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DANUBEPARKS – Danube River Network of Protected Areas Danube Dry Habitat Strategy

Aiming at the reinforcement of a network of dry habitats

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List of abbreviations

EUSDR	EU Strategy for the Danube Region
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
DTP	Danube Transnational Programme
PAC	Priority Area Coordinator (of the EUSDR)
CNPA	Carpathian Network of Protected Areas
ALPARC	Alpine Network of Protected Areas
WWF-DCP	World Wildlife Fund - Danube-Carpathian Programme

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 attempt by 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, present and future corridor for species migration, restoring ecological connectivity of the Danube dry habitats will be a key factor in preserving dry habitat species along the river, maintaining genetic diversity among populations and thus retaining the species' capacity for adaptation to environmental change, which is especially important considering the imminent threat of climate change.

To identify and illustrate semi-dry to dry habitats along the Danube, a GIS analysis using current data from 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 confirmed dry habitats along the Danube is considered quite low, in so far as the quantity and quality of data were adequate for conclusions to be drawn. 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 these other sites is very often too small or the data available are insufficient or non-existent to allow inclusion. Moving forward, more flagship species should be identified and tracked in order to allow N2K sites to provide more information regarding possible hot spots of dry habitat.

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 to the public) and (b) by gathering new data through mappings on more detailed scales and along the entire corridor. In this regard, previously announced improvements in CLC and EUNIS data availability and resolution could provide new and more precise input for a possible follow-up analysis. Furthermore, the orchid species should also be mapped systematically and data made available to experts to improve the data base.

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 and the organization of maintenance measures. Inspiration can be gained from existing dry habitat network projects and measures presented in this paper, such as 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.

This strategic paper aims to constitute a useful and inspiring first step towards 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 relies 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 and to lay 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 was initiated by the members of DANUBEPARKS – Network of Protected Areas in order to counteract habitat fragmentation along the Danube River. Funded by the European Union within a project of the Danube Transnational Programme (Interreg VB) and based on the objectives of the EU Strategy for the Danube Region (EUSDR) the campaign aims to restore and maintain the Danube-wide connectivity of all habitat elements.

Dry habitats are part of any natural river system and are usually 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 dry habitats of the Danube, which have thus far been scantily considered and to provide information on directly applicable maintenance measures.

The issue of dry habitats will be dealt with by focusing on any habitat that is dominated by species, both flora and fauna that prefer dry habitat conditions (xerophilic species). Additionally, semi-dry habitats that 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 pieces for the dry habitat corridor.

Most of these dry and semi-dry areas

- are nutrient-poor
- are open or semi-open
- are either extensively managed or not managed at all
- are directly or indirectly influenced 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 occupied or dominated by xerophilic or mesophilic-xerophilic species. These forest habitats are an important part of the dry habitat corridor and are therefore considered in this strategic paper as well. Other open habitats that 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 also play an important transition role in the future.

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 first workshop in Kopački rit, in which the members were asked about different topics regarding dry habitats in their own protected areas. The most important results of this survey will be mentioned and discussed in this paper. The members of the network also contributed 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 at the project web page 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 a view into the future by identifying opportunities and remaining obstacles regarding 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 a variety of different biogeographic regions and therefore represents 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 began to re-colonize their original areas starting from their southeastern refugia along the river (Litzelmann, E., Walter & Sranka, 1970; Lang, 2004). For example, this post-glacial re-colonization route along the Danube is assumed to have been taken by dry habitat species like the steppe plant *Scorzonera purpurea* (Meindl et al., 2016), the dry grassland species *Sedum album* (Listl et al., 2017) and the steppe toad *Bufo viridis* (Engelmann et al., 1985). Furthermore, this is still an ongoing process.

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 may be promoted and consequently the species' capacity for adaptation to environmental change can be 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 based on 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. For the most part, dry habitats can be found on southerly exposed, open slopes, where a relatively extreme microclimate that strongly deviates from the surrounding areas prevails. Temperature, humidity and wind speed fluctuate with higher amplitude both throughout the day and seasonally.

2.1.2 Substrate

Another important parameter in the development of dry habitats is the prevailing substrate. Essentially, the potential natural vegetation depends on thickness, nutrient content, water storage capacity, acid-base relationships and heavy metal content of the substrate. These elements 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 in 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 influenced by flowing waters secondary biotopes may result from river dynamics such as sedimentation and erosion.

Sedimentation refers to the inherent processes of rivers transporting naturally occurring material. Sediments consist predominantly of rock in varying grain size, ranging from boulder to very fine sand and mud. As an example, such gravel deposits may accrue where dry habitats like *Brenne* or *Heißlände* can evolve. These habitats are subject to continual 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 storms, fires, pests or parasites can open formerly forested areas where, depending on the resulting site conditions, dry habitat species communities 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 simply forms shallow layers on rock, gravel, sand and loess and the microclimate is dry. Habitats that strongly depend on local soil conditions are edaphic characterized biotopes. Often natural site conditions change on a small scale. Therefore, primary edaphic dry habitats frequently occur in mosaic structures, where, for example, dry grassland alternates with dry shrubs and coppice low forest.

Secondary dry habitats evolve initially from deforestation, mowing and/or 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 that are rather homogeneously structured in contrast to primary dry habitats. In general, secondary dry habitats cover larger spaces than naturally occurring primary dry habitats, and yet their species composition is quite similar to primary dry habitats. Therefore, these secondary habitats need to be included in conservation strategies and measures for maintaining the high natural value dry habitats 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 have been connected to varying extents along the Danube corridor, and this has made reactions to changes in climate possible.

There are no comprehensive mappings of dry habitats along the course of the Danube; however, in a few instances, individual mappings do exist. For example, in the context of the EU-project DANUBEparksCONNECTED, studies regarding xerophilic meadows and orchid species were 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, 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 representation: Heisslands and steep slopes were mentioned primarily 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, rock fields were mentioned by members from all regions along the river, although not as frequently 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. Precise predictions about occurrences and frequencies of these habitats cannot be made due to lack of accurate data. This corridor focuses on the sphere of influence of current or past dynamics of the Danube but also goes beyond it (see Chapter 3). Therefore, some dry habitats that 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 grouped into a single 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 of habitats from the supergroups. Special thanks to all photographers for their permission to include these images.

2.3.1 Halophytic habitats

The habitats within this category are dominated by halophytic (salt-adapted) vegetation and 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. High evaporation of ground water during summer leads 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, there are the salt marshes that 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 more closely resembles 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, Dunatetétlen, Hungary. Photo: Daniel Dítě

2.3.2 Inland dunes, old and decalcified

This category includes usually sparse grasslands on sand drifts of inland dunes and other open landscapes, which lie 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 stops shifting, plant communities with moss, lichen and finally dwarf shrubs (e.g. *Calluna*) establish themselves 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 that 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 plants 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 that are 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 and xerophilic heaths. Most shrub heaths result from intensive agricultural land use. They are not intentionally created but rather reflect unwanted “landscape degradation”. Heaths can thrive under a wide variety of environmental conditions. Shrub heaths occur as part of vegetation complexes in any landscapes with acid rock. On sandy soil the dominant species is *Calluna vulgaris*, while on raw humus *Vaccinium myrtillus* prevails. The development of shrub heaths takes many decades, and some heaths developed during centuries of cultivation through grazing, tilt cutting and fire. For this reason, it is almost impossible to restore destroyed heaths. 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	*Juniperus communis* 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 thrive on mostly shallow, skeletal, nutrient-poor or impoverished soils that are 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 that are only covered with small layers of fine material (e.g. *Brenne* or

Heißlände) as well as those occurring on natural rock outcrops that are rich in heavy metal belong to this category as well.

Natural and semi-natural grasslands can have different origins. 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 supporting 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-growing 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 *Alysso-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 endure aridity predominate. 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 contributes 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 by 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, level but elevated terrains or loess ridges formed by fluviatile erosion and accumulation that preferably have southern exposure.

Respective habitats occurring within the Danube corridor:

Code	Habitat Type
6210	Semi-natural dry grasslands and scrubland facies on calcareous substrates (*Festuco-Brometalia*)
6230	Species-rich *Nardus* grasslands, on silicious substrates in mountain areas (and sub mountain 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 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 screes and moraines consisting of either calcareous and calcschist or siliceous rock which is mostly coarse and destabilized. Often, the screes are located on the slopes of mountains, hills or gorges, and the rock is mixed with fine soil. Both screes of montane to Alpine levels and screes 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 habitats have lower species richness than calcareous screes but ferns can be diverse and luxuriant. Vegetation in the respective habitat types may be completely lacking, but at 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 calcschist screes of the montane to Alpine levels (*Thlaspietea rotundifolii*)
8150	Medio-European upland siliceous screes
8160	Medio-European calcareous scree of hill and montane levels

2.3.9 Rocky slopes with chasmophytic vegetation

This category sums up dry habitats that 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 only partly meet the initially defined requirements for dry habitats, 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 screes or colluviums of slopes. Because of these somewhat extreme site conditions, the woods can be fragmentary and low-growing, sometimes only shrubby, as in the case of Pannonic inland sand dune thicket. Depending on the respective habitat type, the predominant 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 as well.

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, screes 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-Balkanic 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

The category of Mediterranean deciduous forests includes 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 potentially rich herb layer. The habitats mainly include annual, pioneer species well adapted to shoreline dynamics.

Respective habitats occurring within the Danube corridor:

Code	Habitat Type
92A0	*Salix alba* and *Populus alba* galleries
92D0	Southern riparian galleries and thickets (*Nerio-Tamaricetea* and *Securinegion tinctoriae*)

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 wide variety of different host plants – are essential for the existence 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 and adapted to 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 biocoenosis for insect fauna.

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

A detailed description or analysis of the fauna of dry habitats was not the focus of this first step of the Danube dry habitat strategy. Therefore, only brief examples for the fauna of dry habitats are mentioned here. In future projects, the faunistic element should be elaborated in more detail, and it should include links to the occurring habitats. Focus could be centered on species of Annex II (and IV / V) of the Habitats Directive. There, examples of species that highlight the role of the Danube corridor and the Danube itself for their development and survival could also be provided.

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

Briefly, with the goal of simplicity and clarity, 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

Initially, the plan was to analyze only the area actually or potentially influenced by the Danube. This would have placed focus primarily on the riparian zones of the Danube. The next idea was to use elevation models in order to consider the long-term influence that 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 various social and political components that 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 was included in the analysis because the available N2K data 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 only scarcely 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 coarser and more 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 sorted into 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 to be a 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 and exempt from current land use. 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 differ significantly from the CLC and RPZ datasets in several respects. For example, data is not gained by one institution via satellite imagery but is individually submitted by each member state of the 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 regarding their particular delimitation and location. By and large, this intelligence of delimitation and location does exist, but it is retained by each EU member state and not freely available.

3.2.4 European Nature Information System (EUNIS)

In its information system EUNIS, the EEA gathers 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 that it will 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 selected as the starting point of the analysis. In order to gain knowledge about the spatial allocation of dry habitats in the Danube corridor, the distinctive and disparate classes of the three datasets needed to be harmonized and categorized consistently and systematically. Consequently, the 44 CLC land use and land cover classes were divided into 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 actually occur in the Danube corridor. The occurring land use classes were categorized either as DHC, SDH or DHS. Those classes that belonged to neither category were not considered relevant for further analyses; nor were those elements of the DHS where there was no additional proof in the RPZ or the N2K data that a relevant dry habitat existed. If neither the RPZ nor the N2K data assured that the DHS was 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 Corri-dor	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 Corri-dor	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 Corri-dor	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. ≥ 30%)		x
4112	Managed grasslands without trees and scrubs (T.C.D. <30%)		x
4211	Dry grassland with trees (T.C.D. ≥0%)	x	
4212	Mesic grasslands with trees (T.C.D. ≥30%)		x
4221	Dry grasslands without tress 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 (*Juncetalia maritimi*)	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 *Hippophae rhamnoides*	x	
23 Inland dunes, old and decalcified			
2310	Dry sand heaths with *Calluna* and *Genista*	x	
2330	Inland dunes with open *Corynephorus* and *Agrostis* 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 *Salix eleagnos*	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 grass-lands	x	
6 Natural and semi-natural grassland formations			
61 Natural and semi-natural grassland formations			
6110	Rupicolous calcareous or basophilic grasslands of the *Alysso-Sedion albi*	x	
6120	Xeric sand calcareous grasslands	x	
6130	Calaminarian grasslands of the *Violetalia calaminariae*	x	
6190	Rupicolous pannonic grasslands (*Stipo-Festucetalia pallentis*)	x	
62 Semi-natural dry grasslands and scrubland facies			
6210	Semi-natural dry grasslands and scrubland facies on calcareous substrates (*Festuco-Brometalia*) (* important orchid sites)	x	
6230	Species-rich *Nardus* grasslands, on silicious substrates in mountain areas (and sub mountain 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 (*Alopecurus pratensis*, *Sanguisorba officinalis*)		x
6520	Mountain hay meadows		x
8 Rocky habitats and caves			
81 Rocky habitats and caves			
8120	Calcareous and calcschist screes (Geröllhalde) of the montane to Alpine levels (*Thlaspietea rotundifolii*)	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 *Sedo-Scleranthion* or of the *Sedo albi-Veronicion dillenii*	x	
9 Forests			
91 Forests of temperate Europe			
9150	Medio-European limestone beech forests of the *Cephalanthero-Fagion*		x
9170	*Galio-Carpinetum* oak-hornbeam forests		x
9180	*Tilio-Acerion* forests of slopes, screes and ravines		x
91H0	Pannonian woods with *Quercus pubescens*	x	
91I0	Euro-Siberian steppic woods with *Quercus spp.*	x	
91L0	Illyrian oak-hornbeam forests (*Erythronio-Carpinion*)		x

N2K Code	LABEL	Core Habitat (DHC)	semi-dry to dry Habitat (SDH)
91M0	Pannonian-Balkanic turkey oak-sessile oak forests	x	
91N0	Pannonic inland sand dune thicket (*Junipero-Populetum albae*)	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 (*Nerio-Tamaricetea* and *Securinegion tinctoriae*)		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 is 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 that supported this effort. 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. In particular, 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 visually exemplify the availability of data for the Danube corridor at the Danube Bend nearby Vác in Hungary. The maps show only the relevant habitats in each dataset. The N2K map shows special areas of conservation which contain relevant habitats, but these habitats do not – in most cases – occupy 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 in order to estimate the percentage of the Danube corridor that the data sources cover.

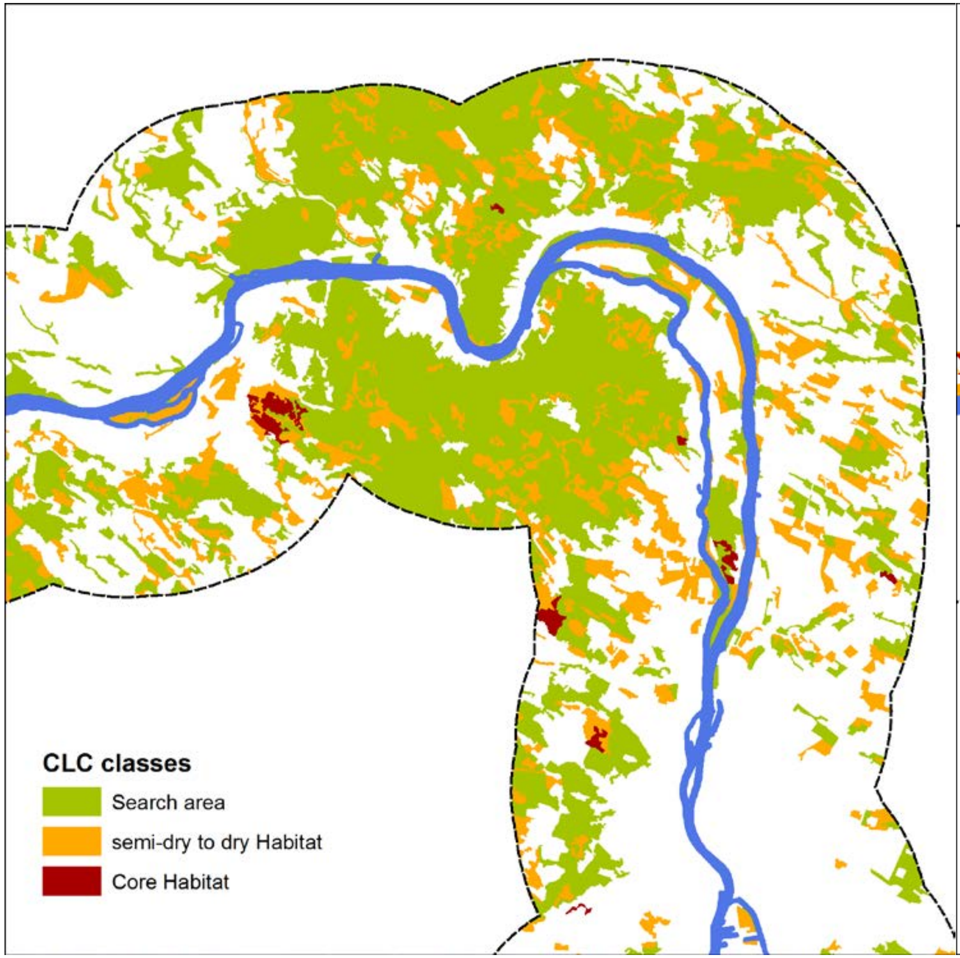


Figure 8: Information yield of CLC data

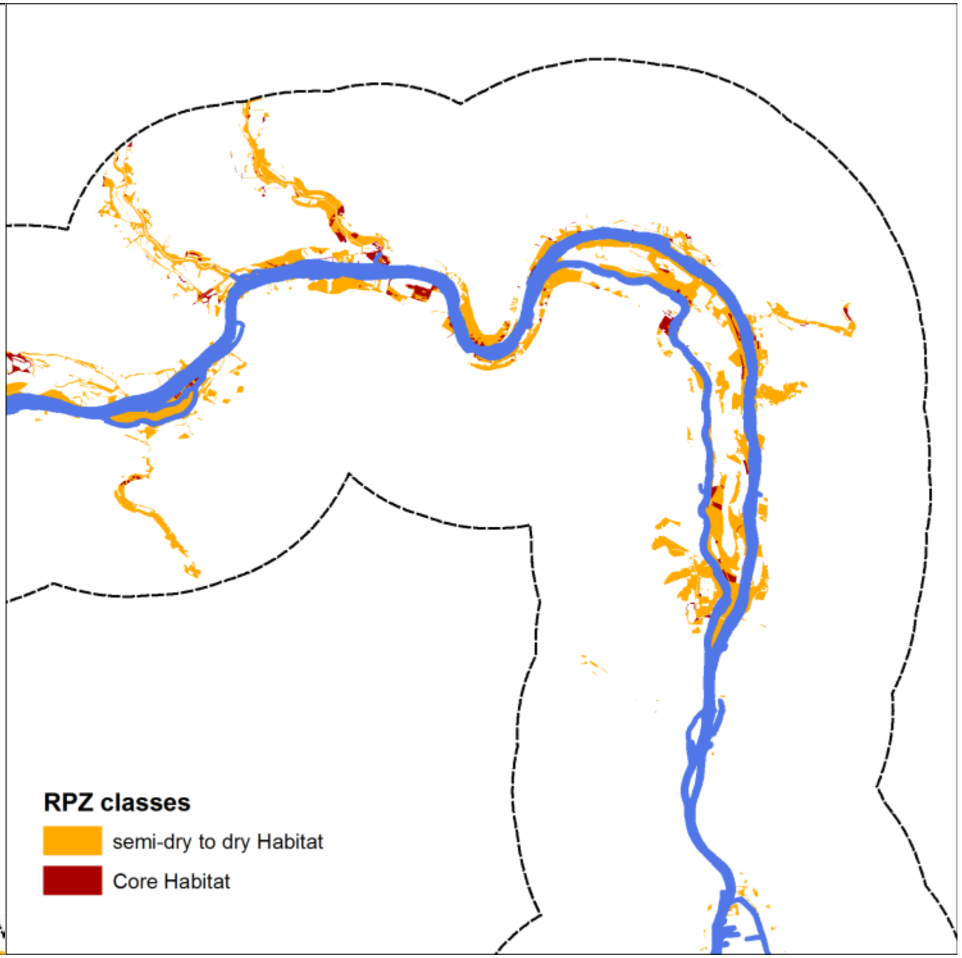


Figure 9: Information yield of RPZ data

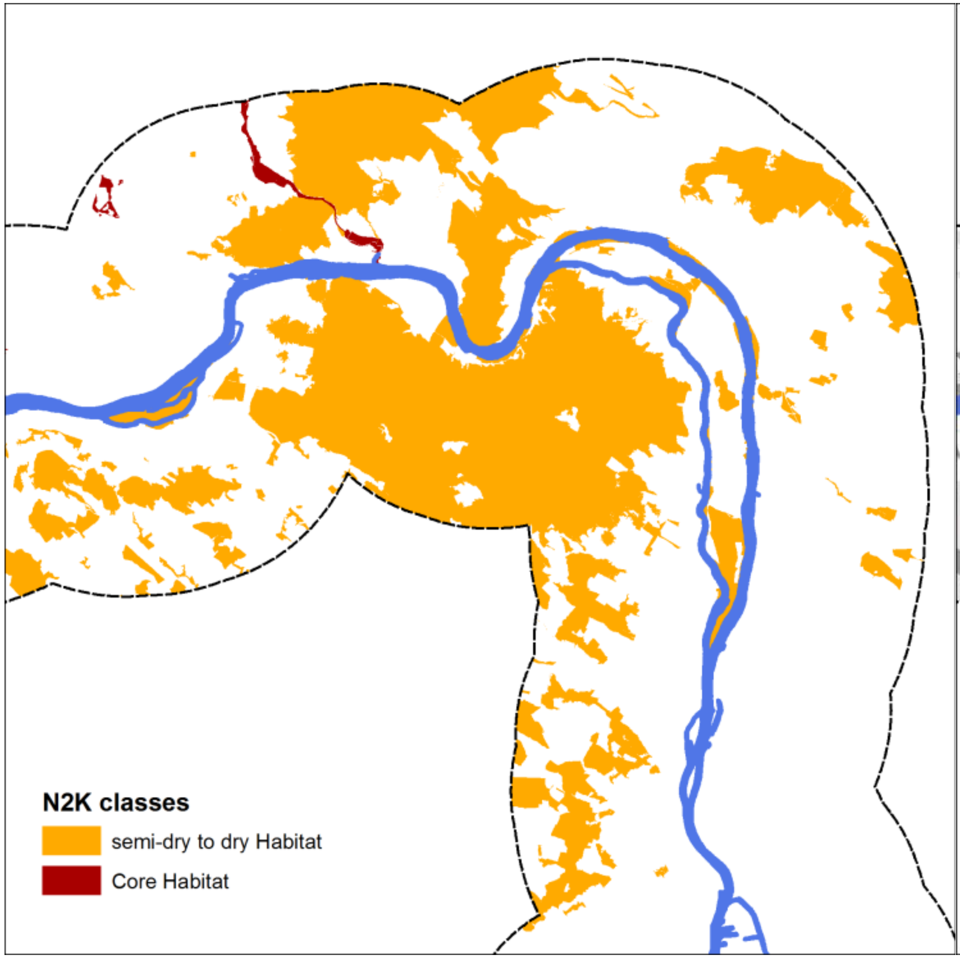


Figure 10: Information yield of N2K data

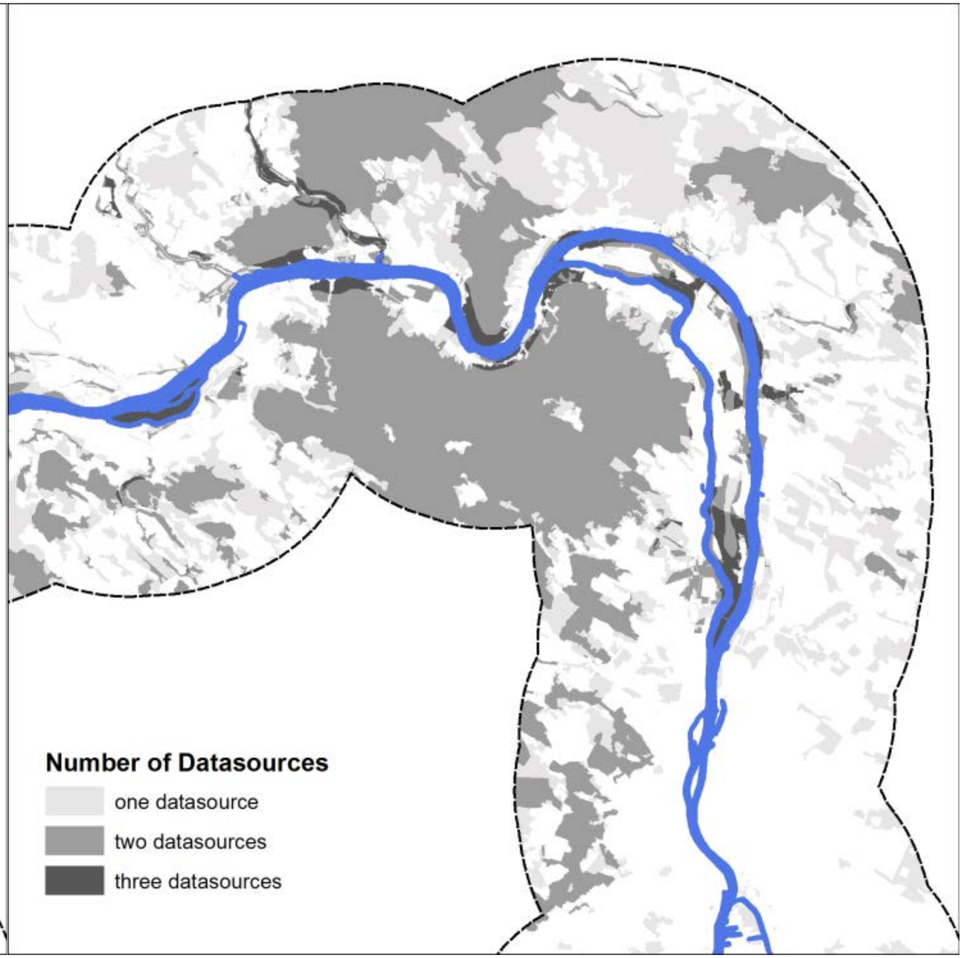


Figure 11: Number of available data sources

3.5 GIS valuation for Danube dry habitats

As mentioned above, there is no secure information regarding 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 covered in 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, the next step was to develop a tool to bring the information of CLC, RPZ, and N2K together in a consistent valuation system. For this purpose, a matrix was developed that 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

