

Safeguarding the biodiversity of dry calcareous grasslands

Results from a conservation project in the Vértes Hills



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"No flocks of sheep with bells jangling signs of life, nor wistful melodies of the young shepherd's fife, birds of song all have left, the plains silent, bereft, not a lone Corn Crake trills amid green tufts of grass, nor a sole cricket to fiddle his tune."

SÁNDOR PETŐFI: THE PUSZTA IN WINTER (1848)



A shepherd with his herd in the Great Hungarian Plain in 1908. Traditional shepherding played a central role in promoting and maintaining the biodiversity of semi-natural grasslands. This form of land use was widespread in Hungary until the mid-20th century, but has since then declined significantly.

Foreword

Dry grasslands are among the most distinctive and ecologically valuable habitats in Hungary. Shaped over centuries by traditional land use, they support an extraordinary variety of plant and animal species, many of which are rare elsewhere in Europe and some found only in the Carpathian Basin.

Today, however, these grasslands face increasing threats. Intensified land use, abandonment and the spread of invasive species – all put pressure on these habitats. Without regular management, open grasslands gradually become overgrown with shrubs and trees – leading to the disappearance of their unique species in the long-term.

In Hungary, more than 21% of the land is part of the Natura 2000 network, established under the EU Birds and Habitats Directives to protect the most valuable nature assets that countries in Europe have. The Natura 2000 site Vértes, with its extensive mosaic of dry calcareous grasslands and thermophilic woodlands, ranks among the most species-rich areas in the country. Maintaining and restoring these valuable habitats and their species in a favourable conservation status vitally requires habitat management. Developing effective management measures depends on close cooperation between conservationists, scientists and landowners as well as the support of local communities for the measures being implemented.

I am therefore delighted that a collaborative project of Hungarian and German conservationists to strengthen the biodiversity in the Vértes Hills has been successfully realised. This booklet invites you to explore the dry calcareous grasslands of the Vértes Hills and learn how we can protect these habitats. I hope you enjoy reading it and discover more about Hungary's natural treasures, or even better, experience them in person along one of the many hiking trails winding through the beautiful landscape of the Vértes Hills.

Yours sincerely,

Mareike Vischer-Leopold
Research Associate at the German Federal Agency for Nature Conservation



Semi-natural grasslands are characterised by a high species richness. Their biodiversity has especially been promoted through long-term, low-intensity land use. Low nutrient levels and a diverse structure create a mosaic of habitats that support many specialised plants and animal species.

Introduction

Semi-natural grasslands rank among the most species-rich habitats in Europe. Their diversity of plants, insects and birds attracts not only conservationists but also people, who come to enjoy these vibrant landscapes. However, the extent of grasslands of high nature value has sharply declined in recent decades. The forest steppes in the Pannonian region remain one of Europe's most important strongholds of species-rich grasslands.

Holding a large-scale network of dry calcareous grasslands, the Vértes Hills in north-western Hungary serve as an exemplary model region for conserving these valuable habitats. These grasslands harbour a remarkable diversity of plants and animals, including numerous species of European conservation concern.

The combination of a dry climate, low productivity of the soils and traditional livestock grazing has facilitated the development of dry grasslands in Hungary. However, in the second half of the 20th century, large-scale agricultural changes led to the cessation of traditional land use in many places. As a result, shrubs and trees are now gradually encroaching on open grasslands, degrading the habitat conditions for many specialised species and putting their populations at growing risk. Without intervention, this trend poses a severe threat to dry grassland biodiversity, underscoring the urgent need for conservation measures to preserve these habitats and their characteristic species over the long term.

In a collaborative project, a Hungarian-German research team assessed the biodiversity of dry calcareous grasslands in the Vértes Hills and, from this data, derived recommendations for their management. These recommendations can also guide conservation actions in dry grasslands in other regions across Europe.



The Pannonian forest steppes are key strongholds of Europe's species-rich grasslands, featuring vibrant landscapes with a characteristic mosaic of open dry grasslands and thermophilic woodlands, as can be found in the Vértes Hills near Csákberény.



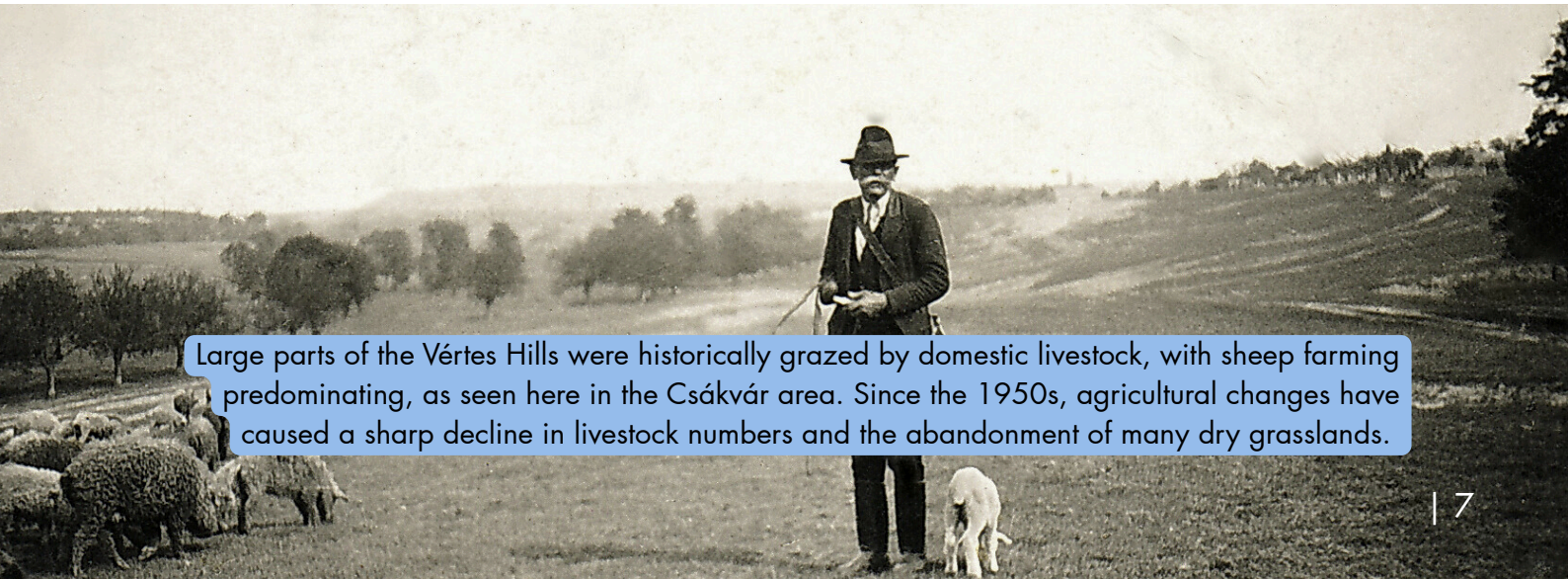
In the Pannonian forest steppes, dry grasslands initially developed on poor soils, where trees and shrubs could hardly grow, such as the rocky dolomite slopes of the Vértes Hills. After human settlement, traditional land use further shaped them and contributed to their outstanding biodiversity.

The origin of dry grasslands

Without human influence, dry grasslands in Europe would occur only in a few areas unsuitable for shrubs and trees. In the Pannonian forest steppes, they have initially developed on poor soils, such as the steep, rocky dolomite slopes of the Vértes Hills, which hardly allow the growth of woody plants. In pre-human times, their distribution was further influenced by wild herbivores and natural wildfires, which restricted the establishment of woody plants and formed a mosaic of open habitats interspersed with woodlands. Since human settlement, these natural dynamics have largely been replaced by traditional land-use practices. The dry grasslands in the Vértes Hills were shaped by livestock grazing over centuries. Today, these habitats can mainly be found on marginal land, unsuitable for arable farming. Those areas are characterised by nutrient-poor, warm and dry habitat conditions, which demand high specialisation from the species that inhabit them.

The extent of dry grasslands closely mirrored Hungary's livestock population, which peaked in the mid-19th century. Historical records indicate that over 20,000 head of livestock grazed in the Vértes Hills during this time. However, agricultural changes throughout the last century, especially since the 1950s, led to a steep decline in these habitats. As livestock numbers dramatically dropped, many grasslands were abandoned, while others were converted to other forms of land use.

