

DANUBE PARKS – Danube River Network of Protected Areas Danube Dry Habitat Strategy

**Aiming at the reinforcement of a
network of dry habitats**



Consignor

Landkreis Passau
*represented by the unit „Naturschutz
und Landschaftspflege“*
Domplatz 11, D-94032 Passau
T +49 851 397-1
naturschutzbehoerde@landkreis-passau.de

Office in Charge

Prof. Schaller UmweltConsult GmbH
Domagkstraße 1a, D-80807 München
T +49 89 36040-320
info@psu-schaller.de

Munich, 20 September 2019

Project co-funded by the European Union

Contact Person of Consignor

Christiane Kotz
Landkreis Passau
Untere Naturschutzbehörde
Domplatz 11, D-94032 Passau
T +49 851 397-313
christiane.kotz@landkreis-passau.de

Project management for Passau District

Marianne Badura
blue! advancing european projects GbR

Brienner Straße 48, D-80333 München
T +49 89 8904881-71
m.badura@the-blue.net

psu

Project Management

Dr. Johannes Gnädinger
T +49 89 36040-330
j.gnaedinger@psu-schaller.de

GIS Processing

Dipl.-Ing. Christine Saala
T +49 89 36040-332
c.saala@psu-schaller.de

M.Sc. Holm Seifert
T +49 89 36040-327
h.seifert@psu-schaller.de

Communication, Strategy

M.Sc. Kerstin Huber
T +49 89 36040-331
k.huber@psu-schaller.de

Dr. Christoph Förster
T +49 89 36040-336
c.foerster@psu-schaller.de

Audit

Dr. Johannes Gnädinger
audited on 19 September 2019

List of contents	Page
Summary	1
1. Introduction	3
1.1 Background and structure of the paper	3
1.2 The importance of the Danube as a migration corridor for dry habitats	4
2. Danube dry habitats	5
2.1 Site conditions for dry habitats	5
2.1.1 Climate and exposure	5
2.1.2 Substrate	5
2.1.3 Land use	5
2.1.4 Erosion, sedimentation, and natural disturbances	6
2.2 Primary and secondary dry habitats	6
2.3 Description of dry habitats in the Danube corridor	6
2.3.1 Halophytic habitats	7
2.3.2 Inland dunes, old and decalcified	8
2.3.3 Alpine rivers and their vegetation	9
2.3.4 Heath and scrub	10
2.3.5 Natural and semi-natural grasslands	10
2.3.6 Semi-natural dry grasslands and scrubland facies	12
2.3.7 Mesophile grassland	13
2.3.8 Rocky habitats and caves	14
2.3.9 Rocky slopes with chasmophytic vegetation	14
2.3.10 Forests of temperate Europe	15
2.3.11 Mediterranean deciduous forests	16
2.4 Fauna of dry habitats	17
3. GIS analyses of Danube dry habitat corridor	18
3.1 Definition of the Danube corridor	18
3.2 Data basis	18
3.2.1 CORINE Land Cover / Land Use (CLC)	19
3.2.2 Copernicus Riparian Zones (RPZ)	19
3.2.3 Natura2000 Protected Areas (N2K)	19
3.2.4 European Nature Information System (EUNIS)	19

3.3	Habitat classification and selection	20
3.4	Scope of information yield	29
3.5	GIS valuation for Danube dry habitats	32
3.6	Quantitative and qualitative overview of Danube dry habitats	34
3.7	Overview and detailed maps.....	36
3.7.1	Overview maps of dry habitats	36
3.7.2	Detailed maps of DANUBEPARKS conservation areas.....	36
4.	Danube dry habitat orchids.....	37
4.1	Results of vegetation surveys	37
4.2	Derivation of N2K data	40
4.3	Orchid species in the Danube corridor.....	41
5.	Condition of Danube dry habitats	45
5.1	Conservation status according to Natura 2000 data	45
5.2	Causes of threat and gaps in biotope network	49
5.2.1	Climate and exposure	49
5.2.2	Substrate	50
5.2.3	Land use	51
5.2.4	Erosion, sedimentation and natural disturbances	52
6.	Strategic steps towards a Danube biotope network	53
6.1	Methods of exploring and promoting biotope networks	53
6.2	DANUBEPARKS dry habitat corridor strategy	55
6.2.1	Next steps in GIS analysis.....	55
6.2.2	Next steps in implementing concrete measures	56
6.2.3	Next strategic steps	57
6.3	Examples of setting up dry habitat corridors	58
6.3.1	The EU Strategy for the Danube Region (EUSDR)	58
6.3.2	Network of heathland habitats in Munich, Germany.....	60
6.3.3	Network of sandy habitats in Franconia, Germany	61
6.3.4	Management of dry grasslands by mowing and shrub removal, Bulgaria	62
6.3.5	Cross-border grazing as an alternative management for dykes, Austria	63
7.	Literature.....	64

List of figures	Page
Figure 1: Pannonic salt steppe (1530) with <i>Suaeda pannonica</i>	8
Figure 2: Pannonic sand steppe (6260)	9
Figure 3: <i>Juniperus communis</i> on calcareous grasslands	10
Figure 4: Heißlände surrounded by a mixed riparian woodland (91F0).....	11
Figure 5: Rupicolous pannonic grasslands (6190) with <i>Stipa</i> , Austria.	12
Figure 6: Semi natural dry grassland (6210) in the East of Munich	13
Figure 7: Riparian gallery forest (92A0)	16
Figure 8: Information yield of CLC data	30
Figure 9: Information yield of RPZ data	30
Figure 10: Information yield of N2K data.....	31
Figure 11: Number of available data sources	31
Figure 12: Matrix principle	33
Figure 13: Matrix results of the Danube Bend	34
Figure 14: Hot spots of xerophilic orchid species	38
Figure 15: Hot spots of meso- to xerophilic orchid species.....	39
Figure 16: Generalized orchid sites based on grid cells	40
Figure 17: Categories for orchid species.....	40
Figure 18: Assumed orchids' spread derived from N2K data	41
Figure 19: Distribution of Natura 2000 Protected Areas	47
Figure 20: Network of heathland habitats in the north of Munich	60
Figure 21: Network of sand habitats in Franconia.....	62

List of tables	Page
Table 1: Land use classes in CLC data and categorization	21
Table 2: Relevant land use classes in RPZ data	23
Table 3: Relevant habitat types in N2K data	25
Table 4: Proportions of the probability classes in the protected areas.....	35
Table 5: Orchid species in Danube corridor	42

List of abbreviations

CLC	CORINE Land Cover / Land Use
RPZ	Copernicus Riparian Zones
N2K	Natura2000 Protected Areas
MMU	Minimum Mapping Unit
EEA	European Environmental Agency
SAC	Special Area of Conservation
EUNIS	European Nature Information System
DHC	Dry Habitat Core
SDH	Semi-Dry Habitat
DHS	Dry Habitat Search
GIS	Geographic Information System

Glossary

coppice	forest composed of shrubs
edaphic	characterized by prevailing soil and rocks
mesoxerophytic	condition between dry and wet
oligotrophic	poor in nutrients
succession	natural process of development of plant communities
xerophilic	characteristic of species to prefer dry habitats

Summary

This paper represents a first approach of the Danube Dry Habitat Corridor campaign to collect components and ideas out of which a network of protected areas with focus on dry habitats along the Danube could be woven. Considering the function and the importance of the Danube as a past, current and future corridor for species migration, restoring ecological connectivity of the Danube dry habitats will be a key factor to preserve dry habitat species along the river, maintain genetic diversity among populations and thus retain the species' capacity for adaptation to environmental change, which is especially important regarding the imminent threat of climate change.

To identify and illustrate semi-dry to dry habitats along the Danube, a GIS analysis with present data of Corine Land Cover and Riparian Zones was conducted. N2K data were added to identify existing protected areas with dry core habitats. In combination with data from vegetation surveys, N2K data were also used to determine the location of orchids, which were chosen as flagship species for this campaign.

In total, the number of real dry habitats along the Danube is quite low, as far as quantity and quality of data were sufficient to come to this conclusion. Based on the analysis of locations with xerophilic orchids, the hot spots of dry habitats along the Danube are Donauauwald (Germany), Duna-Ipoly National Park (Hungary) and Iron Gates National Park (Serbia, Romania). This does not mean that there are no other important areas, but the size of them is very often too small or there are no data / too less data available. The identification of other hot spots of dry habitats along the Danube is fundamentally connected with the implementation of much more uptakes of target-species or -groups and the identification of possible dry habitats and their recording in the N2K network.

For better identification, delimitation and description of dry habitats, it will be necessary to improve these data (a) by getting access to further existing data (perhaps not accessible for the public) and (b) by gathering new data through mappings on more detailed scales and along the entire corridor. In this regard, already announced improvements in CLC and EUNIS data availability and resolution could provide new and more precise input for a possible follow-up analysis. Furthermore, also the orchid species should be mapped systematically to have a better data basis.

Another very important aspect of this dry habitat corridor campaign is to look beyond the current situation and to map out possibilities and priorities for medium- and long-term strategic actions of the network. These include considerations about financing in general, the future management and participation of a diverse member group or the organization of maintenance measures. Inspiration can be gained from already existing dry habitat network projects and measures presented in this paper, as for example the EU Strategy for the Danube Region (EUSDR), but also from our best-practice document about dry habitat maintenance measures to which our members contributed to.

This strategic paper aims to constitute an useful and inspiring first step to a Danube-wide dry habitat network. However, it is important to keep in mind that this paper has at times limited strength concerning data interpretation, because of the insufficient data basis its main analysis grounds on. Nevertheless it is an important first approach to bundle basic components and considerations with regard to a possible dry habitat network along the Danube und lays the foundation for further strategic planning and implementation.

1. Introduction

1.1 Background and structure of the paper

This strategic paper is part of the Danube Habitat Corridor campaign which has been initiated by the members of DANUBEPARKS – Network of Protected Areas in order to counteract habitat fragmentation of the Danube River. Funded by the European Union within an Interreg project the campaign aims to restore and maintain the Danube-wide connectivity of all habitat elements.

Dry habitats pertain to any natural river system and are mostly hotspots of biodiversity. Therefore, the DANUBEPARKS Network decided to highlight the importance of dry habitats and dedicate a whole work package – work package 5 (WP5) – to the dry habitats of the Danube.

This strategic paper is an important pillar of WP5 and seeks to contribute to a better understanding of the so far hardly considered dry habitats of the Danube and to provide information on directly applicable maintenance measures.

The issue of dry habitats will be dealt with by focusing on any habitat which is dominated by species, both flora and fauna, which prefer dry habitat conditions (xerophilic species). Additionally, semi-dry habitats which are occupied by species tolerating a wide amplitude of habitat conditions, ranking from dry to fresh and sometimes wet (mesophilic-xerophilic species), are considered as important puzzle piece for the dry habitat corridor.

Most of these dry and semi-dry areas

- are nutrient-poor
- are open or semi-open
- are extensively or not managed
- are directly or indirectly influenced of or evolved by the dynamics of the Danube
- have a shallow topsoil layer
- provide relatively little water available for plants and animals

However, even if most dry and semi-dry habitats are open or semi-open, there are also forest habitats dominated or occupied by xerophilic or mesophilic-xerophilic species. These forest habitats are an important part of the dry habitat corridor and therefore they are considered in this strategic paper as well. Other open habitats which are less dry but potentially species-rich were not taken into account. But for further development of dry habitats and measures to create a dry habitat network, these sites will play an important transition role in future as well.

The following chapters provide information on existing dry habitats, on the interaction between the Danube and dry habitats as well as on threats to these habitats. One of the most important objectives of WP5 is the search for and illustration of the distribution of the dry habitats of the Danube via GIS analyses. Methods and results of these analyses will be briefly described in the present paper in addition to the maps produced.

Moreover, as part of this work package, a survey among the 16 members of the DANUBEPARKS – Network of Protected Areas was conducted before the 1st workshop in Kopački rit, in which the members were asked about different topics regarding dry habitats in their own protected area. The most important results of this survey will be mentioned and discussed in this paper. The members of the network contributed furthermore also to the creation of a fact sheet document consisting of best practice maintenance measures that they conducted in their respective dry habitats. This document, which can be found in the Annex I, represents a valuable addition to the strategic paper because it contains practical information and recommendations of concrete measures based on the experience of the members of the network.

Finally, this strategic paper tries to give an outlook into the future by identifying opportunities and remaining obstacles for taking the next steps to form a solid network of dry habitats.

1.2 The importance of the Danube as a migration corridor for dry habitats

The Danube is one of the most international rivers in the world. Its basin covers more than 800.000 km² - which is about 10% of the area of the whole continental Europe – and extends into 19 different countries (ICPDR, 2015). Due to this fact, the Danube has always been a very significant aquatic and terrestrial distribution axis for species: Its valley connects lot of different biogeographic regions and therefore poses an important migration corridor between these different landscape units.

The unique role of the Danube regarding species migration was already evident after the last ice age when species, displaced by cold, could re-colonize their original areas coming from their southeastern refugia along the river (Litzelmann, E., Walter & Sranka, 1970; Lang, 2004). This post-glacial re-colonization route along the Danube is for example assumed for dry habitat species like the steppe plant *Scorzonera purpurea* (Meindl et al., 2016), the dry grassland species *Sedum album* (Listl et al., 2017) or the steppe toad *Bufo viridis* (Engelmann et al., 1985). It is furthermore a still ongoing process and not finished yet.

Considering anthropogenic pressures and the imminent effects of Climate Change, restoration of the ecological connectivity of the Danube dry habitats will be a key factor to preserve dry habitat species. By sustaining and re-connecting dry habitats along the stream species migration and thus, gene flow of populations can be promoted and consequently the species' capacity for adaptation to environmental change maintained.

2. Danube dry habitats

The following passages will provide some basic knowledge of dry habitats in general and of the Danube dry habitats in particular.

2.1 Site conditions for dry habitats

The definition of dry habitats in this paper is derived from the following parameters which are, generally speaking, decisive for the development of any biotope:

- Climate and exposure
- Substrate
- Land use
- Erosion, sedimentation, and natural disturbances

2.1.1 Climate and exposure

For dry habitats intense solar radiation and heat are key factors. Consequently, they develop predominantly in open or semi-open locations exposed to the sun. Depending on the annual hours of sunshine, temperature variations, and precipitation, different plant communities thrive. Primarily, dry habitats can be found on southerly exposed, open slopes where a relatively extreme microclimate prevails that strongly deviates from the surrounding areas. Temperature, humidity and wind speed fluctuate with higher amplitude both throughout the day and seasonally.

2.1.2 Substrate

Another important parameter of the development of dry habitats is the prevailing substrate. The potential natural vegetation depends, in the first place, on thickness, nutrient content, water storage capacity, acid-base relation and heavy metal content of the substrate. These parameters are derived from bedrock and from topsoil. Most dry habitats occur on nutrient-poor soil with shallow topsoil layer.

2.1.3 Land use

Dry habitats can be either primary or secondary biotopes. Primary dry habitats thrive on areas either too dry and/or too poor in nutrients to allow the development of forests. They can also be found in clearings within forests, where the substrate does not allow the establishment of trees. Secondary dry habitat types are created by human interference. Therefore, they depend on continuous management mostly through periodic mowing or grazing. This fact is also supported by the survey feedback of our DANUBEPARKS members: Maintenance measures like mowing, grazing or the mechanical removal of bushes are applied by the majority of the members in the dry habitats of their respective protected areas.

2.1.4 Erosion, sedimentation, and natural disturbances

Within the area of influence of running waters secondary biotopes can originate from river dynamics such as sedimentation and erosion.

Sedimentation refers to the natural processes of rivers transporting naturally occurring material. Sediments consist predominantly of rock in varying grain size altering from boulder to very fine sand and mud. Such gravel deposits for instance can be built up where dry habitats like *Brenne* or *Heißblände* can evolve. These habitats are subject to permanent alteration by river dynamics.

The Danube River causes lateral erosion and sedimentation, resulting in slopes of different grain size distribution and exposure.

Natural disturbances such as storm, fire, pests or parasites can open formerly forested areas where, depending on the resulting site conditions, species communities of dry habitat may evolve.

2.2 Primary and secondary dry habitats

Primary dry habitats can either develop as a consequence of the continental climate or occur on sites where the soil forms just shallow layers on rock, gravel, sand and loess and the microclimate is dry. Habitats which strongly depend on local soil conditions are edaphic characterized biotopes. Often natural site conditions change on small scale. Therefore, edaphic primary dry habitats frequently occur in mosaic structures where for example dry grassland alternates with dry shrubs and coppice low forest.

Secondary dry habitats evolve in the first place from deforestation, mowing and grazing on sites where wood is the natural target state of succession. The respective sites are cleared and kept open by human interventions and, depending on the prerequisites of the respective biogeographic region, different types of grassland develop. As soon as the activities that impede succession cease, grasslands change stepwise into wood.

Secondary dry habitats are biotopes which are rather homogeneously structured in contrast to primary dry habitats. In general, secondary dry habitats occur in far bigger spatial extent than naturally occurring primary dry habitats, whereas their species composition is quite similar to primary dry habitats. Therefore, these secondary habitats need to be included into conservation strategies and measures for maintaining the high natural value dry habitats bear for biodiversity and species protection.

2.3 Description of dry habitats in the Danube corridor

The Danube runs through five biogeographic regions (according to the order of passage):

- Continental
- Alpine
- Pannonian
- Steppic
- Black Sea

These regions provide different ecological conditions and therefore host characteristic flora and fauna. Since the last ice age they are connected in varying extensions along the Danube corridor, which made it possible to react to changes in climate.

There are no comprehensive mappings of dry habitats along the course of the Danube; however, occasionally individual mappings exist. For example, in the context of the EU-project DANUBEPARKSCONNECTED, studies about xerophilic meadows and orchid species have been conducted in the protected area of the Danube delta. The results can be found in the report "Pastures specific for dry habitats and orchids flagship species from D.D.B.R." (Covaliov et al. 2018)

According to the survey among the DANUBEPARKS member organizations, the occurrence of (semi-)dry habitats in their respective protected areas is rare. Asked which specific dry habitat types can be found within their protected area or close by, almost all members mentioned different forms of grasslands (oligotrophic, calcareous or silicate, dry grassland hills). Other (semi-)dry habitat types had more regional covering: Heisslands and steep slopes were mentioned preferably by members belonging to the upper stream regions of the Danube, while sand dunes had most mentions by members in the middle and lower stream regions. Similar to grasslands, rockfields had mentions from members from all regions along the river, although not as much as grasslands.

Against this background, the next sections will give an overview of the most important types of dry and semi-dry biotopes that can be found within the potential dry habitat corridor detected by the GIS analyses. Predictions to real occurrences and frequencies of these habitats cannot be given due to lack accuracy of data. This corridor focuses on the sphere of influence of current or past dynamics of the Danube but goes beyond it (see Chapter 3). Therefore, some dry habitats which are not influenced by the Danube are also included in the following characterizations.

The descriptions are oriented to the classification of habitat type of the European Habitats Directive which is the basis of the NATURA 2000 network of special areas of conservation. Similar habitats are composed in one category.

