the best grass in the Hortobágy; salty but not as salty as the blind *szik*, not the true salty place; it is often barren in late summer |
| 9 | *Telek* (78), *állás* (110), *hátas főd* (32) | Nonsaline areas with fertile soils and deep soil water table | The best pasture in each year, strong and rich earth, animals like it, and have rest here; dung produces the first grass in spring, this was the spring pasture; part of it was mown, grass is good, diverse |
| 10 | *Porosállás* (8) | Overtrampled, dusty places for night and noon rest | Dusty place where animals rest, covered with a thick layer of dung; not grazed |
| 11 | *Bozótos* (14), *töviskes* (16), *bokros* (16) | Dense patches with tall herbaceous spiny plants or bushes | Abandoned area, became wild, difficult to go through; with tall, spiny and large weeds; it is neither grazed nor mown, animals do not like such places |
| 12 | *Erdő* (87) | Forests, mostly plantations | Good for day and noon rest, provides shade; we do not graze forests |
| 13 | *Úttél* (40), *árokpart* (10) | Road verges and ditch sides | Good diverse grass, good hay; most are abandoned now |
| 14 | *Szántó* (114) | Arable fields | Barley and wheat were sometimes grazed in late autumn, and alfalfa if frozen |
| 15 | *Tarló* (15) | Stubbles | In summer we went on the stubbles of wheat and barley, later in autumn on maize and sugar-beet; animals like *Polygonum aviculare* and *Convolvulus arvensis* |
| 16 | *Ugar* (28), *parlag* (3) | Fallow and old fields | Good pastures, nutritious; *Tripleurospermum perforatum* and *Cirsium arvense* are good if cut in time |
| 17 | *Vetett* (2), *öntözött fű* (3) | Sown (and in the past irrigated) grasslands | Good nutritious grasses are sown, but original grasses, like fescue also come back; we also grazed on these meadows if mown; on irrigated meadows grass rots and becomes smelly; quantity is high but quality is low |
| 18 | *Fehér főd* (13), *szíkes főd* (47) | Saline habitat mosaics of the landscape | Not black earth, salty, good for pasture, but not for arable use |
| 19 | *Partos hely* (95) | Areas at higher elevations (never flooded) | Good diverse grass, dense fescue, the grass is always good for the animals, animals stop here; in spring this is the pasture |
| 20 | *Tarka főd* (4), *galléros főd* (3), *ligetes* (7), *patkás* (10), *szikpatkás* (6) | Mosaics of saline and non or less saline patches | One place is good, the next is salty, but not salty everywhere |
| 21 | *Róna* (24), *puszta* (135), *Hortobágy* (45) | The whole steppe as a landscape | The Hortobágy, the steppe, all of it |

[1]Numbers in parentheses show how often a name or expression was collected.
[2]Original quotes from herders.

**Table 3.** Most-salient and typical plant folk taxa of the Hortobágy steppe and their salient features, seasonal availability, usage, and forage quantity and quality, according to herders.

