Interreg

Co-funded by the European Union

Alpine Space

PlanToConnect

Project of local ecological network - Alpine space

Mapping report identifying the GBI elements, barriers, connectivity measures in pilot areas

Activity 2.3 Case Studies 2nd step: To design a GBI network for connectivity across administrative boundaries or transnational cross-border areas in pilot sites

Reference in AF: D.2.3.1

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GLOSSARY

“Connectivity” (structural and functional)

“*Connectivity comprises two components, structural and functional connectivity. It expresses how landscapes are configurated, allowing species to move. Structural connectivity, equal to habitat continuity, is measured by analysing landscape structure, independent of any attributes of organisms. […]. Functional connectivity is the response of the organism to the landscape elements other than its habitats (i.e. the non-habitat matrix). This definition is often used in the context of landscape ecology. A high degree of connectivity is generally linked to low fragmentation*.” (EUROPEAN COMMISSION - Technical information on Green Infrastructure (GI), 6.5.2013, Glossary)

(Definition of connectivity see also Deliverable 1.1.1, chapter 8)

“GBI – Green and blue infrastructure”

“*Green infrastructure (GI) is a strategically planned network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services. It incorporates green spaces (or blue if aquatic ecosystems are concerned) and other physical features in terrestrial (including coastal) and marine areas. On land, GI is present in rural and urban settings*.” (EUROPEAN COMMISSION - Green Infrastructure (GI) — Enhancing Europe’s Natural Capital, 6.5.2013)

(Definition of connectivity see also Deliverable 1.1.1, chapter 6)

“Ecological corridor”

Landscape component “A linear strip of vegetation that provides a continuous (or near continuous) pathway between two habitats” (Bennett, 2003)

“Landscape fragmentation”

Landscape fragmentation is the result of transforming large habitat patches into smaller, more isolated fragments of habitat… Despite many improvements in legislation to better protect biodiversity, reduce pollution, and improve water quality, urban sprawl is still increasing and the construction of new transport infrastructure is continuing at a rapid pace. As a consequence, fragmentation of landscapes is rising and the remaining ecological network provides less and less connectivity. (European Environment Agency, 2019)

“Ecological Conservation Areas (SACA1)”

According to the ALPBIONET2030 project definition the SACA1 are areas, where ecological connectivity works quite well, that still have considerable space for connectivity with non-fragmented surfaces and where connectivity should be conserved”.

“Ecological intervention areas (SACA2)”

The ALPBIONET2030 project defines the SACA2 as areas that represent important links between SACA1 areas (ecological conservation areas). Connectivity is currently working to some extent but would benefit from enhancements.

Connectivity restoration areas (SACA3)

The ALPBIONET2030 project defines the SACA3 as areas that represent important barriers between SACA1 areas (ecological conservation areas).

Potential Planning Areas for Biodiversity Protection

According to the Alpine Parks 2030 project, these areas are a spatial planning proposal of protected areas, distributed in nine categories combining the criteria of low fragmentation, low spatial development, and a high level of ecologically favourable areas creating the framework, along with the identification of already existing areas with strong protection. This facilitates the determination of further potentials of protected areas within the Alpine region.

EXECUTIVE SUMMARY

The landscape fragmentation within the Alps is linked to the development of transport infrastructures, urbanisation and other anthropic pressures. The Alpine protected areas cover around 30% of the Alpine Convention surface. Some of these areas are threatened by fragmentation due to barriers that hinder the movement of species and accelerates habitat degradation.

The PlanToConnect project aims to support the creation of a coherent alpine-wide network of green and blue infrastructures (GBI) for ecological connectivity (EC) based on harmonized regional networks under a common alpine planning strategy for EC. The analysis focuses on the main GBI components of the Alpine ecological network, there is an emphasis on areas with a high value for biodiversity conservation, including protected landscapes and other minimally disturbed or undisturbed areas.

The mapping report aims to provide an overview of the Alpine ecological network, structured into five chapters. Each chapter examines various data sources and methodologies to enhance the integration of ecological connectivity into spatial planning. The report also assesses threats and barriers to this implementation and includes recommendations based on both the mapping results and insights from additional case study analyses

1 Introduction

The report is focused on analysing the status, major threats and possible actions to be implemented in the potential ecological network integrated by the potential planning areas for biodiversity protection and the potential regional links. The protection and the enhancement of the connectivity among these areas that go beyond Alpine protected areas geographical limits, is essential to safeguarding Alpine biodiversity.

The first part of the report describes the global project purpose, the objectives pursued and the link between this framework and the analysis elaborated for the case study. The second part will provide an overview of the case study, the location, the surface covered, the types of landscapes included, the current protection status, among other characteristics.

