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Lessons Learned from the Last Moments Captured of Traditional Small-Scale Land Use in a European Fen Meadow

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Abstract: Most of Europe's semi-natural grasslands have been maintained by land use for thousands of years. Consequently, as a side effect of this type of land use, high grassland biodiversity was able to develop in those areas. Today, due to changes in land use, only fragments of the native grasslands and their biodiversity, especially in wetlands, remain. We conducted a study on changes in land use and the conservation context of a species-rich Hungarian fen meadow over 250 years. In addition to the main changes, we focused on sustainable grassland management. For our research, we built a geospatial database in which we attached great importance to georeferenced aerial photographs taken decades ago. To better understand what we can see in aerial photographs, we studied archived newspaper articles and conducted interviews. An aerial photograph taken in 1963 served as an exceptional illustration and data source for the key factors of sustainability and biodiversity. Our case study illustrates most of the major global problems affecting the European fen meadow (drainage, agricultural intensification, expansion of infrastructure networks, abandonment of farming). Based on our research, mosaic, adaptive, small-scale landscape use is necessary for the long-term sustainability of European wet grasslands and their special wildlife.

Keywords: aerial photograph; biodiversity; grassland management; land use history; nature conservation



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1. Introduction

In the forest-rich landscapes of Europe, centuries of hard work by humans have turned forests, woodlands, scrubs, and marshes into treeless areas, where they can offer sufficient pasture and produce enough fodder (hay) for their animals [1]. Mowing and grazing contributed greatly to animal husbandry and thus to the livelihood of the population [2]; pastures and hay meadows were an essential part of the rural landscape [3]. This European cultural landscape has contained diverse mosaics of man-made and semi-natural habitats, with high grassland biodiversity resulting in outstanding cultural and conservation value [3,4]. Some of those anthropogenic grasslands have become biodiversity hotspots in Europe [5]. The wetlands, also deforested for animal husbandry, are valued not only because of their biodiversity but also for their ecosystem services. Their conservation and restoration are supported by EU directives and national legislation for nature protection in the various states [6]. Nevertheless, mainly due to changes in land use, only fragments of the native grasslands and their biodiversity, especially in wetlands, remain [7].

The main reason for their continued decline is that the draining and cultivation of wetlands has been going on for thousands of years [8]. Drainage of the peat soil causes a rapid mineralization process where oxidation and subsidence take place, all of which are irreversible changes [9] that lead to the disappearance of their unique vegetation and wildlife.

The other major driver of biodiversity loss is land use change [10]. During land use intensification, degradation occurred by the homogenization of grassland communities across trophic levels [11] that weakens the associations among the diversities of flora and fauna [12–14].

Lack of legal protection can also be a threat, with over 80% lost in Northern Germany since 1950 from wetlands that were not protected. They have mainly intensified and ploughed up these grasslands, which caused increasing fragmentation of floodplain meadows [15]. In Hungary, three of the Natura 2000 wet meadows habitat types (6440 Alluvial meadows of river valleys; 6410 *Molinia* meadows; 6510 Lowland hay meadows), have lost 90–91% of their area since 1775 [16].

The remaining nutrient-poor extensive pastures have significant botanical value, whether protected or not. Habitat types, which currently are not considered in the European Habitats Directive, should receive the same conservation attention [17]. It has highlighted the importance of existing wet meadows in the case of wildlife as well (see, e.g., wild bees: [18]; shorebirds: [19]). Their preservation has become a cultural and nature conservation objective of European importance [20]; serious restoration projects are underway to revive them [21–23]. However, the wet grassland abandonment studies mainly focus on vegetation, not any other ecosystem properties. Abandoned wet grasslands can be rehabilitated but complete restoration of their biodiversity is hardly feasible [24].

For all these reasons, managing wet grasslands rather than abandoning them is an EU-wide issue [2]. Much has been studied and experimented with to find out how best to treat them, usually using botanical approaches [25–30]. The best way to determine the best rehabilitation tools is to know as much as possible about the history of the system to be treated, including what effects and conditions have led to their current state [31]. The restoration design often applies traditional use, maintaining its elements [32].

In this paper, we presented a case study of how land use in a species-rich Hungarian fen meadow changed over 250 years to help inform and guide future conservation management. The history of use of the area is typical. Drainage, the development of transport infrastructure, and intensification and then abandonment in recent decades are all elements that are typical of European wet meadows. An aerial photograph taken in 1963 [33] has proved invaluable in the study of past land use, revealing many details of the landscape at that time. From botanical resources and interviews, we know the flora and vegetation of the area and details of the landscape use at the time. From this we are convinced that the 1963 aerial photograph [33] shows a land use practice that maintained a species-rich wet meadow complex and can therefore be of considerable help in planning future conservation management.