In the Vértes Hills, geographic names, such as Páskom ("Pasture"), Nyári-állás (roughly "Summer Pasture"), Kecske-hegy ("Goat Hill"), Bika-rét ("Bull Meadow") and Disznó-völgy ("Pig Valley"), still reflect the once widespread practice of livestock grazing. Today, except for a few areas in the foothills, livestock grazing has largely disappeared from the dry grasslands in this region.



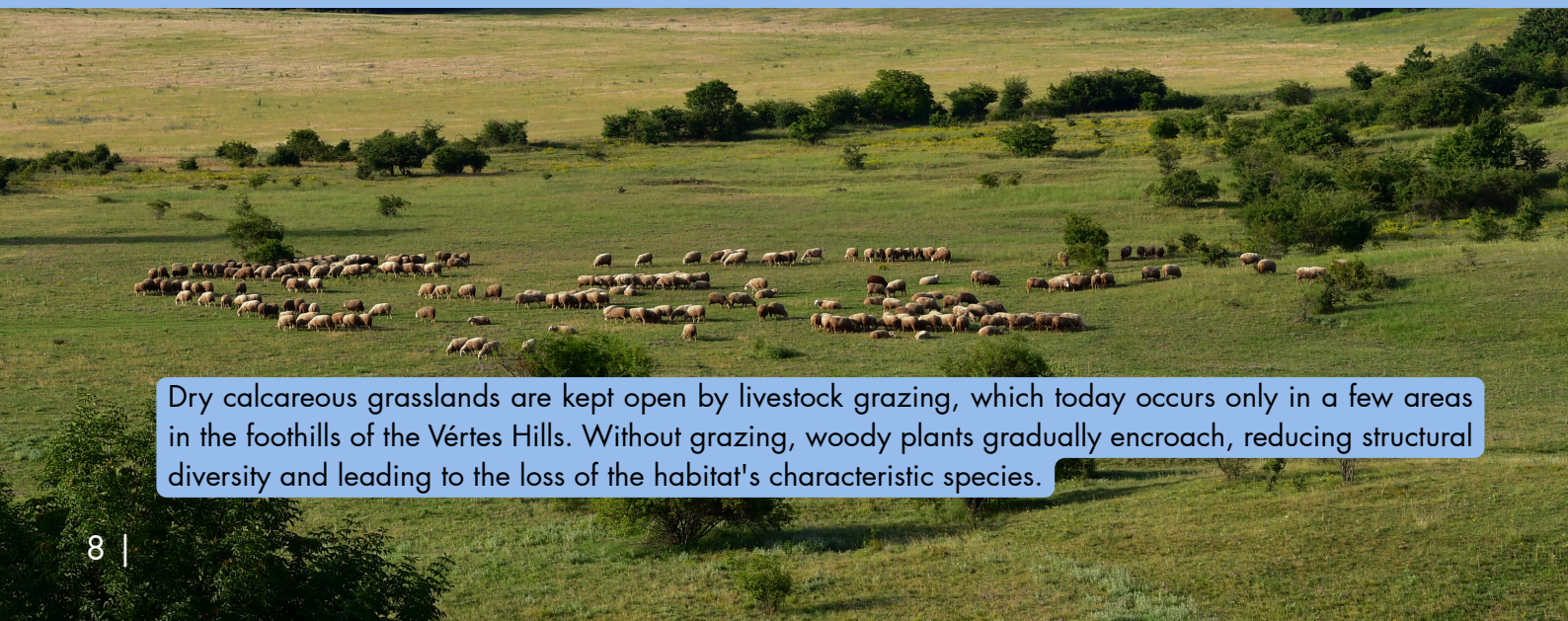
Large parts of the Vértes Hills were historically grazed by domestic livestock, with sheep farming predominating, as seen here in the Csákvár area. Since the 1950s, agricultural changes have caused a sharp decline in livestock numbers and the abandonment of many dry grasslands.

Dry grasslands need care

Dry calcareous grasslands are open habitats characterised by the presence of a wide range of light-demanding and warm-adapted species. More than half of all European plant and animal species are associated with open habitats, underlining their crucial role in maintaining biodiversity. A certain proportion of shrubs, such as Blackthorn or Hawthorn, is typical of dry calcareous grasslands. These shrubs enhance their structural diversity, providing breeding sites and song posts for birds as well as habitats for a variety of insects. As a result, they generally contribute positively to the overall biodiversity of this habitat type.

However, problems arise when traditional land use in dry calcareous grasslands is entirely abandoned. In the absence of disturbance factors that slow succession, such as grazing, mowing, fire or drought, woody plants gradually spread into these habitats. As shrubs and trees encroach, the environmental conditions of the grasslands change significantly, causing many characteristic species to lose their habitats. This process is especially pronounced on fertile soils, where nutrients and water are readily available for woody plants. On dry and shallow soils, such as those of the dolomite slopes in the Vértes Hills, it proceeds far more slowly, but nevertheless causes biodiversity declines in the long term.

Maintaining traditional land-use practices, such as low-intensity livestock grazing, is therefore essential for conserving the biodiversity of dry calcareous grasslands. Grazing not only restricts the growth of woody plants but also creates short swards and small gaps in the vegetation. These gaps are crucial for the establishment of seedlings of light-demanding plant species and serve as microhabitats for warm-adapted insects as well as foraging sites for birds feeding on insects. Although wild ungulates can also suppress the encroachment of woody plants in grasslands to some extent, they often cause conflicts with landowners, foresters and also conservationists, especially when their populations become too large. Therefore, maintaining the right balance is crucial to prevent overgrazing, which is known to be detrimental to many species of dry calcareous grasslands.



Dry calcareous grasslands are kept open by livestock grazing, which today occurs only in a few areas in the foothills of the Vértes Hills. Without grazing, woody plants gradually encroach, reducing structural diversity and leading to the loss of the habitat's characteristic species.



Where the terrain allows, other herbivores, such as Hungarian Grey Cattle, can graze alongside sheep on dry grasslands. As true grazers, they mainly consume grasses, limiting their dominance and allowing less competitive herbs to flourish.

Land-use change in Hungary

Since the mid-20th century, the increasing mechanisation of agriculture, land consolidation measures and the use of mineral fertilisers and pesticides have contributed to severe changes in Europe's agricultural landscapes. While agricultural production intensified on fertile soils, habitats on marginal land, mostly found in the uplands, were increasingly abandoned or afforested. Both processes led to the large-scale loss of valuable habitats and their characteristic species. This development has not bypassed Hungary's dry grasslands, which lost at least half of their area over the last 70 years.

Agricultural collectivisation in Hungary during the 1950s caused notable biodiversity losses and dramatically diminished the role of traditional herding. Grazing on the dry calcareous grasslands of the Vértes Hills was also stopped during this period, as the areas were placed under the authority of the local forestry administration. However, compared to the intensive farming in western Central Europe, the impact of collective farming on the agricultural landscapes in Hungary was less severe, mainly because production methods were less intensive. As a consequence, many species that have become rare elsewhere in Europe remained in relatively large populations in Hungary. For example, this applies to many farmland birds, such as the Skylark or Corn Bunting, whose current breeding densities in Hungary are roughly four times higher than, for instance, in Germany.

After the collapse of collective farming in the 1990s, rapid changes in agricultural land use accelerated the biodiversity loss. The number of grazing animals in Hungary has roughly halved since 1990. This development contributed, for example, to a 70% decline of the Hungarian population of the European Ground Squirrel. Since 2004, EU agricultural policies have further promoted high-productivity farming while still providing insufficient support for low-intensity land use in dry calcareous grassland. Therefore, there is an urgent need for action to strengthen biodiversity conservation in these valuable habitats.



Livestock grazing also played a key role under Hungary's collective agricultural system. Old stables in the Vértes Hills near Csákberény stand as reminders of this era. However, this form of land use rapidly lost its significance following large-scale agricultural transformations from the 1990s.



The collectivisation of agriculture in the 1950s led to the near disappearance of traditional herding in Hungary. There are only a few shepherds left in the country, who still practise herding. Lajos Czirák is one of the last of his kind grazing with sheep in the Vértes Hills.