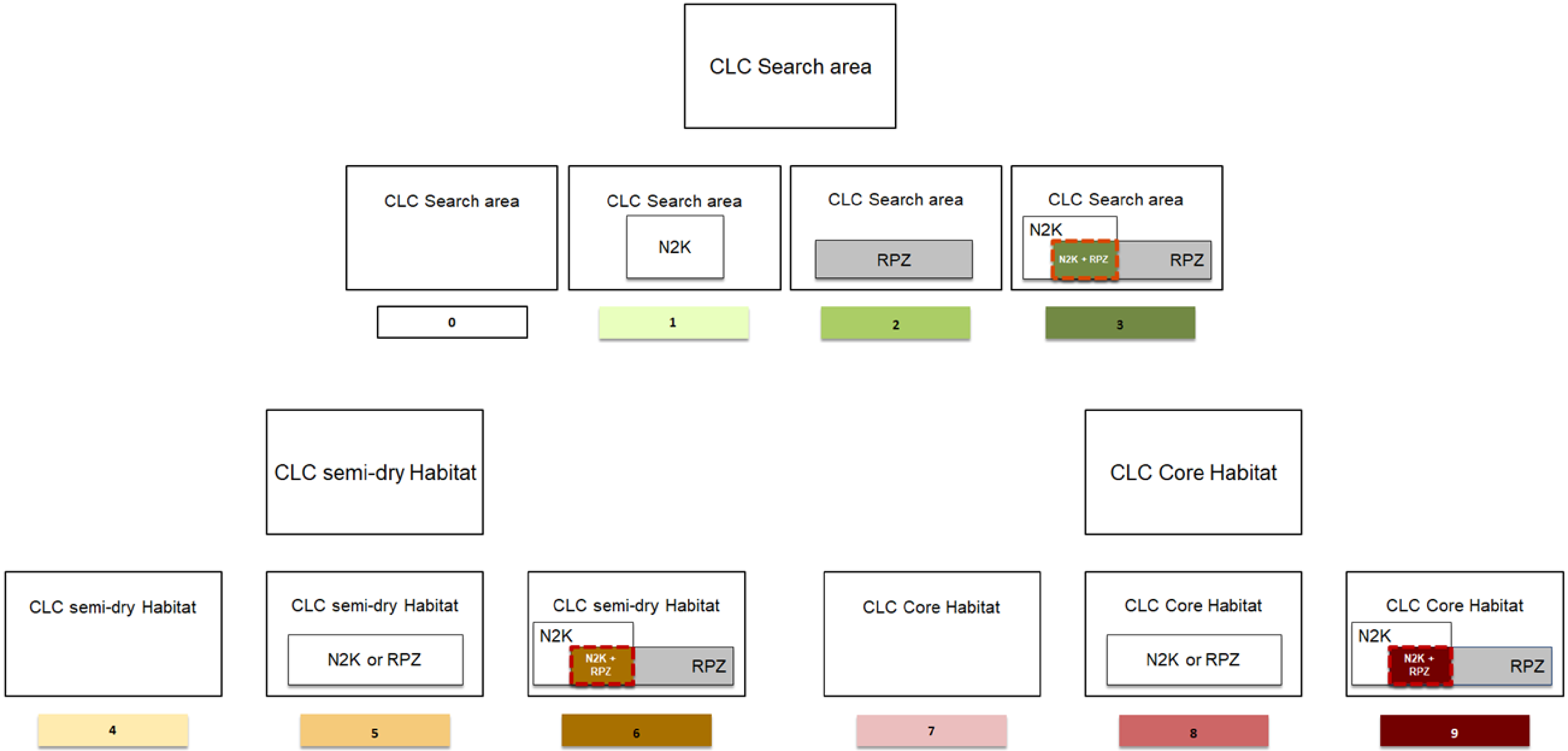


Figure 12: Matrix principle

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

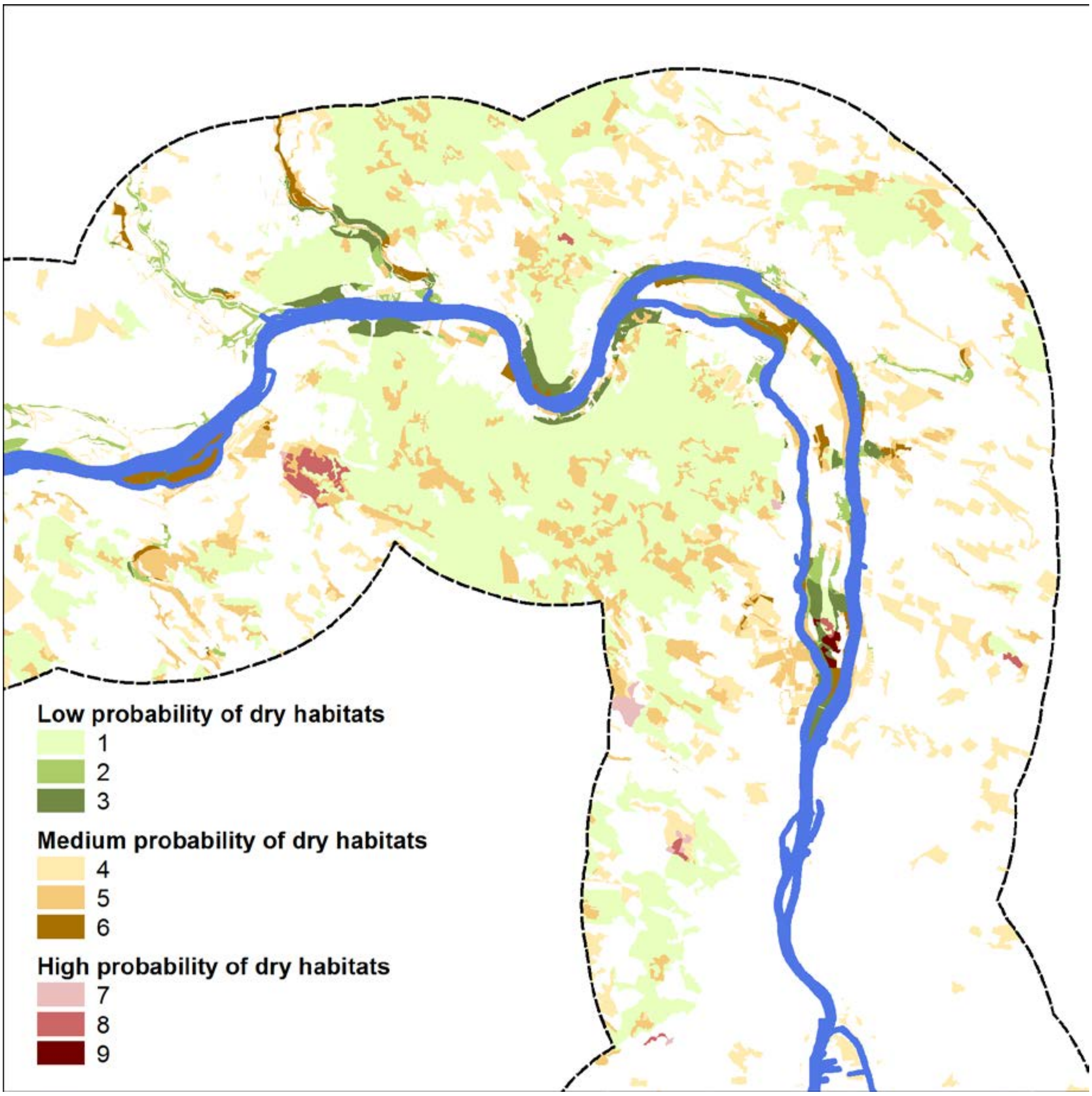


Figure 13: Matrix results of the Danube Bend (class 0 is not visualized)

3.6 Quantitative and qualitative overview of Danube dry habitats

The data basis facilitates 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 lacking 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

		Probability (%) of DANUBEPARK area									
DANUBEPARK member		**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	Fertö Hansag 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 raster employed, very small habitats could not be considered. As a consequence, habitats with high probability disappeared because of their size. This is the reason that the table contains very few 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 each 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 for this raster to register. 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 only potential areas of dry habitats are shown in both categories. Detailed data of dry habitat occurrences are not available. The detailed dry habitat locations that are known are presented in the detailed maps in addition 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 that 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 entailed many uncertainties. Therefore, grid cells measuring one hectare were calculated. 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 that cannot be achieved using the available data basis.

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

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 high-quality data. For those DANUBEPARKS conservation areas where additional data from vegetation surveys was 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 than 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 selected the xerophilic and mesophilic-xerophilic orchid species of the Danube corridor as flagship species of the work package. The primary reason for this choice was the fact that orchids' habitats are very sensitive to disturbances or changes in abiotic parameters. Furthermore, N2K habitats benefit from the presence of orchids by becoming priority habitats. 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. There were two different classes of potential data:

- 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 that they had gained through vegetation surveys. The following figures show the main distribution of xerophilic (Figure 9) and meso- to xerophilic orchids (Figure 10).

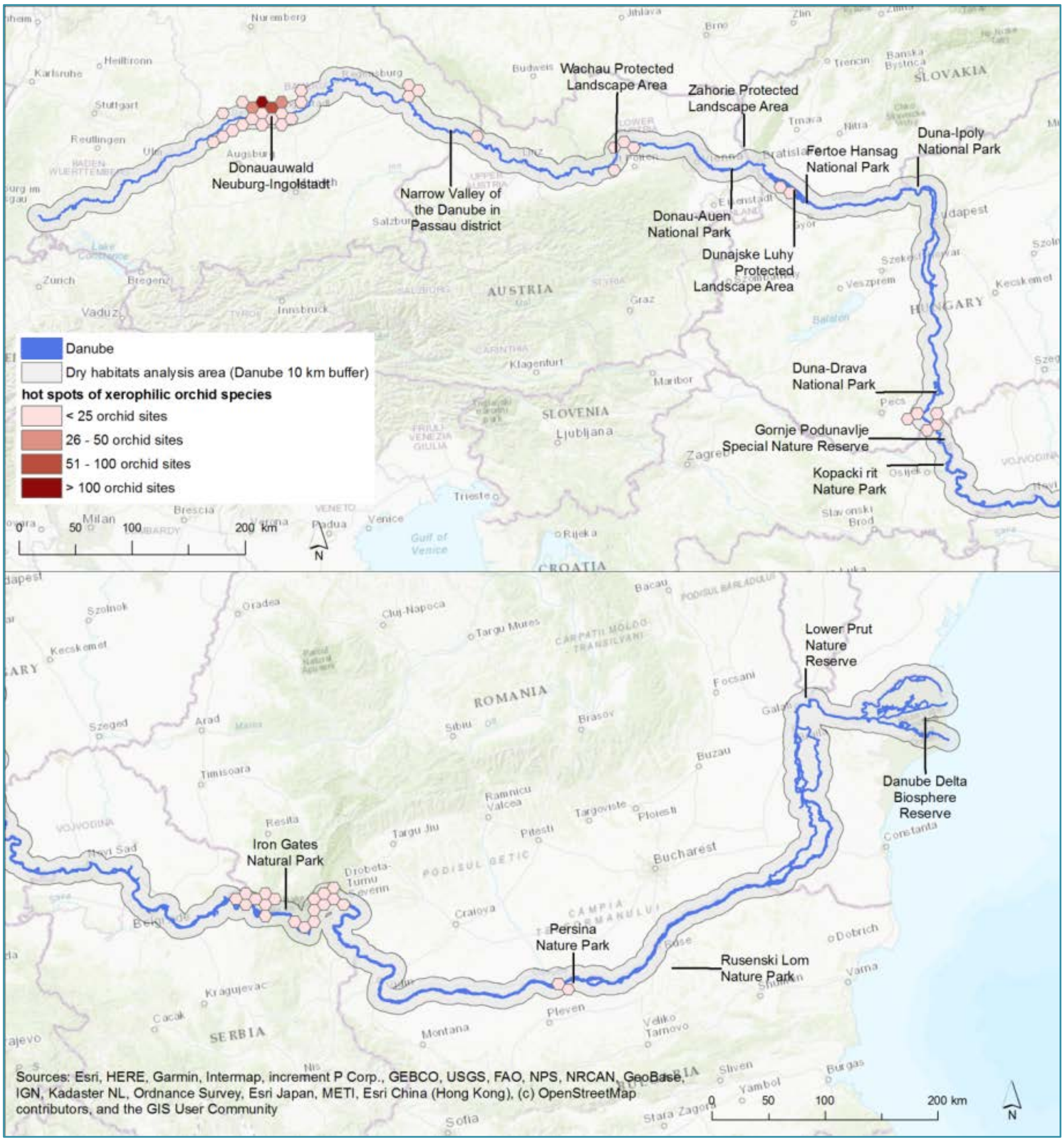


Figure 14: Hot spots of xerophilic orchid species

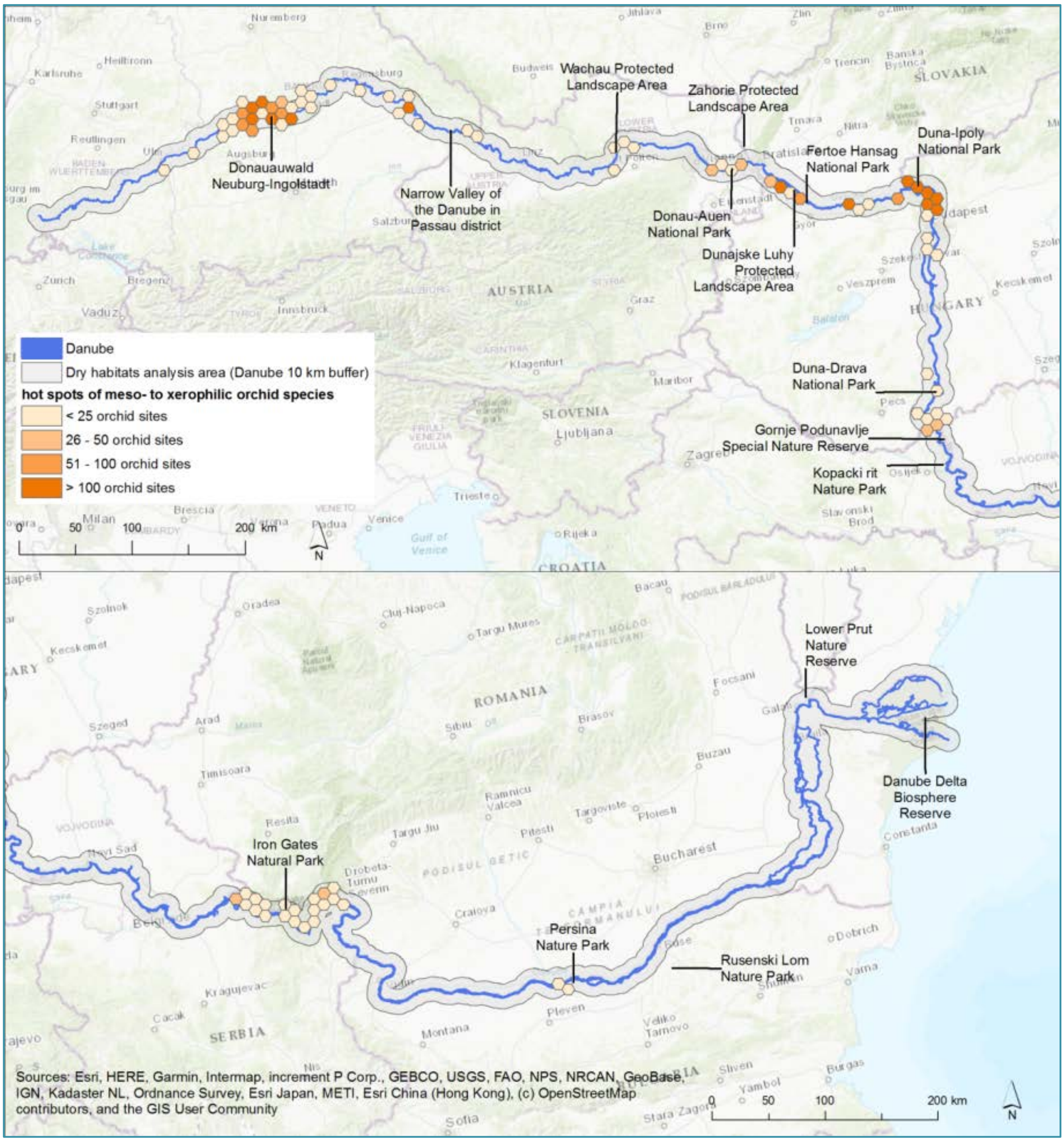


Figure 15: Hot spots of meso- to xerophilic orchid species

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 somewhat 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 points in the middle of the very grid cell (1 ha) where the orchid growth is located.

The following figure illustrates this procedure:

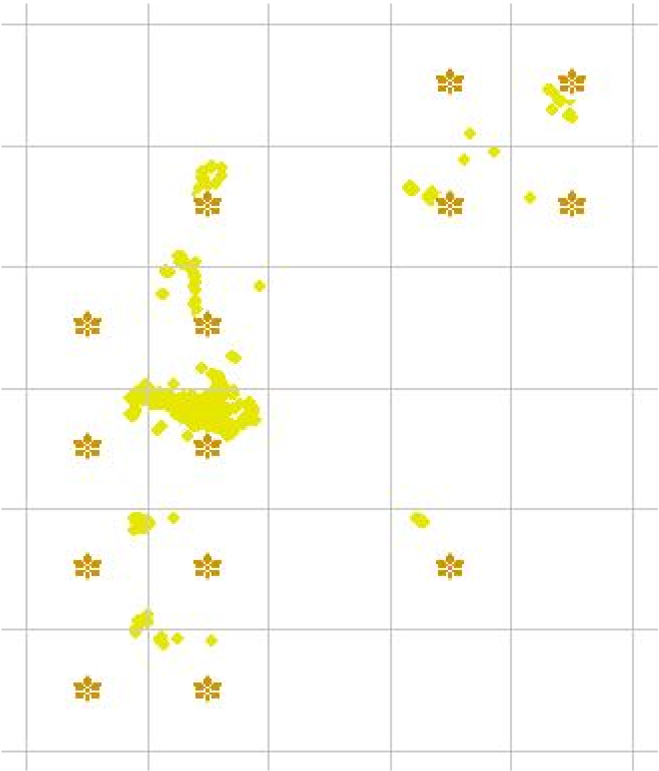


Figure 16: Generalized orchid sites based on grid cells

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 be precisely located.

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

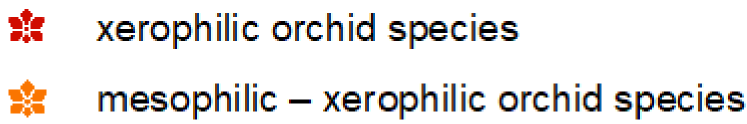


Figure 17: Categories for orchid species

4.2 Derivation of N2K data

For the majority of sites in the Danube corridor detailed vegetation surveys have not been made, or, if they have, 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. Due to 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:

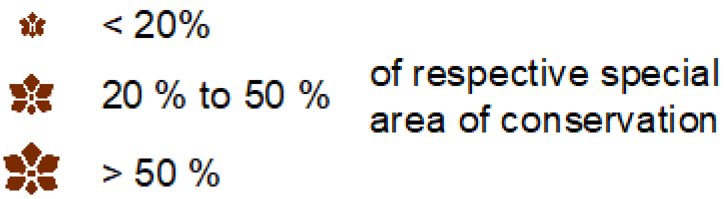


Figure 18: Assumed orchids'-spread derived from N2K data

In the detailed maps this differentiation was enhanced: Not only the orchid sites of the two codes are illustrated separately, but there was also more information on 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 offers an insight into the orchid species composition.

Table 5: Orchid species in Danube corridor

Scientific Name	Other Name	Xerophilic	Mesophilic / Xerophilic	Ecology
Anacamptis coriophora	*Orchis coriophora*		x	periodically fresh, nutrient-poor grasslands; on slightly alkaline to slightly acidic, calcareous soils; sufficient lighting conditions needed
Anacamptis morio	*Orchis morio*		x	dry to periodically humid, nutrient-poor grasslands; preferably on alkaline soils, but also on non-calcareous loam and clay soils when soil is poor in nitrogen; sufficient lighting conditions needed
Anacamptis pyra-midalis			x	dry, nutrient-poor grasslands; on alkaline and calcareous soils when soil is poor in nitrogen; strong solar radiation needed, thermophilic species
Cephalanthera damasonium		x		index species of the Medio-European limestone beech forests of the Ceph-alanthero-Fagions; on alkaline, calcareous soils; shadow-tolerant, but pre-fers sparse forests with warm summers
Cephalanthera longifolia		x		sparse forests and shrubs; on alkaline and semi-acidic soils; in areas with warm summers
Cephalanthera rubra		x		forests, especially on the edges of beech forests or sparse pine forests; on alkaline and calcareous soils; areas of lighting zones of forests
Cypripedium cal-ceolus			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
Dactylorhiza sam-bucina		x		rocky, shallow and summer-dry meadows; mostly on primary rock on mod-erately-acidic soils, avoids calcareous areas
Epipactis atroru-bens		x		preferably dry-warm habitats like sunny edges of forests; on calcareous soils; from sunny to half-shady lighting conditions
Epipactis hellebo-rine			x	half-shady to shady areas in forests, bushes; on slightly acidic to slightly alkaline soils; tolerant of drought, but also found in fresh areas
Epipactis micro-phylla			x	forests; on calcareous, humous and (periodically) fresh soils, moderate tolerance to nitrogen; shady light conditions needed
Gymnadenia co-nopsea 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
Gymnadenia odoratissima			x	habitats similar to Gymnadenia conopsea agg., especially extensive wet-meadows and fens; calcareous soils necessary; more reliant on fresh or at least periodically humid conditions
Himantoglossum adriaticum		x		extensive meadows, herbaceous semi-dry grasslands, seams of shrubs; on calcareous soils
Himantoglossum caprinum		x		extensive meadows, among shrubs and forest glades in light deciduous forests; on stony, calcareous soils; open, sunny places needed
Himantoglossum hircinum		x		nutrient-poor grasslands on calcareous substrates, extensive meadows, seams of shrubs; on calcareous soils
Limodorum abortivum		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
Neotinea tridentata	*Orchis tridentata*	x		open, semi-arid grasslands and extensive meadows; preferably on Zechstein, always on limestone
Neotinea ustulata ssp. aestivalis	*Orchis ustulata ssp. aestivalis*		x	semi-dry grasslands on calcareous substrates, nutrient poor grasslands; on neutral to slightly acidic soils; dry to periodically humid conditions
Neotinea ustulata ssp. ustulata	*Orchis ustulata ssp. ustulata*		x	semi-dry grasslands on calcareous substrates, nutrient poor grasslands; on neutral to slightly acidic soils; dry to periodically humid conditions; blooms earlier than Neotinea ustulata ssp. aestivalis, but same ecology
Neottia nidus-avis			x	fresh forests; on calcareous soils; prefers shady lighting conditions
Neottia ovata	*Listera ovata*		x	various habitats, such as deciduous forests, meadows, fens; not dependent on calcareous soils, relatively tolerant to nitrogen; preferably on half-shady, periodically humid areas
Ophrys holoserica			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
Ophrys insectifera			x	on the edges of forests, sparse pine forests, nutrient-poor grasslands, semi-dry grasslands and suitable secondary habitats; on calcareous soils
Ophrys mammosa			x	sparse deciduous and coniferous forests, nutrient-poor grasslands; on moderately dry to moderately humid soils, which are often alkaline
Ophrys sphegodes			x	semi-dry grasslands on calcareous substrates, nutrient-poor meadows; on calcareous soils; sunny conditions needed
Ophrys sphegodes ssp. araneola			x	more rocky habitats compared to Ophrys sphegodes, steep slopes, gravel slopes; on calcareous soils
Orchis antropo-phora		x		nutrient-poor grasslands on calcareous substrates and sparse shrubs; on calcareous soils
Orchis mascula			x	nutrient-poor meadows, semi-dry grasslands, sparse shrubs and forests; on calcareous soils
Orchis militaris			x	semi-arid grasslands, nutrient-poor grasslands and sparse shrubs; on alka-line and loamy soils; thermophilic
Orchis purpurea			x	semi-arid grasslands with shrubes, sparse beech forests and on the edges of arid grasslands; on calcareous soils
Orchis simia		x		extensive meadows, semi-arid grasslands and nutrient-poor grasslands; on calcareous soils; extremely thermophilic
Platanthera bifolia	*Planthera fornicata*		x	grows between shrubs below the Subalpine level; preferably on fresh, slightly acidic soils; lighting conditions: light shadow
Platanthera chlor-antha			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
Spiranthes spiralis			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 providing the most important information concerning the respective area must be completed. Included in the mandatory information that the EU member states are required to submit is a global assessment which indicates the value of the sites for conserving the type of Annex I natural habitat 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 given a grade:

A excellent

B good

C significant

If the representativeness of a habitat type in an area is low (not-significant), this area is given the fourth grade of 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 in which areas the need is more urgent.

The assessment of the conservation status in the standard form includes evaluation 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 using the existing data. 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.

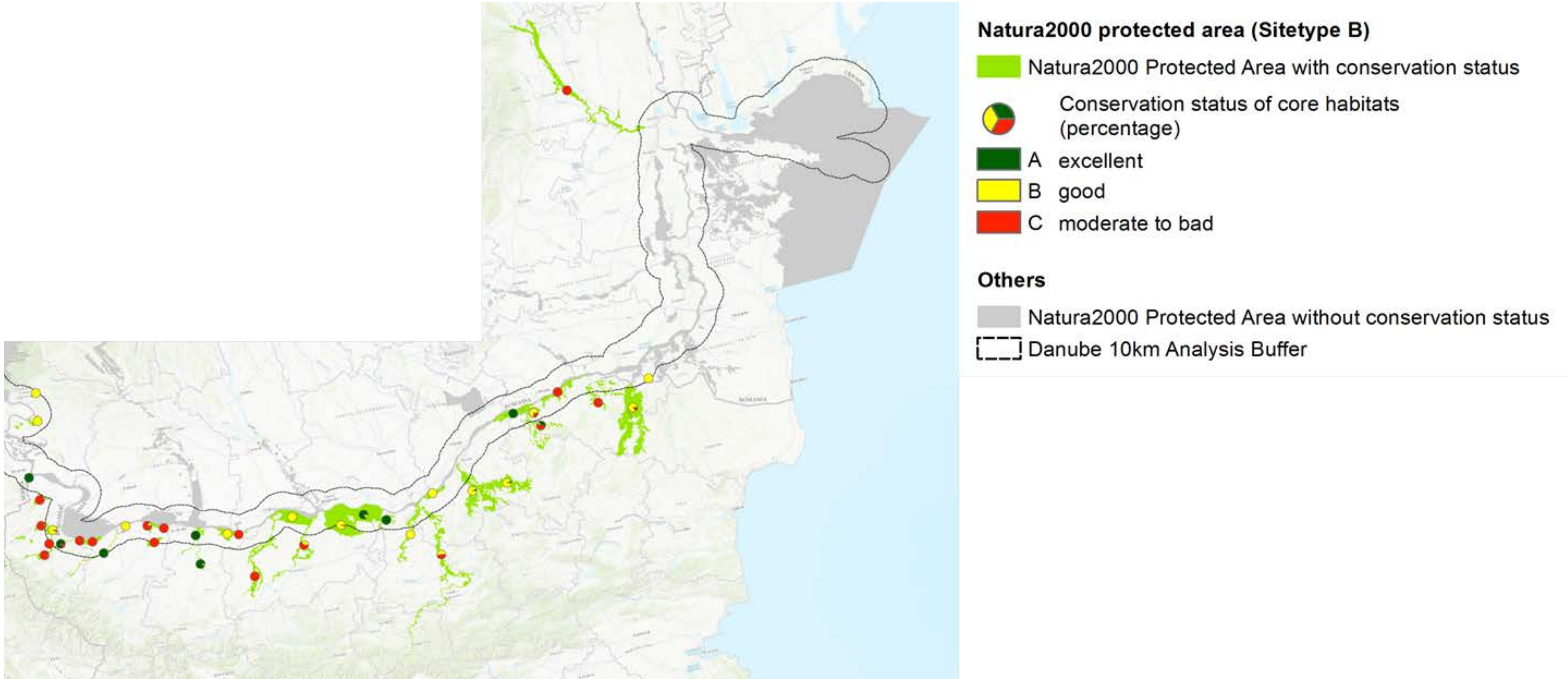


Figure 19: Distribution of core habitats with conservation status A to C within Natura 2000 Protected Areas along the Danube river.