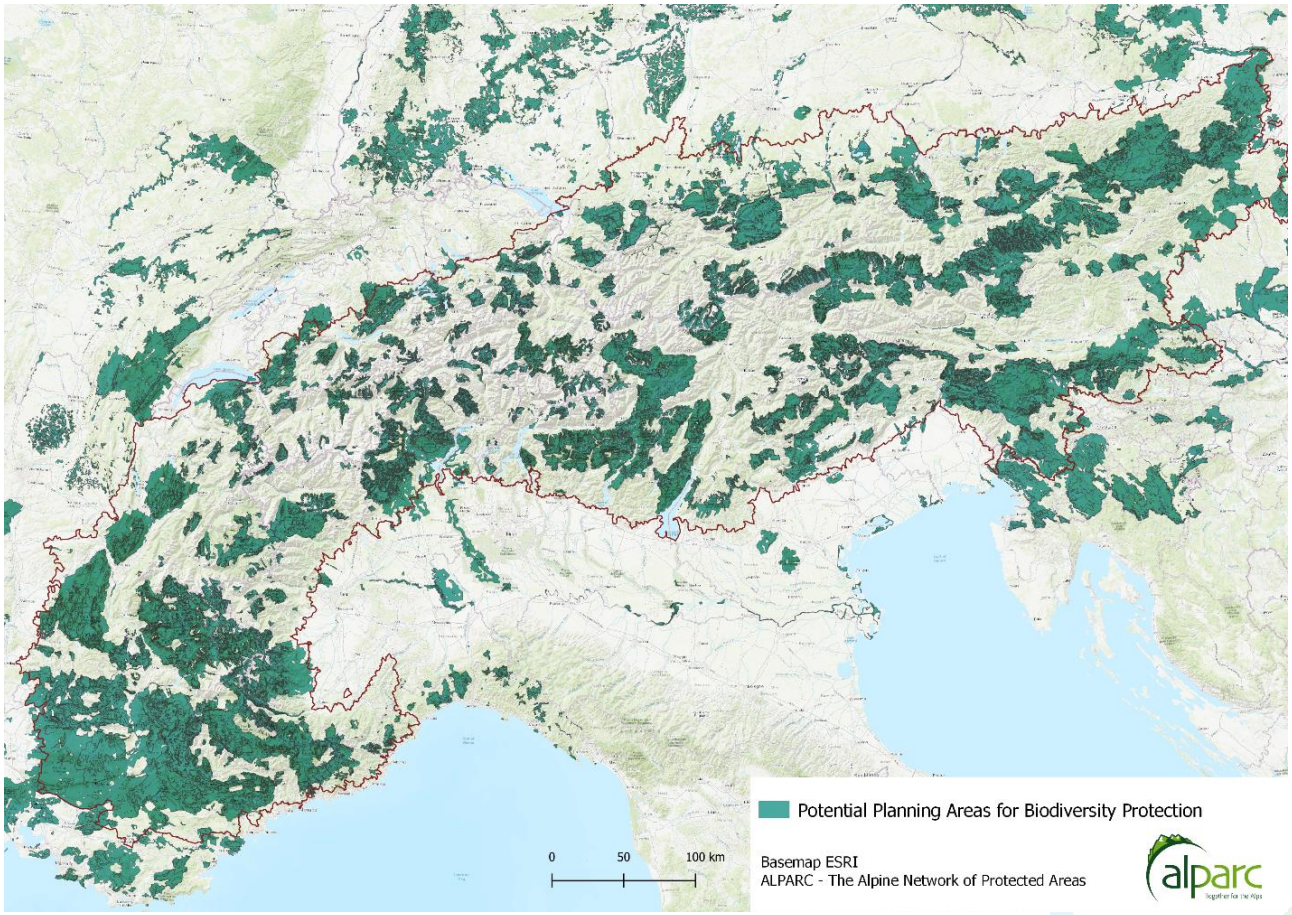
The third part describes the methodological approaches chosen to elaborate the case study analysis, the data sources as well as the procedure followed to obtain the results explained on the fourth part of the report.

The results combine the visualisation of the potential ecological network and the major threats for connectivity within the Alps and also within its interface with the EUSALP space. The final chapter include general recommendations for enhancing and implementing ecological connectivity.

2 Pilot region

The case study covers a selection of surfaces within the Alpine Convention perimeter and the interface with the EUSALP area, this selection is based on different criteria selected by ALPARC in order to elaborate a spatial planning proposal that allows to enhance ecological connectivity among landscapes with high relevance for biodiversity conservation considering the 30% goal.

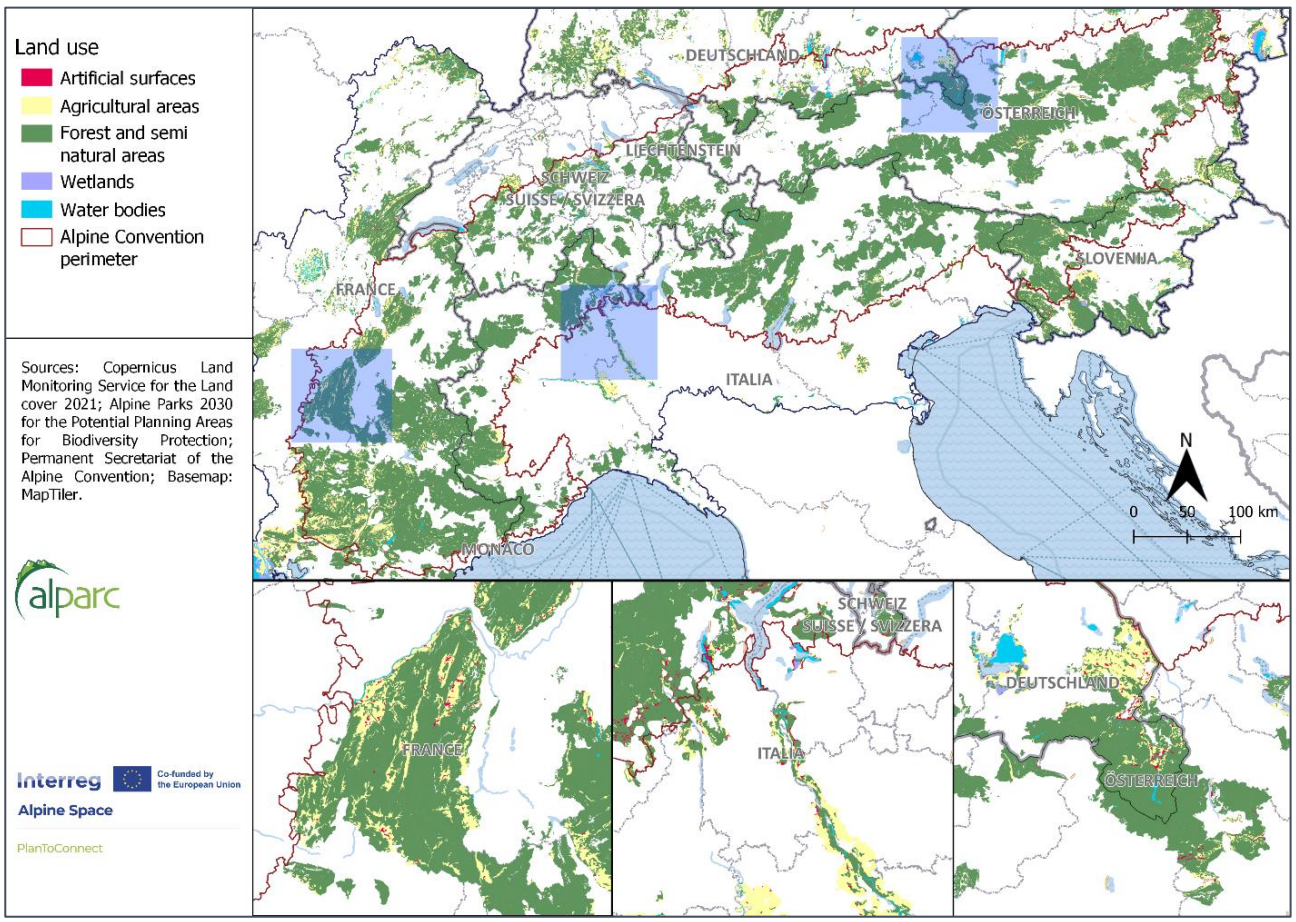
The ecological favourable areas (EFA) are the result of the identification of the current situation of the main features: spatial development, topography, connectivity potential and protection scope of the protection system of the Alps, these areas cover around 73.226 km^2 inside the Alpine Convention perimeter. A further analysis of the EFA resulted on the identification of Potential Planning Areas for Biodiversity Protection covering around 3.828 municipalities and a surface of 72.048 km^2 inside the Alpine Convention perimeter.



