

PROJECT SUMMARY FOR MAVROVO NATIONAL PARK, NORTH MACEDONIA

EU4Green: Support the implementation of the Green Agenda for the Western Balkans

WP1-16: Biodiversity: Integrated Management of Floodplains in Protected Areas

Deliverable WP1-16_Del-1 Project summary for each study area of the 6 economies

February 2026

Project Summary for Mavrovo National Park, North Macedonia

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ABBREVIATIONS

CLC	CORINE Land Cover Class
CLC+B	CLCplus Backbone
EC	European Commission
EU	European Union
GIS	Geographic Information System
IUCN	International Union for Conservation of Nature
MKD	North Macedonia
NbS	Nature-based Solutions
NGO	Non-Governmental Organisation
SDF	Standard Data Form for Natura 2000 sites
WB6	Western Balkans (Albania, Bosnia and Herzegovina, Kosovo ¹ , Montenegro, North Macedonia and Serbia)

¹ This designation is without prejudice to positions on status, and it is in line with UNSCR 1244 and the ICJ Opinion on the Kosovo* declaration of independence.

PREFACE

The world of nature largely depends on the human factor, especially regarding the conservation of biodiversity. At the same time, human well-being depends on biodiversity. The Western Balkans (WB6) are engaged in efforts to safeguard biodiversity, striving to balance the demand for development with the necessity for environmental conservation.

The project EU4Green: Support the implementation of the Green Agenda for the Western Balkans (short: EU4Green) assists the WB6 – Albania, Bosnia and Herzegovina, Kosovo¹, Montenegro, North Macedonia, and Serbia – in greening their economies and in enhancing monitoring and reporting as well as aligning with the EU standards. It is also tightly linked to the Green Agenda for the Western Balkans (GAWB)². The project includes different pillars, with one of them being biodiversity. Financed by the European Union (EUR 10 million) and the Austrian Development Agency (EUR 1 million), the project was implemented by the Environment Agency Austria in cooperation with public authorities and institutions of the WB6. The project was implemented from 2022 to 2025.

EU4Green Biodiversity activities placed their focus on floodplain ecosystems as they encompass a naturally high but threatened biodiversity and unique spatial and temporal variability, while providing important functions and services to landscapes and humans. Shaped by the rivers and the adjacent wetlands and floodplain forests, they are an important and characteristic natural feature of the WB6, in terms of nature conservation but also for recreation and (eco-)tourism. They are increasingly recognized as key assets for the Green Agenda for the Western Balkans. Providing biodiversity conservation, carbon storage, and climate resilience, they are the backbone of a sustainable landscape and its biological heritage. Their protection and restoration align with EU Directives and strategies, underscoring their role in regional ecological and rural development^{3,4}. Yet, they are threatened by river regulation, land-use changes and pollution. Due to their many-faceted character, floodplain ecosystems need conservation measures that maintain their various functions in an integrative way, considering a wide range of different natural assets and their threats. Thus, they act as suitable case studies for training and applying methodologies related to nature conservation.

EU4Green Biodiversity activities provided such trainings and materials to support the WB6 in three thematic fields – species and habitats of Natura 2000 network, Nature-based Solutions, and connectivity. This report outlines the most important background information, used methodologies and achieved results and outputs of the covered topics for the case study of North Macedonia (BiH). Furthermore, the methods used for gathering all knowledge presented in this report can be transposed to other ecosystems, habitats and species.

² EUROPEAN COMMISSION, 2020. Green Agenda for the Western Balkans. Brussels: European Commission. Available at: https://neighbourhood-enlargement.ec.europa.eu/system/files/2020-10/green_agenda_for_the_western_balkans_en.pdf

³ EUROPEAN ENVIRONMENT AGENCY, 2019. Floodplains: a natural system to preserve and restore. EEA Report No 24/2019. Publications Office of the European Union, Luxembourg.

⁴ EUROPEAN COMMISSION, 2020. An Economic and Investment Plan for the Western Balkans: Green Agenda for the Western Balkans. COM(2020) 641 final. Brussels: European Commission.

1. EU4GREEN'S PILOT SITE IN NORTH MACEDONIA

The activities of the EU4Green project were conducted within six pilot sites – one in each economy (Figure 1), selected by the National Focal Points at the beginning of the project.

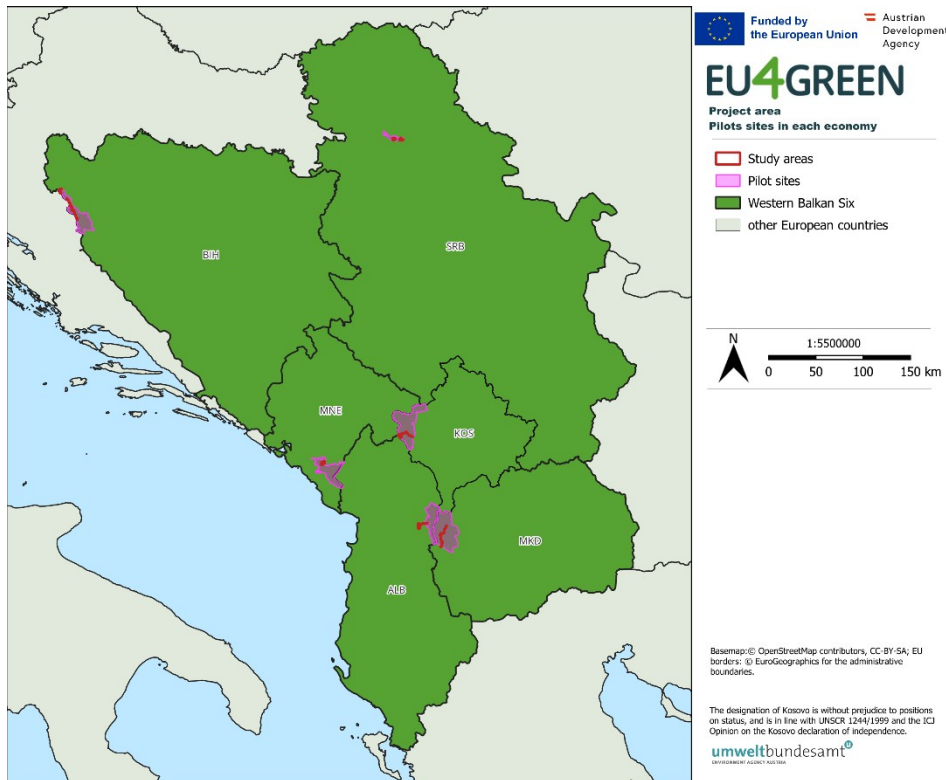


Figure 1: The six pilot sites in the economies of the Western Balkans.

In North Macedonia, the Mavrovo National Park was chosen. The National Park has an impressive history, as it was already established in 1949. The protection regime was extended in 1952, to enforce a stricter protection and a significant increase in area. It is the largest national park of North Macedonia, covering about 78,000 hectares. About 4,417 hectares are strictly protected. Located in the west of North Macedonia, it borders both Albania's Korab-Koritnik Nature Park and Kosovo¹ close to the Malet e Sharrit National Park, thus forming a trilateral network of protected areas with transboundary management.

In the Mavrovo National Park, a wide range of ecosystems and species can be found. Within its boundaries, three different mountain ranges of the Dinaric Alps meet. Also the highest mountain on North Macedonia, the Golem Korab peak with 2764 m.a.s.l., is located within the national park. The mountain systems are divided by the Radika river, which is fed from several small mountain creeks and formed a deep and more than 25 km long canyon. Ultimately, after leaving the Mavrovo National Park, it feeds into the Black Drin. Additionally,

the national park also contains several small glacial lakes and temporary pools, waterfalls, caves and alpine bogs.

Due to the high mountains, cliffs and rocky gorges, with both coniferous and deciduous forests and alpine pastures, the area is considered an Important Bird Area by BirdLife International and an IUCN Key Biodiversity Area. It harbours more than 1,400 vascular plants, with several rare and (sub)endemic species among them. The park also harbours a permanent population of the rare Balkan lynx.

Challenges to the pilot site include climate change, which particularly affects the higher elevations, and natural disasters such as fires, floods and extreme weather events. Further issues are water and soil pollution, erosion and degradation of forest. Along the Radika river, fishing is very common.

Because each thematic field in EU4Green Biodiversity requires its own appropriate spatial scale, the analyses are conducted at different extents around the core study area or pilot site in North Macedonia. This ensures that the applied methods remain feasible and that the conclusions drawn from the elaborated outcomes are meaningful. As a result, each topic refers to a specific spatial extent and corresponding buffer zone (Figure 2Error: Reference source not found).

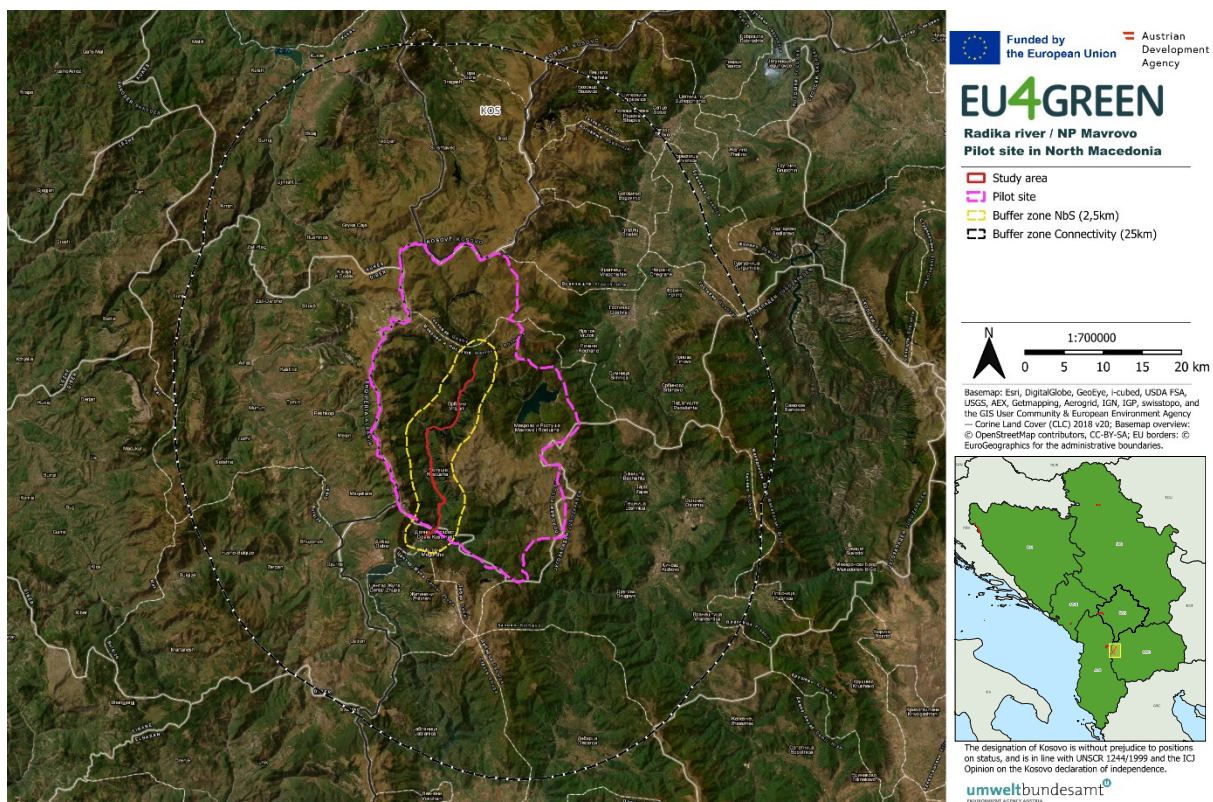


Figure 2: The different spatial extents of the local activities carried out in and around Mavrovo National Park (depicted in pink). The core study area for mapping species and habitats of Natura 2000 sites (chapter Error: Reference source not found, depicted in red) stretches along the river floodplain. The study area for Nature-based Solutions (chapter Error: Reference source not found, depicted in yellow) was derived by adding a buffer

around the core study area. The area assessed for connectivity (chapter Error: Reference source not found, depicted in black) was derived by adding a buffer around the national park's borders.

2. CONNECTIVITY

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2.1. Summary

The ecological connectivity of landscapes shapes species distributions, enables genetic exchange, and ensures long-term biodiversity conservation. In human-modified environments, habitat fragmentation threatens these processes, making the identification and preservation of ecological corridors essential. Protected areas risk isolation without connectivity to other relevant populations, ultimately reducing their effectiveness over time.

To address these challenges, a least-cost path analysis was performed to identify the “cheapest” corridors based on resistance maps. Using CORINE Land Cover data, resistance values were assigned to land cover classes for two target land cover classes: Broad-leaved forest and Natural grasslands. The Mavrovo National Park in North Macedonia served as the study site, with a 25 km buffer zone analysed for ecological connectivity of the two target land cover classes. **Results** show three large Natural grasslands of high alpine meadow which are not well connected to smaller patches in the periphery. However, Broad-leaved forests are fairly well connected. Conservation priorities include the protection of already existing corridors between the patches of target land cover classes and to improve corridors in areas of high human pressure, especially for Natural grasslands. Some critical parts or bottlenecks for the functioning of corridors have been identified. The study acknowledges limitations such as reliance on expert judgment, data resolution, and temporal validity of the land cover dataset, but highlights the method’s simplicity as a practical tool for conservation planning. Ultimately, it underscores the need for strategic spatial conservation planning and cross-border collaboration to secure ecological corridors and enhance biodiversity resilience within and between protected areas.

2.2. Introduction

The movement of organisms is a fundamental ecological process that influences species distribution, population dynamics, and evolutionary trajectories. This movement is shaped by a range of intrinsic and extrinsic factors, including life-history traits, landscape structure and environmental variability⁵. In an increasingly human-modified world, where habitat fragmentation and changes in climate disrupt natural landscapes, understanding and maintaining the functional connectivity of ecosystems is vital for biodiversity conservation.

Landscape connectivity refers to the degree to which the landscape facilitates or impedes movement of organisms among habitat patches⁶. It plays a central role in enabling gene flow across populations, enhancing species' persistence in fragmented habitats, and supporting ecological resilience under changing environmental conditions. Understanding these processes is of particular importance in the light of protected areas, which act as harbours for biodiversity in a more modified landscape. With increased development in the surroundings of protected areas, this effect gets more pronounced over time. For example, without appropriate buffer zones, landscape diversity shows greater decreases closer to national park borders⁷. The resulting isolation of protected areas undermines the effectiveness of long-term conservation of the local populations. However, quantifying connectivity across heterogeneous landscapes is complex and demands robust analytical approaches⁸.

To address this challenge, a variety of modelling tools and algorithms have been developed to simulate and map potential movement pathways. Among these, the least-cost path analysis has emerged as a widely applied method in connectivity modelling. This analysis identifies the 'cheapest' and most efficient route between two areas based on a resistance surface, which acts as a connectivity indicator mapping the 'cost', permeability or relative difficulty for an organism to traverse different habitats^{8,9,10}. Although conceptually simple, this method provides valuable insights into likely movement patterns by highlighting important corridors and potential barriers and therefore supports the design of effective conservation measures along critical pathways facilitating the gene flow between populations.

The aim of this study is (a) to provide a simple method for the planning of corridors to enhance connectivity between populations which can be easily adapted to other areas or

⁵ NATHAN, R., W. M. GETZ, E. REVILLA, M. HOLYOAK, R. KADMON, D. SALTZ & P.E. SMOUSE, 2008. A movement ecology paradigm for unifying organismal movement research. In: *Proceedings of the National Academy of Sciences*, 105(49), 19052–19059. <https://doi.org/10.1073/pnas.0800375105>

⁶ RUDNICK, D.A., S.J. RYAN, P. BEIER, S.A. CUSHMAN, F. DIEFFENBACH, C.W. EPPS, L.R. GERBER, J. HARTTER, J.S. JENNESS, J. KINTSCH, A.M. MERENLENDER, R.M. PERKL, D.V. PREZIOSI & S.C. TROMBULAK, 2012. The role of landscape connectivity in planning and implementing conservation and restoration priorities. In: US Forest Service Research and Development. <https://research.fs.usda.gov/treesearch/42229>

⁷ KUBACKA, M., P. ŻYWICA, J.V. SUBIRÓS, S. BRÓDKA & A. MACIAS, 2022. How do the surrounding areas of national parks work in the context of landscape fragmentation? A case study of 159 protected areas selected in 11 EU countries. In: *Land Use Policy*, 113, 105910. <https://doi.org/10.1016/j.landusepol.2021.105910>

⁸ ZELLER K.A., K. MCGARIGAL, A.R. WHITELEY, 2012. Estimating landscape resistance to movement: A review. In: *Landscape Ecology*, 27(6), 777–797. <https://doi.org/10.1007/s10980-012-9737-0>

⁹ ADRIAENSEN F., J. CHARDON, G. DE BLUST, E. SWINNEN, S. VILLALBA, H. GULINCK & E. MATTHYSEN, 2003. The application of 'least-cost' modelling as a functional landscape model. In: *Landscape and Urban Planning*, 64(4), 233–247. [https://doi.org/10.1016/s0169-2046\(02\)00242-6](https://doi.org/10.1016/s0169-2046(02)00242-6)

¹⁰ KUMAR S.U., S.A. CUSHMAN, 2022. Connectivity modelling in conservation science: a comparative evaluation. In: *Scientific Reports*, 12(1). <https://doi.org/10.1038/s41598-022-20370-w>

updated data sources and (b) to show outputs of this method to provide a first draft of potential corridors for efficient and effective nature conservation actions at the pilot sites.

2.3. Material and methods

2.3.1. Resistance map

The CORINE Land Cover 2018 dataset with a pixel size (resolution) of 100 m x 100 m was chosen as source for the resistance map. CORINE Land Cover (CLC) is a European-wide open-source land cover dataset developed under the Copernicus Programme, managed by the European Environment Agency¹¹. Each CORINE land cover class¹² was assigned a resistance value based on expert judgment, reflecting its relative permeability with respect to the target ecological feature and using a discrete exponential scale (values 1, 2, 4, 8; see Error: Reference source not foundError: Reference source not found).

Table 1: Resistance values of different CORINE land cover classes in relation to Natural grasslands and Broad-leaved forest, respectively. Resistance values are based on expert opinion and form the basis of the resistance maps.

Level 3 Code	CORINE land cover class	Resistance value of	
		Natural grasslands	Broad-leaved forest
1.1.1	Continuous urban fabric	8	8
1.1.2	Discontinuous urban fabric	8	8
1.2.1	Industrial or commercial units	8	8
1.2.2	Road and rail networks and associated land	4	8
1.2.3	Port areas	8	8
1.2.4	Airports	4	8
1.3.1	Mineral extraction sites	8	8
1.3.2	Dump sites	8	8
1.3.3	Construction sites	8	8
1.4.1	Green urban areas	4	4
1.4.2	Sport and leisure facilities	8	8
2.1.1	Non-irrigated arable land	4	8
2.1.2	Permanently irrigated land	4	8
2.1.3	Rice fields	4	8
2.2.1	Vineyards	4	8
2.2.2	Fruit trees and berry plantations	8	4
2.2.3	Olive groves	4	4
2.3.1	Pastures	2	4

¹¹ CORINE Land Cover. [Retrieved November 12, 2025] <https://land.copernicus.eu/en/products/corine-land-cover>

¹² CLC Nomenclature EN. [Retrieved November 12, 2025] https://clc.gios.gov.pl/doc/clc/CLC_Nomenclature_EN.pdf

Level 3 Code	CORINE land cover class	Resistance value of	
2.4.1	Annual crops associated with permanent crops	8	4
2.4.2	Complex cultivation patterns	4	4
2.4.3	Land principally occupied by agriculture, with significant areas of natural vegetation	2	2
2.4.4	Agro-forestry areas	4	2
3.1.1	Broad-leaved forest	8	1
3.1.2	Coniferous forest	8	2
3.1.3	Mixed forest	8	1
3.2.1	Natural grasslands	1	8
3.2.2	Moors and heathland	1	4
3.2.3	Sclerophyllous vegetation	4	2
3.2.4	Transitional woodland-shrub	4	4
3.3.1	Beaches, dunes, sands	4	8
3.3.2	Bare rocks	4	8
3.3.3	Sparsely vegetated areas	2	8
3.3.4	Burnt areas	4	4
3.3.5	Glaciers and perpetual snow	8	8
4.1.1	Inland marshes	4	8
4.1.2	Peat bogs	2	4
4.2.1	Salt marshes	4	8
4.2.2	Salines	8	8
4.2.3	Intertidal flats	8	8
5.1.1	Water courses	8	8
5.1.2	Water bodies	8	8
5.2.1	Coastal lagoons	8	8
5.2.2	Estuaries	8	8
5.2.3	Sea and ocean	8	8

2.3.2. Pilot site, buffer and target land cover classes

Mavrovo National Park was chosen as the pilot site to test the connectivity model in North Macedonia (see also chapter 1). To assess the ecological connectivity, a 25 km buffer was applied around the pilot site's boundary to form a buffer area.