The basic source of information is the Interpretation Manual of European Union Habitats (2007) and the fact sheets of the European Red List of Habitats, worked out in the course of a project on behalf of the European Commission between 2013-2016 which assessed the status of all natural and semi-natural habitat types at European and EU28-level.

Figures below show examples for habitats of the supergroups, as far as use of the photos was permitted. Special thanks to all photographers.

2.3.1 Halophytic habitats

The habitats within this category are dominated by halophytic (salt-adapted) vegetation that can be rich in endemics. However, the particular species composition depends on the regional climate and local soil conditions and there is often a distinctive seasonal pattern of growth and zonation. Halophytic habitats are partly of natural origin and partly develop under a distinct influence of cattle grazing. Within the Danube dry habitat corridor there are two types of halophytic habitats.

On the one hand, there are Pannonic and Ponto-Sarmatic inland salt marshes, salt steppes, salt pans and shallow salt lakes. They thrive under a climate of extreme

temperatures and aridity in summer. Salt steppes and marshes are characteristic of situations where fossil salt lies close to the surface or where relict sea water is present. Due to high evaporation of ground water during summer it comes to enrichment of salt in the soil and to surface efflorescence of crystalline deposits. According to variations in salinity, slope and erosion by spring floods, the steppe vegetation builds a complex mosaic of grasslands and more halophytic herb communities, rich in endemic species and plant communities.

On the other hand, salt marshes occur in the Danube Delta and on the marine sandbanks within the Razelm-Sinoe lagoon complex behind sand dunes or around saline ponds and lakes. These marshes count as Mediterranean salt meadows but their vegetation resembles more continental inland salt marshes.

Respective habitats occurring within the Danube corridor:

Code Habitat Type

1410 Mediterranean salt meadows (*Juncetalia maritimi*)

1530 Pannonic salt steppes and salt marshes



Figure 1: Pannonic salt steppe (1530) with *Suaeda pannonica*. Böddi-szék, Dunatetőlen, Hungary. Photo: Daniel Dítě

2.3.2 Inland dunes, old and decalcified

Here in this category are included usually sparse grasslands on sand drifts of inland dunes and other open landscapes, mainly in the north central European lowlands. The surface of these grasslands is nutrient-poor, highly acidic and prone to wind erosion and hot droughty summers.

The dune systems, particularly the large ones, harbor a unique ensemble of interacting communities and many specialized and localized organisms. Vegetation is dominated by heaths with *Calluna* and *Genista*. As soon as the sand of Inland Dunes and Sand Fields is not in motion any longer, plant communities with moss, lichen and finally dwarf shrubs (e.g. *Calluna*) establish within a few years. The last step of succession is pine and oak forest.

Respective habitats occurring within the Danube corridor:

Code Habitat Type

- 2130 Fixed coastal dunes with herbaceous vegetation (grey dunes)
- 2160 Dunes with *Hippophae rhamnoides*
- 2310 Dry sand heaths with *Calluna* and *Genista*
- 2330 Inland dunes with open *Corynephorus* and *Agrostis* grasslands
- 2340 Pannonic inland dunes



Figure 2: Pannonic sand steppe (6260) in Kiskunság National Park, Hungary. Photo: Daniel Dítě

2.3.3 Alpine rivers and their vegetation

This category sums up two habitat types which describe Alpine Rivers and the either herbaceous or ligneous vegetation that grows on stream gravel. Both habitat types are influenced by an alpine, summer-high, flow regime. Their sediment consists almost exclusively of rocks and boulders and vascular plant are often confined to situations where the current is slower, with temporary accumulation of finer sediments. With regard to the vegetation there are either open assemblages of herbaceous pioneering plants, rich in alpine species, or thickets of woods, especially with *Salix eleagnos*.

Respective habitats occurring within the Danube corridor:

Code Habitat Type

- 3220 Alpine rivers and the herbaceous vegetation along their banks
- 3240 Alpine rivers and their ligneous vegetation with *Salix eleagnos*

2.3.4 Heath and scrub

This category of habitats aggregates mesophilic or xerophilic heaths. Most shrub heaths follow from intensive agricultural land use. They are not intentionally created but are rather unwanted “landscape degradation”. There is high amplitude of possible environmental conditions where heaths can thrive. Shrub heaths as part of vegetation complexes occur in any landscapes with acid rock. On sandy soil the dominating species is *Calluna vulgaris*, on raw humus *Vaccinium myrtillus* prevails. The development of shrub heaths takes many decades, some heaths developed during centuries of cultivation through grazing, tilt cutting and fire. For this reason, destructed heaths are almost not recoverable. However, different species of broom are an exception as they rapidly colonize as pioneers and become dominant within ten to fifteen years.

Respective habitats occurring within the Danube corridor:

Code Habitat Type

4030	European dry heaths
40A0	Subcontinental peri-Pannonic scrub
40C0	Ponto-Sarmatic deciduous thickets
5130	<i>Juniperus communis</i> formations on heaths or calcareous grasslands



Figure 3: *Juniperus communis* on calcareous grasslands formations (5130) at Hundsheimer Berge, Austria. Photo: Manzano

2.3.5 Natural and semi-natural grasslands

The category of natural grasslands contains, generally speaking, dry open to relatively closed thermophilic grasslands and pioneer communities which thrive on mostly shallow, skeletal, nutrient-poor or impoverished soils that are mainly more or less calcareous or siliceous.

Furthermore, location and exposure can be crucial preconditions for the development of natural and semi-natural grasslands. Rupicolous pannonic grasslands for example thrive on steep, dry xeric slopes in medium altitude mountains. Grasslands on river gravels which are only covered with small layers of fine material (e.g. *Brenne* or

Heißlände) as well as on natural rock outcrops which are rich in heavy metal pertain to this category, too.

Natural and semi-natural grasslands can have different causes of origin. Some of them are essentially dependent on environmental stress like soil erosion, others originate from human impact such as clearance, low-intensity land-use, grazing or trampling.

Across the wide range of natural grasslands there is considerable variety of the prevailing dominants and companions of vegetation as well as the plant cover and the expansion of the habitat type itself. Some are mainly open, others moderately open or closed. Most habitats have rich annual and cryptogam floras and are dominated by low-grown perennial succulents, (rosette) herbs, geophytes, small tussock and narrow-leaved grasses. Some grasslands are characterized by highly specialized flora, with subspecies and ecotypes adapted to heavy metals. Mostly, plant communities are rich in species; however, they are subject to considerable inter-annual dynamics in total abundance and species composition, which depends on specific climatic conditions of each year.

Respective habitats occurring within the Danube corridor:

Code Habitat Type

- 6110 Rupicolous calcareous or basophilic grasslands of the *Alyso-Sedion albi*
- 6120 Xeric sand calcareous grasslands
- 6130 Calaminarian grasslands of the *Violetalia calaminariae*
- 6190 Rupicolous pannonic grasslands (*Stipo-Festucetalia pallentis*)



Figure 4: Heißlände surrounded by a mixed riparian woodland (91F0) at Lobau, near Vienna, Austria. Photo: Baumgartner



Figure 5: Rupicolous pannonic grasslands (6190) with *Stipa*, Austria.
Photo: Wiesbauer

2.3.6 Semi-natural dry grasslands and scrubland facies

This category brings together habitat types of dry to semi-dry primary and secondary grasslands. The soils of the respective habitats are usually nutrient-poor and vegetation is low-growing. Species with traits to sustain aridity are predominant. Most sites are species-rich and depend on the traditional land-use of extensive grazing by sheep or cattle.

The following habitat types rank among the category of semi-natural dry grasslands:

On the one hand, there are calcareous grasslands of Festuco-Brometea. This habitat type is either formed by steppic or subcontinental grasslands or by grasslands of more oceanic and sub-Mediterranean regions. The latter can be of primary (Xerobromion grasslands) or secondary (Mesobromion grasslands with *Bromus erectus*) origin. The secondary semi-natural grasslands are characterized by a rich orchid flora.

On the other hand, there is lowland to sub montane grassland which is generally dominated by *Nardus stricta* growing on acidic soils on siliceous substrates. Usually, the low vegetation is grazed by sheep and/or cattle, and burnings occur from time to time. Species composition is closely related to the intensity and type of removal of the above-ground biomass.

Additionally, a variety of steppic grasslands and steppes pertains to the semi-natural grasslands. The respective habitats are dominated by xerothermic communities with tussock-grasses, half shrub and perennials. Soils are nutrient-poor and shallow and characterized of either rocky substrate, clay-sandy sedimentation layers enriched with gravel, loess deposits, mobile or fixed sand. These soil conditions and the crucial high solar radiation often occur on slopes, alluvial sands, subfossil dune systems, plainly but elevated terrains or loess ridges formed by fluvial erosion and accumulation that at best are southern exposed.

Respective habitats occurring within the Danube corridor:

Code Habitat Type

6210	Semi-natural dry grasslands and scrubland facies on calcareous substrates (<i>Festuco-Brometalia</i>)
6230	Species-rich <i>Nardus</i> grasslands, on silicious substrates in mountain areas (and submountain areas in Continental Europe)
6240	Sub-Pannonic steppic grasslands
6250	Pannonic loess steppic grasslands
6260	Pannonic sand steppes
62C0	Ponto-Sarmatic steppes



Figure 6: Semi natural dry grassland (6210) in the East of Munich, Bavaria, Germany. Photo: PSU - Ch. Förster

2.3.7 Mesophile grassland

The grasslands in question are either lowland or mountain and sub-alpine hay meadows. Both are often species-rich and can host distinctive rare and endangered plants. The meadows are traditionally extensively managed and not cut before the grasses flower, then mown only once or twice per year for hay rather than silage. Sometimes, the meadows are lightly grazed in the aftermath. They are vulnerable to any kind of substantial change in farming practice, particularly fertilizing with slurry or chemicals. The topsoil needs to be thick, well-drained and lightly to moderately get fertilized.

Lowland hay meadows are dominated by productive grasses (e.g. *Arrhenatherum elatius*, *Briza media*, *Dactylis glomerata*) herbs, particular rosette plants with taller flowering stems and clonal geophytes. Mountain hay meadows share many species of medium-tall grasses and herbs with mown grasslands of lower altitudes but their distinctive character is provided by special plants such as *Geranium sylvaticum*, *Cirsium helenioides*, *Trollius europaeus*, *Alchemilla vulgaris* agg.

Respective habitats occurring within the Danube corridor:

Code Habitat Type

6510 Lowland hay meadows (*Alopecurus pratensis*, *Sanguisorba officinalis*)

6520 Mountain hay meadows

2.3.8 Rocky habitats and caves

The Dry Habitat Corridor of the Danube hosts several habitat types which belong to the category of rocky habitats and caves. There are scree and moraine consisting of either calcareous and calcshist or siliceous rock which is mostly coarse and un-stabilized. Often, the scree is located on the slopes of mountains, hills or gorges and the rock is mixed with fine soil. Both scree of montane to alpine levels and scree of hill levels and the upland occur in the corridor of analysis. Consequently, the climate conditions show a wide range from cold to often dry and warm climates.

Generally, siliceous have lower species richness than calcareous scree but ferns can be diverse and luxuriant. The vegetation of the respective habitat types can be completely lacking, but in other sites, on rock surfaces and fine soil accumulated in crevices, the vascular contingent can be diverse and lush. Depending on the respective habitat type, vegetation is represented by forb- or fern-dominated, sometimes by moss- or lichen-dominated, often species-poor communities.

Respective habitats occurring within the Danube corridor:

Code Habitat Type

8120 Calcareous and calcshist scree of the montane to alpine levels
(*Thlaspietea rotundifolii*)

8150 Medio-European upland siliceous scree

8160 Medio-European calcareous scree of hill and montane levels

2.3.9 Rocky slopes with chasmophytic vegetation

This category sums up dry habitats which are categorized on the one hand by rocky substrate and on the other hand by often extreme habitat conditions like strong solar radiation, low water content or strong winds. The vegetation of these habitat types needs to be well adapted to these extreme conditions which are caused by the special exposure of slopes, rock faces or crevices. In this category there are both calcareous and siliceous rocky habitats. Generally, the soil is very poorly developed, but in crevices a small amount of fine soil may accumulate. Altogether, the vegetation is mostly open, low growing and characterized by mosses, lichens, ferns, microalgae and herbs. The plants often build tufted, matted, dwarf- and cushion-formed structures. Due to geographical isolation and variety in site conditions numerous relict, endemic, rare and protected species can be found on many of these cliffs. Consequently, the variation in species composition is high, whereby siliceous habitats are generally less species-rich than calcareous ones.

Respective habitats occurring within the Danube corridor:

Code Habitat Type

- 8210 Calcareous rocky slopes with chasmophytic vegetation
- 8220 Siliceous rocky slopes with chasmophytic vegetation
- 8230 Siliceous rock with pioneer vegetation of the *Sedo-Scleranthion* or of the *Sedo albi-Veronicion dillenii*

2.3.10 Forests of temperate Europe

Most of the habitats of this category meet the initially defined requirements for dry habitats only partly as they are at best semi-open. Nevertheless, they are important elements of the dry habitat corridor because they fulfill crucial connecting and bridging functions within the Danube Habitat Corridor. For this reason the occurring dry forest habitats will briefly be described.

Many of the dry forests in the Danube corridor are scarce biotopes with low distribution and highly specialized thermophilic vegetation. The prevailing soils are mostly superficial, nutrient-poor and consist of calcareous but also of siliceous substrates. The site conditions are often characterized by special locations like steep or abrupt rocky slopes, coarse scree or colluviums of slopes. Because of these partly extreme site conditions, the woods can be fragmentary and low-growing, sometimes only shrubby like in the case of Pannonic inland sand dune thicket. Depending on the respective habitat type, the dominating trees are beeches, oaks, limes or hornbeams. Additionally, in the Pannonic, Sarmatic, Dobrogean and Dacian forests juniper, poplar and pine occur.

In most habitats in question the undergrowth hosts abundant herb and shrub vegetation, characterized by sedges, grasses and sometimes orchids. In the Pannonian and steppic woods, xerothermic species from dry grassland or forest fringes, continental steppic vegetation elements and geophytes can occur, too.

Respective habitats occurring within the Danube corridor:

Code Habitat Type

- 9150 Medio-European limestone beech forests of the *Cephalanthero-Fagion*
- 9170 *Galio-Carpinetum* oak-hornbeam forests
- 9180 *Tilio-Acerion* forests of slopes, scree and ravines
- 91AA Eastern white oak woods
- 91H0 Pannonian woods with *Quercus pubescens*
- 91I0 Euro-Siberian steppic woods with *Quercus spp.*
- 91L0 Illyrian oak-hornbeam forests (*Erythronio-Carpinion*)
- 91M0 Pannonian-Balkan turkey oak –sessile oak forests
- 91N0 Pannonic inland sand dune thicket (*Junipero-Populetum albae*)
- 91U0 Sarmatic steppe pine forest

- 91X0 Dobrogean beech forests
- 91Y0 Dacian oak & hornbeam forests

2.3.11 Mediterranean deciduous forests

To the category of Mediterranean deciduous forests belong some dry habitat types within the sphere of influence of the Danube. These forests are irregularly flooded, periodically-inundated riparian forests thriving especially on alluvial or gravelly deposits in river valley and along streamside. The habitats are characterized by a species-poor tree canopy with their respectively dominating typically fast-growing tree species: willow, poplar, oriental plane, tamarisk. The understory is often dense with lianes, ferns, lichen, moss and a sometimes rich herb layer. The habitats mainly include annual, pioneer, well adapted species to shoreline dynamics.

Respective habitats occurring within the Danube corridor:

Code	Habitat Type
-------------	---------------------

92A0	<i>Salix alba</i> and <i>Populus alba</i> galleries
------	---

92D0	Southern riparian galleries and thickets (<i>Nerio-Tamaricetea</i> and <i>Securinegion tinctoriae</i>)
------	--



Figure 7: Riparian gallery forest (92A0) with *Salix alba* and *Populus alba* at Kopački rit nature park, Croatia. Photo: PSU - K. Huber

2.4 Fauna of dry habitats

In Central Europe, primary dry habitats occur mostly in small scattered areas. The conditions offered by primary and secondary dry habitats – particularly their mosaic of gap vegetation and vegetation-free areas, different microbiotopes, a high supply of sunlight and heat as well as a big variety of different host plants – are decisive for the occurrence of many reptiles, birds, small mammals and insects. Most of the species belonging to the spectrum of dry habitats are xerophilic and therefore highly specialized on these conditions.

In Europe, dry habitats host especially high numbers of insect species, among them plenty of rare and endangered grasshoppers, beetles, ants, bugs, cicada, butterflies and bees. Therefore, oligotrophic grassland communities are the most important bio-coenosis for insect fauna.

Furthermore, dry and open biotopes are significant habitats for most European reptiles. Lizards, especially sand lizards, can build mass populations and form the nutritional basis for smooth snakes. Ground-nesting birds of open landscapes depend on the existence of shrub heaths or meadows which are only mown once a year.

A detailed description or analysis of the fauna of dry habitats was not subject of this first step of the Danube dry habitat strategy. Therefore, just brief examples for the fauna of dry habitats are mentioned here. In future projects, the faunistic part should be elaborated in more detail and with links to the occurring habitats. The focus could be put on species of Annex II (and IV / V) of the Habitats Directive. There, examples of species, which underline the role of the Danube corridor and the Danube itself for the development and survival of these species, could be given as well.

3. GIS analyses of Danube dry habitat corridor

The dry habitat analyses were carried out with tools and methods of a Geographic Information System (GIS) and had the following objectives:

- gapless and consistent mapping of the dry habitats of the Danube and its sphere of influence based on a uniform database
- detailed mapping of the dry habitats within the borders of each DANUBE-PARKS conservation area based on the respectively available database

In brief and seeking to give easily comprehensible explanations, the following sections describe the most important steps that were undertaken, the data that were used, and the methods that were developed.

3.1 Definition of the Danube corridor

The first idea was to analyze only the area actually or potentially influenced by the Danube. Consequently, predominantly the riparian zones of the Danube would have been in the focus of interest. The next idea was to use elevation models in order to consider the long-term influence, the Danube has been exerting for thousands of years.

Both ideas would have generated narrow corridors derived from natural prerequisites. These corridors illustrate the actual sphere of influence of the river Danube but ignore social and political prerequisites. However, these prerequisites determine the scope of action of initiatives like the DANUBEPARKS Network in seeking to develop biotope networks.

For this reason, the GIS analysis used generalized information about the influence of the Danube through implementing a buffer of 10 km on both sides of the river. Additionally, any DANUBEPARKS conservation area as well as any Natura2000 (N2K) protected area touched by the corridor is part of the analysis because of the fact that the available N2K data do only provide information on the coverage but not on the delimitation of the 231 habitat types of Annex I. Nevertheless, the N2K areas are not completely illustrated in the overview maps but only in the detailed maps as far as they fit in the sheet lines.