| Plant species[1] | Usage and salient features for herders[2] | Season[3] | Type[4] |
|---|---|---|---|
| *Agrostis stolonifera* L. (88, 80%) | Animals do not like it, only eat it in droughts or if frozen | V–IX | G/H |
| *Alopecurus pratensis* L. (187, 94%) | Good if cut in time, but if dried, it is only good to fill the belly, good also in autumn | IV–X | G/H |
| *Amaranthus retroflexus* L. (85, 98%) | Pigs like it fresh, it was cut and ground in the mill for winter | IV–XI | GF(H) |
| *Artemisia santonicum* L. (110, 94%) | Sheep, cattle, but especially lambs like it, but it is a poor fodder | VI–IX | G |
| *Atriplex tatarica* L. (79, 98%) | Good fodder for pigs, sheep and cattle, we grazed, but it was also mown | V–X | GF/G/H |
| *Bromus hordeaceus* L. and other *Bromus* spp. (63, 100%) | Good grass on *telek* places | IV–VII | G |
| *Camphorosma annua* Pall. (80, 97%) | Sheep like it, drink on it terribly [herders argue, it is an indication of effective feeding], only grows in late summer | VIII–IX | G |
| *Carduus* L. (91, 94%) and *Cirsium* Mill. (64, 98%) spp. | Weeds, we eradicated them, but donkeys like them very much | —— | — |
| *Carex melanostachya* Willd. and other *Carex* spp. (70, 99%) | Animals do not like it, but eat it during droughts, poor fodder, but was used for cattle | V–IX | G/(H) |
| *Chenopodium album* L. (48, 96%) | Pigs like it, but had diarrhea | IV–XI | GF |
| *Cirsium arvense* (L.) Scop. (103, 98%) | Better than alfalfa if cut before it flowers, animals like it, it was ground | V–IX | (G/H) |
| *Convolvulus arvensis* L. (73, 100%) | Good ''grass,'' better than *Trifolium,* grows mostly on stubbles | V–XI | G |
| *Cynodon dactylon* (L.) Pers. (85, 97%) | Animals like it when green | III–XI | G |
| *Eleocharis palustris* (L.) Roem. et Schult. (65, 84%) | Poor fodder, nothing likes it | —— | — |
| *Elymus repens* (L.) Gould (87, 88%) | Animals like it terribly, but only if green | III–XI | G/H |
| *Festuca arundinacea* Schreb., *Festuca pratensis* Huds. (5, no reliable data) | Sown, nutritious | IV–XI | H/G |
| *Festuca pseudovina* Hack. (235, 100%) | The best grass, sheep drink on it, as good as alfalfa, difficult to mow | III–XI | G(H) |
| *Glyceria maxima* (Hartm.) Holmb. (21, 55%) | We have mown it in poor times, but it is not nutritious | V–IX | H/G |
| *Hordeum hystrix* Roth*, Hordeum murinum* L. (138, 100%) | Good fodder in spring, but terrible if ripe, as fruits hurt sheep and dogs | IV–V | G |
| *Lactuca serriola* L. (21, 94%)*, Sonchus* L. spp. (54, 100%) | We collected them fresh for ducks, geese, pigs, rabbits and sheep | V–VII | GF |
| *Lolium perenne* L. (105, 74%) | Terrific [meaning very good] grass, in spring, summer and also in autumn | III–XI | G |
| *Lotus tenuis* Waldst. et Kit., *Lotus corniculatus* L. (93, 100%) | Useful plant, all types of animals like it, it grows in warm weather, after rain | V–X | G |
| *Medicago sativa* L. (34, 100%) | It is sown [on arable fields], the best hay for the winter | IX–XII | H/G |
| *Phalaris arundinacea* L. (67, 90%) | Good diverse hay, animals like it, better than *Phragmites* and *Setaria* | V–IX | H/G |
| *Phragmites australis* (Cav.) Steud. (85, 100%) | Cattle like reed, grazed mostly in droughts | V–IX | G |
| *Poa angustifolia* L. (97, 87%) | Difficult to mow, animals like it [8 data], others said: animals do not like it very much [6 data] | V–X | G/H |
| *Poa bulbosa* L. (79, 64%) | The first grass in spring, not nutritious, geese like it | III–XI | G |
| *Podospermum canum* (C.A. Mey.) Griseb. (68, 85%) | Sheep and pigs like it very much, run after it, eat its flowers | IV–IX | G |
| *Polygonum aviculare* L. (132, 100%) | Extremely good, highly nutritious, all animals like it | VII–XI | G |
| *Setaria viridis* (L.) P. Beauv., *S. pumila* (Poir.) Schult. (52, 100%) | Good grass on stubbles, we also used it as hay | V–IX | G/H |
| *Trifolium angulatum* Waldst. et Kit. et al. (134, 100%) | Good ''grass,'' if animals eat too much, they bloat and may die, they do not grow in each year | IV–VI | G/H |
| *Trifolium pratense* L. (18, 100%), *Trifolium repens* L. (23, 100%) | We usually sow it, but also grows wild, useful | IV–X | H/G |
| *Tripleurospermum perforatum* (Mérat) M. Laínz (78, 98%) | Sheep like it very much, helps milk production, as good as alfalfa, but dries slowly | V–IX | G/H |
| *Typha angustifolia* L. (78, 100%), *Typha latifolia* L. (85, 100%) | Usually animals do not like it | — | G |
| *Xanthium spinosum* L. (63, 96%) | We eradicated them [by mowing], good for nothing | — | — |