We analysed the same two CORINE land cover classes in all six study areas: Broad-leaved forest and Natural grasslands. Broad-leaved forest is the most common land cover type in all assessed sites, covering on average 37 % of the sites' area. They provide crucial ecosystem services such as clean drinking water and timber. Natural grasslands in Europe are biodiversity hotspots, often even at a small scale, but are threatened by land-use change¹³. They are a less common land cover class in the assessed sites, covering only 18 % on average. However, they provide vital ecosystem services such as areas for extensive grazing, and play an important role in providing habitat for a wide range of (critically) endangered species.

2.3.3. Connectivity analysis

To test the connectivity of the largest patches of the target land cover, all directly connected pixels of the target land cover were classified as one patch. Subsequently, the connectivity was tested for the ten largest patches through a least-cost path analysis. The least-cost-path analysis was performed in R with the package *grainscape* (the annotated R code can be found in Annex I). The connectivity of each target land cover class was analysed separately.

¹³ HABEL, J.C., J. DENGLER, M. JANIŠOVÁ et al. 2013. European grassland ecosystems: threatened hotspots of biodiversity. In: *Biodivers Conserv* 22, 2131-2138 (2013). <https://doi.org/10.1007/s10531-013-0537-x>

2.4. Results and discussion

The study area of Mavrovo National Park is a sparsely populated area with a high value for biodiversity and relatively well-connected Natural Grassland patches and Broad-leaved forests. Both habitats are common and cover 38 % (Natural grasslands) and 40 % (Broad-leaved forests) of the pilot site investigated. However, despite only covering a slightly larger share of the area, Broad-leaved forests show a better connectivity than Natural grasslands. Therefore, conservation actions to enhance the connectivity through corridors should focus on Natural grasslands.

2.4.1. Natural grasslands

Error: Reference source not found shows three large and relatively well-connected patches of Natural grasslands in NP Mavrovo and its surroundings (the costs of the corridors range from 13 to 935). All three of them are alpine meadows above the tree line. Smaller patches are found in the periphery of the study area. Some of these smaller patches are not well connected or only show one 'cheap' corridor to the larger main patches (e.g. Figure 3, A), thus increasing vulnerability of the patches. This needs particular attention in the light of the fact that smaller patches frequently hold smaller populations, thereby depending more on good connectivity.

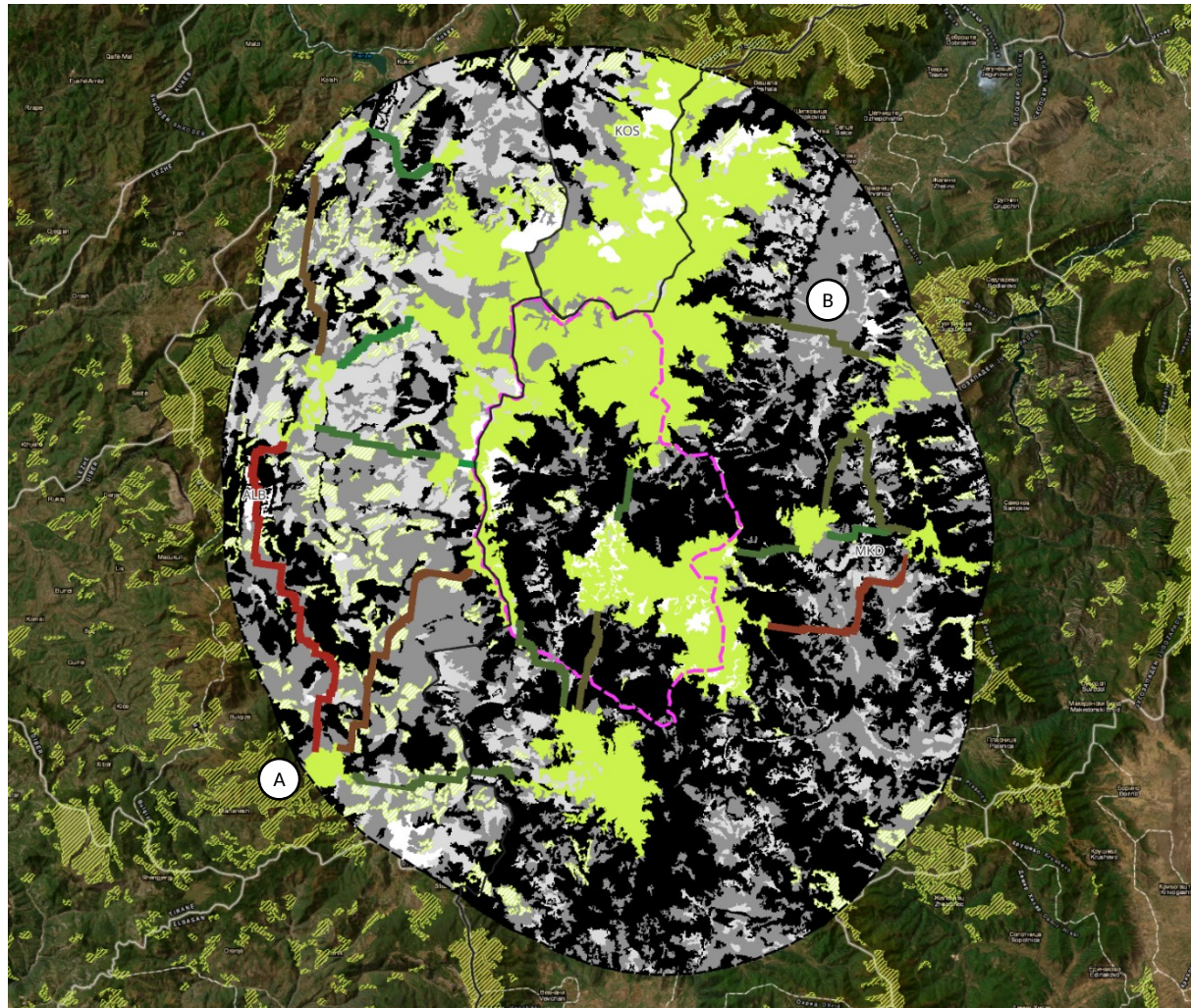
The patches in the west of the study area are situated in a landscape matrix of low resistance land cover types, interspersed with grasslands. This landscape is dependent on small scale, subsistence agriculture with grazing livestock. Those areas are of high value for grassland species but are threatened by abandonment or intensification of farming practices, which both occur frequently during economic development. The patches in the east, however, are surrounded by a high resistance landscape but are spatially relatively close to each other.

One corridor in the north-east of the study area crosses the Polog plains (Figure 3, B). These plains are a highly human-modified landscape. Crucial for this corridor will be to protect and foster patches of grassland between the villages of Forino and Čegrane and between the villages of Toplitsa and Vrapčište (Municipality of Vrapčište). Furthermore, the fenced off motorway A2 runs perpendicular to the corridor and could cause problems for traversing large mammals. The installation of wildlife crosses is recommended.

2.4.2. Broad-leaved forest

Error: Reference source not found shows a large, connected woodland area spreading from the center to the south-east of the study area. A mosaic of smaller, but well-connected patches is found in the east of the study area. One isolated patch of broad-leaved forest is found in the north (Figure 4, A). Only a relatively long corridor connects it to other patches towards the southwest.

One corridor in the northwest of the study area could be improved, especially in the Kukës County, Albania, where forest logging activities hamper the connectivity of this habitat.



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Radika river / NP Mavrovo
Pilot site in North Macedonia

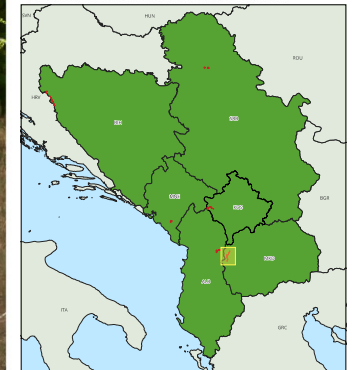
Natural grassland (CLC-321):
10 largest patches in buffer zone
other patches of habitat

Cost of corridors **Resistance of landscape**

High High
Low Low

0 5 10 15 20 km

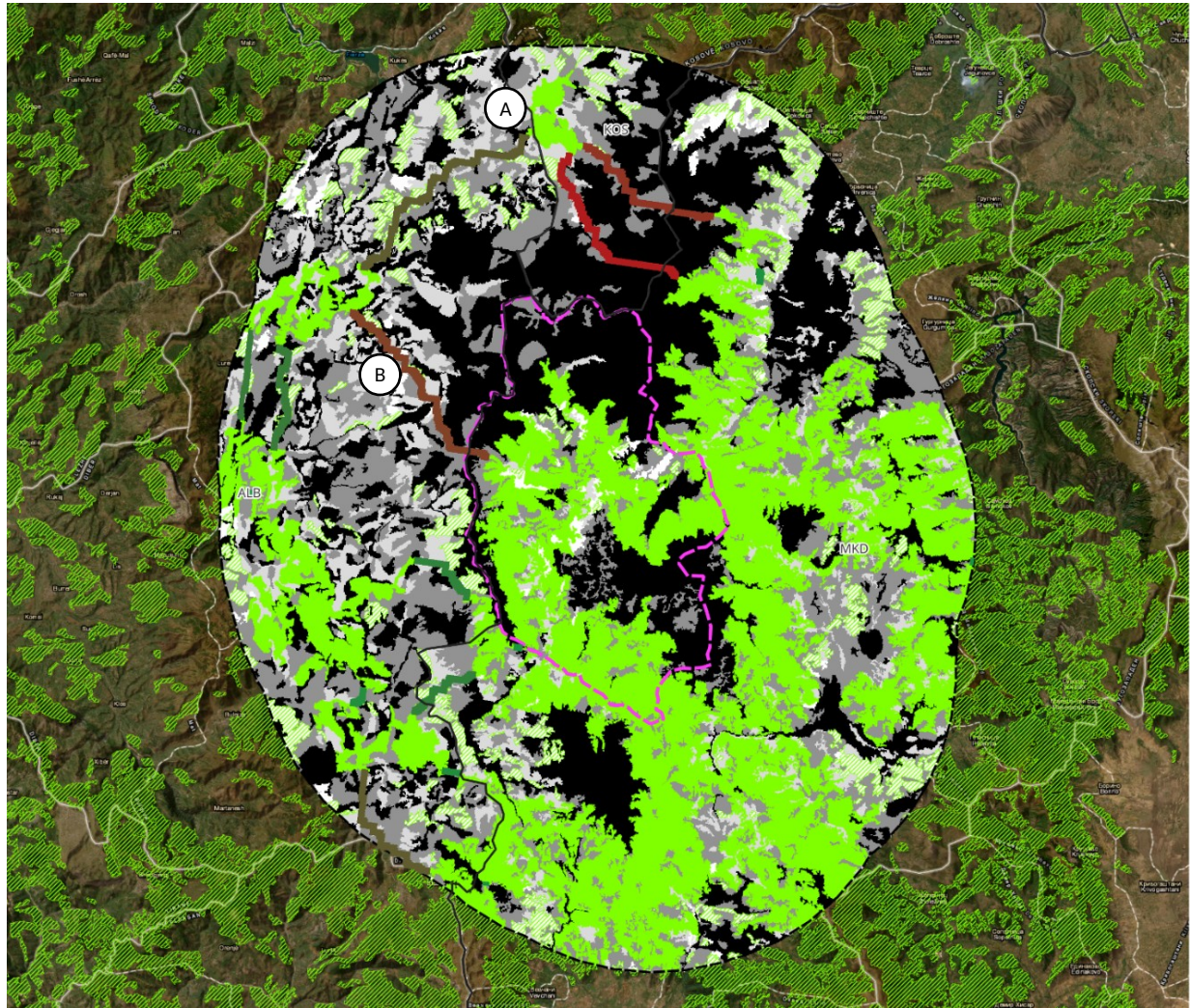
Basemap: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aergrid, IGN, IGP, swisstopo, and the GIS User Community & European Environment Agency — Corine Land Cover (CLC) 2018 v20; Basemap overview: © OpenStreetMap contributors, CC-BY-SA; EU borders: © EuroGeographics for the administrative boundaries.





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
Figure 3: Connectivity of Natural grasslands in the buffer zone around Mavrovo National Park, North Macedonia. The grayscale background map shows landscape resistance values (from 1= white = low resistance to 8 = black = high resistance), green areas show the Natural grasslands. The corridors between the ten largest patches of Natural grasslands show the results of the least-cost path analysis. The colours of the corridors correspond to the cost in relation to the permeability of the landscape (from green = 13 to red = 935). The thickness of the corridors has been enhanced for better visibility. The letters highlight corridors or large patches mentioned in the text.






 Funded by the European Union
  Austrian Development Agency

EU4GREEN
 Radika river / NP Mavrovo
 Pilot site in North Macedonia

 Pilot site
  Economy border
 Buffer zone

Broad-leaved forest (CLC-311):
 10 largest patches in buffer zone
 other patches of habitat

Cost of corridors **Resistance of landscape**
 High to Low  High to Low

 1:700000
 0 5 10 15 20 km

Basemap: Esri, DigitalGlobe, GeoEye, I-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community & European Environment Agency - Corine Land Cover (CLC) 2018 v20; Basemap overview: © OpenStreetMap contributors, CC-BY-SA; EU borders: © EuroGeographics for the administrative boundaries.



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Figure 4: Connectivity of Broad-leaved forests in the buffer zone around Mavrovo National Park, North Macedonia. The grayscale background map shows landscape resistance values (from 1 = white = low resistance to 8 = black = high resistance), green areas show the Broad-leaved forests. The corridors between the ten largest patches of Broad-leaved forests show the results of the least-cost path analysis. The colours of the corridors show the cost in relation to the permeability of the landscape (from green = 4 to red = 1009). The thickness of the corridors has been enhanced for better visibility. The letters highlight corridors or large patches mentioned in the text.

2.4.3. Limits of the study

The least-cost path analysis offers a simple and recommendable scoping tool for gaining insights into connectivity at the local level. Clear advantages of the approach are its modest data requirements and simple application. However, the approach relies on several assumptions. The underlying cost landscape depends on expert judgement which is rarely tested with empirical data¹⁴. The spatial extent of the study area and resolution (pixel size) highly influences the output of the algorithm¹⁵. The used CORINE land cover data set is from 2018. Land use changes since 2018 have therefore not been accounted for. The next CORINE land cover data set is being released in 2026, and stakeholders are being advised to run the model with the provided code (Annex I) again to receive updated results. Another assumption is that organisms find and use these corridors, although individual preference and variability are not accounted for. The concept of least-cost path informed corridors is rarely tested with in-situ movement data¹⁶. The analysis could be taken further by verification of results through movement data, in-situ studies or expert knowledge.

2.5. Conclusion

This study shows potential corridors which facilitate the movement of organisms between large patches of the target land cover classes of Natural grasslands and Broad-leaved forest. The objectives for connectivity in the study area of Mavrovo National Park will be primarily to protect the already existing corridors between the patches of target land cover classes and to improve corridors in areas of high human pressure, especially for Natural grasslands. Some critical parts or bottlenecks for the functioning of corridors have been identified.

The results highlight the need for well-informed and anticipatory spatial planning in the surroundings of the Mavrovo National Park, securing the long-term persistence of corridors. Well-functioning corridors avoid genetic impoverishment of national park itself but also amplify the positive effects of the national park on its surroundings, e.g. by allowing individuals to disperse into adequate habitat patches within the surrounding landscape. To secure these processes and support sustainable development in the surroundings, the designation of less strict spatial protection schemes as buffer zones is a popular tool.

Nature conservation areas in cross-border regions highly profit from transnational collaboration. This is especially true for the topic of connectivity where the natural values of protected areas can be impacted if corridors for connectivity are lost.

¹⁴ STEVENSON-HOLT, C.D., K. WATTS, C.C. BELLAMY, O.T. NEVIN, A.D. Ramsey, 2014. Defining landscape resistance values in least-cost connectivity models for the invasive grey squirrel: a comparison of approaches using expert-opinion and habitat suitability modelling. In: *PLoS One*. 2014 Nov 7;9(11):e112119. doi: 10.1371/journal.pone.0112119. PMID: 25380289; PMCID: PMC4224439.

¹⁵ MUREKATETE, R.M. & T. SHIRABE, 2021. On the effects of spatial resolution on effective distance measurement in digital landscapes. In: *Ecol Process* 10, 50. <https://doi.org/10.1186/s13717-021-00296-3>

¹⁶ LALIBERTÉ J., M.-H. ST-LAURENT, 2020: Validation of functional connectivity modeling: The Achilles' heel of landscape connectivity mapping. In: *Landscape and Urban Planning*, Volume 202, <https://doi.org/10.1016/j.landurbplan.2020.103878>.

3. SPECIES AND HABITAT TYPES OF NATURA 2000 SITES: REQUIREMENTS AND METHODS FOR REPORTING ON THEIR ECOLOGICAL INFORMATION

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3.1. Summary

Identification of suitable sites and preparation of all relevant materials are major milestones required for proposing the future Natura 2000 network to the European Commission and therefore are an important endeavour for Accession Candidates. For each potential Natura 2000 site, a wide range of evidence-based and scientific information is required. Accession Candidates are required to set up systematic approaches to gather this information, but there are pitfalls which should be avoided to gather the required data efficiently. The activities summarised in this chapter are based on the approach developed in Austria. EU4Green offered a training for local biodiversity experts from the WB6, who learned and applied – in an exemplary manner – all subsequent steps of mapping and assessing species and habitat types in potential Natura 2000 sites. They were familiarised with the Standard Data Forms (more particularly, the ecological information), which is the format required for providing the information to the European Commission. All methodologies are described in detail. The fieldwork results of the biodiversity experts are presented and discussed. The chapter illustrates how a synergistic and efficient system for fulfilling the provisions of the Nature Directives towards Natura 2000 sites could look like on the local level.

3.2. Introduction

3.2.1. The Natura 2000 network of protected areas

The designation of protected areas is one of the prime tools in biodiversity protection. The Kunming-Montreal Global Biodiversity Framework, signed by 196 countries, foresees the halt and reverse of biodiversity loss. One of its key global targets for 2030 is effectively conserving and managing 30 % of all land, waters and seas¹⁷. The EU Biodiversity Strategy for 2030 sets out the goal to not only protect at least 30 % of all land and sea, but also bring 10 % of all EU land and sea under strict protection¹⁸. In this context, the GAWB calls upon the WB6 to align their policies to the EU Biodiversity Strategy for 2030¹⁹.

EU4Green placed a strong focus to support the WB6 with alignment to the EU legislation for nature protection, more precisely on the Birds Directive (2009/147/EC ex 79/409) and the Habitats Directive (92/43/EEC). They define species and habitats of Community interest, and measures for species and site protection. The EU Member States are to implement it through interdependent steps, hence for accession candidates, a similar approach was considered.

The primary objective of the EU Nature Directives is achieving and maintaining a Favourable Conservation Status for all species and habitats of Community interest. An important part is the designation and good management of Natura 2000 sites that form an EU-wide coordinated network of protected areas. The aim of each site is to ensure the long-term conservation of the habitats and species of Community interest that occur within them. Additionally, the Natura 2000 sites simultaneously act as contribution to the Pan-European Emerald Network of the Bern Convention²⁰. Accession candidates are required to prepare their future Natura 2000 sites, using the framework of the Emerald Network²¹.

3.2.2. Standard Data Forms

For each Natura 2000 site, Member States fill a Standard Data Form (SDF)²², thereby providing information on area, location, characteristics and management, as well as ecological information on its habitat types and species²³. As the EC uses the SDFs to review the contribution of Natura 2000 towards the achievement of the Nature Directive's objectives, the EC recommends an update to the SDFs at least every six years.

¹⁷ CONVENTION ON BIOLOGICAL DIVERSITY, 2022. Decision adopted by the Conference of the Parties to the Convention on Biological Diversity. 15/4. Kunming-Montreal Global Biodiversity Framework. [Last access: 9 December 2024]. Available at: <https://www.cbd.int/doc/decisions/cop-15/cop-15-dec-04-en.pdf>

¹⁸ EUROPEAN COMMISSION, 2020. EU Biodiversity Strategy for 2030. Bringing nature back into our lives. Brussels: European Union. [Last access: 9 December 2024]. Available at: [EU Biodiversity Strategy](https://ec.europa.eu/biodiversity/en/strategy)

¹⁹ EUROPEAN COMMISSION, 2020. Guidelines to the Implementation of the Green Agenda for the Western Balkans. Brussels: European Union. [Last access: 9 December 2024]. Available at: https://neighbourhood-enlargement.ec.europa.eu/system/files/2020-10/green_agenda_for_the_western_balkans_en.pdf, p. 1 – 22.

²⁰ European Environment Agency, 2023. The Natura 2000 protected areas network. [Last access: 23 September 2025] Available at: <https://www.eea.europa.eu/themes/biodiversity/natura-2000/the-natura-2000-protected-areas-network>

²¹ Secretariat of the Bern Convention, 2017. The Emerald Network. A tool for the protection of European natural habitats. [Last access: 23 September 2025]. Available at: [The Emerald Network](https://www.bernconvention.org/en/activities/emerald-network).

²² The European Commission updated the format of the Standard Data Form in 2023; its use is required from February 2025 onwards.