3.2 Data basis

Data based on actual mappings of dry habitats were barely available, making it impossible to conduct a consistent analysis along the whole Danube based on mappings. That is why the following three main data sources were chosen as the basis for the GIS analysis:

- CORINE Land Cover / Land Use (CLC)
- Copernicus Riparian Zones (RPZ)
- Natura2000 Protected Areas (N2K)

These data sets were used because they are the most current freely available data in best resolution. The CLC and RPZ data cover all countries of interest. The N2K dataset lacks Serbia, Moldova and Ukraine as these countries are not members of the EU. However, in comparison to the data based on actual mappings of dry habitats, these freely available data are more coarse and inaccurate.

3.2.1 CORINE Land Cover / Land Use (CLC)

The CLC dataset covers 39 European countries and uses high resolution satellite imagery in order to gain information about the land cover and land use. This spatial information is classified in 44 classes. The CLC data use a Minimum Mapping Unit (MMU) of 25 ha. The minimum width of linear elements is 100 m. The data used in the GIS analyses are from the year 2018.

3.2.2 Copernicus Riparian Zones (RPZ)

The Copernicus Riparian Zones dataset has the same coverage of countries as the CLC data and is based on high resolution satellite imagery, too. It provides information about the land use and land cover within a buffer zone along large and medium-sized European rivers. The main factor for defining this buffer zone is the potential riparian zone. In general, riparian zones are transitional areas occurring between land and freshwater ecosystems. They are “characterized by distinctive hydrology, soil and biotic conditions and strongly influenced by the stream water” (EEA 2017). The potential riparian zone is defined as the area determined by natural potential whereas current land use is ignored. The dataset uses a MMU of 500 m² and classifies its information about land use in 80 classes. For the GIS analysis data from the years 2013 and 2014 were available.

3.2.3 Natura2000 Protected Areas (N2K)

The N2K data strongly differ from the CLC and RPZ datasets in view of various aspects. For example, data is not gained by one institution via satellite imagery but is individually submitted by each member state of EU and compiled by the European Environmental Agency (EEA). Consequently, there are discrepancies in topicality and quality, especially in precision. The dataset gives information about the borders of special areas of conservation in all 28 signatories of EU Habitats and Birds Directive. Additionally, there is knowledge of the conservation status and coverage of the 231 habitat types within the respective Special Area of Conservation (SAC) but no information of their particular delimitation and location. Predominantly, this intelligence of delimitation and location exists but is reserved to each EU member state and not freely available.

3.2.4 European Nature Information System (EUNIS)

The EEA gathers in its information system EUNIS available European data from several databases and organizations and provides three interlinked modules on sites, species, and habitat types. According to the EEA (EEA 2019), EUNIS includes the following information:

- data on species, habitat types and designated sites compiled in the framework of Natura2000 (EU Habitats and Birds Directives)
- EUNIS habitat classification
- information on species, habitat types and designated sites mentioned in relevant international conventions and in the IUCN Red Lists
- specific data collected in the framework of the EEA's reporting activities, which also constitute a core set of data to be updated periodically, e.g. Eionet

priority dataflow: Nationally designated areas for the Common Database on Designated Areas (CDDA)

With regard to this strategy, the use of EUNIS data on habitat types was considered. According to the EEA homepage and to the answer to an inquiry that PSU sent to the EEA Forum the EUNIS information about habitat types contains the following data sources:

- N2K data – delimitations of the European network of protected sites, without delimitation of habitat types (the distribution of habitat types is provided by the member states)
- Common Database on Designated Areas (CDDA) – delimitations of nationally designated protected areas and their design type (e.g. nature reserve, national park, biosphere reserve), but no information on habitat types

It becomes obvious that EUNIS does not include information on the exact delimitation of habitat types either. Thus, the integration of EUNIS data does not provide any fundamental knowledge gain for the purpose of this strategic paper. Later this year, the EEA announced to publish a number of modelled datasets of suitable areas for the EUNIS habitats which are currently under revision. These datasets will include forest, heathland, and grassland sections.

3.3 Habitat classification and selection

Since the CLC dataset is the only available dataset that provides complete intelligence of the land use of the whole Danube corridor, the CLC data were determined to be the starting point of the analysis. In order to gain knowledge about the spatial allocation of dry habitats in the Danube corridor the differently categorized classes of the three datasets needed to be harmonized and categorized in a consistent system of categories. Consequently, the 44 CLC land use and land cover classes were distinguished in three categories:

- **Core habitat** (dry habitat core = DHC): dominated by species preferring dry habitats (xerophilic species)
- **Semi-dry to dry habitat** (semi-dry habitat = SDH): occupied by species tolerating a wide amplitude of habitat conditions, ranking from dry to fresh and sometimes wet (mesophilic-xerophilic species)
- **Search area** (dry habitat search = DHS): contains few habitats occupied by species preferring dry habitats

The following table shows, inter alia, which land use classes occur in the Danube corridor at all. The occurring land use classes were categorized either as DHC, SDH or DHS. Those classes that belong to neither category are not relevant for the further analyses just like those elements of the DHS where there is no additional proof in the RPZ or the N2K data that there is a relevant dry habitat. If neither the RPZ nor the N2K data assured that the DHS is actually a dry habitat the respective areas were dismissed.

Table 1: Land use classes in CLC data and categorization

CLC CODE	LABEL	Occurrence in Danube Corridor	Core Habitat (DHC)	semi-dry to dry Habitat (SDH)	Search area (DHS)
Artificial surface					
111	Continuous urban fabric	x			
112	Discontinuous urban fabric	x			
121	Industrial or commercial units	x			
122	Road and rail networks and associated land	x			
123	Port areas	x			
124	Airports	x			
131	Mineral extraction sites	x			x
132	Dump sites	x			
133	Construction sites	x			
141	Green urban areas	x			
142	Sport and leisure facilities	x			
Agricultural areas					
211	Non-irrigated arable land	x			
212	Permanently irrigated land				
213	Rice fields				
221	Vineyards	x		x	
222	Fruit trees and berry plantations	x			
223	Olive groves				
231	Pastures	x		x	
241	Annual crops associated with permanent crops				

CLC CODE	LABEL	Occurrence in Danube Corridor	Core Habitat (DHC)	semi-dry to dry Habitat (SDH)	Search area (DHS)
242	Complex cultivation patterns	x			
243	Land principally occupied by agriculture, with significant areas of natural vegetation	x			x
244	Agro-forestry areas				
Orchards					
251	Orchards				
Forest and semi natural areas					
311	Broad-leaved forest	x			x
312	Coniferous forest	x			x
313	Mixed forest	x			x
321	Natural grasslands	x	x		
322	Moors and heathland				
323	Sclerophyllous vegetation				
324	Transitional woodland-shrub	x		x	
331	Beaches, dunes, sands	x	x		
332	Bare rocks	x	x		
333	Sparsely vegetated areas	x	x		
334	Burnt areas				
Wetlands					
411	Inland marshes	x		x	
412	Peatbogs	x			
Water Bodies					
421	Salt marshes				

CLC CODE	LABEL	Occurrence in Danube Corridor	Core Habitat (DHC)	semi-dry to dry Habitat (SDH)	Search area (DHS)
422	Salines				
423	Intertidal flats				
511	Water courses	x			
512	Water bodies	x			
521	Coastal lagoons	x			
522	Estuaries	x			
523	Sea and ocean				

Building upon the CLC habitat selection, the RPZ and N2K data were added to enhance the spatial information about the land use in the Danube corridor. Improvements in knowledge were to be gained only for those areas which are covered by at least one or both datasets. The RPZ and N2K data were differentiated in the classes DHC and SDH according to the following tables whereby only the relevant land use classes and habitat types that occur in the Danube corridor are listed.

Table 2: Relevant land use classes in RPZ data

RPZ Code	LABEL	Core Habitat (DHC)	semi-dry to dry Habitat (SDH)
1 Urban			
1321	Land without current use		x
2 Croplands			
2211	Vineyards		x
3 Woodland and Forest			
3111	Riparian and fluvial broadleaved forest		x
3131	Other natural & semi-natural coniferous forest		x
3211	Riparian and fluvial coniferous forest		x
3311	Riparian and fluvial mixed forest		x

RPZ Code	LABEL	Core Habitat (DHC)	semi-dry to dry Habitat (SDH)
3331	Other natural & semi-natural mixed forest		x
3411	Transitional woodland and scrub	x	
4 Grassland			
4111	Managed grasslands with trees and scrubs (T.C.D. $\geq 30\%$)		x
4112	Managed grasslands without trees and scrubs (T.C.D. $<30\%$)		x
4211	Dry grassland with trees (T.C.D. $\geq 0\%$)	x	
4212	Mesic grasslands with trees (T.C.D. $\geq 30\%$)		x
4221	Dry grasslands without trees and scrubs (T.C.D. $<30\%$)	x	
5 Heathland and Scrub			
No respective land use class occurs in the Danube corridor.			
6 Sparsely vegetated Land			
6111	Sparsely vegetated areas	x	
6211	Beaches	x	
6212	Dunes	x	
6213	River banks	x	
6221	Bare rocks and rocks debris	x	
7 Wetland			
7121	Inland saline marshes	x	
8 Lagoons, coastal Wetlands and Estuaries			
No respective land use class occurs in the Danube corridor.			
9 Rivers and Lakes			
Contains no relevant Habitat.			

RPZ Code	LABEL	Core Habitat (DHC)	semi-dry to dry Habitat (SDH)
10 (Marine) Other			
Contains no relevant Habitat.			

Table 3: Relevant habitat types in N2K data

N2K Code	LABEL	Core Habitat (DHC)	semi-dry to dry Habitat (SDH)
1 Coastal and halophytic habitats			
14 Mediterranean and thermo-Atlantic saltmarshes and salt meadows			
1410	Mediterranean salt meadows (<i>Juncetalia maritimi</i>)	x	
15 Salt and gypsum inland steppes			
1530	Pannonic salt steppes and salt marshes	x	
2 Coastal sand dunes and inland dunes -			
21 Sea dunes of the Atlantic, North Sea and Baltic coasts			
2130	*Fixed coastal dunes with herbaceous vegetation (grey dunes)	x	
2160	Dunes with <i>Hippophae rhamnoides</i>	x	
23 Inland dunes, old and decalcified			
2310	Dry sand heaths with <i>Calluna</i> and <i>Genista</i>	x	
2330	Inland dunes with open <i>Corynephorus</i> and <i>Agrostis</i> grasslands	x	
2340	Pannonic inland dunes	x	
3 Freshwater habitats			
32 Running water			
3220	Alpine rivers and the herbaceous vegetation along their banks	x	
3240	Alpine rivers and their ligneous vegetation with <i>Salix eleagnos</i>	x	

N2K Code	LABEL	Core Habitat (DHC)	semi-dry to dry Habitat (SDH)
4 Temperate heath and scrub			
40 Temperate heath and scrub			
4030	European dry heaths	x	
40A0	Subcontinental peri-Pannonic scrub	x	
40C0	Ponto-Sarmatic deciduous thickets	x	
5 Sclerophyllous scrub - (Matorral)			
51 Sclerophyllous scrub (Matorral)			
5130	Juniperus communis formations on heaths or calcareous grasslands	x	
6 Natural and semi-natural grassland formations			
61 Natural and semi-natural grassland formations			
6110	Rupicolous calcareous or basophilic grasslands of the <i>Alyso-Sedion albi</i>	x	
6120	Xeric sand calcareous grasslands	x	
6130	Calaminarian grasslands of the <i>Violetalia calaminariae</i>	x	
6190	Rupicolous pannonic grasslands (<i>Stipo-Festucetalia pallentis</i>)	x	
62 Semi-natural dry grasslands and scrubland facies			
6210	Semi-natural dry grasslands and scrubland facies on calcareous substrates (<i>Festuco-Brometalia</i>) (* important orchid sites)	x	
6230	Species-rich <i>Nardus</i> grasslands, on silicious substrates in mountain areas (and submountain areas in Continental Europe)	x	
6240	Sub-Pannonic steppic grasslands	x	
6260	Pannonic sand steppes	x	
62C0	Ponto-Sarmatic steppes	x	

N2K Code	LABEL	Core Habitat (DHC)	semi-dry to dry Habitat (SDH)
65 Mesophile grassland			
6510	Lowland hay meadows (<i>Alopecurus pratensis</i> , <i>Sanguisorba officinalis</i>)		x
6520	Mountain hay meadows		x
8 Rocky habitats and caves			
81 Rocky habitats and caves			
8120	Calcareous and calcshist screes (Geröllhalde) of the montane to alpine levels (<i>Thlaspietea rotundifolii</i>)	x	
8150	Medio-European upland siliceous screes	x	
8160	Medio-European calcareous scree of hill and montane levels	x	
82 Rocky slopes with chasmophytic vegetation			
8210	Calcareous rocky slopes with chasmophytic vegetation	x	
8220	Siliceous rocky slopes with chasmophytic vegetation	x	
8230	Siliceous rock with pioneer vegetation of the <i>Sedo-Scleranthion</i> or of the <i>Sedo albi-Veronicion dillenii</i>	x	
9 Forests			
91 Forests of temperate Europe			
9150	Medio-European limestone beech forests of the <i>Cephalanthero-Fagion</i>		x
9170	<i>Galio-Carpinetum</i> oak-hornbeam forests		x
9180	<i>Tilio-Acerion</i> forests of slopes, screes and ravines		x
91H0	Pannonian woods with <i>Quercus pubescens</i>	x	
91I0	Euro-Siberian steppic woods with <i>Quercus spp.</i>	x	
91L0	Illyrian oak-hornbeam forests (<i>Erythronio-Carpinion</i>)		x

N2K Code	LABEL	Core Habitat (DHC)	semi-dry to dry Habitat (SDH)
91M0	Pannonian-Balkan turkey oak-sessile oak forests	x	
91N0	Pannonic inland sand dune thicket (<i>Junipero-Populetum albae</i>)	x	
91U0	Sarmatic steppe pine forest	x	
92 Mediterranean deciduous forests			
92A0	Salix alba and Populus alba galleries		x
92D0	Southern riparian galleries and thickets (<i>Nerio-Tamaricetea</i> and <i>Securinegion tinctoriae</i>)		x

3.4 Scope of information yield

None of the three datasets CLC, RPZ, and N2K provides detailed knowledge of the vegetation cover of the habitats within the Danube corridor. Even though results of vegetation surveys feed into the datasets, guaranteed information are not available for the whole Danube corridor. Many DANUBEPARKS members could provide data gained in vegetation surveys, some surveys were even assigned and carried out as part of the same Interreg Project as this present issue. Since there is no complete coverage for the Danube corridor, the survey data were not used for the overview maps of the Danube corridor but only for the respective detailed maps which were created for each DANUBEPARKS network member.

The CLC data are available for the whole corridor. However, RPZ and N2K data do not exist for all areas in the corridor. Especially N2K data are limited to the special areas of conservation in the states of the signatories of EU Habitats and Birds Directive. The following maps visualize exemplarily the availability of data for the Danube corridor at the Danube Bend nearby Vác in Hungary. The maps show in each dataset just the relevant habitats. The N2K map shows special areas of conservation which contain relevant habitats, but these habitats do – in most cases – not take up all of the respective area.

It is possible to differentiate three classes of relevance based on the number of data sources for the single habitats in the corridor to estimate the percentage of the Danube corridor the data sources cover.