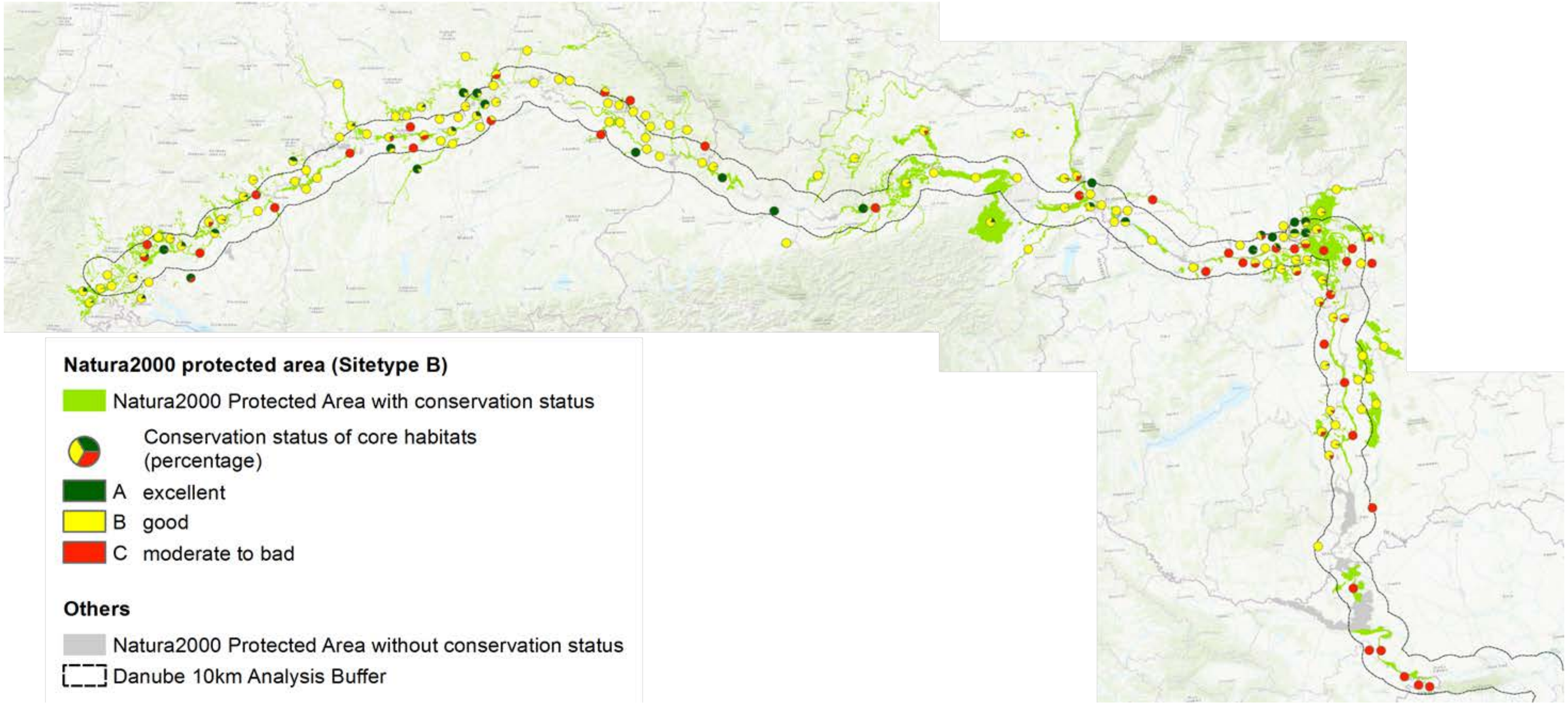


Figure 19 (continuation): Distribution of core habitats with conservation status A to C within Natura 2000 Protected Areas along the Danube river.

5.2 Causes of threats to 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 in the surveys among the DANUBEPARKS members: Land-use, invasive species and succession (after abandonment of extensive land use) 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, while nutrient-input and land-use intensification are seen more as a threat by members of the middle course regions. Fire is mentioned as another threat, especially for the areas at the lower Danube. However, all 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 threats can be categorized according to the previously 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 precipitations and flooding may increase.

As the ramifications of climate change vary between regions, it is very difficult to make general assumptions about the consequences that apply for all dry habitats. Certainly, 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 may resemble previous ones or take on entirely novel characteristics. Other habitats in contrast, could vanish as a result increased humidity. Driven by climate change fire events are expected to occur with increased frequency and intensity, especially after long dry periods.

Consequently, effects of climate change on dry habitats will also influence the species inhabiting these habitats. Species that live in dry habitats likely to be damaged by climate change will face more obstacles to survival than species occupying 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 rapid for them to adapt (Radchuk et al., 2019). Since many species in dry habitats already live at climatic extremes, this fact may further increase their vulnerability to extinction. On the other hand, these species are already highly adapted to the extreme and unstable conditions of dry habitats and have proved themselves 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 fewer 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 their original species because they can threaten the native flora and fauna or form new biocoenosis. On the whole, invasive species have obvious advantages in the new habitats and quickly populate large areas. Thus, indigenous and ancestral species are repressed. This includes plants and animals that depend on their respective host-organisms. Even though new species invade, biodiversity often decreases, since invaders are liberated from the limiting factors and opponents of their home habitats.

With regard to exposure, changes in the orientation to the sun are mostly caused by changes in neighboring land use or land cover. For dry habitats, shadowing by high growing vegetation or man-made constructions is a serious menace. Maintenance can address competing high growing vegetation whereas man-made constructions that shade dry habitats are very rarely built in a way that is being uncritical, such as using transparent components.

5.2.2 Substrate

Many characteristics of substrate can be sensitive to material input. The acid-base relationship, 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 of 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 usually occur 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, nutrients, especially nitrogen, predominate in terms of quantity and impact. As illustrated in chapter 2, most dry habitats need nutrient-poor substrate to thrive. Therefore, an increase in the nutrient content of the soil seriously endangers most dry habitats.

The negative impacts of eutrophication especially affect grasslands by triggering the following consequences:

- promotion of the expansion of nutrient-demanding competitive (tall and/or rapidly growing) vegetation, especially grasses
- promotion of the growth of ruderal species thus accelerating natural succession

In this way, eutrophication impairs the quality of dry habitats over time, finally culminating in a change of habitat type and a loss of the dry habitat.

The various pesticides, in particular herbicides, insecticides and fungicides seriously endanger the balance of established biocoenosis and can even destroy them entirely. They seriously damage species sensitive to change and favor competitive species.

While eutrophication often proceeds successively and can be counteracted by attentive management, the use of pesticides can cause irreversible damage, even after a 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 varied 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 threats related 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 habitats that were formerly unmanaged or extensively managed is intensified in order to increase the return, the basic site conditions fundamentally change.

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-frequency and very early mowing impedes flowering and seed formation so that flowering plants decrease little by little, while grasses spread until they cover almost all available areas. In forestry, intensive management methods include, for example, increased logging and the removal of deadwood, which affect forest ecosystem processes and biodiversity. By harvesting young and middle-aged trees, the age group composition of trees becomes heavily unilateral favoring old trees with no prospect of regeneration.

Furthermore, 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 participants are involved. 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, sooner or later the species composition 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 that require a specific management regime of extensive grazing or mowing. As a result of economic developments, there is a general trend towards rural exodus and abandonment of agricultural management, especially in marginal areas of Europe. This process leads 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 obstruction and even 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 a 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 dry out while dry habitats are flooded. Additionally, the natural mass transport is impeded or significantly 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 wake 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 grows due to permanent stress while, simultaneously, 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 assemblies different possibilities for the DANUBEPARKS Network of Protected Areas to pursue its objective of counteracting habitat fragmentation and degradation as well as restoring and maintaining ecological connectivity in all habitat elements along the Danube river and towards other valuable areas like the Carpathian and Dinaric mountain ranges or the Alps. To achieve this objective, it is important to consider the strategic aspects both at the technical (expert) level and the political level.

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 also apply to biotope networks of different habitat types.

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 evaluation of additional areas necessary for a biotope network. With this goal in mind, target species are used to identify 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 a foundation for assessment of the current situation as well as for the analysis of the need for additional areas to complete 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 requirements 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 implemented through different analysis methods of GIS that aim to identify barriers in the corridors (e.g. for mobile animal species) and to find the most effective connections. After identifying potential corridors, these need to be inspected for possible obstacles or conflicts (e.g. barriers, unchangeable land use etc.) and possible solutions to overcome these obstacles need to be devised.

In this step, the influence of biotic and abiotic vectors on the dispersal and immigration of target-species in habitats must be considered. 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, as well as their seeds or eggs between different habitats. For instance, some species depend on migration corridors of mammals, pastoral herding or human hiking networks. The natural range and the capacities of species to overcome distances vary widely. The calculated distances between stepping stone areas and their layout must take into account respective target species and habitats. For instance, 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 with or adjusted to existing plans of other departments (e.g. regional plan, plans for habitat directive) in order to identify contradictory and corresponding management objectives. Potential conflicts need to be identified and tailored solutions should to be offered.

Concept of measures

Ultimately, the preceding steps generate a conceptual framework with goals and guiding principles of a dry habitat biotope network. This model 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 must be examined and suggestions for the implementation (e.g. farmers, associations) and funding (e.g. foundations) have to be made. Usually, one of the most troublesome obstacles is the acquisition and availability of suitable land. If the monetary and/or temporal resources are limited, priorities need to be determined.

Synchronizing the biotope network concept with 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 strives to integrate nature conservation issues into spatial planning and territorial development in order to better tackle challenges to biodiversity resulting from habitat fragmentation, land use change and loss of habitats. Furthermore, it intends to propose 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 consider in the context of setting up a 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 outcomes of this strategic paper is a vision beyond the current situation and a framework within which to map out possibilities and priorities for medium- and long-term strategic actions.

Striving to close the gaps of a biotope network is always a very demanding objective, especially a biotope network that is defined as the whole Danube corridor. The members of the DANUBEPARKS network have achieved significant progress in bringing together interested and motivated representatives of various different protected areas. They have started a process that assembles a wide 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. Consultations in the network regarding 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

It is clear that 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 only a 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 towards detailed mapping can concentrate on the promising areas, the hot spots. Additionally, it is important to gain more information about highly endangered areas.

As the data basis gives very 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 not readily accessible. The same applies to results of biotope mappings. The respective national authorities, especially those responsible for nature conservation and related scientific institutions, should be asked to provide all useful data.

Furthermore, the CLC data used in this GIS analysis 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 far better precision enabling a better detection of small-scale, potential habitats and therefore improving analysis quality. It might even make the use of RPZ data obsolete.

Additionally, the EEA announced its plan to publish a number of modelled datasets of suitable areas for EUNIS habitats that are currently under revision. These datasets will include forest, heathland, and grassland sections, and, in combination with the new CLC dataset, could provide an interesting option for further analysis in a possible dry habitat follow-up project.

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

Thus, the next steps in GIS analysis are:

- Improve the data basis for dry habitats in quality and quantity (integration of data that is not yet freely available and new mappings)
- Use of data with better resolution (CLC data)
- All data sets gathered under EU financing should be provided to a central institution or data interface management unit to make them available for any other interested party within an EU funded project activity.

6.2.2 Next steps in implementing concrete measures

The present results of the GIS analysis show where highly valuable dry habitats are most likely located. As the resources of the network are limited, it is advisable to focus on those dry habitats that are not only very valuable but also lie within or near the boundaries of the DANUBEPARKS conservation areas. Those valuable habitats that are endangered by conversion, neglect or intensification warrant particular 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 a selection of highly valuable but fragmented habitats already exists and to analyze the potential of dry habitats that lie in other protected areas as stepping stones. The development and establishment of dry habitats in areas where the site conditions are not suitable should be considered only in exceptional cases. This is especially true for dry habitats on formerly intensively cultivated land where the nutrient content of the soil often exceeds the prerequisites for most xerophilic species, making them poor candidates for development. In these cases, it is necessary to remove huge amounts of topsoil or to extract the nutrients step by step 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, most of the Danube corridor is 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 as are the land prices. The acquisition of land is an expensive, complex and time consuming challenge.

Another topic that needs to be addressed is the question of how to manage and maintain open areas. Most dry habitats are barely profitable for farmers because of the intrinsically 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 an arrangement can only be effective when the cooperation is oriented towards long-term commitment.

Therefore, it is advisable to explore other possibilities for habitat maintenance measures. One option that could be explored is the establishment landscape management associations similar to those in Germany. These associations are non-profit organizations that 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 parts of municipal politicians, farmers and conservationists.

If it is not feasible to implement measures to close gaps within the Danube corridor itself, it is necessary to consider so called “bypass-solutions”. This means using suitable biotopes beyond the corridor as stepping stones and connecting Danube biotopes not directly along the river but diagonally, for example in areas where fewer 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 members’ experiences collated in the fact sheets, which are listed in Annex I. Many different actions were implemented and described in detail revealing success as well as failure, thus offering practical land proven lessons.

Some of the DANUBEPARKS members already have concrete plans for next measures. In the protection area of Donauauwald, pasture use by sheep and goats will be expanded. Therefore, a more intense instruction of shepherds and the installation of necessary infrastructure (watering places, fold yards, connecting pathways) will be required.

Generally, an intensification of protection and management is almost always linked to appropriate funding, education and information of the concerned persons as well as the creation of administrative jobs for the protection areas in order to relieve the current staff of management tasks.

Thus, the next steps in implementing concrete measures are:

- Focus on highly valuable habitats including those close to DANUBEPARKS conservation areas
- Establish conservation measures to close gaps between fragmented habitats
- Establish landscape management associations for coordination and preservation
- Integrate farmers in conservation processes via contracts
- Raise the sensitivity of local population and politicians to the valuable habitats around them

6.2.3 Next strategic steps

One of the most important issues is to identify financial support to continue preexisting projects and also start new ones. The surveys revealed that the financing of management activities for dry habitats of our members originates from various sources. Besides regular income like the budget of the protected areas, many 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 temporary funding options are essential because they partially compensate for the inadequate funding of nature conservation (or other) administration bodies responsible for habitat management. Project funds often provide the basis for establishing specific conservation projects and measures, but since most of them are granted just for a specific and limited number of years, they will always entail uncertainties regarding the long-term funding of the processes and measures initiated. Thus, it is advisable to search for new ways of funding to make projects or measures less dependent on temporally limited resources and give them more long-term perspectives.

One option to reduce spending is the use of volunteer programs. These programs are already utilized by some of the DanubePark members and can offer an interesting option to save costs for particular management activities. Some habitat maintenance measures, for instance, do not require specific knowledge (e.g. clearing forest edges, see fact sheets) and are therefore suitable for interested citizens.

Financing has been and remains one of the most important challenges to secure effective and long-term conservation measures. Apart from the examples mentioned above, there are a multitude of other funding sources 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 terms 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 potential follow-up project; however, for some of them this depends on preconditions regarding the extent of work that is required. Members of regions in the lower course of the Danube particularly mentioned that their continued participation would only be feasible if the associated effort required was low, indicating a difference in resource availability of organizations in these countries. This is a factor that must be taken into account in the further strategic planning of the dry habitat network. The members of the DANUBEPARKS network need to determine whether they want to continue all their efforts jointly at the same speed or whether they want to combine the joint efforts with separate more ambitious endeavors by one or more network members.

It is necessary to incorporate more like-minded organizations and institutions as associates in order to pool resources, knowledge and political impact. These can include public as well as non-profit institutions. Cooperation is also possible with institutions with no direct thematic link. For instance, public institutions that are in charge of flood protection can be important associates, as the dykes can be developed as valuable dry habitats and as effective corridors 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, since 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 promote partnerships.

Thus, the next strategic steps are:

- Utilize present funding possibilities
- Open up new resources for funding and cooperation (public, organizations, institutions)

6.2.4 Setting the framework with 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 to develop and harmonize the whole Danube region by extending collaborations between Danube countries and regions and by integrating local 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).

As the current EU funding period will come to an end in 2020, a new Danube Transnational Programme (DTP) is currently under development based on the EU cohesion policy regulations. The future cohesion policy proposes to focus much of its resource on “regions that need to catch up with the rest of the EU the most, to ensure convergence and a fair treatment for all” (European Commission, 2018a). The main thematic fields in which implementation of all aspects of ecological connectivity will likely take place are ‘climate change adaptation’ and the new urban agenda for more sustainable development of cities (the Urban Agenda for the EU - https://ec.europa.eu/futurium/en/urban-agenda). Coping with environmental challenges and developing a greener and low-carbon Europe remain some of the most important political targets for the cohesion policy beyond 2020 (European Commission, 2018b), although the availability of funds may be reduced due to general financial constraints of the EU budget.

Until now, activities for ecological connectivity, including actions for the dry habitat strategy, were addressed under the DTP funding priority of ‘Environment and culture responsible Danube region’, particularly specified by the sub-goal ‘Foster the restoration and management of ecological corridors’. At present, it is most likely that a similar priority will be formulated for the new DTP, which may refer to the topic of ecological connectivity in general as well as its implementation on different levels and beyond all types of borders. Therefore, it is crucial to continue cooperation and exchange within the Danube Parks network and with many different types of players and stakeholders in order to maintain the topic’s position on the political agenda at the EUSDR, Priority Area Coordinators (PAC) and national levels.

The relationships with existing nature conservation networks (e.g. CNPA, ALPARC, WWF-DCP and many regional ones) dealing with ecological connectivity in Europe should be maintained and intensified. The outputs of previous and current initiatives in the program area (including the former SEE cooperation space) can provide helpful information on how to better connect different types of habitats and spaces and address strategic questions on technical and policy levels (Füreder et al. 2011, Favilli et al. 2014).

Moreover, the integration of EU wide policy goals and strategies, e.g. EU Green Infrastructure or the EU Biodiversity Strategy into the new Danube Transnational Programme, is an obligation and must be actively demanded by all involved stakeholders during the currently ongoing program development phase.

6.3 Examples of setting up dry habitat corridors

The following projects and initiatives 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 Masterplan Bavarian Danube Habitats

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 is 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 through specific channels. To set up this master plan, a systematic approach was 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 implement 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 in 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 including their typical communities is rather scattered and isolated within the landscape.

Semi-arid grasslands, which evolved through extensive grazing and which were formerly widespread along the Danube, are now extremely rare due to land-use change (e.g. abandonment of extensive farming techniques, reforestation). Furthermore, loss of ecological stepping stones and reduction of migratory sheep farming, which had historically provided an important dispersal mechanism, has contributed to decline in critical dry habitats. Thus, 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 Continuation of adjusted land-use in open areas is key to achieving this goal, as is encouraging the continuation of extensive land-use methods while preventing land-use intensification.

The guiding principles are implemented within specific projects. Two project ideas are mentioned as 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 dry-warm habitats
- Ecological restoration of suitable habitats

- Forest conversion (clearing of open-area biotopes to promote xerophilic and thermophilic species), establishment of 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 Bavarian implementation of the EUSDR gives a good illustration of how to take a macro-regional strategy and apply it within 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 maintenance of the small core heathland and nature conservation area “Garchinger 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 nearby conservation area “Mallertshofer Holz”, which also contains 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 via sheep as biotic vectors was made possible (see Figure 20).

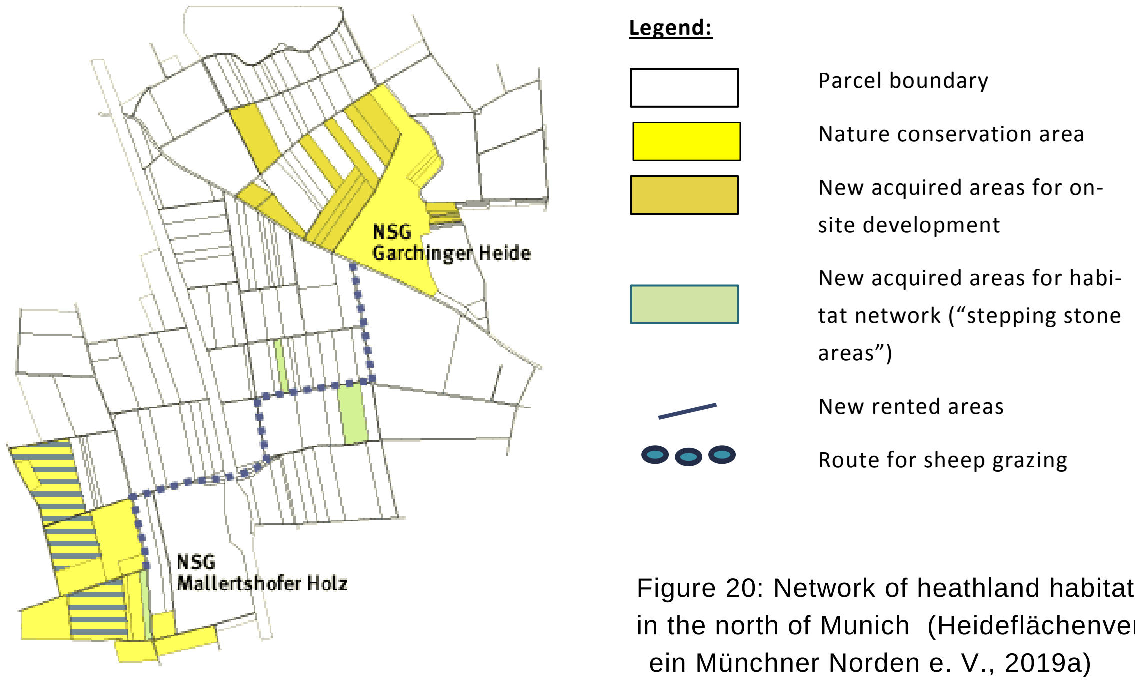


Figure 20: Network of heathland habitats in the north of Munich (Heideflächenverein Münchner Norden e. V., 2019a)

In order to transfer the heathland target species of the core area “Garchinger 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 proto-soil. 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 of autochthonous origin, since nowadays a wide range of seed mixtures with unknown origin are currently marketed. 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 at the new sites were implemented not on a rigid regimented basis but according to the respective development of the vegetation. After the third year, a regular maintenance through mowing or sheep-grazing was 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 excludes different parts of the respective site each year to help small hibernating animals. In addition to mowing, the soil is tilled by a harrow to remove the covering, matted layer consisting of moss and dead weeds in order to create open spots for non-competitive, low-growing species that are characteristic for the area. In former times, this effect was achieved through the grazing of sheep, which automatically created these open spots by trampling.

The project was supervised by the Technical University of Munich, which monitored the success of the efforts. In total, the noteworthy number of 68 target species was spread from the core area “Garchinger 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 a large 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 Landespflege (German federation for landscape maintenance). They collaborated with different project partners like cities, counties, companies, associations and public institutions.

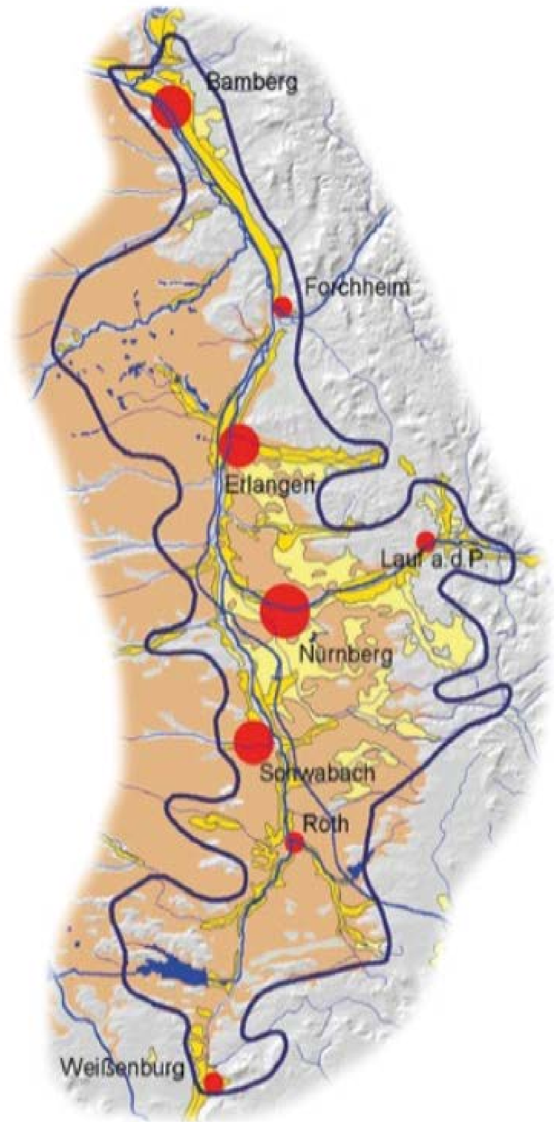
One of the main goals of this project was to rent or purchase sandy habitats in order to preserve and develop these sites and to link them to a wider network of sandy habitats. For example, areas along electric pipeline routes were bought and sandy biotopes created. These biotopes were maintained by 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 piece 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 typically excluded primarily 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 included the restoration of obstructed river areas to promote natural establishment of sandy habitats, the purchase and maintenance of sandpits and the seeding of special autochthonous seed mixtures to create new sandy, nutrient-poor grasslands.

In total, an area of around 500.000 m^2 was purchased or rented, and another 1.000.000 m^2 of sandy habitats in possession of the project partners were established. Over 2.000 individual measures were implemented in the different sandy biotopes.



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 to 2007).

Complemented with capital from 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 contact with land owners, negotiations and coordination with project partners. Significantly, they 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 initial period (400.000 € from 2007 until 2014). Thus, project activities had to be reduced significantly. This example illustrates how continuous funding plays a vital role when it comes to the durable establishment of a habitat network on a regional scale.

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

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. Through mechanical mowing and the removal of bushes and invasive species, a first step was taken to re-establish mesophilic to xerophilic grassland communities. Additionally, the removal of the shrubs on the dykes resulted in easier maintenance of the dykes and reduction of damage by roots.

A final conclusion about the efficacy of these measures cannot yet be made, but there is the intention to expand these measures on longer dyke sections and in large grasslands. At that scale, the measures could contribute to the re-creation of a corridor along the dykes and perhaps between the grasslands as well.

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

At Donau-Auen National Park, grazing on dykes in an area of 10 ha was re-established for a project period in 2018 and replaced the previous mowing. The dykes represent a corridor connecting the surrounding protected semi-dry grasslands. For the preservation of its ecological functions, regular mowing and the removal of crops 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 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 will 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 supplemental work was necessary for aftercare to remove woody plants and herbaceous plants that were ignored by the sheep.

6.3.6 Floristic inventory and dry grassland habitat mapping of Danube region and maintenance of the dykes, Croatia

Aims of the study are to carry out inventory and habitat mapping of dry grasslands in the areas of Kopački rit Nature Park and Natura 2000 ecological networks in the Croatian Danube region, to establish a complete list of flora, to determine the presence and abundance of rare, threatened and protected plant taxa, with particular reference to the orchid family and to evaluate the presence of allochthonous and invasive plant species. Field surveys of vegetation aspects within the study areas were conducted during the spring, summer and autumn of 2017 and 2018.

The 6240* Sub-Pannonic steppic grasslands, 6250* Pannonic loess steppic grasslands habitat types have been identified at 11 locations in the Croatian Danube region. The presence of allochthonous and invasive plant species was confirmed, and results of the study suggested expansion of invasive alien plant species (especially common milkweed (Asclepias syriaca)) as a problem. In July 2018, the public institution Nature Park Kopački rit organized a meeting with representatives from Croatian waters, Agency for Inland Waterways and experts for floristic inventory and mapping, which are included in project activities. All members agreed that it is necessary to apply special regimens of mowing grasslands on the dykes in order to halt the expansion of invasive plant species. This special regimen of mowing is applied before the flowering cycle of the invasive plants as one way to stop them from spreading. It was agreed that from now on activities of mowing of the dykes will start on 10th August. Also, it was agreed that this type of action would be carried out not only in Kopački rit area, but in other locations as well to help maintain biodiversity of flora and fauna.

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Overview map of dry habitats in the Danube corridor

Legend

Graduated probability and evaluation of occurrence of dry habitats

Low probability of dry habitats

1
2
3

Low probability for the occurrence of relevant dry habitats.

Medium probability of dry habitats

4
5
6

Medium probability for the occurrence of valuable dry habitats.

High probability of dry habitats

7
8
9

Maximum probability for the occurrence of highly valuable dry habitats.