²³ C/2023/8623. ABI L, 2023/8623. Available at: [Updated standard data form](https://eur-lex.europa.eu/eli/L/2023/8623)

Filling SDFs requires evidence-based information, with several provisions specified in the explanatory notes of the SDFs²³. To guarantee transparent and reproducible results, particularly regarding the ecological information on habitat types and species, a standardized methodology is required. Nevertheless, the EC does not provide a methodological standard for the required fieldwork and methodology to produce the results for the SDFs. In the light of EU accession, accession candidates are required to develop and apply a methodology that fits the provisions.

EU4Green offered a training for local experts in the Austrian methodology. Throughout the training, the experts learned all subsequent steps of mapping and assessing species and habitats in an exemplary manner. They first learned about the official requirements and the Austrian methodology. One of the most important tasks was adapting the methodology to the local circumstances and the present species and habitats. Then, the experts applied and tested the developed methodology through fieldwork. Ultimately, the results were summarized, following the standards laid out by the SDFs.

3.2.3. Structure and parameters of the SDFs

The SDF contains six main sections with fields to fill (Table 2). Most sections are filled once for the entire Natura 2000 site, like the site location, description and management. However, the ecological information needs to be filled for every habitat type and species, respectively, occurring in the Natura 2000 site. The SDFs are then delivered to the EC through the Reportnet 3.0 of the EU.

Table 2: Sections of the Standard Data Form for species and habitats. Source: European Commission²³.

Section	Requirement
1. Site identification	Required for each Natura 2000 site
2. Site area and location	
3. Ecological information	
3.1 Habitat types	Required for each Annex I habitat type present within the Natura 2000 site
3.1.a Essential information	
3.1.b Site assessment & Degree of Conservation	
3.2 Species	Required for each bird species relevant for Article 4(1) and 4(2) of the Birds Directive and each Annex II species of the Habitats Directive present within the Natura 2000 site
3.2.a Essential information	
3.2.b Site assessment & Degree of Conservation	
3.3 Other species	Optional
Site description	Required for each Natura 2000 site
Site management	
Geospatial representation	

The trainings focused on how to gather the data required for the ecological information. The ecological information includes two sub-sections for both habitat types and species: the essential information (Infobox 1) and the site assessment (Infobox 2).

Infobox 1 - SDF's Essential information

For habitat types, this section includes covers basic information like the **habitat type code**, information on the **period of data collection**, and the **cover** of the habitat type in hectares. The cover can be gathered by either complete mapping, statistical estimation, extrapolation of a limited amount of data, or, with very limited data, by expert opinion.

For species, this section includes **species group, code and name, population type** (e.g. permanent, reproducing) and **size** (min. and max.), and **species abundance** (e.g. common, rare). Population data can come from complete mapping, statistical estimation, extrapolation, or, with very limited data, by expert opinion. It is possible to indicate that species data is sensitive, thereby avoiding disclosure to the public by the EC.

Under certain circumstances, species and habitats can be categorized as non-present or non-significant, so that only selected fields need filling²⁴. Apart from that, the more elaborate site assessment is required.

Infobox 2 – SDF’s Site assessment

For habitat types, this section includes the **representativity** (e.g. excellent, significant) in comparison to the interpretation manual of Annex I habitat types. This parameter equals one of the criteria of Annex III of the Habitats Directive for Natura 2000 site selection and states how typical a habitat type is. Secondly, the **relative surface**, i.e. the share of the habitat types cover *within the Natura 2000 site* in the *total habitat area of the economy*, is classified in one of six pre-defined range categories, from 0 – 2 % up to 75 – 100 %.

For species, this section includes the share of the site’s **population** in the population in the entire economy. There are six pre-defined range categories. Explanatory text may be provided.

²⁴ Non-presence means that either the habitat or species was present at the time of site designation but is no longer present, or was not present at the site of site designation but is intended to be re-established. Non-significance for habitat types means little conservation value (very small, degraded, fragmented, limited fulfilment of ecological functions, structural components, and characteristic species) that does not offer relevant restoration possibilities (already previous to site designation). Non-significant species are very rarely observed on site.

Ultimately, the key parameter of the SDF for both species and habitat types is the Degree of Conservation (Infobox 3).

Infobox 3 - Degree of Conservation

The Degree of Conservation equals the Annex III criteria for Natura 2000 site selection and is also referred to as the **local condition of a habitat type or species**. It addresses the **quality of the habitat type or the habitat of the species** and requires information on the **spatial extent in good or not good / sufficient or non-sufficient quality**.

Depending on the methodology used, the Degree of Conservation offers high potential for synergies with the assessments on biogeographical level, thus providing an efficient and holistic system for mapping and monitoring the species and habitats of Community interest. While the information gathered on site level can be incorporated into Article 17 reporting, the information on biogeographical level provides important input when defining conservation objectives on site level.

3.2.4. Condition indicators and threshold values

When mapping specific species and habitat types in Natura 2000 sites, condition indicators define how to measure and grade the circumstances that affect their local preservation. The application of condition indicators in itself is not a requirement for fulfilling the EU Nature Directives, however, it is an exceptional opportunity for using synergies between the obligations on local (Natura 2000 sites) and biogeographical level²⁵. Therefore, it is applied by several EU member states (e.g. Austria, Germany). Furthermore, it provides a comparable, repeatable and reliable framework for assessing the Degree of Conservation of a species or habitat within a given area.

Condition indicators root in the ecological requirements of species and habitat types and are tightly linked to parameters that are required for Article 17 reporting (Infobox 4).

²⁵ Evans & Arvela (2011): Assessment and reporting under Article 17 of the Habitats Directive. Explanatory Notes & Guidelines for the period 2007-2012, p. 9.

Infobox 4: Condition indicators

For a **habitat type**, condition indicators allow to measure the conservation of its structure and function. To reflect on ecological integrity, condition indicators relate to three assets:

- **Species composition:** presence/absence, number or abundance of indicative species,
- **Structure and functions:** determinative structural, dynamic or ecological factors, and
- **Impacts:** most important driving factors (natural or anthropogenic)

The condition indicators for a **species** relate to three assets:

- **Population:** reproduction or mortality rates, population density
- **Habitat:** necessary habitat size and habitat elements (structures and/or quality required for reproduction, resting, foraging)
- **Impacts:** most important driving factors (natural or anthropogenic)

Population indicators may be difficult to assess and/or fluctuate over time. Therefore, a strong focus is given to the condition of the habitat for the species, like the Degree of conservation does.

Linking these standardized assets to the ecological requirements of the species or habitat type is the basis for formulating condition indicators (Figure 5, Figure 6). Depending upon the complexity of the ecological requirements, up to several indicators per asset can be necessary.

To ensure comparability between different sites, years (repeated monitoring) and experts carrying out fieldwork, condition indicators ought to be measurable. Therefore, for each condition indicator the method of measurement requires definition, specifying how to assess the indicator during fieldwork. In general, quantitative indicators are easier to standardize than qualitative indicators.

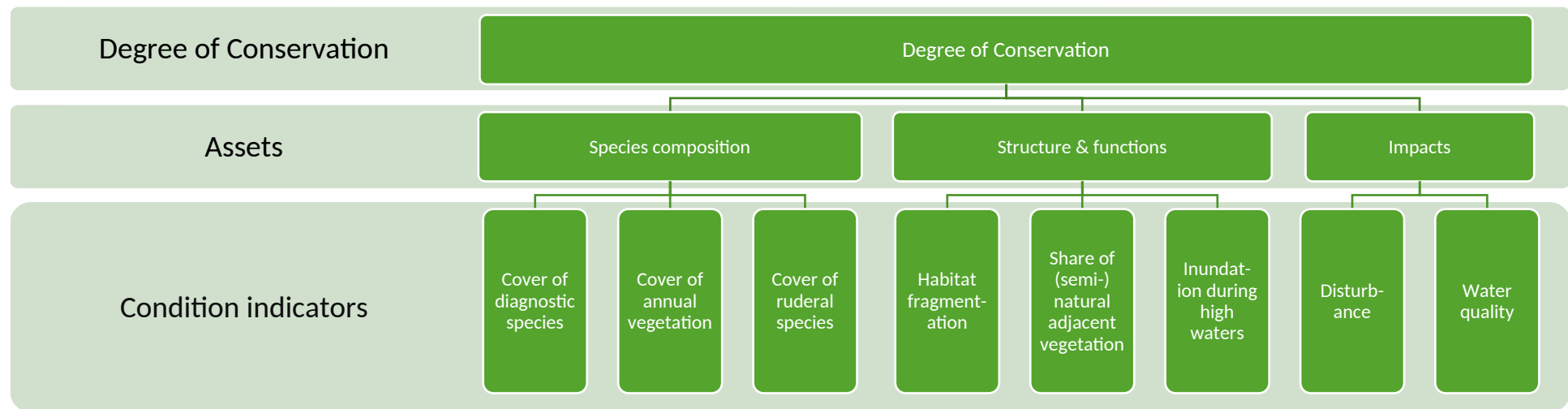


Figure 5: Exemplary illustration of the Degree of Conservation for habitat type '3130 Oligotrophic to mesotrophic standing waters with vegetation of the *Littorelletea uniflorae* and/or of the *Isoeto-Nanojuncetea*' (wording of indicators was simplified for understandability). The Degree of Conservation is composed of three different assets (species composition, structure and functions, and impacts), each of them with condition indicators. For each condition indicator, a method for measurement and a grading system with threshold values is needed.

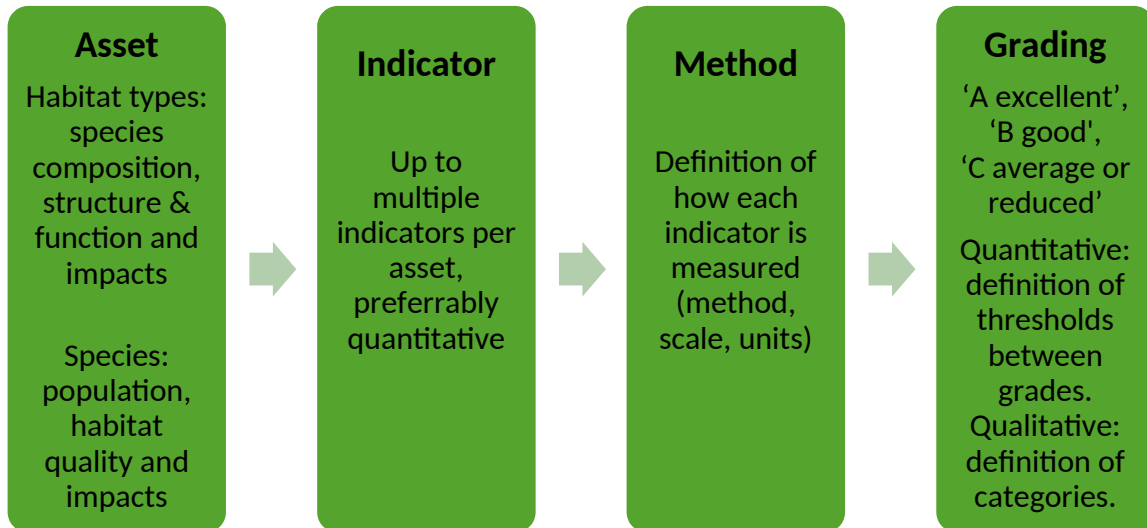


Figure 6: Procedure for defining condition indicators.

Ultimately, a grading system is used to specify if measurements correspond with a good or not-good Degree of Conservation. Based on the provisions for the SDFs, the grading system has three grades: 'A excellent', 'B good' and 'C average or reduced'. For quantitative indicators, thresholds are required to differentiate between excellent, good and average/degraded. For qualitative indicators, the three categories need detailed qualitative description to allow for clear differentiations.

3.3. Material and methods: the case study

3.3.1. Study area

For training the methods, a case study was established (Figure 7). The study area was delineated by the biodiversity expert and measures approx. 10 km² in size. Located along the Radika river valley, the study area lies within the Mavrovo National Park. Established in 1949, Mavrovo National Park is the largest national park in North Macedonia, covering approximately 780 km². It is widely recognised for its high biodiversity, diverse landscapes, and rich cultural heritage.

The park encompasses three alpine mountain systems – Korab, Bistra, and Šar – and includes the country's highest peak within its boundaries. Characteristic features of the park are its deep canyons, most notably the Radika River gorge, which meanders for more than 25 km between steep cliffs and forms the core focus of the study area.

Mavrovo National Park is characterised by pristine river systems, extensive forest complexes, and alpine meadows. It hosts around 1,500 plant species, including a high proportion of endemic and relict taxa. The park is also a key refuge for the critically endangered Balkan lynx (*Lynx lynx balcanicus*), with an estimated population of around 60 individuals, alongside other emblematic species such as brown bears, wolves, wild goats, and more than 140 bird species, including raptors and vultures.

By splitting the study into subareas (approx. 1 km² each), the assessment of the target features (habitats) in corresponding areas was facilitated.

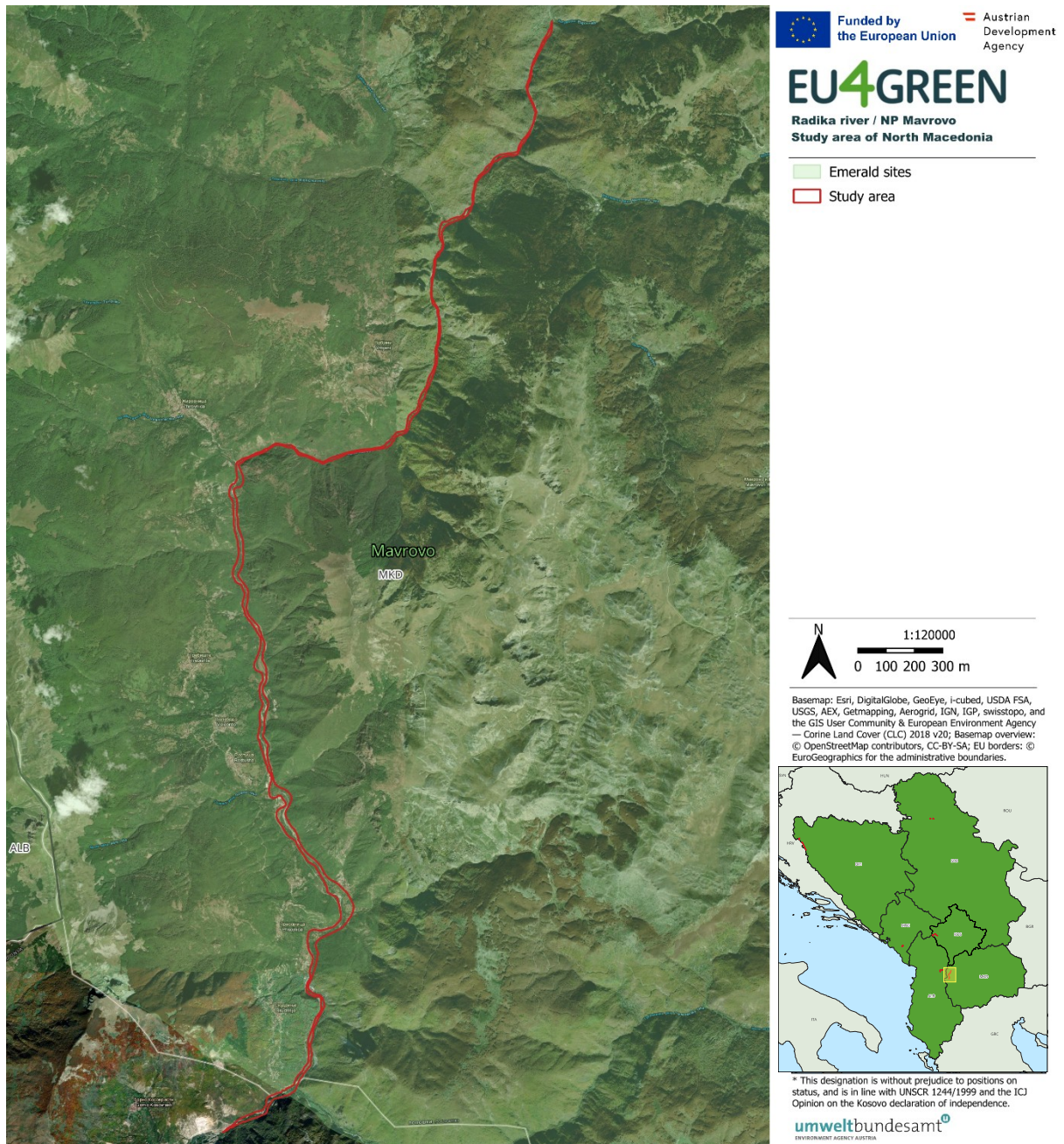


Figure 7: Study area at the Mavrovo National Park, North Macedonia.

The study area was placed based on the subsequent criteria:

- Located within or surrounding the pilot site
- Borders corresponding with natural water dynamics and other already occurring features (roads, dams, trees, etc.)
- Covering the locally typical zonation of the vegetation on one or both sides of the river
- Access possible (almost) entirely (regarding permits, barriers, etc.)
- Appropriate for sampling the selected habitats (see 3.3.2 Features of the Habitats Directive)

The study area was not required to be identical with borders of existing protected areas.

For practical reasons and a more detailed mapping during the fieldwork, the mapping scale was standardized to 1:5.000 and a grid with the cell size of ca. 62.5 ha was created.

3.3.2. Features of the Habitats Directive

The activities of EU4Green focused on habitats as target features that acted as examples, outlining the process behind the conservation assessments. The features sampled within the study area of North Macedonia can be found in Table 3.

Table 3: Assessed habitats for the study area of North Macedonia.

Group	Code	Feature
Habitat types	3220	Alpine rivers and the herbaceous vegetation along their banks
Habitat types	3240	Alpine rivers and their ligneous vegetation with <i>Salix elaeagnos</i>
Habitat types	3270	Rivers with muddy banks with <i>Chenopodium rubri</i> pp and <i>Bidention</i> pp vegetation
Habitat types	6540	Sub-Mediterranean grasslands of the <i>Molinio-Hordeion secalini</i>
Habitat types	8110	Siliceous screes of the montane to snow levels (<i>Androsacetalia alpinae</i> and <i>Galeopsietalia ladani</i>)
Habitat types	8210	Calcareous rocky slopes with chasmophytic vegetation
Habitat types	8220	Siliceous rocky slopes with chasmophytic vegetation
Habitat types	91AA	Eastern white oak woods
Habitat types	91E0	Alluvial forests with <i>Alnus glutinosa</i> and <i>Fraxinus excelsior</i> (<i>Alno-Padion</i> , <i>Alnion incanae</i> , <i>Salicion albae</i>)
Habitat types	92A0	<i>Salix alba</i> and <i>Populus alba</i> galleries

3.3.3. Fact files and condition indicators

The experts developed fact files for the habitat types that were assessed in the pilot sites. These fact files summarize the knowledge available for each habitat, giving a well-structured overview of the identification and ecological requirements (Table 4). During development, the trained experts collaborated and brought together their knowledge to produce harmonized fact files with condition indicators and thresholds that can potentially be applied across the WB6. All fact files are found in Annex II.

Fact files act both as a guidance for field mapping identification (interpretation) and as basis for the assessment of condition indicators. The condition indicators were defined based on the theory specified in chapter 3.2.4 Condition indicators and threshold values.

Table 4: Fact file structure for a habitat type.

Section	Content
Fact File	
Code and name	In accordance with Annex I of the Habitats Directive; names in English and in local languages.
Short profile	Summary of most significant features of the habitat type.
Cross-references to classification systems	Cross-references between the interpretation manual of Annex I habitat types and relevant international, national and/or local classification systems (e.g. phytosociology, biotopes). The classification could be identical (=), broader and therefore encompassing the Annex I habitat type (>), narrower than the Annex I habitat type (<), or partly overlapping (#).
Coenosis	Typical plant species (characteristic, dominant, indicative species), typical other species.
Ecology	Ecological requirements regarding soil (soil type, acidity, nutrients), water regime, climatic condition, elevation.
Structure	Horizontal and vertical structure (e.g. zonation, patchiness, life forms, vegetation layers), structural components (e.g. dead wood).
Dynamics	Vegetation phases, ecological cycles.
Dependency on maintenance	If human maintenance is required, specification of required type of utilization, intensity of use, etc.
Threats and pressures	Future threats and present pressures, Red List status, typical impacts.
Typical conservation measures	Regularly applied conservation measures.
Distribution	Description and/or distribution maps.
Assessment of Degree of Conservation	
Species composition indicators	Indicators for assessing species composition by presence or absence, number or abundance of indicative species. Assigned with thresholds for excellent, good or average/reduced condition.
Structure and functions indicators	Indicators for assessing the determinative structural, dynamic or ecological factors. Assigned with thresholds for excellent, good or average/reduced condition.
Impact indicators	Indicators for assessing the most important pressures and impacts (natural and anthropogenic). Assigned with thresholds for excellent, good or average/reduced condition.
Species observations during fieldwork	Overview of observations made during field work.
Aggregation Scheme	Scheme for aggregating population, habitat and impact indicators.