Map 1 Potential Planning Areas for Biodiversity Protection

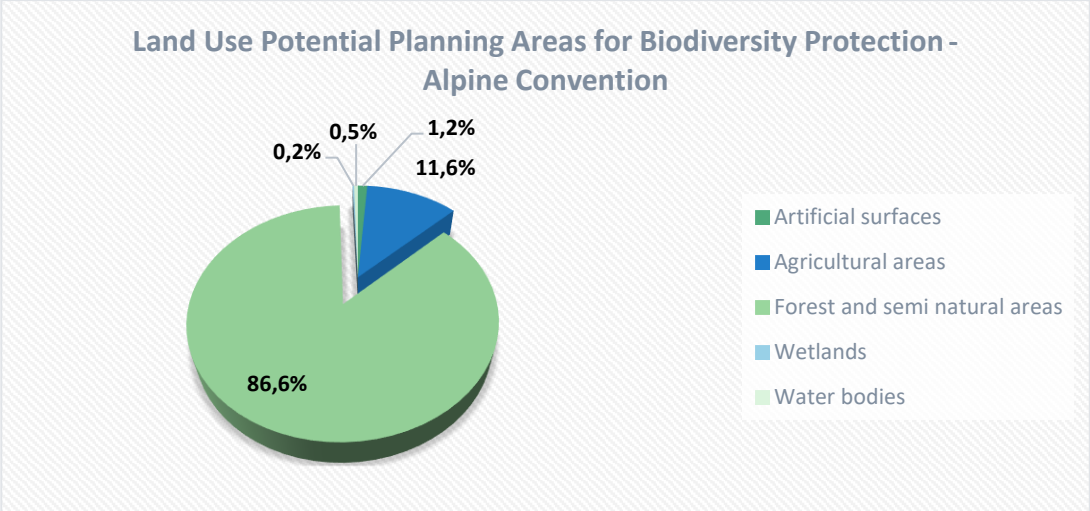
The geographical scope of the case study of ALPARC includes the potential planning areas, these are described as effectively conserved, ecologically representative, and well-

connected areas. The objective this case study is to analyse ecological connectivity linked with the current land use in the selected zones, identify the major barriers and threats to connectivity and provide recommendations to protect and restore ecological connectivity on the Alpine arc.



Map 2 Land use Spatial Planning Areas for Biodiversity Protection

Figure 1 Land Use Potential Planning Areas for Biodiversity Protection



The distribution of the land use illustrated on the Figure 1 shows the value of the areas included on the case study, most of this surface is covered by forests and semi-natural areas the forest subcategories presence is quite heterogeneous inside the Alps, the third category with a smaller proportion (11.6%) is agricultural land, which means that around a 98% of the surface covered by the Spatial Planning Areas for Biodiversity Protection, almost 34% of the surface of the protection perimeter of the Alpine Convention, have a land use that could be compatible with ecological connectivity. The next steps of the document will include the suitability, the identification of the zones to restore and also a barrier analysis to bring more elements for the proposal of a coherent ecological connectivity network.

3 Methodical approach in the pilot area

3.1 Methodical approach

Different methodologies can be used in order to define conservation priorities, the Potential Planning Areas for Biodiversity Protection are a first step into this process. The zoning proposal is a classification made accordingly with the biodiversity conservation importance of the study area, this criterion can integrate indicators to measure the representativity in terms of habitat, conservation of key fauna and flora species, ecological connectivity, nature protection, multifunctionality, among others. (Rincón, et al., 2019) For our case study, the biodiversity conservation importance will be measured by the score of Ecological Favourability presented on the selected areas which allow to address some of the criterion listed before with a limitation concerning fauna and flora representativity as there is currently not enough data to develop more precise analysis on an Alpswide level.

The main objective of this suitability analysis is to obtain a general overview of the key zones for ecological connectivity conservation and restoration and to study the compatibility with the current land uses of the best rated Ecological Favourable Areas by proposing a zoning.