In 1965, the landscape of the Vértes Hills south-west of Gánt was dominated by a mosaic of woodland and large-scale open dry calcareous grasslands. Shrubs accounted for only a small proportion of the grasslands (Image source: Hungarian Geoportal provided by Lechner nonprofit Kft).



After 60 years of abandonment, the dry calcareous grasslands have become increasingly overgrown with shrubs and trees. This development is representative of the development of many dry grasslands in Hungary (Image source: Hungarian Geoportal provided by Lechner nonprofit Kft).

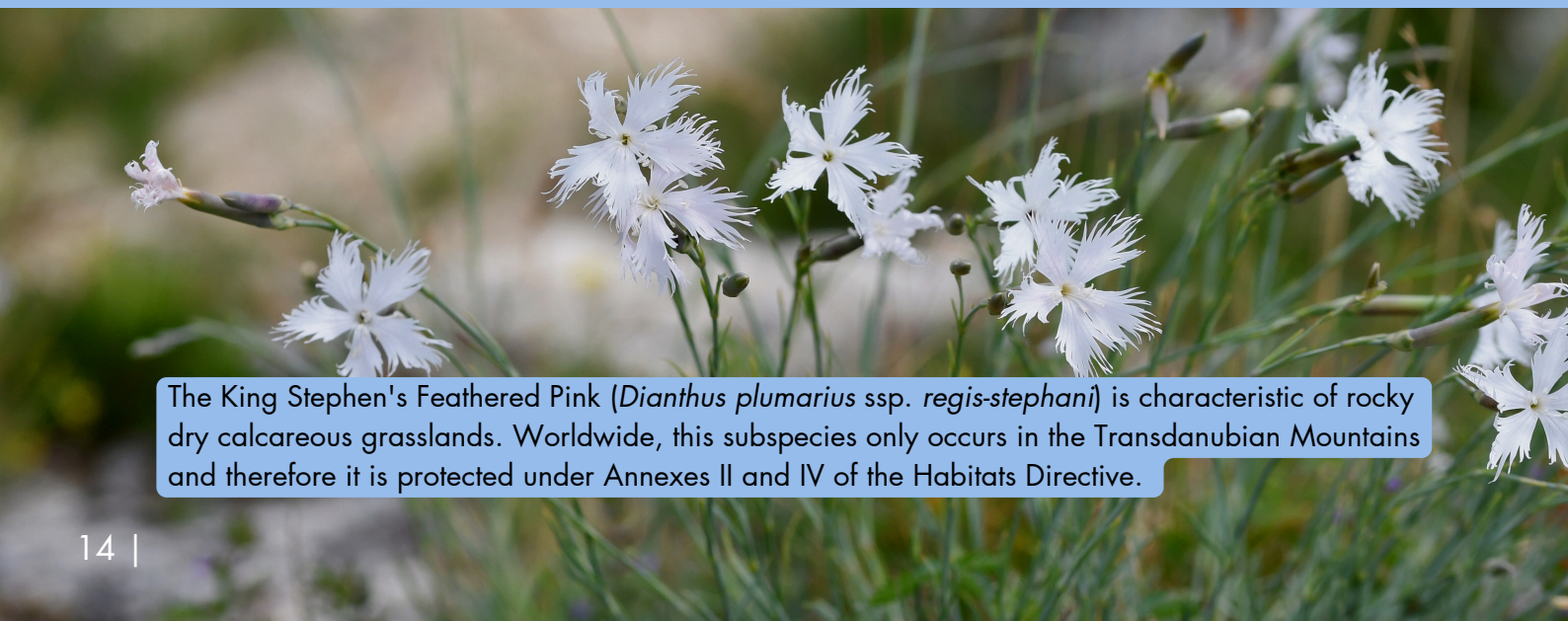
Protected treasures

Due to their outstanding biodiversity, dry calcareous grasslands enjoy legal protection across the EU. They are recognised as priority habitats of community interest for nature conservation, which are protected under Annex I of the EU Habitats Directive. Most of these grasslands are therefore part of the European Natura 2000 protected area network. Established in 2004, the Natura 2000 site Vértes is part of this network in Hungary.

In the Vértes Hills, the dry calcareous grasslands encompass various protected habitat types. Sub-Pannonian steppic grasslands, semi-natural dry grasslands and scrubland facies on calcareous substrates and Pannonian rocky grasslands are the dominant grassland types, together covering an area of over 1,300 hectares. They are mostly interspersed with thermophilic shrubs and dry oak woodlands, which are also protected under the Habitats Directive.

For the conservation of these habitats, the maintenance of characteristic plant and animal species and those of community interest are of particular importance. The latter appear in Annex I of the EU Birds Directive and in Annexes II and IV of the Habitats Directive and rank among the most valuable species for nature conservation in Europe. In the Vértes Hills, occurrences of 53 of these internationally protected species are known. Many of them vitally depend on the maintenance of dry calcareous grasslands.

Beyond designating protected areas, effective conservation in dry calcareous grasslands requires habitat management tailored to the needs of the characteristic and most valuable species of these habitats. For this purpose, management measures targeted to maintain or restore these species and their habitats to a favourable conservation status must be incorporated into the management plans of protected areas.

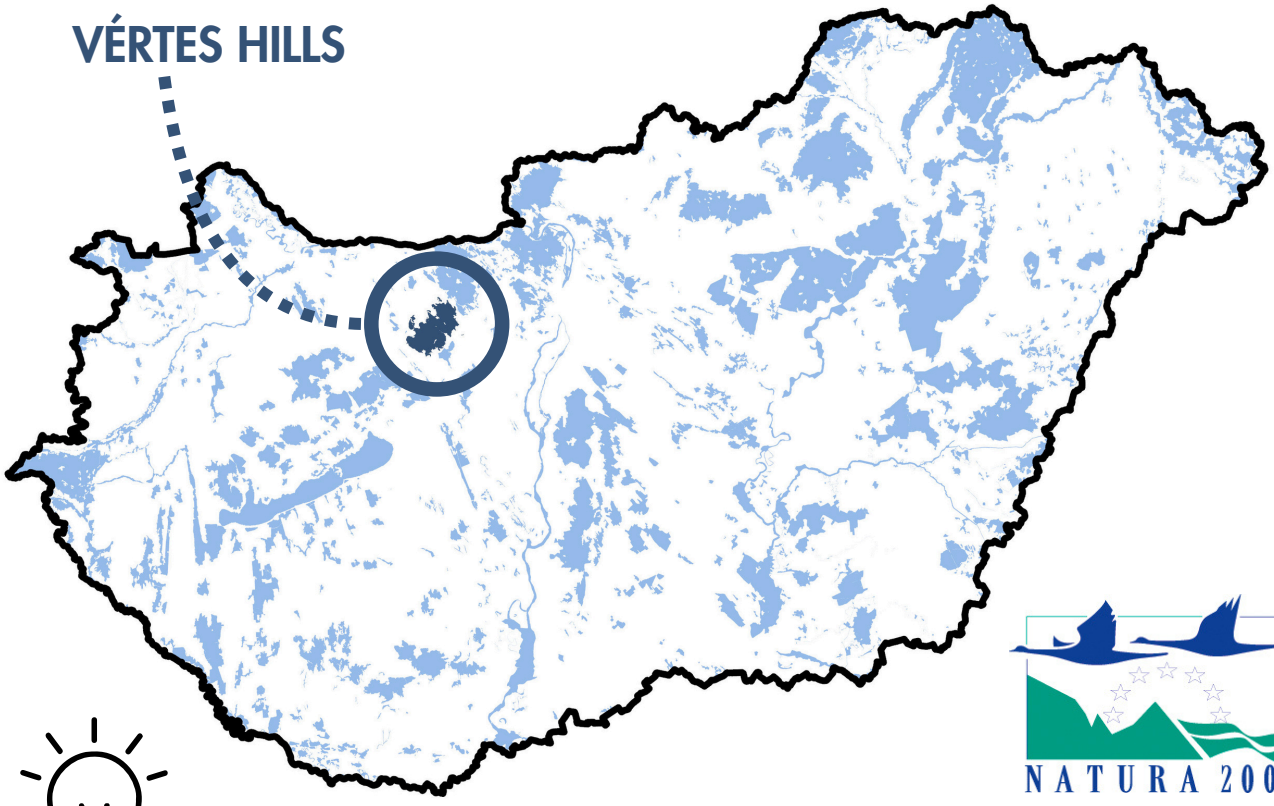


The King Stephen's Feathered Pink (*Dianthus plumarius* ssp. *regis-stephani*) is characteristic of rocky dry calcareous grasslands. Worldwide, this subspecies only occurs in the Transdanubian Mountains and therefore it is protected under Annexes II and IV of the Habitats Directive.