2. Materials and Methods

2.1. Study Site

The 120 hectare Batyk fen meadows (46°59′02.1″N 17°03′33.0″E) are located in the western part of Hungary (Europe) in the river Zala valley (Figure 1). It is not an isolated habitat but is part of the meadows along the river Zala and therefore belongs to the Alsó-Zala-völgy (‘Lower Zala valley’; code: HUBF20037; area: 6561.86 ha) Sites of Community Importance (SCI) under the European Commission’s Habitats Directive. The fact that it is a registered ‘ex lege fen meadow’ provides further legal protection at a national level. The climate is moderately cool (average annual temperature around 10 °C) and moderately humid (expected annual rainfall around 700 mm). There are Gleysols near to the river, while in local depressions, peaty Histosols prevail.

The vegetation of the Batyk fen meadows is a complex of different types of wet meadows. Alluvial meadows of river valleys (EU code: 6440) are characteristic in the vicinity of the river Zala, but most of the area is covered by *Molinia* meadows (EU code 6410) and lowland hay meadows (6510). In the northern part, there are remnants of alkaline mires (7230). The study site stands out from the surrounding areas for its richness of species. Its flora is well documented. In 2022, the occurrence of 40 species protected in Hungary

was documented. The largest number of individuals was *Iris sibirica* (>500,000 shoots), *Veratrum album*, and *Ophioglossum vulgatum* (both > 50,000 shoots). The population size of some typical fen species (*Carex appropinquata*, *C. davalliana*, *Parnassia palustris*) was found to be extremely low, and some previously reported fen species (*Eriophorum angustifolium*, *E. latifolium*, *Menyanthes trifoliata*, *Pedicularis palustris*, *Ranunculus lingua*) were not found [34]. The area also has a rich butterfly fauna. Butterfly species of community interest under the Habitats Directive are *Maculinea nausithous*, *M. teleius*, *Lycaena dispar*, and *Euphydryas aurinia* [35].

