Report on ecological connectivity assessment

Evaluations for the project area and transboundary pilot regions

Deliverable T1.3.1

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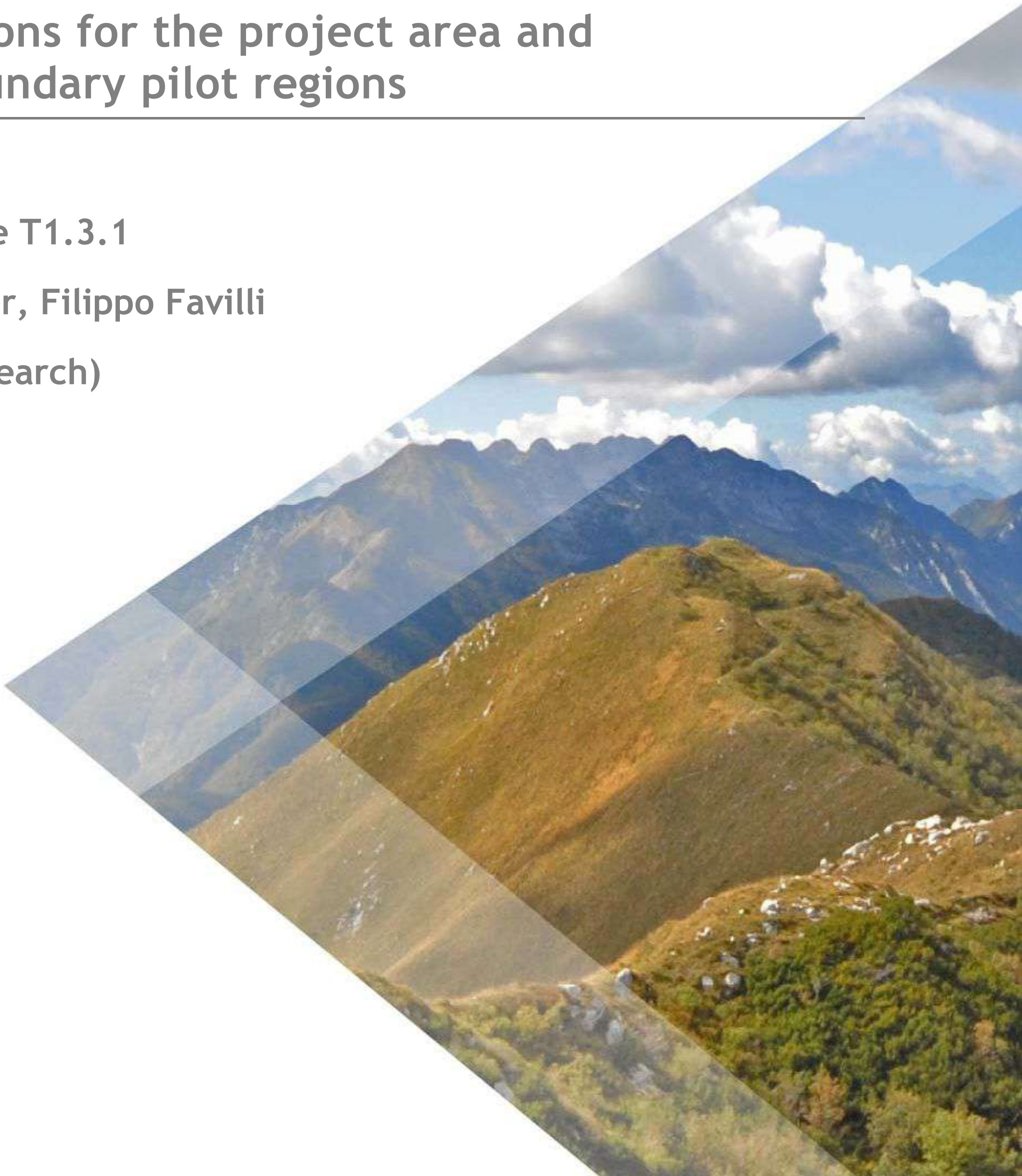
(Eurac Research)

May 2022



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Deliverable T1.3.1 Report on ecological connectivity assessment within the project area and in transboundary Pilot regions

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Acronyms

CSI	Continuum Suitability Index
EC	Ecological Connectivity
EU	European Union
PV	Photovoltaic
SACA	Strategic Connectivity Area

1 Introduction

Based on the GIS model for the permeability of the landscape in former activities of the DinAlpConnect project, an assessment of ecological connectivity was developed.

The main aim of this assessement is the identification of current priority areas and main barriers for ecological connectivity to describe the current state on ecological connectivity at the project area and the level of pilot regions.

This report presents firstly the most permeable and impeding landscape elements between the Alps and Dinaric mountains based on the criteria of the Continuum Suitability Index and gives interpretations for each country involved in chapter 3.1. The model allowes the definition of Strategic Connectivity Areas, which represent the most important ecological areas and intervention areas to establish ecological connectivity (EC), as well as the most important barriers that hinder EC. A mutual comparison of strategic connectivity areas and protected areas was made to assess connectivity within protected areas and most important ecological areas without protection status (chapter 3.2).

After selecting the current main EC priority areas (3.3.1), a more detailled analysis was done for the intervention areas by studying ecological linkages, which can build a complete ecological network (chapter 3.3.2). Based on regional ecological linkages, the assessment to maintain and improve ecological connectivity was carried out in chapter 3.4. The linkages were prioritized by evaluating the biological value, considering also threats and opportunities for the elaborated network. Furthermore, this report shows the results of the grassland analysis and spieces- based connectivity models in the transboundary pilot regions (chapter 4). These were fed into the workshops for the elaboration of pilot action plans for improved transboundary ecological connectivity.

The report concludes in chapter 5 with suggestions and first recommendations for the development of the strategy for EC in the Dinarides and between Alps and Dinaric mountains.

2 Macroregional project area

Figure 1: DinAlpConnect project area and pilot regions for spatial models

3 Identification of priority areas and main barriers at macro-regional level

3.1 Most evident permeable and impeding landscape elements revealed by the continuum suitability analysis

Italy:

Italy has a wide range of protected areas. Most of the high-altitude forests within the project area are in the Italian Alps.

In Italy, on one hand there is a lower human pressure on mountainous landscapes at high altitudes and therefore the main barrier for ecological connectivity in the Italian part of the project area can be the topography, due to the high and steep elevations. On the other hand, in the valley bottom between the Alps and the Adriatic Sea, population pressure and fragmentation of the landscape have a very high impact on the general permeability of landscapes.

Slovenia:

Protected areas in Slovenia are widely established and the topography is affecting ecological connectivity only in the north-western part of the country. Land use indicator has also good values for ecological connectivity in the western part of the country, while in the eastern part and around Ljubljana it appears to be not highly suitable for ecological connectivity.

Although Slovenia is very well protected, it is affected by a high population pressure and fragmentation in the lowlands.

Croatia:

Croatia has as well a well-established network of protected areas. In the Western part of the country, there is an expansive area with a north-south-extension, that provides a high permeability to this part of the country. This area runs parallel to the coastline and could potentially connect Slovenia with Bosnia & Herzagovina.

Population pressure, fragmentation values and anthropogenic land use reach high values in the eastern part of the country.

Bosnia & Herzegovina:

At the one hand, Bosnia & Herzegovina has a low population pressure in the western part of the country, at the border to Croatia. Compared to other countries of the project area, transport infrastructure in Bosnia & Herzegovina affects the ecological network only to a small extent, also due to their lower development. In this country, the topography does not seem to be among the main barriers for ecological connectivity.

At the other hand, the protection of natural areas is among the weakest of all countries within the DinAlpConnect project area. E.g., Ramsar sites are not yet established in Bosnia & Herzegovina. There is also a lack of data accuracy, completeness, and harmonisation of databases for protected areas.

The project "Working together for Natura" is investigating potential NATURA 2000 sites in Bosnia & Herzegovina. The results show an immense potential for protection (Fig. 2).

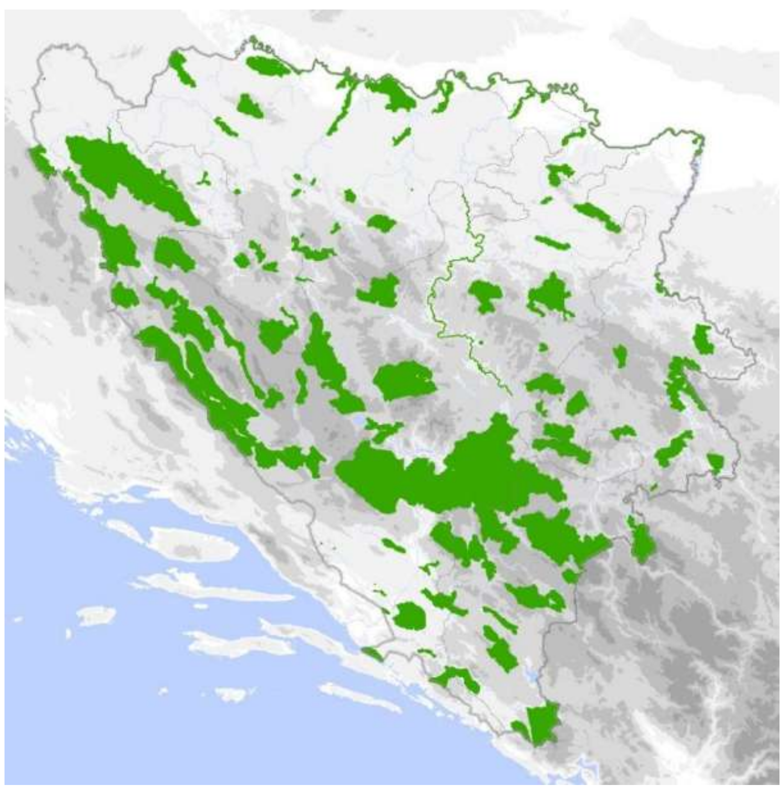


Figure 2: Selected potential NATURA 2000 sites in Bosnia & Herzegovina

Source: Working together for Natura

Montenegro:

High fragmentation indicator values are only present at the coastline. Montenegro has one of the best land use indicator values compared to other countries of the project area. It has a very small population pressure, and the topography seems to be only a barrier in some steep environments.

Nonetheless, environmental protection could be better established to a wider extent. Some natural areas identified as important habitats by the Emerald Network are not yet protected.

Albania:

It is noticeable that the suitable areas for ecological connectivity in Albania are concentrating on the eastern part of the country, with a low population pressure, low fragmentation values and good land use indicator values. Topography can be a barrier, but steep and high landscapes are rather small in comparison to the whole project area.

The biggest barriers are located at the coastline on the western part of the country, with a high population pressure, fragmenting transport infrastructure and unsuitable land use.

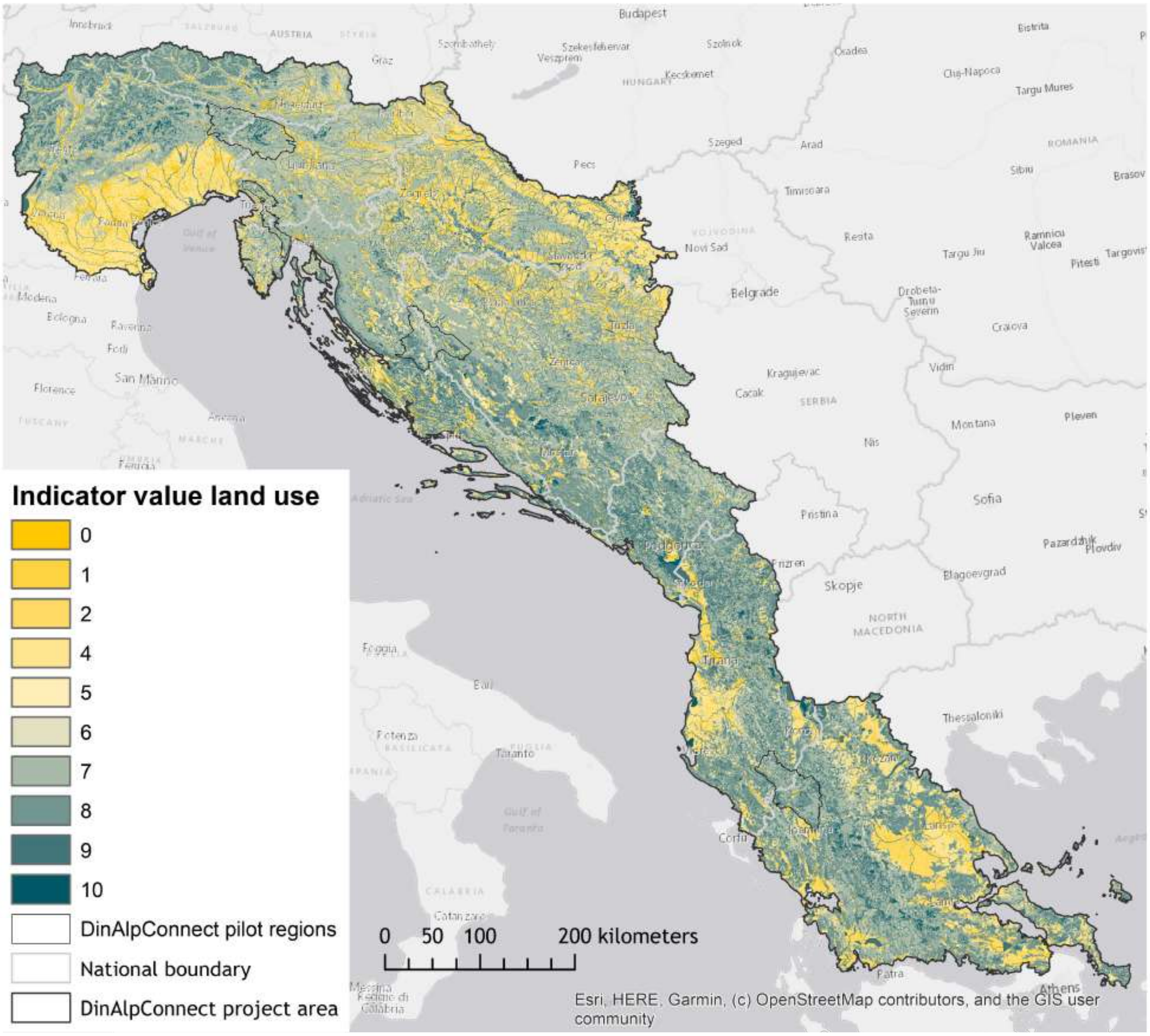
Greece:

Problematic high altitude and steep areas are present in the Pindos mountains, but they have rather a small extend. As part of the EU member states, Greece has a high amount and large extent of protected areas. Anthropogenic land use is present at the coastline to the Ionian Sea and the eastern part of the Greek project area from Lamia to Larisa up to Kozani, while the mountain range in the middle has better land use values for ecological connectivity.

According to the effective mesh density analysis, Greece has in general a rather high fragmented landscape.

The following maps are showing the landscape permeability form 0 (low permeability) to 10 (high permeability) for each of the five indicators and the combined Continuum Suitability Index.

Land use indicator (LAN)



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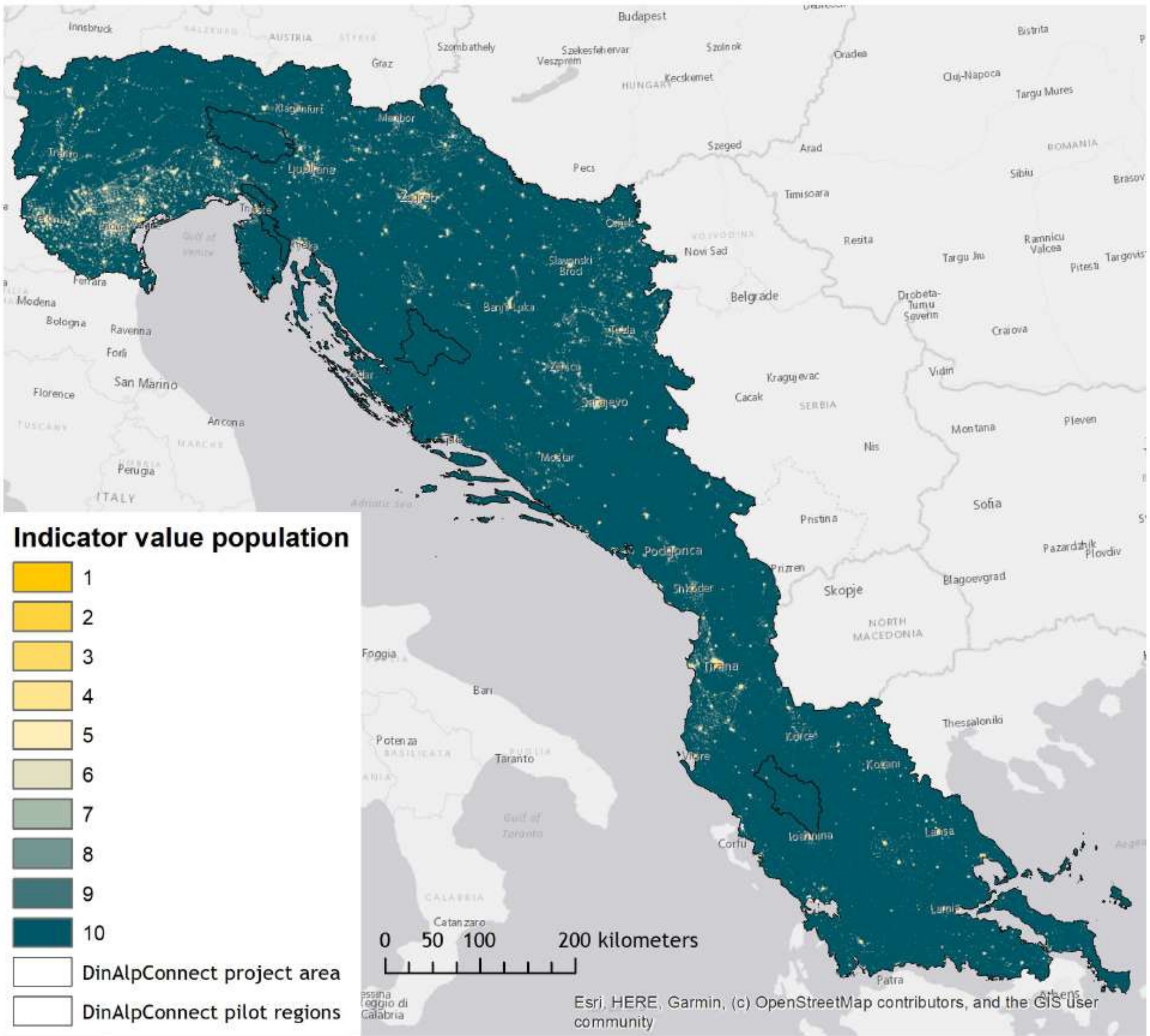
Cartography: Peter Laner
Date: 04.11.2021

Sources: Landcover indicator based on Corine Land Cover 2018; Eurogeographics 2019, OpenStreetMap Contributors, Faculty of Natural Science, department of Geography Sarajevo; Administrative boundaries: Eurostat/GISCO 2016; Basemap: ESRI ArcGIS.

Figure 3: Land use suitability indicator

Population indicator (POP)



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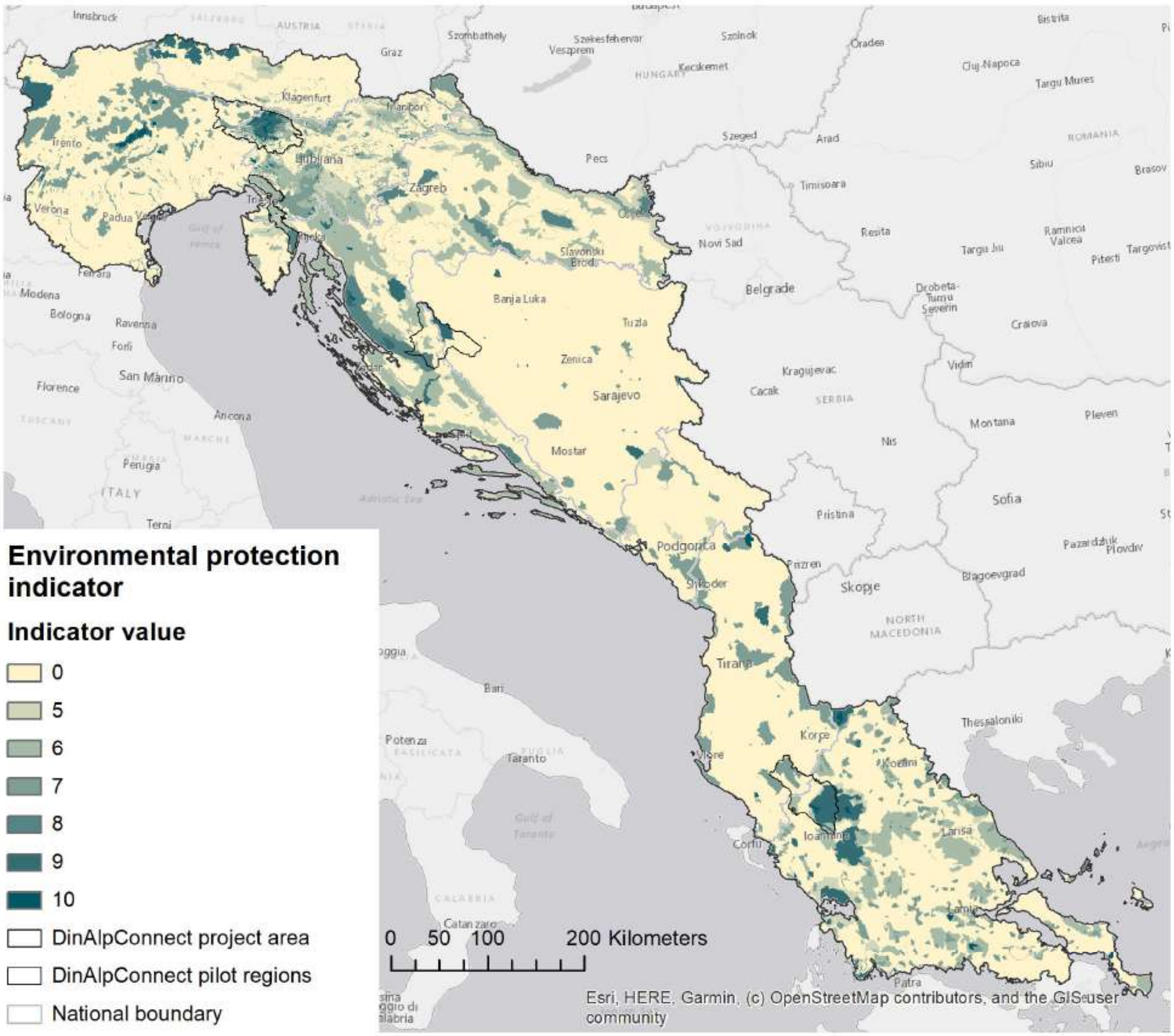
Cartography: Peter Laner

Sources: Population pressure based on GESOSTAT Population Grid 2011, DEGURBA dataset 2018 and national statistical offices; Administrative boundaries: Eurostat/GISCO 2016; Basemap: ESRI ArcGIS.

Figure 4: Indicator for population pressure

Environmental protection indicator (ENV)



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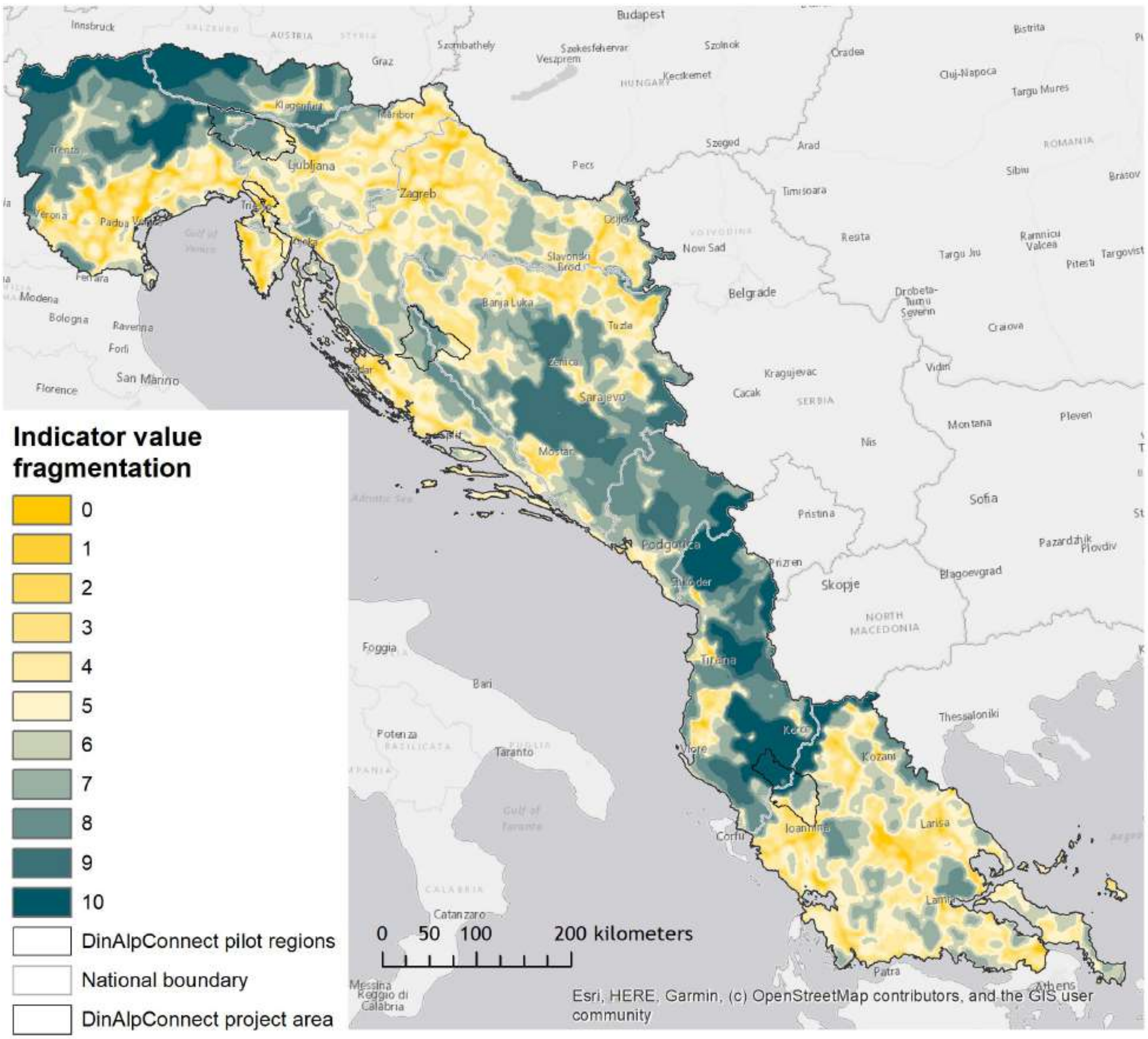
Cartography: Peter Laner

Sources: Environmental protection indicator based on World database of protected areas, CDDA and national data repositories; Administrative boundaries: Eurostat/GISCO 2016; Basemap: ESRI ArcGIS.