[1]Numbers in parentheses show how often data on a species were collected, the percentage of herders that knew the species.
[2]Original quotes from herders.
[3]Roman numerals indicate months from January till December.
[4]G indicates used dominantly for grazing; H, used mostly as hay; and GF, used as green fodder.

**Table 4.** Seasonal changes of traditional pasture use in the Hortobágy steppe according to herders.

| Periods | Pasturing, and pasture types used |
|---|---|
| December–February (winter) | Late autumn, winter and early spring grazing had been limited and practiced only in shortage periods mostly till the 1950s; ''in November nights are cold, the pasture is muddy, later the grass becomes frozen, but they can find something to eat even under the snow [now winter grazing is banned]; in February, if the grass is as big as an oat grain, the sheep does not starve, we went out to the steppe'' |
| March–April (early and midspring) | Usually sheep go to the pasture in mid or late March, the cattle in mid or late April; ''first we have to get them used to each other; we force them to eat not just walk; first the areas higher (on the gradient) is grazed,'' areas that were manured regularly, ''*Hordeum* is eaten up totally; meadows and marshes are not yet grazed, saline areas are also often wet; as time passes we graze further and further from the shed, as grass decreased around it'' |
| May–June (late spring–early summer) | ''Rain in May makes grass strong, animals fatten; the weather is good, and there are no mosquitos and horse flies; we go to places where the place 'catches' the animals; in dew we keep them inside, as they would only trample grass; herders always walk in front or among the animals to prevent running, to force them to eat; as water withdraws from meadows and marsh edges, *Alopecurus* and *Trifolium* grow, we start to graze those places; hay meadows are protected from grazing'' |
| July–August (mid- and late summer) | ''Summers are droughty, grass is dry, and is grazed to the earth, animals eat the dry grass, they graze till midnight, and lick the earth; marshes give the chance of life, but even marshes are cleaned up; rotation is abandoned, we go where there is some grass left; however, four days after a summer rain grass start to grow, the steppe becomes green, meadows also; in a wet summer, the situation is not much better from midsummer onwards, we were allowed to go from the steppes to stubbles of wheat, and barley, where *Polygonum aviculare*, *Setaria* grow; if sheep grazed on stubbles, it gave more milk; meanwhile steppes started to regenerate; we grazed the steppes in the morning, and went to the stubbles in the afternoon, but since the revolution [1989] stubbles are not given to us; now, however, that *Ambrosia* has to be eradicated, again we get more stubbles to graze *Ambrosia* off'' |
| September – October (November) (autumn) | ''Rains in August produce the good autumn grass, we go back to the area around the sheds, but till the 1980s stubbles were also grazed [corn and sugar beet],'' in November ''also frozen alfalfa fields and dense barley fields; cattle go home in early November, but [till the 1950s] they were kept on the pastures till the first snow; sheep stayed longer in November, also grazing cattle pastures, and aftermath on hay meadows; as grass became weak in November we gave extra fodder for the animals (hay or straw), to prevent diarrhoea; in autumn cattle are always hungry, are running away, nights are too long for them, they do not want to stay on the resting place'' |

The number of animals in a pasture is more or less constant from year to year. Because biomass production shows a high interannual fluctuation, overgrazing is usual in dry years, whereas excess grass is mown in wet years and stored for dry years. In dry years, marshes function as reserve pastures. Deliberately saved reserve pastures used only in drought years were never mentioned by the herders. Small reserve pastures close to places for overnight rest are only saved for sick animals or horses or donkeys.

## Traditional and Modern Pasture Improvements

When I asked herders what they can do to maintain or improve pasture quality, more than half of the herders answered that "you cannot do anything; animals improve it; grass always regenerates; the weather decides." However, these sentences were followed by a detailed description of grazing techniques and pasture management (Table 5).