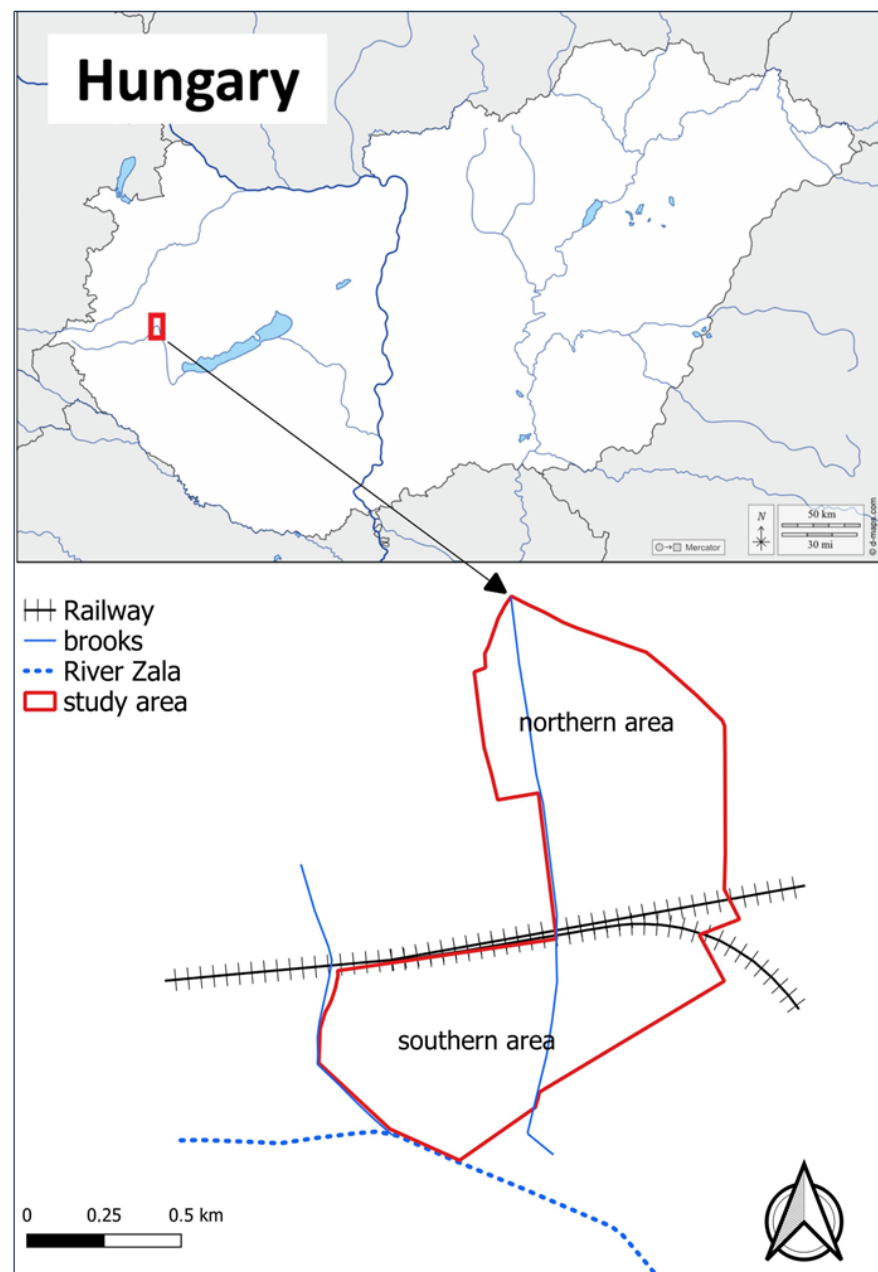


Figure 1. Study site.

2.2. Materials and Methods

For the historical analysis of the study area from a conservation perspective, we have collected different types of sources.

(1) The main sources were military maps of the Habsburg Empire, the first military survey (1784) [36], the second (1855) [37], the third (1879) [38], cadastral maps (1857) [39], WWII

Military Survey (1941) [40], aerial photos (1963–1988) [41], orthophotos (2000–2005) [42], and Google satellite images (2003–2022) [43]. All were available in a georeferenced format, or we rectified during our work with Qgis 3.16 software. We also used maps from the municipality’s archives from the second half of the 20th century, but without an exact date. We interpreted the different patterns and practises of landscape change, drainage, land use, vegetation, and grassland management through maps.

(2) Using keywords, we searched for historical documents, written materials, and photographs in the most comprehensive digital databases in Hungary (Arcanum Digital Newspaper Database [44], Hungaricana—Cultural Heritage Portal [45], National Archives [46]), and the local catalogue of the Göcseji Museum [47]. The archive photographs were used to illustrate the main aspects of grassland management. The photographs were taken in the same geographical region, landscape, and similar vegetation as the study site.

(3) We have collected botanical data about the area.

(4) We conducted semi-structured interviews with four people: the mayor, a water specialist, and two older residents who have memories of the study area from their childhood. One of them is a key informant because he worked as a data collector in the local cooperative, during the communist period. The interviews lasted 1–2 h, and prior to the first interview, informed consent was obtained from all interviewees in compliance with the International Ethnobiological Society’s Code of Ethics [48] and the European Union’s General Data Protection Regulation [49].

We used the written documents, botanical data, and the interviews to improve the information gained from the map and orthophoto sources.

The data sources for each era differ greatly. It is therefore not possible to create and analyse standard, quantified, or quantifiable time series. It is not possible to construct a clear flowchart. We can therefore organise our data not into graphs, but only into pairs or groups of data. Comparison is therefore the most important methodological basis for our landscape research. By studying the past and present of our study area, and by comparing many maps, aerial photographs, and written sources, we draw a possible history of the area over the last 250 years. The data collected, which is considered reliable, must be interpreted and its validity established.

The information from different sources was grouped into pairs or groups of data, based on the era, event, or topic. Comparisons were made between these data and conclusions were drawn. For maps and other data sources organised in GIS systems, visual comparisons were made. For our written sources, we compared facts and findings. Visual and written sources, especially when complemented by interviews, enhance our understanding of the sources. Our aim is to organise the events and accounts of the past into a narrative story that can be described. The data sources of each period differ greatly from each other, so a pattern of understanding cannot be established. Different countries have different histories and therefore specific data sources. For Hungary, we have taken the methodological description of historical landscape ecology by Zsolt Molnár and Marianna Biró as a basis for our study [31].

3. Results and Discussion

3.1. Water Regulation

As early as 1773, it was recorded that the nobility wanted to free the river Zala valley from flooding because they could not cultivate it. The regulation of the river Zala began upstream from its mouth (Lake Balaton). The first interventions of the river took place between 1836 and 1865, but they did not meet the desired outcome, so further regulation took place between 1874 and 1894. Following the regulation, the river section of the study area was reached in 1929 [50]. The last period, between 1960 and 1970, was the time when the present riverbed was formed [Balogh; Liptai ex verbis]. The people of the village of Batyk attempted to make progress with the drainage of their meadows. In 1839, at the request of the locals, the county assembly discussed the question of draining the swampy meadows in the village area [50]. In 1843, a complaint was lodged against a local mill

because its water was backing up and flooding the surrounding meadows. At the same time, they asked for the bed of a brook to be straightened [50]. The cadastral map (1857) [39] shows that the brook (Csider brook) flowing through the study area was regulated and some drainage ditches were dug. For the study area, there is a mention from 1908 that ditches were made for drainage [51]. By 1963 [33], the surface drainage ditches had reached their final length, which was more than 10 km in the 120 ha area (Figure 2).