Figure 5: Indicator for environmental protection

Fragmentation indicator value (FRA)



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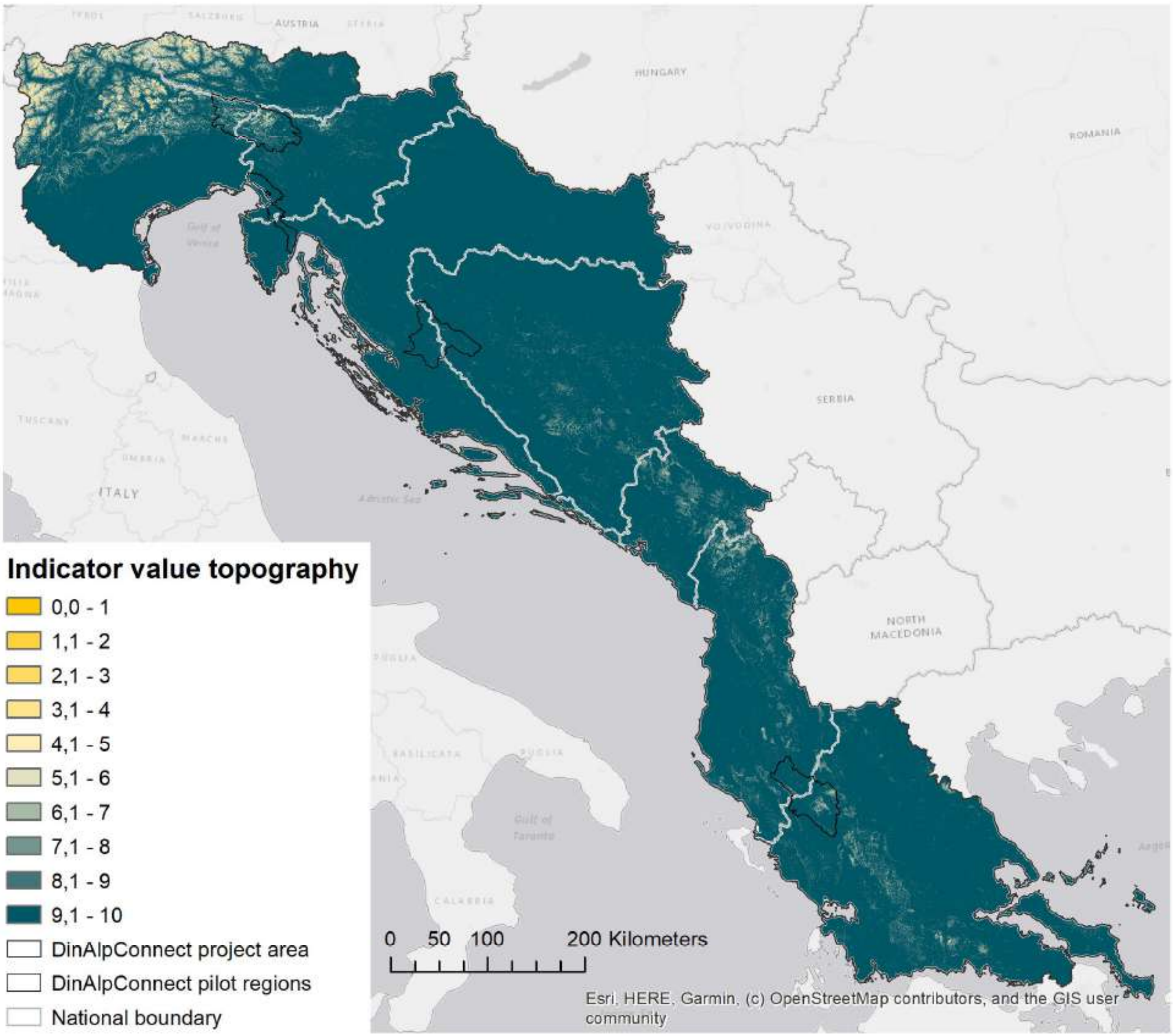
Cartography: Peter Laner

Sources: Fragmentation indicator based on European Global Map of Eurogeographics 2019, OpenStreetMap.org & geofabric.de 2020, Repository of Cener21, Corine Land Cover 2018; Administrative boundaries: Eurostat/GISCO 2016; Basemap: ESRI ArcGIS.

Figure 6: Fragmentation of landscape

Topography indicator (TOP)



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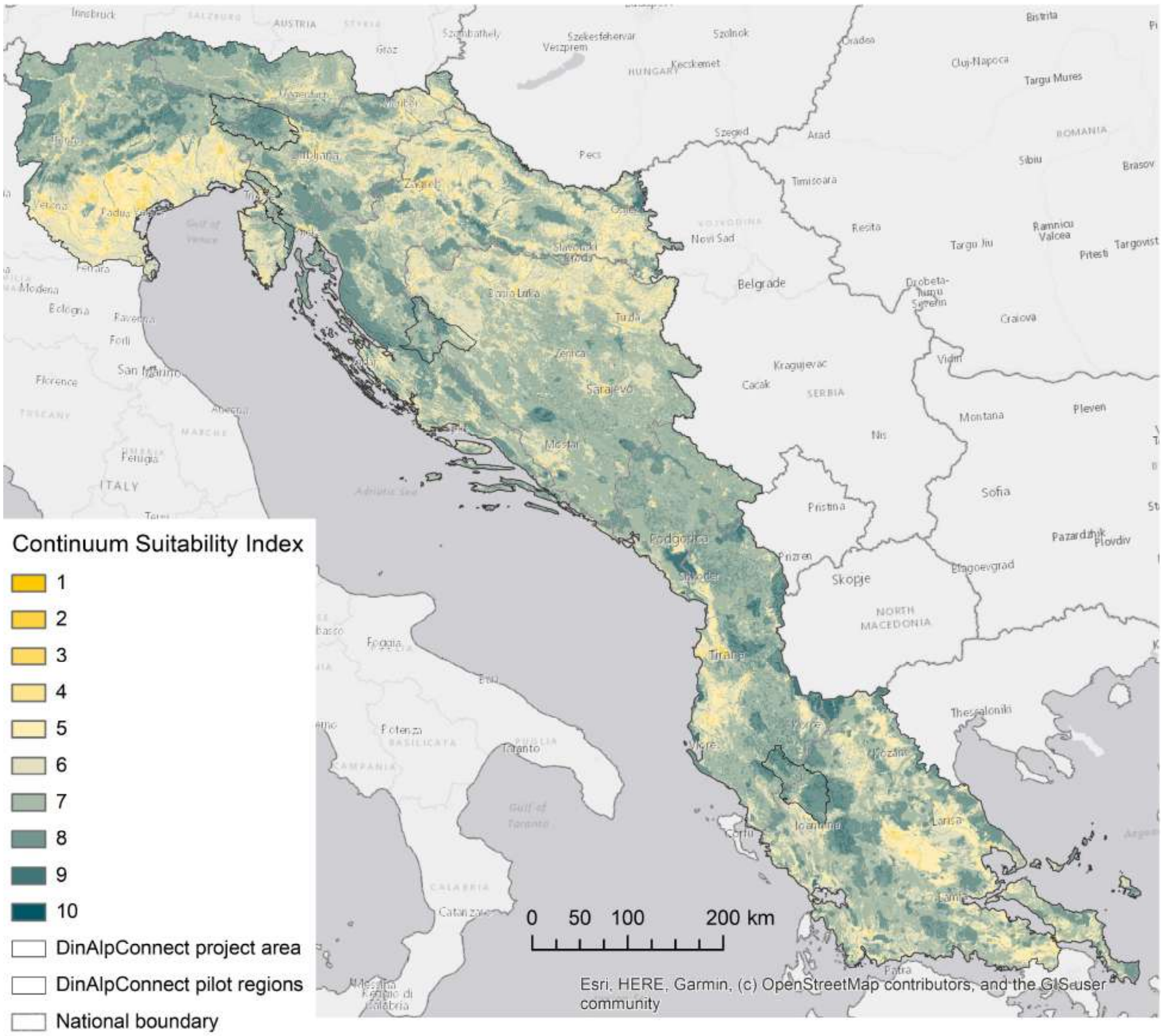
Cartography: Peter Laner

Sources: Topography indicator based on European Digital Elevation Model (EU-DEM); Administrative boundaries: Eurostat/GISCO 2016; Basemap: ESRI ArcGIS.

Figure 7: Topography indicator

Continuum Suitability Index (CSI)



Eurac Research
Institute for Regional Development
Cartography: Peter Laner
Date: 04.11.2021

Sources: Administrative boundaries: Eurostat/GISCO 2016; Basemap: ESRI ArcGIS.

Figure 8: Continuum suitability index

3.2 Strategic Connectivity Areas (SACAs)

The Strategic Connectivity Areas (SACAs) approach is a way to display via GIS the most important sites for the overall ecological network on a macroregional level (SACA1), the zones where potentials for ecological enhancement interventions are present (SACA2), and the ecological barriers, usually referred to artificial elements and human presence (SACA3). The SACAs approach, with due modifications, comes from the Interreg Alpine Space ALPBIONET2030 (2016 – 2019).

3.2.1 Calculation of SACAs

The SACAs are based on the continuum suitability index (CSI – *see Report T1.2.1*) and classified into three categories:

Ecological conservation areas: SACA 1, CSI ≥ 8 AND area ≥ 100 ha

Development/ intervention areas: SACA2, 4 < CSI < 8

Connective restoration areas/Barriers: SACA 3, CSI≤ 4

The graphic below shows the histogram for the values of the CSI of raster cells within the DinAlpConnect project area and the thresholds of the Strategic Connectivity Areas.

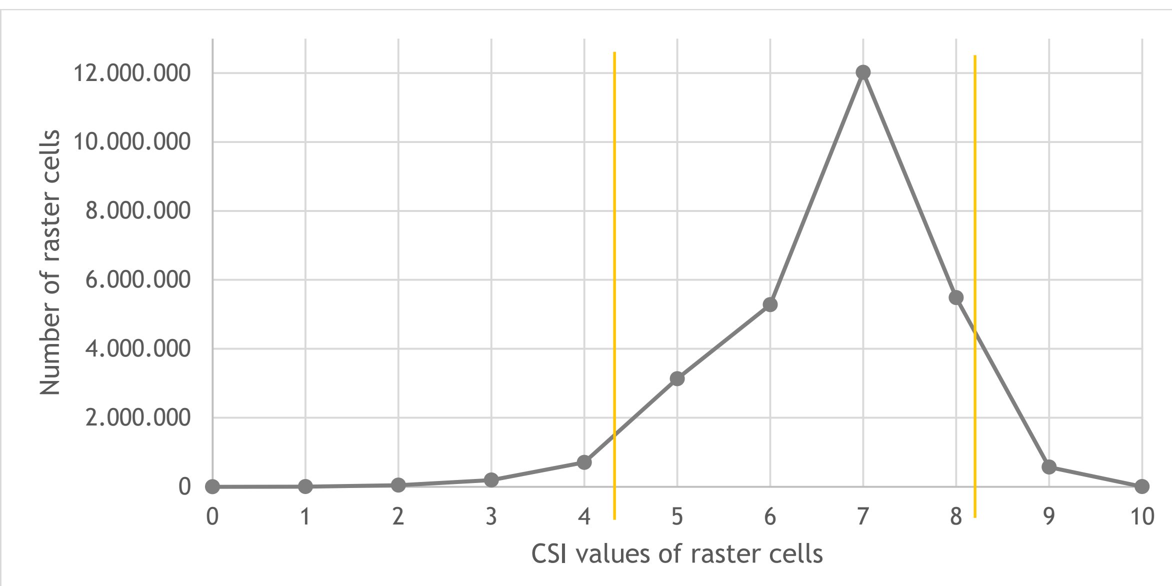


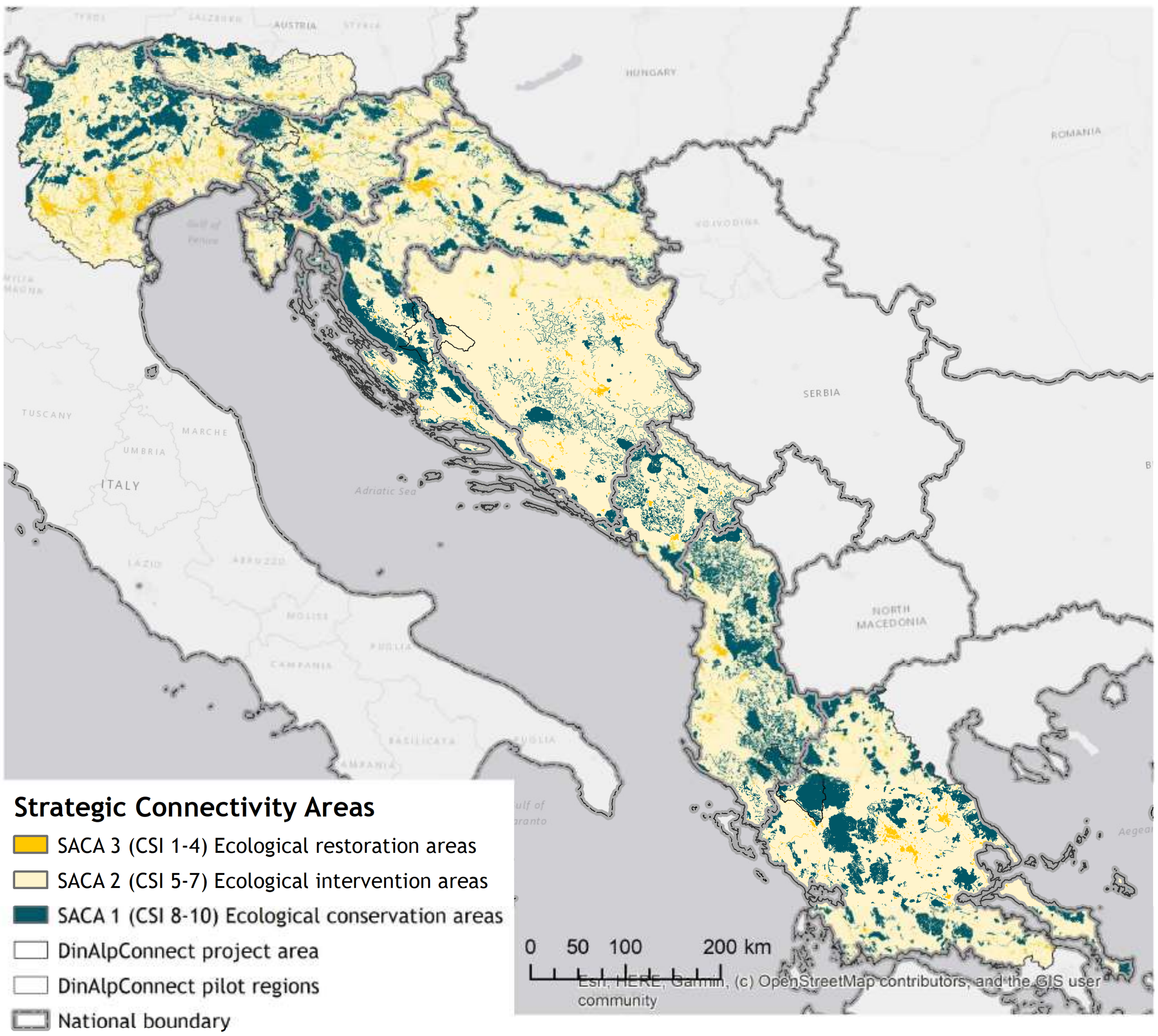
Figure 9: Histogram of the CSI values and thresholds for SACAs

The first category, **SACA1**, are Ecological Conservation Areas where ecological connectivity is functioning well (cf. Interreg Alpine Space Project AlpBioNet2030 2016-2019). They include all areas with a high CSI (> 8) and a size of at least 100 ha. For the calculation, all raster cells with values 8, 9 and 10 were selected. Secondly, the raster values were grouped into contiguous areas. Thirdly, all contiguous areas which consist of more than 99 raster cells of 100x100 meter are smaller than 1 hectare and were thus classified as SACA 1 areas. In this way, all contiguous areas smaller than 100 ha were excluded from the SACA 1 classification.

The second category, **SACA 2**, are Ecological Intervention Areas, which have a high potential for connectivity, and could become the linkage areas for larger SACA1 to be developed in the future (AlpBioNet2030). This approach coming from the AlpBioNet2030 project was applied to the DinAlpConnect project area and ecological linkages located in the intervention areas (SACA2) were defined to connect conservation areas (SACA1).

The third category, **SACA 3**, are so-called Connectivity Restoration Areas. They represent important barriers and have a low continuum suitability index. For the calculation of these areas, all cells with a CSI of 1-4 were selected.

Strategic Connectivity Areas based on the Continuum Suitability Index (CSI)



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Cartography: Peter Laner
Date: 04.11.2021

Sources: Administrative boundaries: Eurostat/GISCO 2016; Basemap: ESRI ArcGIS.

Figure 10: Strategic Connectivity Areas

3.2.2 Evaluation of Ecological Conservation Areas (SACA1)

The CSI analysis of the DinAlpConnect project area revealed that the landscape is structured as follows:

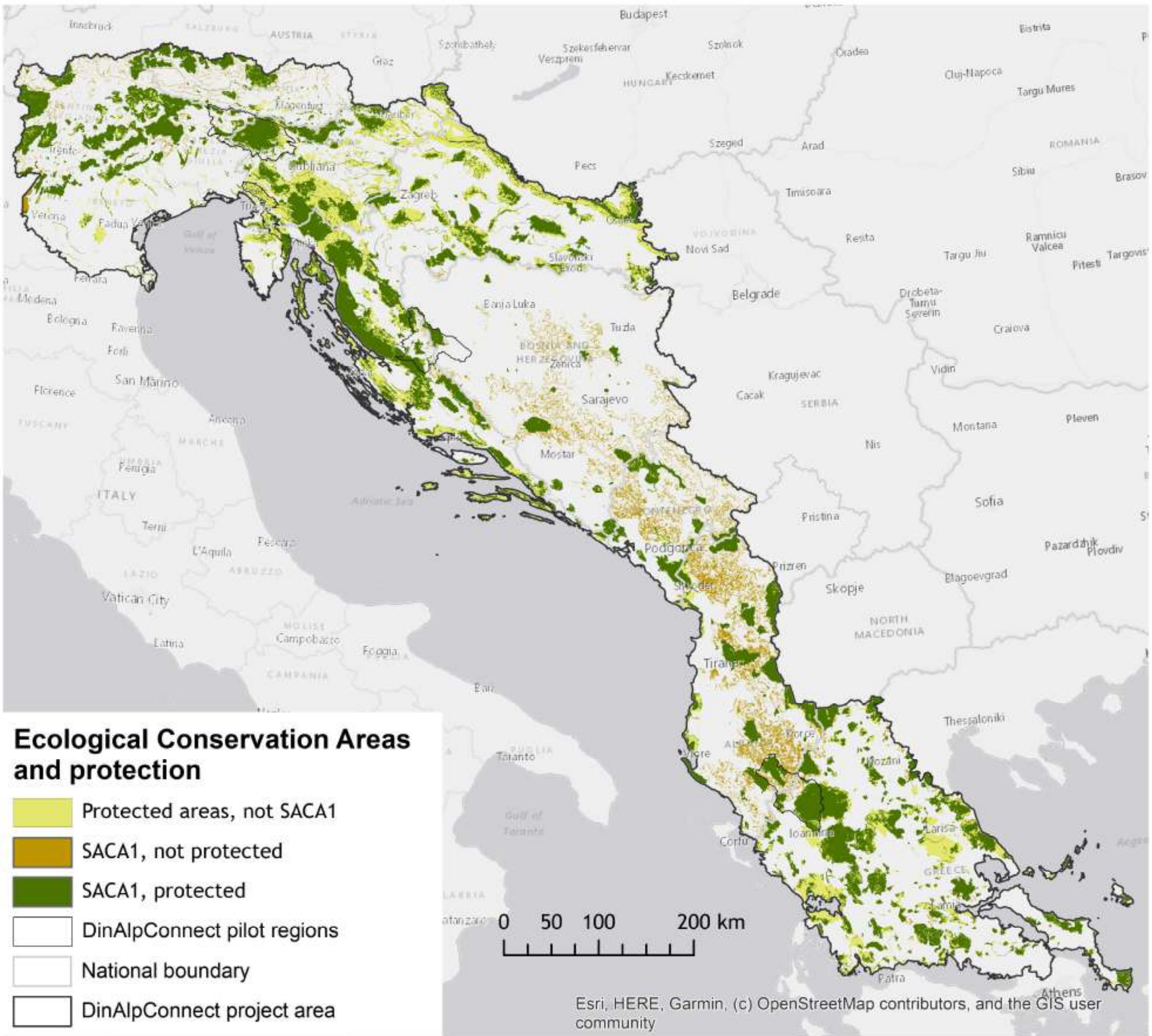
- 3,4% of the total area is classified as Ecological Restoration area (SACA3), which represents the biggest barriers. On the map it is visible that these areas are representing the biggest cities and agglomerations, like the Po valley in Italy, as well as important transport connections. Although it is just a small percentage, these areas have a big impact on connectivity because they increase the fragmentation of the whole landscape.
- 75,4% are Ecological Intervention Areas (SACA2). This result shows that many areas of the Dinaric Alps have a great potential to establish ecological connections between Ecological Conservation Areas (SACA1).
- 21,2% of the total project area are Ecological Conservation Areas (SACA1).

A first evaluation of the SACA1 was made by overlaying them with current protected areas. With this method it is possible to understand which ecological conservation areas fall inside already protected or not protected sites; as well as highlighting whether current protected areas are not ecological conservation areas.

From the maps it is possible to see that 82% of the ecological conservation areas are inside or a part of an already protected site (Table 1). These areas are mostly located in countries which are part of the EU. In Bosnia & Herzegovina, Montenegro and Albania, the greatest part of the ecological conservation areas is in not protected areas.

Additionally, it is also visible that most of the protected areas, which are outside of ecological conservation areas can be found in Slovenia, Croatia and Greece.

Overlay of Ecological Conservation Areas (SACA1) and protected areas



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Institute for Regional Development
Cartography: Peter Laner
Date: 08.11.2021

Sources: Administrative boundaries: Eurostat/GISCO 2016; Basemap: ESRI ArcGIS.

Figure 11: Ecological Conservation Areas and protected areas

Table 1: Evaluation of the protection status of ecological conservation areas (SACA1)

Type of areas	Area [km²]	Percentages [%]	
Protected areas, not SACA1	27.510	36%	of protected areas
SACA1, not protected	10.757	18%	of SACA1
SACA1 protected	49.761	**82%**	of SACA1
All SACA1	60.518	22%	of project area
Protected areas	77.271	28%	of project area
Total Project area	274.981		

3.2.3 Evaluation of protected areas

The overlay of Ecological Conservation Areas (SACA1) and protected areas revealed that 36% of the total extension of all protected areas cannot be categorised as SACA1. These areas are mostly present in Italy, Slovenia, Croatia and Greece, that have a high amount of protected areas, even of small dimensions. In addition to that, the high landscape fragmentation, often also inside of protected areas, contributes to this result.

Especially the eastern part of Slovenia and the region in the north-east of Zagreb (HR) are affected by high fragmentation, although this area has lots of protected areas, but mostly along major rivers. In these regions, also two other factors generate a low landscape permeability:

- Agricultural areas with complex cultivation patterns or fruit trees and berry plantations were included in the protected areas, which are less favourable for EC. These generate low suitability in the land use indicator.
- Some of the protected areas not classified as SACA1 have large extents and are not assigned with a high protection status. Examples are the “Ecologically important areas” in Slovenia or the “UNESCO Man and Biosphere sites” in Croatia.

In Greece, mostly the “Peripheral Zones of National Parks” and also Natura 2000 sites have a lower form of protection. Also there, agricultural areas with low suitability for ecological connectivity are included in protected areas.

In Italy, mostly the topographic conditions of high altitudes and steep slopes generate a low connectivity suitability, although the area would be protected. Sometimes also a low protection status of e.g., World Heritage Sites in combination with difficult topographic conditions generate low suitability for EC. This shows us, that connectivity interventions, and enhancement of landscape protection should be mostly focused on areas outside of protected areas and valley bottoms.

In summary, this shows us the high importance of suitable agricultural practices, that should be installed within protected areas, the importance of high protection status and the importance of measures to counteract landscape fragmentation.

3.3 Definition of ecological corridors

To define the most important corridors within intervention areas (SACA2), that connect the most important ecological conservation areas, an analysis was made on two levels:

Macro-regional corridor:	A macroregional corridor was defined to assess the best north -south – connection and to assess the most important barriers on this line
Regional corridors:	Regional corridors were defined to connect the most important ecological conservation areas (SACA1).

The identification of the linkages was based on the least cost path approach and was conducted with the Linkage Mapper Toolset and its Linkage Pathways Tool (LinkageMapper.org). The least cost path (or "the best path" in this model) represents the route along which the least resistance, given by the landscape matrix to the general wildlife movements, occurs. A species taking this path has to spend a low amount of energy to overcome the distance. It identifies the route of least cumulative resistance for a species moving between two ecological conservation areas (McRae & Kavanagh 2012, Aaron 2015). In terms of the Linkage Mapper tool, the most important ecological conservation areas, which were connected, are called "core areas".

To build a resistance raster for the corridor design, the values of the continuum suitability index were transferred to resistance values ranging from 0 to 100 by a data transformation to get linear resistances.

$$Res_{lin} = (10 - CSI) \times 10$$

These resistance values were slightly modified to give ecological restoration areas (SACA3) a higher barrier effect. This was necessary because in previous test runs some of the corridors crossed settlements, which was not considered as much realistic.

Table 2: Manual data transformation

CSI value	Resistance value
1	100
2	95
3	80
4	65
5	52
6	40
7	30
8	20
9	10
10	0

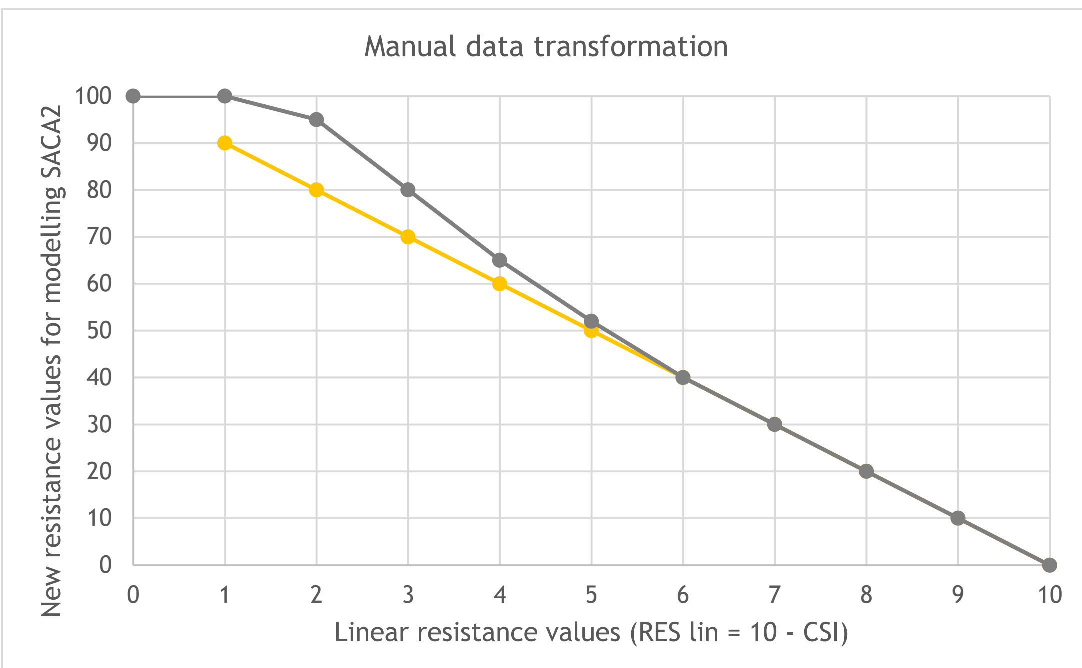


Figure 12: Data transformation from suitability index to resistance raster

3.3.1 Selection of ecological conservation areas (SACA1) for the regional corridor design

The selection of the most important ecological conservation areas for the design of regional corridors was elaborated by the expert opinion of each project partner for each country. In total, 159 Ecological Conservation Areas were selected.