All herders argued that the most important management method of all is grazing itself. Thorough grazing keeps pastures "in good condition. You need a certain amount of livestock, otherwise the pasture becomes hairy, bitter, and smelly, earth is isolated from air." Rotational grazing provides times for regeneration. Manuring was only applied in the past and to the best soils around sheds, by spreading or by having the animals rest for the night farther and farther away from the shed in late summer and autumn. These practices were banned by the national park. Saline places and wetlands were never manured. Artificial fertilization of pastures was also rare.

Harrowing was regularly done around sheds and where litter accumulated. It is difficult to judge how often burning was applied, as undergrazed pastures were rare in the past. Today, burning is also banned, though "it would be good, since there are not enough animals to graze down the grass." Only some of the weeds are removed from the pastures deliberately. Herders have a stick with a sharp metal end with which they remove spiny weeds, such as *Carduus* spp., *Cirsium vulgare*, and *Eryngium campestre*. This practice was mostly abandoned in the 1980s, but became enforced by the new agri-environmental schemes. Herders try to decrease the area covered with the hated *Hordeum* spp. by regular cutting and burning, but are usually unsuccessful. Sowing of seeds in order to improve seminatural pastures was never mentioned.

Herders evaluated intensive pasture improvements by the socialist cooperatives from different aspects: meadows of "sweet" sown grasses produced high-quality hay; fertilized pastures had increased forage availability; irrigated meadows, however, had low-quality, often rotten, smelly grass. Since intensive improvement was never economical and was also banned by the national park, it was abandoned. During the 20th century, large areas were drained by ditches. This dense ditch network was abolished recently by the national park (together with the remnants of the paddock fences). Herders

**Table 5.** Methods of traditional and modern pasture improvements and their effects on the vegetation. Importance of improvement methods in different periods is also given.