3.2 Data used

Land use / land cover

- CORINE Land Cover (CLC) 2018; Copernicus Land Monitoring Service

Biodiversity

- Potential Planning Areas for Biodiversity Protection; Alpine Parks 2030; ALPARC
- Natura 2000 and emerald network sites; European Environment Agency
- Alpine Protected Areas; ALPARC
- Protected areas; World database of protected areas – WDPA

Infrastructures

- Roads and railways; Open Street Maps
- Landscape fragmentation ; European Environment Agency

3.3 Working steps

Table 1 General Working steps

Working Step	Description
1. Compilation of the protected areas within the corridor	Alpine protected areas under designations: - National Parks - Nature / Regional Parks - Nature reserves - UNESCO (Biosphere reserves, world heritage, geopark) - Natura 2000 and emerald network sites - IUCN categories I-IV
2. Compilation and analysis of GBI elements within the corridor (connectivity evaluation)	In a second step, all GBI elements (based on the categories of CORINE Land Cover (2018) within the network are listed and summarised according to the main categories: - Artificial surfaces - Agricultural areas - Forests and semi natural areas - Wetland (marshes, peatbogs) - Water bodies (flowing and standing water)
3. Definition / refinement of objectives for ecological connectivity	The objective is to identify the current status of priority areas for the development of the alpine ecological network and to analyse potential corridors for connecting these areas.
4. Compilation and analysis of regional and local data	Different datasources were integrated into the analysis; however, the data collection does not extend to regional or local datasources to the extensive geographical scope of the case study.
5. Barrier Analysis (based on D 1.2.1 and 1.3.1)	Identification of possible barriers and threats to the components of the potential ecological network of the Alpine space, including core zones, stepping stones and corridors.
6. Identification of priority areas for conservation and restoration	Areas with a high biodiversity value that play a key role into the preservation and reinforcement of the alpine ecological network, also key areas that are under anthropogenic threat where restoration measures are required.

4 Results

4.1 Compilation of the protected areas

The Alps encompass different categories of protected areas. Furthermore, there are regions that have multiple overlapping designations (international, national, and local). The following table summarizes some of the most representative designations of the Alpine protected areas.

Table 2 Protected areas within the network

Protected area	Description	Area km2 inside AC
National Park – Core area	Core areas of 13 National Parks, the activities allowed inside the protected area may vary accordingly to national regulations	7073
UNESCO Biosphere reserve – Transition area	Also denominated as cooperation areas, socio-economic and human activities are allowed under the vision of sustainable development. The protected landscapes would be situated in both the core and buffer zones covering a smaller area.	13560
Nature / Regional park	Nature and regional parks within the Alpine Convention perimeter, the activities and restrictions concerning protection and human activities vary from one country to another.	25708
Particular protection status	Includes national protected designations not comparable between the Alpine countries.	16912
Nature reserve	Strong protected landscapes mostly designated under IUCN categories Ia and Ib.	5512
UNESCO World heritage	Includes the selection of natural world heritage sites.	2650

4.2 Identification of the GBI elements

The zoning proposal is presented by 4 categories of suitability for ecological connectivity. The suitability for the zone 0 will be higher than the category with more challenges to overcome in order to preserve or restore ecological connectivity, zone 4. The distribution by zones allow to differentiate the territorial challenges for the implementation of a coherent network of key areas for nature conservation and environmental protection.

The zone 0 corresponds to areas more suitable for biodiversity preservation and improvements on connectivity, this category will gather the areas with a high result in ecological favourability, located mostly in forest and semi-natural areas, some categories of the agricultural land are also included. The zone 0 is oriented towards preservation activities.

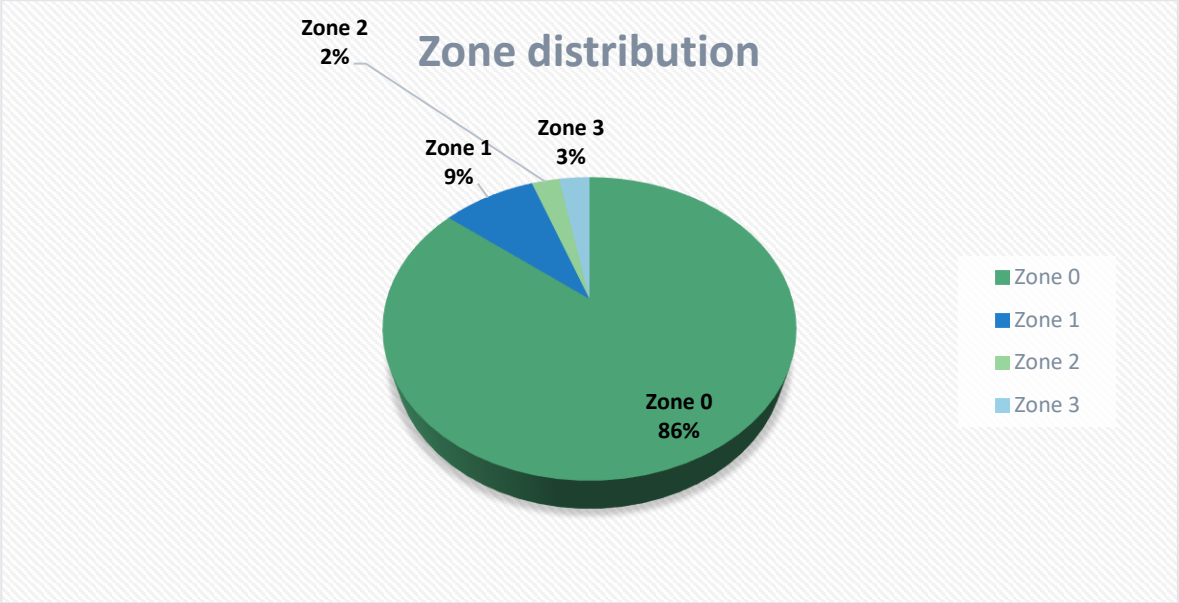
The zone 1 corresponds to areas suitable for biodiversity preservation and improvements on connectivity, this category will gather the areas with a high result in ecological favourability, located in semi-natural areas with low or no vegetation, agricultural land with a more important impact than the categories from the zone 0. The zone 1 is oriented towards preservation and restoration of spaces that micht present an early stage of fragmentation.