Natura 2000 is a network of protected areas safeguarding Europe's most valuable and threatened species and habitats. Covering all 27 EU Member States, it is the largest coordinated system of protected areas in the world. Since joining the EU in 2004, Hungary has designated over 21% of its land as Natura 2000 sites.

NATURA 2000 SITES IN HUNGARY

The location of the Natura 2000 site Vértes (HUDI30001) protected under both Birds and Habitats Directive.



The Habitats and Birds Directives are EU legislative frameworks aimed to preserve, promote and restore biodiversity. By joining the EU in 2004, Hungary has committed itself to implementing these directives. A central element of these directives is the creation of Natura 2000, a pan-European network of protected areas. Sites are designated based on the presence of habitats or species of community interest, which are those of particular conservation concern.

The EU Member States must report every six years on the conservation status of these habitats and species, using standardised monitoring methods. Activities that could harm protected areas must be offset by appropriate measures to prevent or compensate for any deterioration.

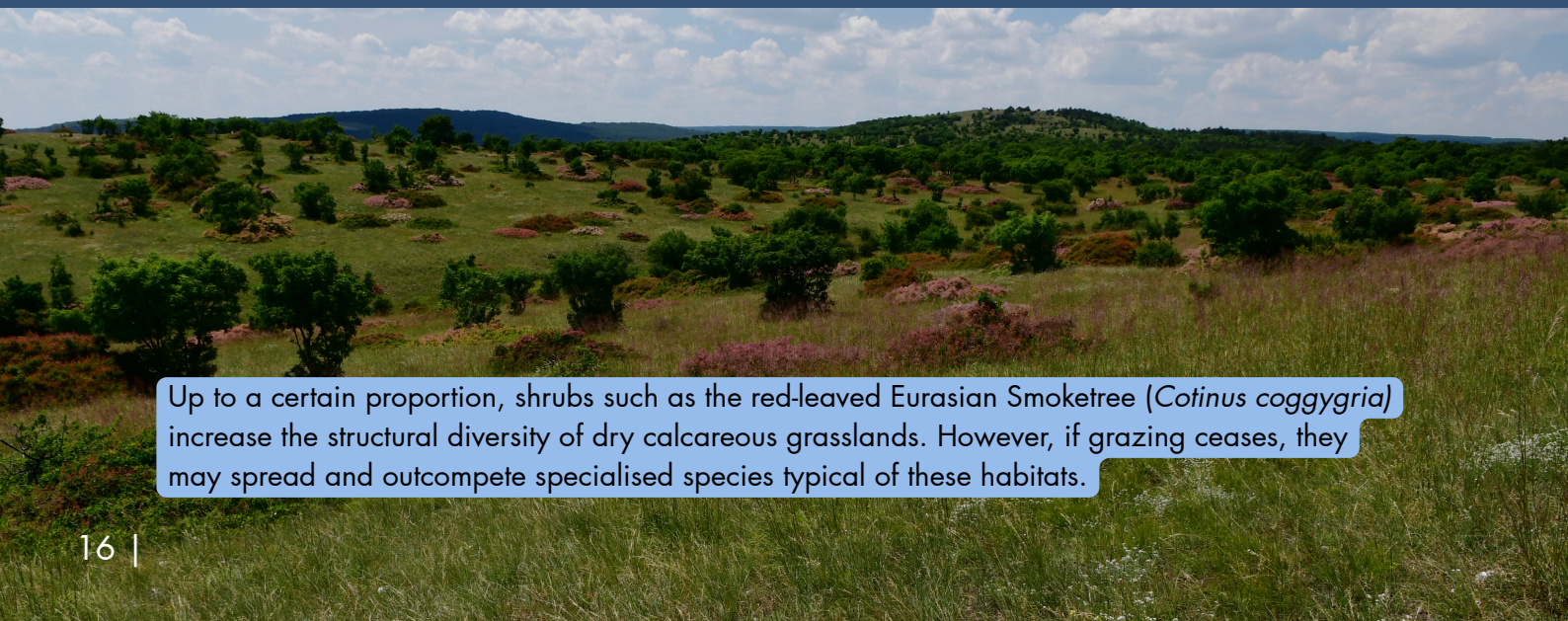
About the Vértes Hills

With an area of 255 km², the Vértes Hills rank among the largest and most species-rich protected areas in Hungary. Located 60 km west of Budapest and stretching between the towns of Oroszlány, Tatabánya, Csákvár and Mór, they form part of the north-eastern Transdanubian Mountains. The northern and central parts of the Vértes Hills have a predominantly submontane climate, while the south-eastern part shows sub-Mediterranean influences. This variety of environmental conditions has given rise to an exceptional diversity of habitats and species.

The landscape is a characteristic mosaic of dry oak woodlands and open grasslands, typical of forest-steppe regions. Favoured by the warm climate, dry calcareous grasslands have developed on the steep, shallow dolomite slopes in the south-eastern part of the Vértes Hills.

Like most grasslands in Europe, the dry calcareous grasslands of the Vértes Hills were shaped over centuries by traditional land use, particularly sheep grazing by local shepherds. Consequently, these habitats are not only vital for biodiversity conservation but also for preserving the region's cultural heritage. The wet meadows in the Zámoly Basin close to Csákvár in the south of the Vértes Hills, which are still grazed in the interest of nature conservation, are an example of outstanding importance.

Although many of these grasslands have been abandoned since the mid-20th century, they still hold a remarkably rich biodiversity. However, some of them are becoming increasingly overgrown with shrubs. Since the Vértes Hills are famous for hunting, high populations of wild ungulates, such as Red Deer, Mouflon and Wild Boar, are shaping the landscape today.



Up to a certain proportion, shrubs such as the red-leaved Eurasian Smoketree (*Cotinus coggygria*) increase the structural diversity of dry calcareous grasslands. However, if grazing ceases, they may spread and outcompete specialised species typical of these habitats.



VÉRTESBOGLÁRI
NAGY-LEGELŐ



GÉM-HEGY, GÁNT

Oroszlány

Csákvár

Mór



HARASZT-HEGY, CSÁKVÁR



ÖREG-HEGY, CSÁKBERÉNY





The dry calcareous grasslands on Öreg-hegy ("Old Hill") near Csákberény are characterised by a very high biodiversity. Besides hosting numerous threatened plant and insect species, the area also supports a variety of farmland birds, including the Northern Wheatear, Skylark, Crested Lark and Hoopoe.

Briefly about the project

With the goal of preserving the exceptional biodiversity of the dry calcareous grasslands in the Natura 2000 site Vértes, a collaborative project of Hungarian and German conservationists was launched under the German Federal Environment Ministry's Advisory Assistance Programme. In the project entitled "Sustainable strategies for the conservation of biodiversity in the cultural landscape of the Vértes Hills (Hungary)", a team of the Osnabrück University has worked together with partners from Hungary along with the directorate of the Duna-Ipoly National Park, which is responsible for protecting the Natura 2000 sites in the Vértes Hills.

As part of the project, the biodiversity of plants, birds, butterflies and grasshoppers was surveyed using standardised monitoring methods across 40 sites (each 5 hectares) dominated by dry calcareous grasslands. The collected data were used to identify the key factors affecting the species richness of the grasslands as well as the presence and abundance of the most valuable species. Based on these findings and on the exchange of knowledge and experience, recommendations for the management of the dry calcareous grasslands in the Vértes Hills were derived to support the long-term maintenance of their biodiversity. The implementation of these measures would also contribute to achieve the objectives of the Habitats Directive, which aims to maintain or restore these habitats and species of community interest to a favourable conservation status. Successful implementation, however, depends on close cooperation with local farmers and forestry, which currently administers much of the dry calcareous grassland areas in the Vértes Hills.



The core project team during the Kick-off meeting in June 2023 in the dry calcareous grasslands near Gánt. From left to right: Norbert Riezing, Mareike Vischer-Leopold, András Ambrus, Sándor Bérces, Thomas Fartmann, Hannah Kalthoff, Jonas Brüggeshemke, Zoltán Kenyeres and Norbert Bauer.