| Type | Description of the method | P1[1] | P2 | P3 | Effects on pasture/grassland quality according to herders |
|---|---|---|---|---|---|
| Traditional ways of pasture improvement | | | | | |
| Grazing (*legeltetés*) | According to herders, the main improvement method of pastures is grazing itself: ''animals improved it, you cannot make harm if you graze it'' | 3 | 3 | 2 | ''Thorough grazing hinders litter accummulation,'' and the spread of some species (e.g., *Phragmites*, bushes), ''helps the rejuvenation of the grass,'' and by trampling, the proportion of grasses in the marshes could be increased |
| Rotation, portioning (*szakaszolás, adagolás*) | Grazing is often rotated, grazed areas are left ungrazed for some time, portioning is also widespread: ''we gave them a strip, forced them to graze it, after we went further, if you do not graze it portion by portion, cattle destroy grass by trampling'' | 2 | 3 | 2 | Rotation and portioning resulted in ''evenly grazed grass,'' provided time for regeneration, and decreased litter left on the pasture |
| Grazing from well to well (*kútról-kútra legeltetés*) | ''We grazed from well to well, we need a well every two hours [ca. 1 km], if we only had one well surrounding areas would become barren'' | 3 | 2 | 1 | Prevents overgrazing and the ''formation of trampled paths,'' and results in more even grazing distribution |
| Manuring by the translocation of resting places (*állásolás, telkesítés*) | ''In late summer and autumn we forced sheep and cattle to rest for the night every couple of days or a week further and further by 50 m, dung improved the pasture, earth became rich and fat'' | 3 | 2 | 0 | ''Grass became tender, of better taste, sweeter,'caught' the animals'' |
| Manuring (*trágyaszórás*) | In late autumn, winter and early spring dung that accumulated in resting places and sheds was distributed: ''we put it where grass was poor, you could see where to put it'' | 2 | 2 | 0 | ''Grass became better, denser and sweeter'' |
| Burning (*égetés*) | ''If litter was dense, and winter ate it, we burnt it, in the past I used to burn it almost every year, especially the marshes, in summer we burnt *Hordeum*'' | 2 | 2 | 0 | ''It became clean, not weedy, as today, litter disappeared''; encroachment of tall plants and bushes was prevented, but ''*Hordeum* was difficult to push back'' |
| Removal of spiny plants (*töviskelés*) | ''We pricked [removed] all the spiny species'' around the sheds, ''we did it all summer round,'' owners of the animals and their children helped | 3 | 3 | 2 | Population density of *Carduus,* and *Cirsium* spp. was successfully decreased, ''the area became clean'' |
| Draining by small ditches (*lecsapolás*) | Some marshes and deeper meadows are drained locally | 1 | 1 | 1 | The grass became sweeter |
| Modern methods of pasture improvement | | | | | |
| Artificial fertilization (*műtrágyázás*) | Sometimes parts of the pastures were fertilized with machinery | 0 | 1 | 0 | ''Fertilized pastures were denser'' |
| Soil improvement by chemicals (*nagyüzemi talajjavítás*) | ''Beet potash and gypsum were spread on the grass around the sheds'' in some cases, and locally ''soil was loosened to improve water infiltration'' | 0 | 1 | 0 | ''It became better,'' salt content of the soil slightly decreased; biomass increased |
| Harrowing, discing (*boronálás, tárcsázás*) | ''Areas around the sheds were regularly harrowed, we did it at the end of every winter; tussocky sedge beds were disced, but they regenerated afterwards'' | 1 | 2 | 0 | ''Grass was loosened, got air, grass changed, became denser, more mixed, mosses disappeared'' |
| Sowing of grasslands (*vetett gyep*) | Ancient grass species were replaced by tall growing, sweet grasses, ''it had higher yield, it was an experiment, we grazed the aftermath, it provided forage even in snow'' | 1 | 3 | 0 | ''It was beautiful''; others said: ''it was not so useful, improved breeds killed the ancient grass, [the native] *Trifolium* and fescue are better'' |
| Irrigation of grasslands (*gyepöntözés*) | Sown grasslands were sometimes irrigated, ''in dry weather it was good, reliable, but sheep did not like it,'' and ''it was expensive,'' aftermath was only mown in these meadows | 0 | 2 | 0 | ''Grass became better, it produced a lot''; but more often they said: ''original grass was killed, by the time water withdrew the grass became rotten and smelly'' |
| Electric or fixed fences (*villanykarám, legelőkert*) | A modern but not widespread way of rotation was fencing; skilled herders were replaced by agricultural workers, ''animals did not like it; rotation by fencing was harmful for the animals'' | 0 | 2 | 1 | More even grazing distribution could be reached |

**Table 5.** Continued.

| Type | Description of the method | P1[1] | P2 | P3 | Effects on pasture/grassland quality according to herders |
|---|---|---|---|---|---|
| Draining by ditch networks (*lecsapolás*) | In the last century a well-structured and dense ditch network was developed | 2 | 3 | 0 | Many marshes and meadows dried out, the Hortobágy area became drier: ''it was good in wet years, but bad in dry ones'' |

[1]P1 indicates practice used in 1930s–1940s; P2, in 1970s–1980s; P3, recently (2005–2012); 3, a widely used practice; 2, less often used; 1, rarely used; and 0, a practice not used in that period.

mostly agree with these restoration measures, but now "in wet years there is too much water on the pasture."

## DISCUSSION

### Perception and Knowledge of Spatio-Temporal Pasture Heterogeneity

Hortobágy herders have a nuanced knowledge of their pastures. They are proud of this knowledge, and like the "freedom" of the steppes: "I saw richer persons, but nobody who was happier [than me]" (cf. Bovin 1990). They can name all habitats of the steppe, and distinguish them by productivity, salinity, wetness, soil, elevation, litter cover, etc. Among nomadic herders in Mongolia and transhumant pastoralists in the Pyrenees, a similarly detailed habitat classification was found with similar criteria (Fernández-Giménez 2000; Fernández-Giménez and Estaque 2012). However, the classification of Mongolian herders contains coarse-scale elements that herders need for their nomadic grazing system (e.g., ecological zone, distance to camps). In contrast, the criteria used by Hortobágy herders are more refined (e.g., patchiness, litter cover, different edge habitats). Among Fulani pastoralists, Krohmer (2010) also found that density and lack of vegetation are important criteria. Similarly to Hortobágy herders, Fulanis also name habitats that are mosaics of two strikingly different types.