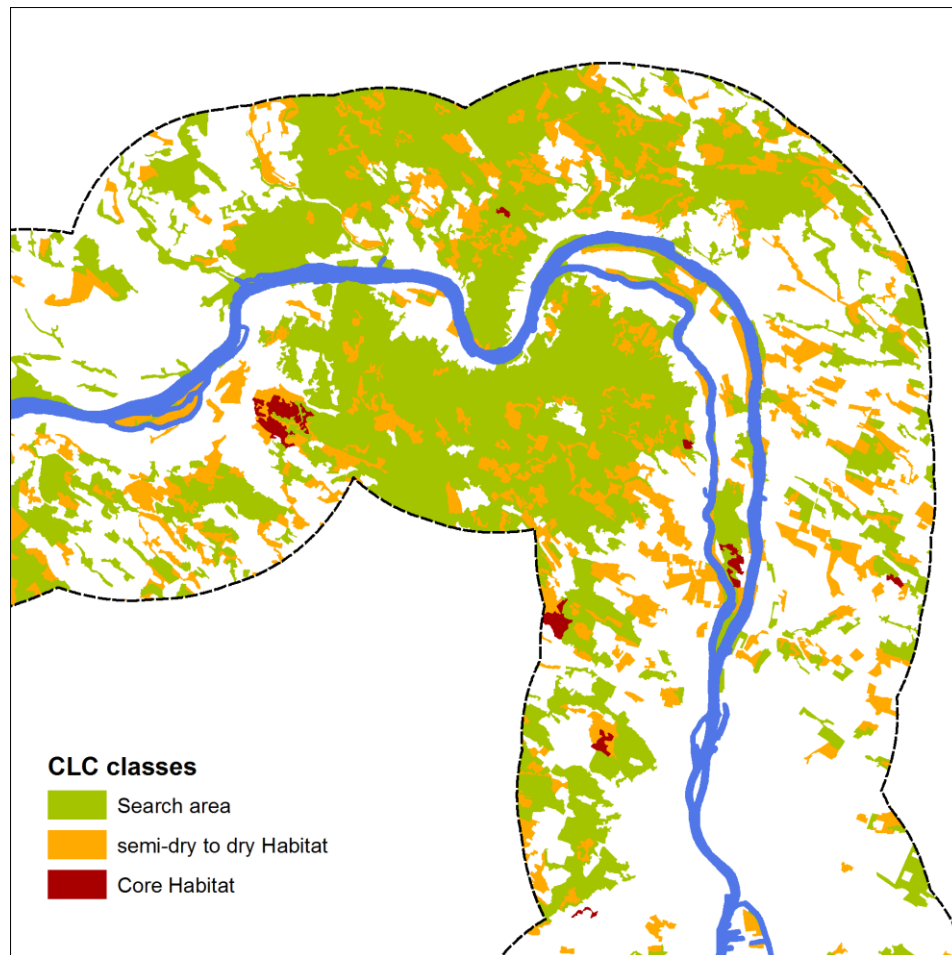


Figure 8: Information yield of CLC data

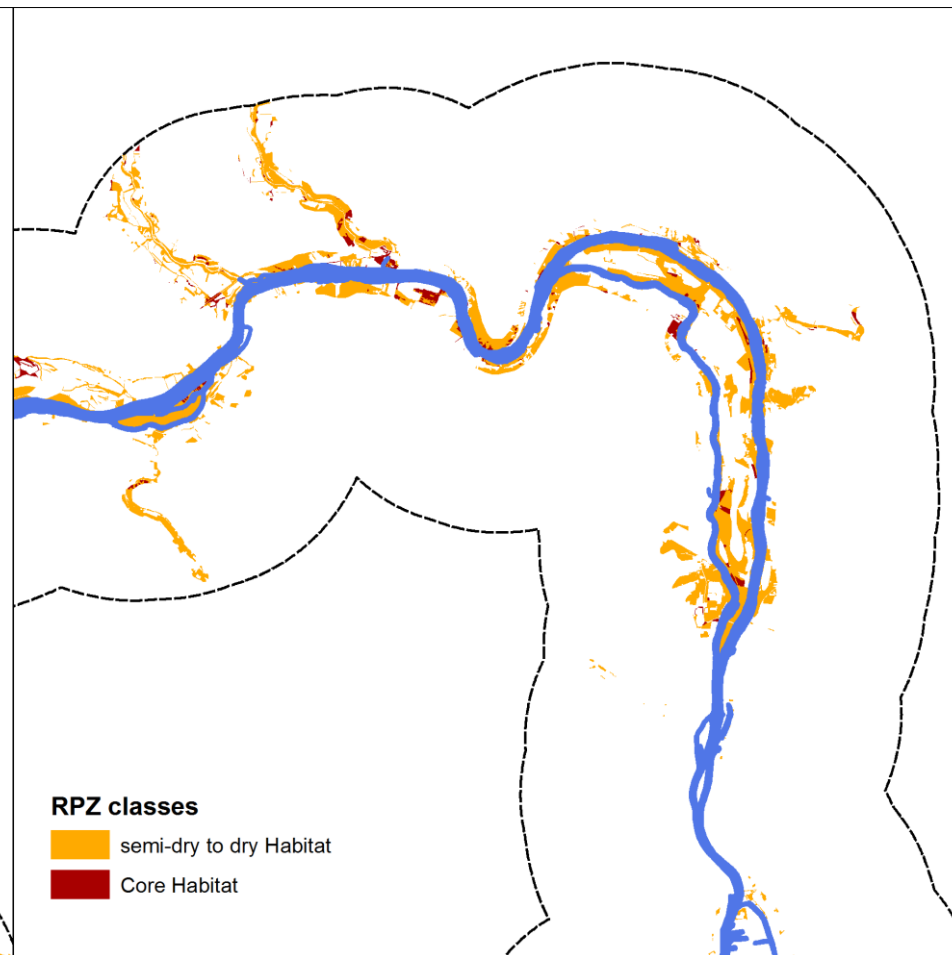


Figure 9: Information yield of RPZ data

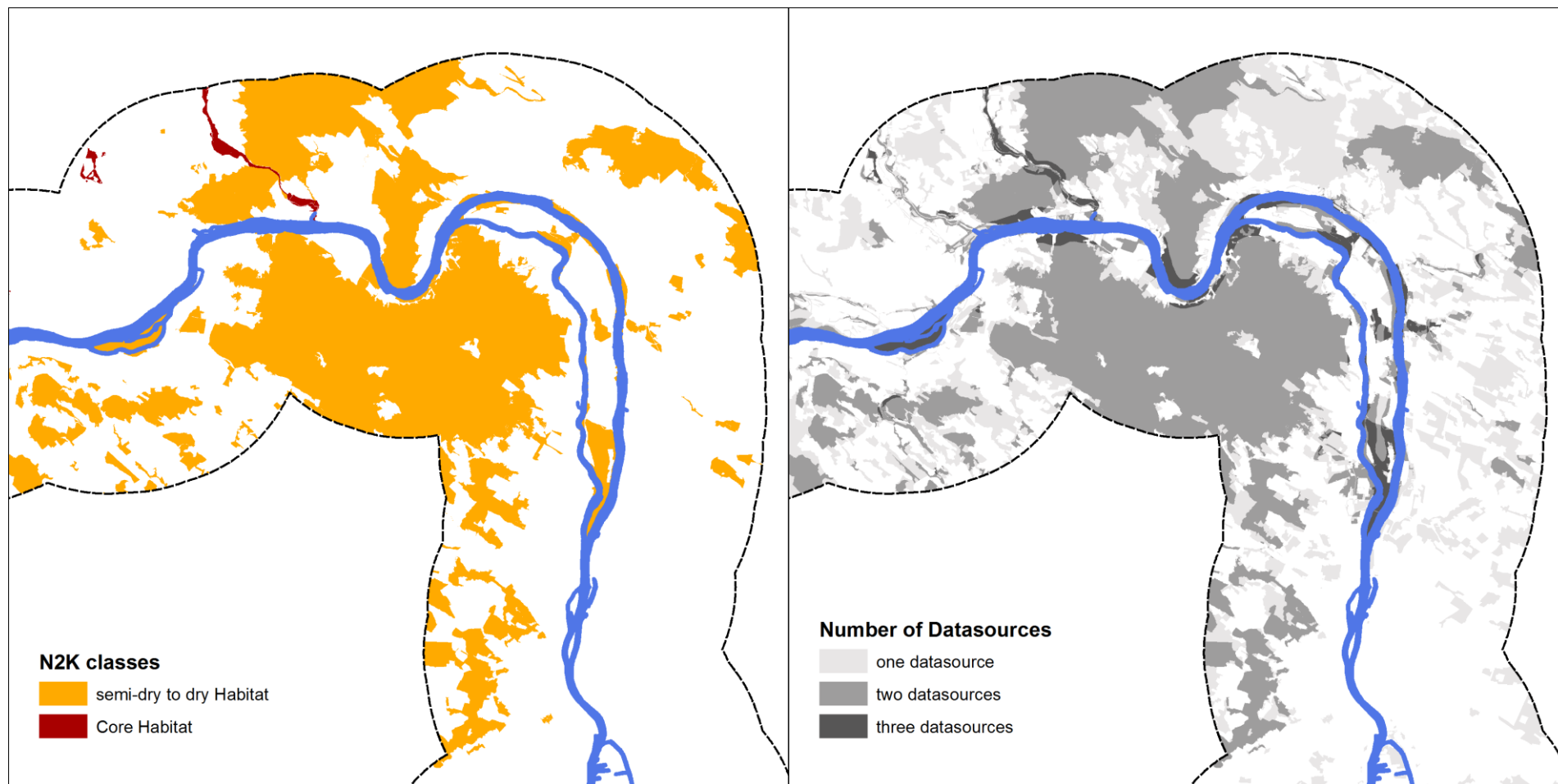


Figure 10: Information yield of N2K data

Figure 11: Number of available data sources

3.5 GIS valuation for Danube dry habitats

As mentioned above, there is no secure information of the exact location and properties of all dry habitats in the Danube corridor because exhaustive vegetation surveys have not been made so far. Using the CLC, RPZ, and N2K data it is possible on the one hand to derive information of how probable it is that a plot hosts a dry habitat. On the other hand, the data provide knowledge of the value and rarity of the occurring dry habitat.

Dry habitats dominated by xerophilic species are the most important habitats for the issue of this work package. Therefore, these habitats are given the highest value.

Having classified and sorted out the relevant from the not-relevant elements of the input datasets, in the next step there had to be developed a tool in order to bring the information of CLC, RPZ, and N2K together in a consistent valuation system. For this purpose, a matrix was developed which takes into account the quality of the respective data as well as the value of the habitat as home for xerophilic species. The highest matrix score is 9, the lowest 1.

The highest value was given to those plots where all three data sources provided information about dry habitats.

If only one of the three datasets points out that a respective plot is qualified as a dry habitat, this plot can maximally reach the value of 7.

The following graphic illustrates the principles of the matrix.

CLC Search Area (0):

just few habitats occupied by species preferring dry habitats but no direct connection to riparian zones or protection status

CLC Search Area + N2K (1) / RPZ (2) / both (3):

the value of this area was higher due to its link to a riparian zone or its protection status

CLC semi-dry Habitat (4):

occupied by species tolerating a wide amplitude of habitat conditions, ranking from dry to fresh and sometimes wet (mesophilic-xerophilic species)

CLC semi-dry Habitat + N2K or RPZ (5) / both (6):

semi-dry habitat with a link to a protection status or a riparian zone or both

CLC dry Core Habitat (7):

dominated by species preferring dry habitats (xerophilic species) without a link to riparian zones or protection status

CLC dry Core Habitat + N2K or RPZ (8) / both (9):

dry core habitat with a link to a protection status or a riparian zone or both

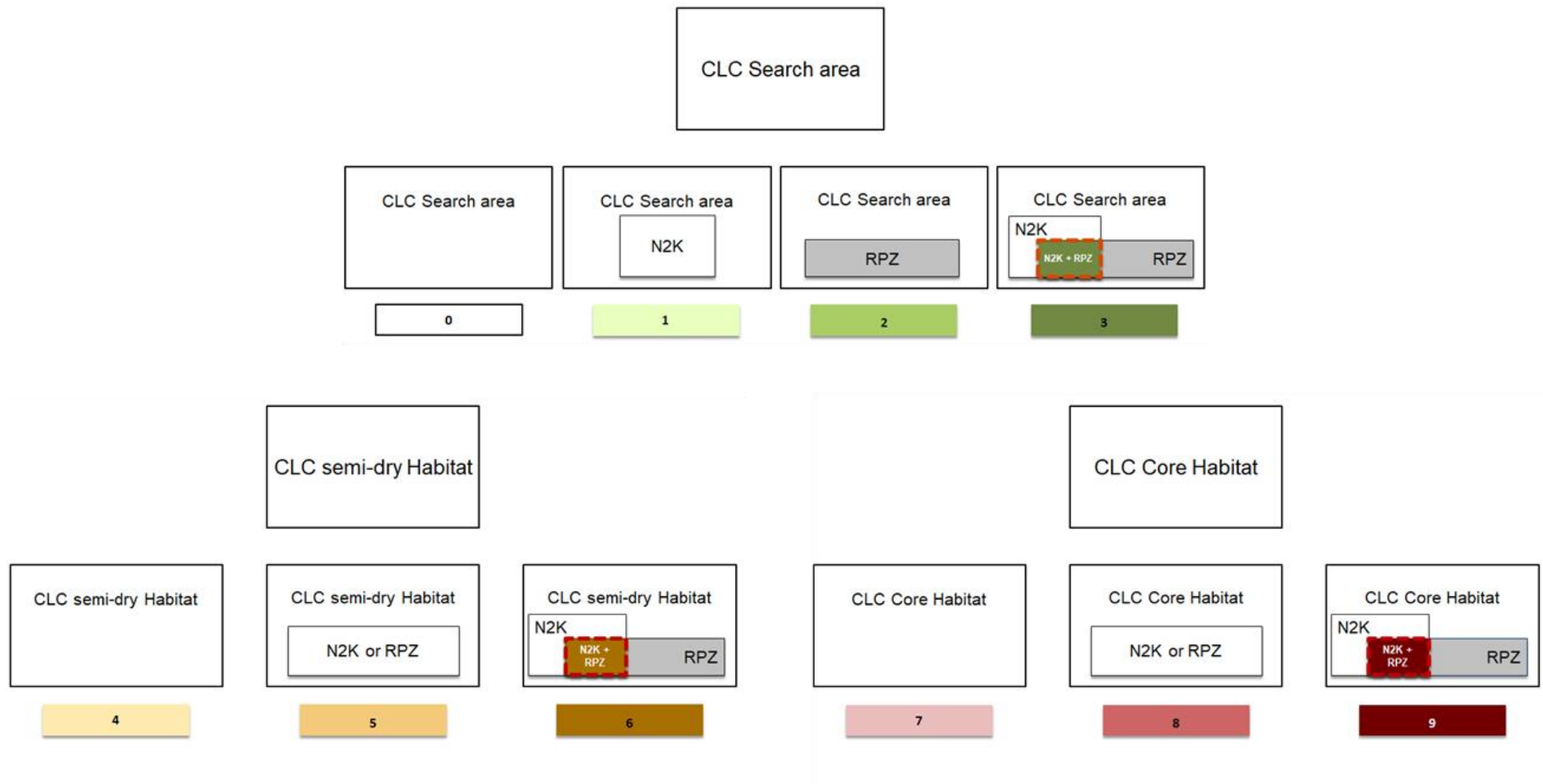


Figure 12: Matrix principle

The results of the matrix in the Danube Bend are visualized in the following figure.

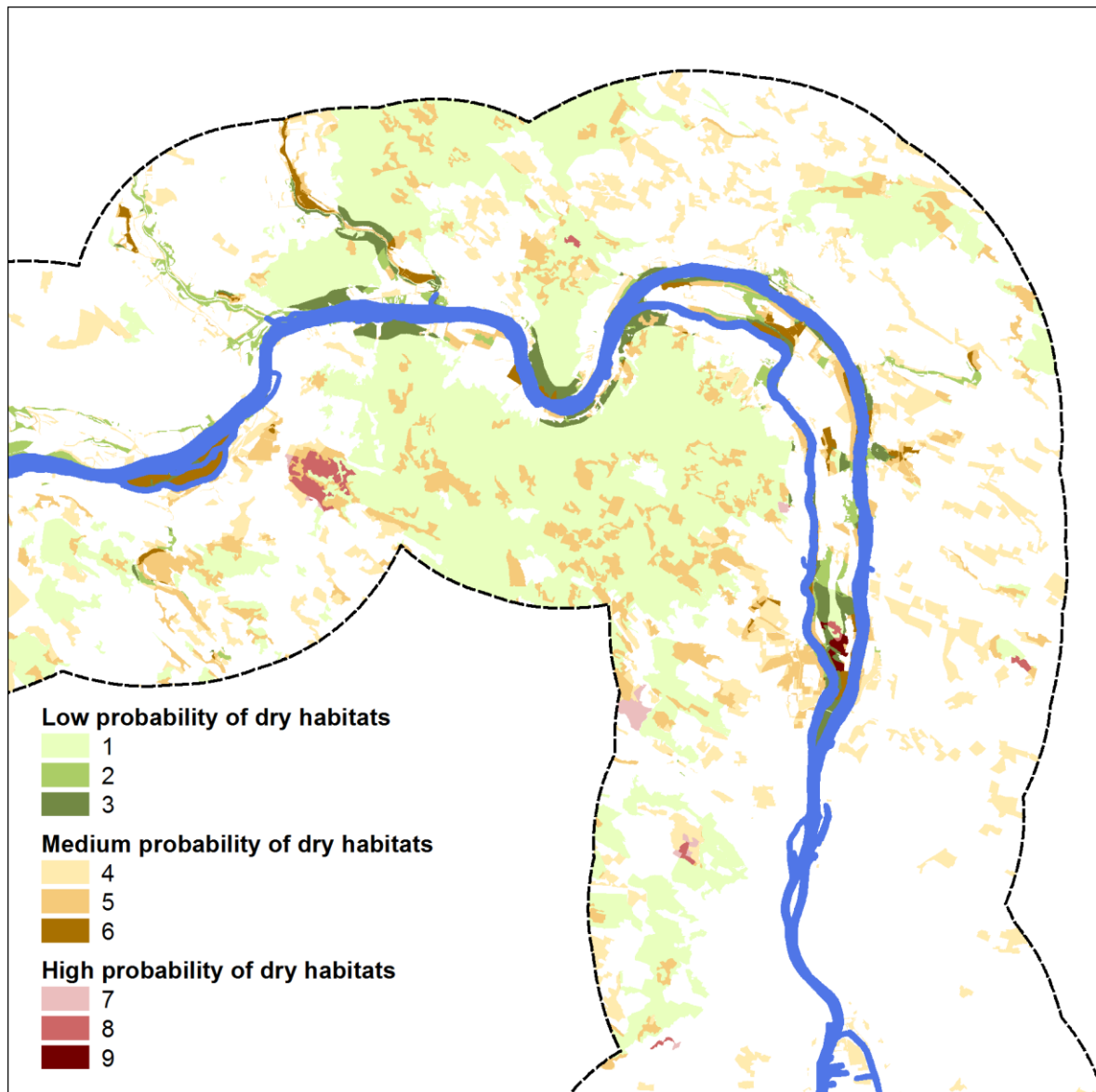


Figure 13: Matrix results of the Danube Bend (class 0 is not visualized)

3.6 Quantitative and qualitative overview of Danube dry habitats

The data basis allows giving an overview of quantitative and qualitative aspects of the potential Danube dry habitats. Just like the information visualized in the maps the following table gives only approximate knowledge of the present situation.

In this table, the results derived from the GIS analyses were evaluated over areas with low, medium or high probability of dry habitats for each protected area. Thus, the area-proportions of the individual classes related to the area of the respective protected area could be determined. Apart from the CLC search area, Class 0 includes all areas without potentially dry habitats in the protected area (all areas that do not belong to classes 1 - 9).

Table 4: Proportions of the probability classes in the protected areas of the DANUBEPARK members

DANUBEPARK member	Probability (%) of DANUBEPARK area									
	0	1	2	3	4	5	6	7	8	9
1 Danube Delta Biosphere Reserve	53	0	2	0	37	3	0	3	1	0
2 Lower Prut Nature Reserve	54	0	25	0	12	10	0	0	0	0
3 Rusenski Lom Nature Park	1	47	0	13	0	14	18	0	3	3
4 Persina Nature Park	60	7	0	10	0	14	7	0	0	0
5 Iron Gates Natural Park	82	0	6	0	7	1	0	4	1	0
6 Kopački rit Nature Park	21	0	20	0	28	30	0	1	0	0
7 Gornje Podunavlje Special Nature Reserve	26	1	32	9	9	16	6	0	0	0
8 Duna-Drava National Park	32	12	23	16	6	7	1	1	2	0
9 Duna-Ipoly National Park	5	77	0	3	0	11	1	0	1	2
10 Fertő Hanság National Park	42	3	13	0	25	6	0	4	7	0
11 Dunajske Luhy Protected Landscape Area	51	9	13	18	3	3	1	0	0	1
12 Zahorie Protected Landscape Area	73	0	9	0	10	7	0	0	0	0
13 Donau-Auen National Park	37	14	0	44	1	2	2	0	0	0
14 Wachau Protected Landscape Area	62	22	1	7	3	4	1	0	0	0
15 Narrow Danube Valley in Passau district	25	4	33	28	4	5	1	0	0	0
16 Donauauwald Neuburg-Ingolstadt	28	49	0	18	1	3	0	0	0	0
All Protected Areas	52	7	5	2	24	5	1	2	1	0

Due to the size of the used raster, very small habitats could not be considered. As consequence, habitats with high probability disappeared because of their size. This is the reason why the table contains just a very little amount of areas with high probability of dry habitat occurrence (classes 7 – 9). For example, the protected areas Iron Gates Natural Park, Wachau Protected Landscape Area and Narrow Danube Valley in Passau district contain precious dry habitats that are not included in the table due to their small-scale extent. Furthermore, a probability of 0 % does not mean that there are no habitats with high probabilities in a reserve, but they could be too small scale for this raster. The use of a smaller raster was not possible due to the resolution of the input-data.

3.7 Overview and detailed maps

The results of the GIS dry habitat analyses were visualized in overview maps as well as in detailed maps of each DANUBEPARKS conservation area. However, because of the coarse data basis just potential areas of dry habitats are shown in both categories. Detailed data of dry habitat occurrences are not available. The detailed dry habitat locations which are known are presented in the detailed maps additionally to the potential areas.

3.7.1 Overview maps of dry habitats

In order to create a common standard of information, the overview maps use only data from CLC, RPZ, and N2K but no additional data which is not available for the whole corridor. Nevertheless, since there are no N2K data for Serbia, Moldova, and Ukraine there is actually no all-embracing common standard.