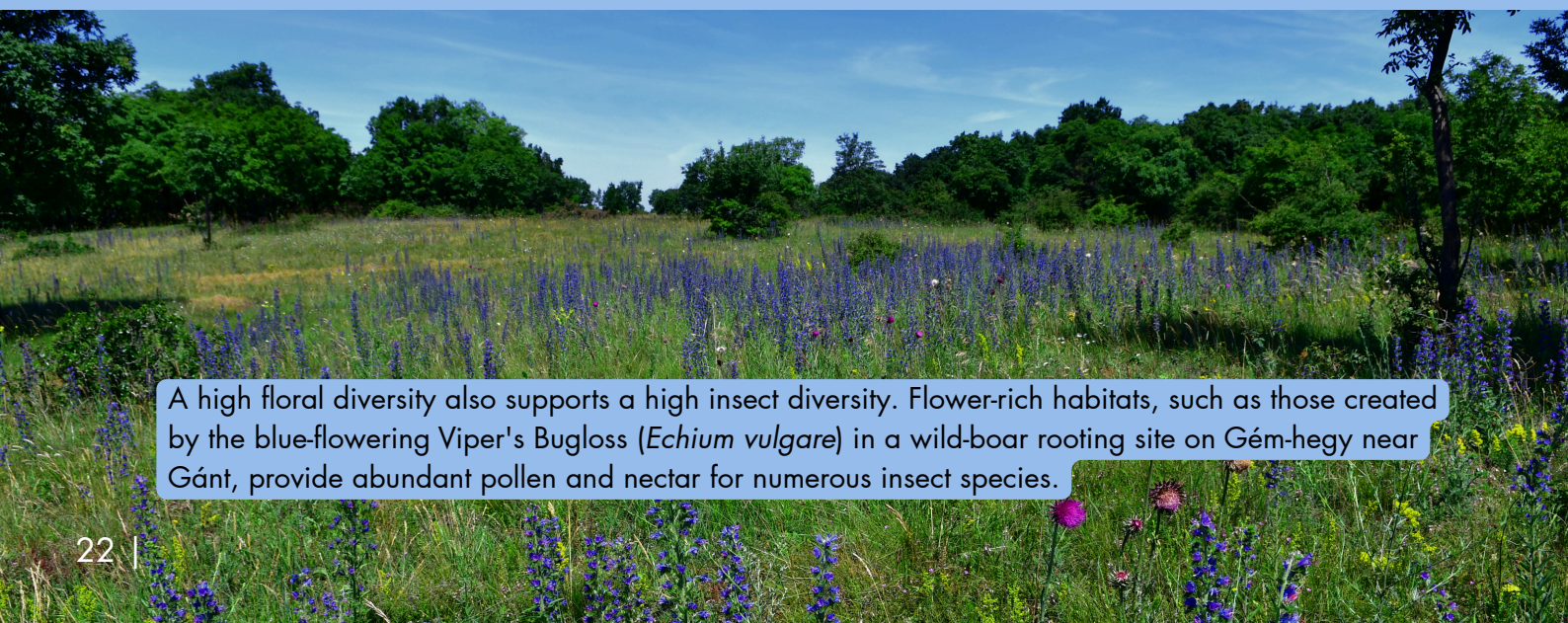


A central element of the project was the exchange of knowledge and experiences between Hungarian and German conservationists, with the goal of developing scientifically sound and practical measures for the management of dry calcareous grasslands.

Hotspots of biodiversity

The dry calcareous grasslands in the Vértes Hills are characterised by a high structural richness. Open rocky dolomite slopes with sparse swards alternate with patches of taller vegetation, shrubs and light woodlands. Together with the large-scale occurrence of well-connected habitats and the favourable climate of the south-facing slopes of the Vértes Hills, the structural richness creates optimal conditions for many highly specialised plant species. In the course of the project, more than 600 vascular plant species were found in the dry calcareous grasslands of the Vértes Hills. The Great Pasque Flower, Pheasant's Eye, Purple Mullein, Purple-flowered Vipergrass, Yellow-flowered Garlic and numerous orchid species, such as the Burnt-tip Orchid and the Green-winged Orchid, are typical representatives of this habitat type. Many of these species are endangered in Hungary or even throughout Europe. Some plants, including the Hungarian Mountain Fennel and King Stephen's Feathered Pink, are endemic, meaning they occur naturally only in Hungary and nowhere else in the world.

The high structural and floristic diversity of the dry calcareous grasslands in the Vértes Hills also supports an exceptionally rich fauna. The Green Lizard, for example, can often be seen darting into shrubs. With some luck, Ground Squirrels may be spotted in the Vértesboglári meadows. Insect life is especially rich: More than 80 butterfly and over 50 grasshopper species were recorded during the project's field work. Many insect species depend directly on a high floral diversity, as their diet is specialised to one or a few plant species. Noteworthy insect species include the Marsh Fritillary, Old World Swallowtail, Spotted Fritillary, Black-spotted Toothed Grasshopper, Predatory Bush-cricket, Macaronius Owlfly and Black Ground-longhorned Beetle. With more than 60 breeding species, the dry grasslands also support a great diversity of birds, including the Barred Warbler, Corn Bunting, Hoopoe, Red-backed Shrike, European Roller, Skylark, Crested Lark and Woodlark – all benefiting from the high abundance of insects. The rare Eastern Imperial Eagle can also be seen hunting in the open grasslands of the Vértes Hills.



A high floral diversity also supports a high insect diversity. Flower-rich habitats, such as those created by the blue-flowering Viper's Bugloss (*Echium vulgare*) in a wild-boar rooting site on Gém-hegy near Gánt, provide abundant pollen and nectar for numerous insect species.



The landscape of the Vértes Hills is famous for the occurrences of many orchid species, such as the Lady Orchid (*Orchis purpurea*). This species can frequently be found both in dry calcareous grasslands and light oak woodlands in this area.

Plants



The Yellow-flowered Garlic (*Allium flavum*), producing loose umbels of nodding yellow flowers in summer, is adapted to dry, sunny sites on calcareous soils. It is characteristic of steppe habitats and commonly occurs on the rocky hillsides of the Vértes Hills.



Burnt-tip Orchid
(*Neotinea ustulata*)



Hungarian Mountain Fennel
(*Seseli leucospermum*)



Purple Mullein
(*Verbascum phoeniceum*)



Purple-flowered Vipergrass
(*Scorzonera purpurea*)



Great Pasque Flower
(*Pulsatilla grandis*)



Pheasant's Eye
(*Adonis vernalis*)



Green-winged Orchid
(*Anacamptis morio*)

Animals: Vertebrates



The European Roller (*Coracias garrulus*), a farmland bird that feeds on large insects, has declined or disappeared in many European countries in the second half of the 20th century. Thanks to increased conservation efforts, it has recently returned to breed at the southern edge of the Vértes Hills.



Northern Wheatear
(*Oenanthe oenanthe*)



Hoopoe
(*Upupa epops*)



European Ground Squirrel
(*Spermophilus citellus*)



Skylark
(*Alauda arvensis*)



Corn Bunting
(*Emberiza calandra*)



European Green Toad
(*Bufo viridis*)

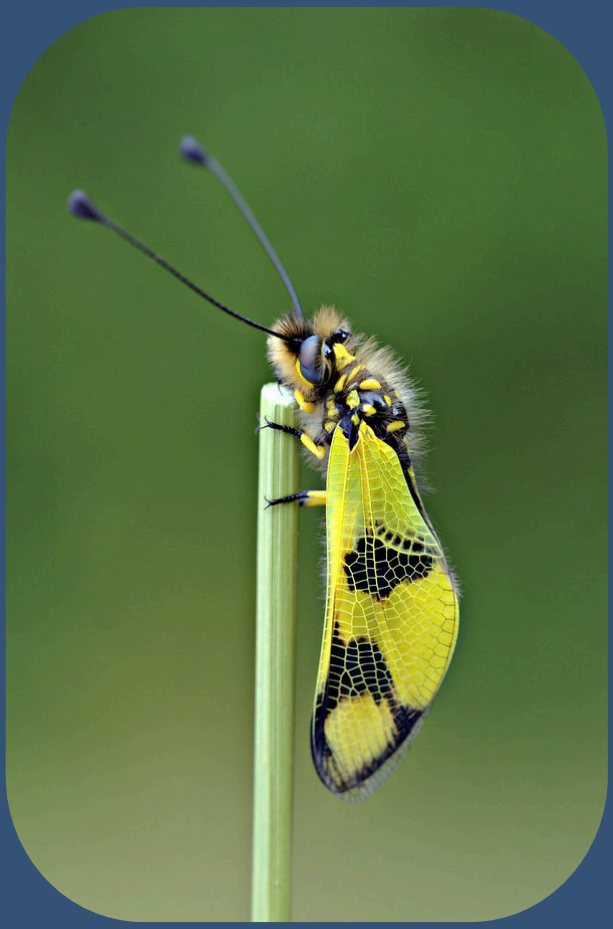


Green Lizard
(*Lacerta viridis*)

Animals: Insects



The dry calcareous grasslands in the Vértes Hills have a high importance for many insects, including a variety of charismatic butterflies, such as the Old World Swallowtail (*Papilio machaon*). More than 100 butterfly species have been recorded here.