Plant species of the steppe were also well known by the herders. The key criteria for describing species were forage quantity and quality, seasonal availability, changes in palatability, and preference by different types of livestock. Similar findings were reported by Fernández-Giménez (2000). Hortobágy herders, however, distinguished native and nonnative species, and had detailed knowledge of whether certain species can be eradicated or not.

Herders had deep understanding of ecological relationships and processes, too. They regarded weather as the most important determinant of temporal change in plant growth and consequently pasture quality: "the weather decides; we cannot do anything." The same was documented for Mongolian herders ("the grass will grow as much as it rains"; Fernández-Giménez 2000; Kakinuma et al. 2008). Like herders in Mongolia, Hortobágy herders rarely mentioned overgrazing as a major cause of changes in pasture conditions. African herders are more aware that overgrazing may also cause bad pasture conditions (Roba and Oba 2009). In the Hortobágy, decreasing stocking densities, accumulation of litter, and consequently the spread of less palatable species (*Elymus repens, Phragmites*) were regarded as the main factors in pasture degradation. Species such as *Polygonum aviculare*, *Bromus* spp., and *Lolium* spp. that are regarded by biologists as indicators of degradation of loess steppes, were valued by herders for their high forage quality.

Not surprisingly, species and habitat knowledge of Hortobágy herders seemed to be based dominantly on utilitarian criteria (cf. Hunn 1982). As Roba and Oba (2009) emphasized, herders' understanding of their pastures combines environmental and livestock productivity indicators. Hortobágy herders used relative calmness and contentment of their animals as an indicator of pasture quality (cf. Fernández-Giménez and Estaque 2012). As Bollig and Schulte (1999) put it: "Pastoralists are not interested in grasses as such, but only in the relation between grasses and herds."

### Adaptation to and Management of Spatio-Temporal Heterogeneity

Herding is a relationship between herders and their animals. Animals are moved or allowed to move around in the landscape to follow the spatially and temporally variable forage resources. Grazing systems tend to be adapted rationally to their fluctuating environments (Widstrand 1975; Ruiz 2001). Under unstable environmental conditions, the best model for pasturing is the one that is opportunistic, and seeks to manipulate states and transitions according to accumulated wisdom (see, e.g., Westoby et al. 1989; Bovin 1990; Warren 1995). Herders in the Hortobágy also adapt to the spatial and temporal variability of their resources. They did develop a more-or-less opportunistic herding system that helps them to make the most use of their small and heterogeneous pastures.

Hortobágy herders perform very strong herding practices. The Hungarian word for herding (*legeltet*; literally *legel*, to graze, and *tet*, to force it to do something, namely to graze) also reflects the emphasis on the precision of herding. Ungulate grazers would have a biologically based, natural grazing distribution in a landscape (Coughenour 1991). Pastures of individual herds in the Hortobágy are too small for such free ranging. Herders have to herd their animals to maximize daily forage intake, and, at the same time, to prevent animals from entering areas that are reserved for later use or forbidden to graze (e.g., neighbors' pastures).

The key point in the Hortobágy grazing system is the highly developed reciprocal learning between animals and herders. It is well known that animals have cognitive abilities to solve complex spatial tasks (Bailey et al. 1998), and their foraging behavior is adjusted to the spatial pattern of resources (Launchbaugh and Howery 2005; Schlecht et al. 2006). Animals also show high levels of seasonal feeding preference (Scoones 1995; Bennett et al. 2007). Hortobágy herders seem to take advantage of these abilities and preferences. On the other hand, animals learn the "logic" of the grazing method herders apply. They conform to it to minimize possible conflicts

with the herder and his driving dogs. Dwyer and Istomin (2008) also found that reciprocal learning is the basis of herding in Nenets and Komi reindeer herders. However, Hortobágy herders herd at a much finer spatial and temporal scale.