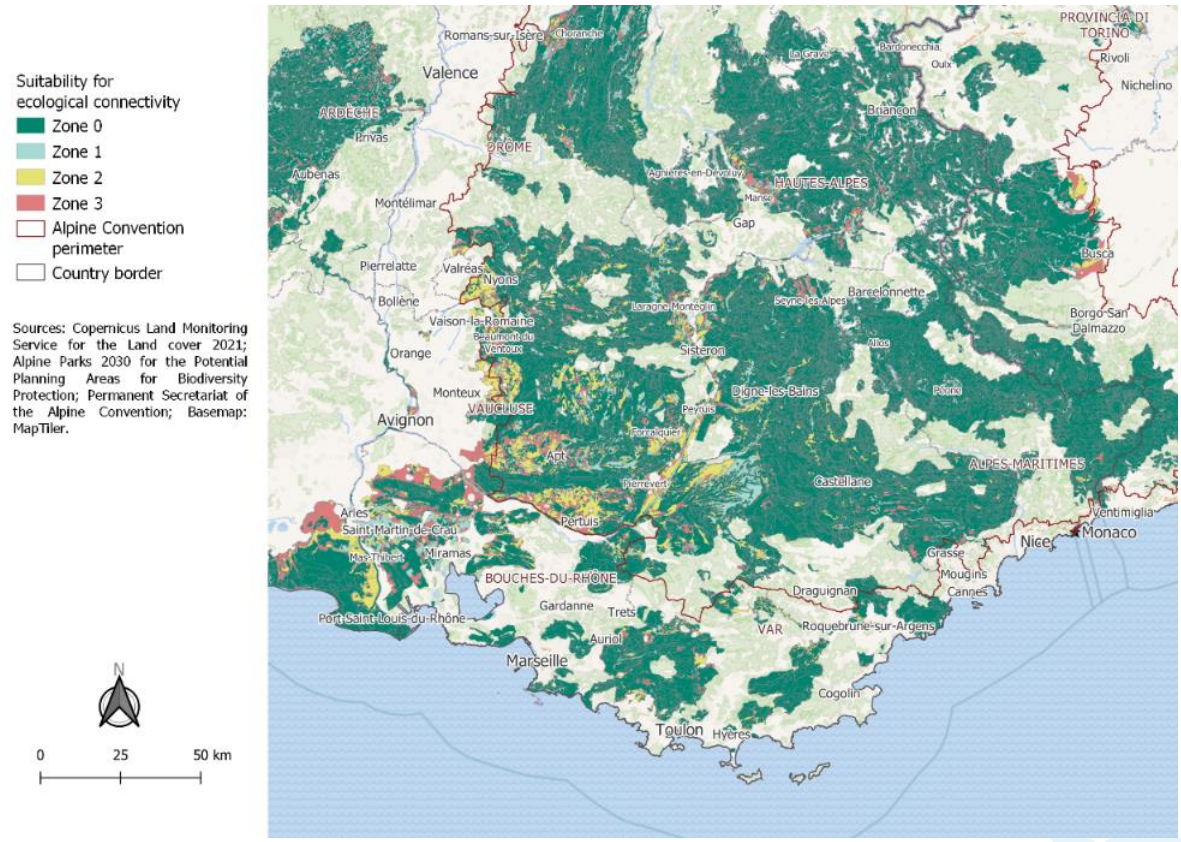
The zone 2 includes a selection of agricultural activities of a significant impact on landscape. The zone 2 is oriented towards adaptation/restoration and is the transition zone between the highly artificialized area around the natural and semi-natural areas.

The zone 3 corresponds to more fragmented and artificialized areas, this category will mostly gather the areas with a result <75 in ecological favourability, located mostly in artificial land or with agricultural activities (eg. Rice fields, Complex cultivation patterns) not compatible with nature conservation. The zone 3 is oriented towards restoration activities, these areas allow to identify the evolution of the threats such as urban sprawl and other infrastructure developments representing a threat for the other 3 zones.

The values on figure 2 show the proportion of each zone into the overall surface, the case study only concerns the Potential Planning Areas for Biodiversity Protection that cover 37.7% of the Alpine Convention protection perimeter.

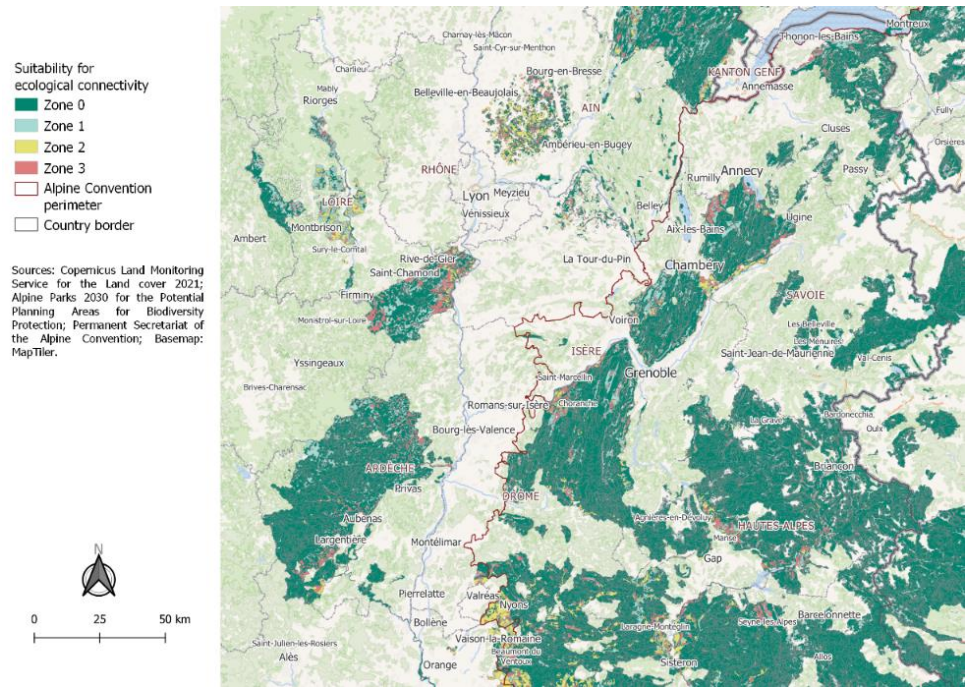
Figure 2 Zone distribution - Alpine Convention perimeter