Macaronius Owlfly
(*Libelloides macaronius*)



Marsh Fritillary
(*Euphydryas aurinia*)



Black-spotted Toothed Grasshopper
(*Stenobothrus nigromaculatus*)



Predatory Bush-cricket
(*Saga pedo*)



Black Ground-longhorned Beetle
(*Dorcadion aethiops*)



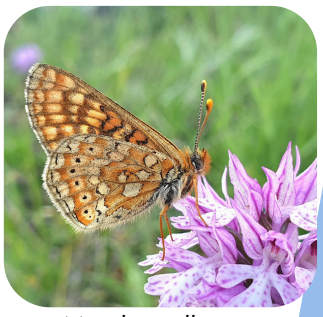
Spotted Fritillary
(*Melitaea didyma*)



Southern Festoon
(*Zerynthia polyxena*)

Key factors for biodiversity

To protect biodiversity effectively, the habitat requirements of as many species as possible must be considered. Since they differ in their ecology and are very sensitive to environmental changes, vascular plants, breeding birds, butterflies and grasshoppers are well-suited indicators of grassland biodiversity. Therefore, within the project, data from these species groups were used to identify factors that benefit the species richness of the dry calcareous grasslands in the Vértes Hills.



Marsh Fritillary
(*Euphydryas aurinia*)



Common Diptam
(*Dictamnus albus*)



Siberian Straw Grasshopper
(*Euchorthippus pulvinatus*)



Hungarian Grey Cattle

HABITAT AREA AND CONNECTIVITY

Large and well-connected habitat patches are essential for supporting a rich biodiversity. This is especially important for butterflies living in metapopulations, such as the Marsh Fritillary. This species colonises separate habitat patches connected by individuals moving between habitat islands, which helps the species to survive even if some patches temporarily lose their populations.

HABITAT HETEROGENEITY

A high structural diversity within grasslands supports a wide range of plants and animals. The mosaic of different successional stages ranging from open grasslands with a high amount of bare ground to light woodlands significantly contributes to the high biodiversity of the Vértes Hills. In addition to species of open dry grasslands, species of thermophilic fringes, such as the Common Diptam can also frequently be found here.

HABITAT QUALITY

Habitat quality is another important driver of specialised plant and insect species of dry calcareous grasslands. Open, sparsely vegetated areas with bare ground or gravel are crucial for light-demanding plants and warm-adapted insect species, such as the Siberian Straw Grasshopper. A lack of land use rapidly reduces the habitat quality for this species and leads to its decline.

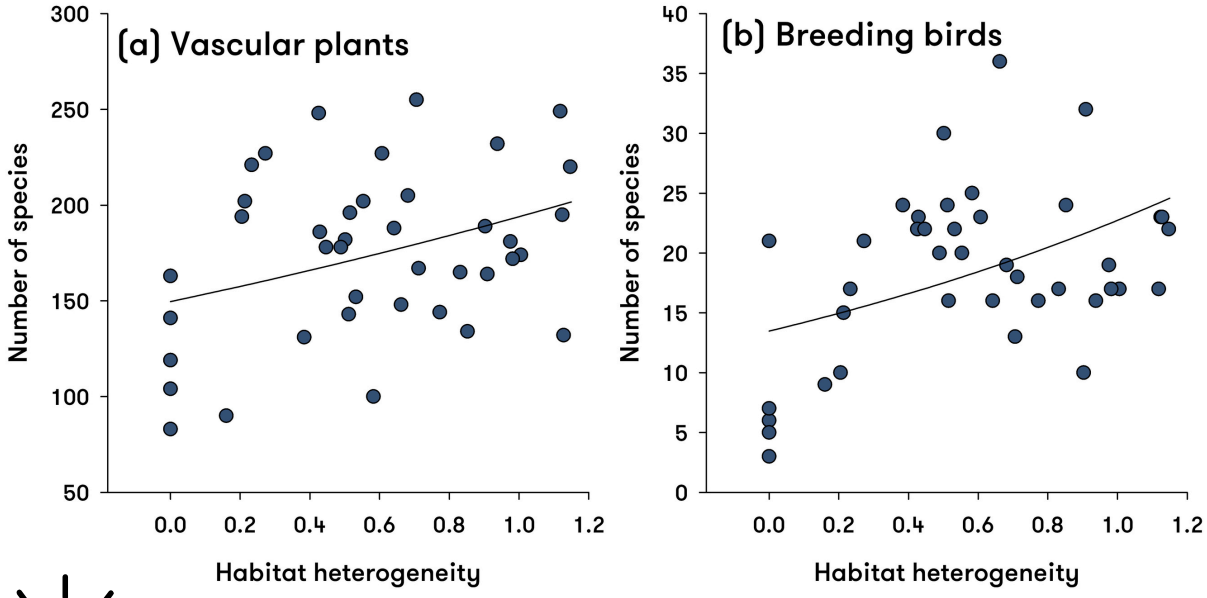
CONCLUSIONS FOR CONSERVATION

To preserve the biodiversity of the dry calcareous grasslands in the Vértes Hills, there is a vital need to maintain large and well-connected habitat patches, to promote their structural diversity and an adequate habitat quality. As only a few areas are currently managed, there is an urgent need to take action to preserve these habitats and their species in a favourable conservation status.

Statistical analyses were used to identify the key factors explaining the species richness and abundance of plants, breeding birds, butterflies and grasshoppers. This approach ensures that measures for habitat management are based on scientific evidence. In addition, expert knowledge should also be taken into account. The effects of measures should be evaluated as part of a standardised monitoring process.

THE ROLE OF HABITAT HETEROGENEITY

The analyses of the biodiversity data within the project revealed that the more heterogeneous the dry grasslands habitats were, the more plant and bird species were present. This is mainly because different species prefer different conditions within these habitats. Furthermore, many insect species rely on a high level of habitat heterogeneity, because their different life stages need different kinds of microhabitats.



THE CASE OF THE PREDATORY BUSH-CRICKET



The Predatory Bush-cricket (*Saga pedo*) is a species of community interest that is protected under the Habitats Directive across Europe. The species strongly depends on habitat heterogeneity. In the Vértes Hills, it inhabits rocky dry grasslands with a mosaic of open patches of bare ground and denser vegetation. The species is adapted to a very warm microclimate. Its eggs are laid in exposed soil spots that heat up quickly, enabling the nymphs to develop well.
As the largest grasshopper species in Central Europe, the adults are also popular prey for birds. Therefore, it is important that its habitat includes denser vegetation to provide protection from predators.



Sparsely vegetated patches rich in bare ground and gravel increase the structural heterogeneity within dry calcareous grasslands. Since they provide a warm microclimate, they are vital for many specialised plant and insect species.



The Great Banded Grayling (*Brintesia circe*) inhabits rocky dry grasslands and is still a common butterfly in the landscape of the Vértes Hills. In contrast, this species has vanished from many areas elsewhere in Europe following shrub encroachment due to abandonment.

Need for monitoring

Standardised monitoring of biodiversity is essential for understanding the drivers of changes in the plant and animal communities. Furthermore, it helps to understand how habitat management affects biodiversity and to identify when management practices need to be adapted. Ideally, monitoring should take place at regular intervals, for example as part of national reporting obligations under the Habitats Directive.