Italy:

In the north-eastern part of Italy, there is a low pressure for infrastructural development at high altitudes. This is where most of protected areas are present. The Alps and their mountainous habitats are therefore important for ecological connectivity. This can be underlined by the presence of umbrella species like wolf and brown bear in the north-eastern Alps of Italy. Due to the wide overlapping of protected areas and SACA1 areas in the Italian Alps, it is possible to refer to the ecological conservation areas.

In former projects about ecological connectivity like AlpBioNet 2030, the south-north-linkages were quite important. The first one starts from Lake Garda and continues through the Brenta Dolomites to the Stelvio national park. A second one starts from the eastern part of Trentino around Lagorai and continues to the Austrian national park Hohe Tauern, passing by Dolomiti di Ampezzo. The third one connects Triglav national park in Slovenia with the northern Italian Alps at the border with Austria and ends also in the national park Hohe Tauern.

Slovenia:

Ecological conservation areas in the southwest are close to the biggest barriers in Slovenia and are thus very important to be protected, since probably this barrier still have some areas that allows migration of species.

Ecological conservation areas in the south are important for the connection of Croatia and the Dinaric Mountains.

Croatia:

The project partner BIOM evaluated ecological conservation areas according to the importance for biodiversity for the whole of Croatia.

The selection is based on the reflection that there are basically two main corridors in Croatia that mainly follow the mountains in the west and the rivers in the east. The big Croatian rivers (Sava, Drava, Dunav) hold most of the biodiversity in the continental part of the country and represent ideal natural corridors. Also, in the eastern part of Croatia, there is an alluvial forest (HR1000006 Spačvanski bazen) that encompasses several SACA1 areas. This is the biggest alluvial forest complex in Croatia.

But the big Croatian rivers (Sava, Drava, Dunav) are underrepresented in the number and size of the SACA1 areas, which could be corrected as they hold most of the biodiversity in the continental part of the country and represent ideal natural corridors. Also, in the eastern part of Croatia, there is an alluvial forest (HR1000006 Spačvanski bazen) that encompasses several SACA1 areas. This is the biggest alluvial forest complex in Croatia and it should be included as a whole in the SACA1 areas (we left a note about that in the 'Remark' column).

Bosnia & Herzegovina:

The selection of important ecological areas was made by the consultation of local external experts and project partners, which are familiar with the territory. The following experts and asked for their opinions: Tina Anić and Lejla Smailagić Vesnić, young experts for biodiversity, Goran Topić - ornithologist from the Association Naše ptice, DINARICA: Kenan Solaković and CENER21 team: Amela Džananović, Adnan Hodžić and Emina Zečić. The result is shown in the annex.

Additionally, Emerald sites (Požar & Cirella 2020, IW:LEARN Spatial Lab 2018) and potential NATURA 2000 sites in Bosnia (Milanović et al. 2015 & Working together for Natura 2015), which are candidates for protected areas, were overlapped with ecological conservation areas (SACA1). The selection is therefore also based on the largest SACA1, which are potential protected areas. Additionally, a part of the Drina river near Bijeljina and the potential NATURA 2000 site Kozièke strane, near Sanski Most were considered, because of its location.

Montenegro:

For Montenegro, important ecological conservation areas that overlap with the Emerald network were chosen for the macro-regional connectivity model. We were limiting the selection to the biggest SACA1 areas.

Albania:

As a principle, the most important SACA1 areas in non-EU Member States coincide with the Emerald sites (IW:LEARN Spatial Lab 2018a). Each of these sites usually has a high conservation value, for example the Balkan fir forest in Bredhi i Hotoves, the water sources and surface water system in Piskal-Shqeri and the forest eco-system in Germenj-Shelegur. These sites can be grouped because of existing connections (i.e. corridors) and/or homogeneity, e.g. the coastal lagoons in Central and Northern Albania or the system of lakes and wetlands in the Greece-Albania-Northern Macedonia border areas.

Firstly, the Ecological Conservation Areas, overlapping with the three most important inner-land protected areas were selected: Lurë–Mali I Dejës, Mali I Dajtit and Mali I Tomorrit.

Secondly, the three coastal areas, are considered as important for ecological connectivity. If well preserved, they would create a "necklace" of relatively near protected wetlands connecting Montenegro and Greece. The coastal areas are seen together with the four important Ramsar sites in Albania, important to connect.

Table 3: Considered Ramsar sites

Site	Relevance to	Issues
Shkoder Lake	Albania-Montenegro	At risk, due to pollution, presence of relatively large cities on the shores (Shkoder -Al, Podgorica - MNE) and industries (MNE).
Karavasta Lagoon	Albania	
Butrint	Albania-Greece	Very well preserved. The nearest Ramsar area in Greece (Arta gulf) is somehow endangered
Prespa Lakes	Albania-Greece-Northern Macedonia	Tri-lateral, object of several projects; particularly important for migratory birds

Thirdly, important potential or actual cross-border connections were considered for Albania:

Cross-border areas which have been already identified as particularly important are:

- Prokletije, Albanian Alps
- border of Montenegro with Albania (Skadar Lake, Sasko jezero, protected landscape of Buna river, Rijeka Bojana, Ada Bojana, etc.)
- border of Albania with North Macedonia (Prespa, Pogradec, Prespansko lake, Ohridsko lake, Galichica)
- Direct cross-border protected areas: National Park Rrajce-Shebenik-Jablanica (Požar & Cirella 2020)

Another high-value cross border area is relevant to the Aoos-Vjosa River basin (protected and non-protected areas spanning from Vikos-Aoos to the sea). This connects different habitats and landscapes: the Vikos-Aoos National Park (GR), where the river springs are located, Bredhi i Hotoves National Park (AL), Piskal-Shqueri (AL) which is a key source of water for Vjosa and finally the protected area of the Vjosa-Narta delta (a coastal wetland). In the eastern part at the border with Greece, Grammos mountain range is a recognized "house" for ungulates and carnivores (e.g., Balkan chamois, brown bear), some of which have been identified as coming from Northern Macedonia.

Greece:

For Greece, the most important ecological conservation areas were chosen based on the expert opinion of the project partner and their local knowledge.

To northern Greece, a group of lakes including Prespa trans-border Park is important for the national and transnational connectivity. To the west, Pindos Mountain system is very important for wildlife, as well as the connection of the big wetlands of the west coast. To the east the most important areas include the mountain range starting with Olympus and ending to Pilio and at the south the complex of wetlands of Spercheios river and the neighbouring mountains of Parnassos and Giona.

For trans-border ecological connectivity especially two ecological conservation areas in the pilot site are very important. The first one is around the river Aoos and the other one around Vourkopotamos-Ganadio-Pyrgos-Pyrsogiannis wildlife refuge.

3.3.2 The best paths connecting Ecological Conservation Areas

Best south – North connection:

Following the assumption that important movements will be on the south – north direction because of climate change, a theoretical path was designed, connecting only the most southern with the most northern ecological conservation areas. After several test runs, it was revealed that the path between the border Italy – Slovenia and Albania-Greece is poorly sensitive to modifications. Therefore, it can be deduced that the best path for the south-north- connection is a robust model.

Regional linkages:

In total, 454 potential linkages between the 159 adjacent core areas were identified by the Linkage Mapper tool.

The calculation was done with "bounding circles" of 60km. "This limit cost-weighted distance calculations from each source core to include only the portion of the landscape likely to be relevant to connectivity between the sources and target cores, reducing processing time." (McRae, B., Kavanagh, D. 2012).

After several test runs with the Linkage Mapper tool and a graphical evaluation of adjacent core areas, 38 connections were removed by hand, because it was evident that the potential connection would intersect existing core areas and linkages near the border of the project area. Additionally, four of them were removed because of unrealistic linkages with Garda Lake (IT). The removals were achieved by using a threshold of maximum 140km for Euclidean distance between two core areas and removing the rest by hand.

After these steps, 416 linkages were identified in total in the whole project area.

Definition of the minimum width and reasonable length:

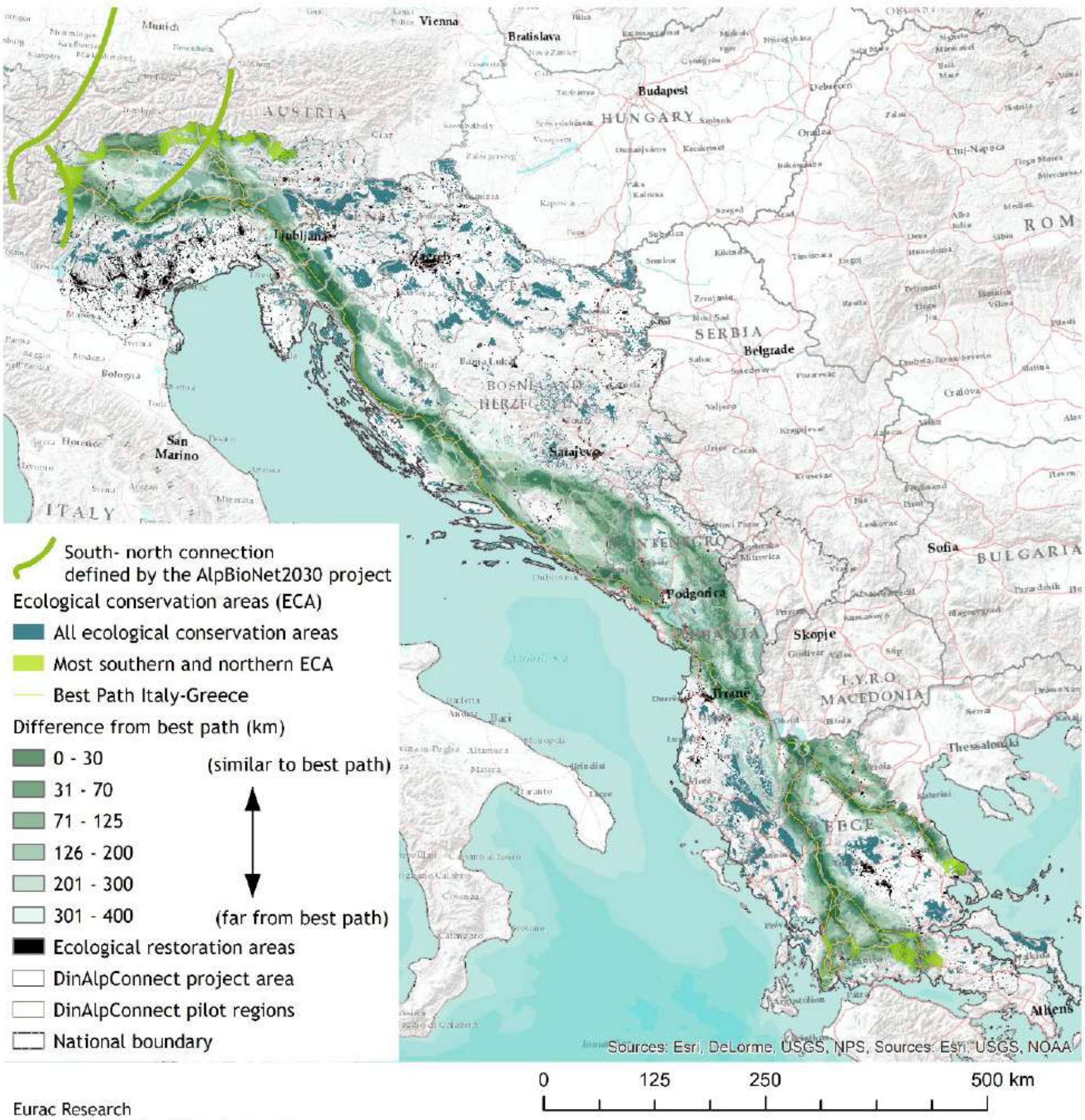
"According to Northern Arizona University ecologist Paul Beier, […] a corridor should be 2 kilometres wide" (Beier P. 2018 in Cayton 2019). The recommendation of a 2 km width considers several issues. According to this study, a width of 2 km would be enough for most of possible terrestrial mammals and with this width it is likely that they become so-called “corridor dwellers”. Additionally, “a corridor 2 km wide can support not only the focal species, but species that were not originally considered when the corridor was designed and implemented as well.” (ibid.). This issue is in line with the aim of the project to consider a wide range of species. Therefore, a minimum width of 2 km will be considered.

In comparison the European Green Belt, which is a vision of a trans- European corridor, the width of 2 km is much smaller. It has a width of around 50 km on the border between Albania and Greece, and around 15 km between the border of Croatia and Hungary.

For the GIS model in DinAlpConnect, an approximate width of 2km was designed by truncating the cost-weighted distances of the corridors at 40.000.

The maximal length of a corridor was defined according to the expert opinion of the project consortium and several test runs. The project consortium considered corridors with a length of 20-50 km as reasonable. The least cost path distances of the corridors are not exceeding 160 km.

Macro-regional corridor for the connection of southern to northern Ecological Conservation Areas

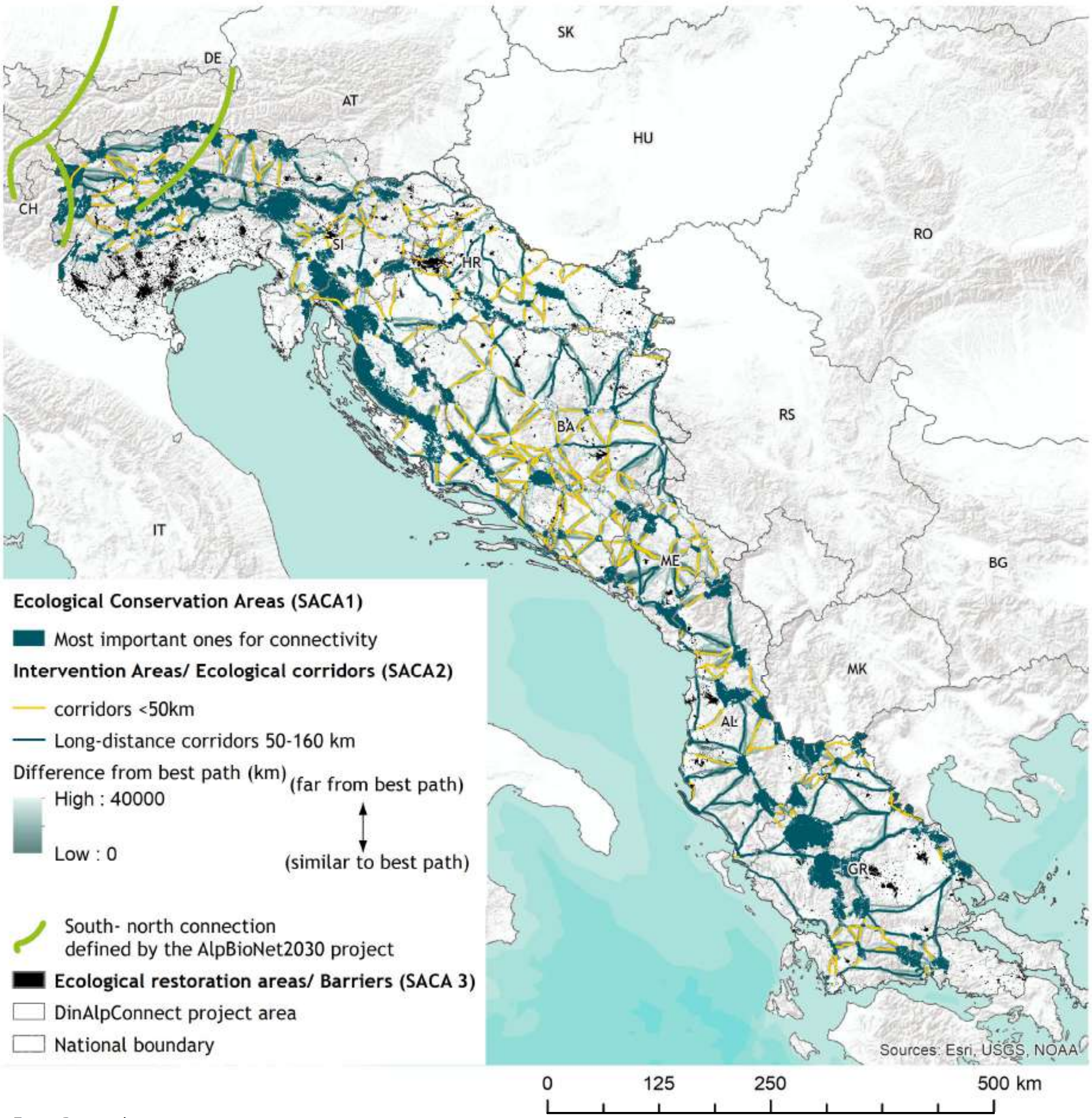


Eurac Research
Institute for Regional Development
Cartography: Peter Laner
Date: 02.12.2021

Sources: Corridors calculated by Linkage Mapper. Administrative boundaries: Eurostat/GISCO 2016; Basemap: ESRI ArcGIS.

Figure 13: Macro-regional corridor for the connection of southern to northern Ecological Conservation Areas

Regional corridors connecting most important Ecological Conservation Areas



Eurac Research
Institute for Regional Development
Cartography: Peter Laner
Date: 16.02.2021

Sources: Corridors calculated by Linkage Mapper. Administrative boundaries: Eurostat/GISCO 2016; Basemap: ESRI ArcGIS.

Figure 14: Regional corridors connecting most important Ecological Conservation Areas

3.4 Assessment of ecological linkages

The assessment of ecological linkages is based on the biological value, as well as on the evaluation of threats and opportunities. The assumption is that the linkages with the highest biological value will be considered as most important ones. After this, the opportunity and potential of a linkage as well as linkages at the highest risk of getting lost will be considered to prioritize the conservation efforts.

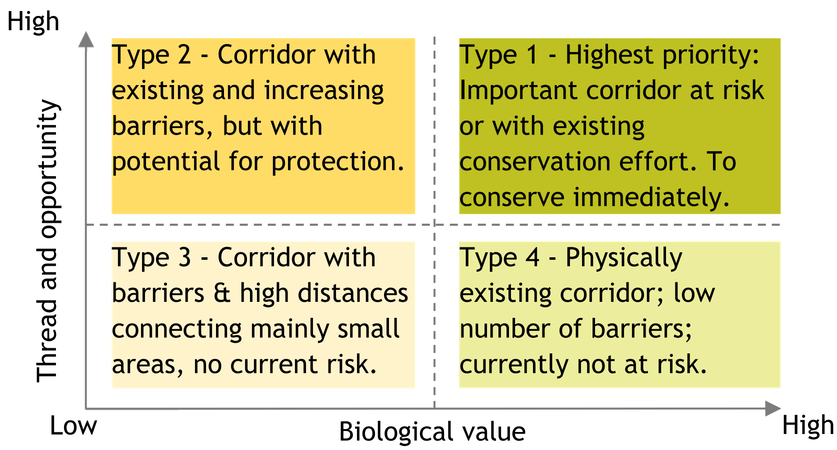


Figure 15: Assessment scheme for ecological corridors

Source: Beier et al. (2013), modified by Laner P. 2022

3.4.1 Biological value

- Linkage biological value 1: Interaction intensity
  The first biological value is a combination of criteria suggested by Beier et al. 2013:
  - Restorable habitat quality in the potential linkage,
  - Size of the core habitats and
  - Habitat quality of the connected wildlands.

  In the DinAlpConnect model, these criteria are operationalized through the following indicators:
  - The restorable habitat quality will be indicated by the cost-weighted distance of a linkage, as a result of the calculation by the Linkage Mapper tool.

To use other indicators for this criterion would have been possible, like e.g. ratio “cost-weighted distance/length”, an existing motorway barrier, effective mesh size, length of the corridor, or steppingstones (smaller SACA1) on the shortest path. However, with the cost weighted distance (CWD), all these indicators are included in a numeric value.

- Size of the core habitats corresponds to the size of Ecological Conservation Areas (SACA1).
- The habitat quality of the wildland will be calculated through the average of all values of the Continuum Suitability Index within an important Ecological Conservation Area. As described in chapter 3.3.1, there is a difference between important Ecological Conservation Areas and steppingstones.

To evaluate the size and habitat quality of Ecological Conservation Areas (SACA1) and the restorable habitat quality on the linkage, a gravity model was applied calculating the interaction intensity according to Kong et al. (2010) and Ye et al. (2020), combining all the three criteria.
First, we calculated the average Continuum Suitability Index ($CSI_{i\emptyset}$) for each Ecological Conservation Areas in ArcGIS. After this procedure, we combined these values with the cost-weighted distances, using the following formula:

$$G_{a,b} = \frac{N_a \times N_b}{{D_{a,b}}^2}$$

$G_{a,b}$ is the interaction intensity between patch *a* and patch *b*, N_a and N_b are the weights of the two patches.

$$N_i = \frac{1}{P_i} \times \ln(S_i) = \frac{\ln(S_i)}{10 - \emptyset\mathrm{CSI}_i}$$

S_i is the area of patch i, P_i is the overall resistance value of the patch, in this case $P_i = 10 - \emptyset CSI_i$. This makes it possible to equalize the size with the habitat quality of the SACA1. If the smallest SACA1 (353ha) would have the best average CSI, which is 8,7 in our case, and the biggest area (231.371ha) would have the worst average CSI of 7,9, then the biggest would count just 1,3 times more than the smallest.

D_{ab} is the standardized resistance value of potential corridors between patch *a* and patch *b*, where:

$$D_{a,b} = \frac{L_{a,b}}{L_{max}}$$

L_{ab} is the cumulative impedance of corridor *L* between nodes *a* and *b*. In this case, it can be derived from the cost-weighted distance (CWD) calculated by the Linkage Mapper Tool, which is equal to the cumulative resistance (0-100) multiplied by 100. To bring it at the level of to the CSI values, the CWD was divided by 1000. L_{max} is the maximum value of the impedance calculated in the study area, in this case it was a value of CSI=0, which means a resistance of 10.

- Linkage biological value 2: Current flow centrality
  "Current flow centrality is a measure of how important a link or core area is for keeping the overall network connected." (McRae 2017)
  The current flow centrality was calculated with the "Centrality Mapper" tool of the Linkage Mapper toolkit (ibid.).

- Linkage biological value 3: Importance for South – North connection:
  All regional linkages contributing to the calculated shortest path for the best South- north connection were selected. The main assumption here is that linkages with a south-north extension, connecting Ecological Conservation Areas which could serve as climate refugia, are more important than the East-West direction.

Biological value
Interaction intensity of Ecological Conservation Areas on regional corridors

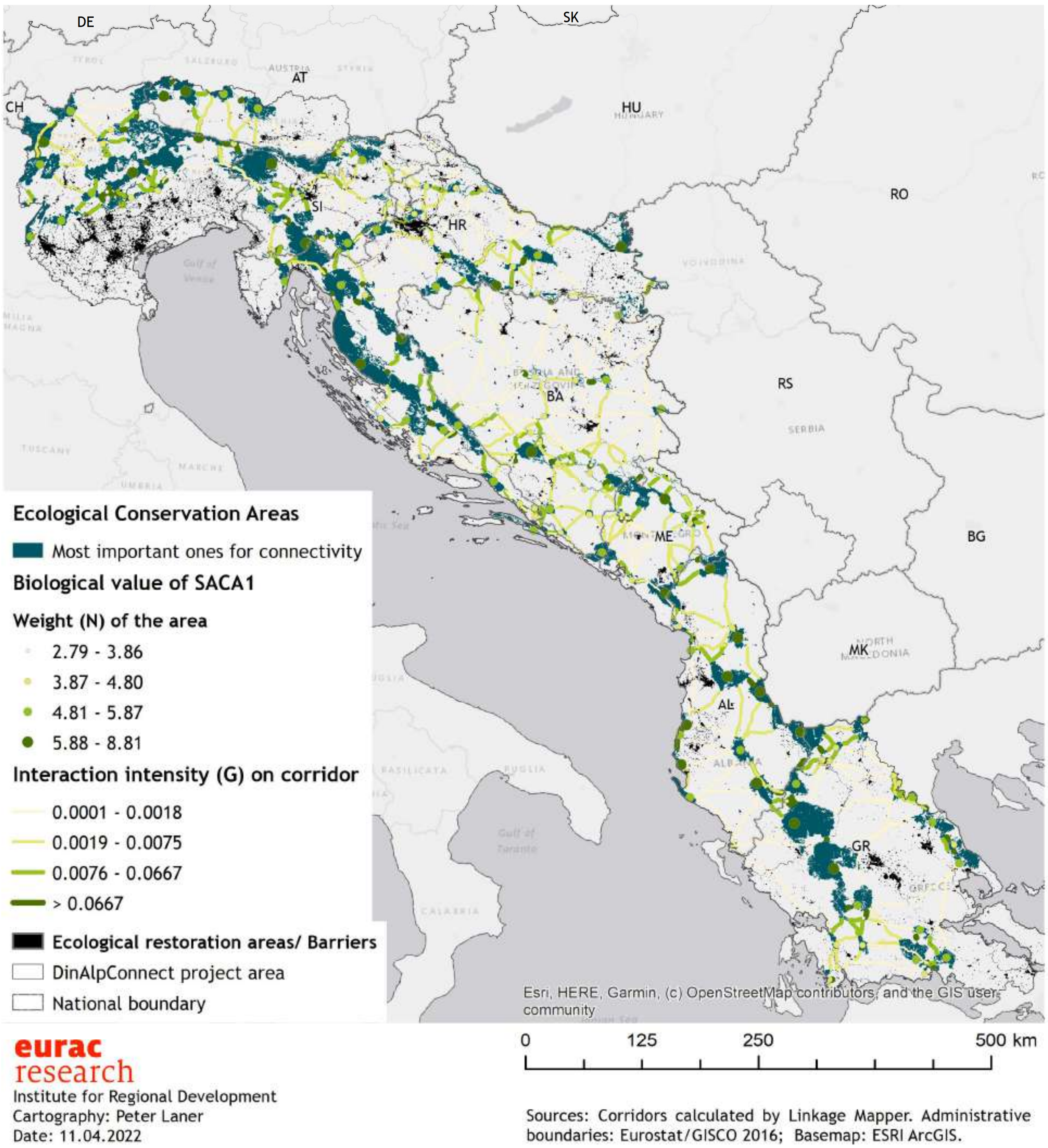


Figure 16: Interaction intensity of regional corridors

Biological value
Centrality of Ecological Conservation Areas and regional corridors