Figure 2. Surface drainage ditches highlighted with blue on aerial image from 1966 [52].

The water supply in the area has been drastically affected by modern infrastructure. Roads [36] bypassed the fen meadow from the north and this has remained unchanged since. This was not the case with the rail network. A railway was first built at Batyk towards the end of the 19th century [53]. Like the road, it bypassed the fen meadow from the north [40]. When this became obsolete and a more modern, stronger railway was needed, a new line was laid in 1970, cutting the fen meadow in two. Here, the railway junction was made more convenient and agricultural considerations were taken into account. The wet, marshy

land was less economically valuable, but where the old railway had been cleared, arable land could be created on its site [54]. The new railway has become the largest railway construction project in the county. First, the topsoil needed to be removed. Drainage pipes were installed at a depth of 2–3 metres, with cleaning wells every 50 metres. This was carried out over a length of 1 km, the aim being to significantly reduce the water table under the trackbed [55]. Once this was achieved, they could start building the rails. To build the railway line, 650,000 cubic metres of earth were moved [56]. The railway embankment rises 4–5 m above the fen meadow. The underground drainage (melioration) of the still wet areas of the region was started in 1973 in the hope of further agricultural use. The aim was to develop drainage on 570 ha [57]. In 1981, drainage work was carried out on 200 hectares of the wet, disused meadow at Batyk, which includes the part of our study area north of the railway line. Subsequent aerial photographs show that despite the drainage work, the area was not turned into arable field and was largely overgrown with either shrubs or trees. Inadequate design or construction could lead to drainage failure, which happened quite rarely. Only near the railway line were there small areas that had been mown for short or long periods.

The southern areas were excluded from drainage due to conservation efforts, but their water supply was also affected by the railway. In 2012, the Balaton-felvidéki National Park management tried to backfill drainage ditches in the southern areas [58]. We now know from experience that this did not solve the problem.

3.2. Changes in Landscape and Wildlife

Before the regulation of the river Zala (until the 18th century), the river flowed through swamps, marshes, and fens, sometimes forming small islands with several branches, sometimes without a clear channel [36,51]. The wetlands were so large that in 1596, the local people hid here from foreign soldiers when they were attacked [53]. These wetlands were along the river and were covered with reeds, sedges, alders, and ashes. The river Zala flooded its floodplain several times a year. Peat soil was common along the river. This peat soil was all formed in fens. At that time, several types of fens were still found in the valley. Part of this landscape was our study area, which was also a wetland with fens, swamps, and reedy areas with patchy woody vegetation (1784) [36,52]. In the mid-19th century, the northern part of the study area is depicted as treed, shrubby, wet meadow. On the map of the second military survey (1855) [37], the meadows along the river are marked in a different colour than the northern part of the study area (Figure 3). This is an important difference as the first botanical reports and the present surveys indicate that the northern areas were fens, while the southern areas were wet meadows [34,59]. Fen meadows are only preserved here, while today only wet meadows are found along the Zala.

In terms of hunting, the area was described in 1884 as follows: ‘its extensive meadows are covered here and there with birch trees and small shrubs. Its southern part is bordered by the Zala river, its eastern and western parts by a crystal-clear stream flowing from a natural spring, and because of its favourable geographical position, it is the eldorado of the Common Quail (*Coturnix coturnix*) and the Grey Partridge (*Perdix perdix*) [60].

Between 1938 and 1955, 35 protected or rare plant species were recorded from the area [34]. An aerial photograph taken in 1963 [33] shows the entire area as grassland, with woody vegetation in the middle, as depicted on the map of the second military survey (1855) [37] (Figure 3). From current botanical surveys, we know that these wooded areas are alder swamps and willow carrs [34]. A few years before 1985, all the woody vegetation in the northern area was cut down [61]. A succession of scrub and woody vegetation then began, becoming dominant in the northern part. Compared to 1963 [33], the southern part has also begun to shrub, but still has the largest grassland cover. Today, the numbers and species of the most water-demanding fen specialist plant species are alarmingly low, but it remains a very valuable area. Several plant species have now been observed for the first time, but they are associated with drier grassland or forest habitats, which also indicates the drying of the area [62].



Figure 3. The study area on the map of the II Military Survey [37].