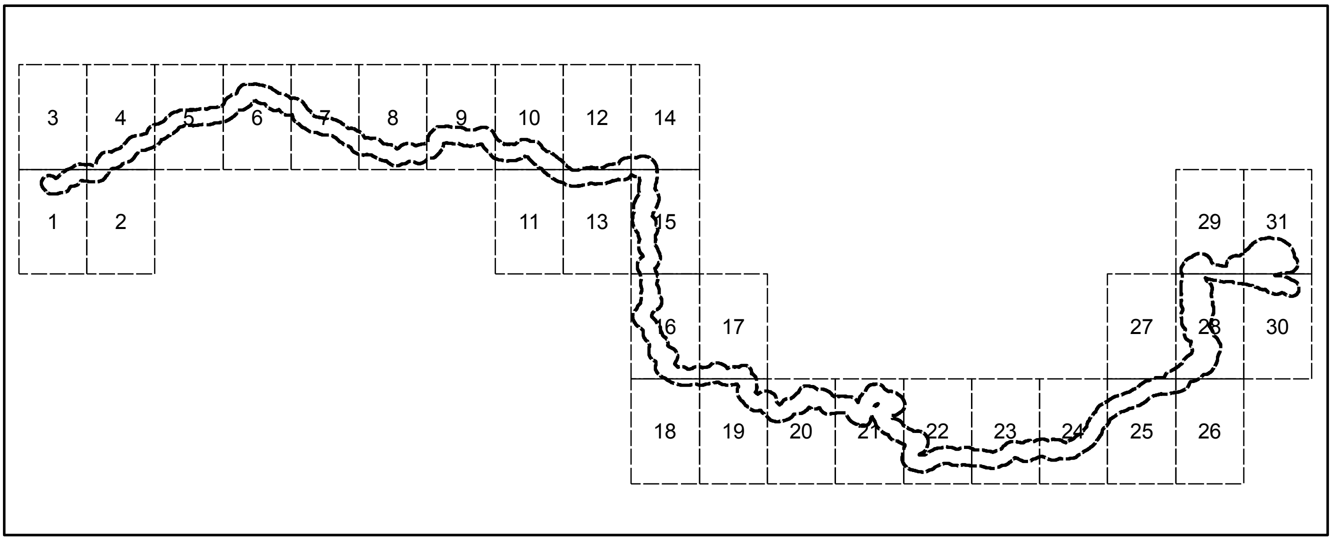
Others

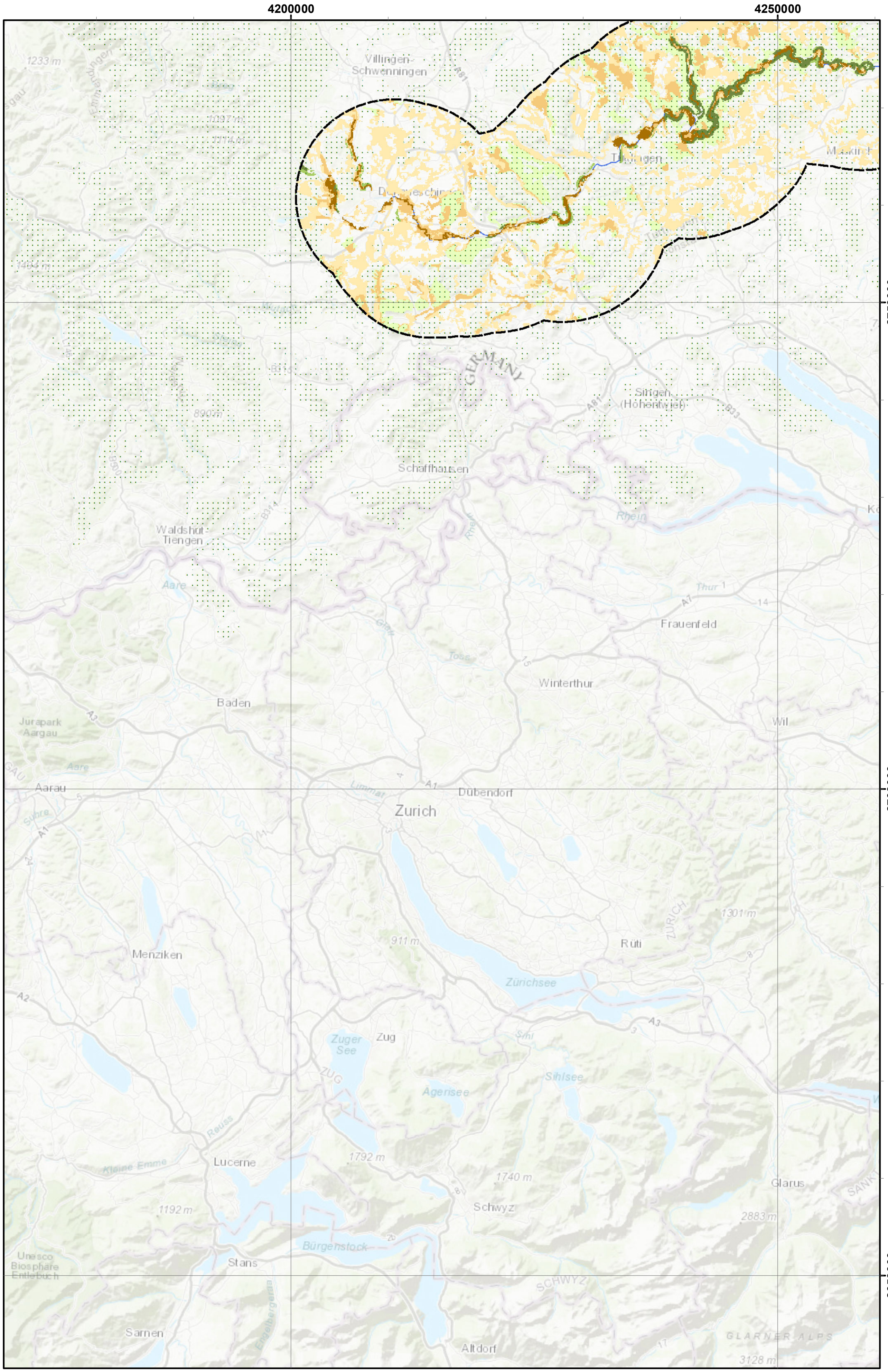
Forest according to CLC

Danube

Danube 10 km-Buffer (Analysis Area)

sheet lines

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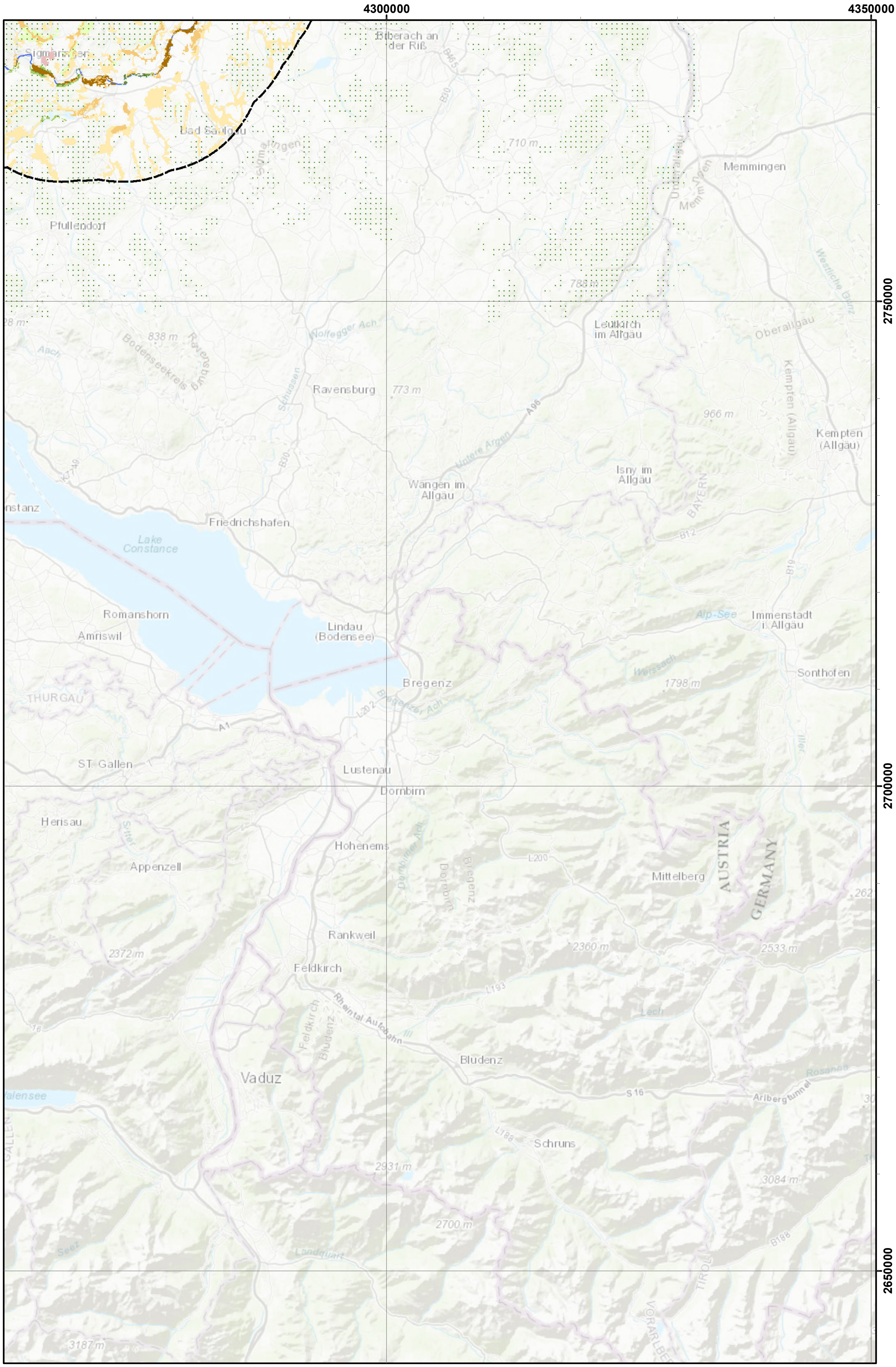
2700000
2650000
Villingen-Schwenningen
Tuttlingen
Schaffhausen
Singen (Hohentwiel)
Waldshut-Tiengen
GERMANY
Frauenfeld
Winterthur
Baden
Wil
Jurapark Aargau
Aarau
Dübendorf
Zurich
Menziken
Rüti
Zürichsee
Zug
Zuger See
Ägerisee
Sihlsee
Lucerne
Schwyz
Glarus
Stans
Bürgenstock
Sarnen
Altdorf
Unesco Biosphäre Entlebuch
GLARNER ALPS
Rhein
Thur
Aare
Limmat
Reuss
Kleine Emme
Sihl
1233 m
890 m
911 m
1301 m
1792 m
1740 m
1192 m
2883 m
3128 m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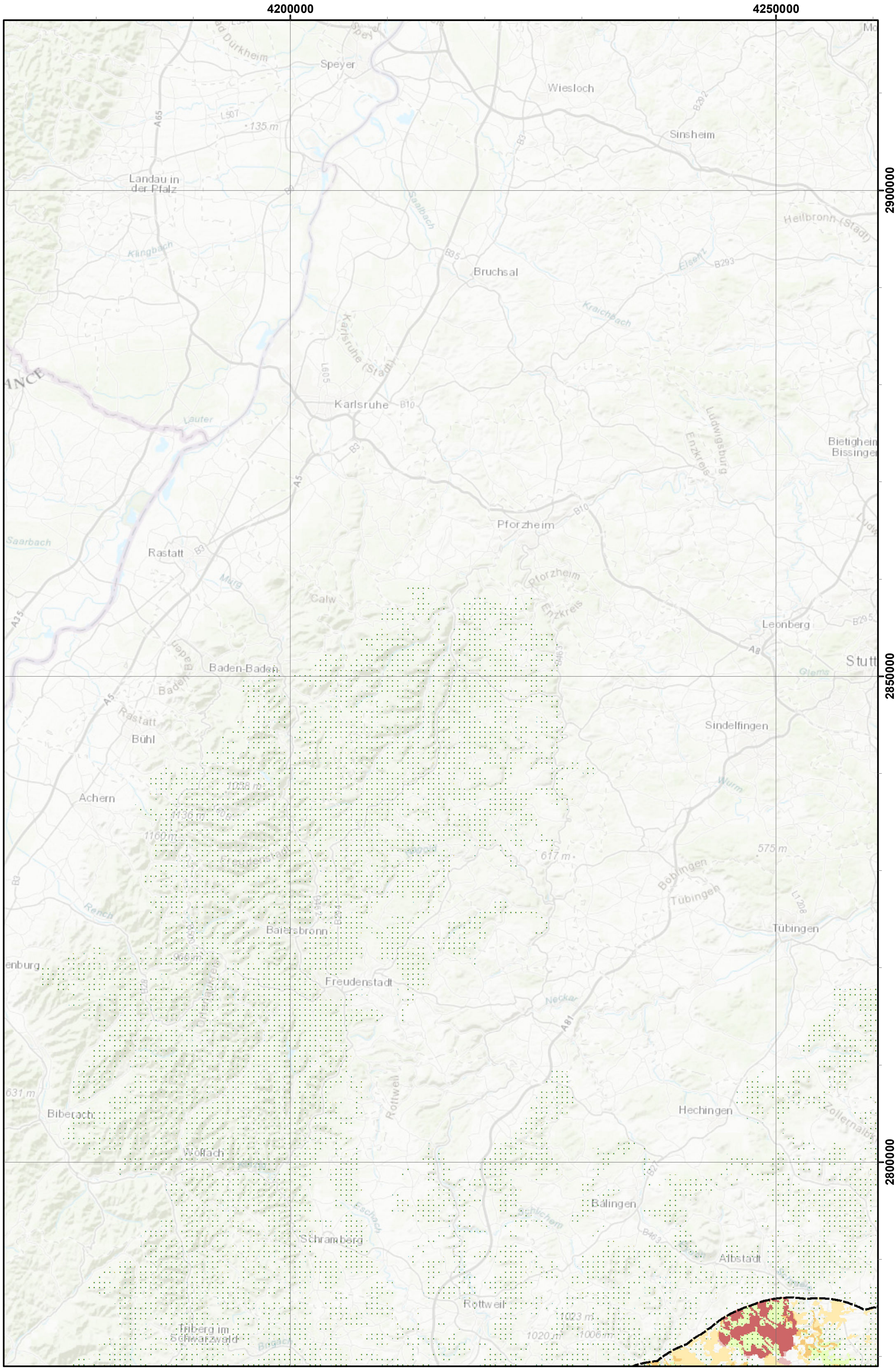
Bad Saulgau
Memmingen
Pfullendorf
Leutkirch im Allgäu
Oberallgäu
Ravensburg
Kempten (Allgäu)
Isny im Allgäu
Wangen im Allgäu
Konstanz
Friedrichshafen
Lake Constance
Romanshorn
Amriswil
Lindau (Bodensee)
Immenstadt i. Allgäu
Sonthofen
Bregenz
THURGAU
ST. Gallen
Lustenau
Dornbirn
Herisau
Hohenems
Appenzell
Mittelberg
AUSTRIA
GERMANY
Rankweil
Feldkirch
Bludenz
Vaduz
Walensee
Schruns
BAYERN
TIROL
Rheintal Autobahn
Arlbergtunnel
A96
A1
B12
B30
S16
L200
L193
710 m
788 m
838 m
773 m
966 m
1798 m
2372 m
2360 m
2533 m
2931 m
3084 m
2700 m
3187 m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Wiesloch
Sinsheim
Landau in der Pfalz
Heilbronn (Stadt)
Bruchsal
Karlsruhe (Stadt)
Karlsruhe
Bietigheim-Bissingen
Pforzheim
Rastatt
Calw
Leonberg
Baden-Baden
Bühl
Sindelfingen
Achern
Böblingen
Tübingen
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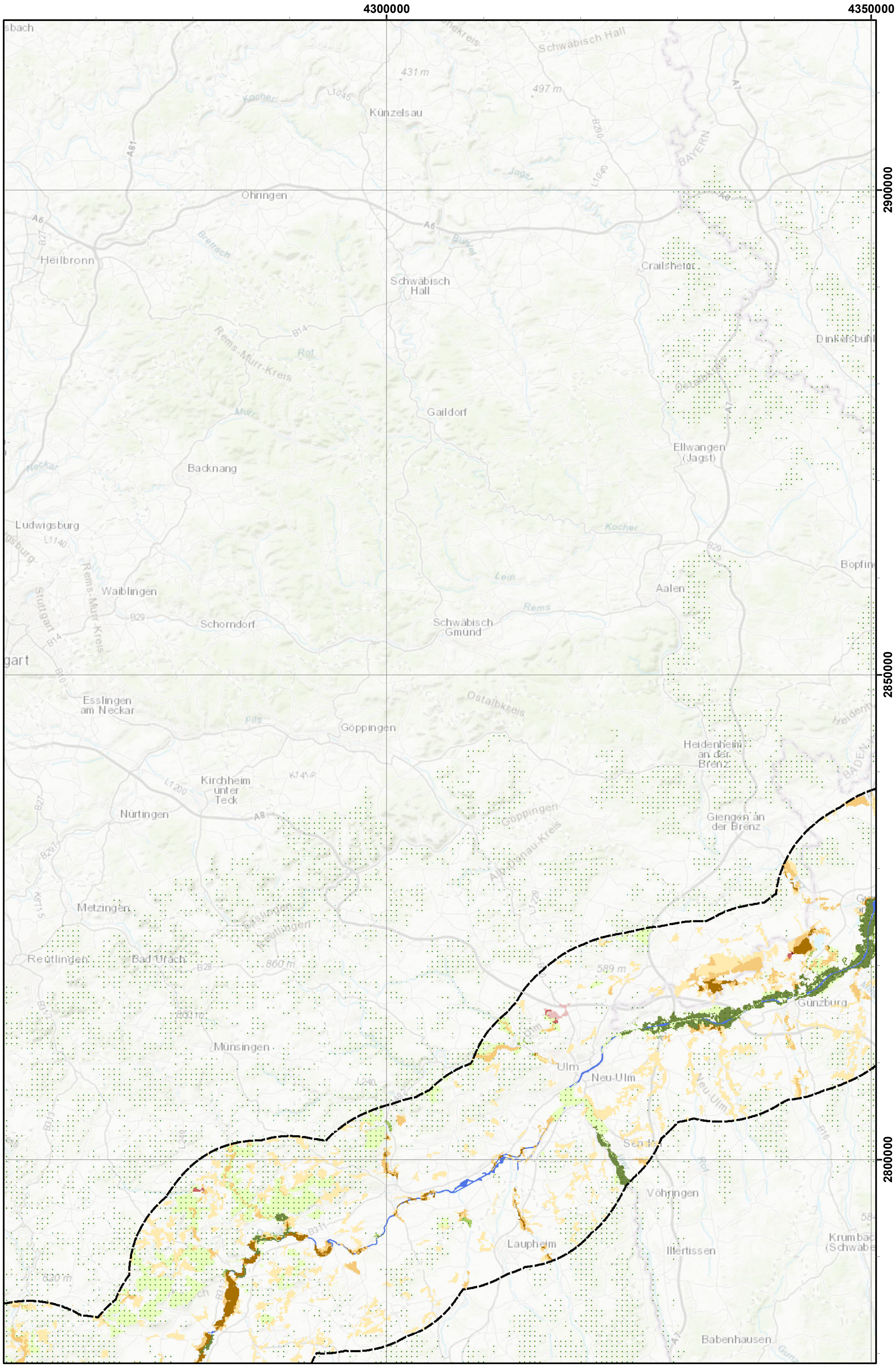
Freudenstadt
Hechingen
Biberach
Wolfach
Balingen
Schramberg
Albstadt
Rottweil
Triberg im Schwarzwald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Künzelsau
Öhringen
Heilbronn
Crailsheim
Schwäbisch Hall
Dinkelsbühl
Rems-Murr-Kreis
Gaildorf
Ellwangen (Jagst)
Backnang
Ludwigsburg
Kocher
Aalen
Bopfingen
Waiblingen
Schorndorf
Schwäbisch Gmünd
Ostalbkreis
Esslingen am Neckar
Göppingen
Heidenheim an der Brenz
Kirchheim unter Teck
Nürtingen
Giengen an der Brenz
Göppingen
Alb-Donau-Kreis
Metzingen
Reutlingen
Bad Urach
Günzburg
Münsingen
Ulm
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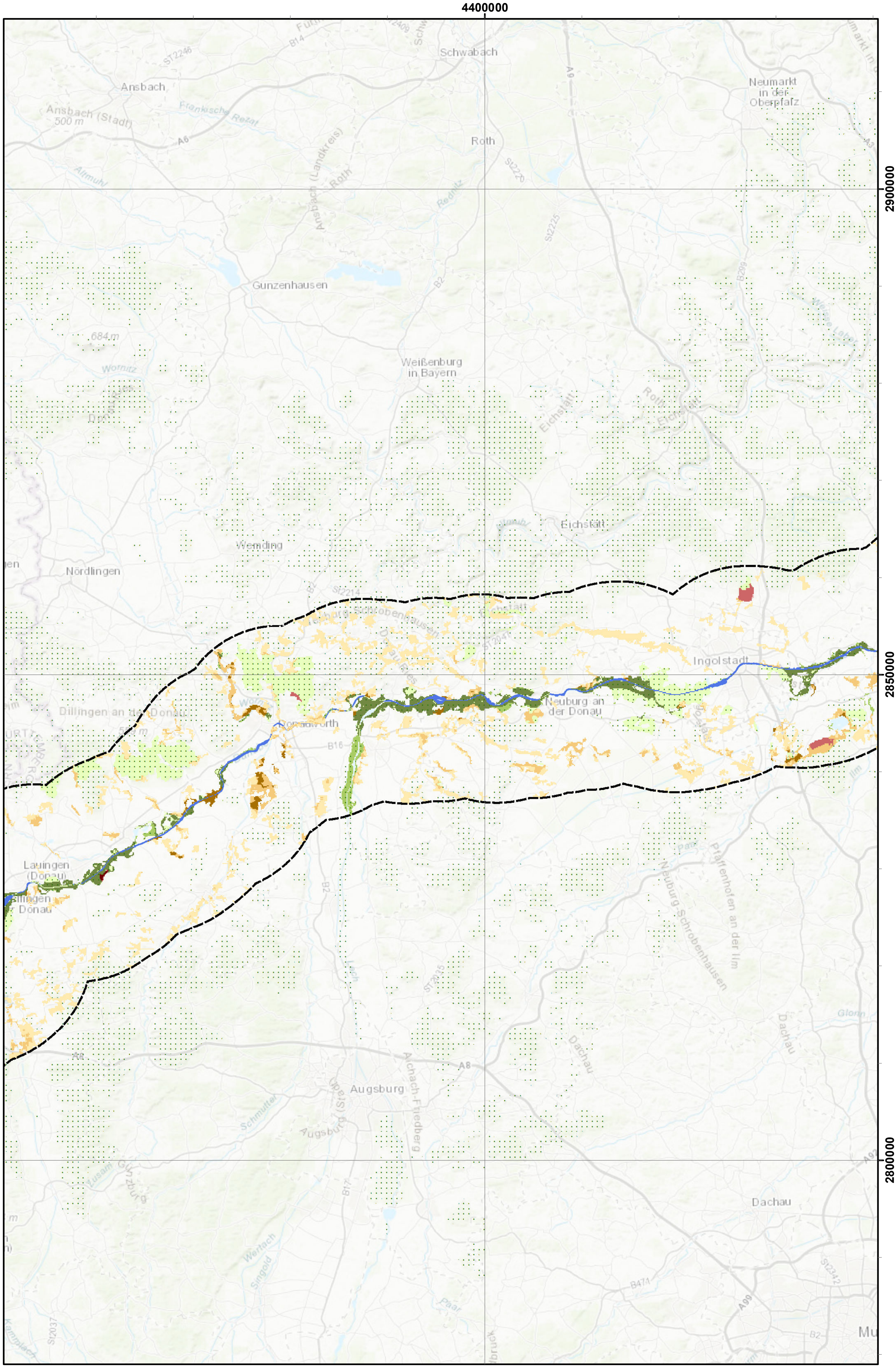
Senden
Vöhringen
Laupheim
Illertissen
Krumbach (Schwaben)
Babenhausen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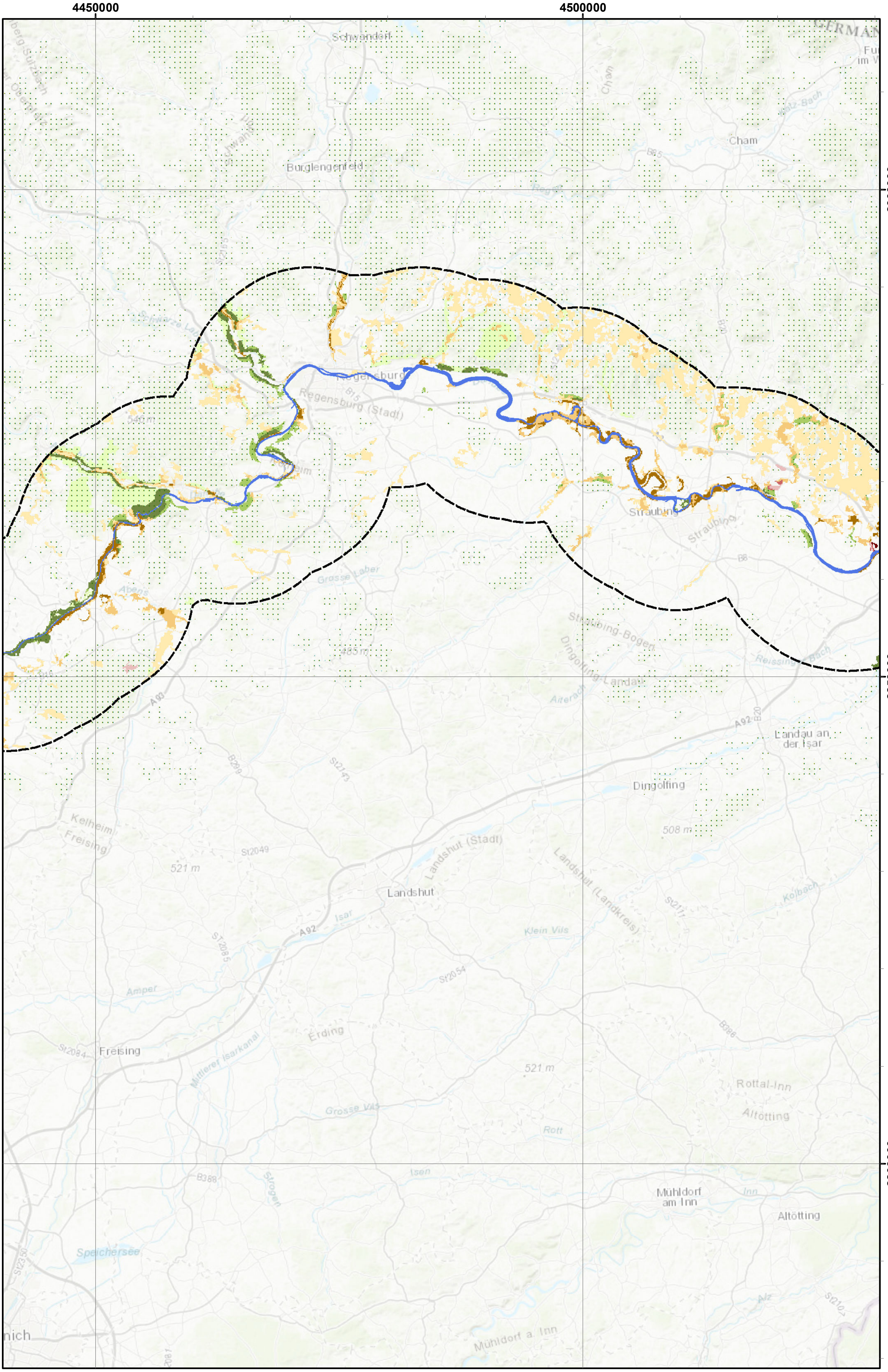
Ansbach
Ansbach (Stadt)
Neumarkt in der Oberpfalz
Roth
Gunzenhausen
Weißenburg in Bayern
Eichstätt
Wemding
Nördlingen
Ingolstadt
Neuburg an der Donau
Donauwörth
Dillingen an der Donau
Lauingen (Donau)
Augsburg
Dachau
A9
A6
A8
A99
B2
B16
B17
B299
B471