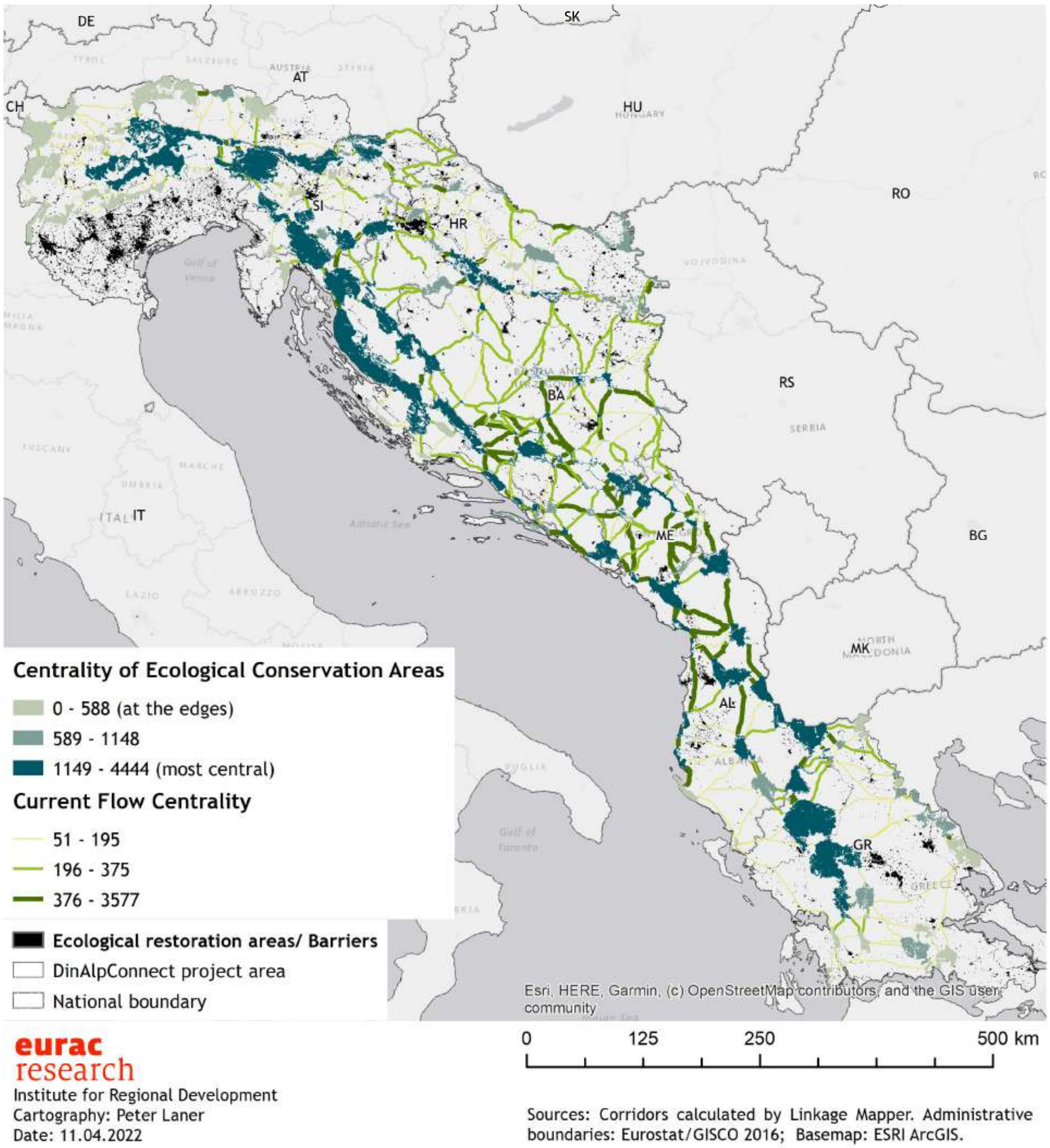


Figure 17: Centrality of regional corridors

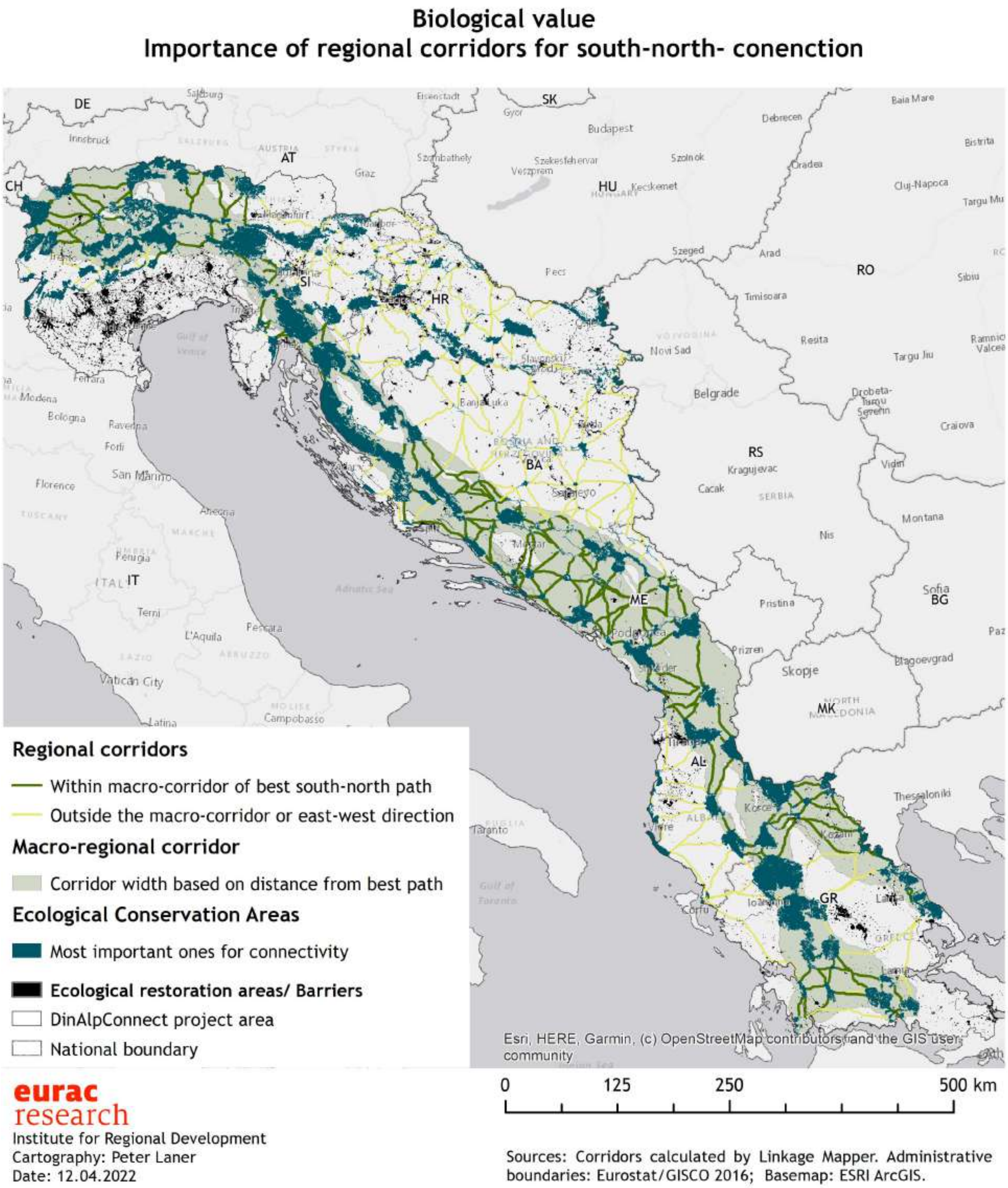


Figure 18: Linkages supporting the south-north connection

The total biological value of the linkages was evaluated by a weighted mean. Firstly, four categories for the interaction intensity and three categories for the centrality were calculated according to quantiles. The results are shown in the maps above. In a second step, these categories were combined with weights for each of the three criteria.

Table 4: Criteria, scales, and weights of biological value

Criteria	Scale/ category	Weight (W_{LBV})
LBV1: Sizes of the two SACA1 connected (ha), habitat quality of SACA1 (CSI) and restorable habitat quality in the potential linkage* (CWD)	1-4	45
LBV2 Other linkages depend on this one (Centrality)	1-3	35
LBV3 Importance for South-North connection (considering climate change)	0/1	20

The criteria were combined as follows:

$$LBV_{tot.} = \frac{LBV1}{4} \times W_{LBV1} + \frac{LBV2}{3} \times W_{LBV2} + LBV3 \times W_{LBV3}$$

A geometric error was found for the linkage between core n°46 and core n°133 in Croatia and was fixed by hand.

The result gives a range between 0 and 100. In total, 285 linkages with values between 50 and 100 can be classified as Type 1 or Type 4 according to the classification scheme. Mostly they have short distances, connecting major Ecological Conservation Areas and are located on the mountain range.

It shows that 131 linkages with values up to 49 can be classified as Type 2 or Type 3. Mostly, these are long distance corridors (>50km) and less important for the south-north – connection. The linkages can be found in northern Bosnia & Herzegovina, eastern Greek part of the project area, as well as in Albania between the mountain range and the coast.

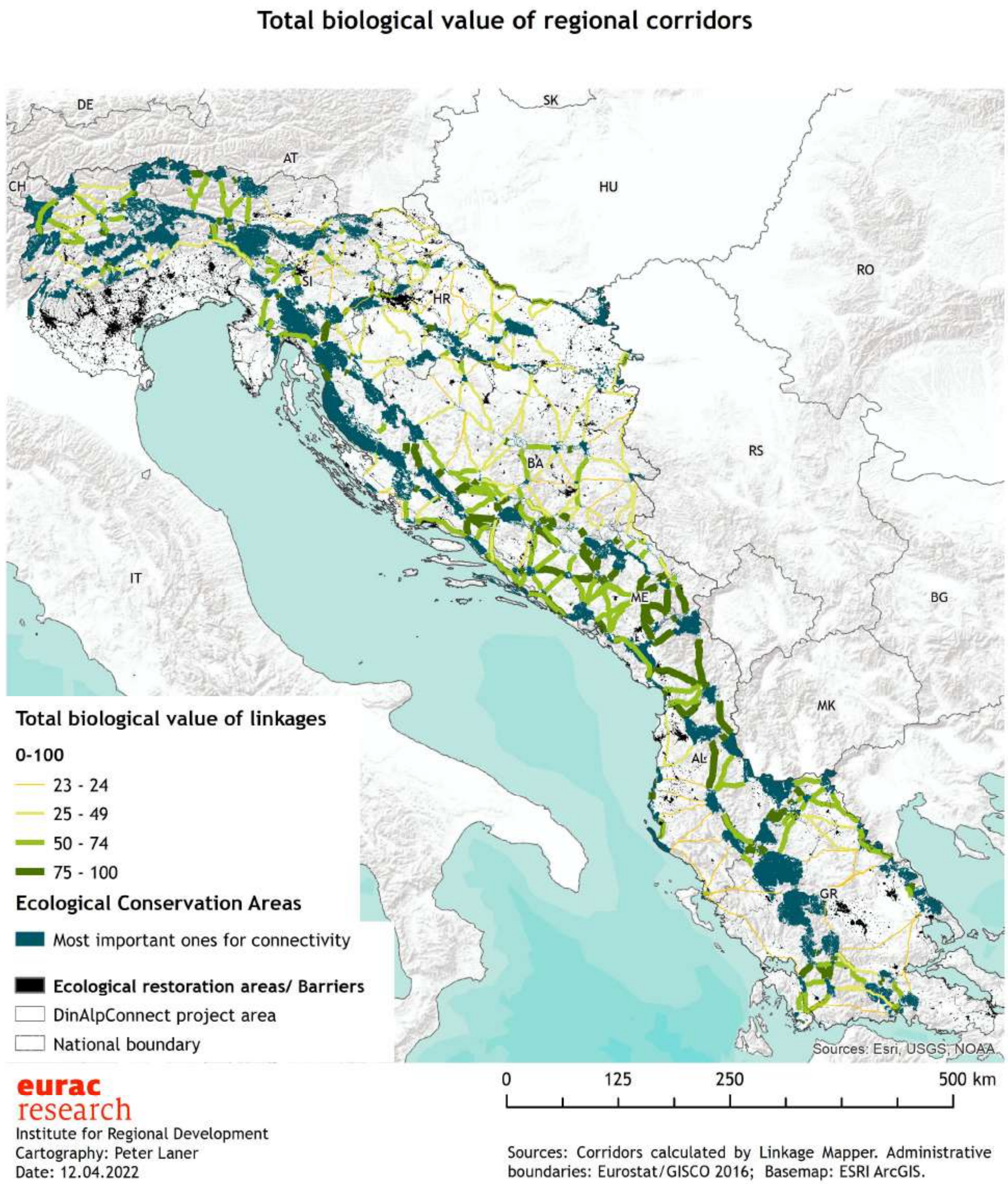


Figure 19: Total biological value

Experts' evaluation:

The biological value regarding the occurrence of threatened or special status species in the potential linkages was not considered in the analysis to keep the focus on the structural approach.

Mostly for Slovenia it would have been more logical to connect Natura 2000 sites, because some conservation areas have a different forestry management. Especially the small Ecological Conservation Area in the west of Trbovlje might receive a too important character for the network in Slovenia because of the high number of linkages. It is a "protective forest" with steep slopes and a low biological value. This SACA1 might be important for the connection from south- east to north – west, but it is not a special habitat. Another example is the wetland Ljubljansko barje in the south- west of Ljubljana, which is not present in the maps, and this shows also the limits of this model, since the model is mainly considering land – based species and birds or water-based species are not the focus here. Nevertheless, according to the projects' experts the Slovenian network, it seems appropriate for integrating it into the whole project area. We consider the criteria regarding species as more important when it comes to the more detailed level of the pilot regions.

For Croatia, some corridors crossing major cities have no chance to get restored, like for example the corridor connecting *Pusinjak* – Gorscica in the north of Zagreb and Turopoljski lug in the south. These must be considered as theoretical linkage. The linkage in the west of Zagreb, connecting Kozjanski park and nature park Žumberak – Samoborsko gorje, is passing through a river dam of a new hydro-powerplant, which is not representing the best path.

In Bosnia & Herzegovina, Montenegro and Albania, the experts agree to the biological value assessment.

We must be aware, that some linkages connecting the western coast of the project area with the central mountain range of the Dinaric Alps are linking areas of two different biogeographical regions (see figure 20). This is especially the case in the southern project countries Albania and Greece.

According to Greek experts, the structure of the corridors seems similar to corridor for birds. Many corridors are passing through wetlands of the west coast while terrestrial species like bear and wolf are not so much belonging to these linkages. The rivers from the mountain range to the wetlands are connecting different ecosystems.

The linkages are following mountain areas that are more appropriate for terrestrial species.

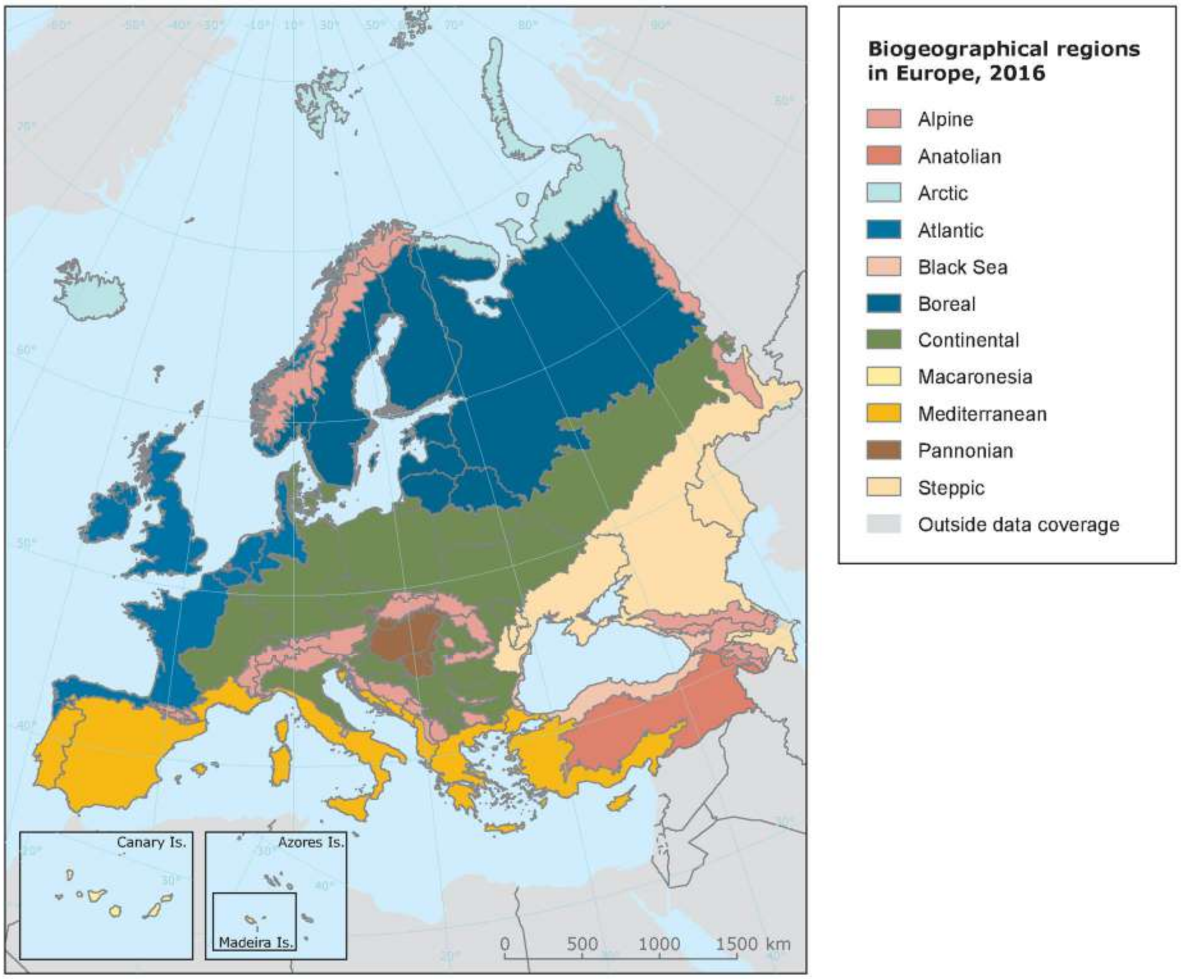


Figure 20: Biogeographical regions in Europe, 2016

Source: EEA 2017

3.4.2 Thread and opportunity

“**Opportunity** typically relates to active conservation efforts”. (Beier et al. 2013) Such active conservation efforts on a macro-regional scale in the DinAlpConnect area were identified by existing macro-regional projects and visions, as well as by the existence of protected areas.

- Opportunity 1: Linkages to other mountain ranges or macro-regional corridors were evaluated as an opportunity.
  In the northern part of the project area, the macro-regional corridors identified by the Interreg Alpine Space project AlpBioNet2030 were considered as opportunity, because it was an active effort to identify these corridors and raise awareness. Furthermore, some of them connect the Alps with the Dinaric mountains (Plassmann et al. 2019). In the more southern and eastern part of the project area, the European Green Belt was identified as an important link to other mountain ranges such as the Carpathians.

- Opportunity 2: Passage through protected areas as approximation of active conservation efforts.
  A linkage design would be more useful “if local groups and funders are working for connectivity in the area.” (Beier et al. 2013)
  As it is very difficult to identify such local groups in a macro-regional model, it was assumed, that if linkages are passing through any kind of protected areas, there might be a conservation effort to protect the potential corridor. This happens quite often. Protected areas which are situated close to each other might be in favor of a collaboration for nature conservation by their management authorities, as the case of National Park Triglav (Slovenia) and Nature Park Prealpi Giulie (Italy) shows. Therefore, in a first step each linkage passing through a protected area was selected. But in a second steps, linkages whose total route was covered only by a small part of the protected area were dropped. This was done by a visual interpretation.
  For Bosnia & Herzegovina, potential new protected areas were considered as existing conservation effort and evaluated as opportunity, also for the potential connected ecological linkages connected to them. Following potential protected areas were considered: Livanjsko Field, Botanical and Flower Reserve Mediteranetum, Bjelašnica– Visočica– Treskavica–Rakitnica River

Canyon, Zvijezda Mountain (see annex). The cave system Vjetrenica was not considered, because it is already protected.
Another opportunity relies in the environmental impact assessment of the planned motorway between northern Mostar and the southern border with Croatia form the Civil Engineering Institute of Croatia in cooperation with Bosnia & Herzegovina Ministry of Communication and Transport (2006). Here, the migration of wildlife species was considered, and 11 tunnels had to be planned in this area.
In Montenegro, new NATURA 2000 sites are in evaluation. The ministry for environment and protection is in negotiation with EU and during 2023 a decision is expected. Currently, additional areas under national protection are not considered. Therefore, no additional conservation efforts were considered for the assessment of ecological linkages.

As we can see from the model, 197 of 416 of the identified linkages (47%) are passing mainly through protected or potential protected areas.

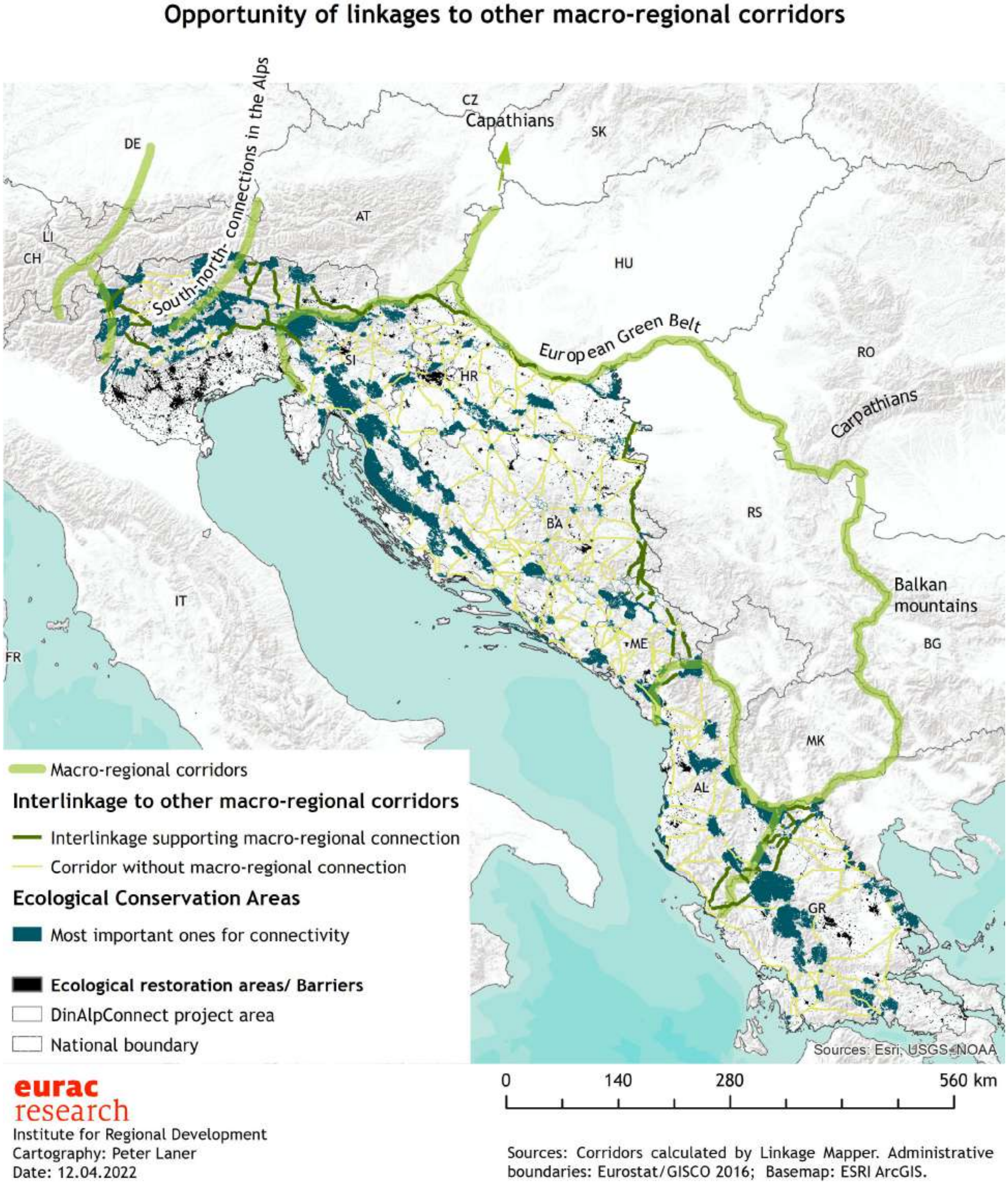


Figure 21: Linkages to macro-corridors

Opportunity of existing conservation effort on the corridor

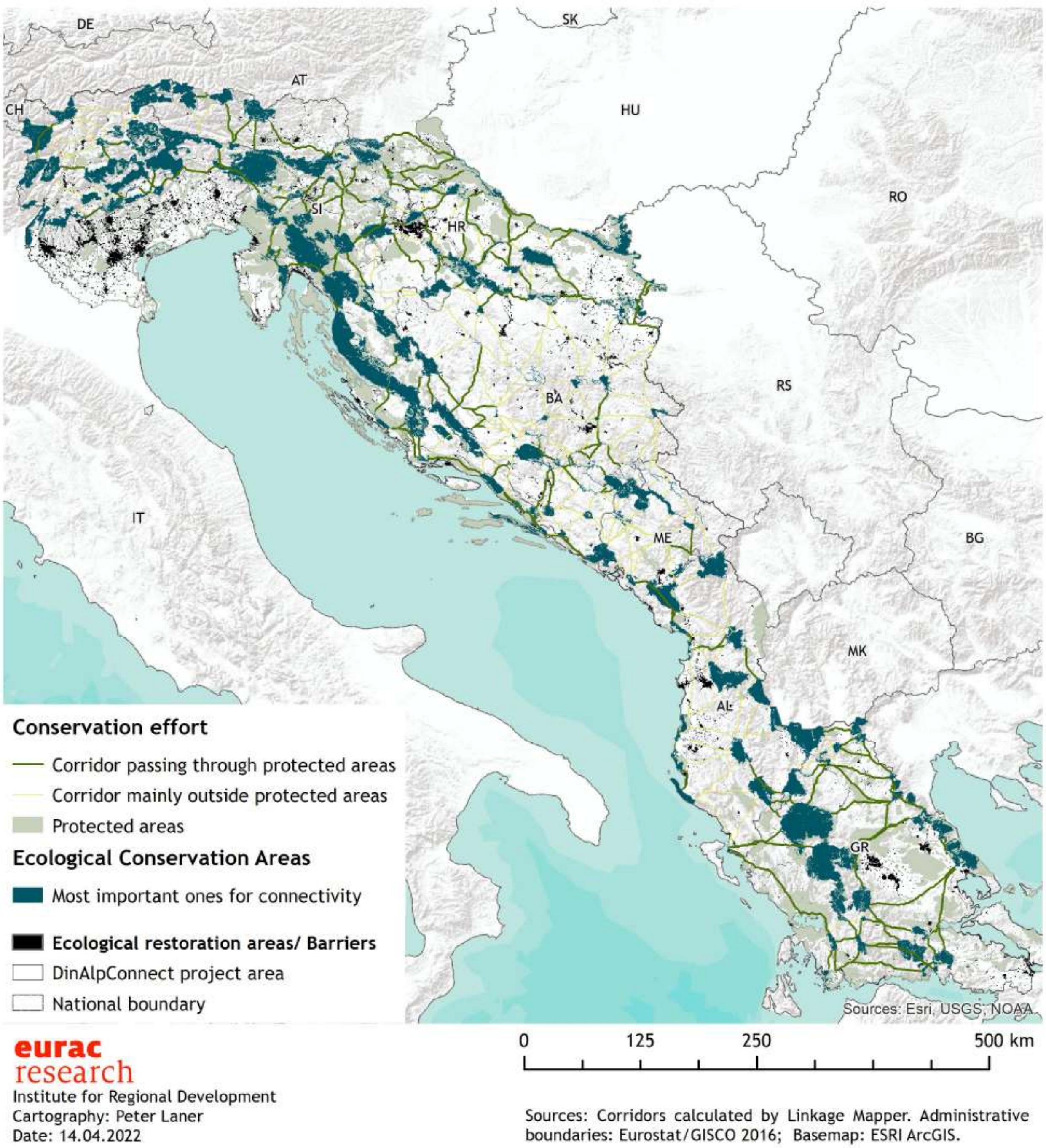


Figure 22: Existing conservation effort

Interreg ADRION ADRIATIC-IONIAN European Regional Development Fund - Instrument for Pre-Accession II Fund DINALPCONNECT

Threats:

Threats relate to existing or future risks, such as an ecological linkage being currently (or in the future) interrupted by constructions or other interventions such as roads, motorways, settlement developments, etc. Other land use changes like agricultural conversions can be a threat too, even if they are less impactful (Beier et al. 2013).