3.3.4. Mapping units, field protocols and fieldwork

Mapping units specify the spatial scale on which the condition indicators are measured. During fieldwork, the habitat expert delineated every patch of homogenous habitat on a map, with the aim to cover the entire study area. After assessing the spatial extent of a homogenous patch, the habitat was classified as either a habitat type of the Habitats Directive or no (protected) habitat type. For the habitat types of Community interest, further data was assessed, including the condition indicators.

The field protocols are to be found in Annex III. All mappings were carried out between July and September 2024 (Table 5).

Table 5: Mapping period and fieldwork days for each study area and feature group.

Feature group	Mapping period	Fieldwork days
Habitat types	July, August and September 2024	11
Total	July - September 2024	11

3.3.5. Aggregation within mapping units

On completion of fieldwork, the condition indicators were aggregated, first within each asset and then for the entire mapping unit. If an asset had two or more condition indicators, logical aggregation was used (Annex IV). In case a particular asset had only one condition indicator, the grade was used directly for the asset. The grading system is designed in a way that single condition indicators with low grading have a significant effect on the aggregated grade of the asset and the grade of the entire mapping unit (Figure 8).

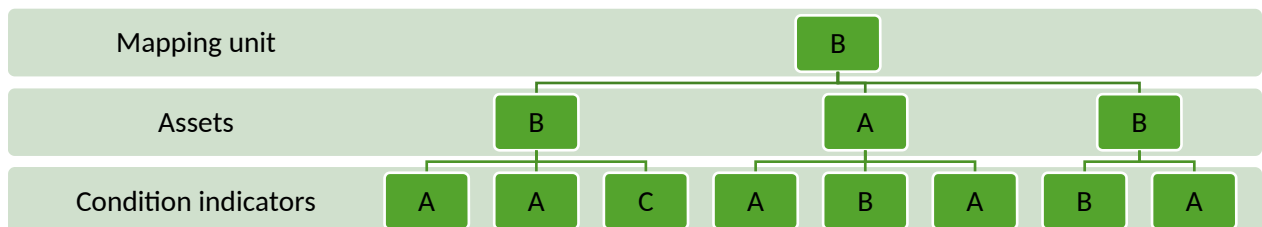


Figure 8: Exemplary illustration of the aggregation from the grades of condition indicators to the grades of the assets within each mapping unit.

For habitats, all three assets were then aggregated to receive the aggregated grade for the entire mapping unit, i.e. the habitat polygon.

3.3.6. Aggregation to Degree of Conservation and Area in Good Condition

The final step was aggregating the mapping units within the entire pilot site for each habitat. For this, the area of all relevant mapping units with identical aggregated grade (A, B or C) was summed up. For the categorized Degree of Conservation, thresholds were applied:

- If $\geq 70\%$ of the habitat area within the pilot site is graded A, the categorized Degree of Conservation is A.
- If $\geq 50\%$ of the habitat area within the pilot site is graded C, the categorized Degree of Conservation is C.
- For all other cases, the categorized Degree of Conservation is B.

For the Area in Good Condition, the sums of grade A and B were combined. The Area in Not Good Condition is the area of all mapping units with grade C.

3.3.7. Software

Geo data compilation and spatial analysis was done in QGIS²⁶. Statistical analysis was carried out with Microsoft[®] Excel[®] 2016 and R version 4.3.1²⁷.

²⁶ QGIS Development Team. (2025). QGIS Geographic Information System (Version 3.40). QGIS Association. <https://www.qgis.org>

²⁷ R Core Team (2023). R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna, Austria. <https://www.R-project.org/>

3.4. Results and discussion

3.4.1. Habitat types

With a total of ten recorded habitat types under the Habitats Directive, the study area at the Mavrovo National Park contains a rich diversity of habitat types protected in the EU. During fieldwork, all habitat types of the Habitats Directive were identified and spatially delineated to gather their distribution (Figure 9, Figure 10, Figure 11). The habitat patches (= occurrences) can be found along the entire river stretch, covering extensive areas of the narrow study area, reaching from the upper regions at the confluence of the Bogdevska River tributary to the sub-catchment of the Mala Reka river near the village Dolno Kosovrasti.

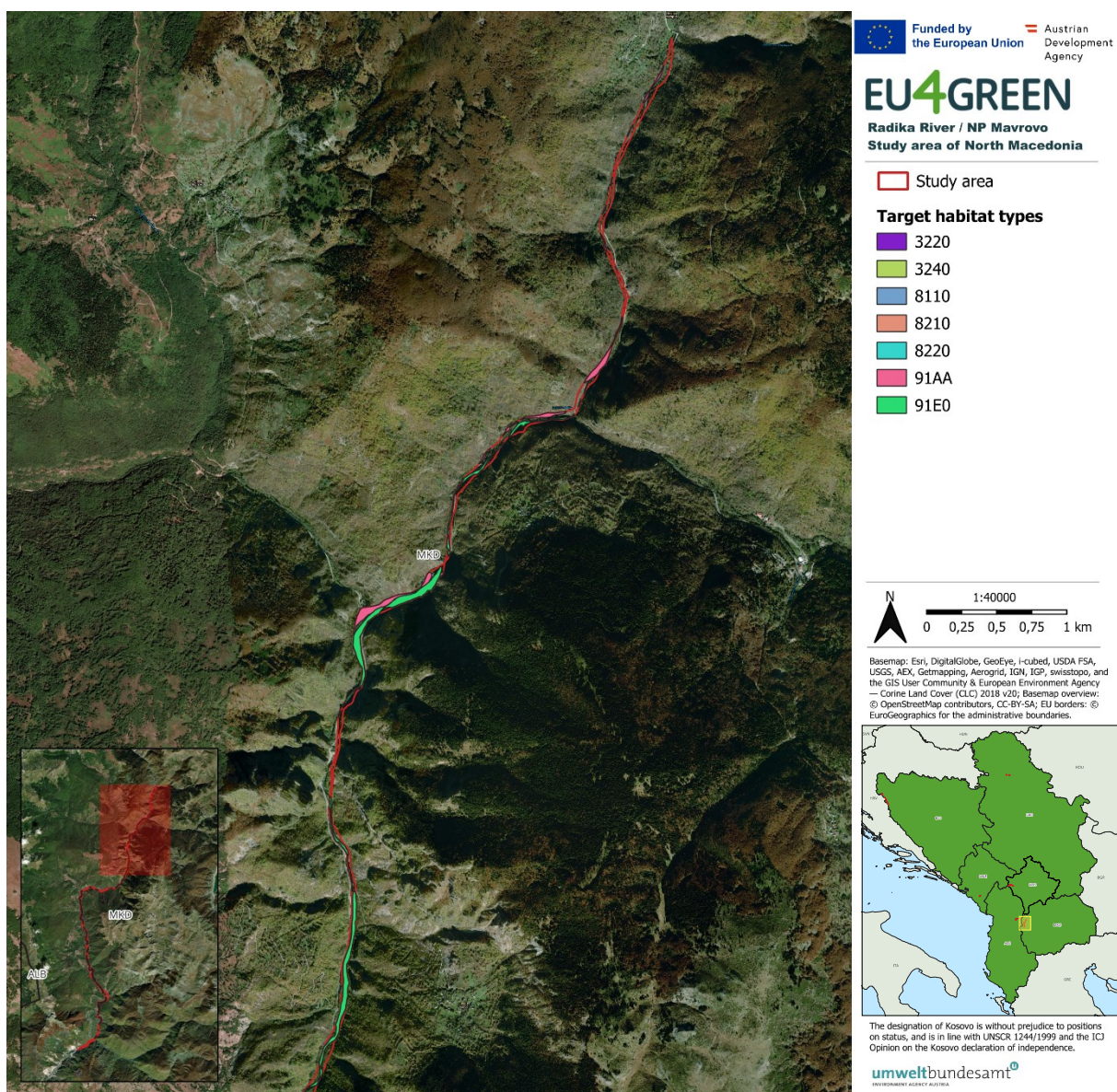


Figure 9: Distribution of the assessed Natura 2000 habitat types in the Mavrovo National Park study area, northern part.

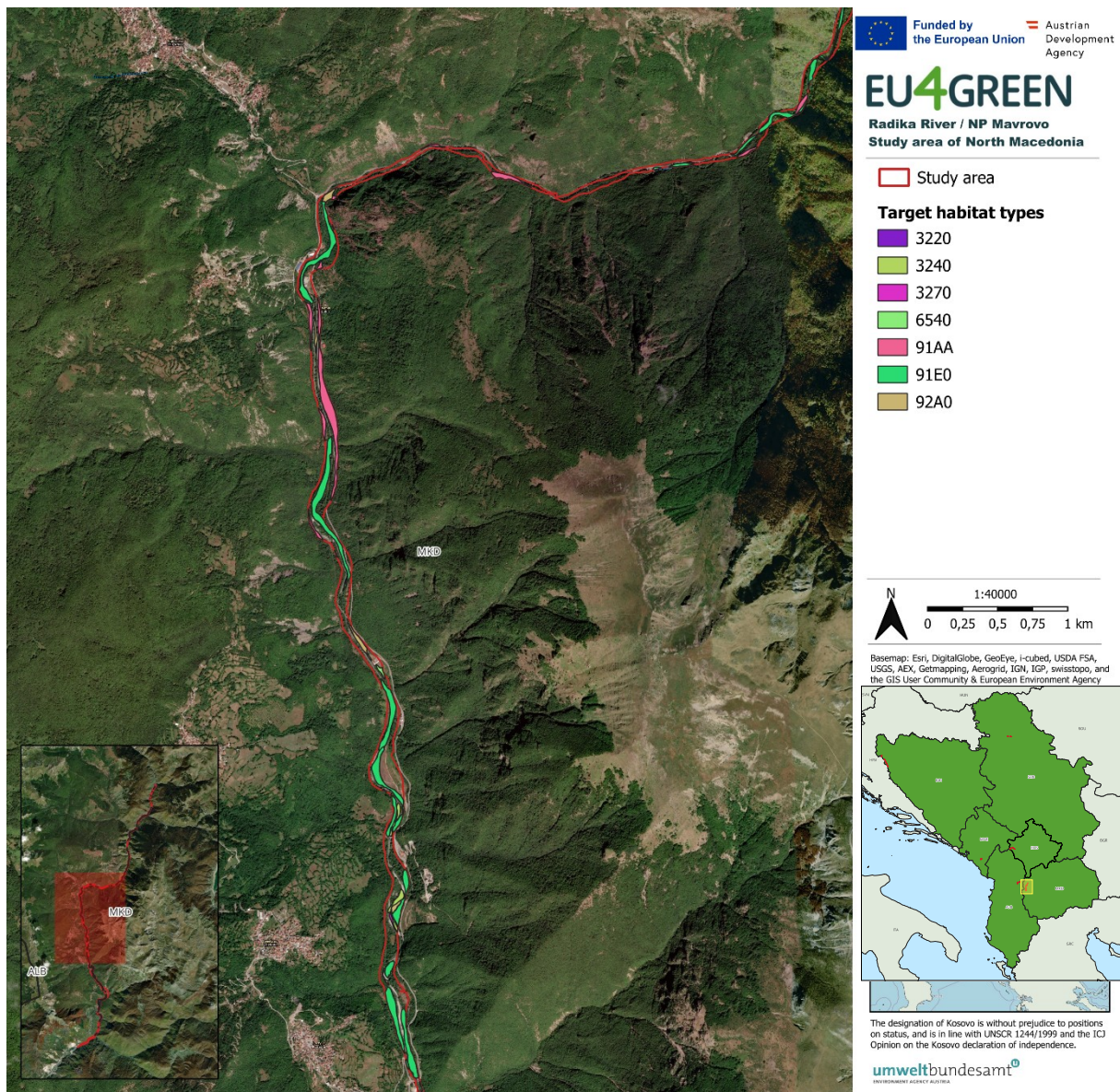


Figure 10: Distribution of the assessed Natura 2000 habitat types in the Mavrovo National Park study area, central part.

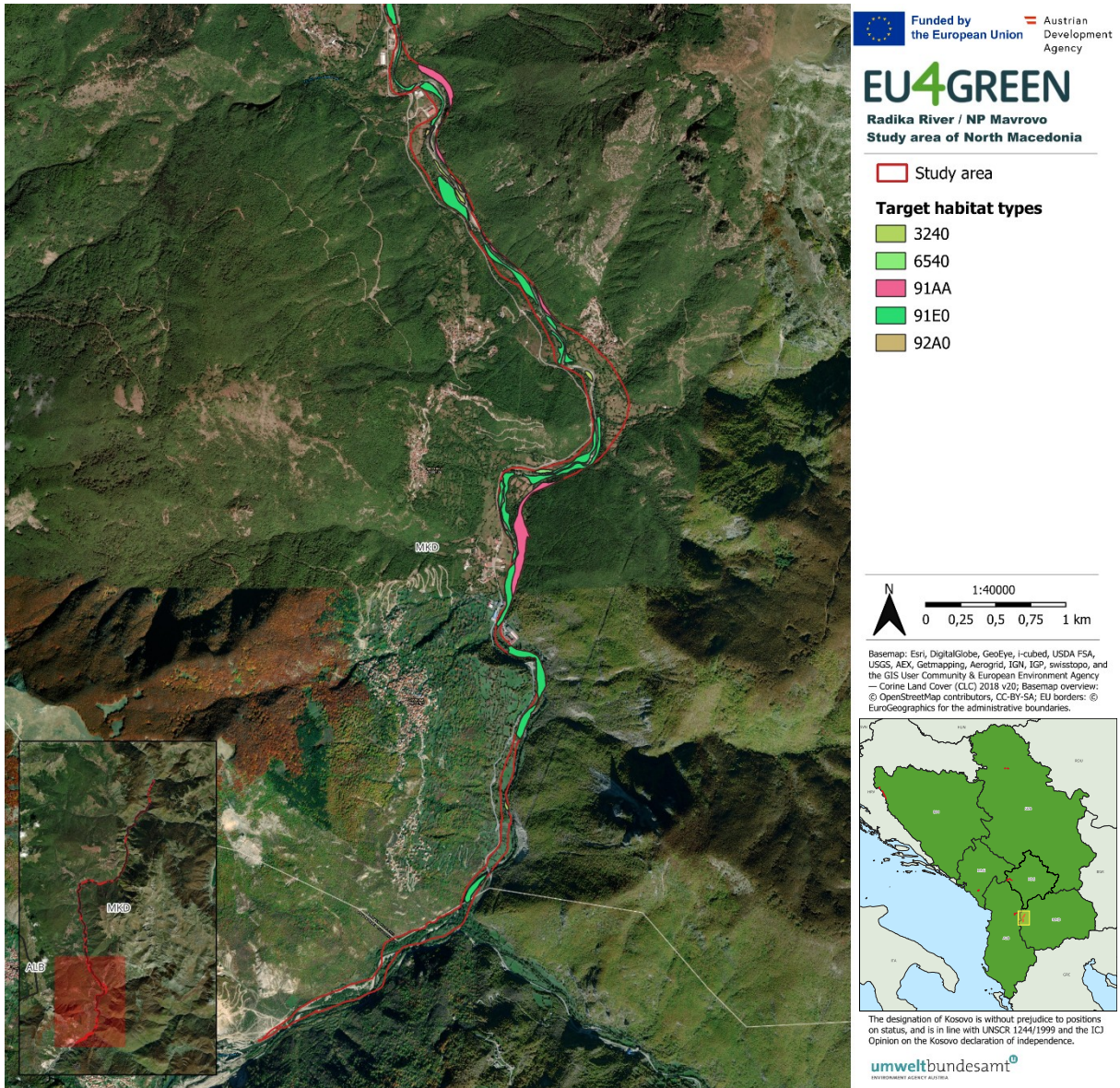


Figure 11: Distribution of the assessed Natura 2000 habitat types in the Mavrovo National Park study area, southern part.

Most of the habitat types are extraordinarily well-preserved, as the overall condition of most habitat types is graded as 'B good' or 'A excellent' (Error: Reference source not foundFigure 12, Figure 13, Figure 14 and Figure 15).

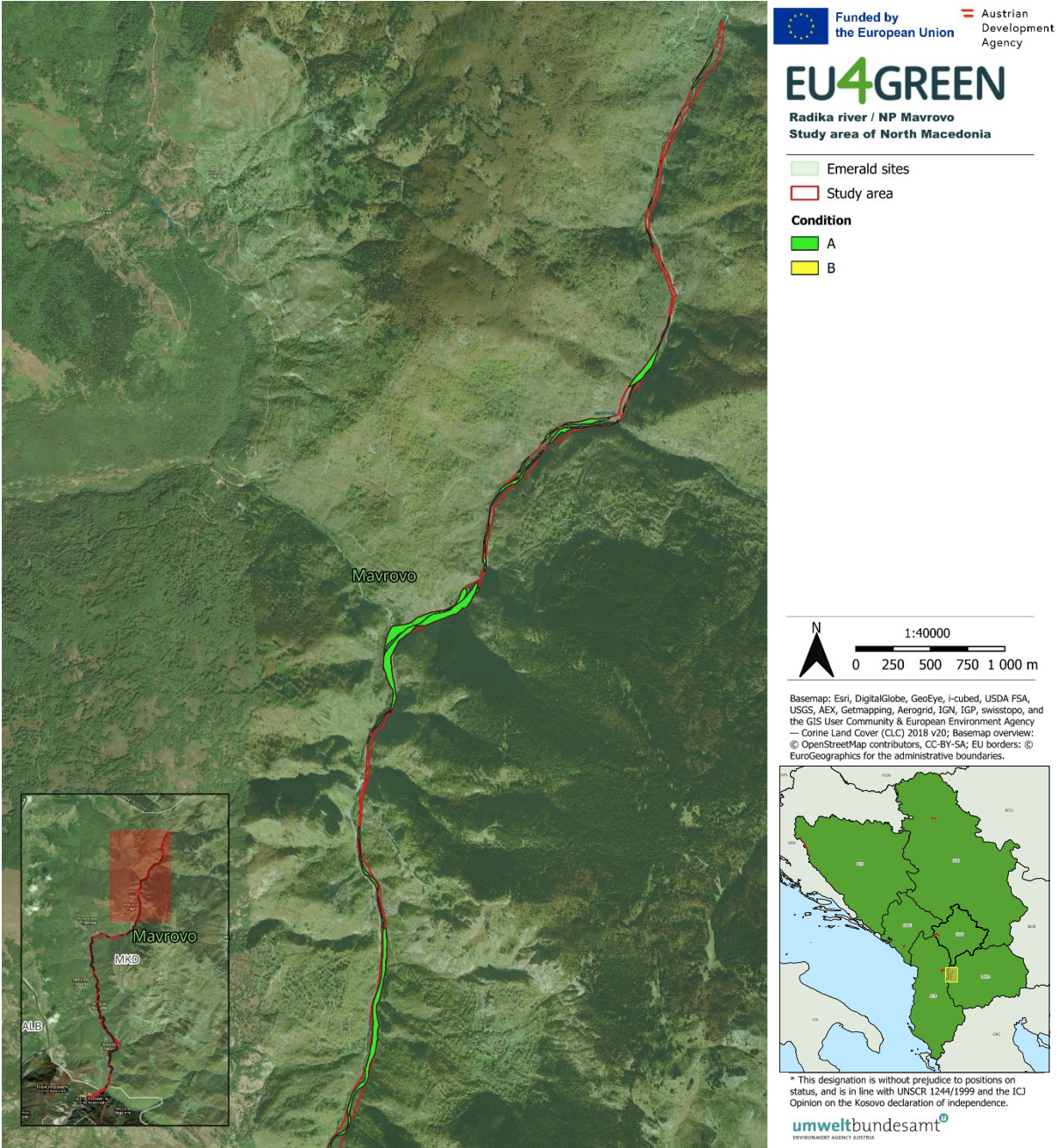


Figure 12: Condition of the assessed Natura 2000 habitat types in the Mavrovo National Park study area, northern part.