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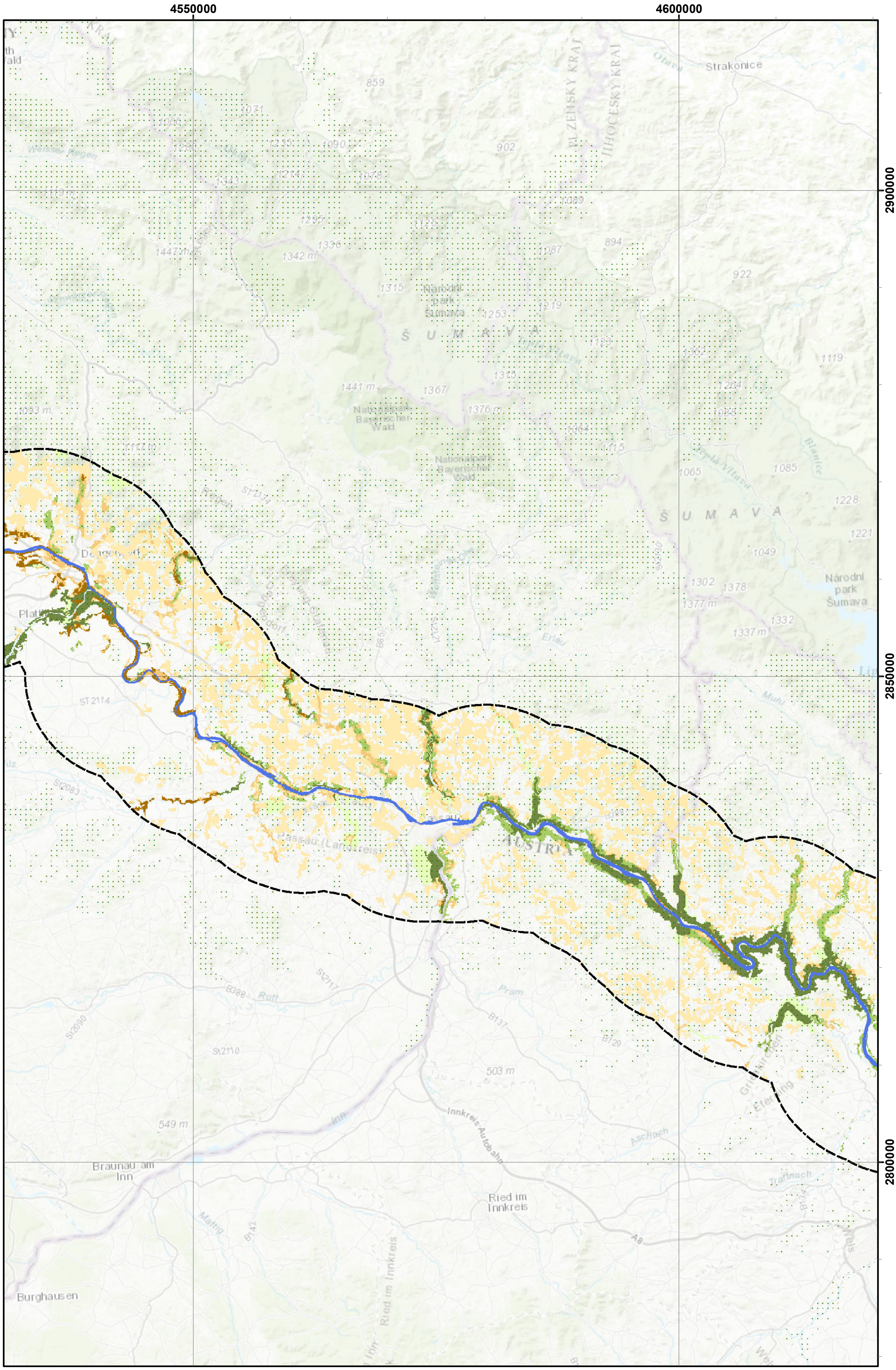
Schwandorf
Cham
Burglengenfeld
Regensburg
Regensburg (Stadt)
Straubing
Straubing-Bogen
Dingolfing-Landau
Landau an der Isar
Dingolfing
Kelheim
Freising
Landshut (Stadt)
Landshut
Landshut (Landkreis)
Erding
Rottal-Inn
Altötting
Mühldorf am Inn
Mühldorf a. Inn
Speichersee
Grosse Laber
Klein Vils
Grosse Vils
Amper
Isar
A92
A93
521 m
508 m
485 m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JIHOČESKÝ KRAJ
Š U M A V A
Národní park Šumava
Nationalpark Bayerischer Wald
Deggendorf
Plattling
Passau (Landkreis)
AUSTRIA
Braunau am Inn
Ried im Innkreis
Burghausen
Innkreis-Autobahn
Eferding
Grieskirchen
Inn
Rott
Pram
Aschach
Erlau
Mühl
Teplá Vltava
Blanice
Otava
503 m
549 m
1342 m
1441 m
1376 m
1377 m
1337 m
1315
1367
1253
1085
1228
1221
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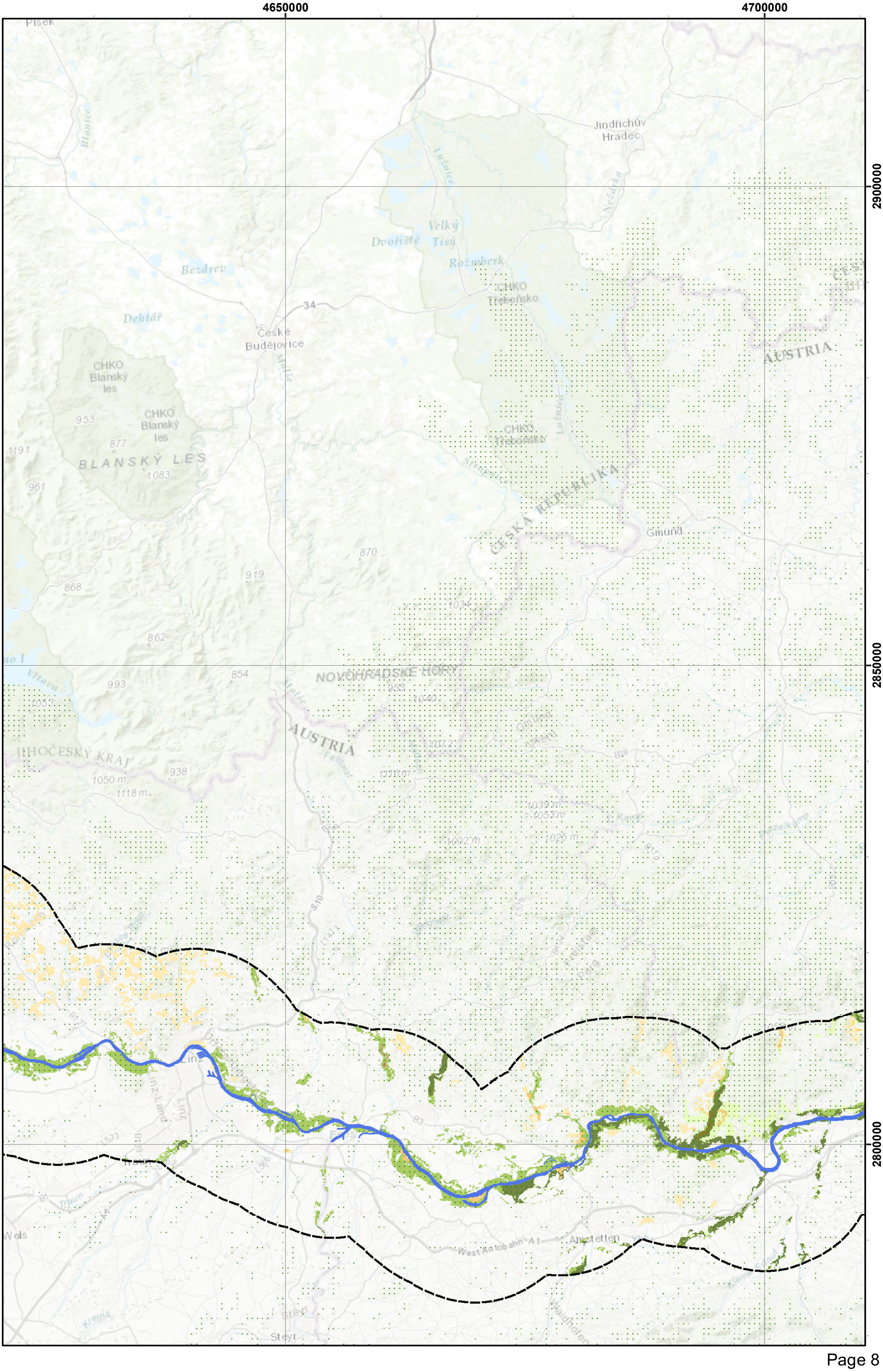
922
894
902
859
1119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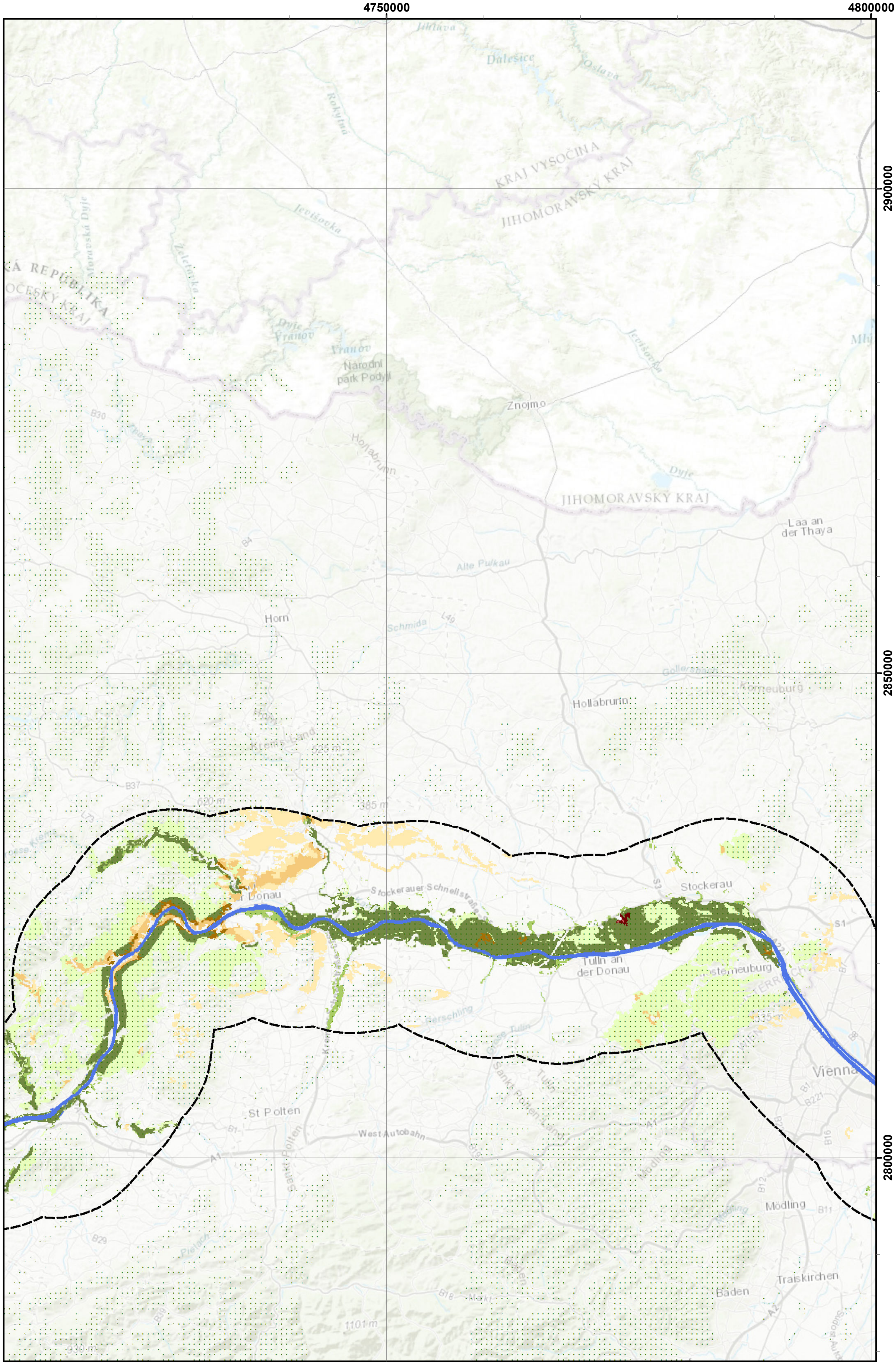
Lužnice
Nežárka
Blanice
Velký Tisý
Dvořiště
Rožmberk
CHKO Třeboňsko
Bezdrev
Dehtář
34
České Budějovice
AUSTRIA
CHKO Blanský les
BLANSKÝ LES
953
877
1083
1191
961
CESKÁ REPUBLIKA
Gmünd
870
919
868
862
1034
NOVOHRADSKÉ HORY
854
993
1053
Vltava
AUSTRIA
JIHOČESKÝ KRAJ
938
1050 m
1118 m
1002 m
1025 m
S10
Linz
Enns
B3
B1
A1
Traun
Wels
Steyr
Amstetten
West Autobahn A1
Waidhofen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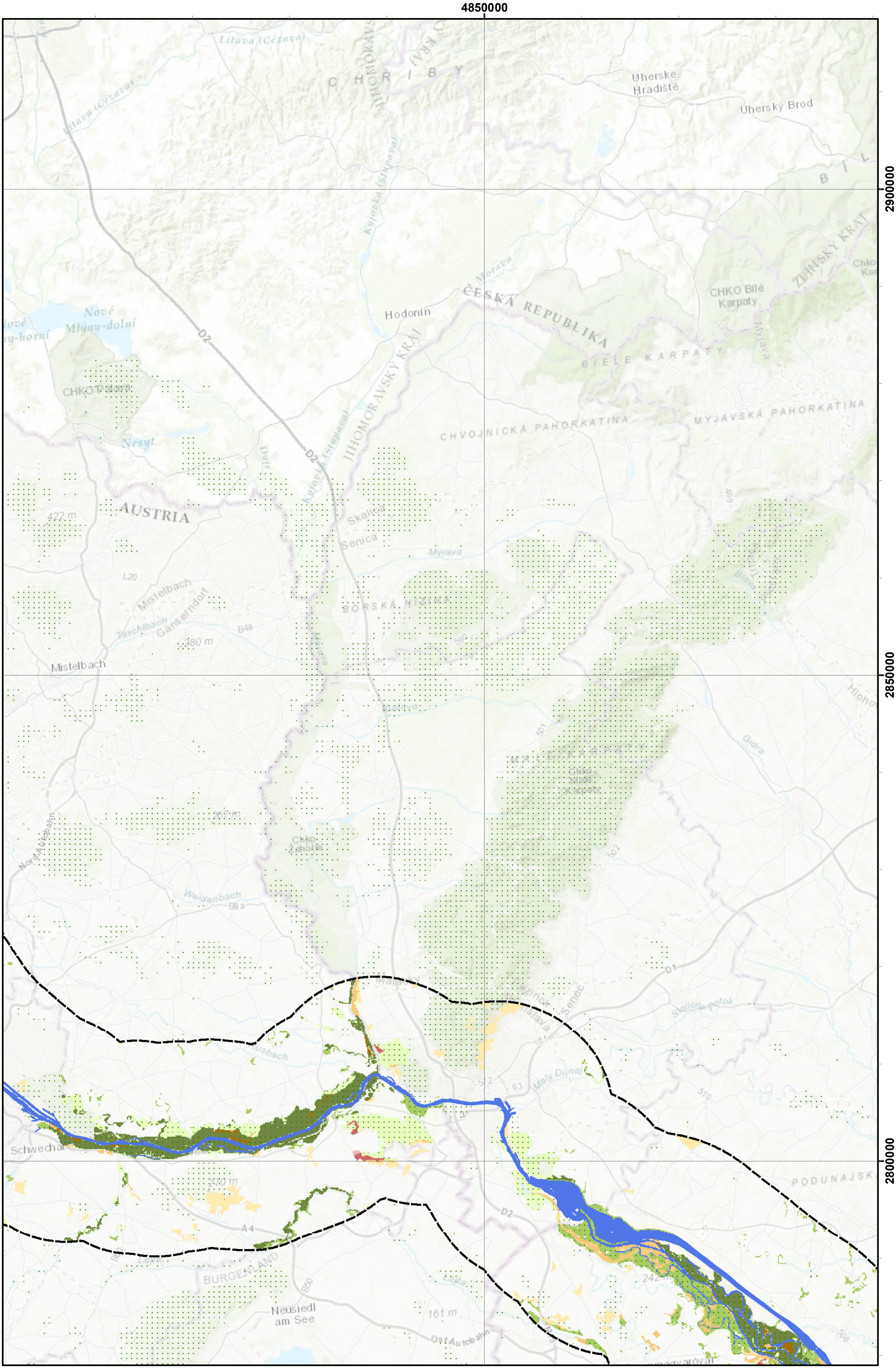
KRAJ VYSOČINA
JIHOMORAVSKÝ KRAJ
Národní park Podyjí
Znojmo
Dyje
Vranov
Jevišovka
Dalešice
Oslava
Jihlava
Hollabrunn
JIHOMORAVSKÝ KRAJ
Laa an der Thaya
Alte Pulkau
Horn
Schmida
Hollabrunn
Korneuburg
Stockerau
Stockerauer Schnellstraße
Tulln an der Donau
Klosterneuburg
Perschling
Vienna
St Polten
West Autobahn
Mödling
Traiskirchen
Baden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Hodonín
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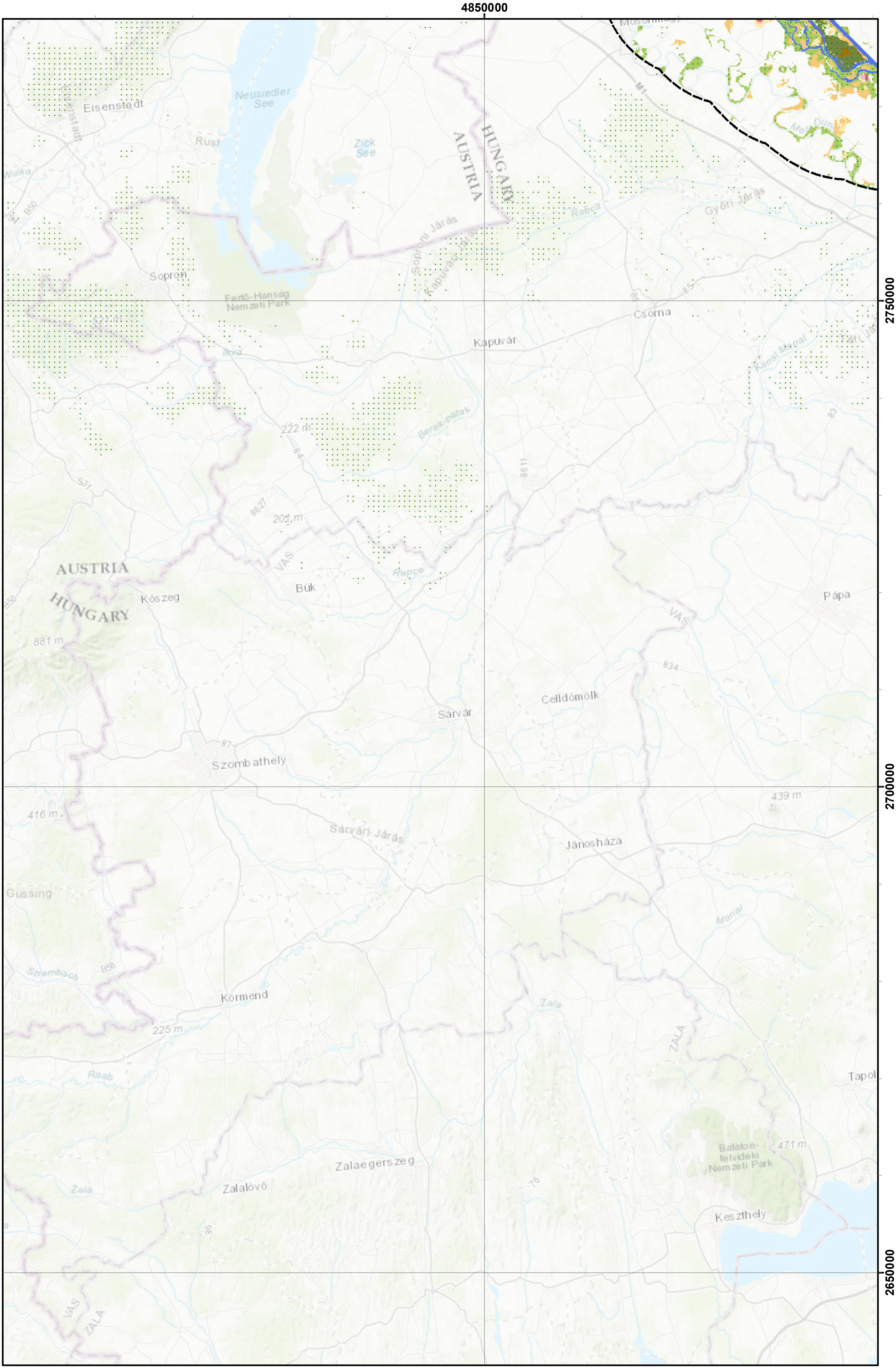
BIELE KARPATY
CHKO Bílé Karpaty
ZLÍNSKÝ KRAJ
JIHOMORAVSKÝ KRAJ
CHVOJNICKÁ PAHORKATINA
MYJAVSKÁ PAHORKATINA
AUSTRIA
Skalica
Senica
Myjava
BORSKÁ NÍŽINA
Mistelbach
Gänserndorf
Schwechat
BURGENLAND
Neusiedl am See
Ost Autobahn
Nord Autobahn
PODUNAJSK
Malý Dunaj
CHOMORAVS
CHŘIBY
Morava
Nesyt
D2
A4
D1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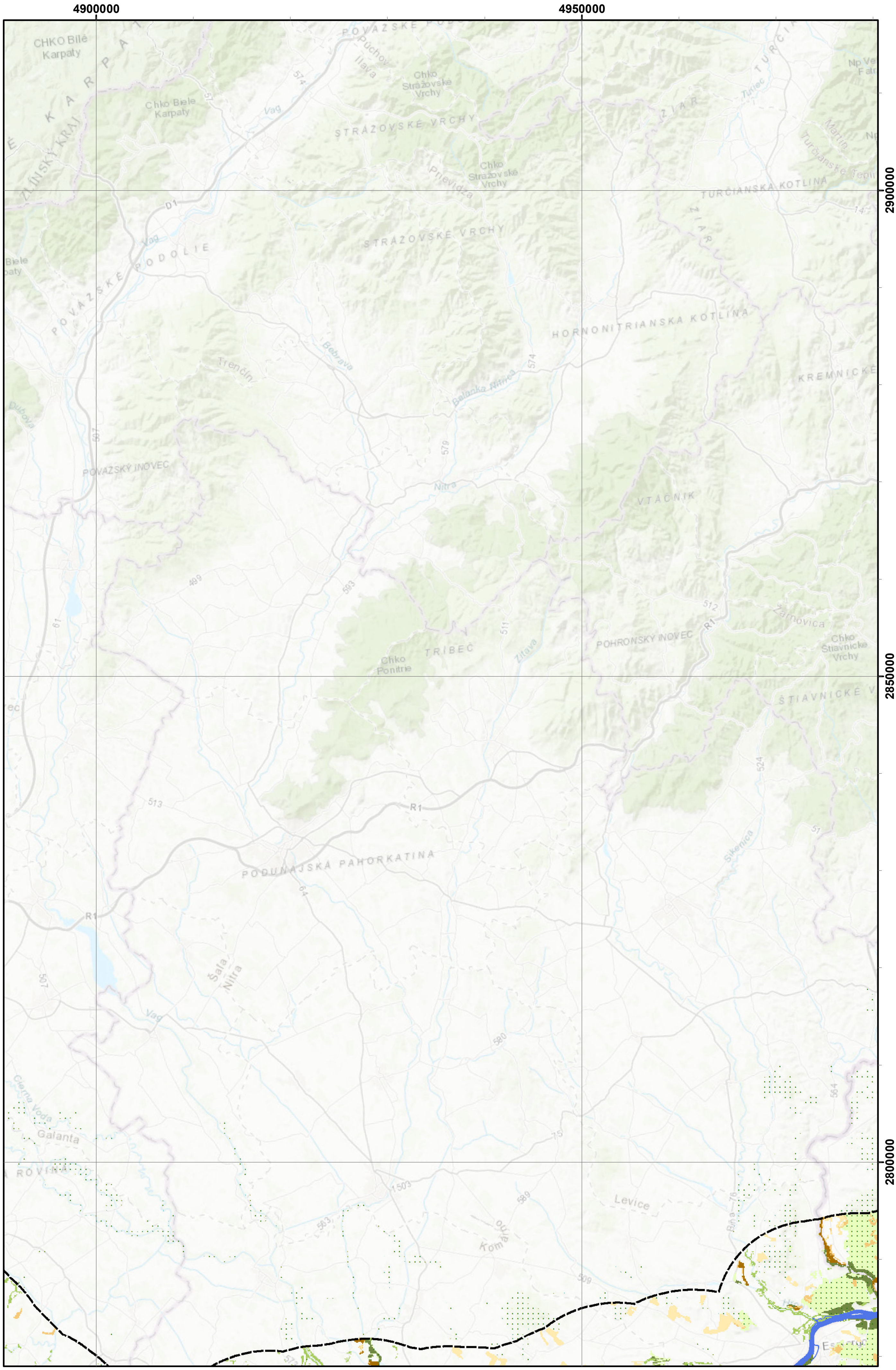
Eisenstadt
Neusiedler See
Rust
Zick See
AUSTRIA
HUNGARY
Sopron
Fertő-Hanság Nemzeti Park
Kapuvár
Csorna
Soproni Járás
Győri Járás
Rábca
M1
Ikva
222 m
201 m
Berek-patak
Repce
VAS
Bük
Kőszeg
881 m
Pápa
834
Celldömölk
Sárvár
Szombathely
416 m
439 m
Sárvári Járás
Jánosháza
Güssing
Marcal
Strembach
Körmend
225 m
Zala
ZALA
Raab
Tapol
Balaton-felvidéki Nemzeti Park
471 m
Zalaegerszeg
Zalalövő
Keszthely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ZLÍNSKÝ KRAJ
POVAŽSKÉ PODOLIE
Púchov
Ilava
Chko Strážovské Vrchy
STRÁŽOVSKÉ VRCHY
Prievidza
TURČIANSKA KOTLINA
Martin
Turčianske Teplice
Turiec
ŽIAR
D1
Váh
Trenčín
Bebrava
HORNONITRIANSKA KOTLINA
Belanka Nitrica
KREMNICKÉ
Dubová
POVAŽSKÝ INOVEC
Nitra
VTÁČNIK
Žarnovica
POHRONSKÝ INOVEC
Chko Ponitrie
TRIBEČ
Žitava
Chko Štiavnické Vrchy
ŠTIAVNICKÉ V
R1
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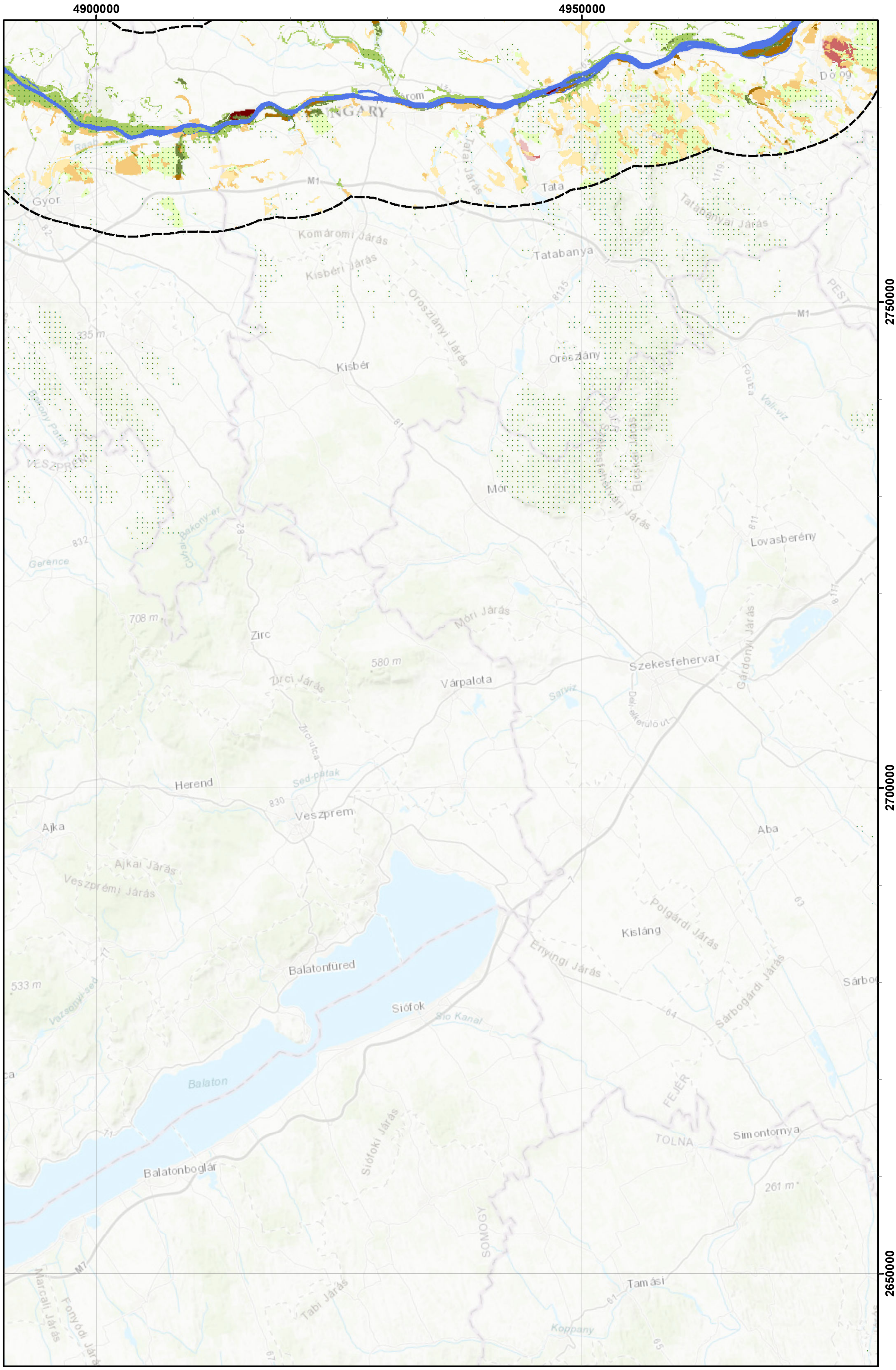
Šaľa
Sikenica
Čierna Voda
Galanta
Levice
Komárno
Esztergom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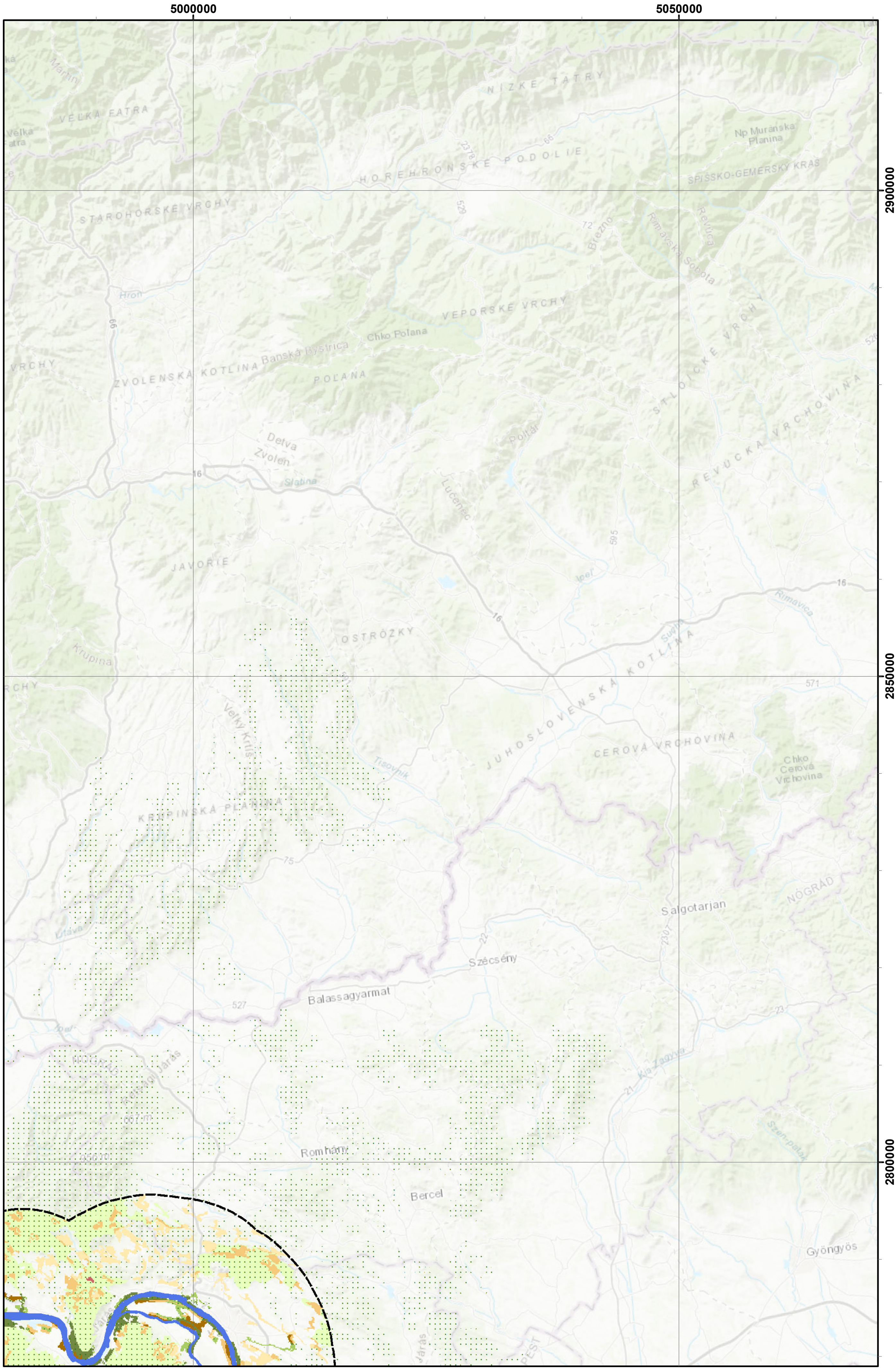
Gyor
Komáromi Járás
Kisbéri Járás
Tatabanya
Tata
Tatai Járás
Oroszlány
Kisbér
Mór
Lovasberény
Móri Járás
Zirc
Zirci Járás
Várpalota
Szekesfehervar
Herend
Veszprem
Ajka
Ajkai Járás
Veszprémi Járás
Aba
Kisláng
Polgárdi Járás
Enyingi Járás
Sárbogárdi Járás
Balatonfüred
Siófok
Balaton
Balatonboglár
Siófoki Járás
Simontornya
TOLNA
FEJÉR
SOMOGY
Tamási
Tabi Járás
Koppany
Marcali Járás
Fonyódi Járás
Gárdonyi Járás
M1
M7
Dorog
335 m
708 m
580 m
533 m
261 m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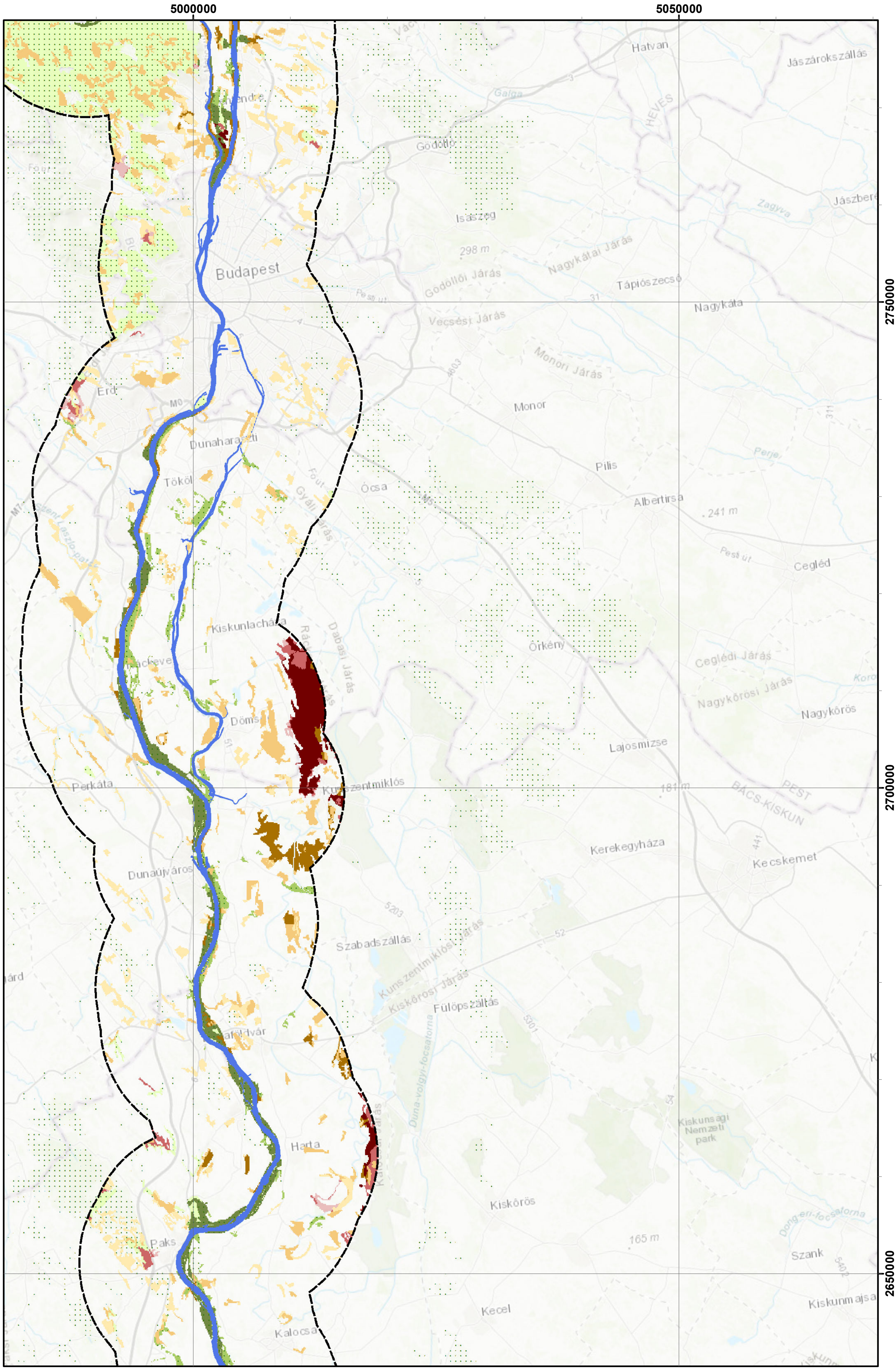
NIZKE TATRY
VELKA FATRA
HOREHRONSKE PODOLIE
Np Muránska Planina
SPISSKO-GEMERSKY KRAS
STAROHORSKE VRCHY
Hron
VEPORSKE VRCHY
Chko Poľana
Banská Bystrica
ZVOLENSKÁ KOTLINA
POĽANA
STOLICKE VRCHY
REVUCKA VRCHOVINA
Detva
Zvolen
Slatina
Lučenec
Rimavská Sobota
Brezno
JAVORIE
Ipeľ
Rimavica
OSTRÔZKY
Krupina
JUHOSLOVENSKÁ KOTLINA
CEROVA VRCHOVINA
Chko Cerová Vrchovina
Veľký Krtíš
Tisovník
KRUPINSKÁ PLANINA
Salgotarjan
NÓGRÁD
Szécsény
Balassagyarmat
Kis-Zagyva
Romhány
Bercel
Gyöngyös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Hatvan
Jászárokszállás
Jászberé
Zagyva
Gödöllő
Isaszeg
298 m
Gödöllői Járás
Nagykátai Járás
Tápiószecső
Nagykáta
Budapest
Vecsési Járás
Monori Járás
Monor
Érd
Dunaharaszti
Tököl
Ócsa
Pilis
Albertirsa
241 m
Cegléd
Perje
Kiskunlacháza
Dabasi Járás
Örkény
Ceglédi Járás
Nagykőrösi Járás
Nagykőrös
Ráckeve
Dömsöd
Lajosmizse
Kunszentmiklós
Perkáta
181 m
BÁCS-KISKUN
PEST
Kerekegyháza
Kecskemét
Dunaújváros
Szabadszállás
Kunszentmiklósi Járás
Kiskőrösi Járás
Fülöpszállás
Duna-völgyi-főcsatorna
Solt
Harta
Kiskunsági Nemzeti park
Kiskőrös
Paks
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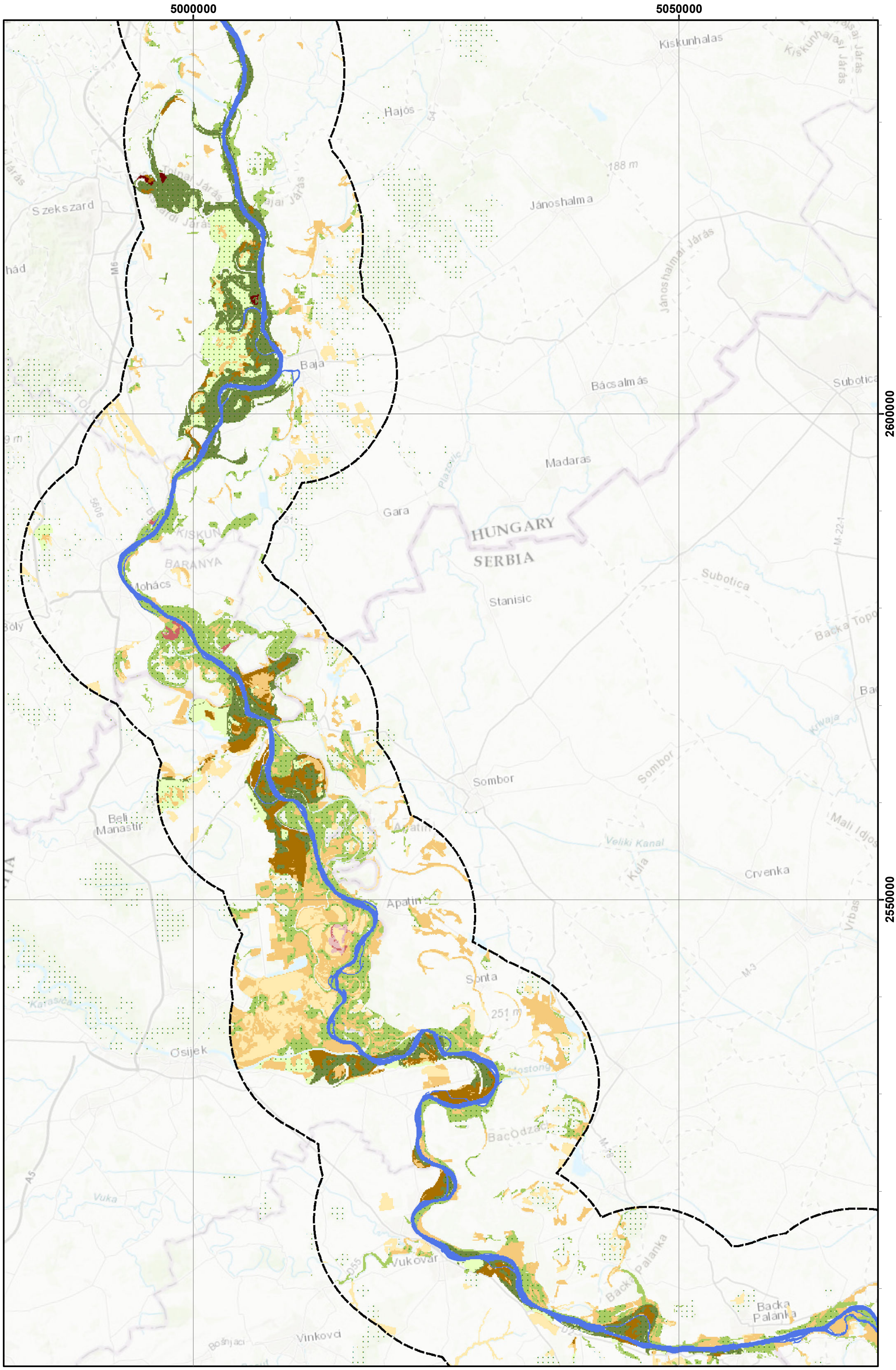
Szank
Kecel
Kalocsa
Kiskunmajsa
HEVES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Jánoshalma
Szekszárd
Baja
Bácsalmás
Subotica
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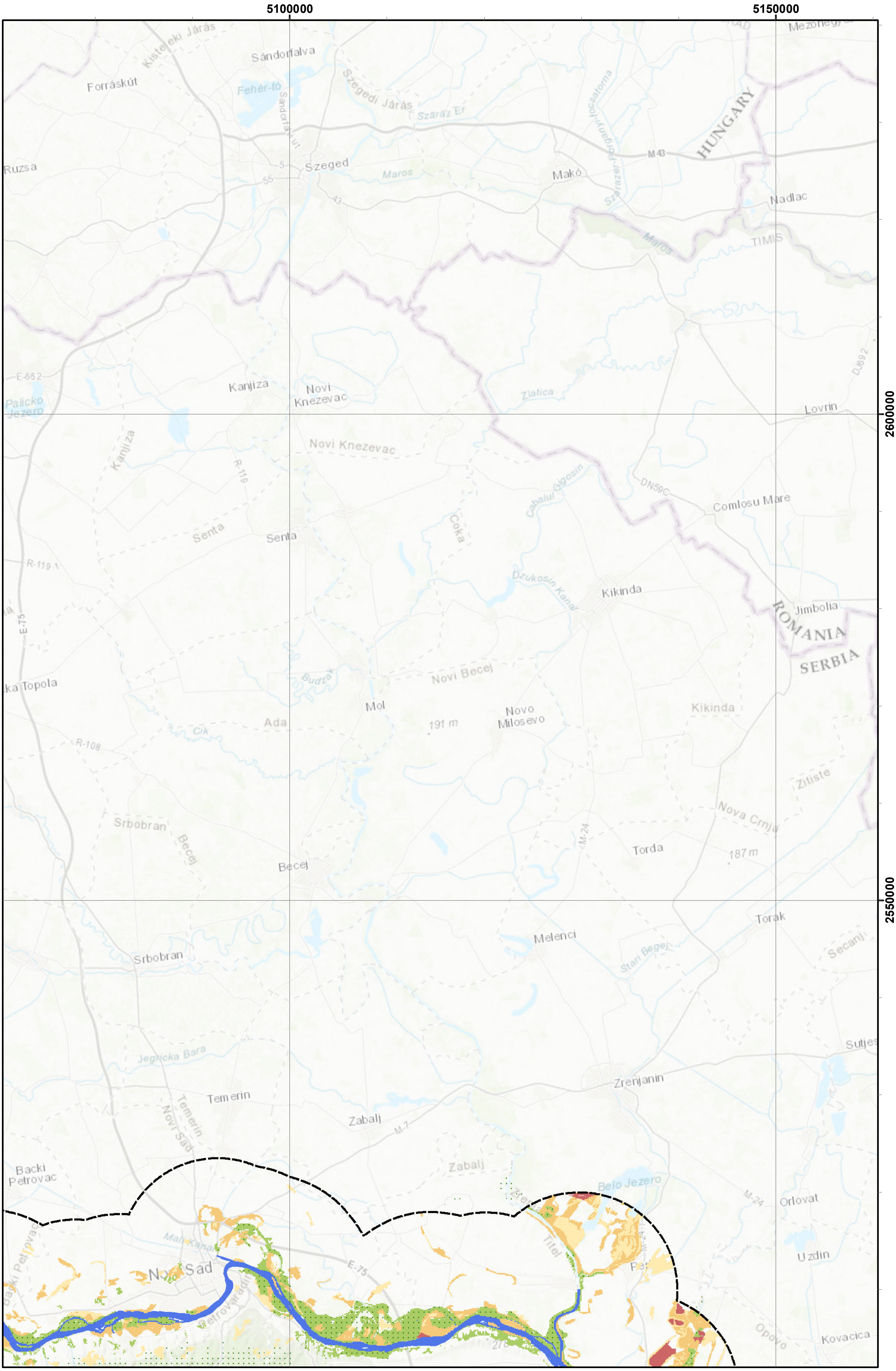
Gara
HUNGARY
SERBIA
Stanisic
Mohács
Sombor
Beli Manastir
Apatin
Crvenka
Sonta
Osijek
Vukovar
Backa Palanka
Vinkovci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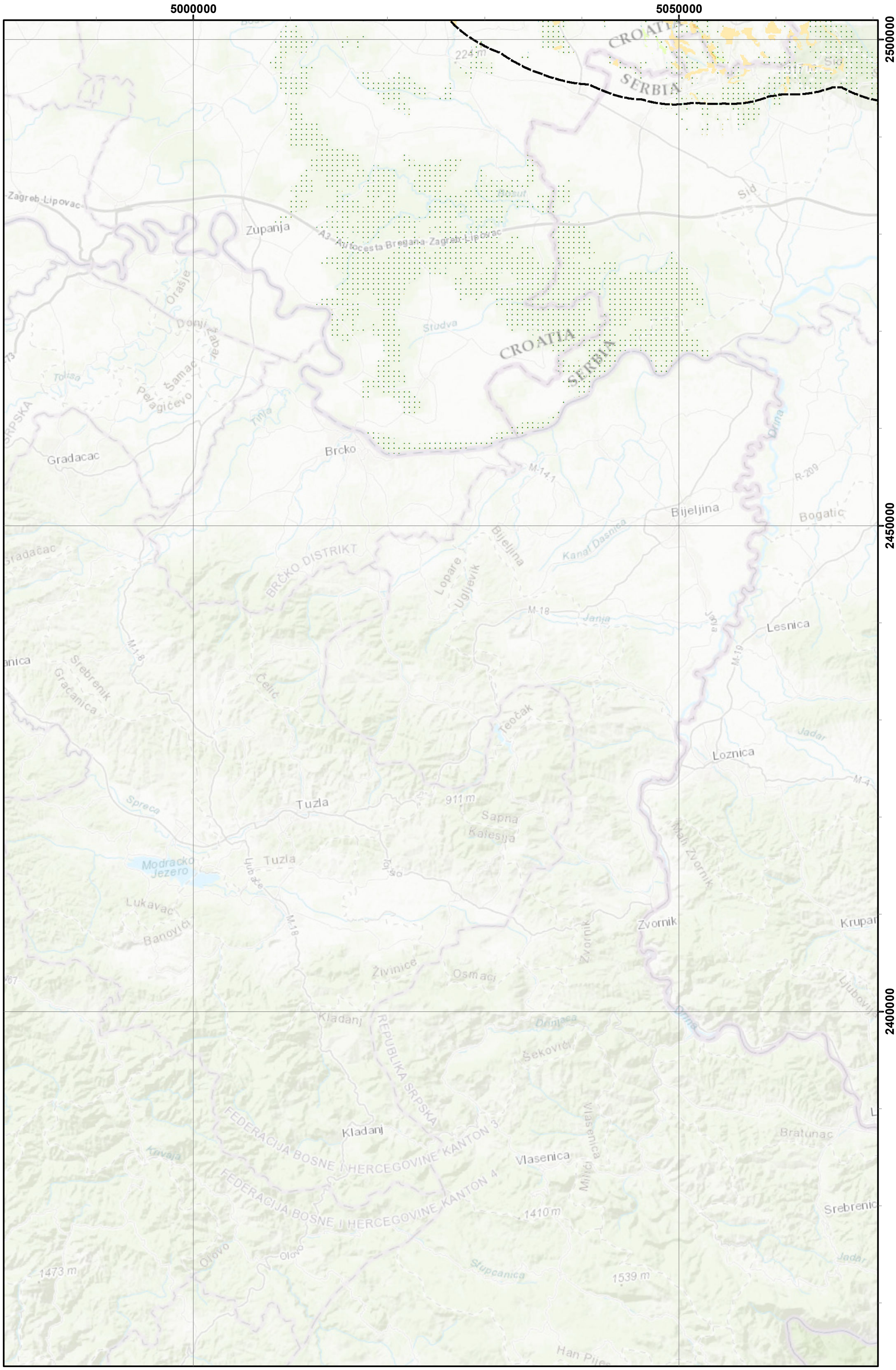
Szegedi Járás
Száraz Ér
Kisteleki Járás
Ruzsa
Szeged
Maros
Makó
HUNGARY
M43
Nadlac
TIMIS
Kanjiza
Novi Knezevac
Palicko Jezero
E-662
Zlatica
Lovrin
Novi Knezevac
R-119
DN59C
Comlosu Mare
Senta
Senta
Coka
R-119.1
Dzukosin Kanal
Kikinda
Jimbolia
ROMANIA
SERBIA
E-75
Novi Becej
Mol
Novo Milosevo
191 m
Kikinda
Ada
Cik
R-108
Zitiste
Srbobran
Becej
M-24
Torda
Nova Crnja
187 m
Becej
Torak
Melenci
Srbobran
Stari Begej
Secanj
Jegricka Bara
Sutjes
Zrenjanin
Temerin
Temerin
Novi Sad
Zabalj
M-7
Backi Petrovac
Zabalj
Belo Jezero
Orlovat
Mali Kanal
Novi Sad
E-75
Titel
Uzdin
Opovo
Kovacica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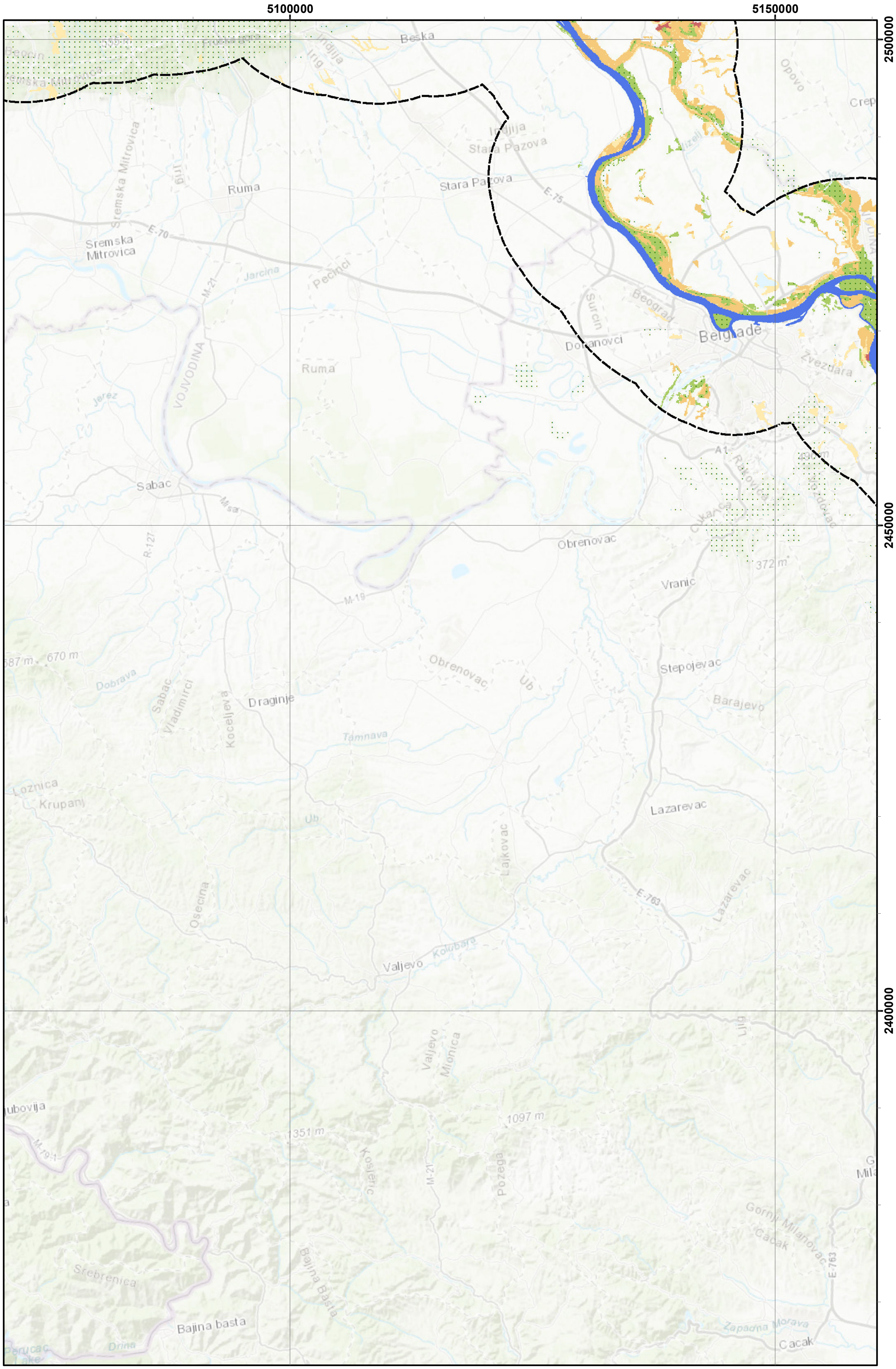
SERBIA
Zagreb-Lipovac
Zupanja
A3 Autocesta Bregana-Zagreb-Lipovac
Bosut
Sid
Orašje
Donji Žabar
Šamac
Pelagićevo
Tolisa
Studva
CROATIA
SERBIA
Tinja
Gradacac
Brcko
M-14.1
Drina
R-209
Bijeljina
Bogatic
Gradačac
BRČKO DISTRIKT
Lopare
Ugljevik
Bijeljina
Kanal Dasnica
M-18
Janja
Janja
Lesnica
M-19
M-18
Srebrenik
Gračanica
Čelić
Teočak
Jadar
Loznica
M-4
Spreca
Tuzla
911 m
Sapna
Kalesija
Modracko Jezero
Tuzla
Ljubače
Lukavac
Banovići
M-18
Mali Zvornik
Zvornik
Zvornik
Krupanj
Živinice
Osmaci
Ljubovija
Kladanj
REPUBLIKA SRPSKA
Drinjača
Drina
Šekovići
Bratunac
Kladanj
FEDERACIJA BOSNE I HERCEGOVINE KANTON 3
Krivaja
Vlasenica
Vlasenica
Milići
FEDERACIJA BOSNE I HERCEGOVINE KANTON 4
1410 m
Srebrenica
Olovo
Olovo
1473 m
Stupčanica
1539 m
Jadar
Han Pijesak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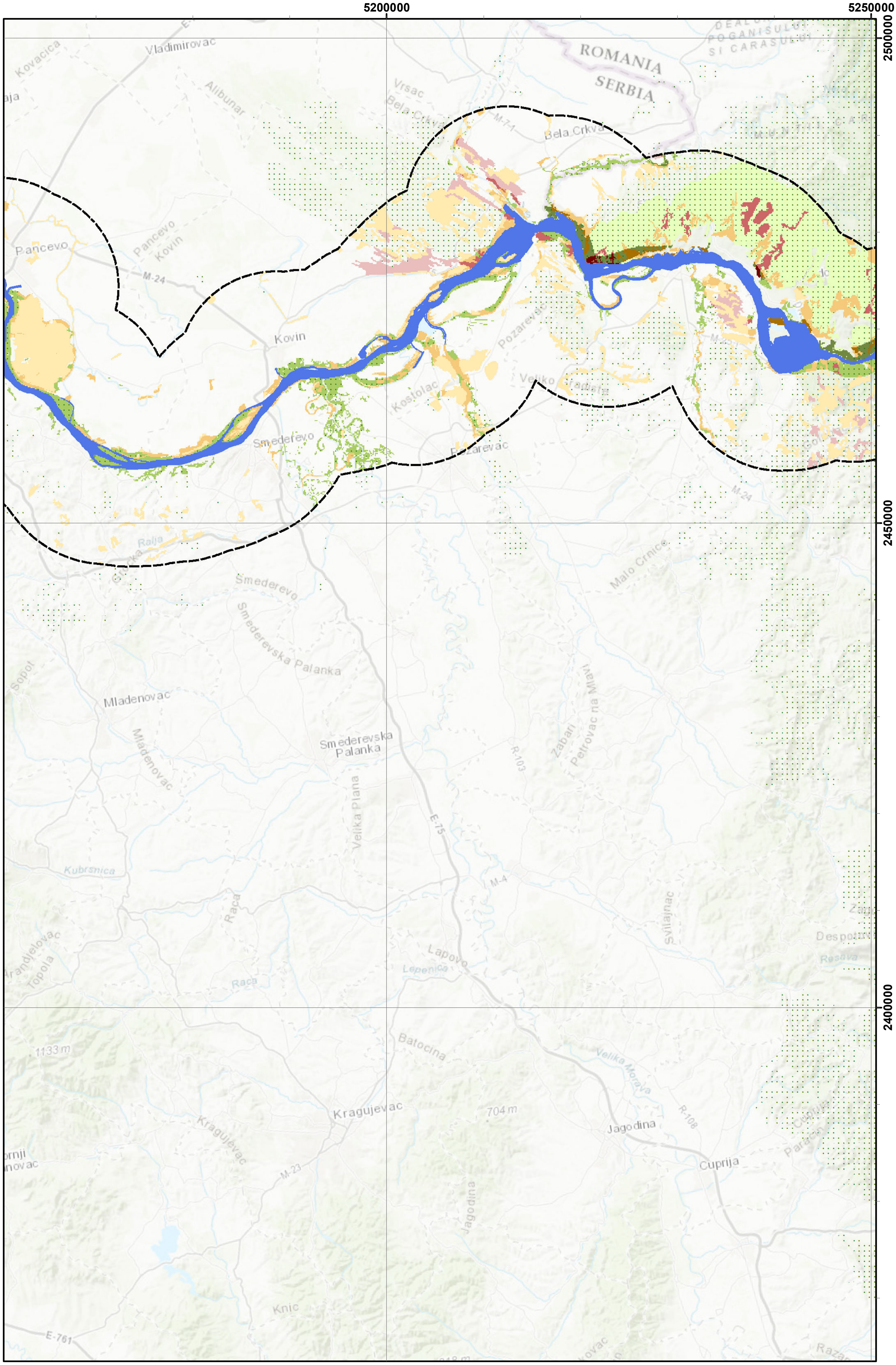
Beska
Indjija
Stara Pazova
Stara Pazova
Opovo
E-75
Ruma
Sremska Mitrovica
Sremska Mitrovica
Irig
E-70
Jarcina
Pecinci
M-21
Surcin
Beograd
Belgrade
Dobanovci
Zvezdara
VOJVODINA
Ruma
Jerez
Sabac
Obrenovac
R-127
A1
372 m
Vranic
M-19
587 m
670 m
Dobrava
Obrenovac
Ub
Stepojevac
Barajevo
Sabac
Vladimirci
Koceljeva
Draginje
Tamnava
Loznica
Krupanj
Ub
Lazarevac
Lajkovac
Osecina
E-763
Lazarevac
Valjevo
Kolubara
Ljig
Valjevo
Mionica
Ljubovija
1351 m
1097 m
Kosjeric
M-21
Pozega
Srebrenica
Gornji Milanovac
Cacak
E-763
Bajina basta
Bajina Basta
Drina
Zapadna Morava
Cacak