The GIS analyses had to face many uncertainties. Therefore, there were calculated grid cells measuring one hectare. By using this tool, the outcomes are to some extent simplified, standardized and abstracted. Thus, the resulting maps do not feign a scale of precision which cannot be achieved using the available data basis.

In total, there were made 30 overview maps on a scale of 1:200.000.

3.7.2 Detailed maps of DANUBEPARKS conservation areas

In contrast to the overview maps, the detailed maps were not simplified and standardized with grid cells. Actually, the information of CLC, RPZ, and N2K were intersected.

The quality and information value of the detailed maps highly depend on the availability of data in good quality. For those DANUBEPARKS conservation areas where there was additional data from vegetation surveys available, maps on a scale of 1:25.000 were made, resulting in 16 maps of six conservation areas.

The maps of those DANUBEPARKS conservation areas without additional information were made on a scale of 1:50.000, resulting in 25 maps of 10 conservation areas. Even though they do not contain detailed knowledge of surveys, these maps provide better information of the Danube dry habitats as the overview maps because of the scaled down visualization and because of the intersection of CLC, RPZ, and N2K.

4. Danube dry habitat orchids

The DANUBEPARKS Network decided to refer to the xerophilic and mesophilic-xerophilic orchid species of the Danube corridor as flagship species of the work package. Main reason for this choice was the fact, that orchids' habitats are very sensitive for disturbances or changes in abiotic parameters. Furthermore, N2K habitats benefit from the presence of orchids in becoming a habitat with priority. In future projects, similar analysis can focus on other species or species-groups preferring dry habitats or adapted to climate change.

Therefore, it was one of the crucial objectives of the GIS analyses to locate and illustrate as best as possible the sites where the respective orchid species occur. Two different classes of data could be used as source of information:

- Results of vegetation surveys
- Derivation of N2K data

4.1 Results of vegetation surveys

Some of the DANUBEPARKS Network members could provide data on their orchid sites gained in vegetation surveys. The following figures show the main distribution of xerophilic (Figure 9) and meso- to xerophilic orchids (Figure 10).

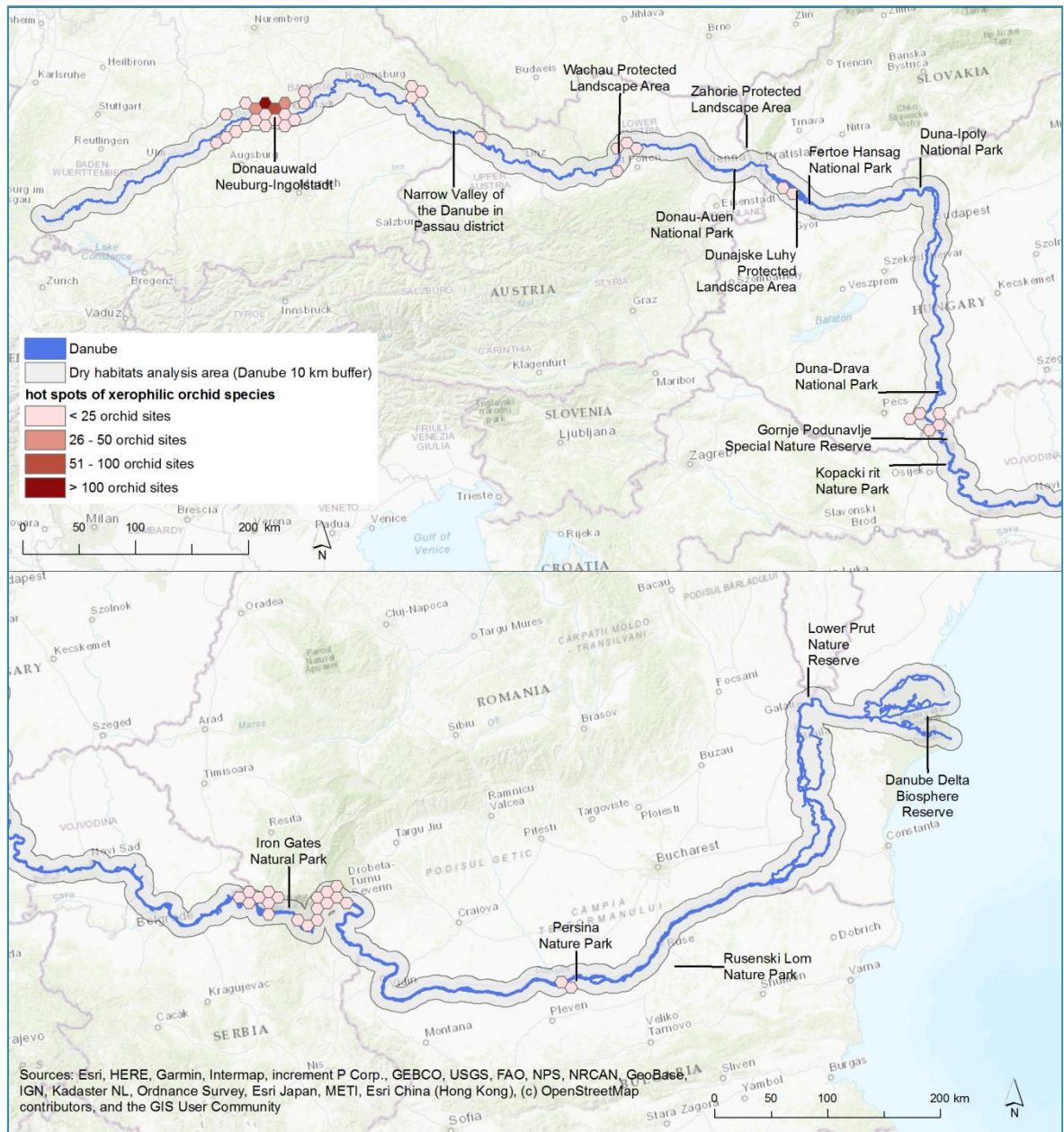


Figure 14: Hot spots of xerophilic orchid species

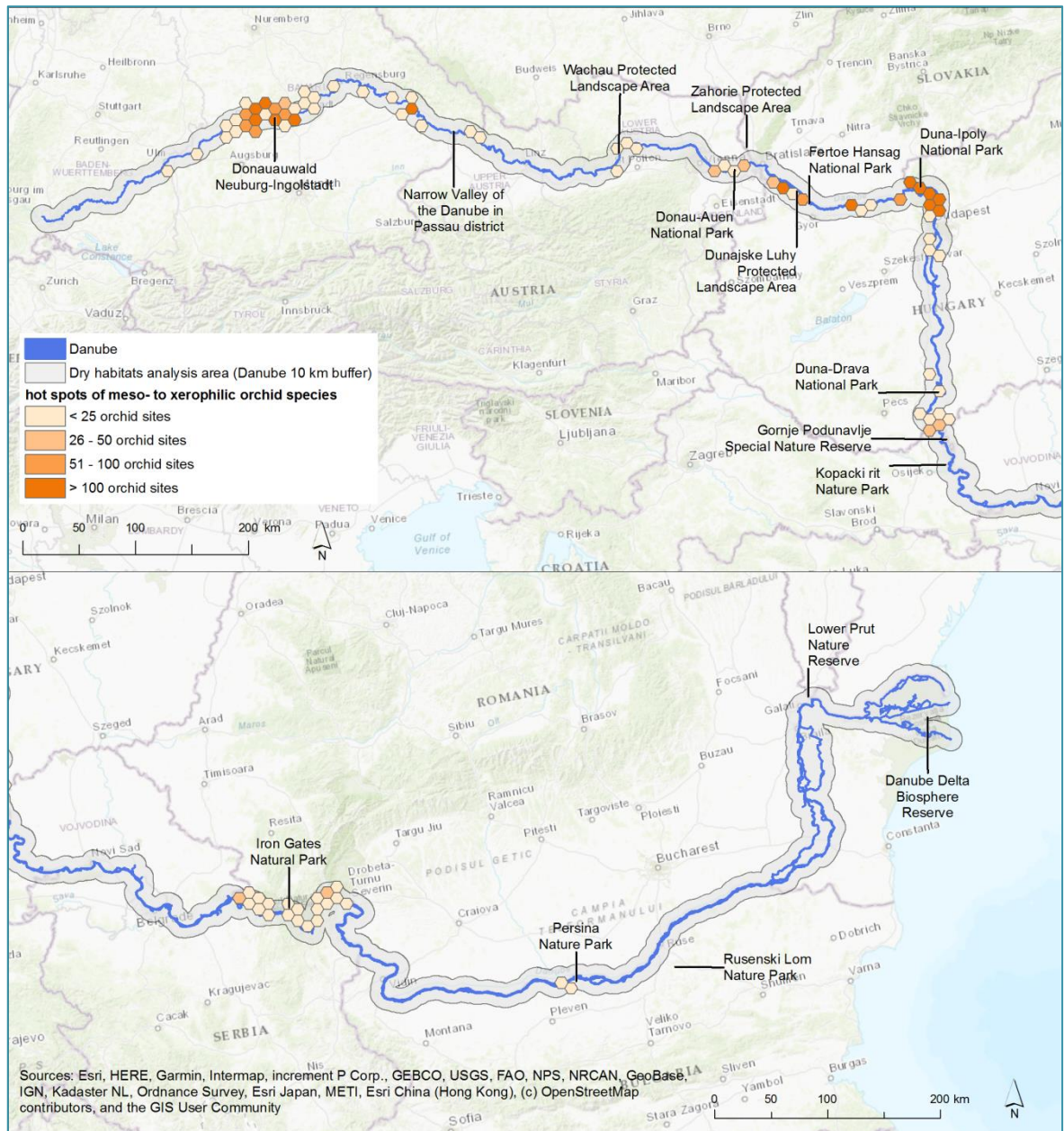


Figure 15: Hot spots of meso- to xerophilic orchid species

The network members delivered either exact points where the orchids were found or areal delimitations of orchid sites. Both, the points and areas, give quite detailed information which needed to be generalized in order to protect the partly endangered orchid species from illegal removal and possible destruction of the (surrounding) habitats.

For this purpose, the orchids in the overview maps are visualized as point in the middle of the very grid cell (1 ha) where the orchid point is located.

The following figures illustrate this procedure:

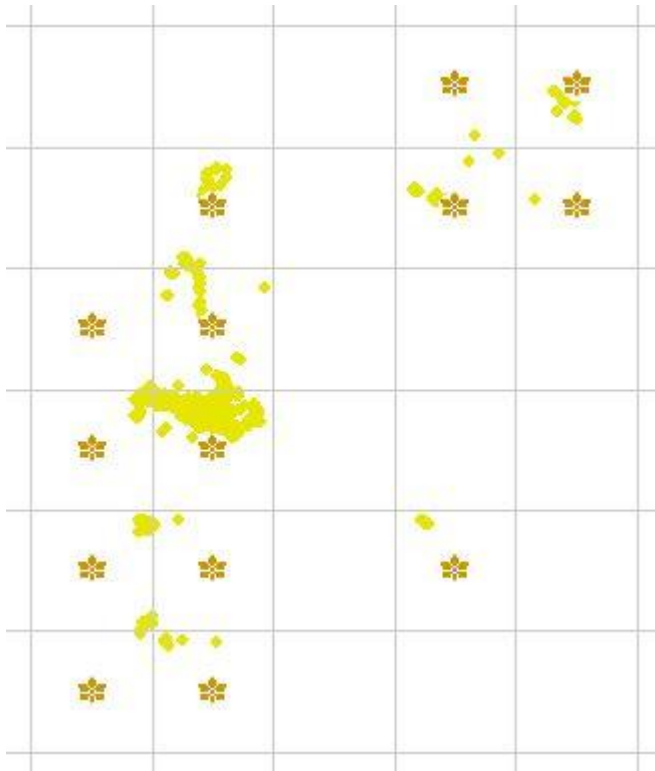


Figure 16: Generalized orchid sites based on grid cells

In the detailed maps, the orchid sites are visualized either as aggregated points in case of an accumulation of more than one point or as center point in the respective orchid area. Thus, the orchid sites are generalized and cannot exactly be located.

The orchid species were categorized in two groups depending on their habitat demands:



-  **xerophilic orchid species**
-  **mesophilic – xerophilic orchid species**

Figure 17: Categories for orchid species

4.2 Derivation of N2K data

For the majority of sites in the Danube corridor there have not been made detailed vegetation surveys or if so, their results are not freely available. For these sites in the GIS analysis the N2K data were used to gain at least a vague idea of the allocation of orchids in the corridor. The N2K habitat types 6210* and 9150 are defined as habitats where xerophilic or xerophilic-/mesophilic orchids occur. Unfortunately, the standard forms of the N2K special areas of conservation do not all differentiate between the code 6210 and 6210*. Only the latter is a habitat where orchids occur. Because of this lack of knowledge, both codes were used to derive orchid sites. Consequently, the respective information in the maps overestimates the quantity of orchid sites in the Danube corridor.

Using the N2K data, the maps indicate an orchid-symbol in those SAC where there are habitats either of one or both relevant codes. For lack of knowledge of the exact habitat location, the orchid-symbols were placed in the middle of the respective SAC. On the basis of the information of the area size of the 6210 and 9150 habitats the maps show three different categories of probable orchid spread:

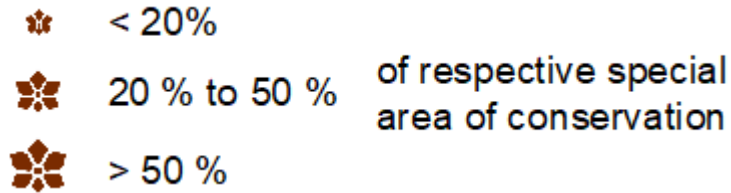


Figure 18: Assumed orchids' spread derived from N2K data

In the detailed maps this differentiation was enhanced: On the one hand, the orchid sites of the two codes are illustrated separately, on the other hand, there is more information of the respective spread.

4.3 Orchid species in the Danube corridor

According to the information delivered by the DANUBEPARKS Network members the following table could be elaborated. It cannot provide complete knowledge of all orchid species that occur in the Danube corridor. Nevertheless, it enables an insight in the orchid species composition.

Table 5: Orchid species in Danube corridor

Scientific Name	Other Name	Xerophilic	Mesophilic / Xerophilic	Ecology
<i>Anacamptis coriophora</i>	<i>Orchis coriophora</i>		x	periodically fresh, nutrient-poor grasslands; on slightly alkaline to slightly acidic, calcareous soils; sufficient lighting conditions needed
<i>Anacamptis morio</i>	<i>Orchis morio</i>		x	dry to periodically humid, nutrient-poor grasslands; preferably on alkaline soils, but also on non-calcareous loam and clay soils when soils poor in nitrogen; sufficient lighting conditions needed
<i>Anacamptis pyramidalis</i>			x	dry, nutrient-poor grasslands; on alkaline and calcareous soils when soils poor in nitrogen; strong solar radiation needed, thermophilic species
<i>Cephalanthera damasonium</i>		x		index species of the Medio-European limestone beech forests of the Cephalanthero-Fagions; on alkaline, calcareous soils; shadow-tolerant, but preferred in sparse forests with warm summers
<i>Cephalanthera longifolia</i>		x		sparse forests and shrubs; on alkaline and semi-acidic soils; in areas with warm summers
<i>Cephalanthera rubra</i>		x		forests, especially on the edges of beech forests or sparse pine forests; on alkaline and calcareous soils; areas of lighting zones of forests
<i>Cypripedium calceolus</i>			x	preferably in sparse deciduous and coniferous forests, but also in shady areas of Juniperus-heathlands; on calcareous soils that can be slightly acidic; sufficient lighting conditions needed
<i>Dactylorhiza sambucina</i>		x		rocky, shallow and summer-dry meadows; mostly on primary rock on moderately-acidic soils, avoids calcareous areas
<i>Epipactis atrorubens</i>		x		preferably dry-warm habitats like sunny edges of forests; on calcareous soils; from sunny to half-shady lighting conditions
<i>Epipactis helleborine</i>			x	half-shady to shady areas in forests, bushes; on slightly acidic to slightly alkaline soils; tolerant to drought, but also in fresh areas
<i>Epipactis microphylla</i>			x	forests; on calcareous, humous and (periodically) fresh soils, moderate tolerance to nitrogen; shady light conditions needed
<i>Gymnadenia conopsea</i> agg.			x	various habitats, e.g. semi-dry grasslands on calcareous substrates, fens or sparse pine forests; calcareous soils necessary, tolerant to slightly acid-

Scientific Name	Other Name	Xerophilic	Mesophilic / Xerophilic	Ecology
				ic and slightly alkaline conditions; dry to wet conditions
<i>Gymnadenia odoratissima</i>			x	habitats similar to <i>Gymnadenia conopsea</i> agg., especially extensive wet-meadows and fens; calcareous soils necessary; more reliant on fresh or at least periodically humid conditions
<i>Himantoglossum adriaticum</i>		x		extensive meadows, herbaceous semi-dry grasslands, seams of shrubs; on calcareous soils
<i>Himantoglossum caprinum</i>		x		extensive meadows, among shrubs and forest glades in light deciduous forests; on stony, calcareous soils; open, sunny places needed
<i>Himantoglossum hircinum</i>		x		nutrient-poor grasslands on calcareous substrates, extensive meadows, seams of shrubs; on calcareous soils
<i>Limodorum abortivum</i>		x		shrubs of downy oak, sparse mixed pine forests, seams of shrubs; not specifically attached to calcareous soils (slightly acidic soils also possible) preferably on deep loam and loess soils
<i>Neotinea tridentata</i>	<i>Orchis tridentata</i>	x		open, semi-arid grasslands and extensive meadows; preferably on Zechstein, always on limestone
<i>Neotinea ustulata</i> ssp. <i>aestivalis</i>	<i>Orchis ustulata</i> ssp. <i>aestivalis</i>		x	semi-dry grasslands on calcareous substrates, nutrient poor grasslands; on neutral to slightly acidic soils; dry to periodically humid conditions
<i>Neotinea ustulata</i> ssp. <i>ustulata</i>	<i>Orchis ustulata</i> ssp. <i>ustulata</i>		x	semi-dry grasslands on calcareous substrates, nutrient poor grasslands; on neutral to slightly acidic soils; dry to periodically humid conditions; blooms earlier than <i>Neotinea ustulata</i> ssp. <i>aestivalis</i> , but same ecology
<i>Neottia nidus-avis</i>			x	fresh forests; on calcareous soils; prefers shady lighting conditions
<i>Neottia ovata</i>	<i>Listera ovata</i>		x	various habitats like deciduous forests, meadows, fens; not dependent on calcareous soils, relatively tolerant to nitrogen; preferably on half-shady, periodically humid areas
<i>Ophrys holoserica</i>			x	warm, nutrient-poor grasslands on calcareous substrates, dry meadows; on loose loam and loess soils; preferably mild winter climate

Scientific Name	Other Name	Xerophilic	Mesophilic / Xerophilic	Ecology
<i>Ophrys insectifera</i>			x	on the edges of forests, sparse pine forests, nutrient-poor grasslands, semi-dry grasslands and suitable secondary habitats; on calcareous soils
<i>Ophrys mammosa</i>			x	sparse deciduous and coniferous forests, nutrient-poor grasslands; on moderate dry to moderate humid soils, which are often alkaline
<i>Ophrys sphegodes</i>			x	semi-dry grasslands on calcareous substrates, nutrient-poor meadows; on calcareous soils; sunny conditions needed
<i>Ophrys sphegodes</i> <i>ssp. araneola</i>			x	more rocky habitats compared to <i>Ophrys sphegodes</i> , steep slopes, gravel slopes; on calcareous soils
<i>Orchis antropophora</i>		x		nutrient-poor grasslands on calcareous substrates and sparse shrubs; on calcareous soils
<i>Orchis mascula</i>			x	nutrient-poor meadows, semi-dry grasslands, sparse shrubs and forests; on calcareous soils
<i>Orchis militaris</i>			x	semi-arid grasslands, nutrient-poor grasslands and sparse shrubs; on alkaline and loamy soils; thermophilic
<i>Orchis simia</i>		x		extensive meadows, semi-arid grasslands and nutrient-poor grasslands; on calcareous soils; extremely thermophilic
<i>Platanthera bifolia</i>	<i>Platanthera fornicata</i>		x	grows between shrubs below the subalpine level; preferably on fresh, slightly acidic soils; lighting conditions: light shadow
<i>Platanthera chlorantha</i>			x	in light shadow of shrubs, in sparse forests but also swampy meadows; on slightly humid (periodically humid), humous, alkaline soils over limestone and gneiss
<i>Spiranthes spiralis</i>			x	semi-arid grasslands and dwarf shrub heathlands; on at least periodically fresh, low-calcareous to calcareous soils that are superficially acidified

5. Condition of Danube dry habitats

5.1 Conservation status according to Natura 2000 data

For any N2K special area of conservation a standard form needs to be filled out providing the most important information concerning the respective area. Among the mandatory knowledge the EU member states have to submit there is a global assessment which indicates the value of the sites for conserving the natural habitat type of Annex I concerned.