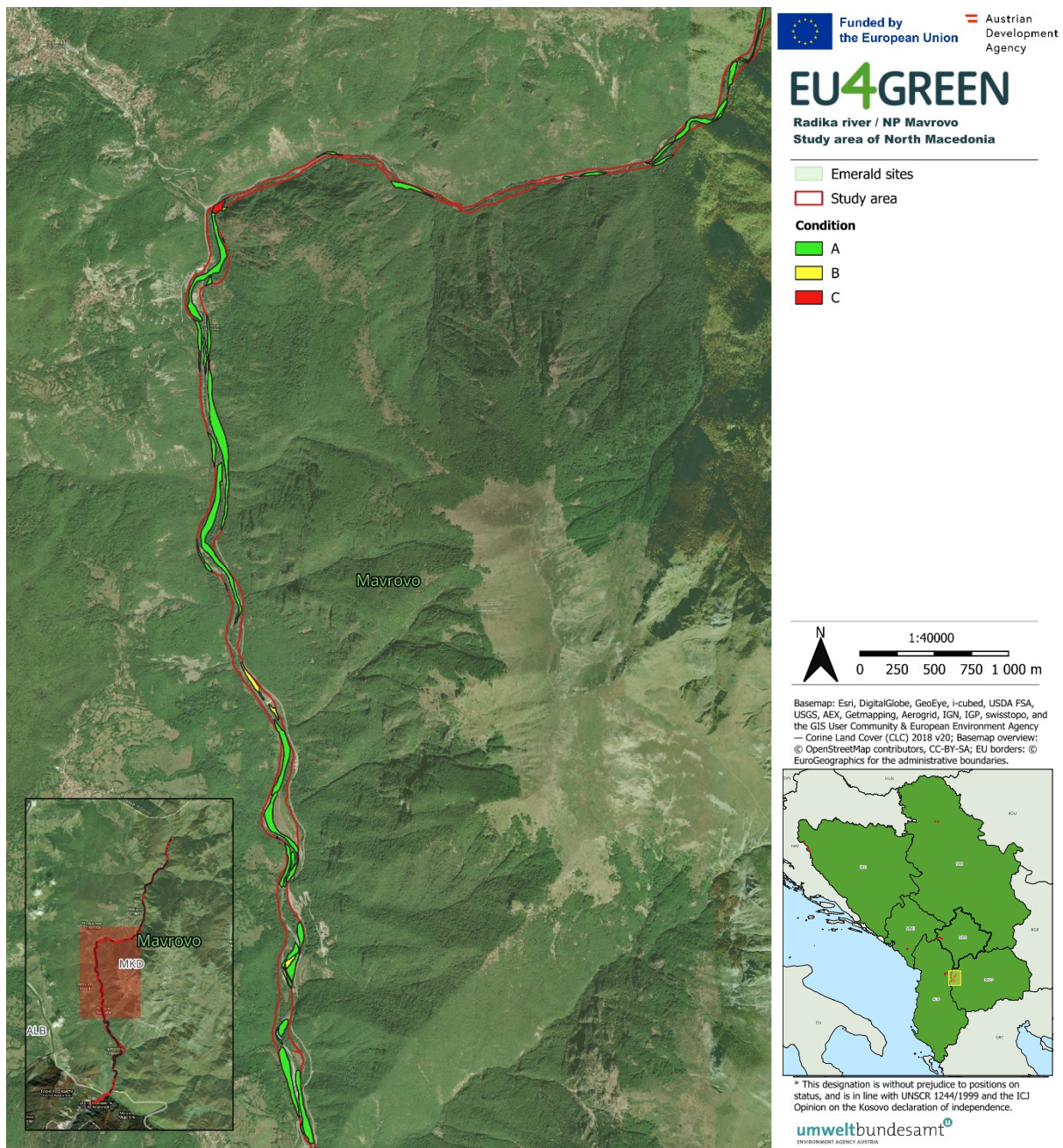


Figure 13: Condition of the assessed Natura 2000 habitat types in the Mavrovo National Park study area, central part.

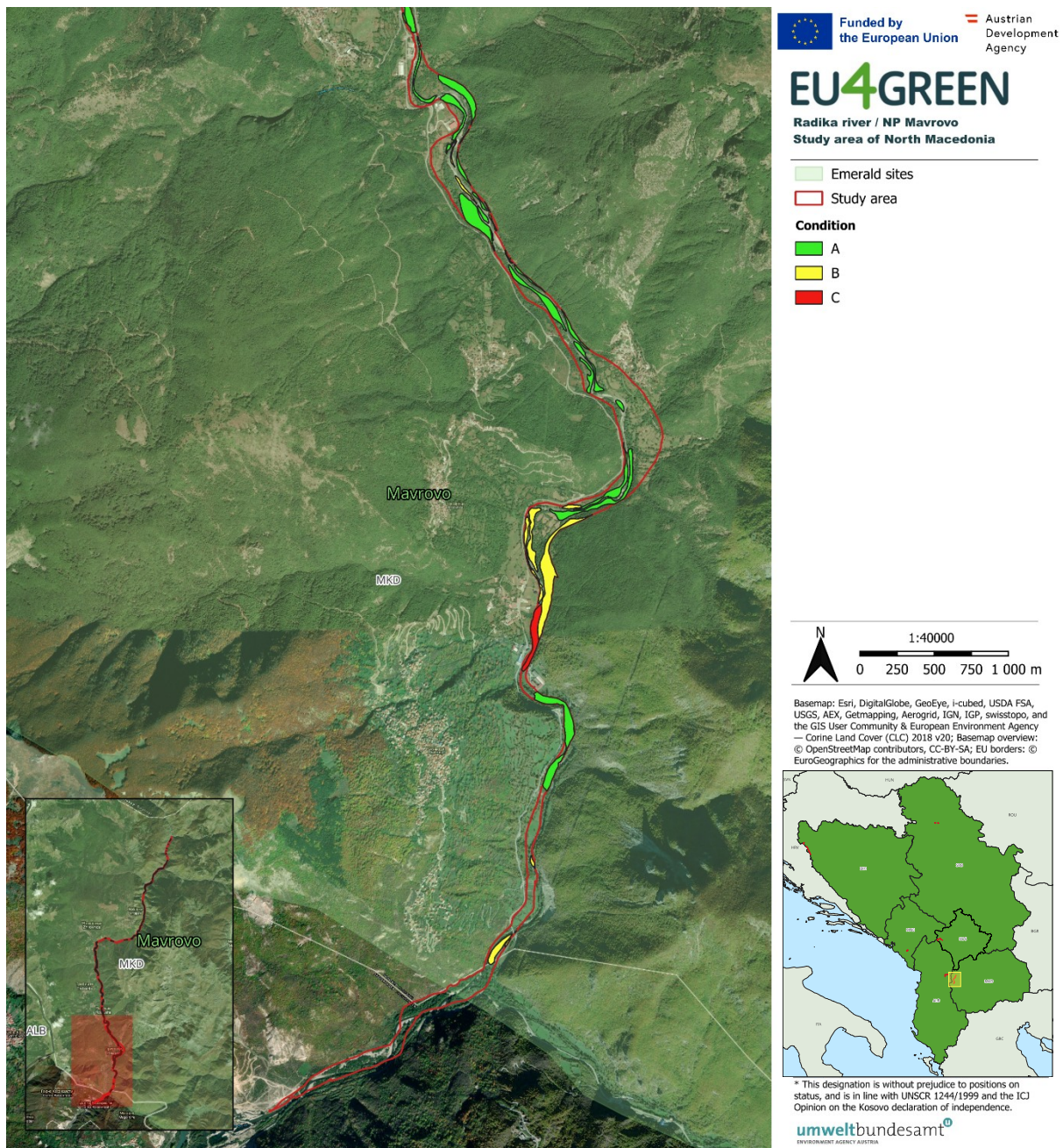


Figure 14: Condition of the assessed Natura 2000 habitat types in the Mavrovo National Park study area, southern part.

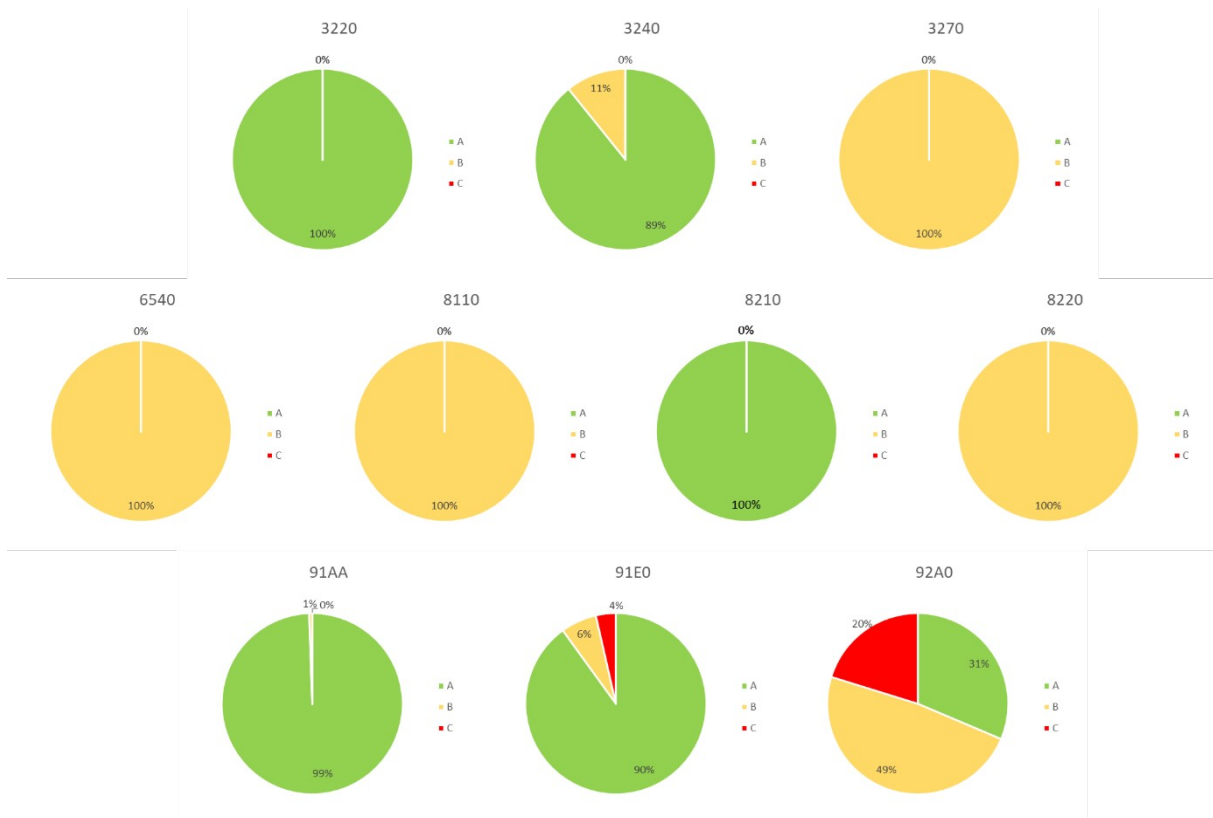


Figure 15: Condition of the assessed habitat types in the Mavrovo National Park study area

The information collected during fieldwork was subsequently integrated into the ecological data of the Standard Data Forms (Table 6, Table 7, Table 8, Table 9, Table 10Error: Reference source not foundError: Reference source not found). Since the contracted expert assessed and delineated habitat types beyond the defined study area within Mavrovo National Park, the ten Standard Data Forms presented here represent an excerpt of the more comprehensive dataset provided in the Annex V. In total, the full table covers 17 habitat types, including areas extending beyond the study area boundaries. The cover in ha shown in the tables also refers to the comprehensive data set.

Table 6: Ecological information for ‘3220 -Alpine rivers and the herbaceous vegetation’ along their banks and ‘3240 - Alpine rivers and their ligneous vegetation with *Salix elaeagnos*’ at the Mavrovo National Park study area (10 km²).

Information	Habitat 1	Habitat 2
3.1a Essential information (habitat type)		
3.1.1 Habitat type code	3220	3240
3.1.2 Priority form	not applicable	not applicable
3.1.3 Non-presence	not applicable	not applicable
3.1.4 Cover	0.46 ha	9.19 ha
3.1.5 Caves		not assessed
3.1.6 Method used for cover	complete survey or a statistically robust estimate	complete survey or a statistically robust estimate
3.1.7 Period of last data collection		not assessed
3.1b Site assessment (habitat type)		
3.1.8 Significance	Significant	Significant
3.1.9 Representativity	A: excellent	A: excellent
3.1.10 Relative surface	C: 2% ≥ p > 0%	C1: 2% ≥ p >0%
3.1.11 Relative surface explanations (optional)		
3.1.12 Degree of conservation		
3.1.12.1 Degree of conservation – categorised	A: excellent	A: excellent
3.1.12.2 Degree of conservation – area	Good condition: 0.46 ha Not-good condition: 0 ha	Good condition: 8.84 ha Not-good condition: 0.35 ha
3.1.12.3 Degree of conservation – method used	Based mainly on extrapolation from a limited amount of data (expert judgement)	Based mainly on extrapolation from a limited amount of data (expert judgement)
3.1.13 Conservation objectives		
3.2.14 Conservation objectives – explanations		
3.2.19 Global	A: excellent value	A: excellent value
3.2.20 Update date	December 2024	December 2024

Table 7: Ecological information for ‘3270 -Rivers with muddy banks with *Chenopodium rubri* pp and *Bidenton* pp vegetation’ and ‘6540 -Sub-Mediterranean grasslands of the *Molinio-Hordeion secalini*’ at the Mavrovo National Park study area (10 km²).

Information	Habitat 3	Habitat 4
3.1a Essential information (habitat type)		
3.1.1 Habitat type code	3270	6540
3.1.2 Priority form	not applicable	not applicable
3.1.3 Non-presence	not applicable	not applicable
3.1.4 Cover	0.13 ha	1.58 ha
3.1.5 Caves		not assessed
3.1.6 Method used for cover	complete survey or a statistically robust estimate	complete survey or a statistically robust estimate
3.1.7 Period of last data collection		not assessed
3.1b Site assessment (habitat type)		
3.1.8 Significance	Significant	Significant
3.1.9 Representativity	A: excellent	C: significant
3.1.10 Relative surface	C: 2% ≥ p > 0%	C: 2% ≥ p > 0%
3.1.11 Relative surface explanations (optional)		
3.1.12 Degree of conservation		
3.1.12.1 Degree of conservation – categorised	A: excellent	C: reduced
3.1.12.2 Degree of conservation – area	Good condition: 0.13 ha Not-good condition: 0 ha	Good condition: 0.3 ha Not-good condition: 1.29 ha
3.1.12.3 Degree of conservation – method used	Based mainly on extrapolation from a limited amount of data (expert judgement)	Based mainly on extrapolation from a limited amount of data (expert judgement)
3.1.13 Conservation objectives		
3.2.14 Conservation objectives – explanations		
3.2.19 Global	A: excellent value	B: good value
3.2.20 Update date	January 2025	January 2025

Table 8: Ecological information for ‘8110 -Siliceous screes of the montane to snow levels (*Androsacetalia alpinae* and *Galeopsietalia ladani*)’ and ‘8210 -Calcareous rocky slopes with chasmophytic vegetation’ at the Mavrovo National Park study area (10 km²).

Information	Habitat 5	Habitat 6
3.1a Essential information (habitat type)		
3.1.1 Habitat type code	8110	8210
3.1.2 Priority form	not applicable	not applicable
3.1.3 Non-presence	not applicable	not applicable
3.1.4 Cover	0.13 ha	0.48 ha
3.1.5 Caves		not assessed
3.1.6 Method used for cover	complete survey or a statistically robust estimate	complete survey or a statistically robust estimate
3.1.7 Period of last data collection		not assessed
3.1b Site assessment (habitat type)		
3.1.8 Significance	Significant	Significant
3.1.9 Representativity	B: good	B: good
3.1.10 Relative surface	C: 2% ≥ p > 0%	C: 2% ≥ p > 0%
3.1.11 Relative surface explanations (optional)		
3.1.12 Degree of conservation		
3.1.12.1 Degree of conservation – categorised	B: good	B: good
3.1.12.2 Degree of conservation – area	Good condition: 0.04 ha Not-good condition: 0.1 ha	Good condition: 0.12 ha Not-good condition: 0.36 ha
3.1.12.3 Degree of conservation – method used	Based mainly on extrapolation from a limited amount of data (expert judgement)	Based mainly on extrapolation from a limited amount of data (expert judgement)
3.1.13 Conservation objectives		
3.2.14 Conservation objectives – explanations		
3.2.19 Global	B: good value	B: good value
3.2.20 Update date	January 2025	January 2025

Table 9: Ecological information for ‘8220 - Siliceous rocky slopes with chasmophytic vegetation’ and ‘91AA - Eastern white oak woods’ at the Mavrovo National Park study area (10 km²).

Information	Habitat 7	Habitat 8
3.1a Essential information (habitat type)		
3.1.1 Habitat type code	8220	91AA
3.1.2 Priority form	not applicable	not applicable
3.1.3 Non-presence	not applicable	not applicable
3.1.4 Cover	0.01 ha	2510.82 ha
3.1.5 Caves		not assessed
3.1.6 Method used for cover	Insufficient data	complete survey or a statistically robust estimate
3.1.7 Period of last data collection		not assessed
3.1b Site assessment (habitat type)		
3.1.8 Significance	Significant	Significant
3.1.9 Representativity	A: excellent	A: excellent
3.1.10 Relative surface	C: 2% ≥ p > 0%	C: 2% ≥ p > 0%
3.1.11 Relative surface explanations (optional)		
3.1.12 Degree of conservation		
3.1.12.1 Degree of conservation – categorised	A: excellent	B: good
3.1.12.2 Degree of conservation – area	Good condition: 0.01 ha Not-good condition: 0 ha	Good condition: 2510.82 ha Not-good condition: 0 ha
3.1.12.3 Degree of conservation – method used	Based mainly on extrapolation from a limited amount of data (expert judgement)	Based mainly on extrapolation from a limited amount of data (expert judgement)
3.1.13 Conservation objectives		
3.2.14 Conservation objectives – explanations		
3.2.19 Global	B: good value	A: excellent value
3.2.20 Update date	January 2025	January 2025

Table 10: Ecological information for '91E0 - Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (Alno-Padion, Alnion incanae, Salicion albae)' and '92A0 - *Salix alba* and *Populus alba* galleries' at the Mavrovo National Park study area (10 km²).

Information	Habitat 9	Habitat 10
3.1a Essential information (habitat type)		
3.1.1 Habitat type code	91E0	92A0
3.1.2 Priority form	not applicable	not applicable
3.1.3 Non-presence	not applicable	not applicable
3.1.4 Cover	59.85 ha	2.22 ha
3.1.5 Caves		not assessed
3.1.6 Method used for cover	complete survey or a statistically robust estimate	complete survey or a statistically robust estimate
3.1.7 Period of last data collection		not assessed
3.1b Site assessment (habitat type)		
3.1.8 Significance	Significant	Significant
3.1.9 Representativity	A: excellent	A: excellent
3.1.10 Relative surface	C: 2% ≥ p > 0%	C: 2% ≥ p > 0%
3.1.11 Relative surface explanations (optional)		
3.1.12 Degree of conservation		
3.1.12.1 Degree of conservation – categorised	A: excellent	B: good
3.1.12.2 Degree of conservation – area	Good condition: 59.85 ha Not-good condition: 0 ha	Good condition: 2.22 ha Not-good condition: 0 ha
3.1.12.3 Degree of conservation – method used	Based mainly on extrapolation from a limited amount of data (expert judgement)	Based mainly on extrapolation from a limited amount of data (expert judgement)
3.1.13 Conservation objectives		
3.2.14 Conservation objectives – explanations		
3.2.19 Global	A: excellent value	A: excellent value
3.2.20 Update date	January 2025	January 2025

3.5. Conclusions

The fieldwork conducted within Mavrovo National Park proved its exceptionally high natural value, yielding particularly strong results for the studied habitats of the Radika River with its herbaceous and ligneous vegetation along their banks (3220, 3240) as well as the calcareous rocky slopes (8210). In the mostly forested valleys, habitat types associated closely with the river, like alluvial forests and galleries (91E0, 92A0) and the rather thermophilically characterised Eastern white oak woods (91AA) are also dominant in an overall good condition. At the same time, the investigations brought to light several challenges, both in terms of methodology and conservation practice, which should be addressed in future work to record and, subsequently, improve the valuable natural features in the area and beyond.

The exemplary assessments and evaluations indicated the need for action specifically regarding the fragmentation and naturalness of the water body of the Radika river. The existing pressures impact some of the assessed target features more than others but nonetheless causing the lack of connectivity and natural river dynamics. Future Site-specific conservation objectives and conservation measures could target those challenges. The applied approach serves as a foundation for developing new objectives to guide the management of the National Park. These findings highlight how the local circumstances, both natural and human-influenced, can be brought together with the overall conservation status through a structured approach, ensuring that each site contributes as much as possible to the conservation of the species or habitat type.

In the eyes of EAA experts on biodiversity, the expert responsible for the fieldwork demonstrated a high level of professionalism and motivation, successfully tailoring the methodological framework to local circumstances. In doing so, they gained valuable new insights that will prove highly useful for extending and refining mapping activities in the future, thereby strengthening the long-term conservation efforts in Mavrovo National Park. They also gathered important knowledge to support the development of a general methodology to map potential future Natura 2000 sites in North Macedonia.

4. NATURE-BASED SOLUTIONS IN FLOODPLAINS: METHODS FOR ASSESSING IMPLEMENTATION POSSIBILITIES ON A REGIONAL LEVEL

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4.1. Summary

EU4Green aimed to highlight the potential of innovative Nature-based Solutions (NbS) at the Mavrovo National Park in North Macedonia. River regulation, intensification of land use and habitat fragmentation threaten biodiversity, ecosystem services and human well-being. NbS are increasingly recognised in policy frameworks such as the Green Agenda for the Western Balkans, the EU Biodiversity Strategy 2030 and the EU Nature Restoration Regulation as effective, multifunctional responses to these challenges. To define realistic objectives for the development of NbS, the methodology combined literature review, expert questionnaires and participatory workshops with an analysis of geospatial data to identify and localise priority areas. The results were developed in close consultation with local experts and the expertise of the non-governmental organisation Eko-svest.