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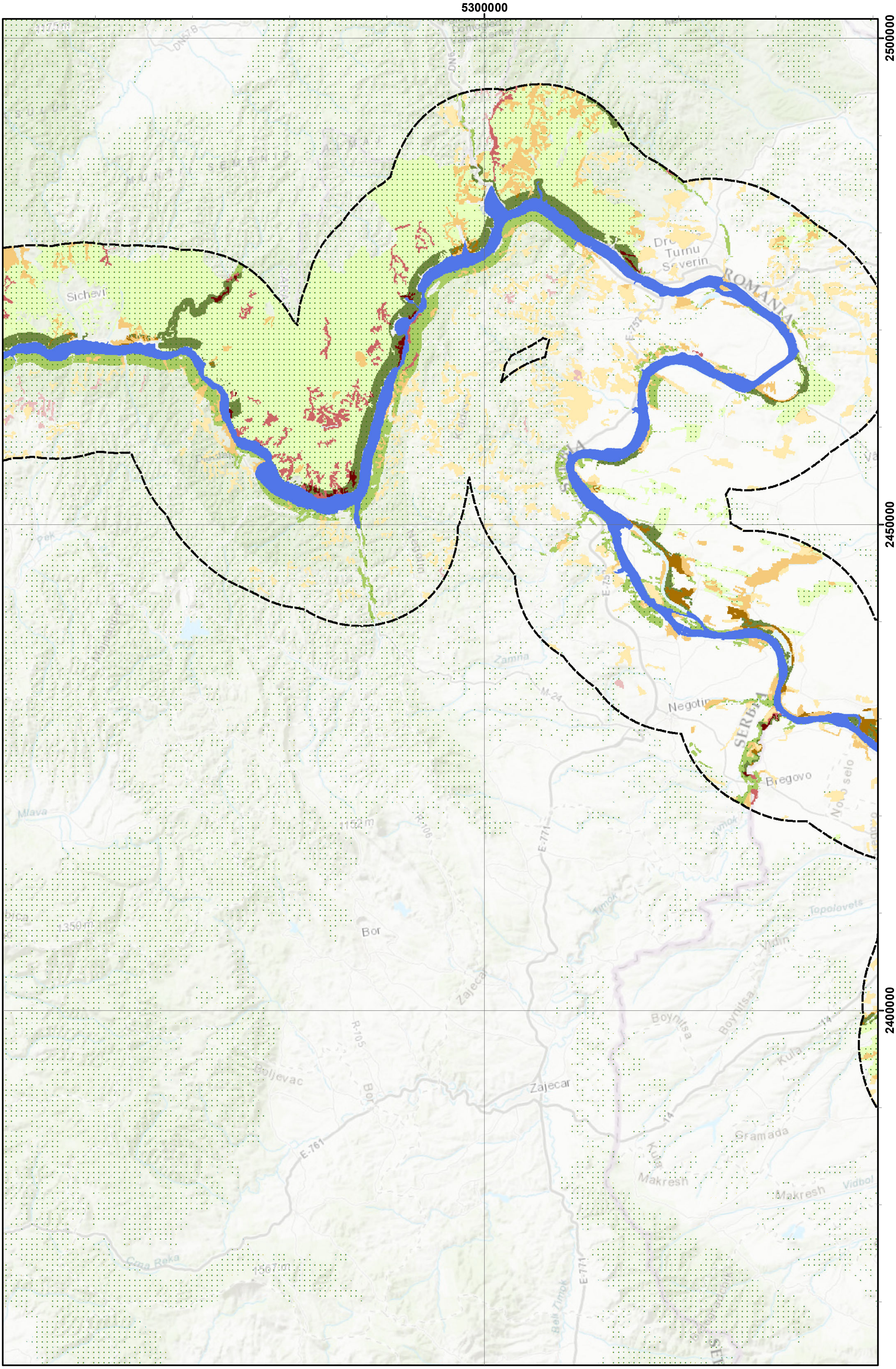
Vladimirovac
Kovacica
Alibunar
Vrsac
Bela Crkva
Pancevo
Kovin
M-24
Smederevo
Kostolac
Pozarevac
Veliko Gradiste
Malo Crnice
Ralja
Sopot
Mladenovac
Smederevska Palanka
Velika Plana
Petrovac na Mlavi
Zabari
R-103
E-75
M-4
Kubrsnica
Raca
Svilajnac
Arandjelovac
Topola
Lapovo
Lepenica
Despotovac
Resava
Batocina
Kragujevac
704 m
1133 m
Jagodina
R-108
Velika Morava
Cuprija
Paracin
M-23
Knic
E-761