The global assessment for a given natural habitat type is a synthesis of the assessment of the following criteria:

- **Representativeness:** degree of representativeness of the natural habitat type on the site
- **Relative surface:** area of the site covered by the natural habitat type in relation to the total area covered by that natural habitat type within the national territory
- **Conservation status:** degree of conservation of the structure and functions of the natural habitat type concerned and restoration possibilities

Each of these criteria is graded by three classes:

- A excellent
- B good
- C significant

If the representativeness of a habitat type in an area is low (not-significant), this area is graded at a fourth category D.

- D non-significant (only criteria representativeness)

According to the Natura 2000 explanatory notes, the remaining criteria should not be marked and a total assessment cannot be given if one of the three criteria is classed as “non-significant”. The conservation status of relevant N2K special areas helps to estimate if there is a need to start conservation measures and where the need is more urgent than elsewhere.

The assessment of the conservation status in the standard form is composed of the assessment of three sub-criteria:

- i) degree of conservation of the structure
- ii) degree of conservation of the functions
- iii) restoration possibility

The given limitations of the N2K data allow only an approximate gain of knowledge of the conservation status of the Danube dry habitats. A clear and informative visualization of the conservation status cannot be made. Therefore, the following figure shows the graphical illustration of the statistical analyses which the available data allow. The classification of the conservation status is according to the N2K definitions:

- A excellent
- B good
- C moderate to bad

Class D is not displayed in the maps, because a total assessment cannot be given in these cases.

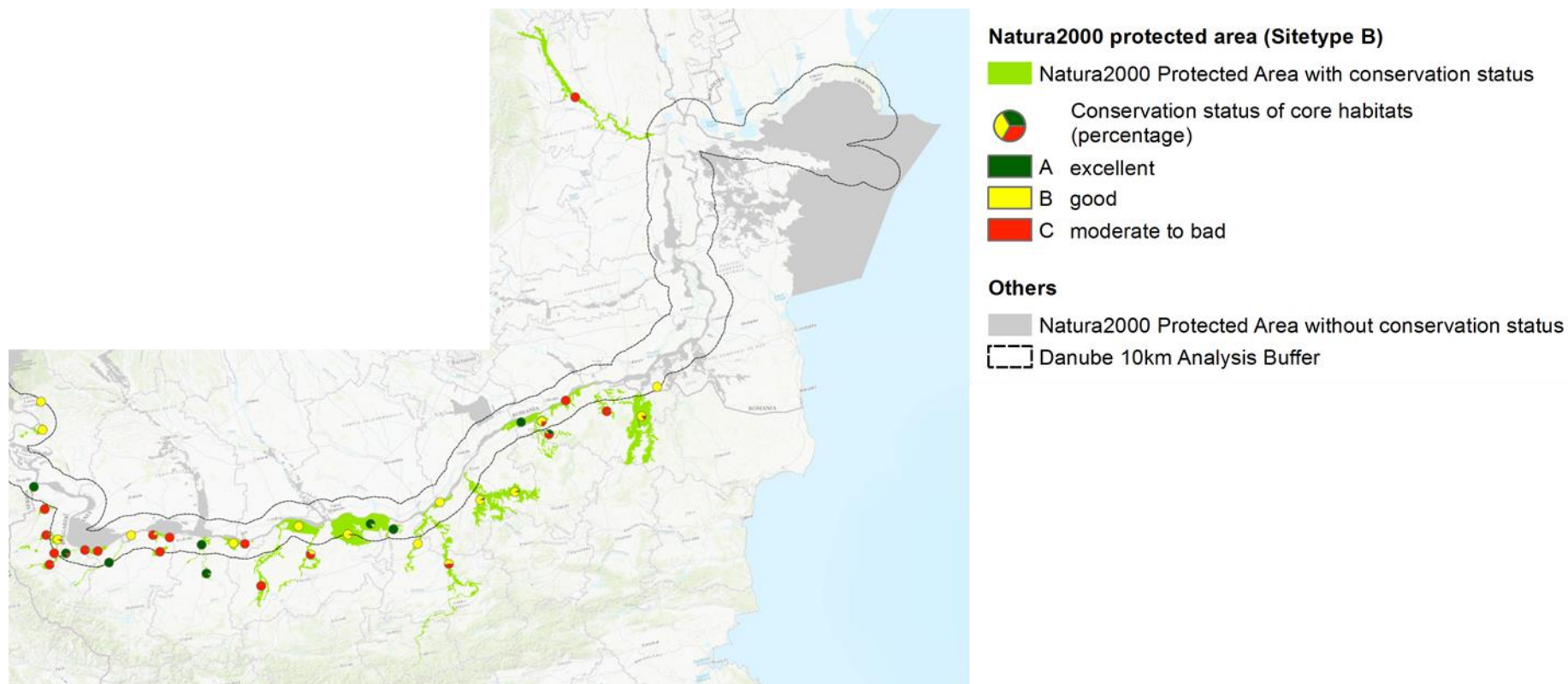


Figure 19: Distribution of Natura 2000 Protected Areas with conservation status A to C of core habitats along the Danube river.

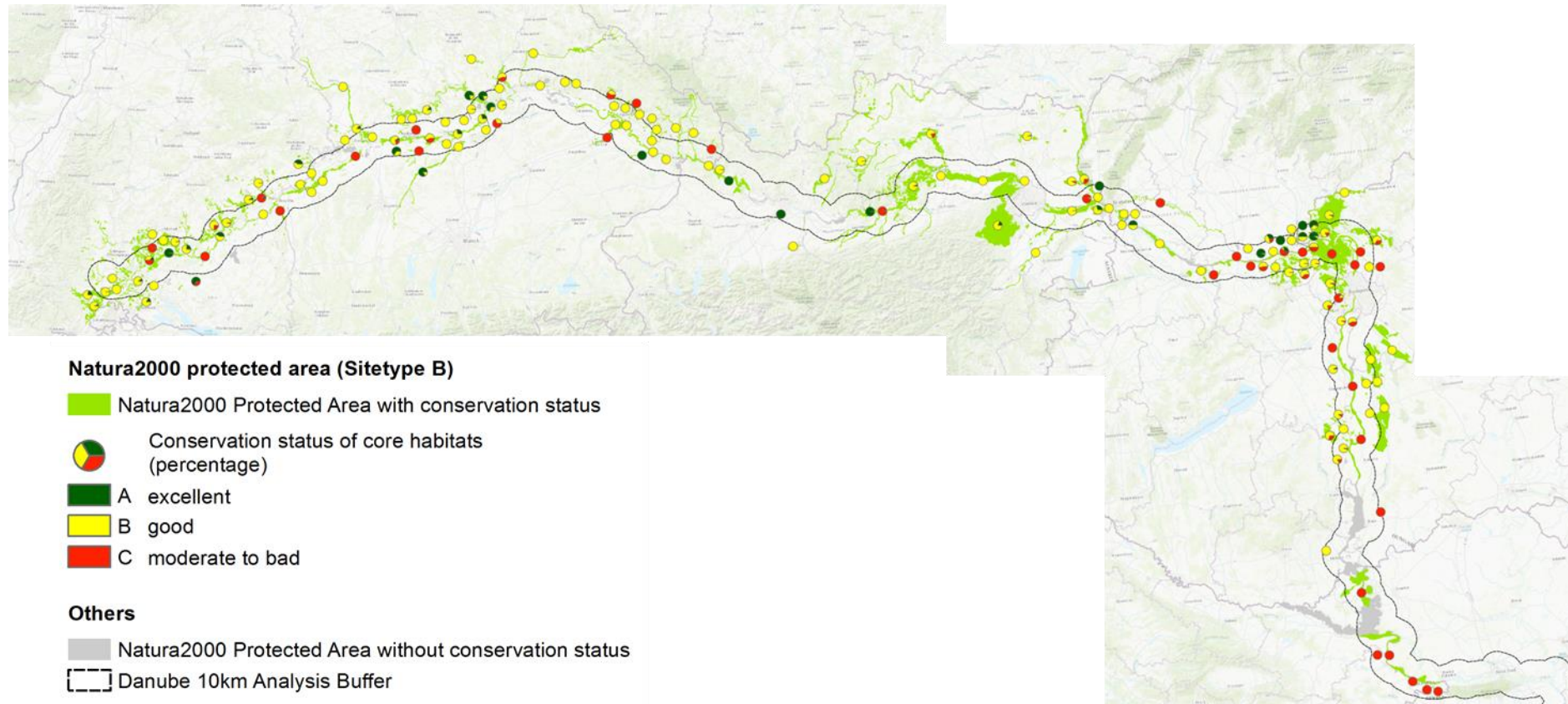


Figure 19 (continuation): Distribution of Natura 2000 Protected Areas with conservation status A to C of core habitats along the Danube river.

5.2 Causes of threat and gaps in biotope network

According to the Millennium Ecosystem Assessment (2005), between 10 and 20% of the global drylands are already degraded. Many of the main drivers of biodiversity loss in general are also contributing to the ecological degradation of dry habitats (Davies et al., 2012).

This is also reflected by the surveys among the DANUBEPARKS members: Land-use, invasive species and succession are seen as the main threats to the majority of (semi-)dry habitats along the Danube. Some threats seem to have more regional importance, with the loss of river dynamics mentioned predominantly by the members coming from regions of the upper course and nutrient-input and land-use intensification seen more as a threat by members of the middle course regions. Fire is mentioned as another thread, especially for the areas at the lower Danube. However, the threats are already making an impact on the dry habitats: Most of the surveyed members assigned the (semi-)dry habitats in their own Protected Area a medium habitat quality.

The causes of threat can be categorized according to the already specified site conditions of chapter 2.1.

5.2.1 Climate and exposure

In a global context, climate change is expected to cause increases in temperatures and a tendency to variable and extreme changes to precipitation regimes (IPCC, 2013). It is probable that these alterations will take very different shapes in the different biogeographic regions (Li et al. 2018). While in some regions there may be more droughts and less precipitation in other regions there may be raising precipitations and an increase in flooding.

As the consequences of climate change vary between regions, it is very difficult to make general assumptions about the consequences that apply for all dry habitats. For sure, if there are changes in abiotic conditions the biotic conditions will be affected to a greater or lesser extent causing habitat shifting and alteration. In general, increasing temperatures and an alternating precipitation regime is expected to lead to a global expansion of drylands (Davies et al., 2012), for example with some habitats evolving due to decreasing humidity. Newly evolving habitats might be similar to habitats known from different regions or can form shapes never seen before. Other habitats in contrast, could vanish in the course of increased humidity. Driven by climate change fire events are expected to occur especially after long dry periods in higher frequencies and intensity.

Consequently, effects of climate change on dry habitats will also influence the species inhabiting these habitats. Species which live in dry habitats that will be affected of climate change will face more obstacles to survive than species which occupy dry habitats that are favored by effects of climate change. Moreover, for some species there are fears that the speed of climate change will be too fast for them to adapt to it (Radchuk et al., 2019). Since many species of dry habitats do live already at the climatic extremes, this fact may even increase their vulnerability for extinction. On the other hand, these species are already very adapted to the extreme and instable conditions of dry habitats and have proved to be able to survive under very dry and

variable circumstances, which might be also an advantage in regard to the effects of climate change (Davies et al., 2012).

Furthermore, it is expected that invasive species, especially plants, will benefit or at least have less problems with climate change in comparison to native species, for instance due to their broad ecological niches, high dispersal capabilities and short generation intervals (Walther et al. 2009; Diez et al. 2012). They pose a risk to habitats and its original species because they can threaten the native flora and fauna or form new biocoenosis. Mostly, invasive species have blatant advantages in the new habitats and quickly populate large areas. Thus, indigenous and ancestral species get repressed, plants as well as animals which depend on their respective host plants. Even though new species invade, often biodiversity decreases as the limiting factors and opponents of the home habitats of the invading species are missing.

With regard to exposure, changes in the orientation to the sun are mostly caused by changes of neighboring land use or land cover. For dry habitats, shadowing by high growing vegetation or man-made constructions is a serious menace. Competing high growing vegetation can be counteracted by maintenance. Whereas man-made constructions that shade dry habitats can only seldom be built in a way that is uncritical, for example by using transparent components.

5.2.2 Substrate

Many characteristics of substrate can be sensitive to material input. The acid-base relation, the heavy metal and especially the nutrient content can easily be modified by the increase or absence of inputs.

The origins of these inputs are diverse. The biggest unnatural emitters are the sectors traffic, industry and agriculture which add various substances to the soil either indirectly via atmospheric inputs or directly via pesticides as well as organic or inorganic fertilizers. While the atmospheric inputs occur normally unintentionally the direct inputs are caused by intentional agricultural land management, by leaching of fertilizers or pesticides from nearby agriculturally managed areas, or by improper waste disposal.

Among the different emitted substances the share and impact of nutrients, especially nitrogen, is dominant. As illustrated in chapter 2 most dry habitats need nutrient-poor substrate to thrive. Therefore, an increase of the nutrient content of the soil seriously endangers most dry habitats.

Eutrophication negatively affects especially grasslands by triggering the following consequences:

- promotion of the expansion of nutrient-demanding competitive (high-grown) vegetation, especially grasses
- promotion of the growth of ruderal species thus accelerating natural succession

That way eutrophication by and by impairs the quality of dry habitats finally culminating in a change of habitat type and a loss of the dry habitat.

The various pesticides, in particular herbicides, insecticides, fungicides, seriously endanger the balance of established biocoenosis up to destroying them totally. They seriously damage those species that are hardly resilient to shocks and favor competitive species.

While eutrophication often proceeds successively and can be counteracted by consequent management, the use of pesticides can cause irreversible damage even with one single application when keystone species are seriously affected.

5.2.3 Land use

In general, the potential threats to biodiversity caused by land use are just as various as the shapes human land use can assume (Foley et al. 2005). By reviewing the Fact Sheets of the European Red List of Habitats (2016), we categorized and summed up the land use related threats to dry habitats in three sections:

1. Conversion

Habitats are threatened when total changes in land use destroy the basic site conditions. For instance, this applies to land-take for urbanization, forest clearing for farming or to the establishment of quarries and open-cast mining.

2. Intensification

When the use of formerly not or extensively managed habitats is intensified in order to increase the return, the basic site conditions get fundamentally changed.

In modern agriculture, intensive grazing and the heavy use of fertilizers lead to nutrient enrichment (N, P, organic matter) and to the degradation of soils. High-frequent and very early mowing impedes flowering and seed formation so that flowering plants decrease little by little and grasses spread, until they cover almost all possible areas. In forestry, intensive management methods include for example increased logging and the removal of deadwood, which affect forest ecosystem processes and biodiversity. By logging already young and middle-aged trees the composition of age groups of trees becomes heavily unilateral so that old trees predominate without the possibility of regeneration.

Not to forget intensification of land-use can also mean a more significant human impact through leisure activities and tourism, resulting in direct destruction of habitats for example through human trampling or outdoor sports like motocross. Leisure activities, even if extensive in character like hiking or biking, can have massive negative effects on habitats when too many users perform them. Quite often, visitors disregard rules of conduct and, for example, deviate from the walks, dump waste or disregard rest periods.

3. Neglect

Secondary habitats depend on the continuity of their respective form of land use. If the necessary processes cease, the species composition sooner or later changes so that in the end a different habitat type develops.

Many valuable dry habitats are grasslands. Often, they are part of old, pastoral landscapes, which require a specific management regime of extensive grazing or mowing. As a result of economic developments, there is a general trend of rural exodus and abandonment of agricultural management, especially in marginal areas of Europe. This processes lead to the invasion of (sub-)shrubs and trees transforming meadows to scrub and woodland. Characteristic light-demanding species, many of which are small chamaephytes, disappear in this process just like the habitat itself does in the end.

5.2.4 Erosion, sedimentation and natural disturbances

The intense water management and exploitation of the Danube for diverse purposes result in the obstruction up to the loss of natural river dynamics. For instance, the construction of dams for hydropower, river regulation and canalization as well as the expansion of navigable river sections result in heavy modifications of the natural water body system (Sommerwerk et al., 2009). On the one hand, these modifications cause flooding of formerly open river banks and islands, on the other hand they result elsewhere in a lack of flooding and the drop in water level. Consequently, the riparian vegetation composition is being altered and finally replaced by different species. The development of new islands and shapes of river banks takes place. Thus, habitats depending on wet conditions fall dry whereas dry habitats are flooded. Additionally, the natural mass transport is impeded or strongly decreased through water management and quarrying resulting in disturbances up to the loss of sedimentation and the deposit of gravel and other material.

As mentioned in the chapter 5.2.1, in the course of climate change, it is possible that there will be an increase in quantity as well as massive changes in the quality of natural disturbances. Storms, fires, droughts and flooding directly result from weather and climate. Thus, the vulnerability of existing habitats rises due to permanent stress while at the same time the conditions for many parasites and pests, native or invading from different regions, improve.

6. Strategic steps towards a Danube biotope network

On the one hand, this chapter seeks to give a basic overview of potential methods of analyzing, enhancing and managing biotope networks of dry habitats. On the other hand, it assembles different possibilities for the DANUBEPARKS Network of Protected Areas to carry on with its objective of counteracting habitat fragmentation and degradation as well as of restoring and maintaining connectivity in all habitat elements.