3.3. Grassland Management and Land Use

In the Middle Ages, the settlement of Batyk was not in an agriculturally favourable position as it was situated next to a large wetland. It was however advantageous for water mills and for crabbing, fishing [52], and grazing animals. According to a record from 1770, the meadow and pasture were of great value. The settlement suffered considerable damage from the frequent flooding of the river Zala, as well as from its wet and infertile soils [52]. They had a small area of grassland, which led to the renting of pasture from the neighbouring settlement in 1772 [52]. In 1854, the inhabitants of Batyk complained that their pasture had been taken away when the settlement boundaries were drawn [52].

According to the cadastral map of 1857, the study area consisted of many private meadow parcels. Each of these parcels was only a few metres wide, but long. Most of the Batyk families had land here because there was no other hay meadow in the village. Families harvested their own winter feed for their animals. The parcels were inherited by the owner's children, but they could also sell or exchange them. The village did have grassland outside the study area, but it was pasture, not mown [39]. These conditions did not change until the mid-20th century [38,40].

The first available high-resolution aerial photograph of our study area was taken on 16 September 1963 from an altitude of 1850 m. The $16,316 \times 17,719$ pixel image was enlarged to determine the relevant details [33]. The different stages of grazing, scything, haymaking, and hay transport can be seen in the area. At the time of the aerial photograph, the following six activities can be observed simultaneously: (a) cattle grazing; (b) scything; (c) loading hay onto carts; (d) transporting hay by ox cart; (e) haystacks and hayracks; and (f) scythed area without hayracks (already brought in) (Figures 4 and 5). Even then, the northern part was a wetter area than the southern part. Only at the end of the summer in dry weather when the heat had dried up the water could scything be performed, mostly for bedding, because there was a lot of sedge. If there was no rain, only then could they go on with the ox cart. If it was a rainy summer, the locals could not even scythe the fen meadow [Ódor ex verbis].

In the southern part, good hay could be mown for fodder, which was mown twice a year if the floods did not occur. The first time they mowed in early June, the second in August, and the grass that grew afterwards was no longer mown but grazed. The village had its own pasture, but sometimes they also grazed here, depending on how much grass had grown and the rainfall. They worked with hand tools, using scythes, rakes, and forks. The grass scythed was turned over on the third day to dry and air. On the 4th day, it was collected in haystacks. After that they made tall, pointed hayracks. The reason for the hayracks was that if it was dry but they could not bring it in and it rained, the entire hay would not become wet. The ox cart pulled up to the hayracks and they loaded as much hay as they could onto the cart. This work was carried out in a week or two. The whole family took part in this work often with the help of the neighbours. Some of them would throw the seeds that had accumulated in the manger and the hayloft back into the meadow. In the past, every plot of land was mowed, even during the communist period (1956–1989), but later many areas became overgrown. In Batyk, a farmers' cooperative was established in 1960, and from then it was no longer private land ownership. The Hungarian government forced farmers to join cooperatives with their lands and started an agricultural intensification [Hideg ex verbis]. The transition took a few years, during which time the aerial photograph was taken. Until the first tractors came along, in the late 1960s and early 1970s, they were still working with hand tools [Ódor; Hideg ex verbis]. As a supplementary nutrient, the manure was mainly applied to arable land but was also spread on meadows. Later, fertiliser was used in large quantities. The western side of the southern part is still mown and used by farmers. The eastern side is managed for nature conservation purposes only (occasional shrub and herb mulching).