Major societal challenges – such as flood risk, water pollution, soil erosion and habitat degradation – were linked to appropriate NbS, associated ecosystem services, indicators and data sources. Ten NbS objectives were defined across five fields of action: sustainable agricultural landscapes, forests and wooded ecosystems, riparian ecosystem restoration, protection of high-value ecosystems and soil de-sealing. Priority measures include conservation agriculture, grassland restoration, ecological forest management, afforestation of steep slopes, riparian buffer zones, floodplain restoration, river connectivity measures, protection of sensitive Natura 2000 habitats and permeable surfaces in built-up areas. The results demonstrate both the high potential of NbS in the Radika river valley and key challenges, including limited site-specific data, competing land uses, existing riverbank constructions and complex land ownership patterns. Successful implementation will require strong partnerships with National Park authorities as central coordinators supported by municipalities, landowners, farmers and the wider public. Overall, the EU4Green NbS outputs provide a robust and practical basis for advancing restoration, biodiversity conservation and climate resilience on the local level, in line with EU and global objectives.

4.2. Introduction

4.2.1. EU4Green's activities on NbS

EU4Green assessed and highlighted the potential of NbS on pilot site level. Because of anthropogenic activities, such as river regulations, intensification of land use and habitat fragmentation, the pressure on riparian ecosystems like floodplains is increasing. Over time, these pressures threaten the rich nature of those ecosystems and affect human well-being. The disturbed natural systems contribute to a range of societal challenges, e.g. water pollution, flood risk or soil erosion. NbS can serve as a valuable tool that help to tackle those challenges, reducing the exposure of negative effects.^{28, 29}

Furthermore, NbS are promoted as valuable tool by the GAWB² and explicitly mentioned in many other major EU frameworks and strategies, such as the EU Biodiversity Strategy 2030¹⁸, the EU Nature Restoration Regulation³⁰, the Common Agricultural Policy³¹ and the Water Framework Directive³². These alignments emphasise the importance and necessity of the NbS concept.

Within EU4Green, the promotion of the NbS concept was supported through capacity building, such as expert workshops and webinars and establishment of a Community of Practice together with IUCN. Furthermore, EU4Green developed a comprehensive guidance document on riparian buffer zones, a NbS that provides multiple benefits when implemented along rivers. The guidance document highlights how to plan, finance, implement and evaluate such NbS.

Ultimately, the concept was also expanded to the pilot sites, with the aim to narrow down and target the crucial societal challenges and define potential NbS to improve the situation effectively and sustainably. This process was conducted in consultation with local experts and relevant stakeholders such as expert organisation, taking into account the relevant data and knowledge already gathered on the pilot site.

²⁸ INTERNATIONAL UNION FOR CONSERVATION OF NATURE (IUCN), 2016. WCC-2016-Res-069-EN: Defining Nature-based Solutions. Resolution adopted at the IUCN World Conservation Congress, Honolulu, Hawaii, USA. Available at: <https://portals.iucn.org/library/node/46456>

²⁹ Seddon N, Chausson A, Berry P, Girardin CAJ, Smith A, Turner B, 2020. Understanding the value and limits of nature-based solutions to climate change and other global challenges. *Phil. Trans. R. Soc. B375*: 20190120. Available at: <http://dx.doi.org/10.1098/rstb.2019.0120>

³⁰ Regulation 2024/1991. Regulation (EU) 2024/1991 of the European Parliament and of the Council of 24 June 2024 on nature restoration and amending Regulation (EU) 2022/869. *Nature Restoration Regulation*. Official Journal of the European Union, L 1991. Available at: <http://data.europa.eu/eli/reg/2024/1991/oj>

³¹ Regulation 2021/2115. Regulation (EU) 2021/2115 establishing rules on support for strategic plans under the Common Agricultural Policy (CAP Strategic Plans). Official Journal of the European Union, L 435, 1–186. Available at: <http://data.europa.eu/eli/reg/2021/2115/oj>

³² Directive 2000/60/EC. Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy. *Water Framework Directive*. L 327, 1–73. Available at: <https://eur-lex.europa.eu/eli/dir/2000/60/oj/eng>

4.2.2. NbS as sustainable tool

Definition of societal challenges, NbS & ecosystem services

Before diving into the topic of Nature-based Solutions, a few definitions are required for a common understanding of terms and, furthermore, intention and aim of the activities.

The term *societal challenges (SC)* refers to complex issues and problems that affect communities, societies, or humanity at large. They often require collective efforts and solutions to address them effectively. General examples would be poverty or inequality.

Nature-based Solutions (NbS) are defined as strategic actions that protect, sustainably manage, and restore natural or modified ecosystems to address societal challenges. In the current case study of floodplains, this would target more specifically climate change, disaster risk, water and food security, and public health. While at the same time biodiversity and human well-being are being enhanced as well.^{33, 34, 35}

Unlike conventional engineering solutions (e.g. dams or concrete barriers), NbS rely on natural processes. For instance, restoring wetlands or riparian forests can offer flood protection while supporting biodiversity, sequestering carbon, and providing recreation. Compared to grey infrastructure, such interventions often deliver greater ecosystem services and long-term adaptability³⁶.

Ecosystem services (ES) are the benefits that humans derive from ecosystems, encompassing a wide range of goods and services that contribute to human well-being³⁷. They comprise of biotic/abiotic and biophysical/geophysical services that are classified in 3 main categories:

- Provisioning services (e.g. food, water, raw materials)
- Regulation & maintenance services (e.g. climate regulation, nutrient cycling, pollination)
- Cultural services (e.g. recreation, education, spiritual fulfilment)³⁸

³³ Cohen-Shacham, E., Walters, G., Janzen, C. and Maginnis, S. (eds.) (2016). Nature-based Solutions to address global societal challenges. Gland, Switzerland: IUCN. xiii + 97pp.

³⁴ Sowińska-Świerkosz, B., & García, J. (2022). What are Nature-based solutions (NBS)? Setting core ideas for concept clarification. *Nature-Based Solutions*, 2, 100009.

³⁵ Dumitru, A., & Wendling, L. (2021). Evaluating the impact of nature-based solutions: A handbook for practitioners. European Commission EC.

³⁶ Turkelboom, F., Demeyer, R., Vranken, L. et al. How does a nature-based solution for flood control compare to a technical solution? Case study evidence from Belgium. *Ambio* 50, 1431–1445 (2021). <https://doi.org/10.1007/s13280-021-01548-4>

³⁷ Grima, N., Jutras-Perreault, M. C., Gobakken, T., Ørka, H. O., & Vacik, H. (2023). Systematic review for a set of indicators supporting the Common International Classification of Ecosystem Services. *Ecological Indicators*, 147, 109978.

³⁸ Haines-Young, R. (2023): Common International Classification of Ecosystem Services (CICES) V5.2 and Guidance on the Application of the Revised Structure.

Benefits of NbS

NbS offer a multifaceted approach to address environmental challenges, particularly in the context of climate change and ecosystem degradation. By enhancing carbon sequestration in e.g. wetlands, NbS contribute significantly to climate mitigation while also adapting urban areas to extreme heat through increased vegetation cover³⁹. Moreover, they support biodiversity conservation by protecting and restoring critical habitats in terrestrial and aquatic ecosystems⁴⁰. NbS also improve water quality and availability by filtering pollutants through vegetated buffers and wetlands, while simultaneously enhancing soil health through erosion control and nutrient cycling⁴¹.

Beyond ecological gains, NbS deliver social benefits as well, which improve human well-being and community resilience. Green infrastructure, such as parks and urban forests, reduces stress, enhances mental health, and promotes physical activity⁴². NbS also buffer the impacts of natural disasters by restoring natural floodplains and stabilizing slopes, reducing the risk of floods and landslides⁴³. Importantly, many NbS projects are participatory, involving local communities in planning and maintenance, which fosters social cohesion and a sense of ownership⁴⁴.

Economically, NbS provide cost-effective alternatives to traditional technology-based solutions while generating green jobs and supporting sustainable agriculture. They reduce long-term infrastructure costs by minimizing the need for expensive engineered solutions. Restoration and conservation work also drives employment in sectors like forestry, agriculture, and ecotourism. Furthermore, integrating agroecological practices improves soil and water management, leading to higher and more sustainable agricultural productivity⁴⁵.

4.2.3. Relevant guidelines and documents

To support the systematic planning, implementation and evaluation of NbS in the WB6, a range of European and international frameworks and guideline documents are available. These frameworks provide conceptual definitions, methodological standards and practical tools to assess the condition of the targeted ecosystems, ecosystem services and the effectiveness of NbS interventions. Together, they ensure coherence with EU and global biodiversity and restoration policies, enable evidence-based decision-making and support the translation of strategic objectives into measurable, site-specific actions.

³⁹ Griscom, B. W., et al. (2017). Natural climate solutions. *Proceedings of the National Academy of Sciences*, 114(44), 11645–11650.

⁴⁰ Seddon, N., et al. (2020). *Understanding the value and limits of nature-based solutions to climate change and other global challenges*. *Philosophical Transactions of the Royal Society B*, 375(1794), 20190120.

⁴¹ Brauman, K. A., Daily, G. C., Duarte, T. K., & Mooney, H. A. (2007). *The nature and value of ecosystem services: an overview highlighting hydrologic services*. *Annual Review of Environment and Resources*, 32, 67–98.

⁴² Hartig, T., Mitchell, R., de Vries, S., & Frumkin, H. (2014). Nature and health. *Annual Review of Public Health*, 35, 207–228.

⁴³ Cohen-Shacham, E., Walters, G., Janzen, C., & Maginnis, S. (2016). *Nature-based solutions to address global societal challenges*. IUCN.

⁴⁴ Raymond, C. M., et al. (2017). *A framework for assessing and implementing the co-benefits of nature-based solutions in urban areas*. *Environmental Science & Policy*, 77, 15–24.

⁴⁵ Titttonell, P. (2014). *Ecological intensification of agriculture—sustainable by nature*. *Current Opinion in Environmental Sustainability*, 8, 53–61.

IUCN Global Standard for Nature-based Solutions⁴⁶

The IUCN Global Standard for Nature-based Solutions provides a structured framework to support the effective design, implementation and evaluation of NbS. Developed by IUCN, it defines eight criteria and 28 indicators on key aspects such as biodiversity outcomes, ecosystem integrity, trade-offs, stakeholder involvement and adaptive management. The document ensures that NbS address major societal challenges (e.g. climate change, biodiversity loss and disaster risk) while delivering measurable and sustainable benefits for both people and nature. By promoting scientifically robust and socially inclusive approaches, it supports scalable, economically viable and policy-relevant solutions that strengthen ecosystem health, human well-being and long-term resilience.

In addition, it should also be mentioned, that the IUCN provides many more reports, policy briefs and other supporting documents on NbS. Some of the most relevant for the cause of the projects work are the following:

- IUCN Global Standards for Nature-based Solutions⁴⁷
- Nature-based Solutions for climate: A compendium of best practices in the Western Balkans⁴⁸
- Nature-based Solutions in the Post-2020 Global Biodiversity Framework Targets⁴⁹

Alignment with the Post-2020 Global Biodiversity Framework⁵⁰

The Kunming–Montreal Global Biodiversity Framework defines 23 global targets for 2030, including the protection and restoration of 30 % of land and seas and the sustainable use of natural resources. NbS provide a practical path to implement these targets, particularly those related to ecosystem restoration, climate resilience, sustainable land use and nature's contributions to people. By translating global goals into locally adapted, multifunctional measures, NbS help bridge biodiversity, climate and development agendas and increase the feasibility, acceptance and impact of GBF implementation in the Western Balkans.

EU4Green: Guidance document on NbS: riparian buffer zones

The guidance document provides an overview of relevant principles and approaches for the planning, implementation, and monitoring of riparian buffer zones as a key NbS along rivers

⁴⁶ International Union for the Conservation of Nature (IUCN). (2020a). IUCN Global Standard for Nature-based Solutions: A user-friendly framework for the verification, design and scaling up of Nature-based Solutions (1st ed.). IUCN.

<https://doi.org/10.2305/IUCN.CH.2020.08.en>

⁴⁷ International Union for the Conservation of Nature (IUCN). (2020a). IUCN Global Standard for Nature-based Solutions: A user-friendly framework for the verification, design and scaling up of Nature-based Solutions (1st ed.). IUCN.

<https://doi.org/10.2305/IUCN.CH.2020.08.en>

⁴⁸ IUCN (2021). *Nature-based Solutions for Climate: A Compendium of Best Practices in the Western Balkans*. Gland, Switzerland: International Union for Conservation of Nature (IUCN). https://iucn.org/sites/default/files/2023-12/nbs-compendium-western-balkans_finale.pdf

⁴⁹ IUCN (2020). *Nature-based Solutions in the Post-2020 Global Biodiversity Framework Targets*. Gland, Switzerland: International Union for Conservation of Nature (IUCN). <https://iucn.org/sites/default/files/2022-11/nbs-in-gbf-targets-brief-november-2022.pdf>

⁵⁰ Convention on Biological Diversity (CBD). (2022). Kunming-Montreal Global Biodiversity Framework. CBD COP15, Montreal.

and floodplains in the WB6. While the main concepts and methodological foundations are described in the respective chapter of this summary report, the detailed guidance and concrete steps are addressed in depth and in the dedicated EU4Green deliverable.

Catalogue of NbS for Water Management in the Eastern Partnership Countries⁵¹

This catalogue provides a comprehensive overview of 34 NbS relevant to water management at the river basin scale, with applicability also to the WB6. Each factsheet combines documented case studies, technical references and indicative cost information, supporting informed decision-making by practitioners, authorities and planners. Within EU4Green Biodiversity activities, a targeted selection of these NbS forms the analytical basis for defining NbS objectives and measures in the five pilot study areas.

Voluntary Guidelines for the design and effective implementation of ecosystem-based approaches to climate change adaptation and disaster risk reduction and supplementary information⁵²

The CBD voluntary guidelines provide support to governments, organisations, and communities for designing and implementing ecosystem-based approaches to climate change adaptation and ecosystem-based disaster risk reduction. It emphasizes the use of biodiversity and ecosystem services as sustainable, cost-effective, and inclusive strategies to reduce vulnerability to climate hazards while enhancing human and ecological resilience. The guidelines outline principles and practical steps for embedding NbS into policies and projects, highlighting co-benefits such as improved livelihoods, food security, and cultural values. Supplementary case studies and tools illustrate how ecosystem restoration, conservation, and sustainable management can function as NbS that simultaneously address climate risks, safeguard biodiversity, and support long-term development goals.

⁵¹ EU4Environment – Water Resources and Environmental Data. (2024). Catalogue of Nature-based Solutions for the water sector in the Eastern Partnership countries (Sept. 2024, Version Final). EU4Environment. [Water Resources and Environmental data](#)

⁵² Secretariat of the Convention on Biological Diversity (2019). Voluntary guidelines for the design and effective implementation of ecosystem-based approaches to climate change adaptation and disaster risk reduction and supplementary information. Technical Series No. 93. Montreal, 156 pages.

4.3. Material and methods

4.3.1. Literature research

As basis for all further activities, the first step consisted of screening the literature. In combination with expert's knowledge, the aim was to get an overview of the most relevant NbS for societal challenges typically related to floodplains and other riparian ecosystems. As main references for this preliminary work, the CICES nomenclature⁵³ on ecosystem services was used together with the systematic review on ecosystem services of Grima et al.⁵⁴. Within EU4Green, we created a first selection by linking the relevant societal challenges with the corresponding NbS and suggested indicators.

4.3.2. Workshops with local experts

Together with the biodiversity experts of each pilot region, who were already involved in a close cooperation for the assessment of the Natura 2000 features, a participative workshop on NbS was held. The workshop started with a theoretical part, giving input on definitions and examples of SC & NbS. In the following participative working sessions, the plenum of experts was consulted on their estimations of the regional and local circumstances of each study area. With their active involvement, questionnaires on currently pressing SC and potential NbS for the areas were filled out to complement the preselected list of key challenges and potential measures. Each assessment was followed by a prioritization of the elaborated SC and NbS lists for each pilot area.

The ranked collection was evaluated and constituted the final selection of SC & NbS for the subsequent outputs, such as the NbS Matrix and the guidance document on NbS.

4.3.3. NbS-Matrix

The NbS-Matrix was compiled as key output subsequently to the expert workshop, combining the outputs of the participative session with further findings from literature. The resulting list was then extended by linking ecosystem services and suitable indicators according to Grima et al.⁵⁵.

As additional information, the ranked priority for societal challenges and NbS in each economy was integrated as well. Since data availability is a significant issue for the WB6, valuable information of existing data sources was added.

⁵³ Haines-Young, R. (2023): Common International Classification of Ecosystem Services (CICES) V5.2 and Guidance on the Application of the Revised Structure.

⁵⁴ Grima, N., Jutras-Perreault, M. C., Gobakken, T., Ørka, H. O., & Vacik, H. (2023). Systematic review for a set of indicators supporting the Common International Classification of Ecosystem Services. *Ecological Indicators*, 147, 109978.

⁵⁵ Grima, N., Jutras-Perreault, M. C., Gobakken, T., Ørka, H. O., & Vacik, H. (2023). Systematic review for a set of indicators supporting the Common International Classification of Ecosystem Services. *Ecological Indicators*, 147, 109978.

4.3.4. NbS objectives

Study area

The selection of the case study sites was primarily guided by the explicit interest of the beneficiary in the development of NbS objectives for EU4Green's pilot site, Mavrovo National Park, which highlighted a demand to explore NbS as a tool to address local challenges and support alignment with EU standards. The choice also reflected each economy's progress in implementing the GAWB and built on earlier work of EU4Green on Natura 2000 preparation.

For the analyses, the study area mapped for Natura 2000 features was extended by a 2.5 km buffer. This scope was chosen to capture the most relevant surrounding landscape and integrate additional data beyond the core Natura 2000 assessments.

Data basis

To identify suitable NbS measures for the pilot region, core datasets from the EU4Green project were combined with selected external sources to provide a robust data basis for regional decision-making. The analysis relied largely on harmonised remote-sensing data available for the entire WB6, including data from CLC+ Backbone^{56,57} and Copernicus DEM⁵⁸, meaning that the resulting maps indicate priority areas for action and may include generalisations or artefacts inherent to the spatial resolution and thematic limits of the datasets.

Key inputs for the further analysis included Natura 2000 habitat assessments from EU4Green (chapter Error: Reference source not found), which document Annex I habitat types and other relevant land cover classes within the core study areas, complemented by additional data for the surrounding landscape. Land cover information was derived from the CLC+ Backbone raster (2023, 10 m resolution) and vector dataset (2018, MMU 0.5 ha), providing detailed and up-to-date insights into land cover patterns and dynamics. Topographic information was taken from the Copernicus DEM GLO-30 and processed into contour lines to support the identification of flood- and water-related NbS action areas. OpenStreetMap data⁵⁹ were used to supplement small and linear watercourses not fully captured in CLC+ datasets, due to their relatively rough resolution.

The selection of measures was further informed by the Catalogue of Nature-based Solutions for the water sector⁶⁰. Table 11 shows the measures for the NbS objectives within the case

⁵⁶ European Environment Agency & Copernicus Land Monitoring Service. (2018). CLC+ Backbone 2018 – Vector dataset. European Union. DOI: <https://doi.org/10.2909/d45d5114-fb86-4265-9c5a-a7225a511f7c>

⁵⁷ European Environment Agency; Copernicus Land Monitoring Service. (2025). CLCplus Backbone 2023 (Raster, 10 m). European Union. DOI: <https://doi.org/10.2909/b0bd43c6-1fa1-4d88-9c45-98b13a95d0b2>

⁵⁸ European Space Agency & European Commission (2022). Copernicus Digital Elevation Model (DEM) for Europea with a resolution of 30 m, derived from Copernicus Global 30 m data set. <http://data.europa.eu/88u/dataset/f576cda8-d598-478c-b8fe-ad2634c927e8>

⁵⁹ OpenStreetMap contributors. (2024). OpenStreetMap data on streams and rivers. OpenStreetMap Foundation. <https://www.openstreetmap.org>

⁶⁰ EU4Environment – Water Resources and Environmental Data. (2024). Catalogue of Nature-based Solutions for the water sector in the Eastern Partnership countries (Sept. 2024, Version Final). EU4Environment. [Water Resources and Environmental Catalogue of Nature](#)

study area, according to the NbS catalogue. As another output developed during the EU4Green project, the NbS matrix (Annex VI) synthesises expert input from workshops and literature, linking societal challenges to suitable NbS, ecosystem services and potential indicators. It provides additional options beyond those mapped in this document.

Table 11: Selection of NbS for water management, according to the Catalogue of NbS by EU4Environment (2024), listed by main land cover categories found in the study areas.