6.1 Methods of exploring and promoting biotope networks

For the establishment of a potential dry habitat biotope network, the following steps can be taken. They apply to biotope networks of different habitat types, too.

Assessment of the current situation and analysis of requirements

The first step in establishing a biotope network is the assessment of the current situation in the dry habitat biotopes (“core areas”) and an evaluation of the need for gaining additional areas for a biotope network. Therefore, target species are used to specify the requirements for the selection of new areas for a dry habitat network (Burkhardt et al., 2004). These target species (plants and/or animals) must be representative for the target dry habitat types and have special needs with regard to connectivity.

The target species and further available data will provide the basis for the evaluation of the current situation as well as for the analysis of the need for adding areas to the biotope network.

Determining deficiencies

Next, an assessment of the connectivity deficiencies of the dry habitats should be carried out. This step needs to take into consideration the respective habitat needs and the present distribution of the target species in the planning area. The results can be documented in GIS maps and textual documents.

Identification and assessment of suitable corridors

Based on the core areas of the dry habitats and their connectivity deficiencies, suitable corridors must be identified and possible areas for the development of connective measures within these corridors must be assessed. These steps can be done with different analysis methods of GIS which aim to identify barriers in the corridors (e.g. for mobile animal species) and to find the most effective connections. After identifying potential corridors, they need to be inspected for possible obstacles or conflicts (e.g. barriers, not-changeable land use etc.) and possible solutions to overcome these obstacles need to be made up.

In this step it is necessary to take into consideration that the dispersal and immigration of target-species in habitats can occur via the influence of biotic and abiotic vectors. Important biotic vectors are animals and humans, the most important abiotic vectors are wind and water. Even man-made vehicles, especially for transport and agriculture, can transport individuals of species, their seeds or eggs between different habitats. For instance, species depend on migration corridors of mammals, pastoral herding or human hiking networks. The range of motion and the capacities of

species to overcome distances vary widely. Subject to the respective target species and habitats the distances between stepping stone areas and their design must be adapted. Dry habitats like sun-exposed railway embankments and roadsides, non-recultivated quarries or gravel pits can be important stepping stones for reptiles and xerophilic insects.

Comparison with existing planning aims

As a next step, the elaborated development goals of the dry habitat biotope network (core areas, corridors) must be integrated or adjusted to existing planning of other departments (e.g. regional plan, plans for habitat directive) to identify contradictory and corresponding management objectives. Potential conflicts need be pointed out and solutions to be offered.

Concept of measures

In the end a concept of measures with goals and guiding principles of a dry habitat biotope network results from the preceding steps. This concept needs to include various suggestions of measures that can be taken to improve the connectivity of the biotope network. In addition, the feasibility of the measures has to be examined and suggestions for the implementation (e.g. farmers, associations) and funding (e.g. foundations) have to be made. Mostly, one of the most troublesome obstacles is the acquisition and availability of suitable land. If the monetary and/or temporal resources are small priorities need to be determined.

Synchronizing the biotope network concept to other planning

As a last step, the results of the concept have to be compared to and harmonized with other local or regional network planning and adjusted, if necessary. One example of such a planning strategy is the Green Infrastructure Initiative of the European Union (EU, 2013). This Initiative is part of the EU strategy for biodiversity and biodiversity policy and targets to integrate nature conservation issues into spatial planning and territorial development to be able to better tackle on biodiversity resulting from habitat fragmentation, land use change and loss of habitats. Further it intends to pose a framework to promote and facilitate Green Infrastructure projects within existing legal, policy and financial instruments.

The Green Infrastructure strategy consists of four main elements:

- Promoting Green Infrastructure in the main EU policy areas
- Supporting EU-level Green Infrastructure projects
- Improving access to finance for Green Infrastructure projects
- Improving information and promoting innovation

This makes it a very interesting option to look at in the context of setting up dry habitat network. Germany, for example, integrated the EU Green Infrastructure concepts at the national level through a “Federal Green Infrastructure Concept” (BfN 2017).

6.2 DANUBEPARKS dry habitat corridor strategy

One of the most important steps to be taken in this strategic paper is to look beyond the current situation and to map out possibilities and priorities for medium- and long-term strategic actions.

It is always a very demanding objective to strive to close the gaps of a biotope network not to speak of a biotope network that is defined as the whole Danube corridor. The members of the DANUBEPARKS network have reached a lot in bringing together interested and motivated representatives of various different protected areas. They have started a process which assembles a big variety of measures and issues concerning the Danube biotope network – e.g. Danube islands, canyons, forests, power lines – where the issue of the dry habitats is one important puzzle piece.

The present Interreg funding will terminate in November 2019. According to the surveys, all members of the DANUBEPARKS dry habitat network declared their interest in a continued participation, which lays the groundwork for a possible follow-up project to continue the efforts to establish a dry habitat corridor network along the Danube. The consultations in the network about the next strategic approaches are in process. Therefore, the following considerations are meant to illustrate possibilities and challenges for future efforts to build a Danube biotope network of dry habitats.

6.2.1 Next steps in GIS analysis

For sure, one very important next step is to gain more information about quality, quantity and location of the dry habitats in the Danube corridor. The present results give just a very rough picture because of the lack of detailed and freely available information.

Nevertheless, the GIS analysis could show where it is highly probable to find valuable dry habitats. Using this knowledge, efforts for detailed mapping can be concentrated on the promising areas, the hot spots. Additionally, it is important to gain more information about highly endangered areas.

As the data basis gives only little knowledge about the conservation status, it is crucial to get access to more detailed data. Because of the EU Habitats and Birds Directive many of these details are known but are not accessible freely. The same applies to results of biotope mappings. The respective national authorities, especially those responsible for nature conservation, should be asked to provide any useful data.

Furthermore, the CLC data used in the GIS analysis dates were from the year 2018. The announced updates for CLC data in the course of 2020 will bring improvements in MMU from 25 to 1 ha. Consequently, an update of the GIS analysis using the same methods could produce an output with a far better precision in enabling a better detection of small-scale, potential habitats and therefore improving analysis quality. It could possibly even make the use of RPZ data obsolete.

Later this year, the EEA announced to publish a number of modelled datasets of suitable areas for EUNIS habitats which are currently under revision. These datasets will include forest, heathland, and grassland sections, and could pose, together with the new CLC dataset, an interesting option for further analysis in a possible dry habitat follow-up project.

Using the achieved results and complementing them with more detailed data, it is possible to execute GIS processes for exploring biotope networks described in chapter 6.1.

6.2.2 Next steps in implementing concrete measures

The present results of the GIS analysis show where most likely highly valuable dry habitats are located. As the resources of the network are limited, it is advisable to focus on those dry habitats which are on the one hand very valuable and on the other hand lie within or near the boundaries of the DANUBEPARKS conservation areas. Especially those valuable habitats which are endangered by conversion, neglect or intensification need to be taken into consideration. The first priority is to guarantee the survival of the existing valuable habitats by implementing maintenance measures. As second priority, measures for closing gaps in the biotope network can be undertaken.

It is advisable to start processes for closing biotope network gaps in areas where there is an accumulation of highly valuable but fragmented habitats and to analyze the potential as stepping stones of dry habitats which lie in other protected areas. The development and establishment of dry habitats on areas where the site conditions are not suitable should be considered only as exception. Especially the development of dry habitats on formerly intensively cultivated land where the nutrient content of the soil exceeds many times the prerequisites for most xerophilic species is not recommendable. In these cases it is necessary to remove huge amounts of topsoil or to extract step by step the nutrients by cultivating nutrient-demanding plants and removing all vegetation for many years.

Many times, the efforts to develop, enhance, and maintain dry habitats require a great deal of time. Consequently, the best way to overcome deficiencies in biotope networks and to sustain the results is to acquire the most suitable areas. However, the Danube corridor is in most areas densely populated or intensively agriculturally used. Some of the biggest and most vibrant European cities are located along and around the Danube. Accordingly, the competition for land is high just like the prices. The acquisition of land is an expensive, complex, and time consuming challenge.

Another topic that needs to be addressed is the question how management and maintenance of open areas can be organized. Most dry habitats are hardly profitable for farmers because of the normally low nutrient content of their soils. Therefore, it can be an attractive offer to contract farmers and compensate them for implementing measures of maintenance. Nonetheless, such a cooperation can only be effective when the cooperation is long-term oriented. Therefore it is recommendable to explore other possibilities for habitat maintenance measures. One option that could be explored is the establishment landscape management associations like in Germany. These associations are non-profit organizations which organize and coordinate measures of landscape maintenance or conservation. They aim to preserve the diverse and species-rich cultural landscapes, to support local farmers in acquiring funding and to strengthen regional economic cycles. The management board consists in equal share of communal politicians, farmers and conservationists.

If there is no possibility to implement measures to close gaps within the Danube corridor itself, it is necessary to take into account so called "bypass-solutions". This means to use suitable biotopes beyond the corridor as stepping stones and to connect Danube biotopes not directly along the river but diagonally for example in areas

where less with land-use conflicts can be expected. Thus, functionality of the habitat network can be maintained even when there is no option to realize a direct corridor.

The network can profit from the experiences collected by the members in the fact sheets which are listed in annex I. Many different actions were carried out and described in detail revealing success as well as failure, thus giving a practical lessons learned report.

Some of the DANUBEPARKS members already have concrete plans for next measures. In the protection area of Donauauwald, it is provided to expand the pasture by sheeps and goats. Therefore, a more intense instruction of shepherds and the installation of necessary infrastructure (watering places, fold yards, connecting pathways) are evident.

Generally, an intensification of protection and management is almost everywhere linked to appropriate funding, education and information of the concerned persons as well as the creation of jobs at the administration of the protection areas for controlling and management to relieve the current staff.

6.2.3 Next strategic steps

One of the most important issues is to find financial support to continue already running projects and to start new ones. The surveys revealed that the financing of the management activities for dry habitats of our members originates from various sources. Besides regular income like the budget of the protected areas, a lot of our members rely on more temporally limited funding like EU-funds (e.g. for rural development) or funding for conservation projects (e.g. LIFE+) to carry out conservation measures for dry habitats. These temporal funding options are essential because they often provide the basis for setting up specific conservation projects and measures, but since most of them are granted just for a specific amount of years they will always bring uncertainties regarding the long-term funding security of projects. Thus, it is advisable to search for new ways of funding to make projects or measures less dependent on temporally limited funding and give them more long-term perspective.

One option to avoid large spending are volunteering programs. These programs are already applied by some of our members and can pose an interesting option to save costs for particular management activities. Some habitat maintenance measures for instance don't require specific knowledge (like clearing forest edges, see fact sheets) and are therefore suited to be introduced to interested citizens. Financing is and remains one of the most important challenges to secure effective and long-term conservation measures. Apart from the mentioned examples, there are many different other sources of funding on various levels. The different organizations set different prerequisites for obtaining support. Examples for further funding possibilities beyond LIFE and Interreg at EU level are:

- European Agricultural Fund for Rural Development (EAFRD)
- European Regional Development Fund (ERDF)
- Liaison entre actions de développement de l'économie rurale (LEADER)

The heterogeneity of the network members in view of their institutional framework is on the one hand an advantage for all partners as it brings together different perspectives and experiences. On the other hand, the heterogeneity is a challenge as the available resources beyond the common funding – regarding e.g. staff, land use

rights and political impact – are not spread evenly. As mentioned before, all members of the DANUBEPARKS dry habitat network declared their interest in participating in a possible follow-up project; however, for some of them this is depending on preconditions regarding the extent of work that is required. Especially members of regions in the lower course of the Danube mentioned that a continued participation of them would just be feasible if the effort connected with it is low, indicating a difference in resource availability of organizations in these countries. This is a factor that has to be taken into account in the further strategic planning of the dry habitat network. The members of the DANUBEPARKS network need to come to an understanding if they want to continue all their efforts jointly in the same speed or if they want to combine the joint efforts with separate more ambitious efforts of one or more network members.

It is necessary to gain more like-minded organizations and institutions as associates in order to pool resources, knowledge and political impact. Among these associates there can be public as well as non-profit institutions. Cooperation is also possible with institutions with no direct thematic link. For instance, public institutions which are in charge of flood protection can be important associates as the dykes can be developed as valuable dry habitats and as effective corridor for the spread of xerophilic species. The experiences of the network in developing and maintaining dry habitats can be very helpful for the other institutions leading to a win-win-situation. Furthermore, the proliferation of dry habitats can cause synergetic effects with the promotion of tourism as they often form very aesthetic landscapes or landscape elements. As many measures to enhance and develop dry habitats require an extensification of land use, the water quality of the groundwater is normally improved in the context of biotope network measures. These synergetic effects need to be communicated to the respective institutions in order to gain associates.

6.3 Examples of setting up dry habitat corridors

The following projects can serve as good examples of realizing dry habitat networks. They represent conservation and management efforts on different scales, in different regions, within the Danube corridor and beyond

6.3.1 The EU Strategy for the Danube Region (EUSDR)

The EU Strategy for the Danube Region (EUSDR) is the second macro-regional strategy of the European Union after the Baltic Sea strategy and was launched in 2011. The EUSDR aims for development and harmonization of the whole Danube region by extending collaborations between Danube countries and regions and integrating communal and regional participants. The four pillars of the strategy are connection of the regions, protection of the environment, building of prosperity and strengthening of the region, each of them containing two or three priority areas (EU, 2016).

The Bavarian State Ministry of the Environment and Consumer Protection is one of the coordinating authorities of the priority area “Biodiversity and Landscapes (Nr. 6)” and therefore responsible for the implementation of concrete measures to maintain and enhance biodiversity in the Bavarian part of the Danube. That is why the ministry created a “Master Plan Bavarian Danube Habitats” (StMUV, 2017), a plan for the development and selection of projects to implement the aims and ideas of the

EUSDR into specific projects. To set up this master plan, a systematic approach is followed: First, guiding principles for several distinctive landscape features (e.g. floodplains, cultural landscape in the valley area, slopes and terrace edges) were defined. At the moment, key projects are being realized that represent concrete measures to reach the guiding principles.

In the categorization of the master plan, dry habitats are contained within the landscape features of steep slopes and terrace edges, because these are located on dry and sunny places along the Danube. In combination with the geological conditions of the sites and extensive land-use, precious dry habitats with characteristic communities (especially of plants) evolved over time. However, nowadays the distribution of these habitats together with the typical communities is rather scattered and isolated in the landscape. Especially semi-arid grasslands, which evolved through extensive grazing and which were formerly widespread along the Danube, are nowadays very rare due to land-use change (e.g. abandonment of extensive farming techniques, reforestation). Furthermore, the loss of ecological stepping stones and the decline of migratory sheep farming, which provided an important dispersal mechanism, were critical developments for the dry habitats. That is why the guiding principle of the master plan for the dry habitats in the Bavarian steep slopes and terrace edges is focused on the re-establishment of a coherent, high-quality network of these dry habitats. Key to achieve this goal is the development of concepts for the continuation of adjusted land-use for open areas and the avoidance of abandonment of extensive land-use methods as well as preventing land-use intensification.

The guiding principles are conducted within specific projects. Two project ideas are mentioned to be key examples for the development of dry habitats:

- Sunny Danube Sites: Dry habitats at Danube Gorge between Regensburg and Jochenstein (Key Project 12)
- Sunny Danube Sites: Protection and Optimization of south exposed Danube steep slopes between Bertoldsheim and Ingolstadt (Key Project 13)

Measures to reach a coherent network of dry habitats include for example:

- Securing the remaining of dry-warm habitats
- Ecological restoration of suitable habitats
- Forest conversion (clearing of open-area biotopes to promote xerophilic and thermophilic species), establishment of a maintenance management
- Promotion of extensive viticulture
- Specific conservation measures dedicated to endangered species
- Land acquisition
- Visitor guidance, public relations

Apart from providing concrete measures for establishing a dry habitat network, the example of Bavarian implementation of the EUSDR gives a good example of how to take a macro-regional strategy and implement it into a regional framework.

6.3.2 Network of heathland habitats in Munich, Germany

The association „Heideflächenverein Münchner Norden e.V.“ strives to preserve and enhance the characteristic heathlands in the north of Munich, Germany. Their conservation efforts are a good example of realizing a dry habitat network on local scale.

Since the sole maintenance of the small core heathland and nature conservation area “Garching Heide” could not fulfill the conservation targets for biotopes and species, measures for expansion and connection became necessary. That is why the association purchased and rented around 62 ha of land to develop and expand the existing heathland and to connect it to adjacent conservation areas.

This included for example the establishment of a connection to the close-by conservation area “Mallertshofer Holz”, which contains also heathlands. In this case, new areas in between the two conservation areas were acquired and a route for sheep grazing created. Through the wandering of the sheep between the conservation areas and along the new stepping stone areas, exchange of species through sheep as biotic vectors was made possible (see Figure 20).

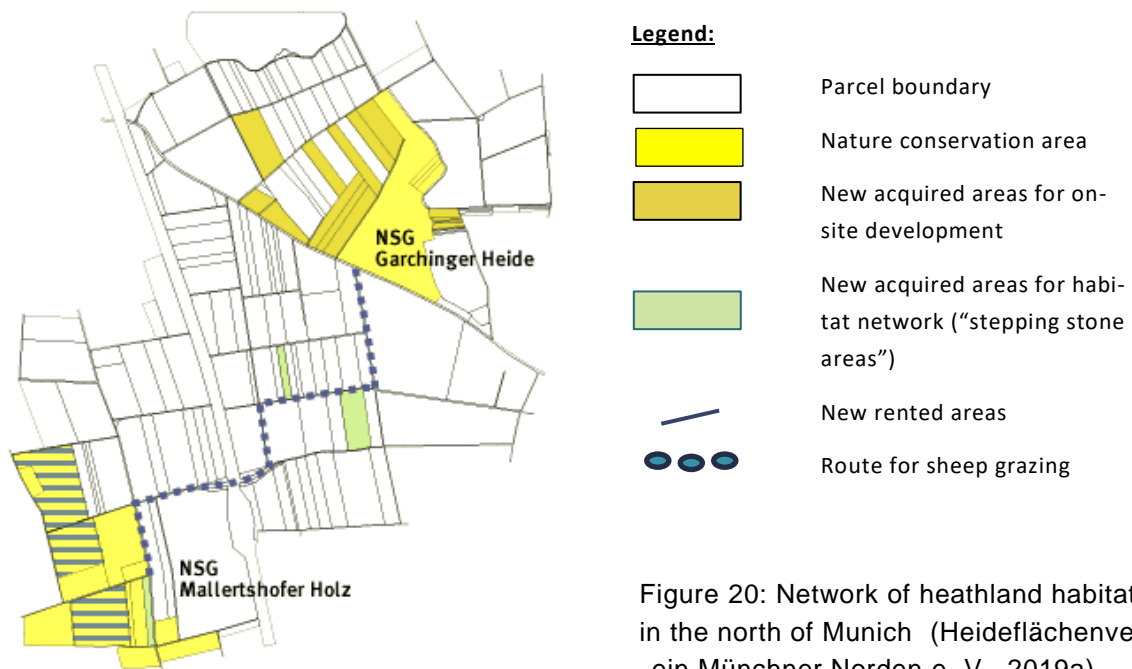


Figure 20: Network of heathland habitats in the north of Munich (Heideflächenverein Münchner Norden e. V., 2019a)

In order to transfer the heathland target species of the core area “Garching Heide” to newly acquired areas for on-site development, top-soils of humus-rich grounds were removed and mowed grass from the core area was transferred to the remaining protoil. For species that could not be transferred with this method additional seeding was carried out. The association highlighted the importance of using locally grown seeds with autochthonous origin, since nowadays a wide range of seed mixtures with unknown origin is offered in the market. These mixtures often cause problems like genetic modification of regional plant communities or the dissemination of invasive species. In the first three years, the measures for maintenance on the new sites were implemented not on a rigid regular basis but according to the respective development of the vegetation. After the third year a regular maintenance through mowing or sheep-grazing has been established.