Threats were evaluated using rather a qualitative approach.

A first evaluation was elaborated by selecting least cost path, passing 50m near Ecological Restoration Areas (SACA3) or intersecting them. The main assumption behind this procedure is that settlements are in phase of growing and they could potentially affect existing interlinkages. After this, it was evaluated by graphical interpretation, if a linkage would be interrupted, if urban growth would completely close a barrier or if it would just extend the length of the calculated best path.

In a second step, project partners from the single project countries were consulted as experts with local knowledge. The experts indicated or confirmed regions and linkages, where the most important threats of new motorway constructions, upcoming urbanization threats, or other threats occurs.

Expert evaluation of additional threats:

Between Velenje and Celje (SI), a new major road is planned, that will cross an ecological linkage. Another upcoming threat is a new highway that will be built between Velenje and Lubliana. Even if this new highway will have a certain number of EC-related measures, this will not actually improve the situation of ecological connectivity, and so it will be considered a highway threat.

Industrial zones are representing a continuous threat in Slovenia. For built up areas like industrial zones the pressure on ecological linkages is much higher because restoration measures are nearly impossible. Mitigation measures for traffic infrastructure are present and possible to realize, but not for industrial zones. Threats regarding the extension of industrial zones are difficult to localize at macro-regional level. To identify such threats, an investigation at local level is more appropriate.

The project partners from Croatia confirmed the revealed urbanization threat. However, linkages around Rijeka and Dubrovnik should also be considered at risk by urban sprawl of these two major cities.

Additional highways threats were also revealed in Croatia:

- Motorway Osijek - Hungary: A new highway between Osijek and Hungary will put under pressure the whole river system around the confluence of Drava and Danube River, because it is cutting the end part of the Drava River. This river system was identified as Ecological Conservation Area. Ecological linkages within Croatia will not be affected.

Figure 23: Motorway Osijek - Hungary under construction

- Motorway Zagreb - Sisak: Most of this motorway is already done, and there is a plan for the construction of the last segment between Lekenik and Sisak, which will affect a potential linkage.
- Motorway Ploče - Dubrovnik: This is rather a vision than a concrete future highway plan. If the motorway will ever be built, it will affect three ecological linkages.

According to the project partners, cities in Bosnia & Herzegovina are shrinking. Urbanization threats could be existing in areas, where the corridors are passing very close to cities or agglomeration areas. Other threats in Bosnia & Herzegovina might be found in the project list of the Western Balkans Investment Frameworks. (WBIF 2022 [2]). However, they were not included in the assessment.

10 linkages are affected by new highway constructions between the cities Doboj, Zenica, Konjic, Mostar and Čapljina in Bosnia & Herzagovina (WBFI [1] 2022, JP Autoceste FBiH 2022).

In Montenegro, a highway project is under construction to connect the cities Bar – Podgorica – with the cities Sjenica and Belgrad in Serbia. Other infrastructure pressures are not present in Montenegro. Especially in mountain areas, a land abandonment process is ongoing.

In Greece, urbanization threat is especially present near the costal zones, because of tourism infrastructures. Mountain areas in Greece are mainly characterized by land abandonment. A relatively new problem raises with renewable energy installations. However, at the current stage it is difficult to evaluate the impacts of all renewable energy installations for terrestrial species in the whole project area. Therefore, this topic was only considered for Greece in the identification of main barriers (see chapter 3.4.4), and it would have big potential for further investigations.

The result of most important threats shows that 73 linkages are passing near urbanized areas, which could interrupt connectivity, if urban growth would close the remaining open natural corridor and 22 linkages are at risk of highway projects.

The final result of the dimension "threat and opportunity" is showing ecological linkages by 7 different types of threats and opportunities. Linkages not at risk and without existing conservation effort or opportunity for linking other macro-regional corridors can be evaluated as type 3 or type 4 according to the general classification scheme.

Possible threats for ecological interlinkages

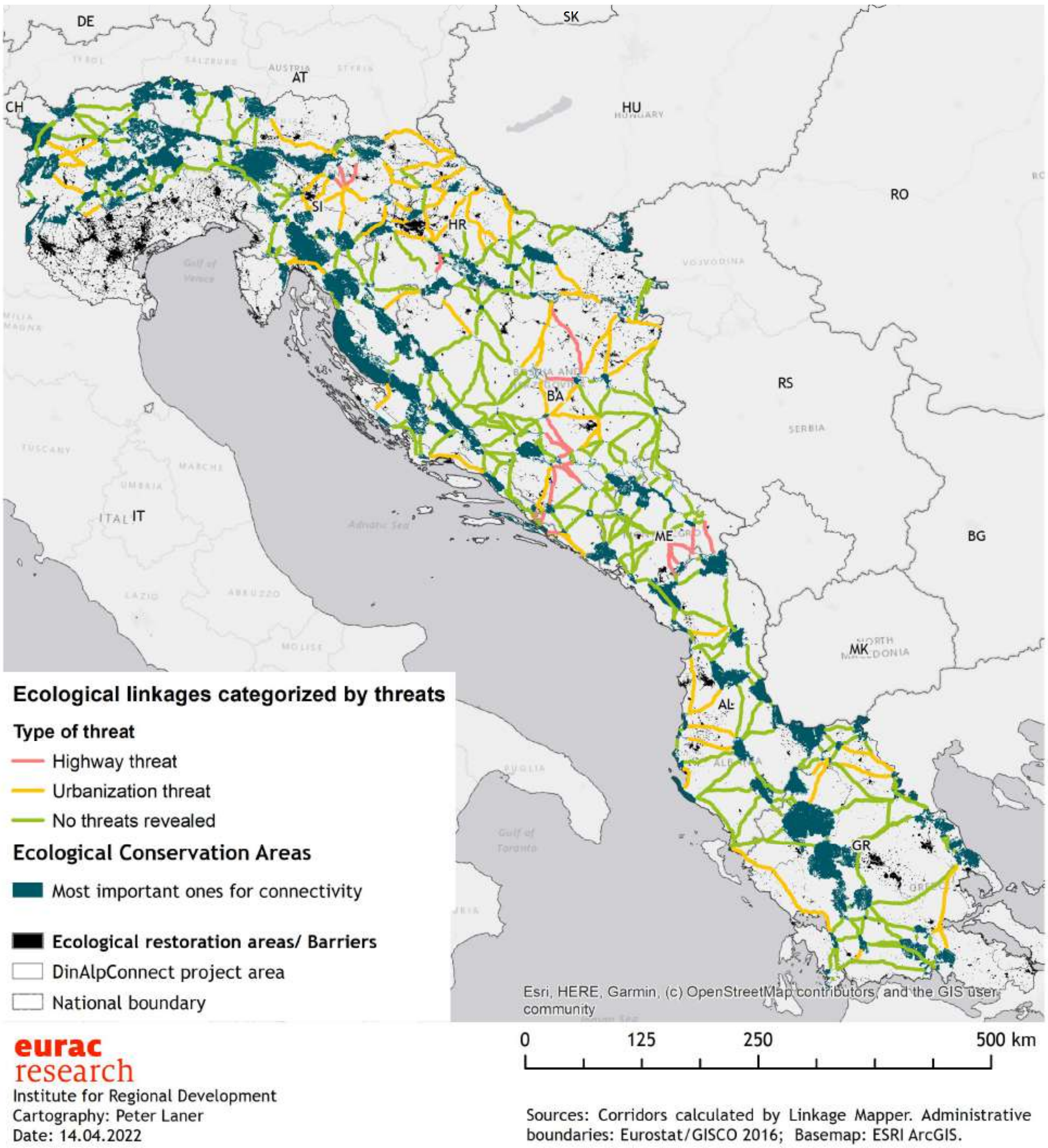


Figure 24: Ecological linkages categorized by threats

Ecological linkages by type of threat and opportunity

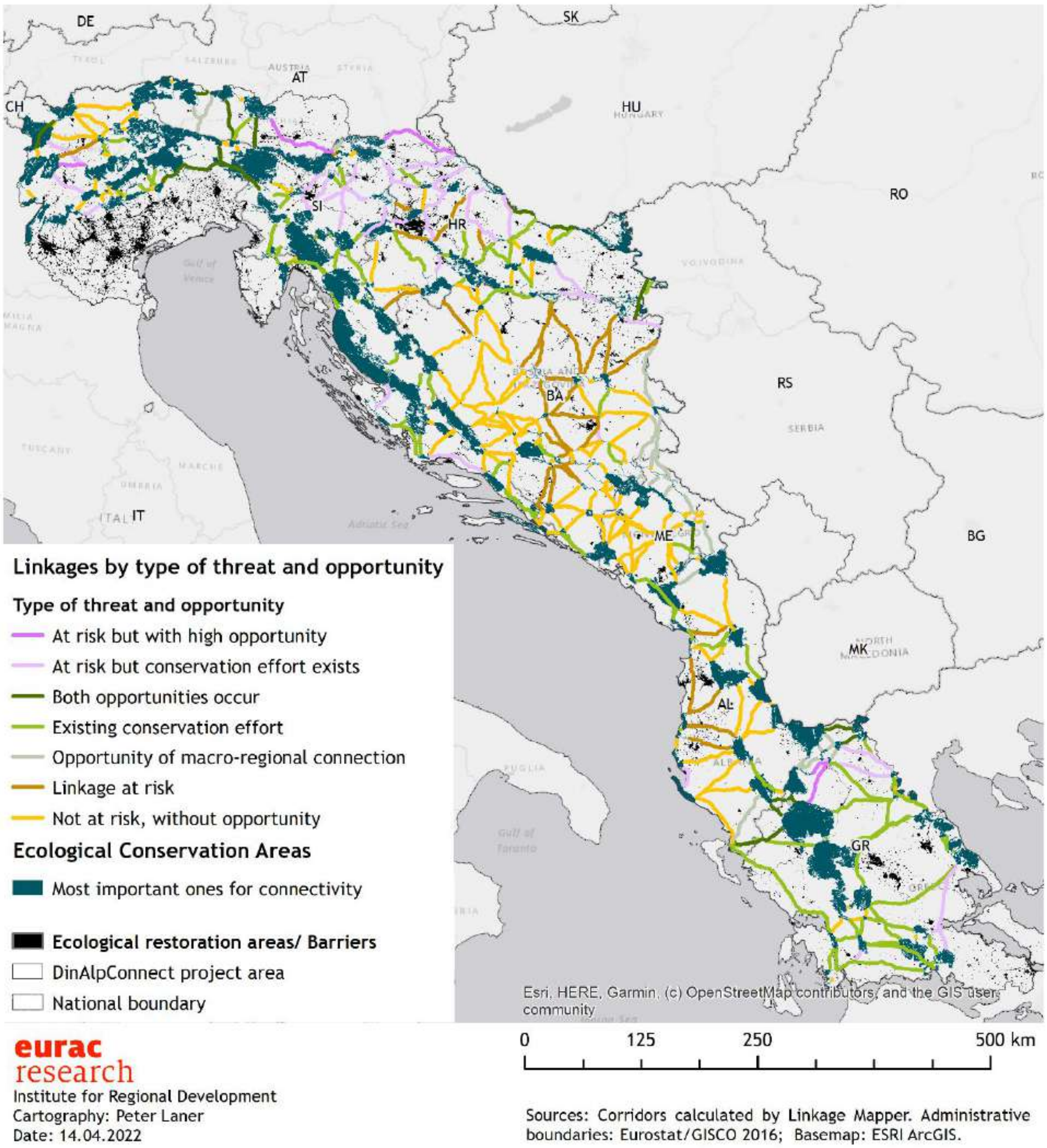


Figure 25: Ecological linkages by type of threat and opportunity

3.4.3 Prioritization assessment

The final combination of biological value and threat and opportunity according to the classification scheme at the beginning draws the final picture of the status of ecological connectivity between the Alps and the Dinaric mountains.

Type 1: Around 40% of the linkages (in total 166) were identified with a high priority for conservation and are classified as type 1. Each of them has a high biological value. Additionally, they are at risk or have a valuable opportunity, like an existing conservation effort or the potential linkage to other macro-regional corridors. According to Beier et al 2013, these are the first ones that should be conserved, because invested effort would gain the best benefit for connectivity.

Type 2: Almost a quarter of the linkages (96 connections) have a small biological value, but they would have big potential for protection or restoration, according to existing threads & opportunities.

Type 3: Less than 10% of the linkages (35 connections) have a low biological value and they have neither an existing conservation effort, nor a revealed threat. These interlinkages have the lowest priority for restoration.

Type 4: Around 28% of the linkages (119 connections) have a high biological value, but have neither an existing conservation effort, nor a revealed threat. This means there is enough time for the protection of such linkages.

The whole assessment was discussed among the project consortium.

Assessment of ecological linkages
according to the biological value, threats and opportunities

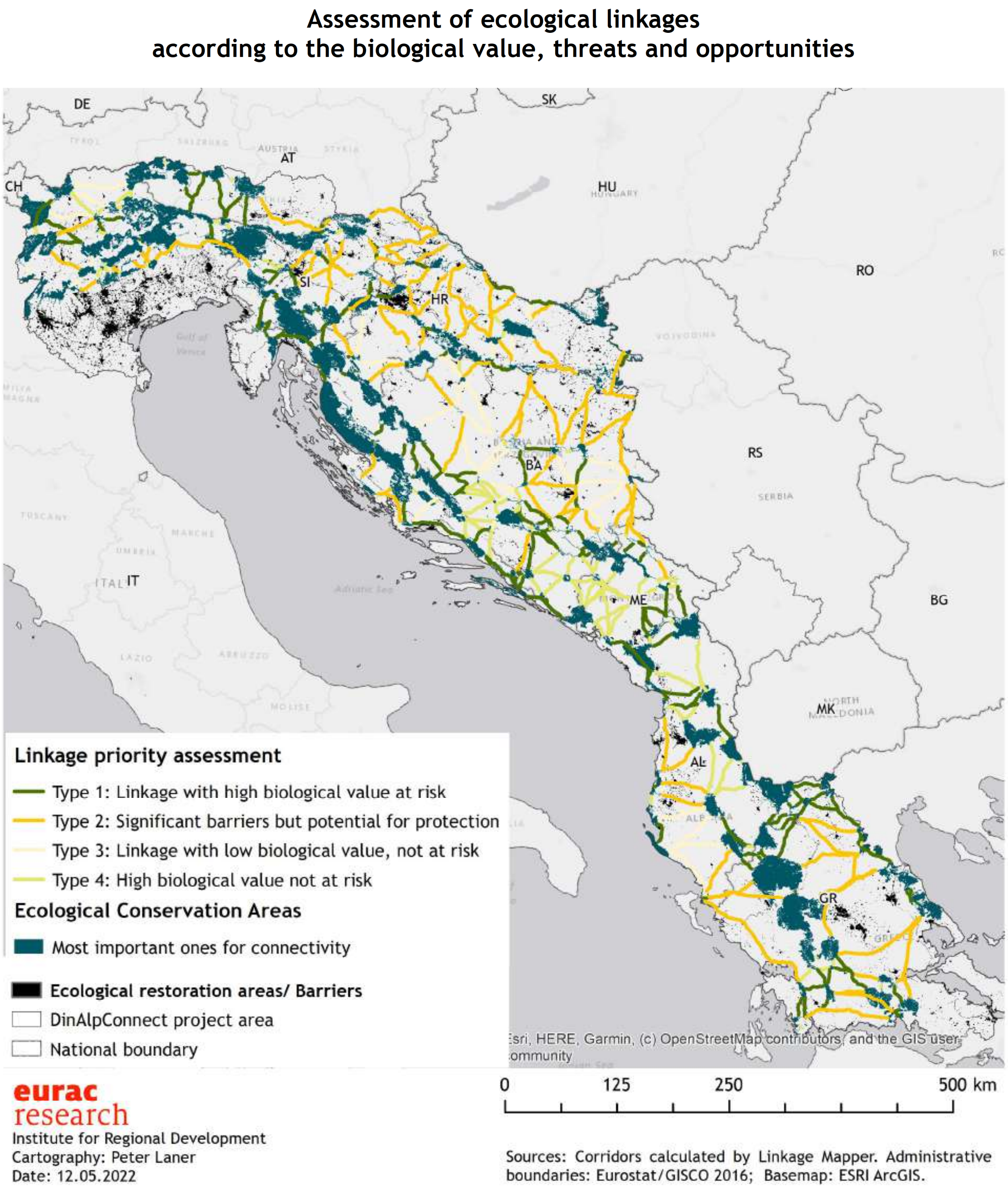


Figure 26: Priority assessment of ecological linkages

3.4.4 Identification and evaluation of main barriers

The identification of the main barriers was made through different ways.

GIS analysis:

1) by intersecting identified regional corridors with existing motorways
2) by intersecting identified regional corridors with the most fragmented areas of a mesh density >12 meshes per 1000km^2, which corresponds to a fragmentation indicator value 0-4.
3) By intersecting corridors with existing intensive agricultural areas.

A statistical evaluation of the GIS analysis revealed the following situation regarding the number of barriers and prioritization types.

- 88% of the linkages of type 1 have in average one barrier on their path.
- Linkages of type 2 mostly have two barriers on their path.
- Linkages of type 3 have in average 1-2 barriers on their path.
- In average just 23% of linkages of type 4 have one barrier on their path.

This confirms the initial hypotheses of the assessment scheme.

The consultation of project partners as experts of the developments in their countries did not reveal significant additional barriers for wildlife species on land. However, the barrier effect of renewable energy installations, especially of windmills and hydropower installations is still a topic which would need further investigations.

Motorways:

The result shows that there are 108 existing intersections with motorways in the whole project area. These intersections have to be considered from a cartographic/ geographical point of view. By evaluating the dataset of Motorways and by a graphical assessment with Google Earth, it can be revealed that 48 of these intersections don't represent a real barrier. In these cases, rivers in the surroundings of the intersection are building a green corridor under the motorway, or the motorway is passing through a tunnel, or a green bridge was already built, so that the barriers is physically resolved. 13 linkages overpass motorway tunnels, 35 linkages underpass motorway bridges.

Figure 27: Corridor passing under a motorway near Varaždin (HR)

Source: Google Earth (2022)

There remain 60 real physical barriers with motorways. Some linkages are intersecting motorways twice. Some motorway intersections are a barrier for two linkages, which have the same path for a certain section of the linkage. In total, 61 linkages are affected by motorway intersections. On the map it is visible, that Bosnia & Herzegovina and Montenegro have very few intersections and these countries have a big chance to prevent such barriers in future, when it comes to new motorway constructions. In the western part of Slovenia, highway barriers have a big impact on ecological connectivity. Some mitigation measures should be installed and should be considered as an opportunity for the improvement of ecological connectivity.

Intersections of linkages with motorways representing a real physical barrier

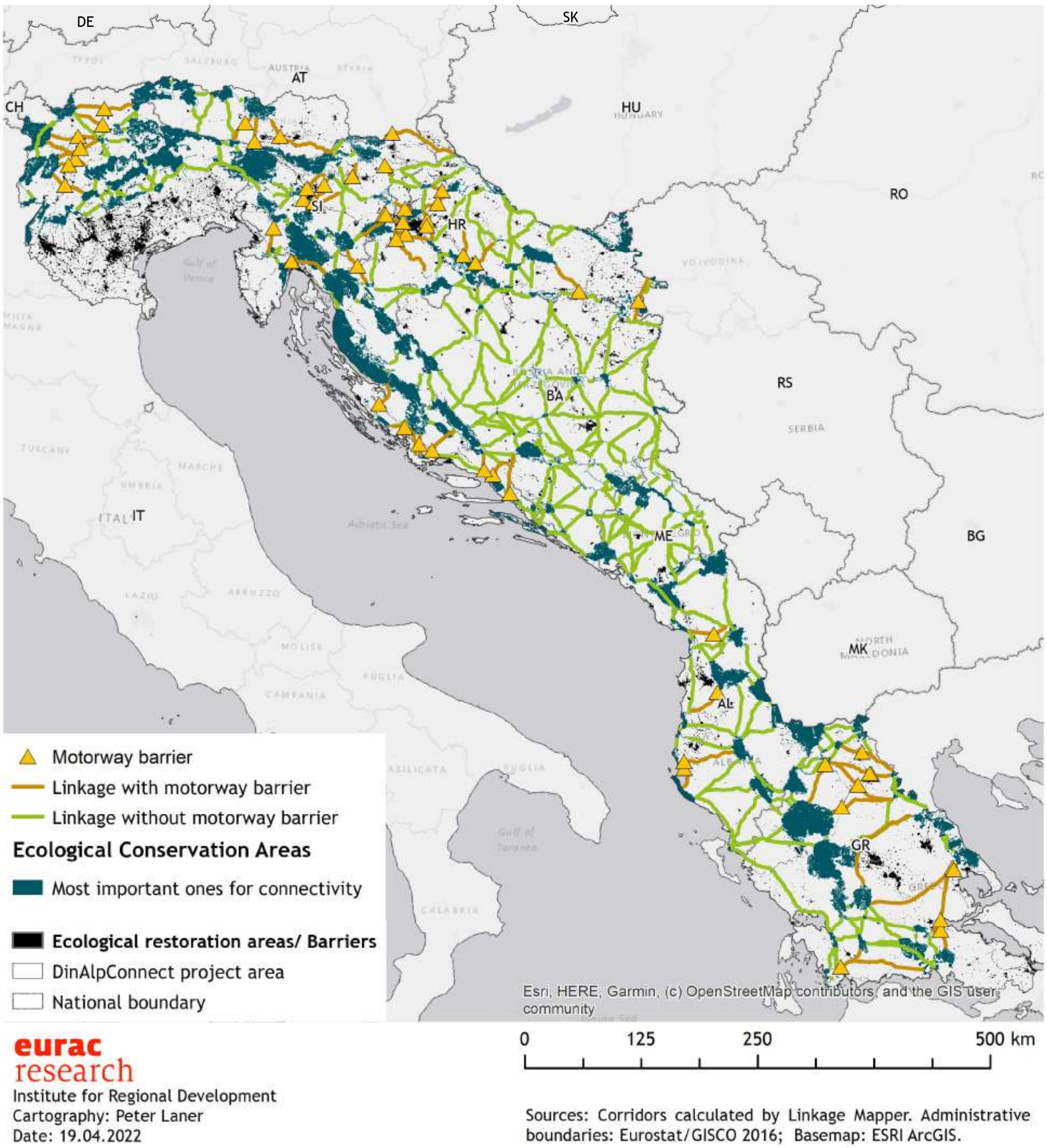


Figure 28: Motorway barriers

Fragmented areas:

Fragmented areas were considered as barriers, where actions are still feasible to restore or maintain ecological corridors. To define the most problematic and impeding landscapes, the fragmentation indicator from the continuum suitability index was considered by filtering values between 0 and 4.

It was revealed that 143 linkages are passing through the most fragmented areas, which represents more than one third of the total amount of linkages. Most of these linkages can be found in Slovenia, Croatia, and Greece.

Intersections of linkages with most impeding fragmented areas

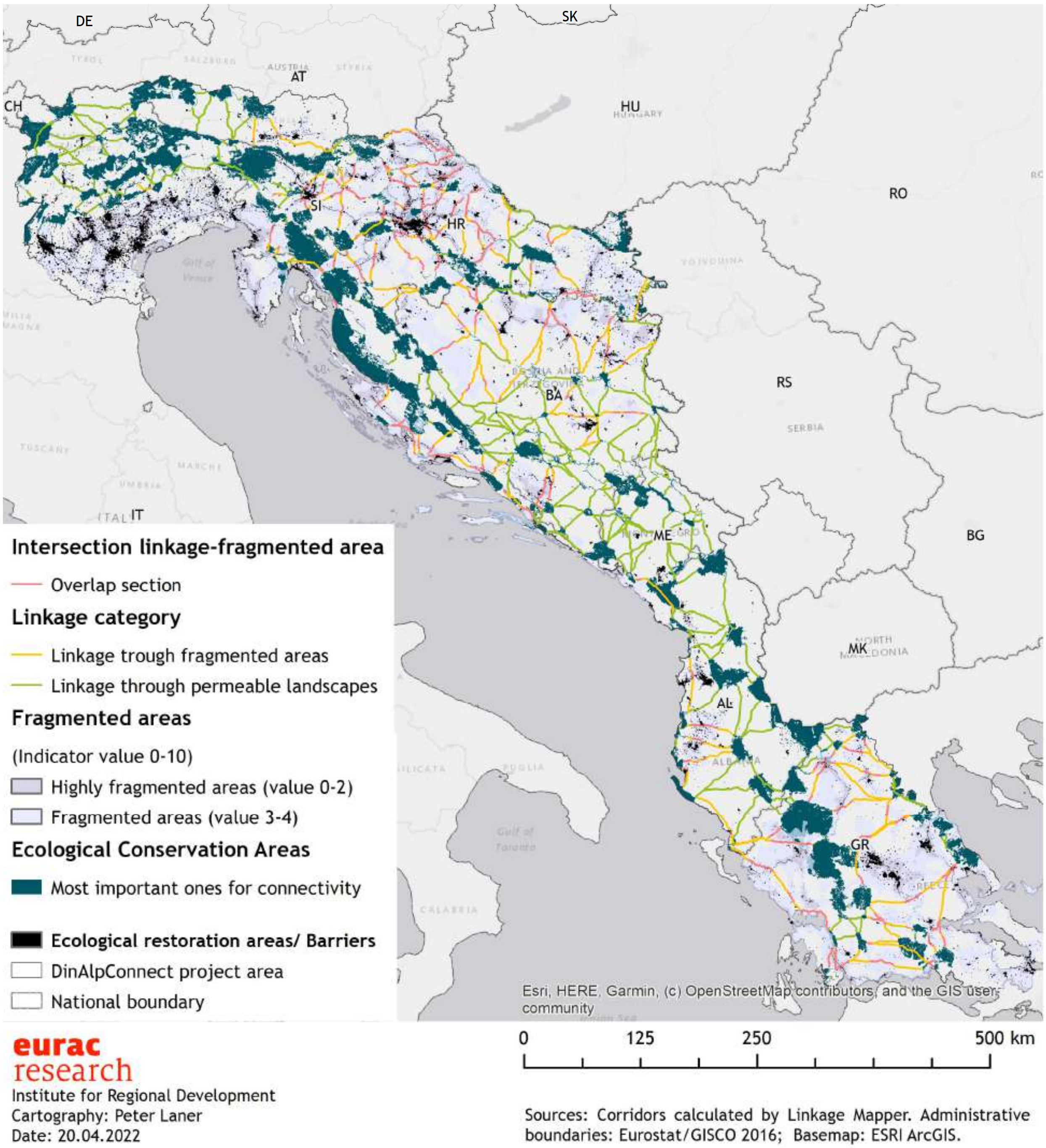


Figure 29: Intersection of linkages and fragmented areas

Intensive agriculture:

To reveal the linkages, with most impeding agricultural areas, agricultural land use categories were filtered from the Corine Land Cover Dataset, which indicate intensive cultivation that might disturb ecological connectivity. Basically, each category of arable land and permanent crops were selected and “Heterogeneous agricultural areas” were partially included. Exceptions were made for the category 2.4.3 - “Land principally occupied by agriculture, with significant areas of natural vegetation”, category 2.3.1 - “Pastures”, and category 2.4.4 “Agro-forestry areas”. Within the Continuum Suitability Index, they have a land use value more than 4 and are thus more permeable. It should be noted that pastures were evaluated with a CSI of 5, but they can include “permanent grasslands under strong human disturbance” (EEA 2019).