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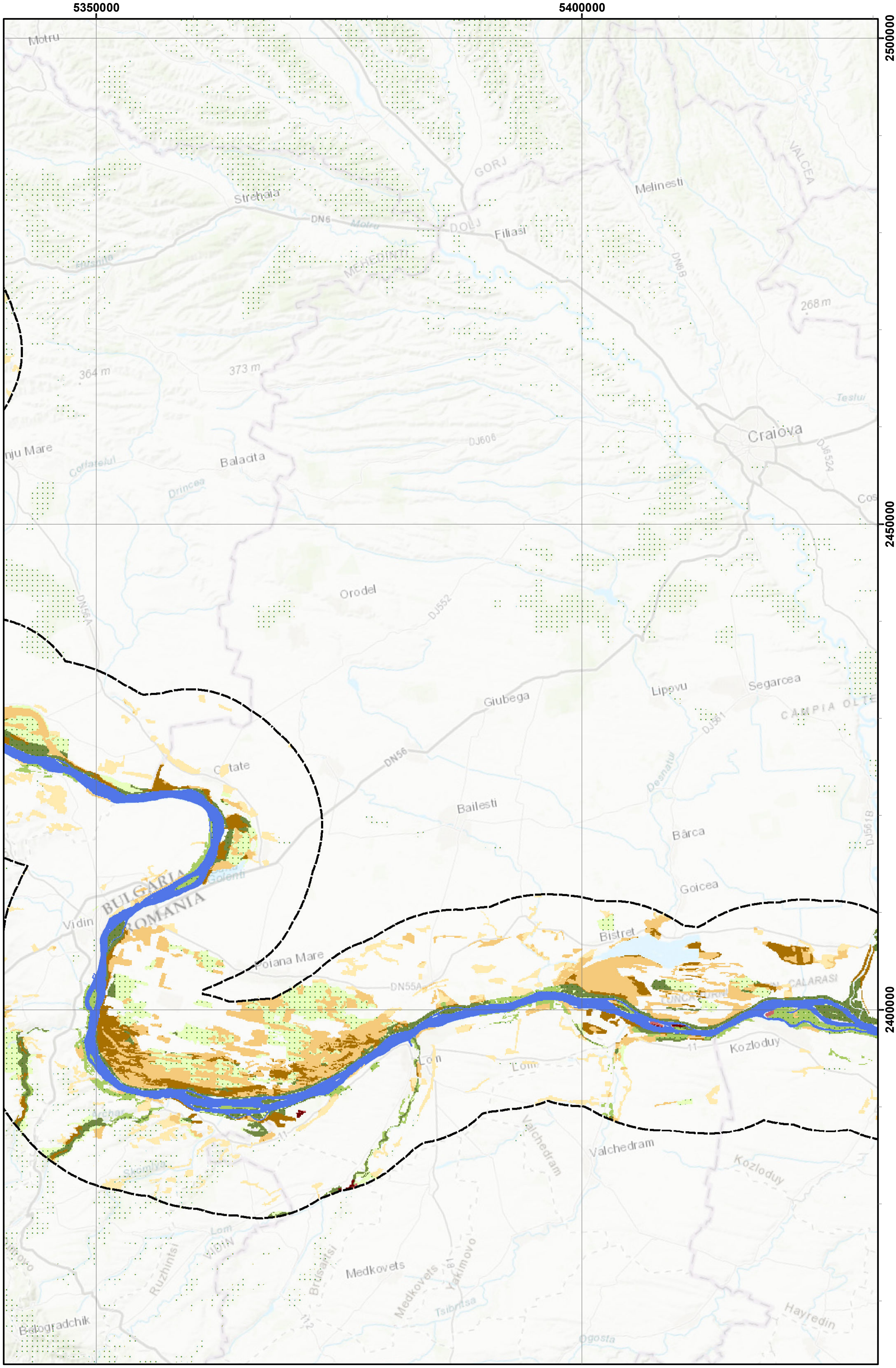
Sichevi
Turnu
Severin
ROMANIA
SERBIA
Negotin
Bregovo
Novo selo
Zamna
M-24
E-771
R-106
R-105
1152m
1350m
Bor
Zajecar
Boljevac
E-761
Mlava
Pek
Crna Reka
Topolovets
Vidin
Boynitsa
Kula
Gramada
Makresh
Vidbol
Timok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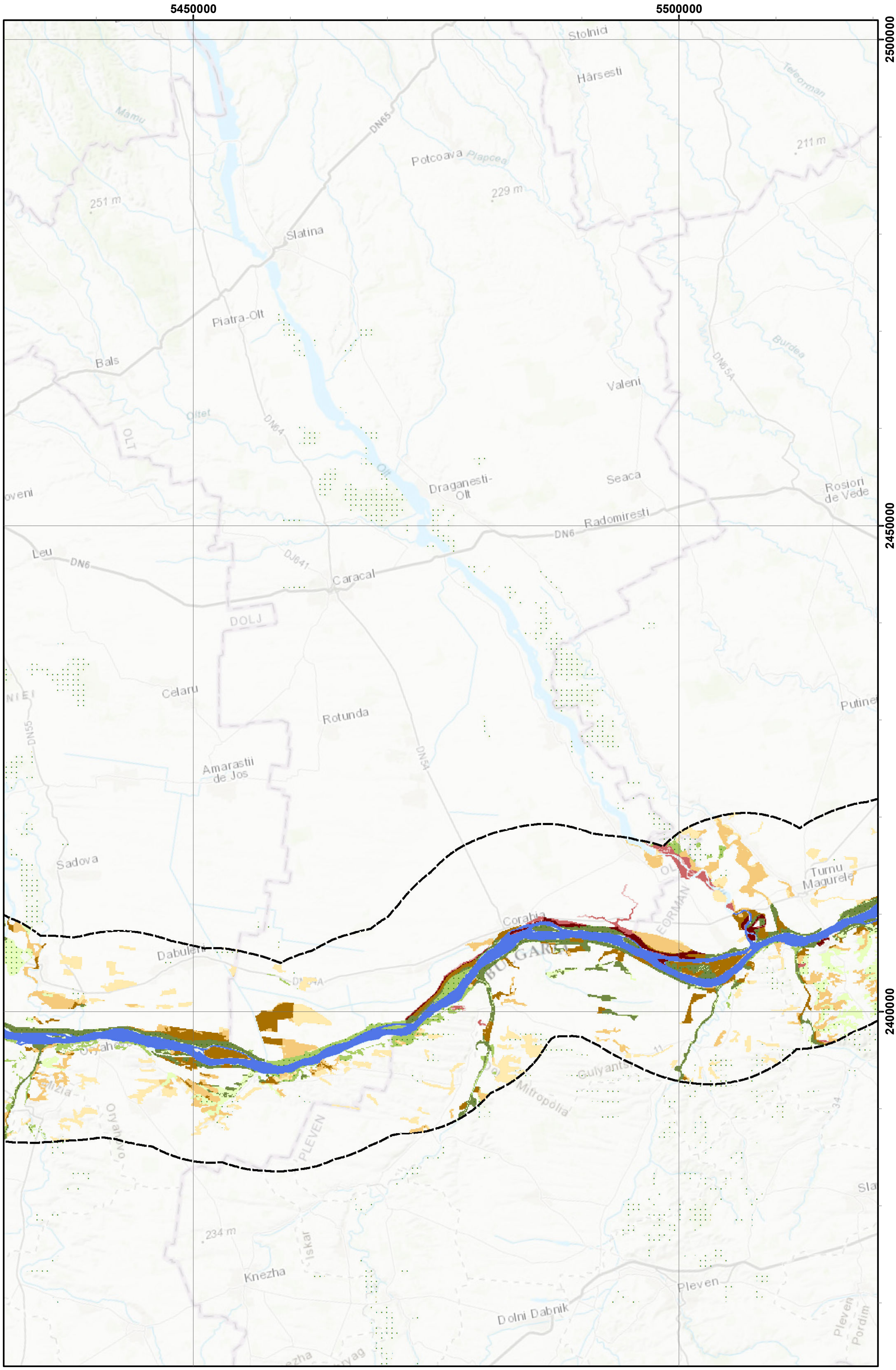
Motru
Strehaia
GORJ
DOLJ
Filiasi
Melinesti
VALCEA
MEHEDINTI
DN6
Motru
268 m
364 m
373 m
Craiova
Teslui
DJ606
Balacita
Orodel
DJ552
Giubega
Lipovu
Segarcea
CAMPIA OLT
DN56
Bailesti
Bârca
Goicea
BULGARIA
ROMANIA
Vidin
Poiana Mare
DN55A
Bistret
CALARASI
Kozloduy
Lom
Valchedram
Medkovets
Yakimovo
Ruzhintsi
Brusartsi
Belogradchik
Hayredin
Ogosta
Tsibritsa
VIDIN
DN56A
DJ561
DJ561B
DJ652A
DN6B
Desnatui
Drincea
Skomlya
Archar
Golenti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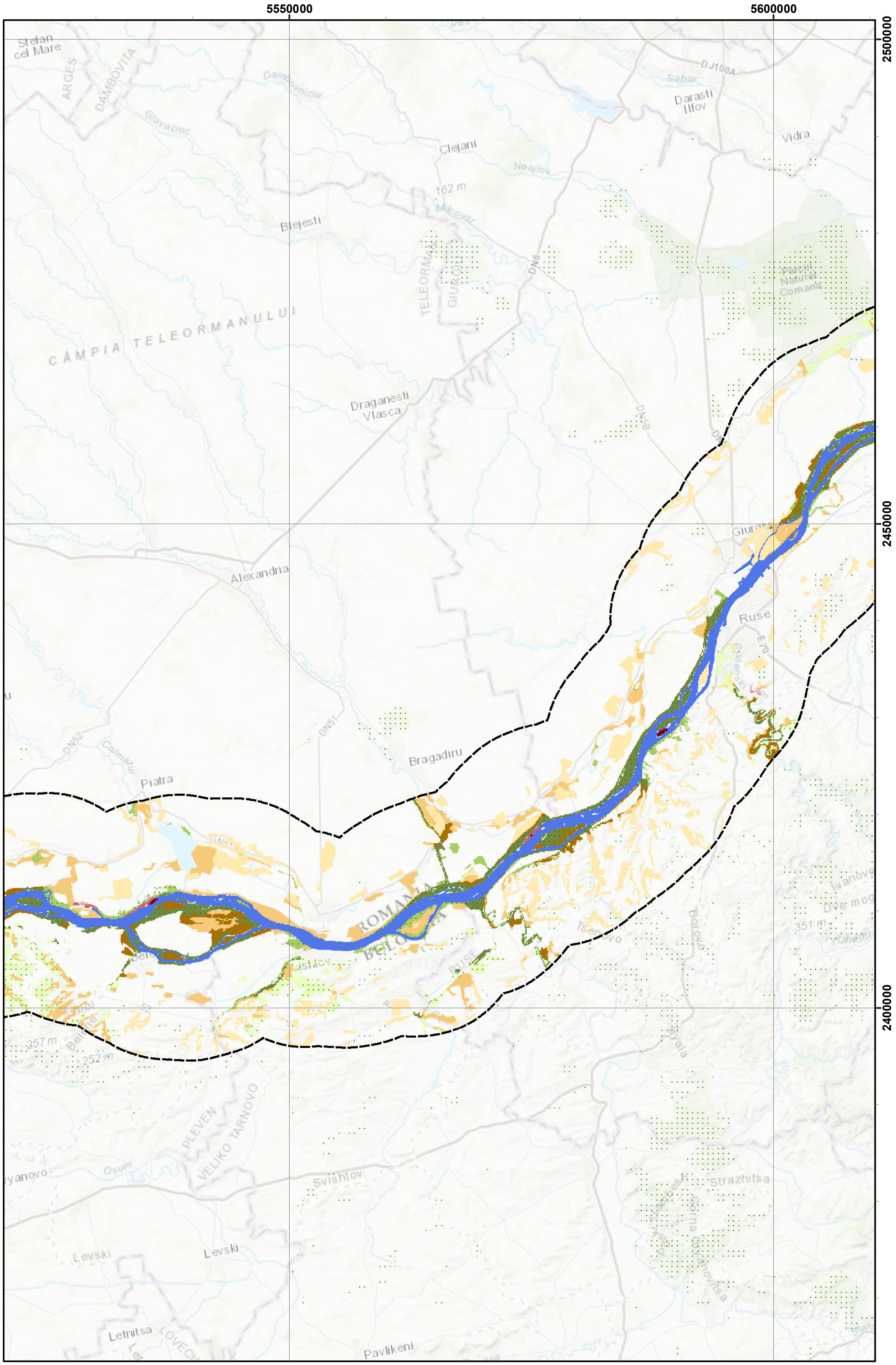
Stolnici
Hârsesti
Teleorman
Mamu
DN65
Potcoava
Plapcea
211 m
229 m
251 m
Slatina
Piatra-Olt
Bals
Burdea
DN65A
Valeni
Oltet
OLT
DN64
Olt
Draganesti-Olt
Seaca
Rosiori de Vede
Radomiresti
DN6
Leu
DN6
DJ641
Caracal
DOLJ
Celaru
Rotunda
Putine
DN55
Amarastii de Jos
DN54
Sadova
Turnu Magurele
Corabia
Dabuleni
Gulyantsi
Mitropolia
Oryahovo
PLEVEN
234 m
Iskar
Knezha
Pleven
Dolni Dabnik