Dry calcareous grasslands are home to many species of international conservation concern that can also serve as valuable indicators of the effects of conservation measures. Monitoring these species helps to show whether management measures, such as livestock grazing, low-intensity mowing or shrub removal, are working as intended. The data collected as part of the project provide a good basis for future monitoring activities in the Vértes Hills.

To ensure that data are comparable across European countries, it is important to use internationally standardised monitoring methods. Examples include the ones of pan-European initiatives, such as the European Butterfly Monitoring Scheme (eBMS) and the Pan-European Common Bird Monitoring Scheme (PECBMS) as well as those of national programmes like the German Insect Monitoring Scheme. The participation of volunteer naturalists, which already plays an active role in European butterfly and bird monitoring, could greatly support long-term biodiversity monitoring and assessments in the Vértes Hills, too.



Monitoring should be based on internationally standardised monitoring methods. Grasshopper sampling using a box quadrat is the standard method within the German Insect Monitoring Scheme. This method allows sampling of data on grasshopper densities that are comparable across Europe.



Breeding birds were sampled using territory mapping. This method is probably the most precise way to count breeding birds. It is widely applied and one of the preferred methods in the Pan-European Common Breeding Bird Monitoring Scheme.

Grazing for biodiversity

Managing dry calcareous grasslands should aim to support as many species as possible, which requires maintaining a high structural diversity within habitats. Extensive, low-intensity grazing is one of the most effective ways to create a mosaic of short grass, taller vegetation, shrubs and open woodland. In areas with a network of large-scale grasslands, such as the Vértes Hills, year-round grazing with a very low stocking density is a suitable tool to sustain these habitat conditions.

Because the dry calcareous grasslands are protected under the Habitats Directive, the local conservation authorities have a legal responsibility to maintain them in a favourable conservation status, which demands appropriate management combined with regular monitoring in the long term. However, implementing habitat management in the Vértes Hills faces challenges. It requires close cooperation between different stakeholders, such as conservationists, foresters and farmers. Year-round grazing is often difficult to apply because it is only possible on large areas and, therefore, mostly requires the consent of various landowners. Moreover, there are only a few herders left in the Vértes Hills that can provide low-intensity grazing and many grassland parcels are currently ineligible for agri-environmental funding programmes, which could financially support the work of herders. Where year-round grazing is not applicable, rotational grazing offers a practical alternative. In this approach, animals are moved between different areas over the year. This allows some grassland patches to be grazed more, others less and some not at all for a while. As a result, several stages of vegetation – short, medium, tall and shrubby – can exist within grasslands side by side. Because the grazing happens only for a short time in each patch, the land can also tolerate slightly higher livestock numbers without being harmed.

Grazing pressure must also match the local conditions: rocky dry grasslands on shallow soils change slowly and need only occasional grazing, whereas grasslands on deeper soils can become more quickly overgrown by shrubs and thus require more frequent intervention.



Traditional livestock breeds like Hungarian Grey Cattle are well-adapted to the regional conditions, making them ideal animals for conservation grazing. However, compared with sheep and goats, they thrive better in more productive grasslands and are less suited to the driest, least fertile sites.



The dry calcareous grasslands of the Vértes Hills have long been grazed by various types of livestock, with sheep being the most common. Among these, the Racka Sheep is particularly well adapted to the nutrient-poor conditions of the rocky dry grasslands.

The Csíkvarsai Meadows

The Pro Vértes Foundation has been engaged in the Csíkvarsai Meadows, which are located in the southern foreground of the Vértes Hills near Csákvár, for many years. The area located in the Zámoly Basin was placed under protection in the 1980s, and work began on rewetting drained meadows. Today, it is one of Hungary's most important wetland areas, with outstanding significance as a breeding and resting area for birds. For example, the largest population of the European Roller in the surrounding of the Vértes Hills can be found here.

Since 1997, the Pro Vértes Foundation has used traditional livestock grazing as a central tool to maintain the ecological balance of the Csíkvarsai Meadows. Today, over 700 Hungarian Grey Cattle, 200 Water Buffalo and several horses graze more than 500 hectares of this unique landscape. Grazing from early spring to late autumn, these animals play a vital role in creating a structurally diverse habitat, which in turn supports the rich biodiversity of the area on the edge of the Vértes Hills. Unlike the rocky, dry calcareous grasslands of the dolomite slopes, the Csíkvarsai Meadows are considered agricultural land. This classification has allowed conservation measures to be supported and expanded with EU funding, enabling sustainable habitat management. Through careful, continuous grazing, the meadows retain their traditional character while remaining a vital refuge for numerous plant and animal species, demonstrating how livestock can be a powerful tool for biodiversity conservation.

Furthermore, nature-friendly mowing is applied in the Csíkvarsai Meadows, which is a measure that can be also beneficial for the maintenance of biodiversity in dry grassland areas in the foothills of the Vértes Hills.

The Fornapuszta model farm offers insights into the traditional agricultural land use and its importance for biodiversity. The meat from the cattle and water buffalo is processed into regional meat and sausage products. Selling these products helps to support landscape management through grazing.



The Pro Vértes Foundation has long been engaged for the conservation of the Csíkvarsai Meadows. Since 1997, the area has been grazed by Hungarian Grey Cattle. Water Buffalo and horses are also used for conservation grazing, sustaining the high structural richness of this area.



Hungarian Grey Cattle grazing has a long tradition in the Csíkvarsai Meadows.



The Northern Lapwing (*Vanellus vanellus*) is a very common breeder in the Csíkvarsai Meadows.



In the model farm Fornapuszta, visitors can learn more about traditional land use.



About 200 Water Buffalo are grazing the wetlands.



The Whinchat (*Saxicola rubetra*) can be found where the vegetation remains taller.



The Csíkvarsai Salami enjoys popularity among the local community.



The Common Redshank (*Tringa totanus*) can also be observed regularly in the wetlands.

The role of wild ungulates

The game populations in Hungary have increased roughly tenfold over the past decades. This trend is also evident in the Vértes Hills, a region long known as a rich hunting ground. Today, Wild Boar, Red Deer, Mouflon and Roe Deer are particularly abundant.

These wild ungulates affect grassland ecosystems in several ways. Red Deer, through their browsing on shrubs and young trees, can help to slow the spread of woody vegetation in dry grasslands. The ecological impact of Mouflon resembles that of domestic sheep. Their grazing creates short swards that many bird species rely on for hunting insects. Wild boar, with their characteristic rooting, disturb the soil surface and create patches of bare ground. These can be valuable germination sites for light-demanding plants and can serve as microhabitats for warm-adapted insects. In addition, the movement and trampling of wild animals can also enhance structural diversity in dry grasslands, much like the effects of livestock grazing.



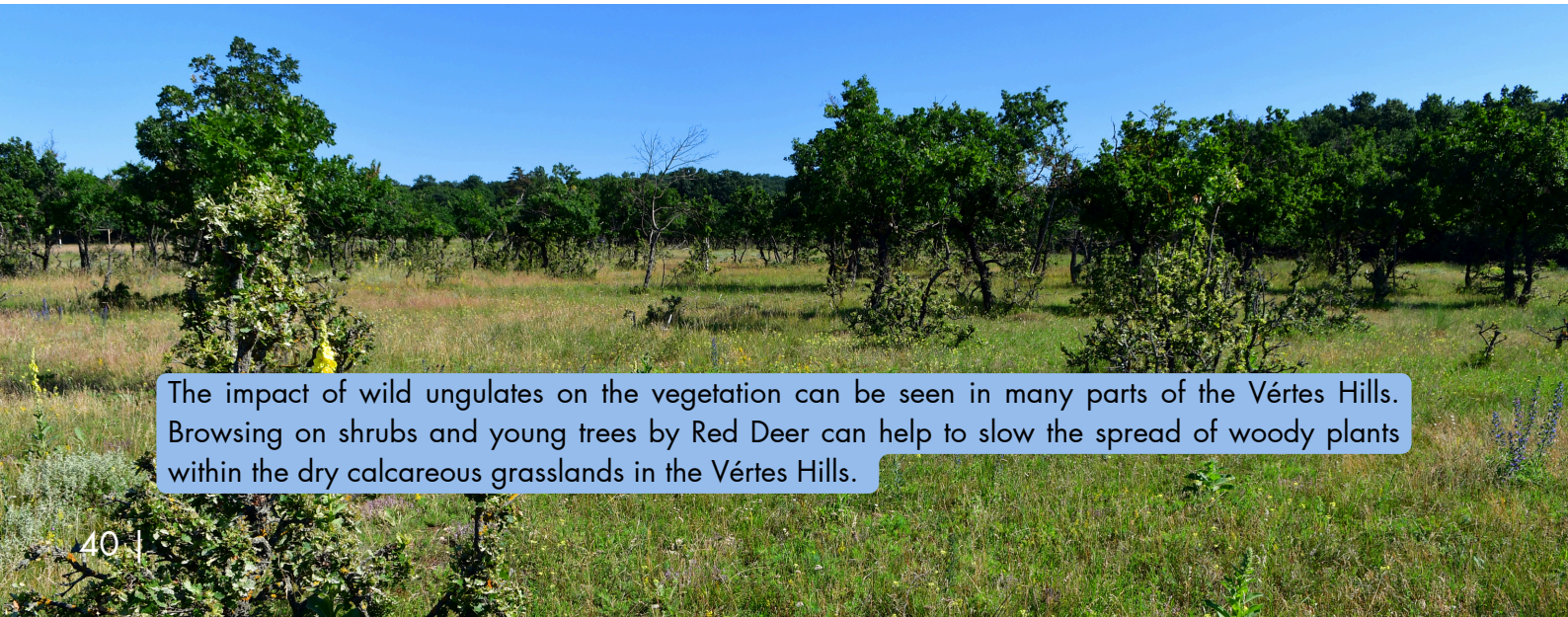
Wild Boar
(*Sus scrofa*)