The best paths of the linkages were intersected with intensive agricultural land to reveal which linkages are facing barriers of agricultural practices. To simplify the analysis, linkages with a cumulative distance through intensive agricultural landscapes of less than 500m were not considered.

Project partners from Slovenia stated, that many agricultural land properties are very small. The local situation is very difficult to localize on a macro-regional level. Therefore, it is important to make further investigations on the local implementation level for each linkage. Project partners from Croatia confirmed, that in their country mostly there is a lack of grazing and most of pastures are not intensively grazed. Therefore, the assumption to exclude pastures as “intensive agriculture” is reasonable. Partners from Bosnia & Herzegovina confirmed, that in the north of the country agriculture is more intensive than in the south. For Montenegro it was confirmed, that in mountainous areas, extensive farming is pursued.

A small bias could be present in Greece, where overgrazing is a problem, also around and within protected areas. Especially for linkages around Pindus National Park, pastures could be considered as intensively used instead of excluding them from the analysis.

The result shows, that almost half of the identified linkages (197 linkages) are passing through intensive agricultural areas. This shows the high relevance of suitable agricultural practices for the maintenance of ecological connectivity. The intersections of agricultural land uses were mapped and now it is possible to interact in specific areas.

However, it is difficult to make further assessments based on geographical data, because also small passages through intensive agricultural areas can be blocked. The situation of ecological connectivity must be further investigated in details on pilot area level. For example, further investigations on grassland restoration and preservation suitability in agricultural practices were made for most of the pilot sites in this project.

Intersections of linkages with intensive agricultural land uses

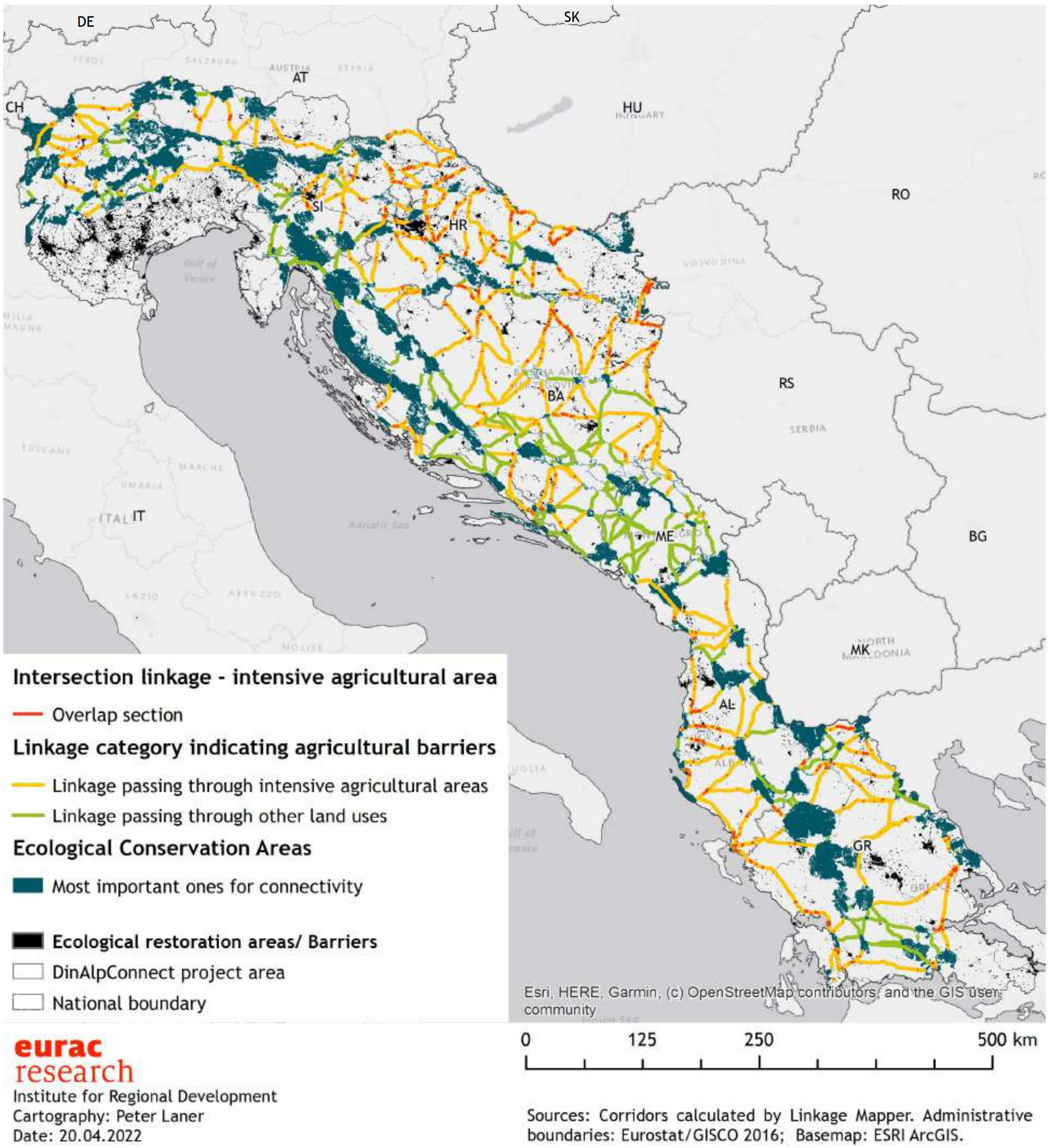


Figure 30: Agricultural barriers

Renewable energies:

Installation of infrastructures for renewable energies like hydropower installations, wind farms, solar panels, and photovoltaic panels (PV) installations in mountain areas of Greece are an upcoming problem for ecological connectivity in Greece. The amount of existing and upcoming installations in Greece is significant, as the geoportal of the Regulatory Authority of Energy (RAE 2022) shows. Recent studies also show an inventory on "anthropogenic barriers to longitudinal river connectivity in Greece" (Panagiotou et al. 2022).

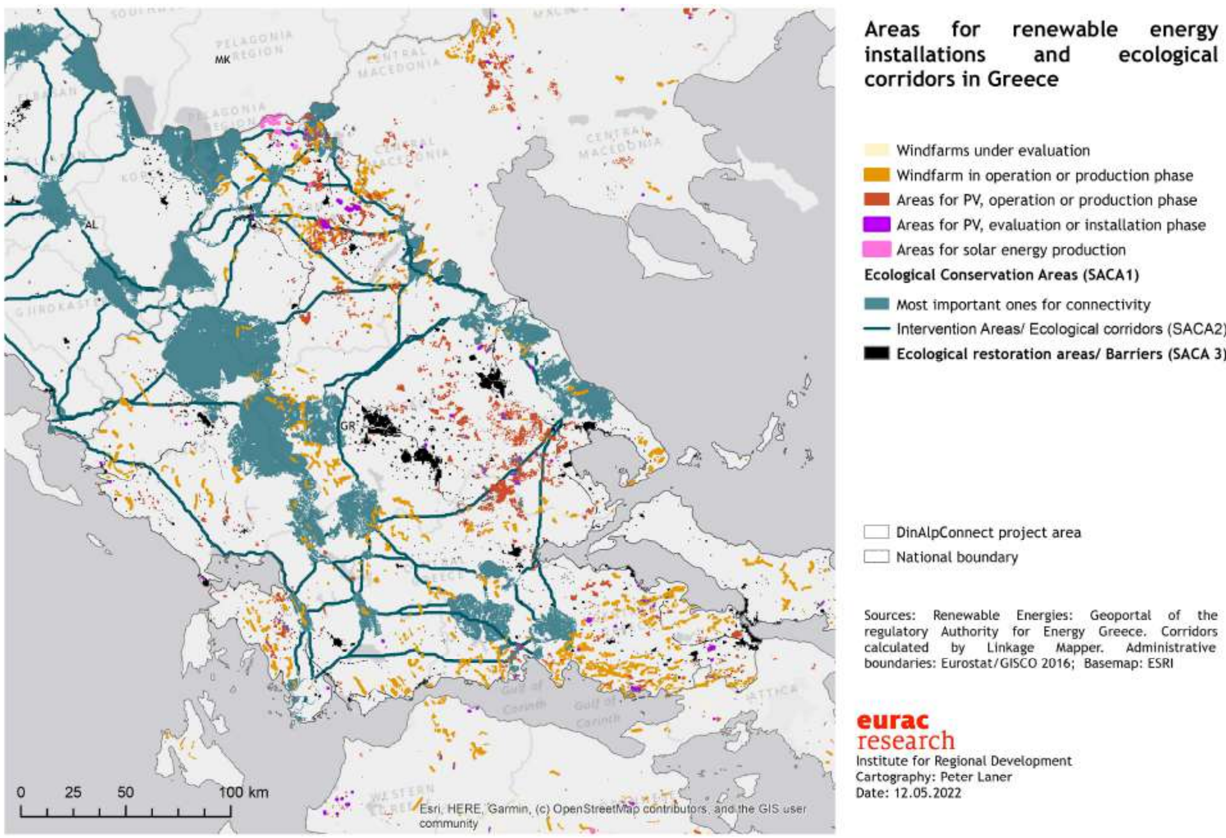


Figure 31: Areas for renewable energy installations in Greece

Additional analysis on “long distance corridors”:

Corridors longer than 50 km are less probable to be “realistic” according to the project consortium and thus were classified as long-distance corridors.

In total 76 long-distance corridors were identified, of which 17 corridors have a high biological value. They are often passing through protected areas, which might be an opportunity, as an existing conservation effort already exists.

Croatia: Long-distance corridors in Croatia are mostly passing through steppingstones (less important Ecological Conservation areas). Thus, they represent possible and important connections, which should not be neglected for further implementation of connectivity measures.

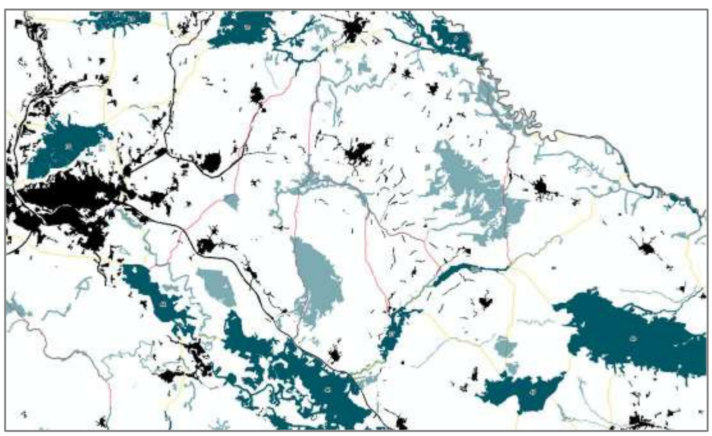


Figure 32: Long-distance corridors in Croatia with steppingstones

Bosnia: Long distances between Save river in the north and the southern part of Bosnia are not passing through steppingstones. Therefore, it is important to give them a width of more than 2 km, when it comes to concrete implementation.

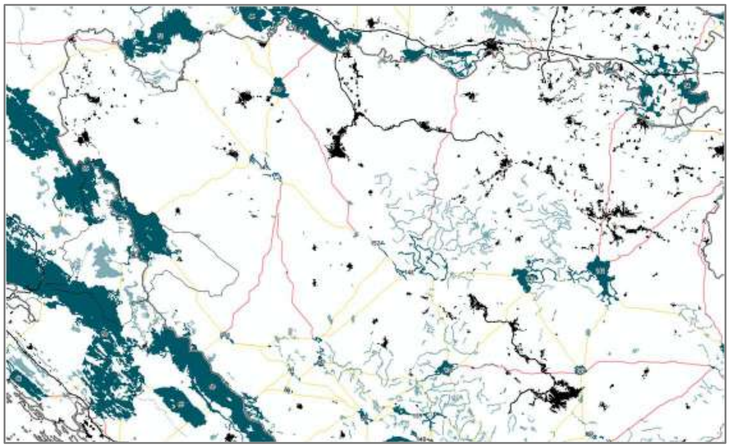


Figure 33: Long-distance corridors in Bosnia without steppingstones

Albania: Protected sites at the coast are far from those in the mountainous region of Albania. Most of the long-distance corridors in Albania are revealed in this sort of transition zone. Cities between the coast and the mountain range represent the main barriers for these linkages.

Greece: Linkages of long distances exist between the central mountain range and the protected areas on the eastern and western coastline.

4 Transboundary pilot regions

4.1 Albania -Greece

The analysis on grassland preservation suitability in Albania – Greece revealed a diverse picture.

Many of the grassland patches are bigger than 10 ha and are therefore suitable for connectivity. While the accessibility and the presence of small settlements is given, the distance to water sources seems to be an important factor for farming activities. The socioeconomic factors revealed that, despite the population is in a stable condition, livestock is changing strongly. In Greece there is a clear trend from sheep and goats towards bovine with a shrinking livestock equivalent unit. This can be also observed in the municipality of Kolonje (AL), while in Permet livestock numbers are growing over the last 10 years.

The result shows high suitability along the Vjose – river, in the mountain range Vikos and in the national park Piskal-Shqeri. A low suitability is present on the south-western hillside of the Vikos river, despite it would be a big continuous grassland patch.

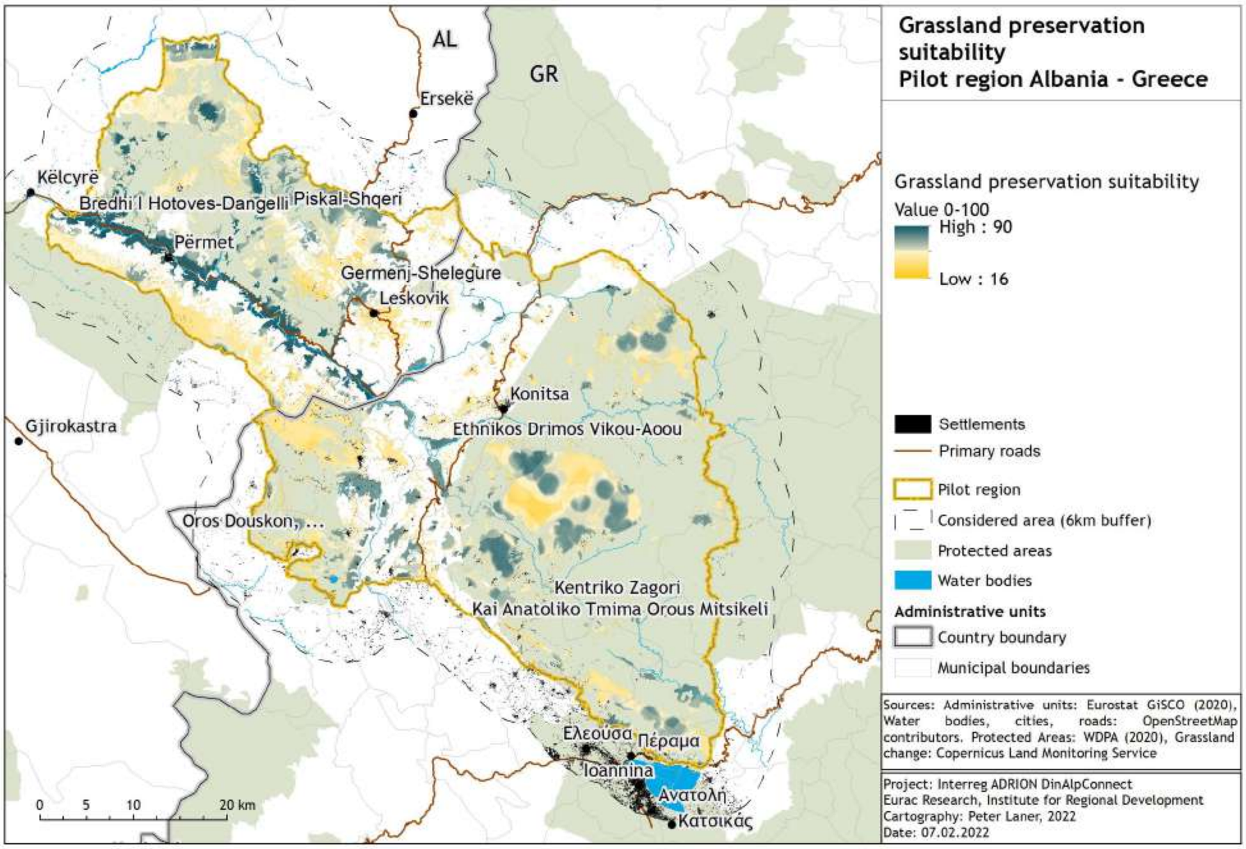


Figure 34: Pilot region Albania – Greece, Grassland preservation suitability

On the Albanian side, we can find unstable grassland conditions in the nature park Piskal Shqeri by overgrowing grassland, while in the north of this area, at the border of the pilot site, grassland is overgrazed. Around Leskovik, many grassland areas are in phase of overgrowing, and between Piskal and Leskovik many grassland areas are in an unstable condition with alternating overgrazing and overgrowing areas.

In Greece, most of the grassland is in stable condition. Around the town of Konitsa, there are unstable grassland conditions with overgrowing and overgrazed areas. Strong overgrazing is present around Kavasila (between Konitsa and Albanian border). Overgrazing and strong overgrazing is also present at the Eastern side of the pilot site, in the Greek National Park Ethniko Parko Pindou, between the villages Distrato and Samarina.

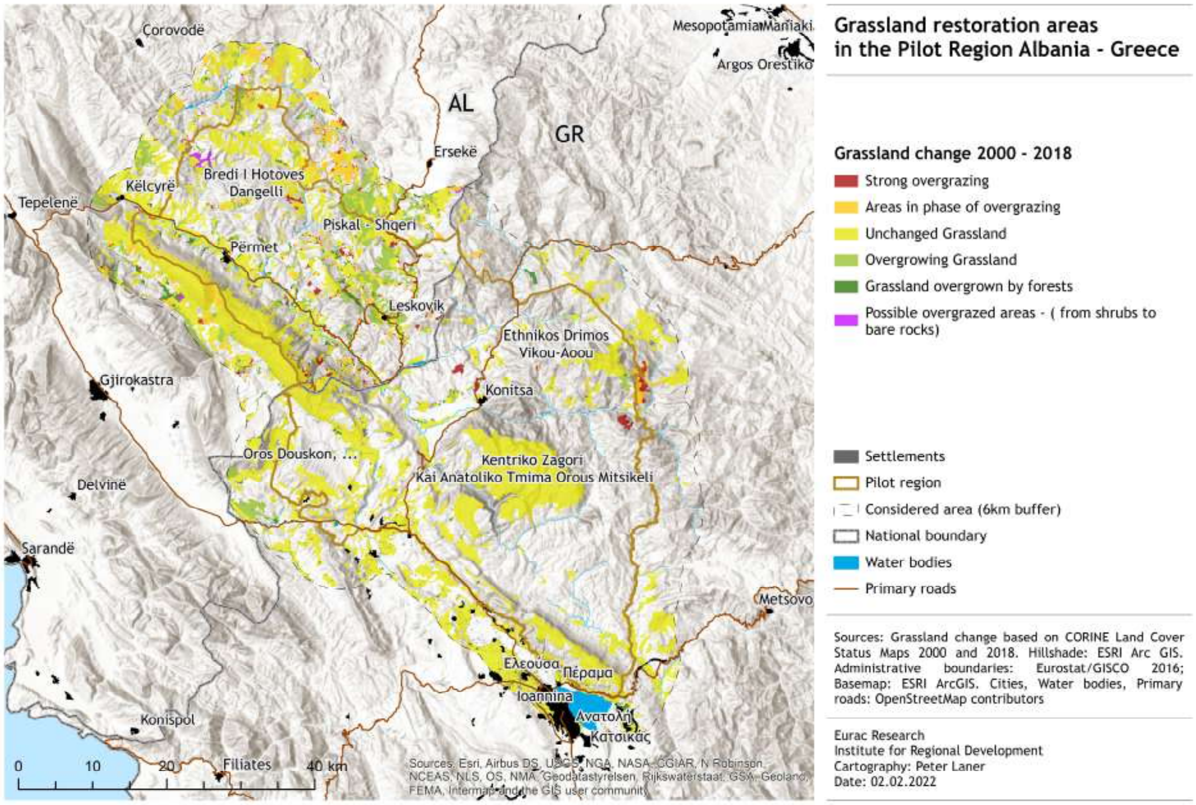


Figure 35: Pilot region Albania – Greece, Grassland restoration areas

4.2 Croatia - Bosnia & Herzegovina

The analysis of different factors for preservation and restoration of grassland areas in the pilot region Croatia – Bosnia & Herzegovina revealed favourable and hindering conditions. In the interpretation, these factors were combined with the ecological corridors revealed in the macro -regional model.

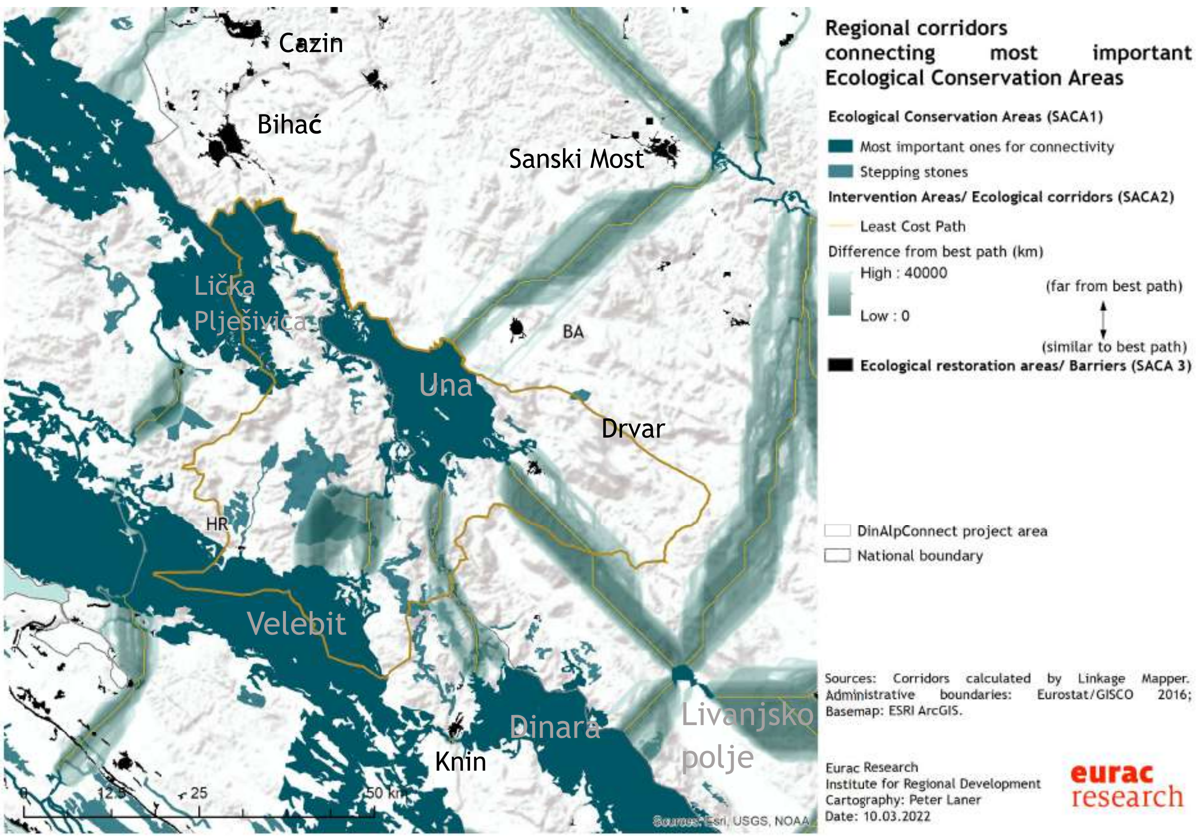


Figure 36:Ecological corridors and ecological conservation areas in the pilot region HR-BIH

Favourable conditions for grassland preservation

- In the pilot region there are large continuous grassland patches, also in mountainous and more steep areas, which is advantages for ecological connectivity.
- From a socioeconomic point of view, the numbers of farms are increasing, probably because of the return of former inhabitants after war in the 90ies. This can be interpreted as a good indicator, that agriculture will be maintained.

- The dense road network guarantees accessibility to grassland patches and don't seem to be a hindering factor.

Risk factors for grassland preservation:

- On one hand, in the municipality of Bihac, there is a strong decrease of livestock, which might bring the risk of grassland loss and overgrowing. On the other hand, there is a strong increase in Gračac, which brings the risk of overgrazing. In Drvar and Donji Lapac, there is a slight increase of livestock, and the development seems to be equilibrated.

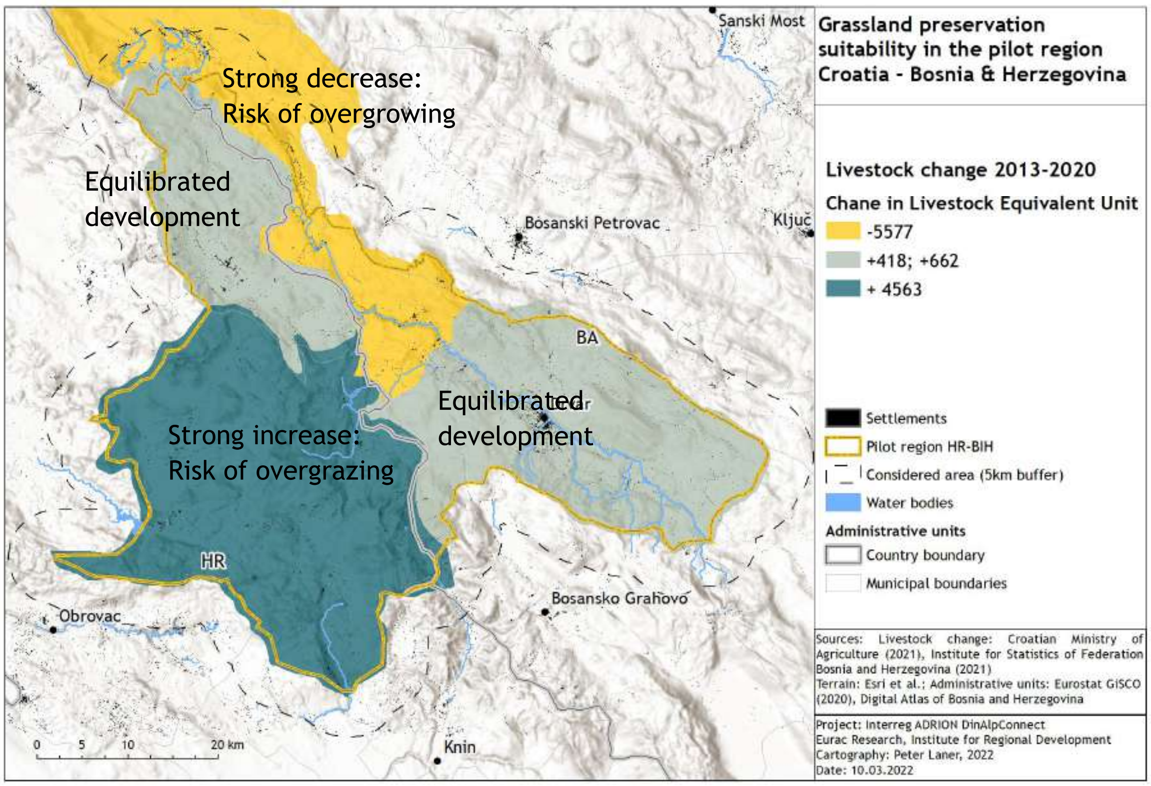


Figure 37: Livestock change 2013-2020 in the pilot region HR-BIH

- The reduced water resources in the pilot region seem to be a very limiting factor for the maintenance of livestock. However, such detailed water infrastructure couldn't be integrated in this GIS analysis. Thus, there is a need to discuss whether artificial water pipes for agriculture can meet the demand for water in the pilot region.