Main Category	NbS Measures
<i>Rivers, streams, and floodplains</i>	Restoration of buffer strips, riparian forest and gallery forest Floodplain restoration and management Natural bank stabilisation Stream and river restoration Reconnection of oxbow lakes Removal of lateral barriers Removal of transversal barriers
<i>Agriculture and grasslands</i>	Agroforestry, buffer strips and hedges Conservation agriculture Conversion to meadows and pastures Restoration of existing pastures, steppes and natural grasslands Sustainable pasture management
<i>Forests and woodlands</i>	Adapted forestry in floodplains and wet forests Afforestation Close-to-nature forestry Coarse woody debris in rivers and streams
<i>Settlements and built-up areas</i>	Permeable surfaces
<i>Cross-cutting measures</i>	Conservation of existing high environmental value ecosystems

Definition of NbS objectives and measures

The identification of action zones in the study areas followed a systematic, data-driven approach combining ecological information, spatial analyses and remote-sensing data. Natura 2000 habitat assessments and CLC+ Backbone land-cover data formed the baseline for defining the ecological context, while Copernicus DEM data were used to capture terrain characteristics such as slope, hydrological pathways and flood-prone areas. Additional spatial parameters, including buffer zones and distance analyses, helped prioritise areas with high pressure, degradation risk or potential for improved ecological connectivity.

Based on these spatial characteristics, suitable NbS were assigned to each area, ensuring that proposed measures directly address site-specific ecological and socio-environmental challenges. This process resulted in 10 recommended NbS objectives, structured across five

fields of action and linked to spatial layers and 18 concrete NbS measures. The framework enables clear visualisation of priority areas and provides a solid basis for future implementation planning (see Table 12Table 12).

The five fields of action cover the following land-use and ecosystem categories: sustainable agricultural landscapes, forests and wooded ecosystems, riparian ecosystem restoration, protection of high-value ecosystems and soil desealing.

Table 12: Fields of action linked to the respective NbS Objectives, specific measures for realisation and land cover type with the used criteria.

Field of action	NbS Objective	NbS measure (according to EU4Environment, 2024)	Land cover type & criteria
Sustainable agricultural landscapes	1) Enhancement and restructuring of homogenised, agricultural landscapes	Agroforestry, buffer strips and hedges	Large coherent farmland and grassland with > 100m distance from the next landscape element (e.g. forest) below an altitude of 1500m
	2) Conservation agriculture	Conservation agriculture	All agricultural areas
	3) Grassland conversion, restoration & sustainable use	Conversion to meadows and pastures Restoration of existing pastures, steppes and natural grasslands Sustainable pasture management	All grassland
Forests and wooded ecosystem	4) Ecological forest management	Adapted forestry in floodplains and wet forests Close-to-nature forestry	All forests of the catchment area in proximity to the river
	5) Expanding forest cover	Afforestation	Open land with moderate to steep slopes below an altitude of 1500m
Riparian ecosystem restoration	6) Restoring aquatic habitat structures	Coarse woody debris in rivers and streams	Forests within 50m proximity to the river, below an altitude of 1500m
	7) Revitalising floodplains and riparian buffer zones	Floodplain restoration and management Restoration of buffer strips, riparian forest and gallery forest	Forests and open land on gentle slopes within 100m proximity to the river
	8) Restoring river dynamics and connectivity	Natural bank stabilization Reconnection of oxbow lakes Removal of lateral barriers Removal of transversal barriers Stream and river restoration	Water courses buffered with 25m
Protection	9) Protection of high-value ecosystems	Conservation of existing high	Assessed annex I habitat types

tion of high-value ecosystems	environmental value ecosystems	
Soil desealing	10) Sustainable built-up areas Permeable surfaces	Sealed or built-up surfaces > 500m ²

Stakeholder involvement

To ensure the practicality and local relevance of the proposed NbS objectives and measures, regional stakeholders were consulted during the development process. Their input was crucial for validating the results on-site conditions and assessing the feasibility and compatibility of the proposed measures with existing land-use and conservation frameworks. For the Mavrovo National Park study area in North Macedonia, the experts of the non-governmental organisation Eko-svest, with an intensive working focus on the Radika river valley provided their site-specific expertise on environmental conditions, land ownership as well as management constraints and opportunities, through email exchanges.

The involvement of the colleagues in Eko-svest allowed feedback and clarifications regarding the given document on NbS objectives and site-specific conditions.

4.3.5. Software

Geo data compilation and spatial analysis was done in QGIS⁶¹.

⁶¹ QGIS Development Team. (2025). QGIS Geographic Information System (Version 3.40). QGIS Association. <https://www.qgis.org>

4.4. Results and discussion

4.4.1. NbS matrix

The NbS matrix represents the condensed output of the literature review, expert workshops and questionnaires as well as data acquisition process carried out within the project. It provides a structured overview linking societal challenges (SC) identified in the study areas with potential NbS, their associated ecosystem services (ES), suitable indicators, and exemplary data sources. The matrix thus serves as an integrative tool to connect pressures, responses and measurable outcomes in a transparent and comparable manner.

For North Macedonia, societal challenges were identified and ranked based on expert input, reflecting their relative importance at the regional level. Corresponding NbS measures were then assigned to each challenge and flagged as NbS or non-NbS based on expert judgement and alignment with established NbS definitions. Where applicable, an NbS ranking was included to reflect the perceived relevance or effectiveness of the measure in addressing the specific challenge.

The matrix further links each NbS to relevant ecosystem services, such as biodiversity conservation or enhancement, and proposes potential indicators (e.g. number of species, α -/ β -diversity) to support monitoring and evaluation. Exemplary data sources, including zoological and botanical surveys, are referenced to indicate how these indicators could be operationalised in practice.

The full NbS matrix, including detailed rankings and data references, is provided in Annex VI.

4.4.2. Guidance document on NbS

The elaborated Guidance document on NbS: riparian buffer zones focused on an impactful and highly relevant NbS for floodplains within the Western Balkan pilot sites. Riparian buffer zones represent a powerful NbS to address pressing environmental and societal challenges associated with floodplains. As linear habitat structures along rivers and floodplains, they provide multiple benefits: reducing flood risk, improving water quality, conserving biodiversity, and enhancing ecosystem services for local communities.

The key elements covered in the guidance document encompass:

- An overview of the concept and benefits of NbS, aligned with international standards.
- Practical guidance on the design, management, and integration of riparian buffer zones into broader conservation and land-use strategies.
- A focus on indicators and monitoring approaches that enable administrations to track effectiveness, adapt management, and demonstrate outcomes.
- A designated chapter by Green Finance experts that outlines potential finance and funding opportunities available for NbS projects in the WB6.

While the proposed NbS offer significant opportunities, implementation in the region still faces barriers such as limited data availability, financial constraints, fragmented governance, and competing land-use interests. Addressing these challenges requires cross-sectoral cooperation, long-term commitment, and investment in knowledge and capacity building.

For protected area administrations, this guidance provides a practical tool to strengthen floodplain resilience, enhance biodiversity conservation, and contribute to EU environmental objectives. By adopting evidence-based and participatory approaches, administrations can ensure that riparian buffer zones deliver sustainable, multifunctional benefits for both people and nature.

4.4.3. NbS objectives

The NbS objectives and recommended measures for floodplain landscapes are based on the Catalogue of NbS for Water Management in the Eastern Partnership Countries⁶². Together, they address key pressures on floodplain ecosystems while delivering multiple co-benefits for biodiversity, water management and climate resilience. Across all objectives, early and continuous involvement of relevant stakeholders is essential for successful implementation.

In the following, the five broader **fields of action** and their ten *objectives* are elaborated, each comprising specific **NbS measures**.

Sustainable agricultural landscapes



Objective 1 – Enhancement of homogenised agricultural landscapes

This objective addresses structurally poor agricultural landscapes lacking natural elements and habitats. Measures such as **agroforestry systems, hedges and buffer strips** introduce woody and linear landscape features into farmland and adjacent infrastructure. These measures reduce surface runoff and wind erosion, improve soil water infiltration and retention, and provide habitats for a wide range of species, including pollinators and natural pest controllers, but also serve as vital migration corridors through the most intensive parts of the agricultural landscapes.



Objective 2 – Conservation agriculture

Conservation agriculture aims to improve soil health, biodiversity and ecosystem services through reduced soil disturbance, permanent soil cover and diversified crop rotations. Practices such as no- or low-till cultivation, strip cropping, early sowing and crop diversification enhance biological processes above and below ground, increase water and nutrient efficiency and support stable long-term production. While implemented at farm

⁶² EU4Environment – Water Resources and Environmental Data. (2024). Catalogue of Nature-based Solutions for the water sector in the Eastern Partnership countries (Sept. 2024, Version Final). EU4Environment. [Water Resources and Environmental Data](#)

scale, the impacts must be assessed at watershed scale to effectively mitigate environmental pressures.

Objective 3 – Grassland conversion, restoration and sustainable use

This objective targets the loss and degradation of grasslands caused by abandonment or intensification. Measures include **converting arable land back to meadows or pastures**, **restoring degraded grasslands** through seed transfer from species-rich sites, and applying sustainable grazing or mowing regimes. These practices enhance biodiversity, carbon sequestration and ecosystem resilience while maintaining forage production.

Forests and wooded ecosystems

Objective 4 – Ecological forest management

Adapted forest management in floodplains and wet forests aims to maintain riparian forest integrity and ecosystem services. Measures include rewetting, filling drainage ditches, limiting grazing and restricting wood extraction. As another effective NbS, **close-to-nature forestry** under the umbrella of Sustainable Forest Management can be mentioned. It promotes natural structures, diverse tree species and age classes, and key habitat features such as deadwood and veteran trees.

Objective 5 – Expanding forest cover

Afforestation and reforestation restore forest cover on degraded or deforested land using native species. Implementation can follow natural succession or active planting and includes approaches such as agroforestry. These measures enhance connectivity, carbon storage and climate resilience.

Riparian ecosystem restoration

Objective 6 – Restoring aquatic habitat structures

The reintroduction of **coarse woody debris** into rivers and streams moderates flow velocity, increases local water levels and creates diverse aquatic habitats. When carefully designed, these measures contribute to the mitigation of floods and erosion and the enhancement of biodiversity without compromising river stability or species migration.

Objective 7 – Revitalising floodplains and riparian buffer zones

Floodplain restoration and the **establishment of riparian buffer zones** restore natural river dynamics and create space for flooding and sediment processes. These measures improve water retention, reduce flood and drought risks, filter pollutants and excess nutrients from agricultural runoff, and enhance habitat diversity. Buffer width varies depending on site-specific conditions.

Objective 8 – Restoring river dynamics and connectivity

This objective focuses on **stream and river restoration**, implementing NbS like reconnecting rivers with their floodplains and side channels by removing or modifying lateral and transversal barriers. Measures include **reconnecting oxbow lakes**, **removing dams or weirs**, **dismantling bank reinforcements** and applying **natural bank stabilisation** techniques to restore sediment transport, flow diversity and habitat connectivity.

Protection of high-value ecosystems

Objective 9 – Protection of high-value ecosystems

This objective supports the **conservation and improvement of existing Annex I habitat types** and other high-value ecosystems identified in Natura 2000 assessments within the study area during the project's course. Site-specific, long-term management is essential to maintain favourable conservation status and safeguard ecosystem functions such as water purification, biodiversity support and climate regulation.

Soil desealing and built-up areas

Objective 10 – Sustainable built-up areas

Permeable and porous surfaces replace sealed areas in urban and rural settings, allowing rainwater infiltration, groundwater recharge and controlled runoff. These measures are applicable to roads, farmyards and urban spaces and require regular maintenance to ensure long-term functionality.

4.4.4. Maps of the NbS objectives and measures

Based on the spatial analysis of the study area and the feedback obtained through stakeholder involvement, concrete areas of action could be delineated for each of the 10 NbS objectives. The professional input provided by Eko-svest was systematically integrated into the results, ensuring that site-specific ecological conditions, management priorities and constraints were adequately reflected in the interpretation of the findings.

The following figures present a series of maps illustrating the spatial distribution of the identified areas of action and their corresponding NbS objectives. These maps represent a synthesis of geospatial analyses and expert validation and are intended to support orientation and future planning rather than prescribe fixed interventions.

The comments and input from the experts of Eko-svest were used to adjust and refine the proposed action zones by considering existing challenges, anthropogenic pressures and priority areas as well as other ecological or administrative constraints. This ensures that the mapped NbS objectives are consistent with the current situation of the Radika river valley and provide a realistic, implementation-oriented basis for further prioritization and discussion.

Land cover types

As shown in Figure 16, the studied area is predominantly covered by broad-leaved forests (light-green) in lower altitudes (eastern part) as well as a few coniferous forests (dark green) in the higher altitudes (northern part). Above the tree line, alpine heaths and meadows predominantly occur in the study area. Within the mostly forest areas, some larger and smaller patches of open land can also be found, mostly consisting of different grassland types (olive-green) and a hand full of agriculturally used areas (yellow). Along the valley in proximity to the Radika River and its numerous tributaries, several small villages are located. The largest one of them – Dolno Kosovrasti – is downstream in the very south of the study area, next to a mining site.

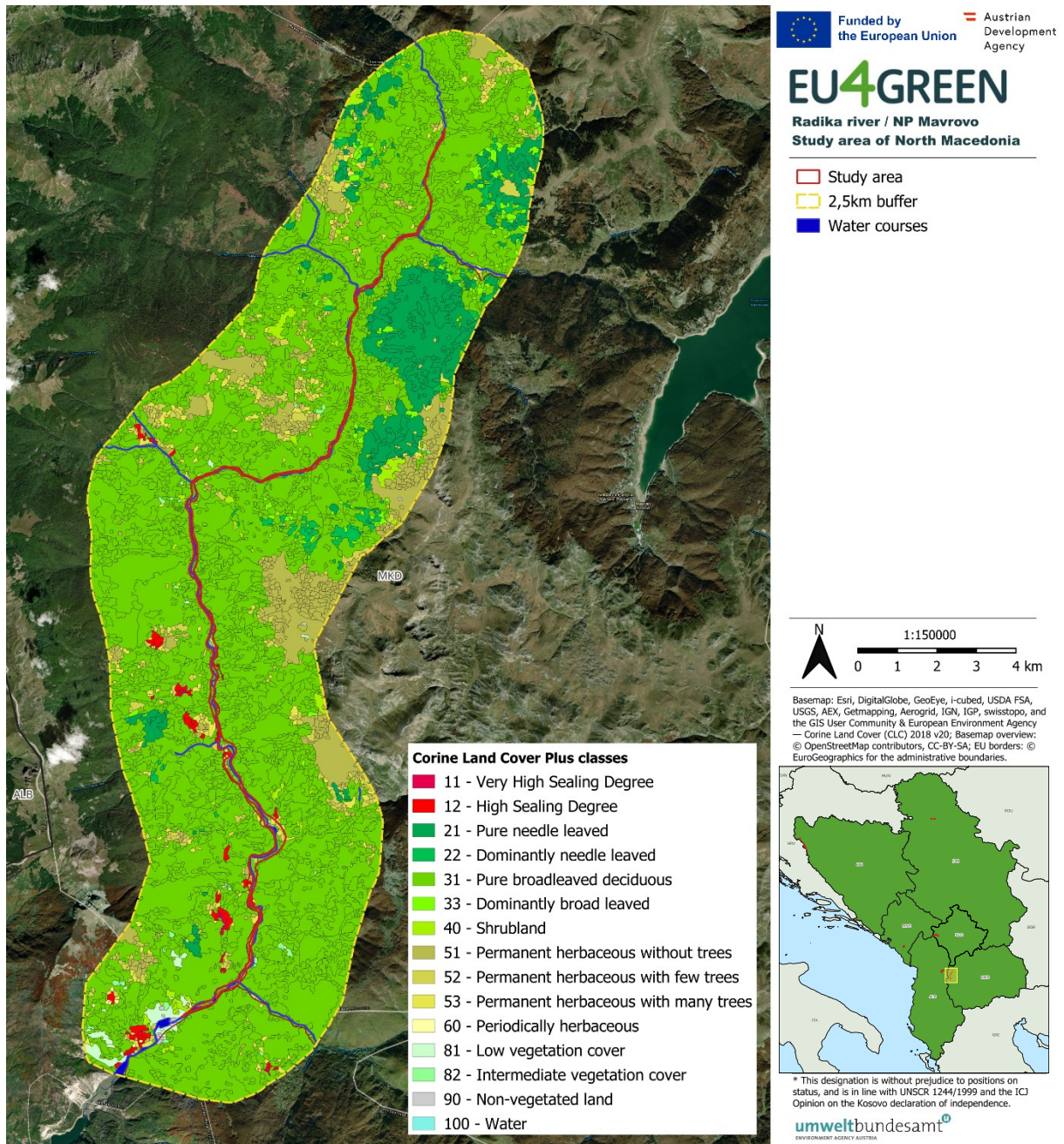


Figure 16: Land cover types according to the CLC+ Backbone raster (2023, 10 m resolution) and vector dataset (2018, MMU 0.5 ha) datasets in the Mavrovo National Park study area, North Macedonia.

Sustainable agricultural landscape

Given the limited extent of farmland within the study area and the generally small parcel structure, measures aimed at restructuring large homogeneous agricultural patches or implementing conservation agriculture are not considered as primary objectives. As illustrated in Figure 17, the majority of open agricultural land is dominated by grassland, including extensive alpine meadows and pastures above 1500 m. Where appropriate, efforts should therefore focus on promoting sustainable grassland management practices and supporting the restoration of abandoned or degraded meadows and pastures to enhance ecological value and maintain traditional land use.

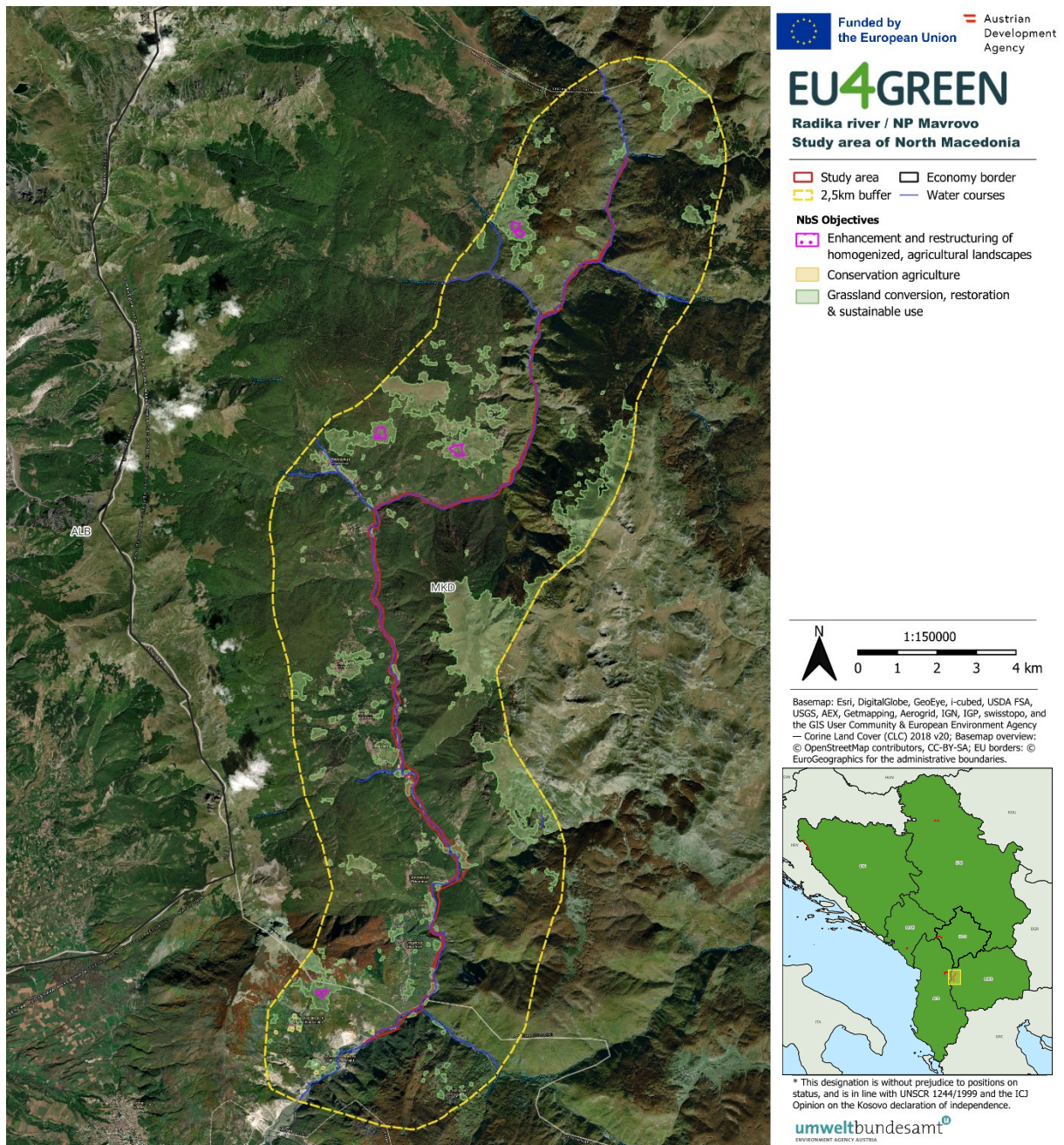


Figure 17: The NbS objectives for the field of action “Sustainable agricultural landscapes” in the Mavrovo National Park study area, North Macedonia.