Regarding the maintenance of existing areas with established vegetation, measures like sheep grazing and mowing are carried out on a yearly basis. For example, a

stripe mowing takes place which leaves out different parts of the respective site each year to help small animals hibernating. Additionally to the mowing, the soil is getting tilled by a harrow to remove the covering, matted layer consisting of moss and dead weeds to create open spots for non-competitive, low-growing species that are characteristic for the area. In former times, this effect was reached through the grazing sheep, which created these open spots automatically by trampling.

The project was supervised by the Technical University of Munich, which monitored the success of the efforts. In total, the high number of 68 target species could be spread from the core area "Garching Heide" to the new development areas. The long-term trusteeship of the Heideflächenverein Münchner Norden guarantees continuity for the conservation efforts. (Heideflächenverein Münchner Norden e. V., 2019a, 2019b)

6.3.3 Network of sandy habitats in Franconia, Germany

The project "Sandachse Franken" (Sand Axis Franconia) can serve as model for enhancing habitat networks on big scale. It is one of the biggest conservation efforts of this kind in Bavaria, aiming to protect and connect sandy habitats along the rivers Regnitz, Pegnitz and Rednitz between the cities of Bamberg and Weißenburg extending to a total length of 100 km from north to south. The project was led by the Bavarian fund for nature conservation BUND, the Landesbund für Vogelschutz in Bayern (Bavarian association for bird protection) and the Deutscher Verband für Landschaftspflege (German federation for landscape maintenance). They collaborated with different project partners like cities, counties, companies association or public institutions.

One of the main aspects of this project was to purchase and rent sandy habitats in order to preserve and develop these sites and linking them to a big network of sandy habitats. For example, areas along electric pipeline routes were bought and sandy biotopes created. These biotopes were maintained by ecological route management in collaboration with the owners and operators of the pipeline routes. The elongated structure of the new habitats along the pipeline routes form important corridors and represent an important puzzle for the whole biotope network.

Regarding the management of the sandy habitats, classical maintenance measures like mowing, grazing or the removal of shrubs played an important role for the project sites. Additionally, new ways of managing sandy habitats were pursued: In former times, several sandy biotopes within the network were used as military training areas.

On the one hand, this special form of land-use excluded typical mostly negative human influences like fertilization, mining and fragmentation. On the other hand, military training activities created open spaces and prevented excessive development of shrubs so that valuable habitats like heathlands or sandy, nutrient poor grasslands could be preserved by this special form of land use. In order to maintain the good conservation status of the habitats in the former military training areas, Przewalski's horses (*Equus ferus przewalskii*) were used to replace and imitate the landscape conservation by military use.

Further measures to maintain and develop the habitat network were for instance the restoration of obstructed river areas to promote natural establishment of sandy habi-

tats, the purchase and maintenance of sandpits and the seeding of special autochthonous seed mixtures to create new sandy, nutrient-poor grasslands.

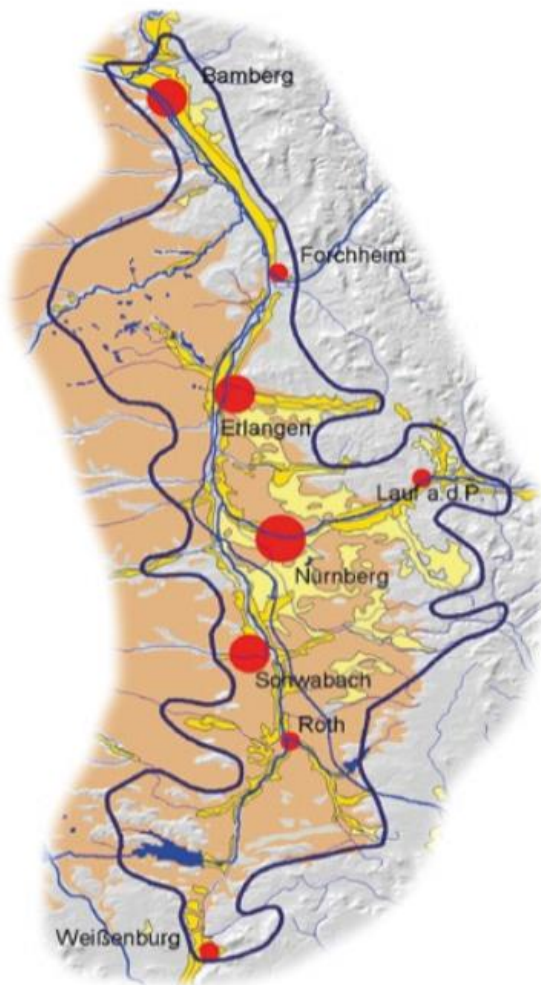


Figure 21: Network of sand habitats in Franconia (Bund Naturschutz in Bayern e. V., 2015)

In total, an area of around 500.000 m² was purchased or rented, another 1.000.000 m² of sandy habitats in possession of the project partners were established. Over 2.000 individual measures in the different sand biotopes were taken.

One of the key factors for success was the funding of the BUND which provided 2.400.000 € over the project duration of seven years (2000 – 2007). Complemented with capital of the various project partners, there were enough funds to establish a project office staffed with three employees who were in charge of the establishment of contacts to land owners, negotiations and the coordination with project partners. They significantly assumed responsibility from the local conservation authorities and associations. Fortunately, after the end of the funding period, the project received further financial support from the BUND, the project leaders and partners to continue its work. However, this support fell below the amount of the starting period (400.000 € from 2007 until 2014). Thus, project activities had to be reduced significantly. This example illustrates that continuous funding plays a vital role when it comes to the durable establishment of a habitat network on a regional scale.

6.3.4 Management of dry grasslands by mowing and shrub removal, Bulgaria

At Persina Nature Park, 1.2 ha dyke and 4.8 ha former dry grasslands were overgrown with shrubs and valuable species were threatened by invasion of alien bushes. By mechanical mowing and the removal of bushes and invasive species a first step was done to re-establish mesophilic to xerophilic grassland communities. Additionally, the removal of the shrubs on the dykes means an easier maintain of the dykes and a reduction of damages by roots.

A final conclusion about the effort of these measures cannot be given yet, but there is the intention to expand these measures on longer dyke section and at large grasslands. At that scale the measures are able to contribute at the recreation of a corridor along the dykes and maybe between the grasslands.

6.3.5 Cross-border grazing as an alternative management for dykes, Austria

At Donau-Auen National Park, grazing on dykes at an area of 10 ha was reestablished for a project period in 2018 and replaced the previous mowing. The dykes are a corridor connecting the surrounding protected semi-dry grasslands. For the preservation of its ecological functions regular mowing and the removal of the crop is necessary. Leaving the crop leads to nutrient enrichment and to a felting of the vegetation and represents a relevant problem from an ecological point of view. Grazing makes the removal of the crop superfluous and therefore represents an interesting alternative or complementary maintenance measure to mowing as well as a cost-effective approach compared to the removal and disposal of biomass on the dyke along Donau-Auen National Park. In 2019, grazing should continue with an increased pasture size. But even after the first year, grazing seemed to be an alternative approach for the management of a bio-corridor, although supplement work was necessary for aftercare to remove woody plants and herbaceous plants that were ignored by the sheep.

7. Literature

- BAYERISCHES STAATSMINISTERIUM FÜR UMWELT UND VERBRAUCHERSCHUTZ (2012). Bayern Arche Donau – Lebensader im Herzen Europas. Retrieved from https://www.stmuv.bayern.de/themen/naturschutz/biodiversitaet/naturraum_donau/doc/bericht2012.pdf [last access on 11.09.2019].
- BAYERISCHES STAATSMINISTERIUM FÜR UMWELT UND VERBRAUCHERSCHUTZ (2017). Lebensraum Bayerische Donau - Masterplan zur Entwicklung und Auswahl von Projekten zur Umsetzung der Europäischen Donaunraumstrategie in Bayern. Retrieved from https://www.stmuv.bayern.de/ministerium/eu/makroregionale/doc/masterplan_eu-donaunraumstrategie.pdf [last access on 06.09.2019].
- BFN - FEDERAL AGENCY FOR NATURE CONSERVATION GERMANY (2017): Federal Green Infrastructure Concept. BfN, Bonn. Retrieved from https://www.bfn.de/fileadmin/BfN/planung/bkgi/Dokumente/BKGI_Broschuere_englisch.pdf [last access on 17.09.2019].
- BUND NATURSCHUTZ IN BAYERN E.V., LANDSCHAFTSPFLEGEVERBAND MITTELFRANKEN E.V. (2015): SandAchse Franken – Sandlebensräume zwischen Weißenburg und Bamberg. Retrieved from https://www.bund-naturschutz.de/fileadmin/Bilder_und_Dokumente/Themen/Natur_und_Landschaft/SandAchse_Franken/Broschuere-Sandlebensraeume-zwischen-Wei%C3%9Fenburg-und-Bamberg.pdf [last access on 18.03.2019].
- BURKHARDT, R., BAIER, H., BENDZKO, U. & OTHERS (2004): Empfehlungen zur Umsetzung des § 3 BNatSchG „Biotopverbund“ – Ergebnisse des Arbeitskreises „Länderübergreifender Biotopverbund“ der Länderfach-behörden mit dem BfN. In: Naturschutz und Biologische Vielfalt (2): 5-57
- COVALIOV, S. (2018): "Pastures specific for dry habitats and orchids flagship species from D.D.B.R.", 21 pages. Report. Tulcea, România.
- DANUBE PARKS CONNECTED (2017): Results of a Survey about dry habitats before the 1st workshop in Kopački rit; unpublished
- DAVIES, J., POULSEN, L., SCHULTE-HERBRÜGGEN, B. & OTHERS (2012): Conserving Dryland Biodiversity. xii +84p. Retrieved from https://www.iucn.org/sites/dev/files/content/documents/conserving_drylands_biodiversity_iucn_unccd_book_1_0.pdf [last access on 13.09.2019].
- DIEZ J. M., D'ANTONIO C. M., DUKES, J. S. & OTHERS (2012): Will extreme climatic events facilitate biological invasions? *Front. Ecol. Environ.* 10: 249–257. Retrieved from <https://doi.org/10.1890/110137> [last access on 16.09.2019].
- ENGELMANN, W., GÜNTHER, R. & OBST, F.J. (1985): Lurche und Kriechtiere Europas. – Radebeul (Neumann).
- EUROPEAN COMMISSION DG ENVIRONMENT (2007): Interpretation Manual of European Union Habitats. Retrieved from https://ec.europa.eu/environment/nature/legislation/habitatsdirective/docs/2007_07_im.pdf [last access on 04.03.2019].
- EUROPEAN COMMISSION (2013): Building a Green Infrastructure for Europe. European Union Publications Office, Luxembourg. Retrieved from <https://doi.org/10.2779/54125> [last access on 17.09.2019].
- EUROPEAN ENVIRONMENT AGENCY (EEA) (2017): Copernicus Land Monitoring Service – Local Component: Riparian Zones. Retrieved from <https://land.copernicus.eu/user-corner/publications/rz-flyer-a4/view> [last access on 09.01.2019].

- EUROPEAN ENVIRONMENT AGENCY (EEA) (2019): About the European nature Information System, EUNIS. Retrieved from <https://eunis.eea.europa.eu/about> [last access on 04.03.2019].
- EUROPEAN ENVIRONMENT AGENCY (EEA) (2019): Nationally designated areas (CDDA). Retrieved from <https://www.eea.europa.eu/data-and-maps/data/nationally-designated-areas-national-cdda-13> [last access on 04.03.2019].
- EUROPEAN RED LIST OF HABITATS (2016): Fact Sheets. Retrieved from <https://forum.eionet.europa.eu/european-red-list-habitats/library/> [last access on 04.03.2019].
- EUROPEAN UNION (2016): Danube Region Strategy: Success Stories. European Union Publications Office. Retrieved from <https://www.danube-region.eu/communication/publications> [last access on 06.09.2019].
- FOLEY, J. A., DEFRIES, R., ASNER, G. P. & OTHERS (2005): Global Consequences of Land Use. *Science*, Vol. 309, Issue 5734, pp. 570-574. Retrieved from <https://doi.org/10.1126/science.1111772> [last access on 16.09.2019].
- HEIDEFLÄCHENVEREIN MÜNCHENER NORDEN E.V. (2016): Pressemitteilung: Erste Pflegemaßnahmen in der Garchingener Heide. Retrieved from https://www.heideflaechenverein.de/service/aktuelles/2016-02-22_Pressemitteilung_Striegeln_GH.pdf [last access on 13.03.2019].
- HEIDEFLÄCHENVEREIN MÜNCHENER NORDEN E.V. (2019a): E+E-Vorhaben. Retrieved from https://heideflaechenverein.de/projekte/ee_vorhaben.html [last access on 04.03.2019].
- HEIDEFLÄCHENVEREIN MÜNCHENER NORDEN E.V. (2019b): Erprobungs- und Entwicklungsvorhaben (E+E). "Sicherung und Entwicklung der Heiden im Norden von München". Retrieved from https://heideflaechenverein.de/projekte/Flyer_E+E_Entwicklung_Heiden.pdf [last access on 04.03.2019].
- IPCC CLIMATE CHANGE (2013): The Physical Science Basis. Working Group I Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. 2013. Cambridge: Cambridge University Press.
- ICPDR – INTERNATIONAL COMMISSION FOR THE PROTECTION OF THE DANUBE RIVER (2015). The Danube River Basin District Management Plan. ICPDR Secretariat, Vienna, Austria. Retrieved from <http://www.icpdr.org/main/sites/default/files/nodes/documents/dr bmp-update2015.pdf> [last access on 11.09.2019].
- KAULE, GISELHER (1986): Arten- und Biotopschutz. Verlag Eugen Ulmer, Stuttgart.
- KRETZSCHMAR, HORST (2018): Die Orchideen Deutschlands. Finden und Bestimmen. 3. Auflage, Quelle & Meyer Verlag, Wiebelsheim.
- LAUNERT, EDMUND (1998): Biologisches Wörterbuch: Deutsch-Englisch; Englisch-deutsch. Ulmer, Stuttgart.
- LANG, G. (1994): Quartäre Vegetationsgeschichte Europas. G. Fischer Verlag, Jena.
- LI D., WU S., LIU L. & OTHERS (2018): Vulnerability of the global terrestrial ecosystems to climate change. *Glob. Chang. Biol.* 2018; 24(9): 4095–4106. Retrieved from <https://doi.org/10.1111/gcb.14327> [last access on 13.09.2019].
- LISTL, D., POSCHLOD, P. & REISCH, C. (2017): Phylogeography of a tough rock survivor in European dry grasslands. *PLoS ONE* 12(6):e0179961. Retrieved from <https://doi.org/10.1371/journal.pone.0179961> [last access on 11.09.2019].
- LITZELMANN, E. (1938): Pflanzenwanderungen im Klima der Nacheiszeit. Hohenlohesche Buchhandlung Ferd, Rau.

- MEINDL, C., BRUNE, V., LISTL, D. & POSCHLOD, P. (2016): Survival and postglacial immigration of the steppe plant *Scorzonera purpureata* Central Europe. *Plant Syst Evol* (2016) 302:971–984. Retrieved from <https://doi.org/10.1007/s00606-016-1311-9> [last access on 11.09.2019].
- MILLENNIUM ECOSYSTEM ASSESSMENT (2005): Ecosystems and Human Well-being: Desertification Synthesis. World Resources Institute, Washington, DC. Retrieved from <https://www.millenniumassessment.org/documents/document.355.aspx.pdf> [last access on 13.09.2019].
- MOSS, DORIAN (2008): EUNIS Habitat Classification – a Guide for users. European Topic Centre on biological Diversity. Retrieved from https://www.eea.europa.eu/data-and-maps/data/eunis-habitat-classification/documentation/eunis-habitat-classification-users-guide-v2.pdf/at_download/file [last access on 04.03.2019].
- OBERDORFER, ERICH (1978): Süddeutsche Pflanzengesellschaften. Teil II. 2., stark bearbeitete Auflage. Gustav Fischer Verlag, Stuttgart.
- OBERDORFER, ERICH (2001): Pflanzensoziologische Exkursionsflora für Deutschland und angrenzende Gebiete. 8. Auflage. Verlag Eugen Ulmer, Stuttgart.
- POKORNY, MARIA/ STRUDL, MICHAEL (1986): Trockenrasen als Lebensraum. In: HOLZNER, W., HORVATIC, E., KÖLLNER, E. & OTHERS (1986): Österreichischer Trockenrasenkatalog. „Steppen“, „Heiden“, Trockenwiesen, Magerwiesen: Bestand, Gefährdung, Möglichkeiten der Erhaltung. Grüne Reihe des Bundesministeriums für Gesundheit und Umweltschutz. Band 6. Wien, S 12-14.
- POKORNY, MARIA/ STRUDL, MICHAEL (1986): Trockenrasen des pannonischen Raumes In: HOLZNER, W., HORVATIC, E., KÖLLNER, E. & OTHERS (1986): Österreichischer Trockenrasenkatalog. „Steppen“, „Heiden“, Trockenwiesen, Magerwiesen: Bestand, Gefährdung, Möglichkeiten der Erhaltung. Grüne Reihe des Bundesministeriums für Gesundheit und Umweltschutz. Band 6. Wien, S 36-40.
- RADCHUK, V., REED, T., TEPLITSKY, C. & OTHERS (2019): Adaptive responses of animals to climate change are most likely insufficient. *Nature Communications* 10 (1). Retrieved from <https://doi.org/10.1038/s41467-019-10924-4> [last access on 16.09.2019].
- SOMMERWERK, N., BAUMGARTNER, C., HEIN, T. & OTHERS (2009): The Danube River Basin. in: *Rivers of Europe*, Edition: 1, Chapter: 3. Elsevier, Academic Press, San Diego, pp. 59-112.
- WALTER, H. & STRAKA, H. (1970): Arealkunde — Floristisch-historische Geobotanik, 2nd Ed. Ulmer, Stuttgart.
- WALTHER, G. R., ROQUES, A., HULME, P. E. & OTHERS (2009): Alien species in a warmer world: risks and opportunities. *Trends Ecol. Evol.* 24: 686–693. Retrieved from <https://doi.org/10.1016/j.tree.2009.06.008> [last access on 16.09.2019].