Red Deer
(*Cervus elaphus*)

However, high densities of wild ungulates also carry risks such as overgrazing. Their selective feeding towards nutritious herbs can lead to a dominance of grasses at the expense of low-competitive species. Furthermore, they often cause conflicts with landowners.

For these reasons, targeted grazing with domestic livestock remains the preferable method for managing the biodiversity of dry calcareous grasslands.



The impact of wild ungulates on the vegetation can be seen in many parts of the Vértes Hills. Browsing on shrubs and young trees by Red Deer can help to slow the spread of woody plants within the dry calcareous grasslands in the Vértes Hills.



Trampling by wild ungulates creates patches of bare ground within dry calcareous grasslands. These increase the structural heterogeneity within the habitats. Mainly, light-demanding and warm-adapted species benefit from the occurrence of these bare patches in the grasslands.

Other management options

Low-intensity mowing is another option for the management of dry grasslands. In the Vértes Hills, mowing is restricted to dry grasslands on loess soils, such as the Vértesboglári Meadows. Unlike grazing, which creates patchy vegetation and a variety of microhabitats, mowing tends to favour grasses and can reduce populations of light-demanding herb species. Nevertheless, it can be considered for biodiversity conservation in grasslands, especially in areas where livestock grazing is not possible for any reason.

Because mowing removes the vegetation abruptly, it can be harmful to insects and other wildlife, such as birds. To reduce these negative impacts, some patches within grassland areas should be left uncut. These uncut patches act as refuges, providing food, shelter and stable microclimates and allowing insects to recolonise mown areas. The timing of mowing is also critical: Large-scale mowing should usually take place only after mid-June to avoid damage of nests of ground-nesting birds. The use of biodiversity-friendly mowing machinery, such as the installation of insect flushing bars, can help to reduce harmful effects on insects during mowing.

On smaller areas, shrub removal or prescribed burning can also be used to maintain open dry grasslands. Shrub removal, however, is often very time-consuming and must always be followed by grazing or mowing to ensure long-term success. Prescribed burning requires appropriate fire-safety measures and should be limited to small patches within the grasslands only. According to current scientific findings, this can be highly effective in promoting the biodiversity of dry grasslands.

Carefully considering which measures are suitable for preserving the biodiversity of dry calcareous grasslands and which measures are feasible in a particular region, facilitates effective habitat management for biodiversity conservation.



The use of biodiversity-friendly mowing machinery, such as insect flushing bars, can help reduce harmful effects on insects during mowing. Even more important is maintaining uncut patches that act as refuges for insects and allow them to recolonise mown areas.



The Keeled Plump Bush Cricket (*Isophya costata*) is sensitive to mowing because cutting removes the tall vegetation it depends on. Preserving structurally diverse grasslands, for example by leaving some areas uncut, is essential to maintain viable populations of this species protected under the Habitats Directive.

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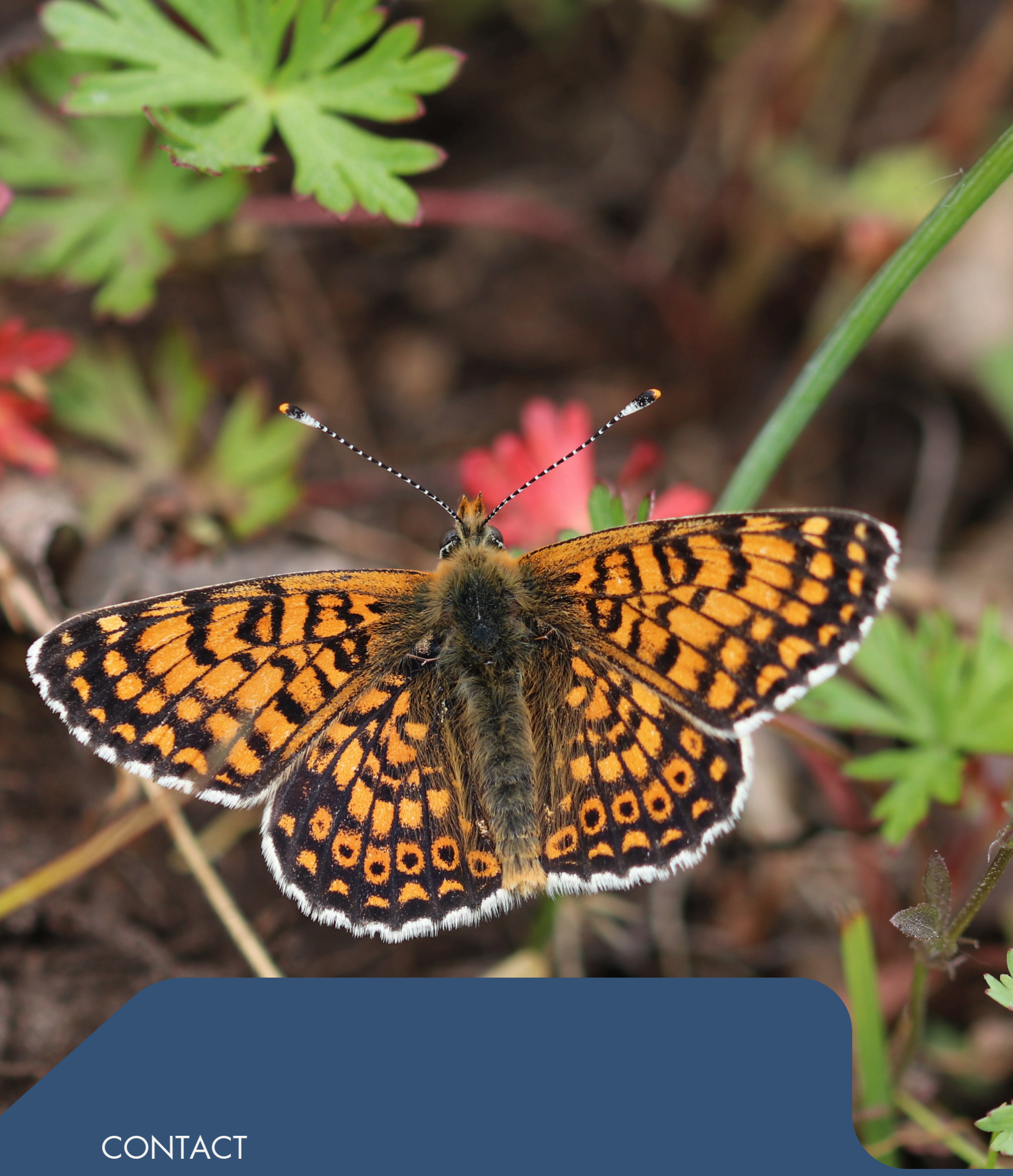
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