5550000
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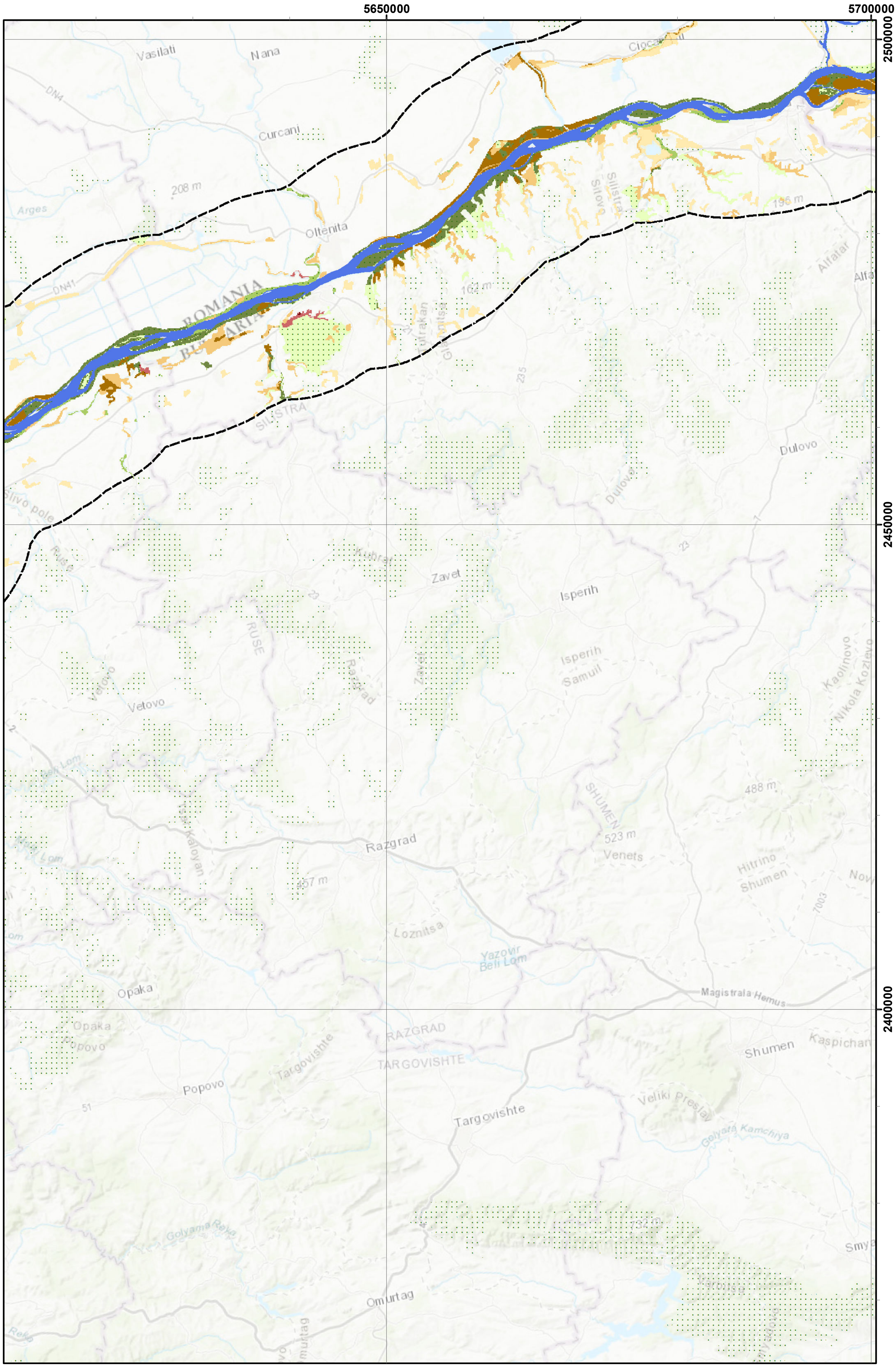
Stefan cel Mare
ARGES
DAMBOVITA
Dambovnicul
Glavacioc
Clejani
Neajlov
DJ100A
Sabar
Darasti Ilfov
Vidra
162 m
Blejesti
TELEORMAN
GIURGIU
DN6
Parcul Natural Comana
CÂMPIA TELEORMANULUI
Draganesti Vlasca
DN5B
Alexandria
Ruse
E70
DN51
DN52
Bragadiru
Piatra
ROMANIA
BULGARIA
257 m
252 m
351 m
PLEVEN
VELIKO TARNOVO
Osum
Svishtov
Strazhitsa
Levski
Letnitsa
LOVECH
Pavlikeni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5700000
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2450000
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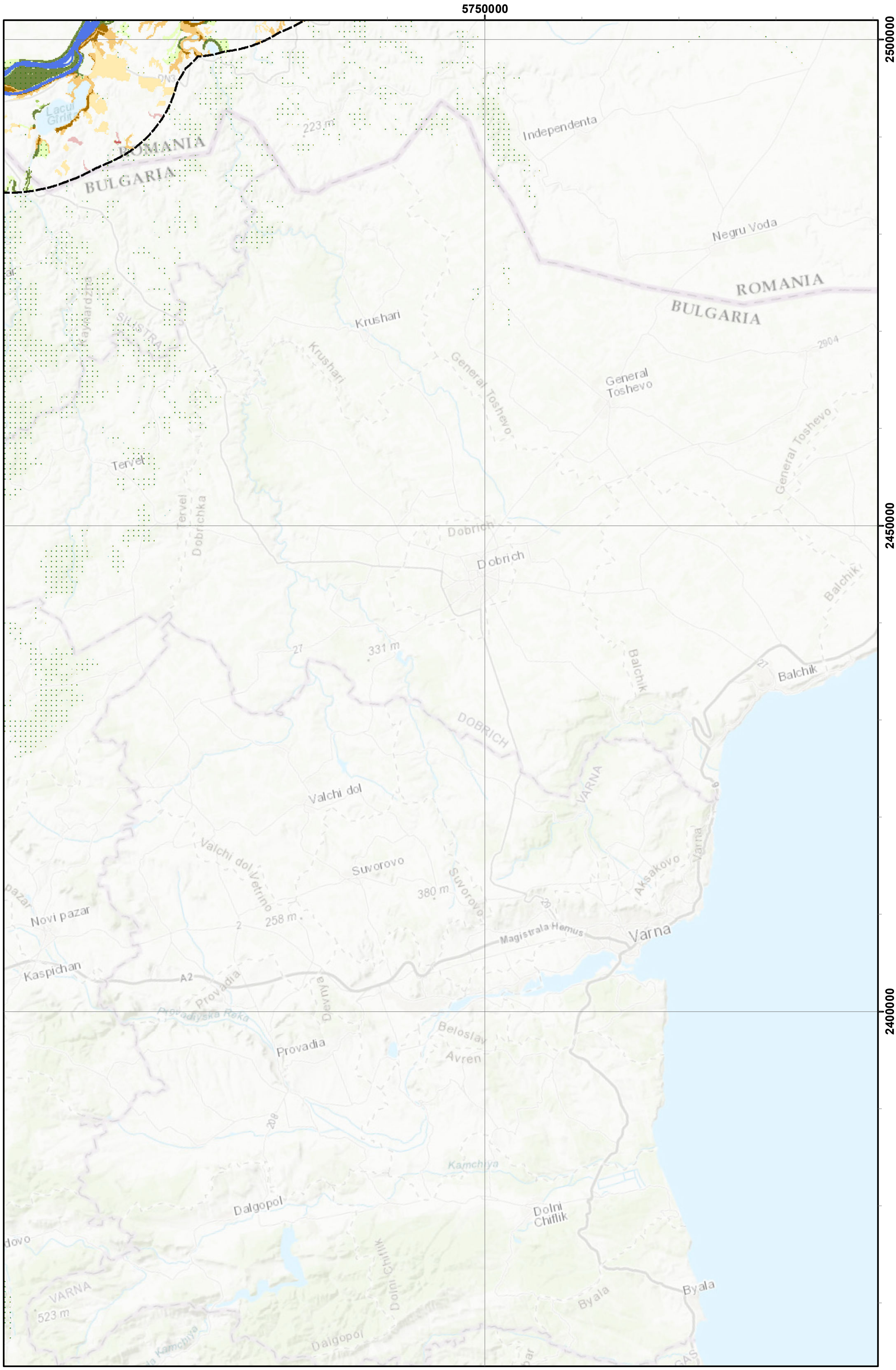
Vasilati
Nana
Curcani
208 m
Arges
Oltenita
ROMANIA
BULGARIA
DN41
DN4
Ciocanesti
Silistra
Sitovo
195 m
Altatar
Tutrakan
Glavinitsa
SILISTRA
Dulovo
Slivo pole
Ruse
Kubrat
Zavet
Isperih
RUSE
Razgrad
Samuil
Vetovo
Kaolinovo
Nikola Kozlevo
SHUMEN
488 m
523 m
Venets
Hitrino
Shumen
Beli Lom
Loznitsa
Yazovir Beli Lom
Opaka
Magistrala Hemus
RAZGRAD
TARGOVISHTE
Popovo
Targovishte
Veliki Preslav
Golyama Kamchiya
Kaspichan
Golyama Reka
Omurtag
Smyadovo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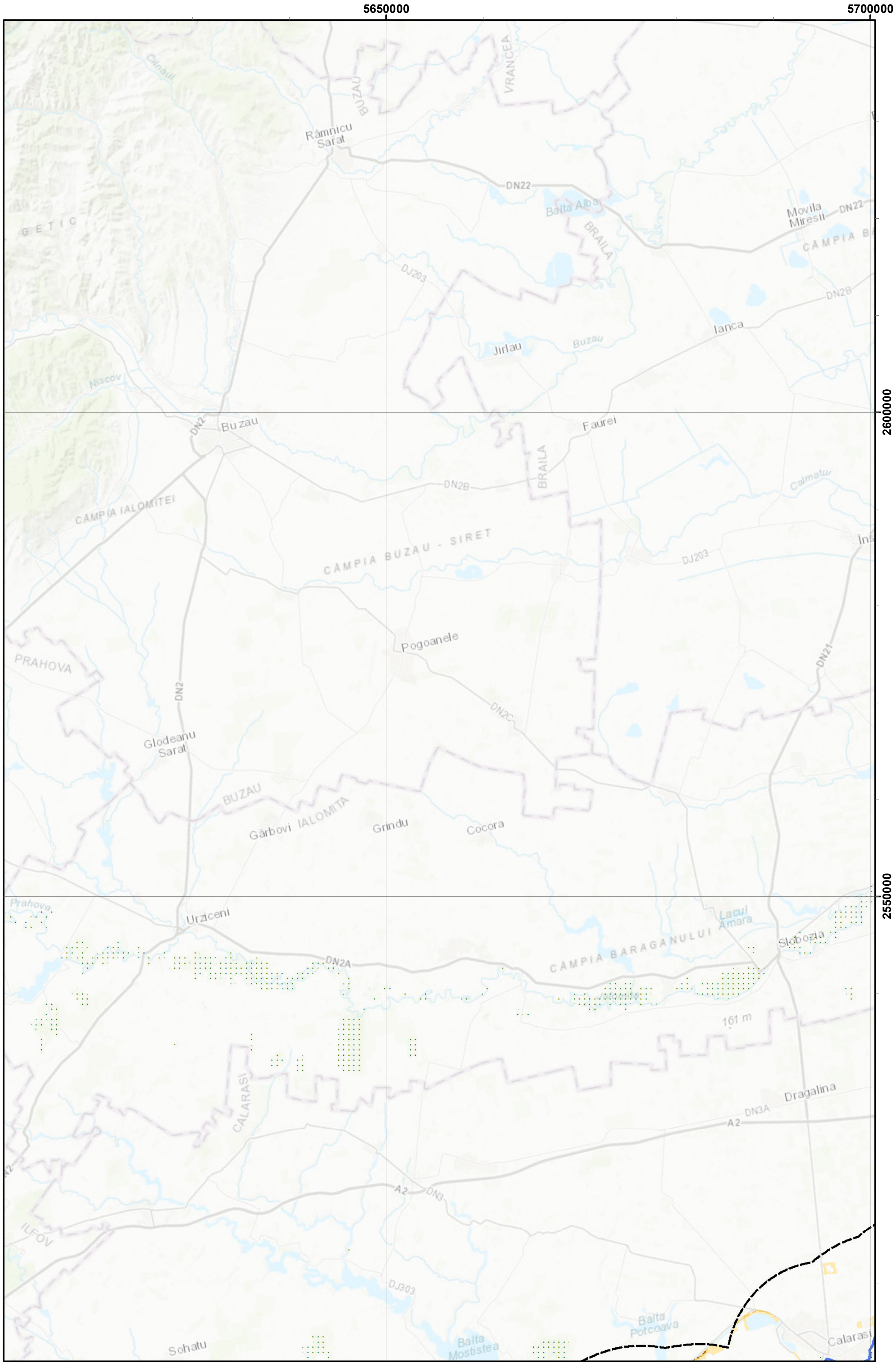
ROMANIA
BULGARIA
Independenta
Negru Voda
ROMANIA
BULGARIA
Krushari
General Toshevo
Tervel
Dobrich
Balchik
Valchi dol
Suvorovo
Novi pazar
Kaspichan
Varna
Magistrala Hemus
Provadia
Beloslav
Avren
Dalgopol
Dolni Chiflik
Byala
Kamchiya
VARNA
DOBRICH
Aksakovo
223 m
331 m
380 m
258 m
523 m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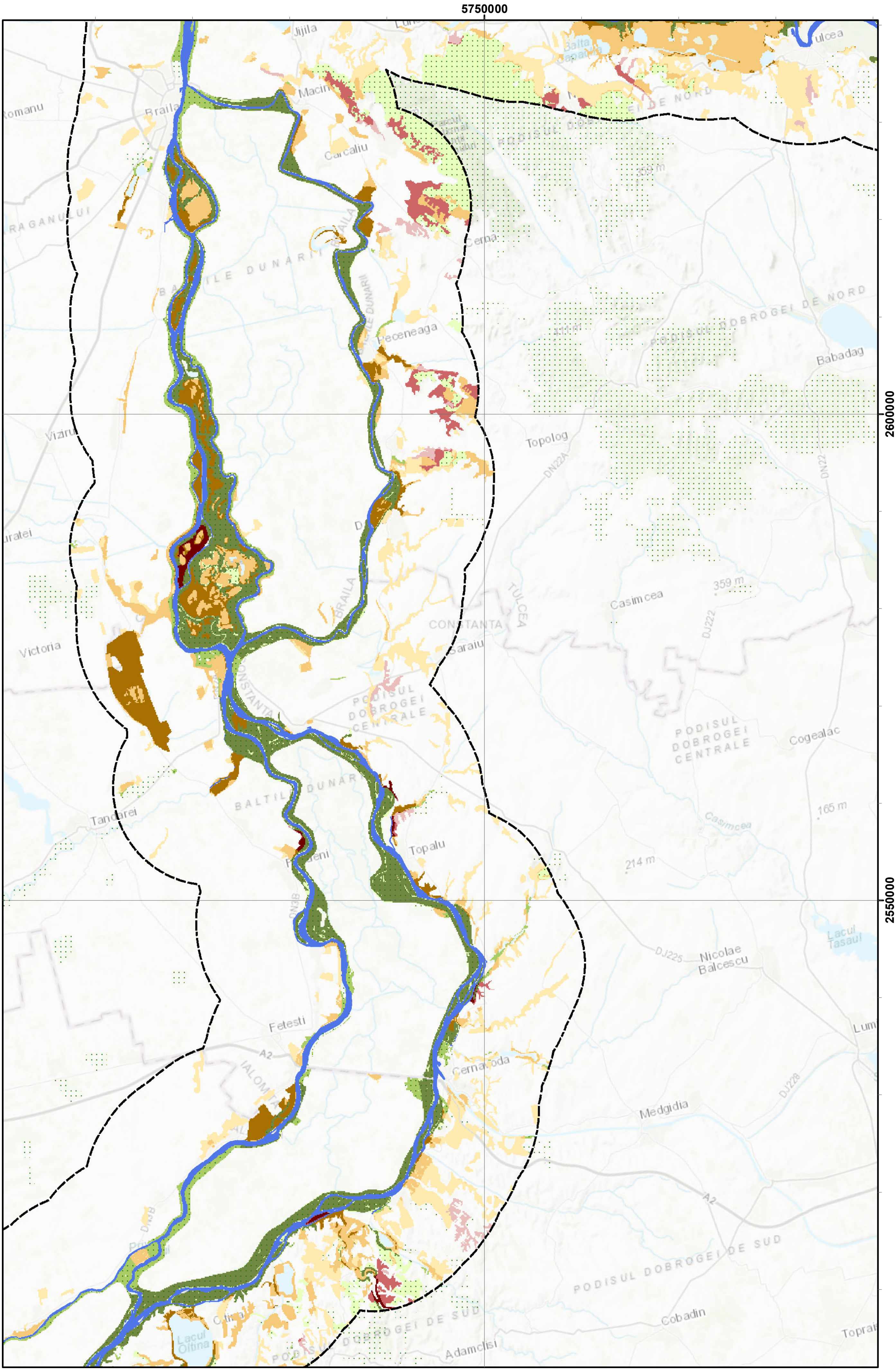
Râmnicu Sarat
BUZAU
VRANCEA
DN22
Balta Alba
BRAILA
Movila Miresii
CAMPIA
DJ203
DN2B
Ianca
Jirlau
Buzau
Niscov
GETIC
DN2
Buzau
Faurei
CÂMPIA IALOMITEI
CÂMPIA BUZAU - SIRET
PRAHOVA
Pogoanele
DN21
DN2C
Glodeanu Sarat
BUZAU
IALOMITA
Gârbovi
Grindu
Cocora
Prahova
Urziceni
Lacul Amara
Slobozia
CÂMPIA BARAGANULUI
DN2A
161 m
CALARASI
Dragalina
DN3A
A2
A2
DN3
ILFOV
DJ303
Balta Potcoava
Calarasi
Sohatu
Balta Mostistea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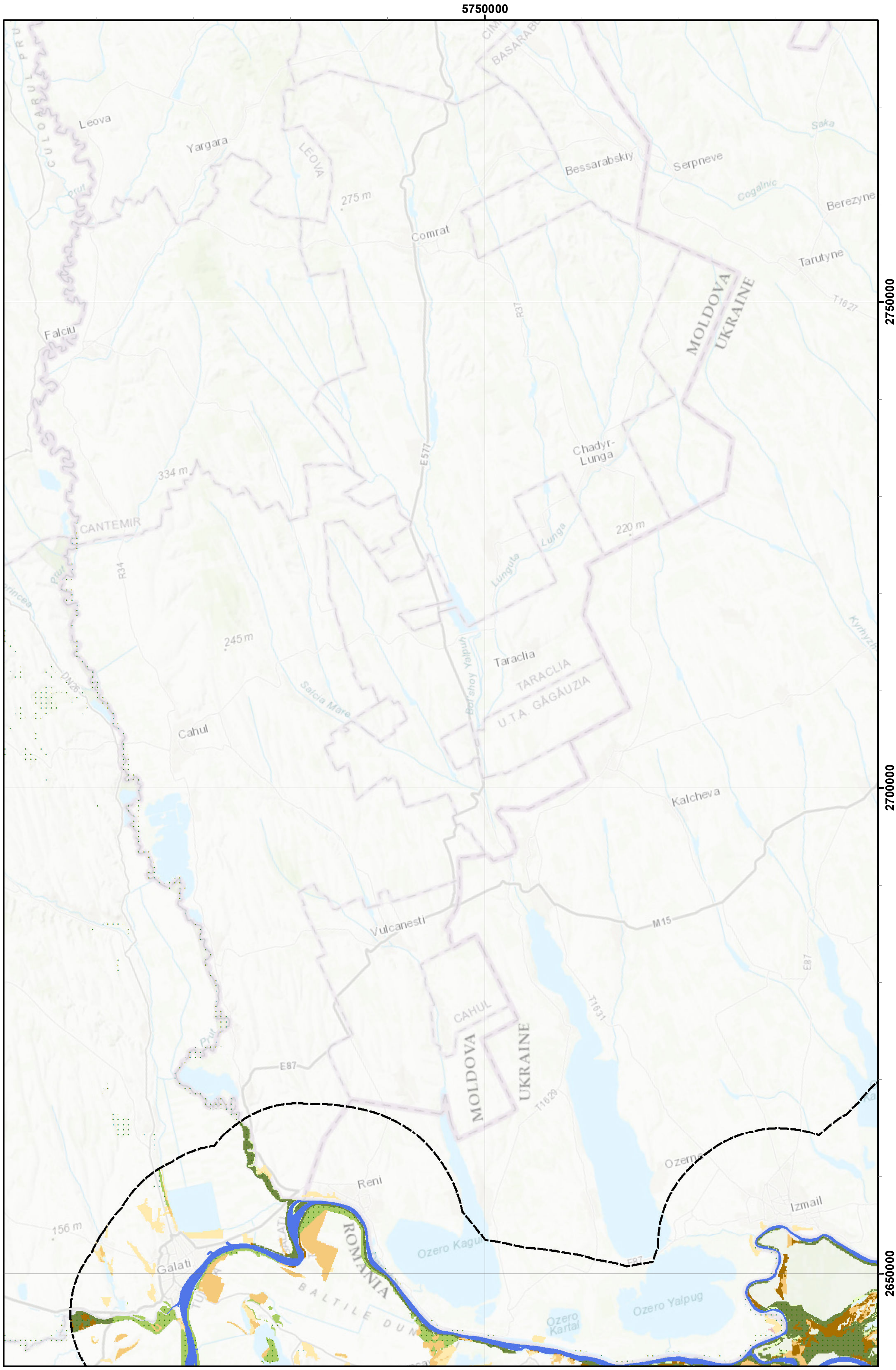
Jijila
Braila
Macin
Carcaliu
Cerna
Peceneaga
Topolog
Casimcea
Saraiu
CONSTANTA
TULCEA
Victoria
Tandarei
Topalu
Fetesti
Cernavoda
Medgidia
Nicolae Balcescu
Cogealac
Babadag
Cobadin
Adamclisi
Lacul Oltina
Lacul Tasaul
PODISUL DOBROGEI CENTRALE
PODISUL DOBROGEI DE NORD
PODISUL DOBROGEI DE SUD
BALTILE DUNARII
359 m
214 m
165 m


5750000
2750000
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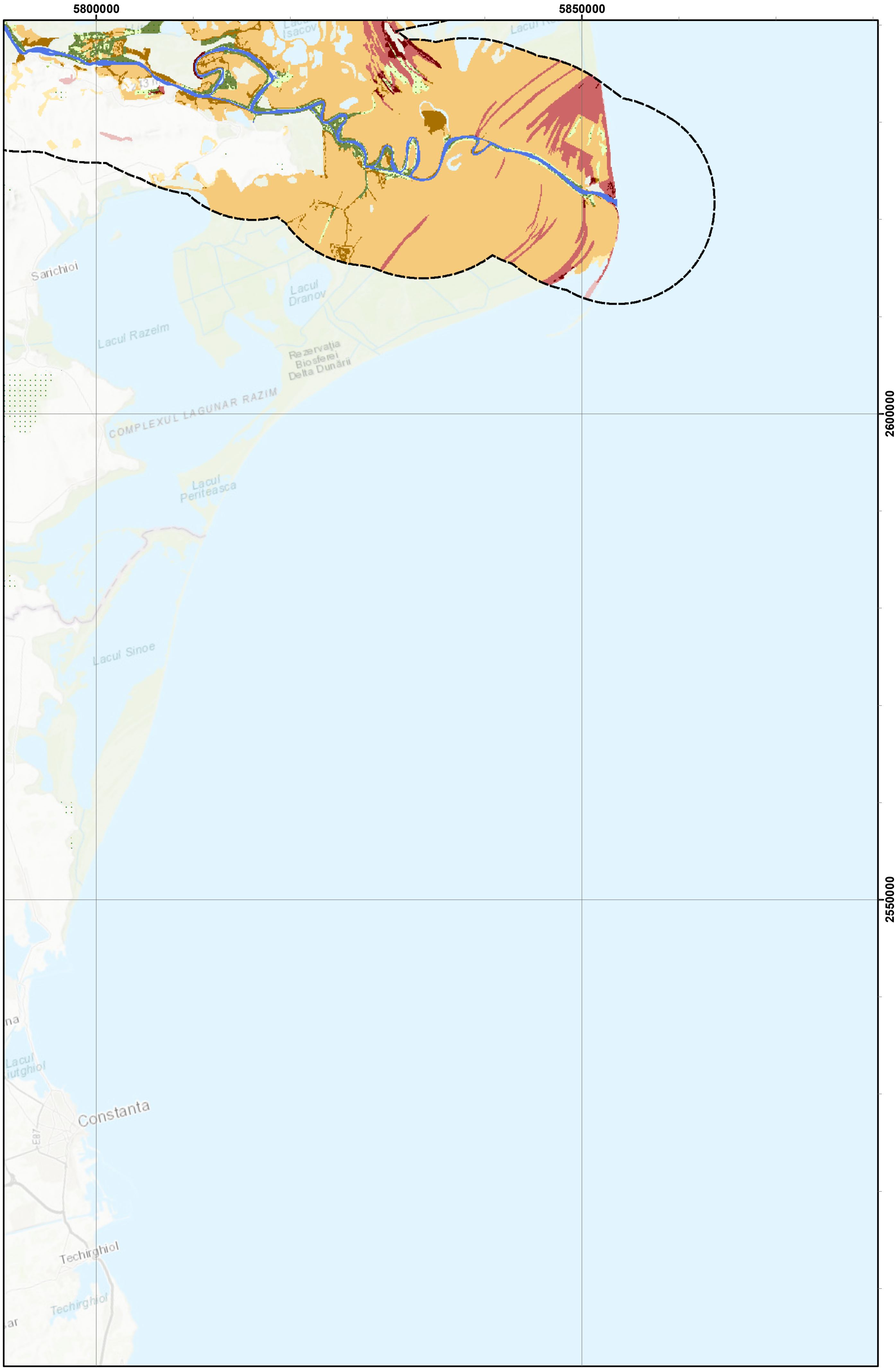
Leova
Yargara
LEOVA
275 m
Comrat
Bessarabskiy
Serpneve
Berezyne
Tarutyne
MOLDOVA
UKRAINE
Falciu
Chadyr-
Lunga
334 m
CANTEMIR
220 m
245 m
Taraclia
TARACLIA
U.T.A. GĂGĂUZIA
Cahul
Kalcheva
Vulcanesti
M15
CAHUL
MOLDOVA
UKRAINE
E87
Reni
Izmail
156 m
Galati
ROMANIA
Ozero Kagul
Ozero Yalpug
Ozero Kartal



5800000
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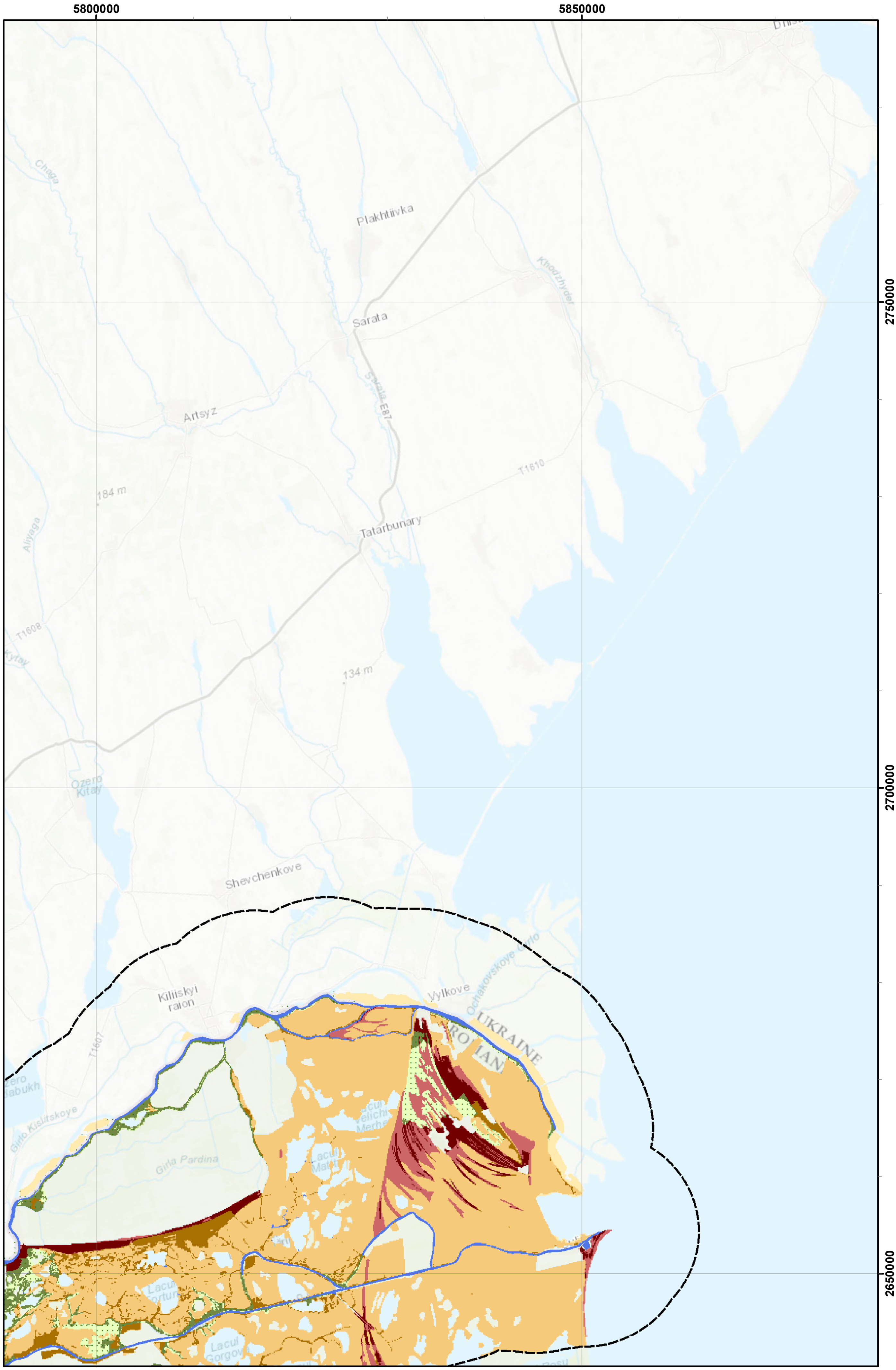
Sarichioi
Lacul Razelm
Lacul Dranov
Rezervația Biosferei Delta Dunării
COMPLEXUL LAGUNAR RAZIM
Lacul Periteasca
Lacul Sinoe
Constanta
Techirghiol


5800000
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Chaga
Plakhtiivka
Khodzhyder
Sarata
Artsyz
T1610
184 m
Tatarbunary
Aliyaga
T1608
134 m
Ozero Kitay
Shevchenkove
Kiliiskyi raion
Vylkove
Ochakovskoye Girlo
UKRAINE
T1607
Girlo Kislitskoye
Girla Pardina
Lacul Matei
Lacul Gorgova