Daily grazing routes are opportunistic and flexible, and are determined by the actual wetness of the day, month, or year and the condition of livestock. Actual rotation between habitats or parts of the pasture depended on the carrying capacity of the patch, the place of the patch in the rotation pattern, and the nutritional needs of animals. Balancing between higher- and lower-quality parts of the pasture, while focusing on the appetite of the animals, as emphasized by Meuret (1997), is important also in the Hortobágy. Areas grazed in the morning and after the noon rest are paired (one poorer with one richer). In summer and autumn, more habitat types are grazed than in spring (cf. Coppock et al. 1986) when forage is abundant.

Excess grass is mown in late spring for winter fodder. However, forage shortage is more often the problem, though the effect of droughts is far less severe than in many African regions. One widespread strategy used in many parts of the world to cope with fluctuating pasture resources is to set aside reserve pastures for cold or dry seasons (Krader 1955; Fernández-Giménez 1993; Coppolillo 2000). Hortobágy herders only do it very locally, and only for sick animals. In summer, they graze the marshes on their pastures, or move to stubble fields adjacent to the pastures. Contrary to most nomadic herders in Eurasia and similarly to many pastoralists in Africa (e.g., Coppolillo 2000; Schlecht et al. 2006), Hortobágy herders graze the palatable weed species and crop residues on stubble fields.

Traditionally, large tracts of the steppe remained unmanaged. More precisely, herders managed and still manage saline pastures by proper grazing (preventing litter accumulation, and helping regeneration by rotational grazing—as they argue). It is widely accepted among pastoralists and range scientists that grazed areas provide better quality forage than ungrazed ones by higher biomass concentration, lower proportion of dried biomass, and higher metabolizable energy content (McNaughton 1984; Fernández-Giménez and Estaque 2012).

For an efficient use of pastures, Hortobágy herders do not simply adapt to the environment, but also apply improvements such as manuring, burning, and removal of spiny weeds. Manuring concentrated on areas with nonsaline chernozem soils around sheds and wells. Indirect and direct manuring of these areas was crucial for seasonal rotation, as these areas were and still are high-quality key resources in spring. This is a specialty of the Hortobágy: the piosphere (Lange 1969) is the most nutritious pasture, as it has the best and most manured soil. In the Hortobágy, the vegetation around sheds was totally transformed into grazing lawns (sensu McNaughton 1984) (*Lolium perenne*, *Festuca pseudovina*, *Trifolium* spp., etc.). Today, manuring is banned by the national park as it might introduce nonnative weeds into the steppe areas (A. Molnár, personal communication, February 2013).

Burning, a widespread method of pasture improvement all over the world, was only irregularly and locally used in the Hortobágy, mostly in marshes. Nowadays, there is discussion among local botanists and conservationists about how to use fire in steppe management, but data are scarce for an evidence-based decision. In general, grassland burning is banned in Hungary. Agri-environmental schemes also do not allow it as a management practice. With a permit, however, burning can be applied locally as a conservation management tool. Biologists working in the national park would be in favor of burning, but have limited facilities for well-executed controlled burning (A. Molnár and Z. Végvári, personal communication, February 2013).

I can conclude that herders graze and improve different habitats along the habitat gradient differently following a fine-scale spatial pattern. The degree of precision Hortobágy herders apply might have developed as a response to three factors: 1) high spatial heterogeneity of their pastures; 2) high temporal variability of fodder availability; and 3) the relatively small extent of the pastures of individual herds. Spatial and temporal heterogeneity of the Hortobágy steppe is natural, but transformation of large tracts of the steppe into arable land during the 18–19th centuries decreased available pasture land (Molnár and Borhidi 2003). Consequently, the fine-scale traditional herding and improvement practices in the Hortobágy might have developed from earlier grazing practices only during the last centuries.