- In general, the scattered settlement structure brings the risk that livestock is competing with wildlife animals. This risk especially occurs on the important ecological corridor between national park Una and nature park Velebit, around the protected area of Lisac. Additionally, the strong increase of livestock brings a risk of overgrazing on this corridor.
- Some areas far away from settlements and farms are present in the pilot region, which could bring the risk of overgrowing.

Proposals for action plan:

In general, agricultural activities along the border should continue because there are many important ecological areas and corridors along the border, especially on the corridor connecting Una national park and the Natura 2000 site Dinara.

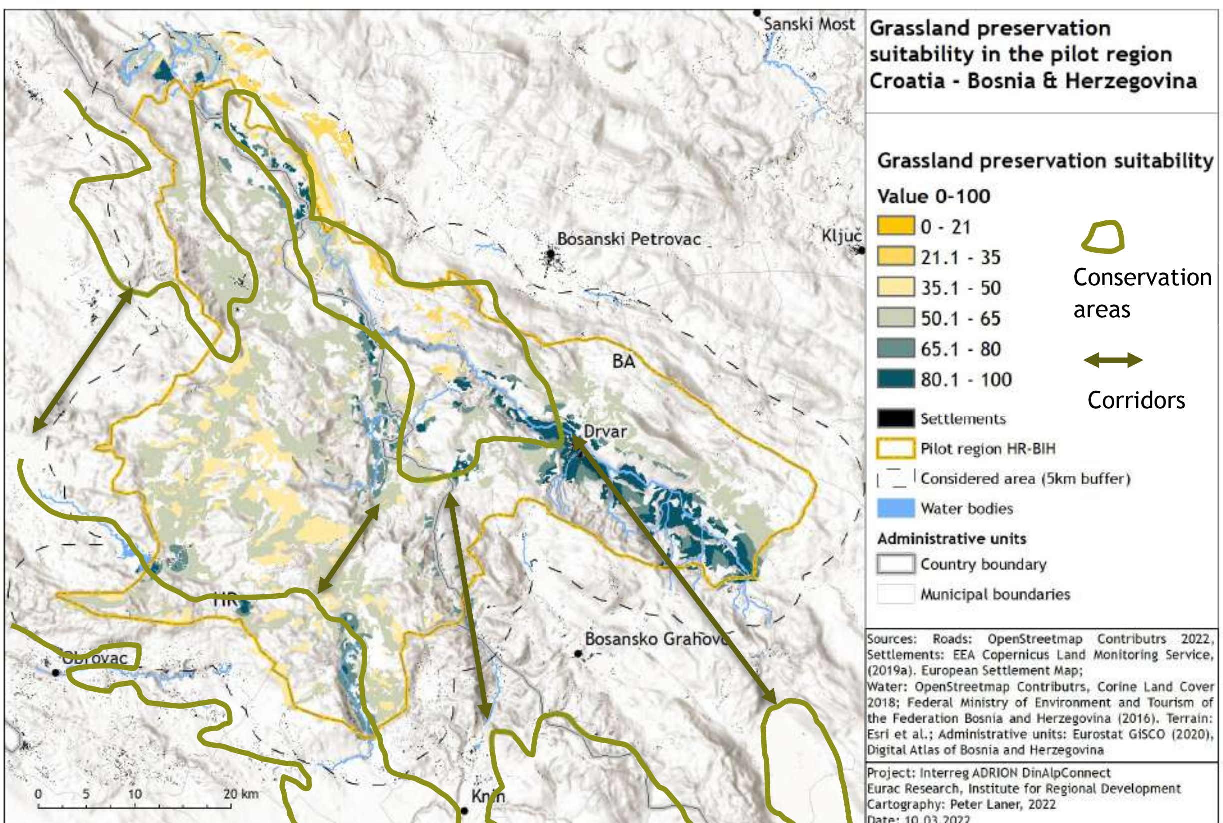


Figure 38: Grassland preservation suitability in the pilot region HR-BIH

- Municipality Drvar & Donji Lapac:
  In the municipalities of Drvar and Donji Lapac, areas in phase of overgrazing and areas in phase of overgrowing are alternating. A solution might be, that

the municipalities could restore the overgrowing grassland areas and to re-distribute livestock among restored grassland areas to avoid overgrazing. This could contribute to the maintenance of the original extension of grassland areas.

- Municipality Gračac:
  In the municipality of Gračac, the strong increase of livestock is leading to overgrazing. The grassland change map is showing this development especially in the western part of the municipality. Measures to counteract this development should be discussed.
- Municipality Bihac:
  Bihac has lost grassland areas from 2000 to 2018, which are now overgrown by forests and a lot of areas are still in phase of overgrowing. This is caused by the strong livestock decrease and socioeconomic factors, although some grassland areas are high suitable for farming activities. Solutions to maintain grassland should be linked to the socioeconomic situation of farmers.

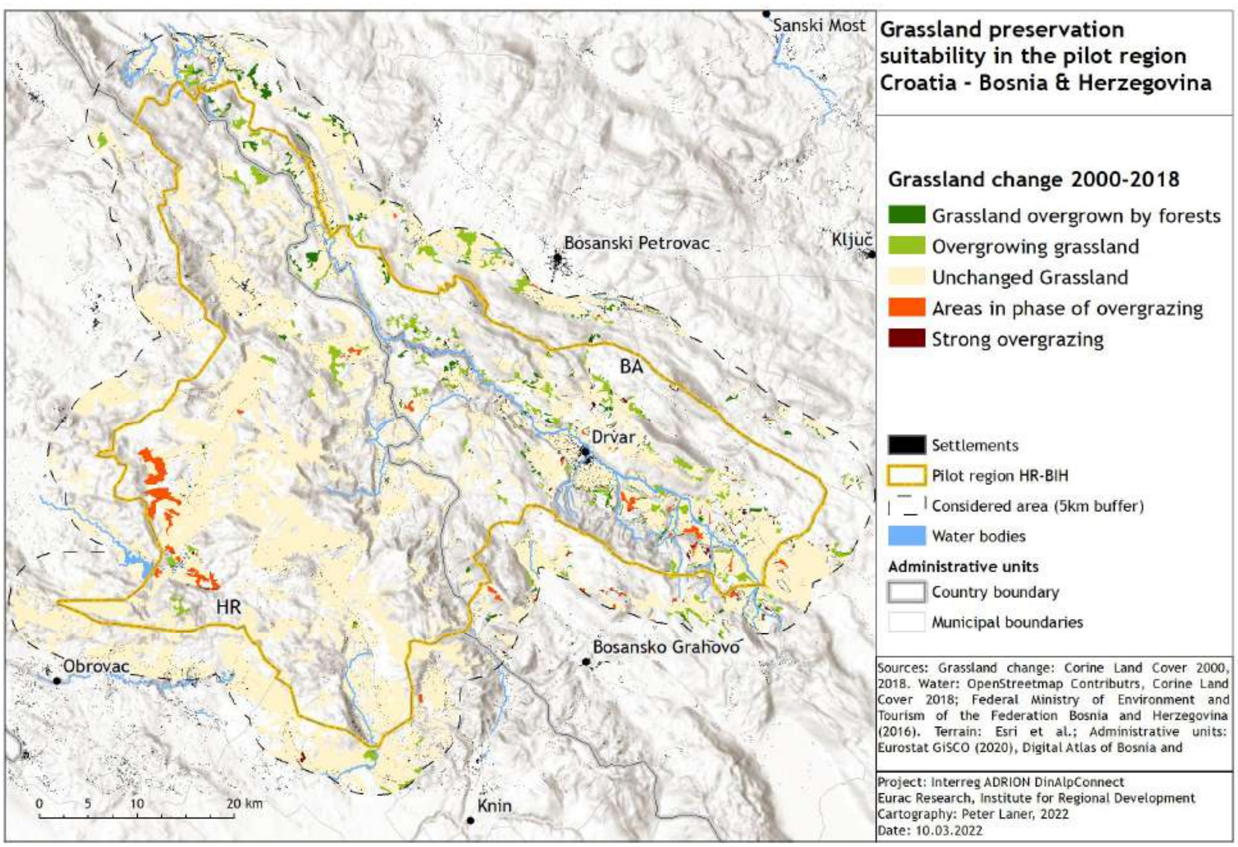


Figure 39: Grassland change 2000-2018 in the pilot region HR-BIH

4.3 Slovenia – Croatia

The Pilot region Slovenia-Croatia encompasses several Natura 2000 sites, two in Slovenia (SPA - SI5000023 Kras; SCI - SI3000276 Kras) and three in Croatia (SPA - HR1000018 Učka i Ćićarija; SCI - HR2000601 Park prirode Učka, HR2001304 Žbevnica). In all SCI sites, the habitat type 62A0 Eastern Sub-Mediterranean dry grasslands (Scorzoneratalia villosae) is a target habitat type and it needs to have a favourable conservation status in each Natura 2000 site (Art. 6., Habitat directive).

The favourable status is based on the habitat’s representativity, relative surface to the national territory, degree of conservation of its structure and function, as well as its restoration possibilities. Most of these parameters are based on the interpretation of available data through expert judgement.

Since the Pilot region is facing problems of depopulation in rural areas, land abandonment and lack of interest in sustainable agriculture, the once widespread grasslands are being reclaimed by the surrounding forest. Although the conservations status in SI3000276 Kras and HR2001304 Žbevnica is favorable, in time it will decrease as the sites are likely to lose large areas of the target habitat due to succession. Habitat loss of grassland consequently will lead to fragmentation, which will speed up this process and lower the overall biodiversity of the area. This will have an impact on a large number of species, many of which are target species of these 5 Natura 2000 sites.

Moreover, every member state must define conservation measures for target species and habitats and for the Croatian SCI sites in the Pilot region SLO-CRO, these are as follows:

- Conserve 2.330 ha of existing areas of the target habitat (62A0) and increase the target habitat area by 200 ha (HR2000601 Park prirode Učka).
- Conserve 3.800ha of suitable habitats (grasslands, forest edges) for the target species Euplagia quadripunctaria (HR2000601 Park prirode Učka).
- Conserve existing areas of the target grassland (62A0) where it forms complexes with other habitats (1.55ha) and where it is the sole habitat type (35 ha).

- Conserve 190 ha of suitable habitats (open rocky grasslands with deep soil) for the target species Serratula lycopifolia.

The grassland preservation suitability showed that many grassland patches are >10ha and therefore suitable for ecological linkages. On the Slovenian part, the fragmentation of grassland areas is much higher than in the Croatian part. An important factor seems to be the socioeconomic factors. The northernmost municipality (SI) and the municipalities at the national border on the Croatian side are faced a strong decrease in livestock over the last 10 years. The Slovenian municipalities Sežana (SI) has a strong decrease in number of farms. This leads to a low suitability for farming. Distances to farms, roads and water availability are minor problems in this pilot region.

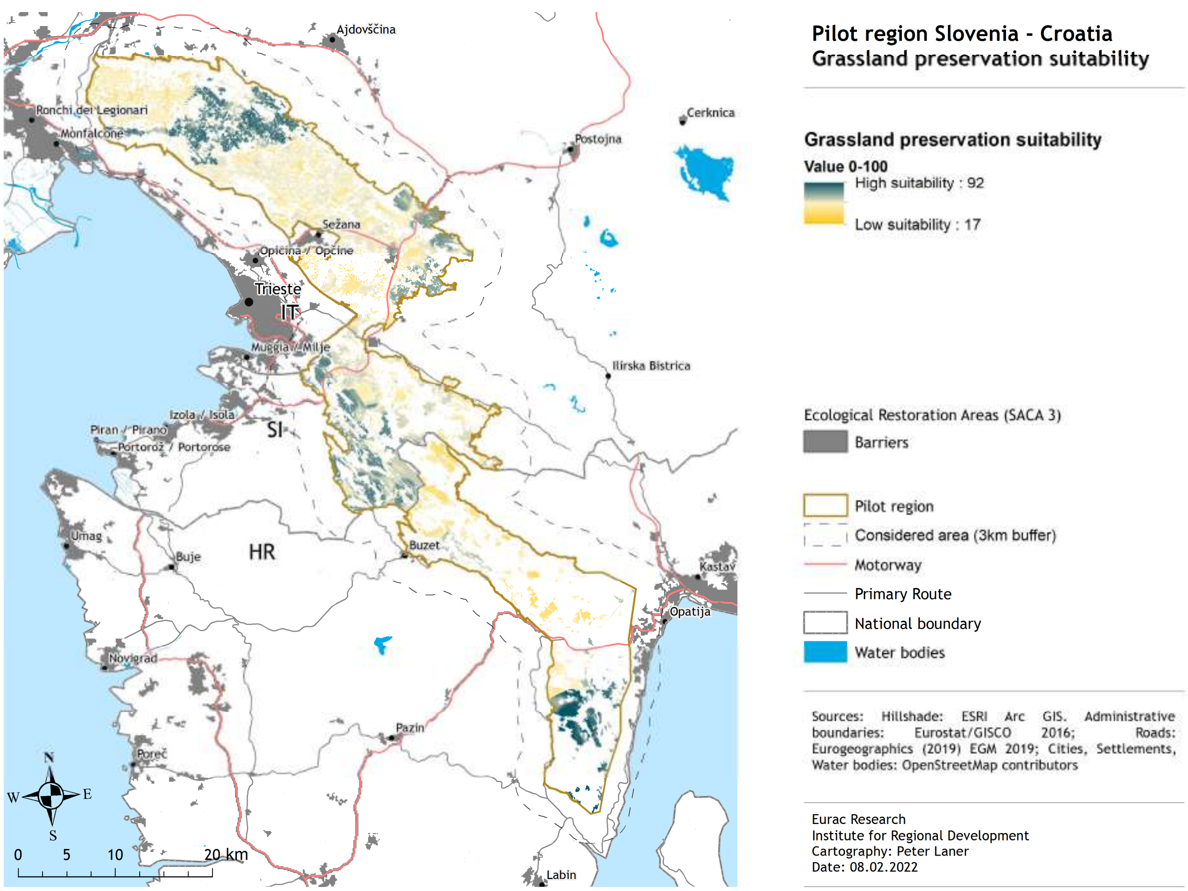


Figure 40: Pilot region Slovenia - Croatia, Grassland preservation suitability

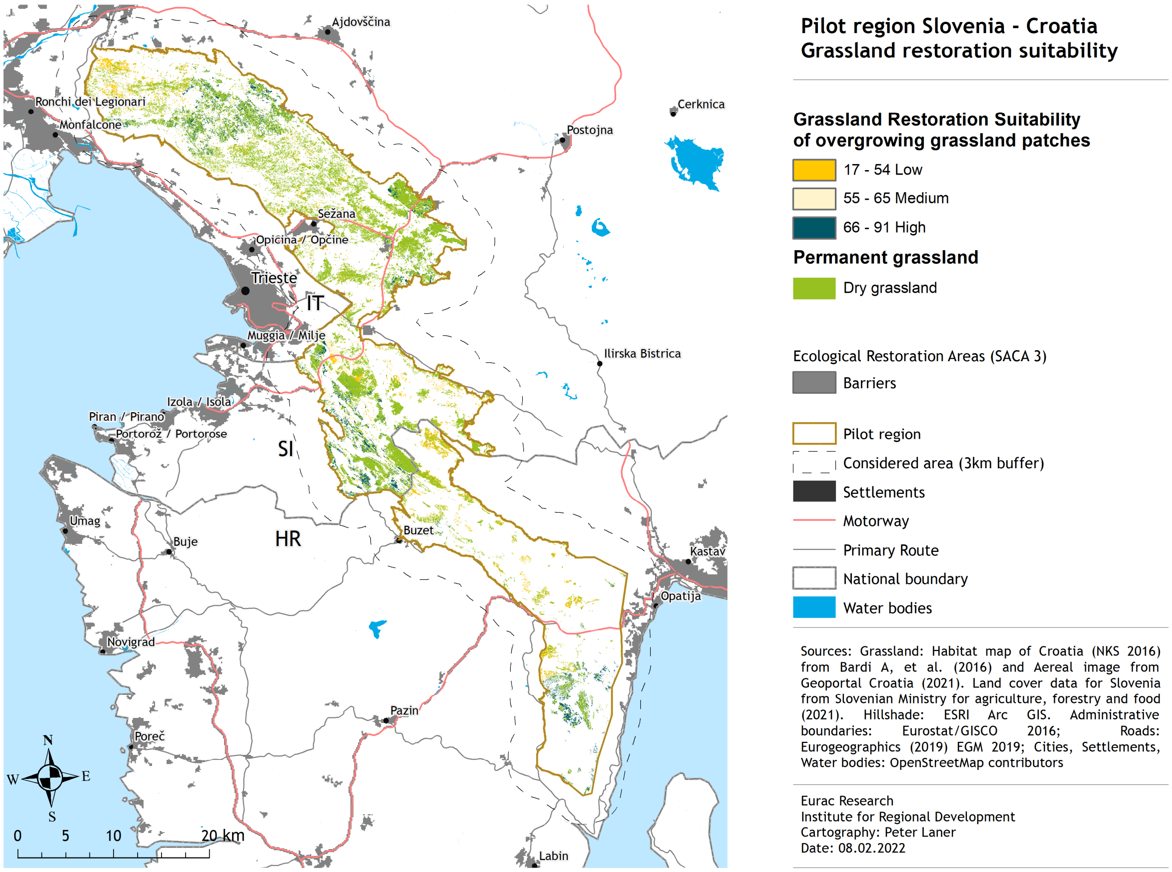


Figure 41: Pilot region Slovenia - Croatia, overgrowing grassland areas, and suitability for restoration

The figure 44 shows permanent grassland patches, not in phase in overgrowing in green colour. Yellow to blue shows patches in phase of overgrowing. Big overgrowing patches can be found in the municipality Koper (SI), not far from Trieste, as well as in the southernmost and the northernmost part of the pilot region.

The analysis revealed, that especially at the national border (SI-HR) there are suitable areas for grassland restoration, also in the municipality Komen (SI), as well as in the southern part of the nature park Učka (HR). Grassland patches with low restoration suitability are present in Lupoglav (HR), in the middle of the Croatian part and in Miren-Kostanjevica (SI) at the northernmost part of the pilot region. It is questionable, if a continuity of grassland can be guaranteed by only restoring patches with high suitability for farming.

4.4 Italy - Slovenia

The analysis on three different wildlife species in the pilot region Italy – Slovenia revealed areas that represent suitable existing and potential habitats, potential and existing core areas and ecological corridors for these species.

This analysis can be used in different ways:

- The habitat suitability maps can be overlapped with existing population data to reveal potential expansion areas. They could be useful in the moment of selecting the most appropriate measures to sustain wildlife species' population expansion.
- The corridor maps serve to reveal where potential movements of species are possible and to implement actions for the mitigation of barriers.
- The analysis of core areas can be a basis for the identification of protection actions to counteract human disturbance.