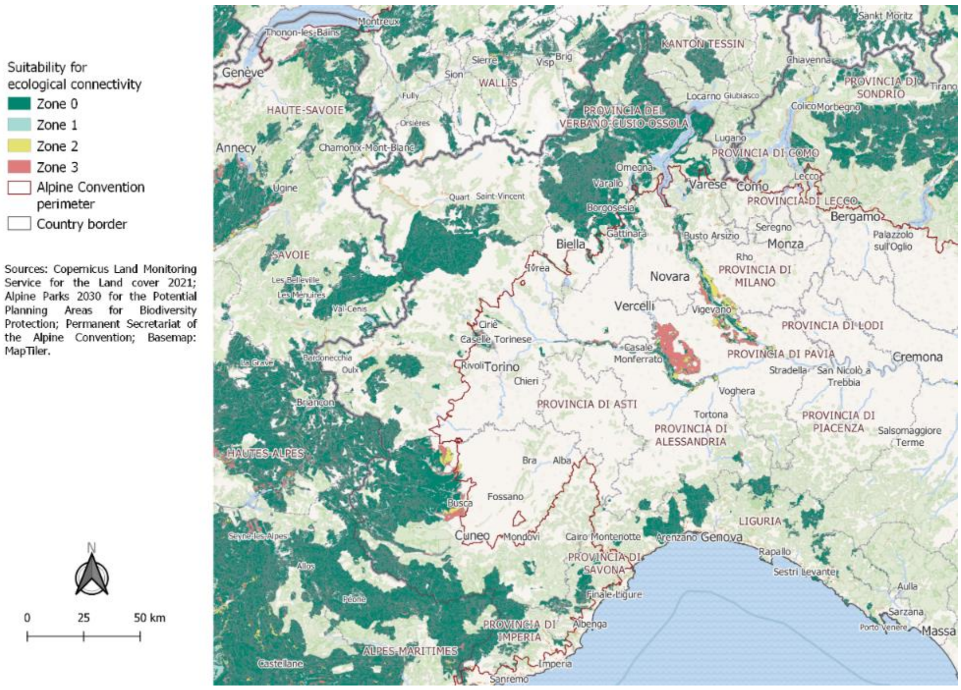
Map 3 Suitability for Ecological connectivity – p

The South Western Alps have a multiplicity of land uses, some areas are particularly concerned by urban sprawl and the development of agricultural activities, some of which enter in conflict with nature protection and hinder the development of the ecological network on this area. The presence of cities and other highly artificialized land on the western side of the Alpine Convention perimeter affects the ecological connectivity network. Despite this, the zone also contains areas of high biodiversity importance, expressed on a multiplicity of protection categories. However, preservation efforts are limited by heterogeneity on the limits and regulations associated with a particular level of protection.



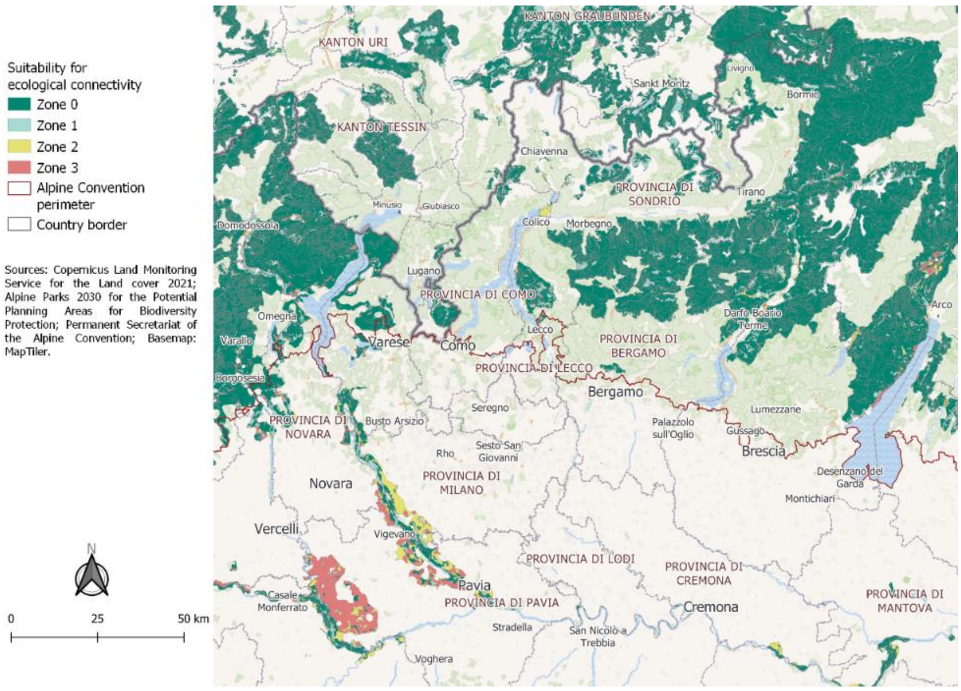
Map 4 Suitability for Ecological connectivity - Western Central Alps

The Western Central Alps region regroup different protected areas, the challenges for ecological connectivity on this zone are primarily located on the surrounding area of the Ecrins National Park and involve also the preservation and restoration of key links between protected areas, mainly Nature Regional Park