## Implications for Evidence-Based Nature Conservation

Although the Hortobágy steppe has been pastured for millennia, and a great portion of it was declared a national park where the main management type is pasturing, there are still problems in its management. First, the knowledge base of conservation management is still weak, and management decisions cannot be based solely on available scientific evidence. In addition, the available evidence is often too discipline-specific, and thus difficult to apply to the complex system of nature, livestock, and herders. Unfortunately, biologists and conservationists still often think that they do not need to take into consideration the knowledge of local people: "They [the herders] do not know nature, they have forgotten it, they learnt it in socialist schools, and now sell it [sic!] as traditional knowledge." I argue that evidence-based conservation should build more on the expert knowledge of traditional herders, as their knowledge is highly relevant to the management of saline steppes. Nature conservation management should reintroduce some old herding techniques (e.g., opportunistic pasture use, grazing of marshes, and burning) (cf. Poschlod and WallisDeVries 2002). Herders' knowledge could also help the fine-tuning and local adaptation of European agri-environmental regulations (cf. Bérard et al. 2005).

Another problem stems from conflicting policies. Though the European Union (EU) provides support for the maintenance of traditional herding (Nori and Gemini 2011), other development decisions of the EU undermine these measures, and result in decreasing profitability of herding. In some cases, EU regulations prevent the development of locally adapted management: e.g., subsidies for mowing are high, and thus farmers are less interested in continuing or reintroducing grazing on their grasslands. As a herder put it, "the national park [including EU policies] wants to save this ancient steppe life, but with these regulations it will destroy it."

A third problem is that, though the Hortobágy is designated as a World Cultural Heritage Site, little has been done to keep immaterial cultural heritage alive (even a management plan has not yet been prepared). Ageing of the pastoral population endangers the survival of their traditional lifestyle, which will be difficult to reorganize once it is lost (cf. Manzano Baena and Casas 2010; Fernández-Giménez and Estaque 2012). Good examples of ongoing management that helps maintain immaterial cultural heritage are 1) the banning of electric and fixed fencing, which maintains the need for well-experienced herders; 2) regulation of rural architecture, which results in the maintenance of old and the building of new traditionally thatched sheds; and 3) support of herders festivals.

In Africa, the application of traditional ecological knowledge of pastoralists to range management resulted in an increasing appreciation of local herding practices, and contributed to a paradigm shift in management. In some cases, it also led to a more opportunistic management of available resources, though problems and failures were not rare (Warren 1995; Manger et al. 1996; Bollig and Schulte 1999; Mapinduzi et al. 2003; Adriansen 2008; Roba and Oba 2009). Comanagement of territories by First Nations and government agencies also has a comparatively long history in Canada. Experiences show that there is a wide range of opportunities to comanagement, but incompatibilities of world views often create obstacles, and many successes are actually hidden failures (Nadasdy 2003; Houde 2007). In Europe, the deep ecological knowledge on which traditional pasturing is based is still neglected (but see Inga 2007; Roturier and Roué 2009; Fernández-Giménez and Estaque 2012).

## MANAGEMENT IMPLICATIONS

To broaden the evidence base for pasture management of the Hortobágy steppe and, in general, the saline steppes of Europe, I suggest focusing future research on 1) the ecological effects of different traditional grazing techniques, especially rotations in different habitats; 2) the possibilities and consequences of traditional manuring; 3) the traditional use of fire to remove accumulated plant litter; 4) the alternatives to coping with the abundant biomass of meadows in spring; 5) the decision-making strategies of herders and conservationists and the nonecological factors that affect their decisions. To sum up, a more complex socio-ecological understanding is needed of the internal and external factors affecting adaptation of the Hortobágy herders to their changing environment and society (cf. Manger et al. 1996).

I argue that new management methods have to be based in any case on those that have shaped the particular landscape for centuries. Traditional practices and the related, culturally embedded, and locally adapted traditional, local ecological knowledge could provide a firm basis for the development of old–new pasture management techniques (Berkes et al. 2000; Molnár et al. 2008; Johnson and Hunn 2010; Karl et al. 2012). As our research among the Hortobágy herders showed, traditional ecological knowledge even in Europe is still a rich source of ideas, concepts, and data, which could be used for evidence-based pasture management and nature conservation.

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