4.4.1 Ibex

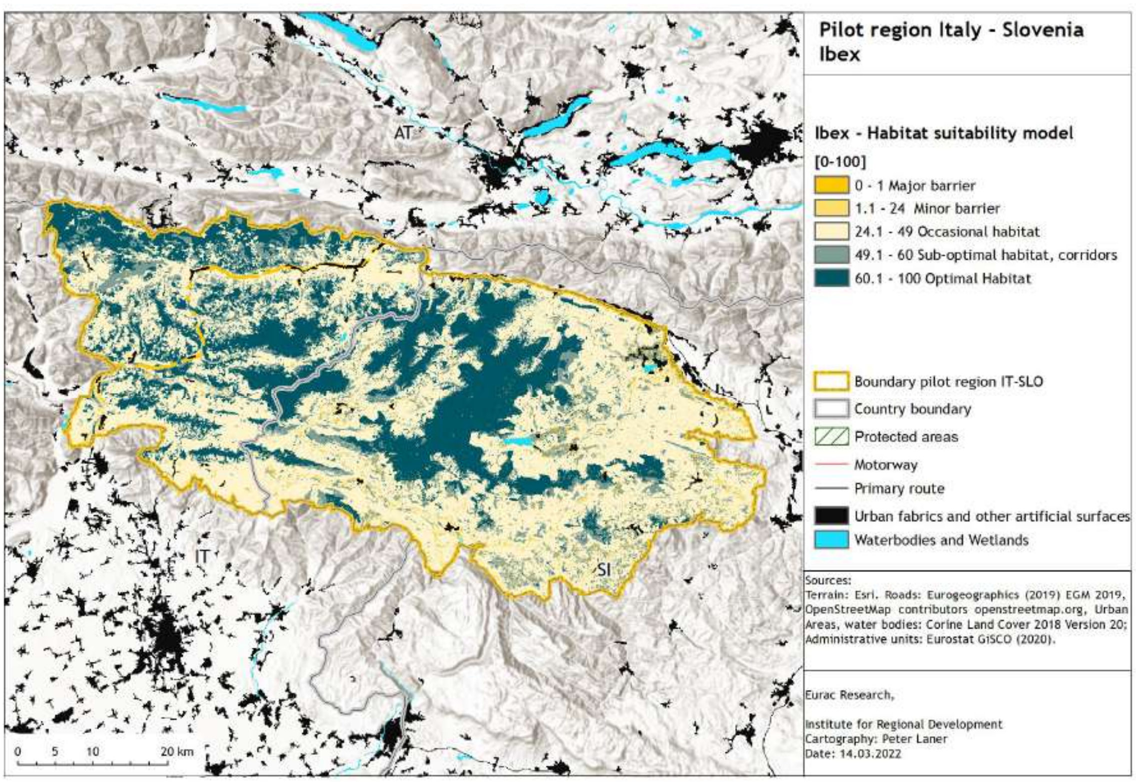


Figure 42: Habitat suitability model for ibex

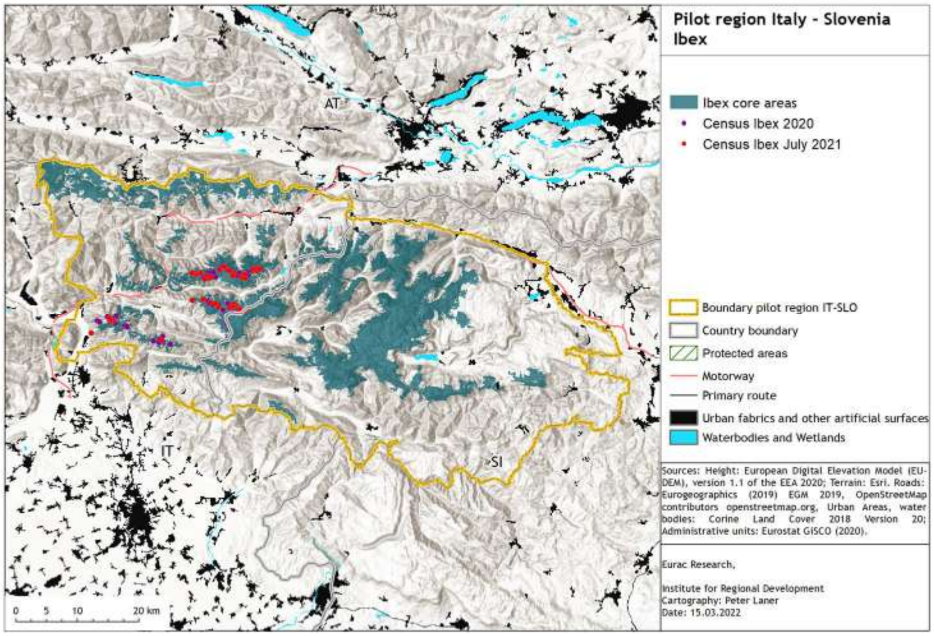


Figure 43: Core areas for ibex

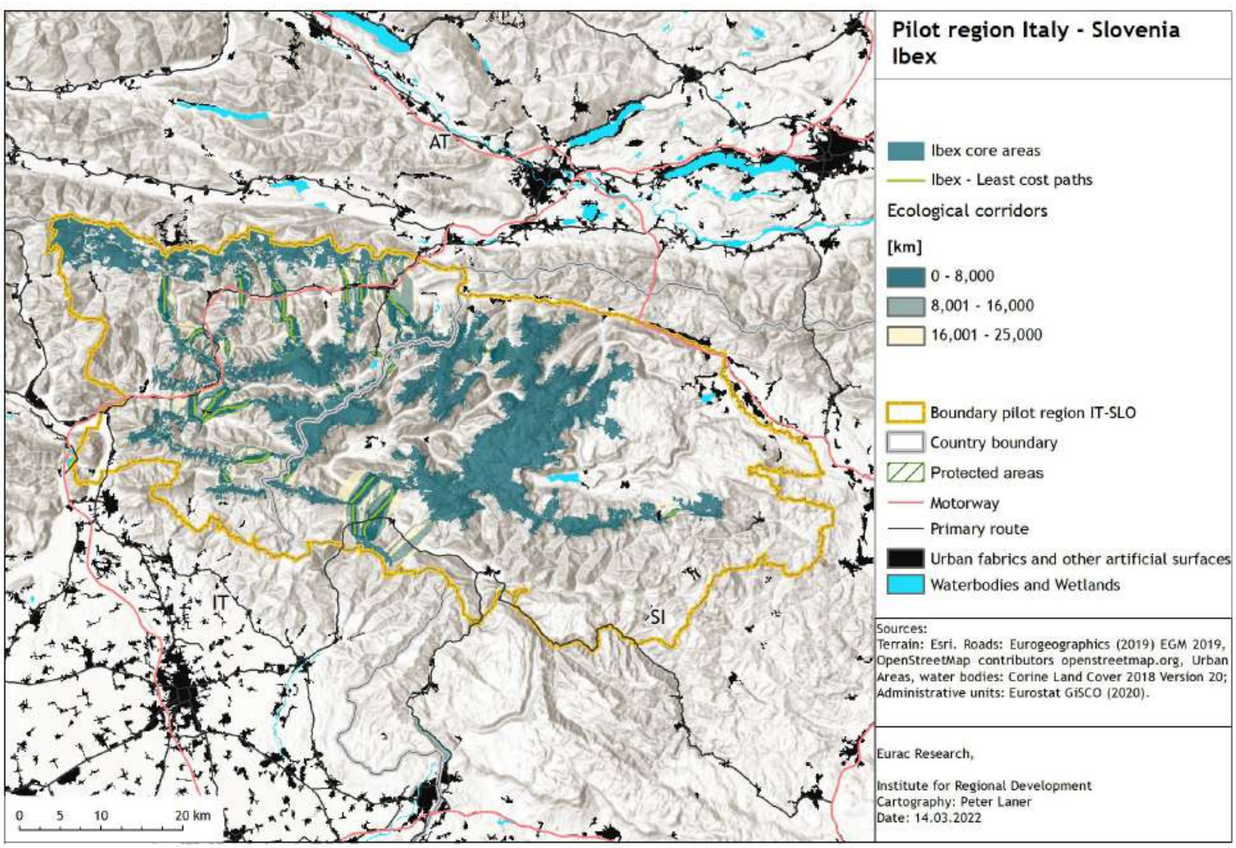


Figure 44: Ecological corridors for ibex

4.4.2 Chamois

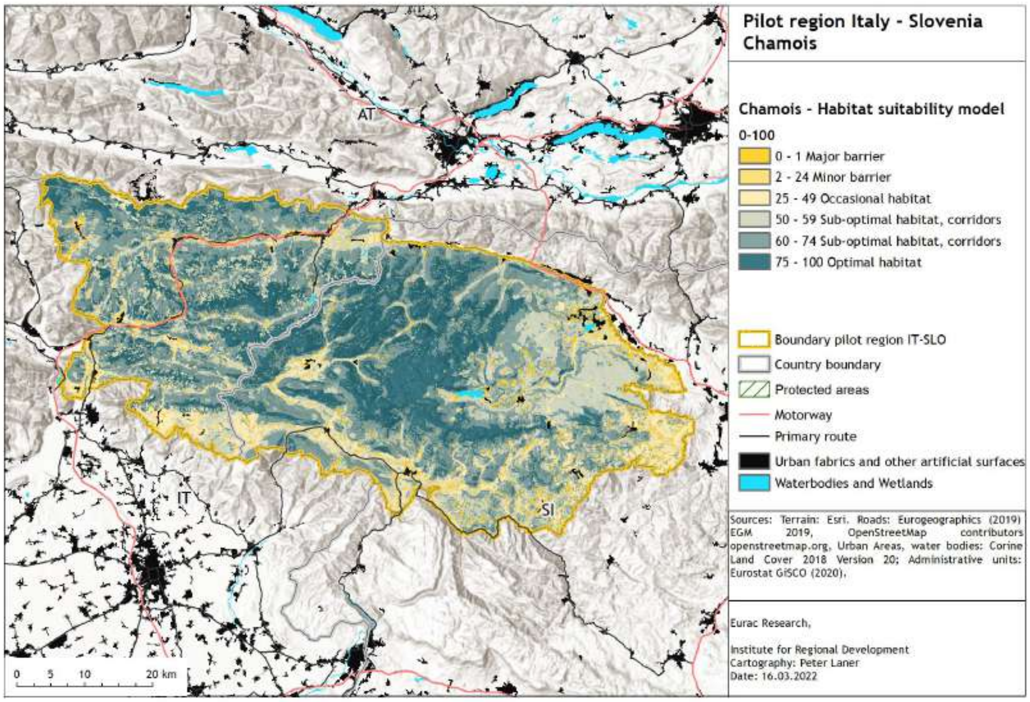


Figure 45: Habitat suitability model for chamois

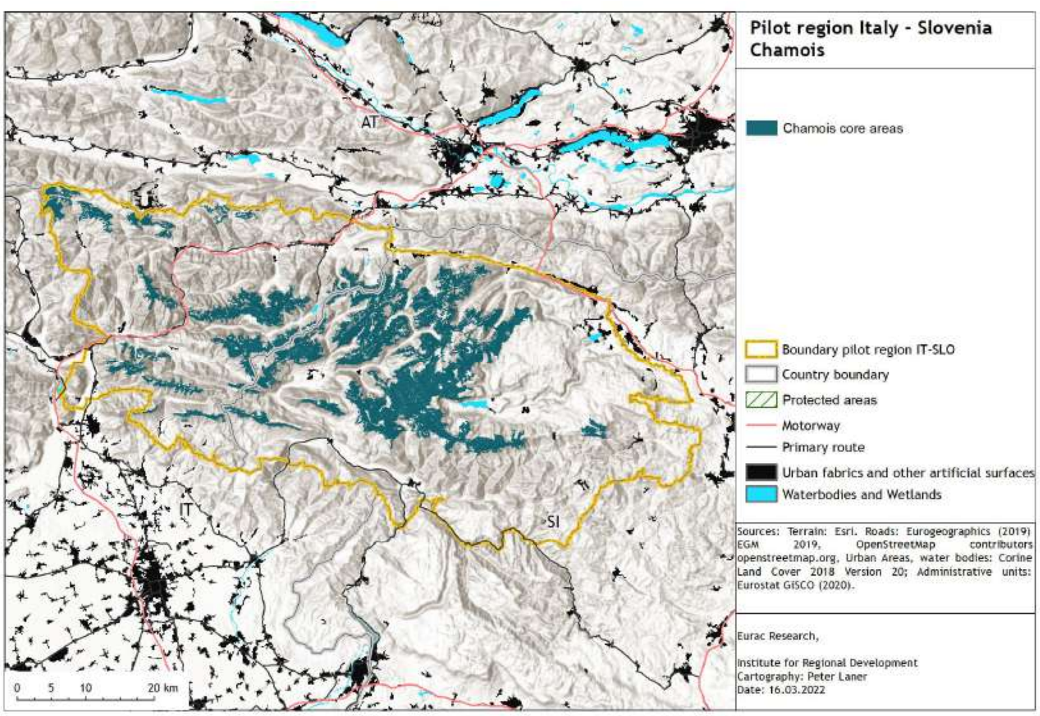


Figure 46: Core areas of chamois

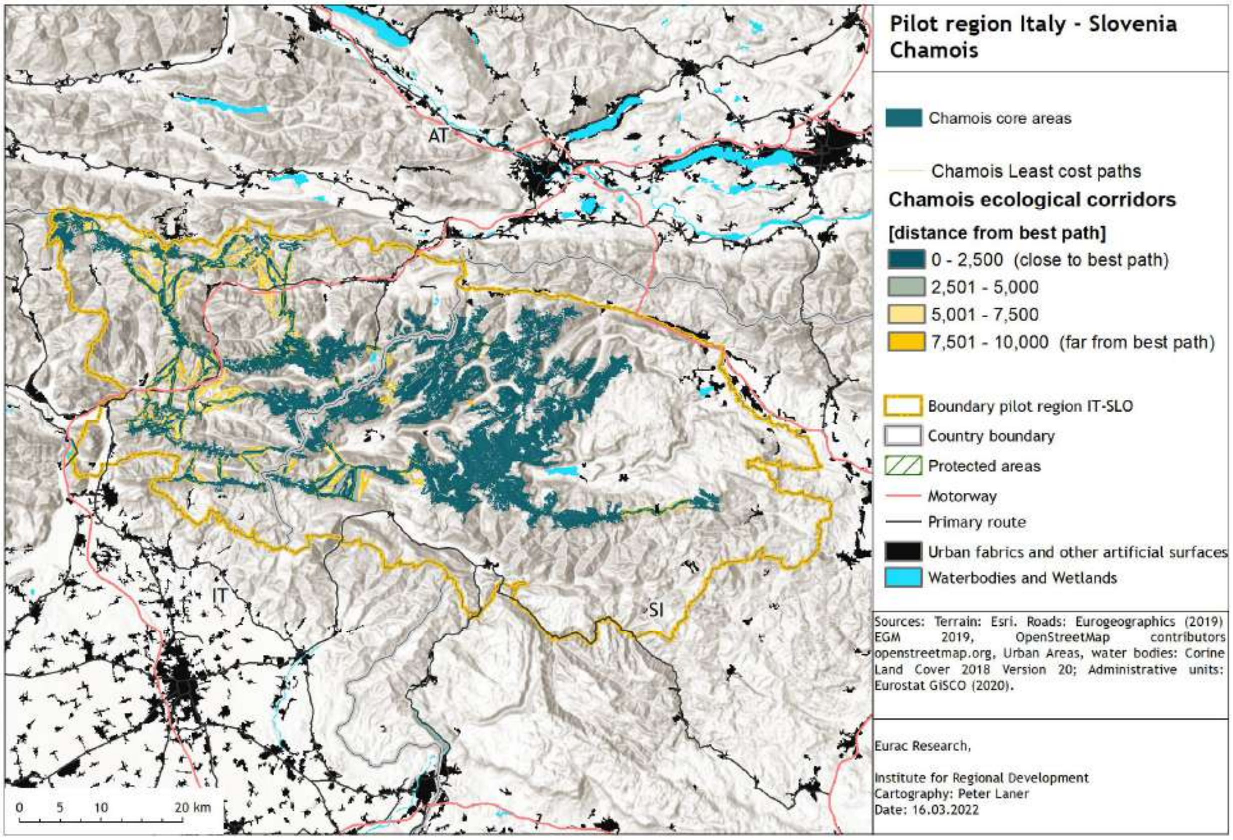


Figure 47: Ecological corridors for chamois

4.4.3 Capercaillie

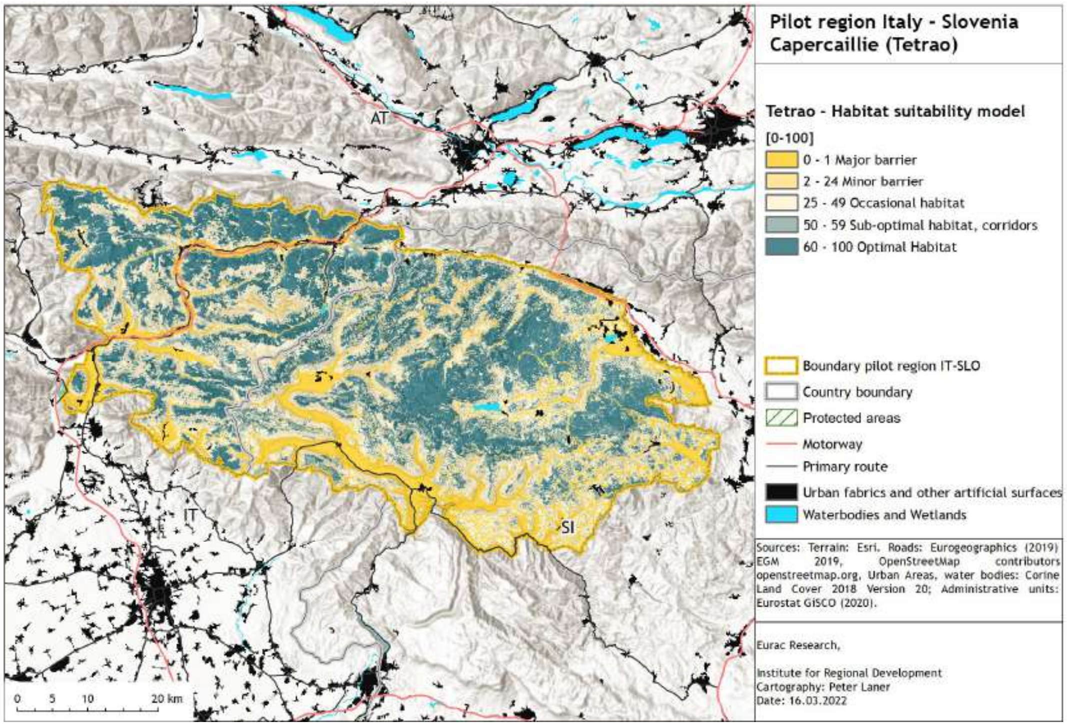


Figure 48: Habitat suitability model for capercaillie

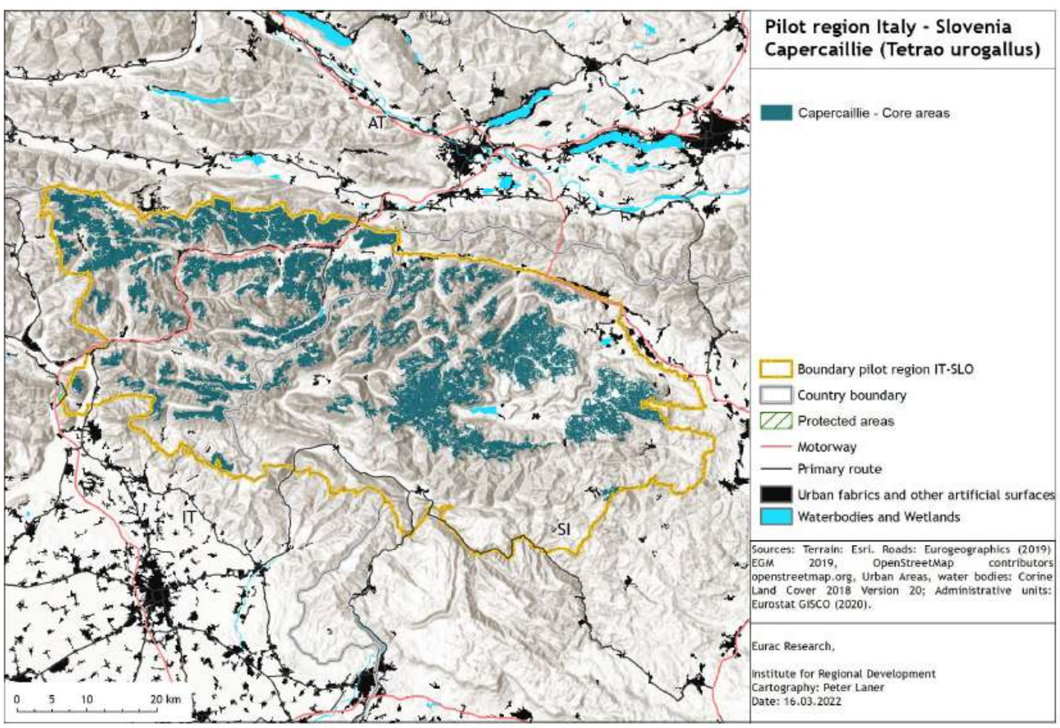


Figure 49: Core areas of capercaillie

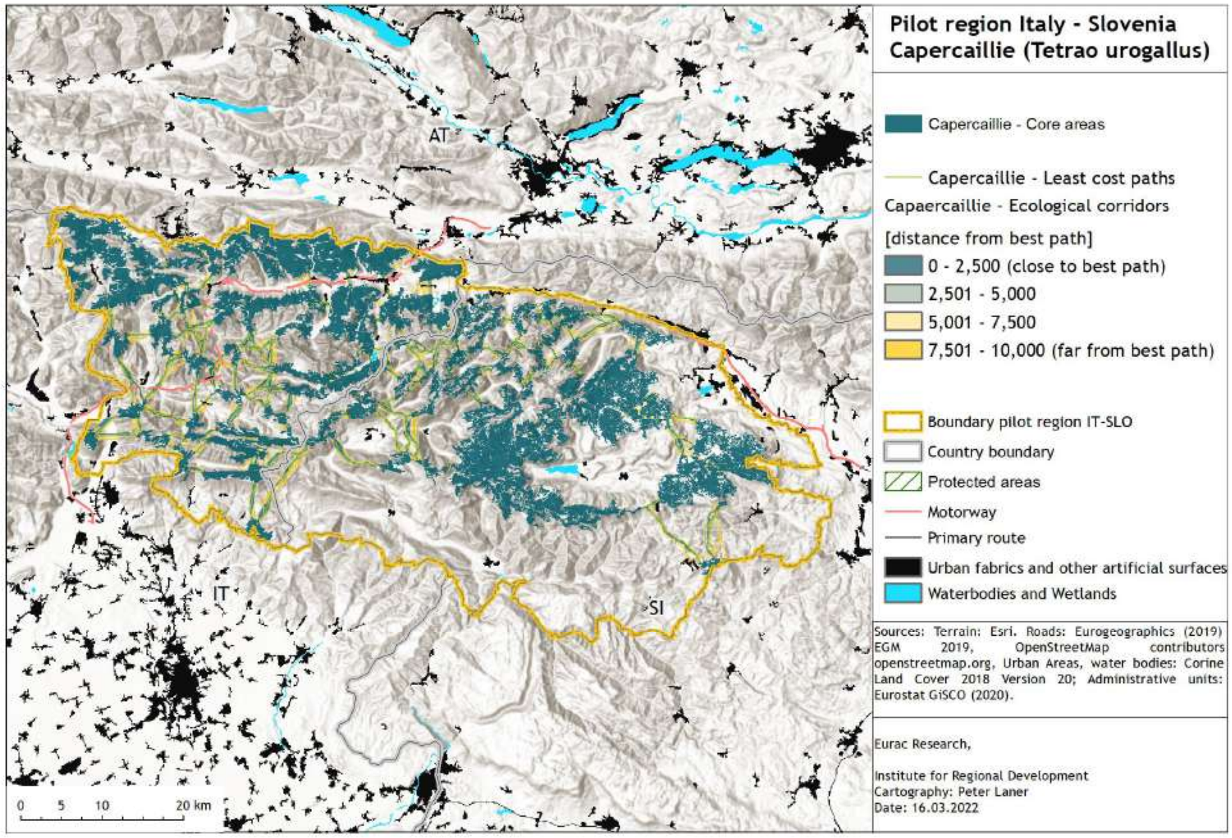


Figure 50: Ecological corridors for capercaillie

5 Conclusions for a strategy for EC in the Dinaric Mountains and connectivity with the Alps

For a macro-regional strategy, the presented analysis can be used by prioritizing measures for ecological connectivity. It should be focused on the selected Ecological Conservation areas (see chapter 3.3.1) and the prioritized corridors (see chapter 3.4).

In general, it seems that there are two groups of member states, which should focus on different types of strategic measures for improving EC:

1) Bosnia & Herzegovina, Montenegro, Albania:
   From the low percentage of protected ecological conservation areas, it can be concluded that the countries should protect additional ecological areas. To protect such areas would facilitate the country to follow a sustainable way when planning technical infrastructures for their further development, since these countries experience an infrastructural development. Planning of green infrastructure should be the priority.

2) Italy, Slovenia, Croatia, Greece:
   The part of these countries that are within the DinAlpConnect project area, should focus on the reduction of landscape fragmentation. These can be achieved for example by the establishment of green bridges or by safeguarding agricultural land and forested areas, to keep free open spaces for ecological connectivity. Italy should also consider the introduction of protected areas into valley bottoms, because many protected areas in high altitudes have difficult topographic conditions even for wildlife species.

This result shows the importance of the harmonisation of protection efforts for EU and non-EU member states.

The result of existing parts of protected areas that cannot be classified as ecological conservation areas (SACA1), revealed the high importance of measures to counteract landscape fragmentation. Furthermore, this shows the importance of a high protection status and the importance of suitable agricultural practices for ecological connectivity, that should be installed within protected areas.

For the macro- regional strategy of ecological connectivity between the Alps and the Dinaric mountains, it is important to focus on the Type 1 of the prioritization assessment. Around 40% of the linkages were identified with this high priority for conservation. Almost a quarter of the linkages are defined as Type 2. They have a small biological value, but they would have big potential for protection or restoration. Less than 10% of the linkages can be neglected because of their low biological value and the absence of threats or opportunities. 28% of the linkages have a high biological value, but they are currently not at risk, although not yet protected. However, this can change in very short times, as Slovenian project partners experienced in the past.

For the elaboration of the macro-regional strategy, it could be considered, that corridors of Type 1 and Type 4 with high biological values should be implemented at national level to give them a normative dimension. There is an urgent need that the important ecological linkages will be included in spatial plans to define them as real ecological corridor.

Type 2 and 3 could be important at regional level, especially linkages of type 2, which can have an ongoing conservation effort.

Three types of main barriers on the best paths of the linkages were analysed. 60 intersections with motorways were identified, that represent a real physical barrier. More than one third of the linkages are passing through highly fragmented areas. Most of these linkages can be found in Slovenia, Croatia, and Greece. A new upcoming infrastructural topic is the need of large areas for renewable energies, which could harm ecological connectivity, especially in Greece. Almost half of the linkages are passing through intensively used agricultural land uses. This shows the high relevance for suitable agricultural practices, that can maintain or restore ecological connectivity between the Alps and the Dinaric mountains.

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7 Annex

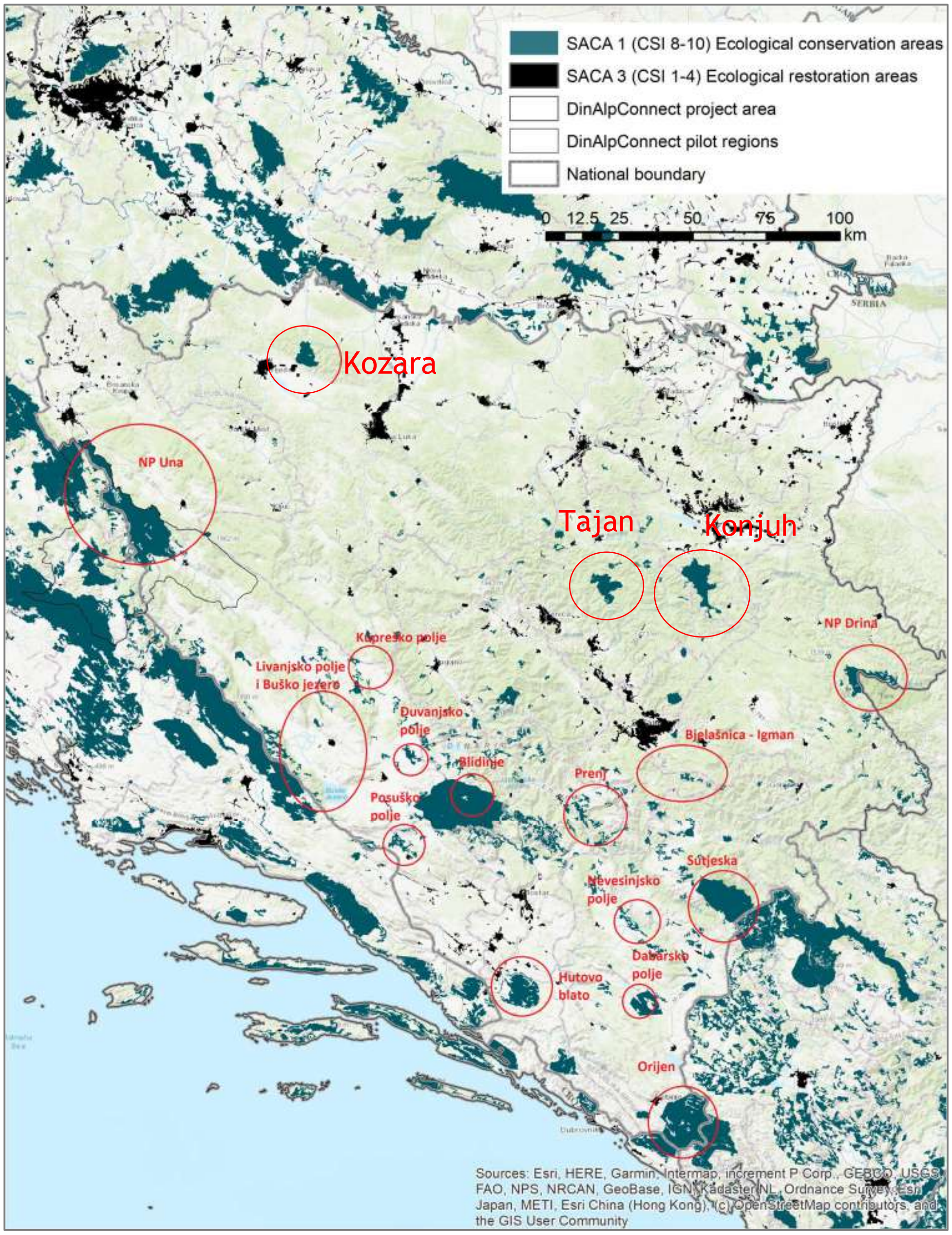

Figure 51: Selection of important ecological conservation areas (SACA1) in Bosnia & Herzegovina

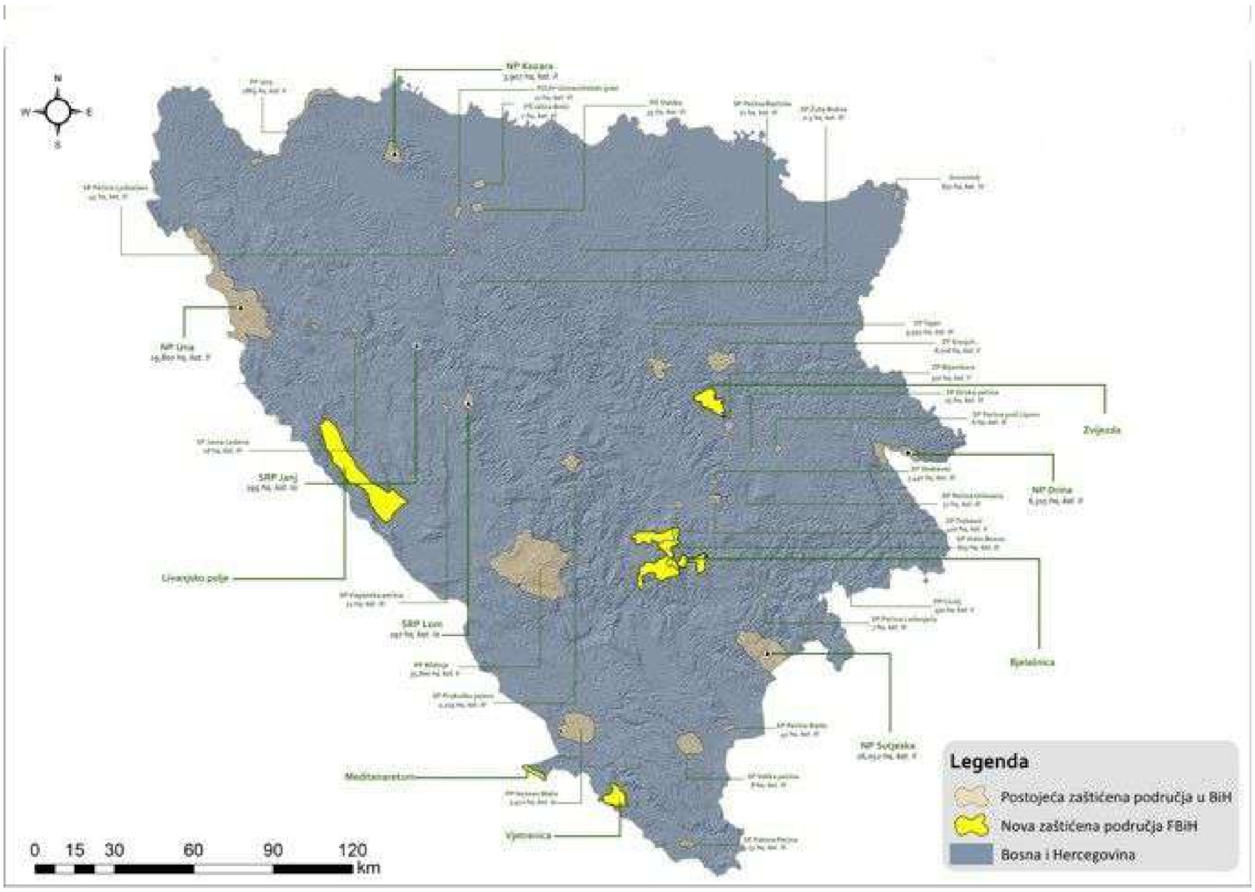

Figure 52: Potential protected areas in Bosnia & Herzegovina

Source: CENER21, Project: Achieving biodiversity conservation through creation, effective management and spatial designation of protected areas and capacity building, Client: UNEP