Map 5 Suitability for Ecological connectivity - Piemonte / Valle d'Aosta

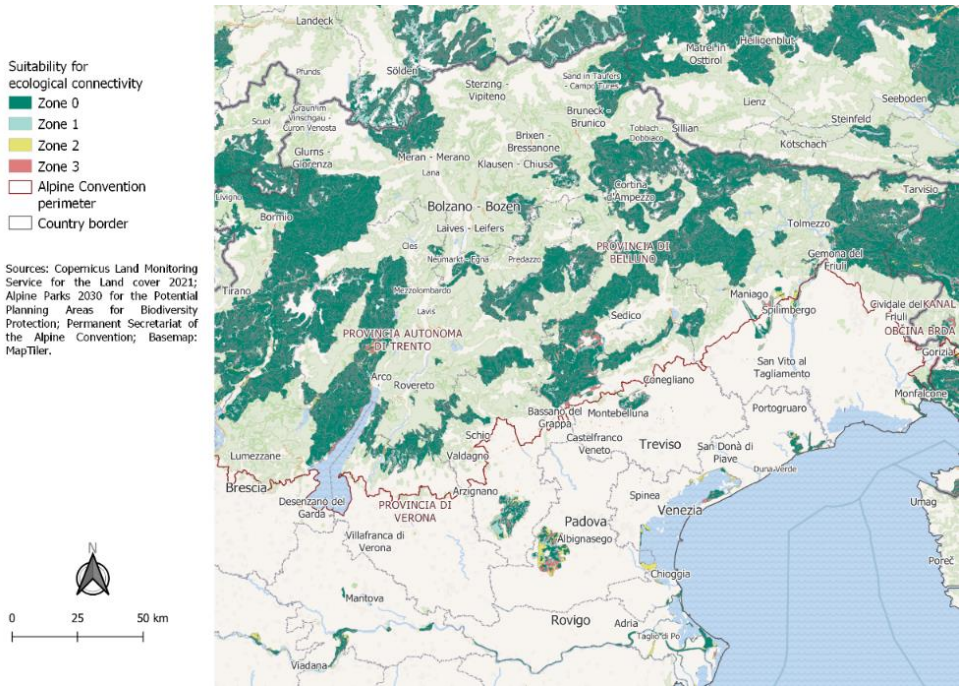
The Valle d'Aosta and Piemonte regions are characterized by the presence of transboundary protected areas, the efforts on international cooperation and coordination are essential for the biodiversity preservation on these zones.



Map 6 Suitability for Ecological connectivity – Lombardia

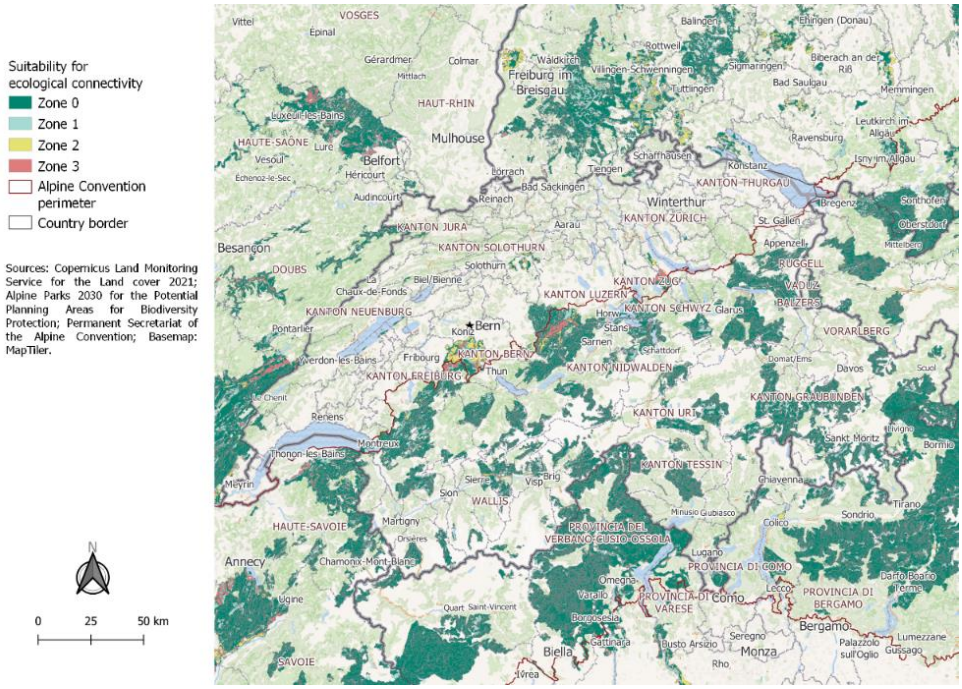
The Lombardia region is one of the regions where structuring an ecological network presents the greatest challenges. The presence of large urban centres causes fragmentation not only

within the region but also between the Alps and their surrounding areas. Most spaces in the area are classified in zones 3 and 4, indicating that despite the presence of areas with high biodiversity value, the extensive infrastructure development limits the possibility of creating connections between habitats.



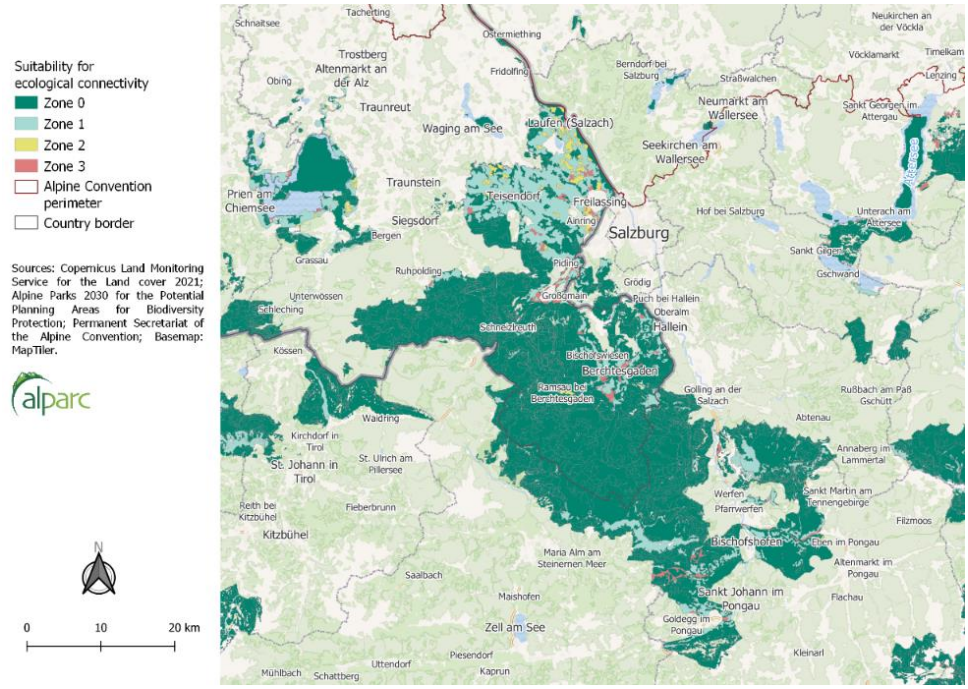
Map 7 Suitability for Ecological connectivity - Trentino - Veneto - Friuli Venezia Giulia

Trentino - Veneto - Friuli Venezia Giulia is another interface zone between the Alps and surrounding areas. It contains habitats of significant natural value that are close to large urban areas and extensive infrastructures, which complexifies the connection between these habitats. Nevertheless, some of these areas identified under the category 0 are also under some protection measure.