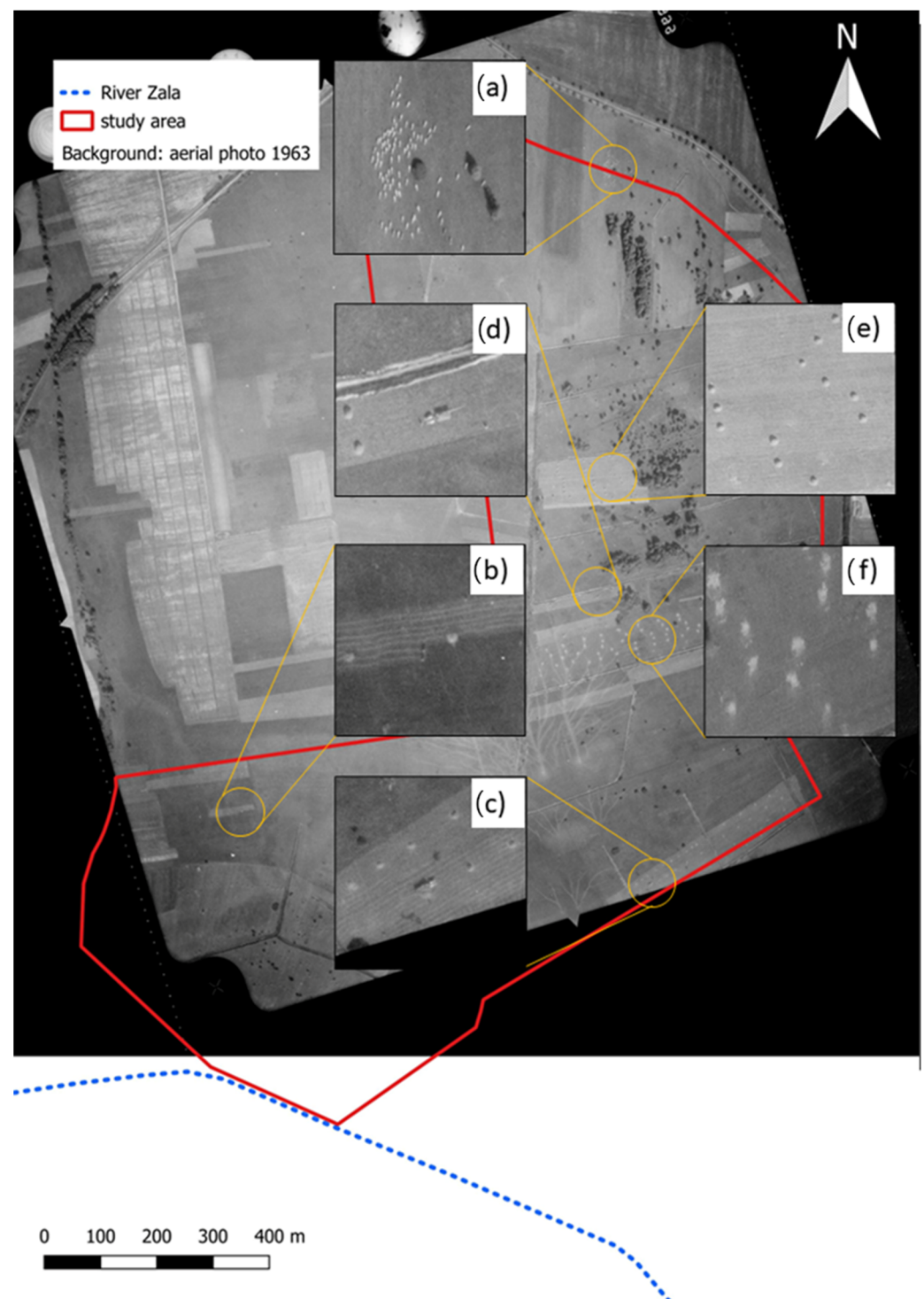
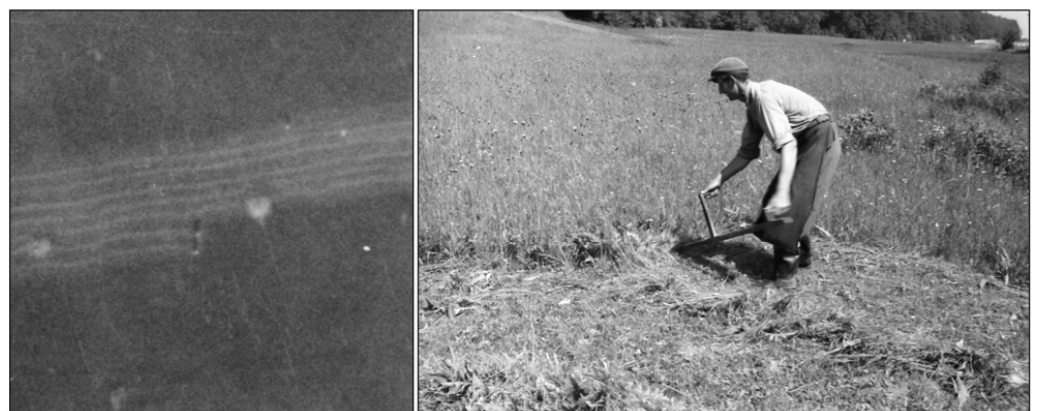


Figure 4. Observed grassland management activities from aerial photograph 1963 [33]: (a) cattle grazing; (b) scything; (c) loading hay onto carts; (d) transporting hay by ox cart; (e) haycocks and hayracks; and (f) scythed area without hayracks (already brought in).