Forests and wooded ecosystems

The study area along the Radika River is dominated by broad-leaved and coniferous forests. Where feasible, given the steep terrain, ecological and site-adapted forest management is recommended, especially for forest stands adjacent to the river network. Priority areas for afforestation and close-to-nature forestry are located within the catchments of key tributaries as well as along the middle and upper sections of the Radika River itself (Figure 18). Potential target sites include areas near the villages of Janche, close to the Galicka River tributary, and Dolno Kosovrasti, both located in the south of the study area.

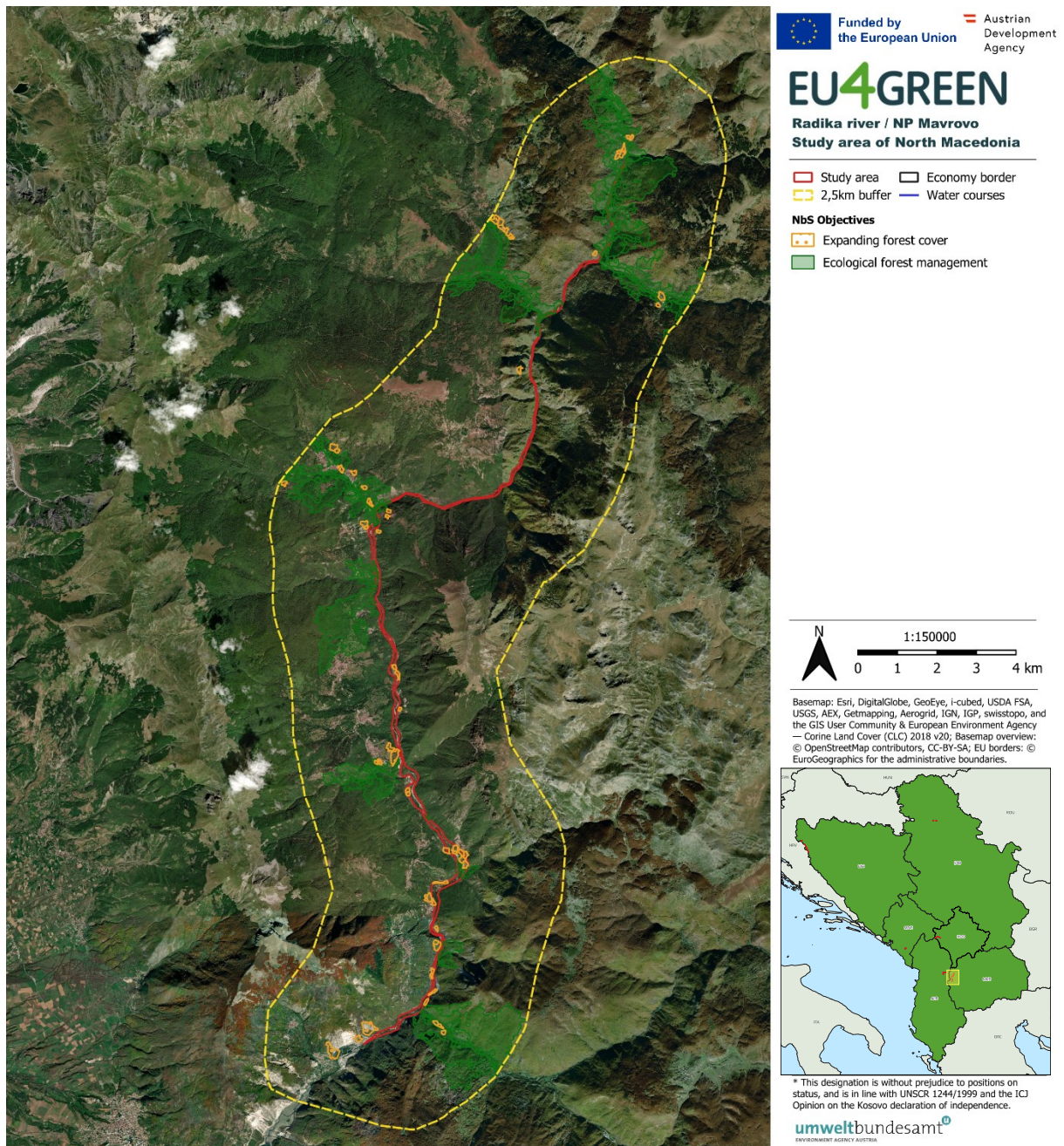


Figure 18: The NbS objectives for the field of action “Forests and wooded ecosystems” in the Mavrovo National Park study area, North Macedonia.

Riparian ecosystems restoration

Given the predominantly steep and largely forested terrain of the Radika River valley, together with the limited extent of wider floodplain areas, the most suitable objectives focus on improving aquatic habitat quality, restoring longitudinal and transversal river connectivity and strengthening riparian integrity (Figure 19). Large-scale floodplain reconnection is geomorphologically unrealistic along most of the river's sections; therefore, floodplain restoration measures should be limited to local valley widenings, such as near Dolno Kosovrasti, where targeted management of floodplain morphology and the promotion of native vegetation have the highest impact regarding the enhancement of natural retention and flood mitigation.

In narrow and fast-flowing reaches, appropriate NbS measures include the enhancement of habitat structures in the stream, for example through the introduction of coarse woody debris. Such interventions increase habitat heterogeneity, provide refugia for aquatic organisms, and diversify flow patterns. In addition, riparian restoration and nature-based riverbank stabilisation are particularly relevant along sections adjacent to settlements and road infrastructure, helping to reduce erosion and improve water quality.

NbS implementation should remain concentrated on priority rivers and tributaries to ensure effectiveness. Accordingly, near-term pilot interventions are recommended in the most affected tributaries, especially the Adzina River as well as the Brodecka, Bogdevska, and the Mala Reka system. Further priority actions include measures supporting the enforcement of ecological flows, particularly in reaches impacted by water abstraction linked to the Shara Waters and Mavrovo hydropower systems, where reduced or dry riverbeds have been observed.

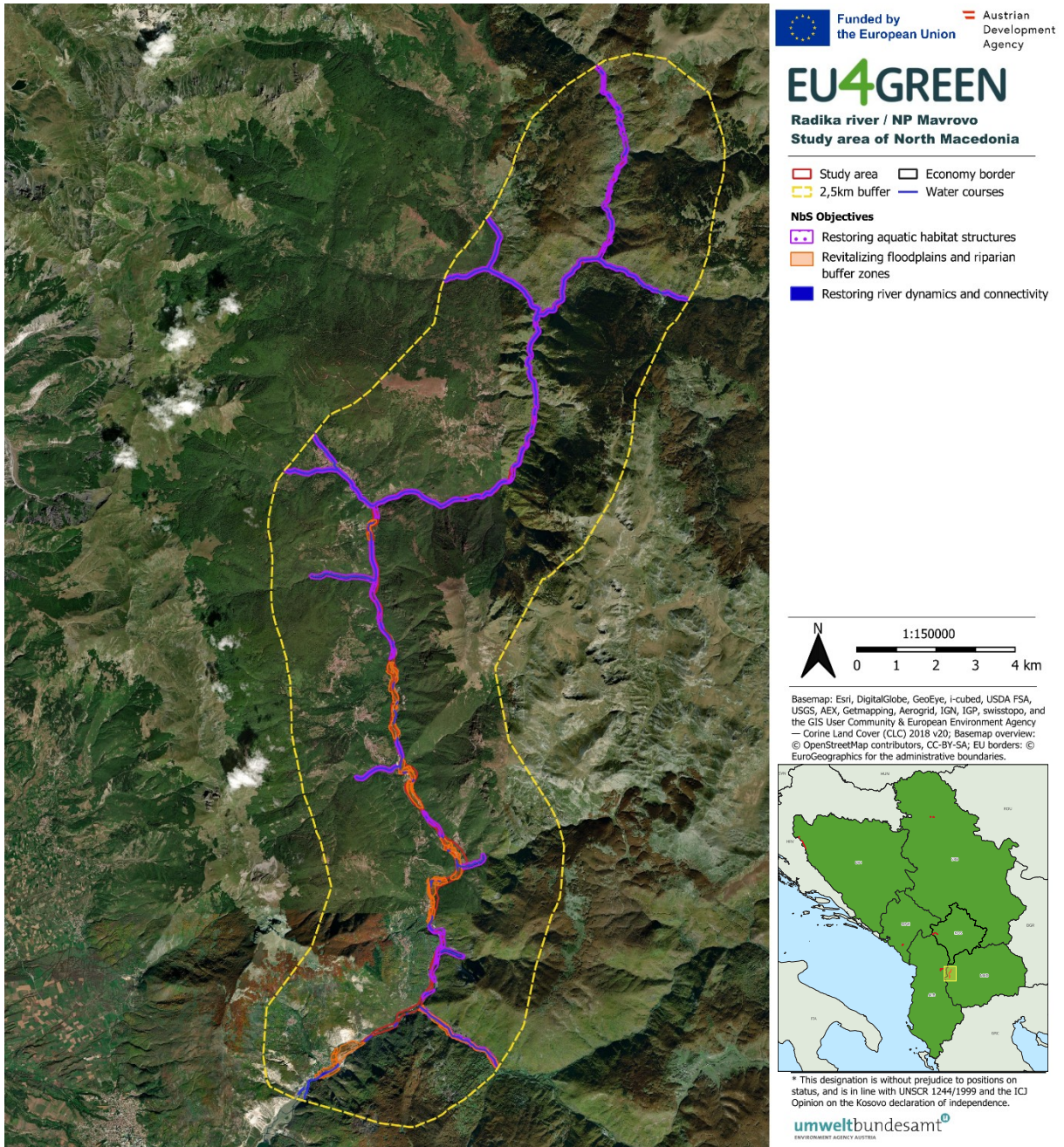


Figure 19: The NbS objectives for the field of action “Riparian ecosystems restoration” in the Mavrovo National Park study area, North Macedonia.

Protection of high-value ecosystems

In the area of the Radika River, the majority of Natura 2000 habitat types consists of forests, such as riparian forest ('91E0 Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior*' and '92A0 *Salix alba* and *Populus alba* galleries') but also forest types less associated with the river dynamic ('9270 Hellenic beech forests with *Abies borisii-regis*', '9410 Acidophilous *Picea* forests of the montane to alpine levels' or '91AA Eastern white oak woods') (Figure 20). Smaller and narrower strips of riparian vegetation located at the riverbanks of Radika River ('3240 Alpine rivers and their ligneous vegetation with *Salix elaeagnos*' and '3220 Alpine rivers and the herbaceous vegetation along their banks' could be identified as well. Besides some few sites with '6540 Sub-Mediterranean grasslands of the *Molinio-Hordeion secalini*', several habitat types of scree and rocky slopes exist in the valley (8110, 8140, 8210, 8220).

The diverse habitat mosaic of the Radika River valley calls for targeted protection measures, in particular for its forest and riparian ecosystems. The emphasis should be laid on maintaining natural river dynamics and stabilising erosion-prone slopes along the main stream but also its tributaries. Priority measures include restoring riparian buffer zones, applying close-to-nature forest management and safeguarding sensitive scree and rocky slope habitats from disturbance. Natural riverbank restoration and improved connectivity should further enhance habitat quality for both aquatic and terrestrial biodiversity. Effective implementation will require close coordination with the Mavrovo National Park administration and local stakeholders to ensure long-term conservation success.

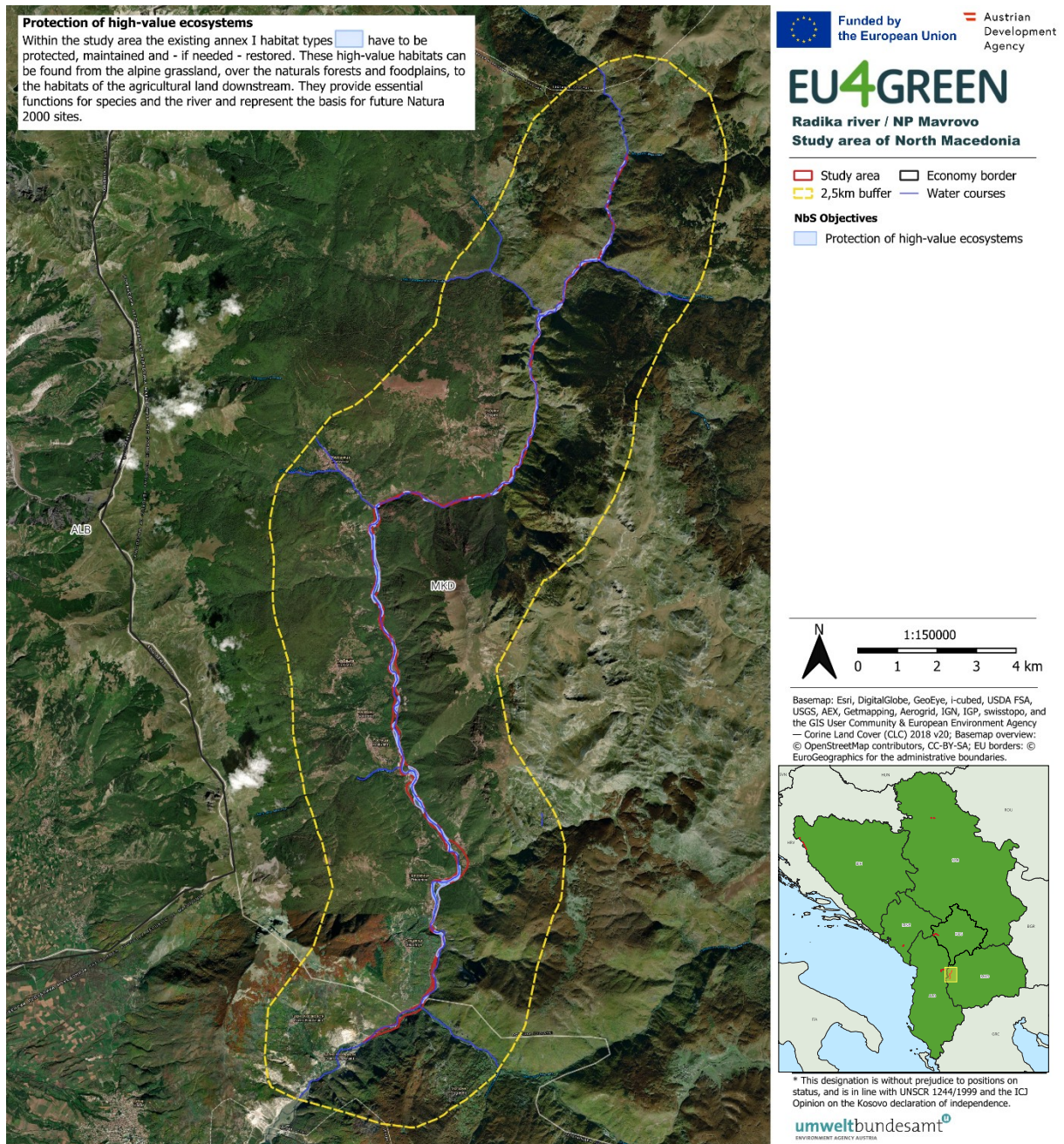


Figure 20: The NbS objectives for the field of action “Protection of high-value ecosystems” in the Mavrovo National Park study area, North Macedonia.

Soil desealing

As shown in Figure 21, potential areas for implementing permeable surfaces and enhancing water retention are primarily located in the southern half of the study area, where most settlements are concentrated. In addition, the main north-south road running along the river could be adapted using permeable or porous pavement concepts, complementing river bank stabilisation measures to mitigate the impacts of transport infrastructure.

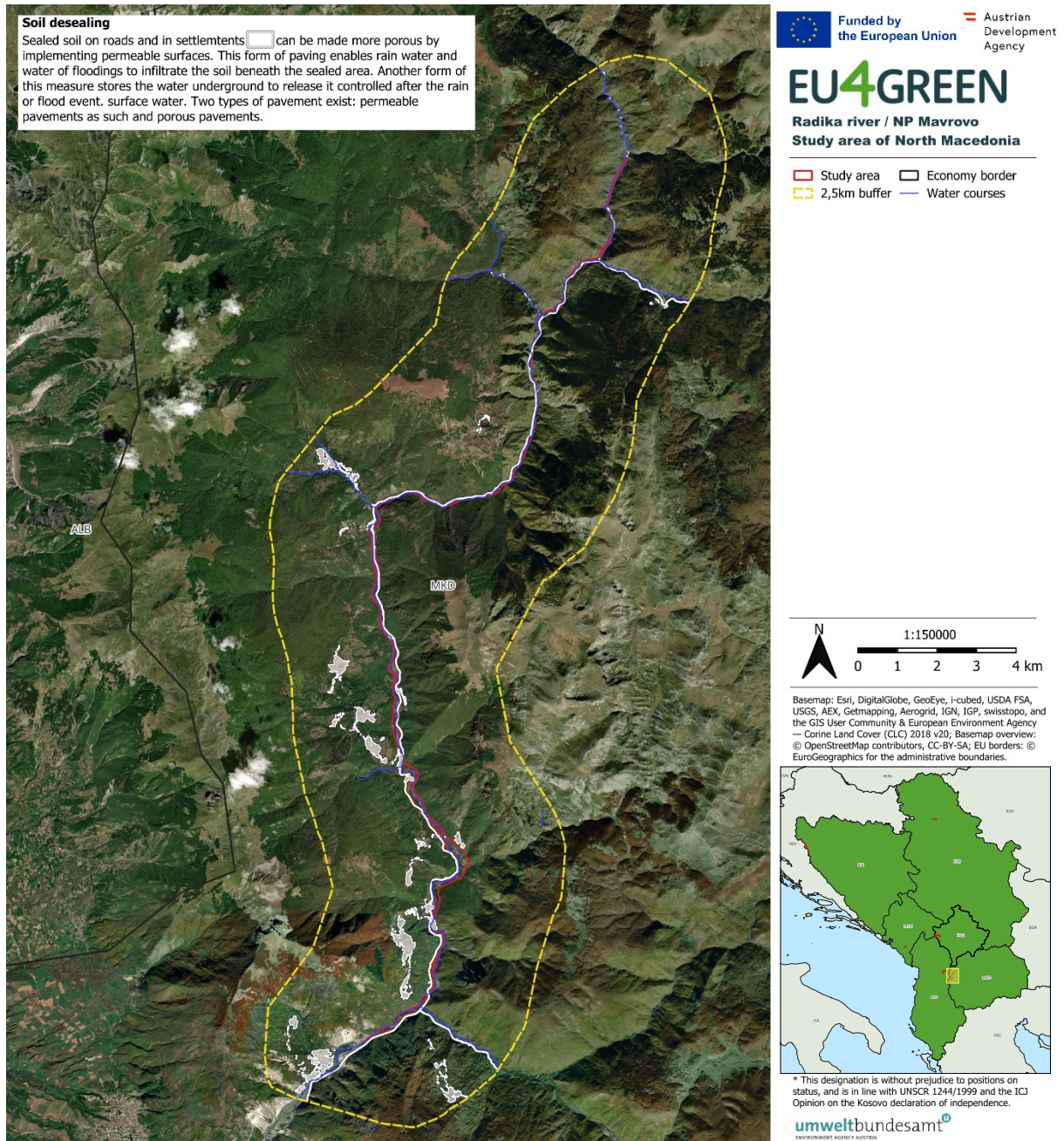


Figure 21: The NbS objectives for the field of action “Soil desealing” in the Mavrovo National Park study area, North Macedonia.

4.5. Conclusions

The development of NbS objectives and the guidance document on riparian buffer zones highlighted both the opportunities for various fields of action and also constraints of applying NbS in the study area of North Macedonia. While the availability of harmonised geospatial datasets enabled a consistent analysis across ecosystems, limitations in site-specific data – particularly on land ownership, silvicultural practices and detailed management regimes, but also a higher thematical resolution of the habitat types beyond the core study area of the project – remain a key challenge for implementation-oriented planning. These gaps underline the need for complementary field assessments and locally maintained databases to refine priorities and measures.

The main challenges for NbS implementation relate to water abstraction, river dysregulation and mismanagement of forests as well as fragmentation through infrastructure. Accordingly, future efforts should prioritise forest management and restoration as well as the restoration of river continuity and connectivity, the enrichment of aquatic structures and the prevention of erosion with nature-based approaches, and ecologically adapted forestry in floodplain, riparian forests and the rivers' catchments. These measures offer high potential to enhance biodiversity, water quality and flood resilience while delivering additional ecosystem services.

Effective implementation will depend on strong partnerships and participatory governance. Mavrovo National Park authorities play a central role as coordinators and facilitators, but successful NbS deployment also requires early involvement of municipalities, landowners, farmers and the wider public. On a higher political level, decision-makers need to be brought on board, and awareness needs to be raised. This is crucial for the mobilisation of financial resources and securing fundings on the short and long term. Strengthening cross-sectoral cooperation, clarifying land-use and ownership conditions, and embedding NbS into management plans and local development strategies will be essential next steps to translate the developed objectives and guidance into sustainable and effective practice and actions.

The project outputs, with their strong practical and implementation-oriented focus for the WB6 context, together with the wide range of international guidelines and standards on NbS, provide a well-founded basis for the future implementation of NbS measures in the Radika River valley.