(a)

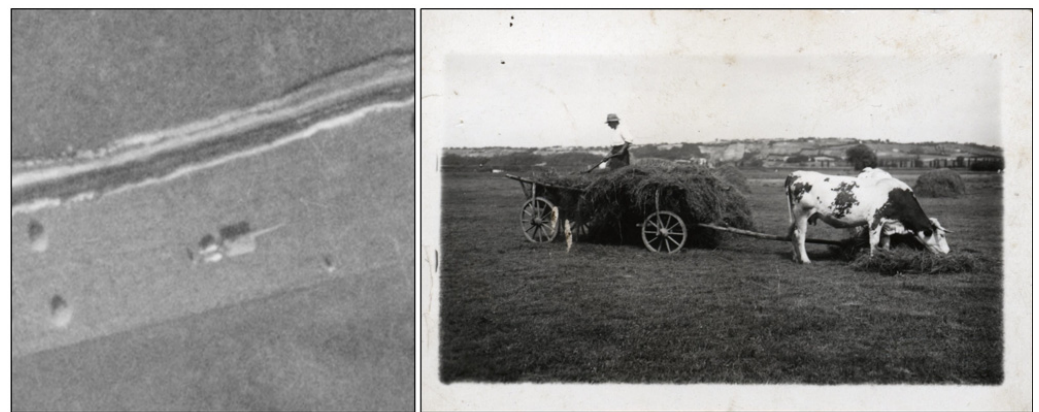


(b)



(c)

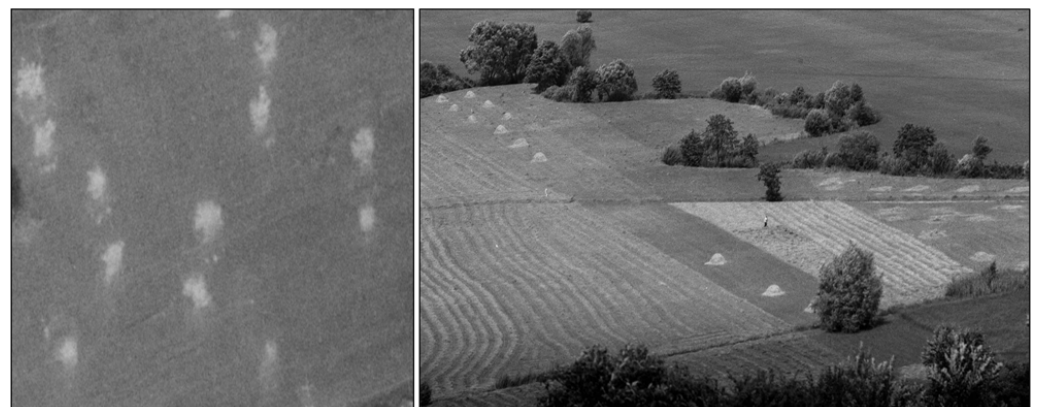
Figure 5. *Cont.*



(d)



(e)



(f)

Figure 5. The figure shows an illustration of the details extracted from Figure 4. In all cases, the image on the left is from the 1963 aerial photograph [33]. The right side of the image pair shows the same activity, illustrated with contemporary photographs from the same region on similar habitats. (a) [63] cattle grazing; (b) [64] scything; (c) [65] loading hay onto carts; (d) [66] transporting hay by ox cart; (e) [67] haycocks and hayracks; and (f) [68] scythed area without hayracks (already brought in).

Arable land was visible in the vicinity of the study area on the earliest maps, but grassland was much larger. Over time, more and more grassland was converted to arable land, until under communism in the 1980s the purpose was to convert the entire area

to arable land [69]. At that time, many meadows were ploughed up to where stands of Snakeshead Fritillary (*Fritillaria meleagris*) and Spring Snowflake (*Leucojum vernal*) were growing [Hideg ex verbis]. Most of our study area has never been ploughed, but small areas have been ploughed in the northern and southern parts. In places, ploughing was observed for shorter or longer periods at six locations during our surveys (Figure 6).



Figure 6. Observed arable fields from different times in study area [43].

3.4. Synergistic Effects of Interventions

Records from the 18th century exist about our study area, which is of importance from a nature conservation point of view, documenting the desire to regulate the river and drain the wetlands in order to make better use of the meadows, to create arable land and, in general, to improve agricultural use. River regulation and wetland drainage were carried out over a number of periods, at different stages, to varying degrees, and using techniques appropriate to the time. Until the beginning of the 19th century, the extent of water regulation depended on the skills of the local population and was therefore

limited. From the mid-19th century, state-sponsored, organised drainage companies were established, greatly increasing the scale and efficiency of water control, but still relying on manual and animal traction. In 1963, the railway had not yet affected the ecology of the area. River flooding, rainfall, and seepage not only affected the quality of natural and semi-natural vegetation, i.e., forage, but also the permeability of the area. For this reason, the timing and method of grazing or scything and the area covered could vary from year to year or even be combined. Swamp woodlands were formed along zones of seepage from the ground. These habitats can be even more persistent than grasslands, making them particularly valuable in grassland-dominated areas.

From the mid-20th century onwards, machinery increasingly improved the possibilities for water control interventions. Surface water drainage in our area reached its maximum by the 1960s at the latest, but in 1970, the groundwater level was reduced by underground drainage for the construction of the railway line. In the 1980s, underground drainage was used to convert all the surrounding wetlands and wet grassland into arable land. This technology could be used to dry out wetlands that could only be partially drained by surface drainage. In our case, the construction of the railway also involved significant drainage, which not only affected the water balance, but also the habitat fragmentation. Scattered throughout our study area, we detected areas that had been used as arable land for shorter or longer periods, but never permanently. Arable land that was abandoned for a longer period had regenerated well. The fact that the whole area was not permanently converted to arable land was partly due to poor drainage and partly due to conservation efforts at the time.

3.5. International Outlook

The history of our study area is, with minor differences, similar to the history of other wetland areas at a global or European level. The history of the area can be linked to the following international developments. The changes in wetlands through surface waterways and groundwater drainage were a global anthropogenic process that has been going on for thousands of years [8]. The main driver for changes, as we have also seen in our studied fen meadow area, is to achieve economic growth through the conversion to arable land [7,70]. The conversion to arable land is 50% responsible for the drainage of the Earth's wetlands. The peak of conversion occurred around 1950, when many countries had government support for this activity [7]. The situation was the same in Hungary in the 1970s and 1980s, where government support was extremely high [Balogh ex verbis]. In some wetlands, humans created grasslands. Some of those anthropogenic grasslands have become biodiversity hotspots in Europe [5]. But as the population grew, more and more grasslands were converted into arable land. From the first half of the 20th century, a high level of agricultural industrialisation occurred in Western European countries. This resulted in a massive decrease in the area of extensively managed land and fragmentation and decline in biodiversity. In most parts of Eastern Europe, these negative trends were not so marked until the switch to a communist economy from the 1950s to 1990s [2]. Before industrialisation and the communist economy, people used their grasslands extensively, which has partly helped preserve biodiversity [71,72]. It was the small-scale traditional management that impacted the biodiversity. It is now clear that the main cause of the biodiversity crisis is the change in traditional land use [73]. In addition to changes in farming, infrastructural interventions such as railways can also have a very negative impact on the wildlife in the area [74,75].

4. Conclusions

Humans have always shaped their environment, as far as they could, and they had different opportunities to do so in different ages. Looking at the history of our study area, we have identified the negative conservation events and highlighted the positive management that has maintained the habitats of rare species. We found a match between major local and global trends. In the European Union, at least some of the most valuable areas

have been protected [76], but identifying the most appropriate conservation managements is often difficult [22,30,77]. For conservation management, it is not enough to know the present, it is necessary to understand the history of the area [31,78]. In our case study, we have not only provided an example of a wetland conversion experiment in the second most drained country in the world [7], but we have also tried to explore and illustrate the characteristics of a land use that was not only sustainable but also contributed to the maintenance of the biodiversity of the area for centuries [34,60,67]. The aerial photograph [Figure 4] taken on 16 September 1963 proved invaluable in this respect as it was the very first aerial photograph of the area and the last to be taken before the area was prepared for intensive mechanised farming. In the aerial photograph [Figure 4], the different stages of vegetation are shown by the different shades of grey, which is a result of farming activity. A few years later, these vegetation structures were no longer visible. In that time, the traditional grassland management could follow changes in vegetation and environmental conditions, even in the short term. Scything and haymaking were carried out as quickly as possible, but the work could take several days or weeks because of the hand tools, the speed of the ox carts, and the time needed for the hay to dry. The small size of the 120 hectares meant that it was owned by many people, and the plots were often less than 10–20 m wide, but were long. Although families helped each other, work progressed at different rates in space and time. For this reason, it is possible that several haymaking and grazing operations can be seen at the same time in (Figures 4 and 5).

Humans have used and maintained grasslands but have not fundamentally altered natural processes. We are witnessing the last moment of a mosaic, an adaptive use of the landscape in space and time. This use, a mosaic in space and time, adapting to the landscape at a small scale, is the message that this image is intended to send to the future. It could be the key to sustainable agriculture and biodiversity. The aim cannot be to recreate the economic conditions and technological development of nearly 100 years ago, but the activities that sustained the landscape then can serve as inspiration for today's farmers and conservationists, so it is important to collect traditional ecological knowledge and expand research into the history of landscape use.

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