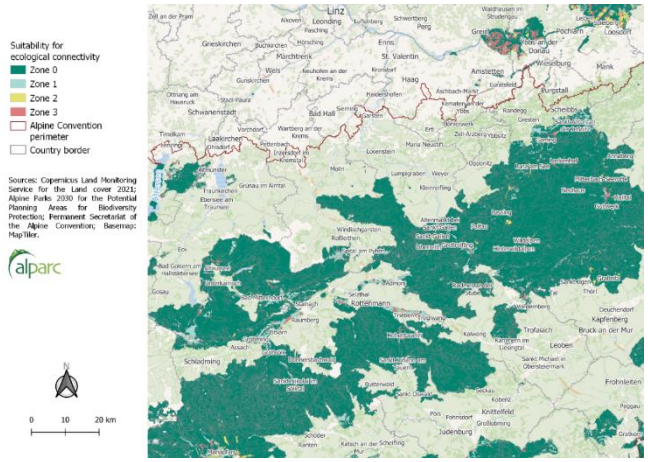
Map 8 Suitability for Ecological connectivity – Switzerland

Areas suitable for ecological connectivity of different sizes are distributed throughout the Swiss territory, there are various possibilities to strengthen the connection between these areas, however, the challenges arise in terms of inter-massive connection, a strong urban presence and the development of some agricultural activities hinder the development of ecological connectivity outside the limits of the Alps.

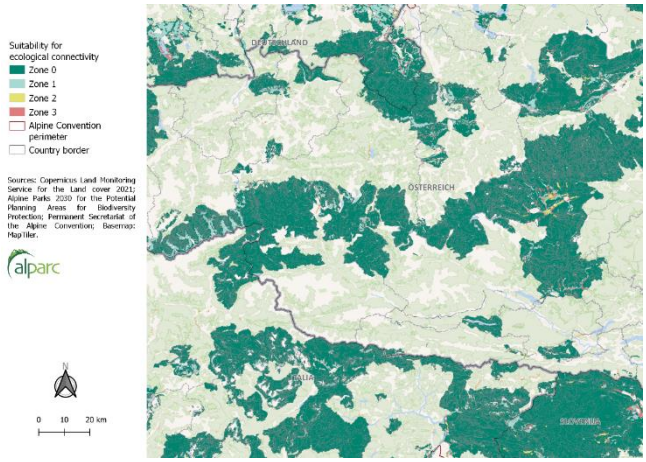


Map 9 Suitability for Ecological connectivity - Eastern Bavaria Region

The Eastern Bavaria region has a convergence of different types of landscapes and activities. On the map, you can see the development of agricultural activities and small settlements (light green, yellow and red colours), which can create obstacles to ecological connectivity. However, the presence of nature preservation measures largely maintains the area's connectivity potential.

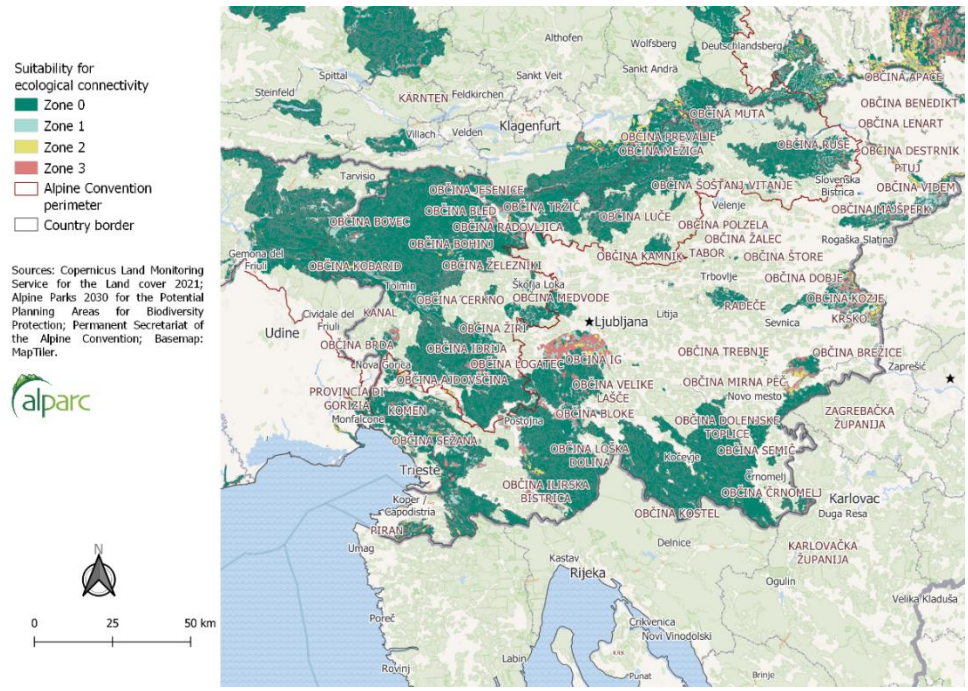


Map 10 Suitability for Ecological connectivity - Northern Limestone Alps



Map 11 Suitability for Ecological connectivity - Central Alpine Region

The Northern Limestone and Central Alpine regions have a large coverage of protected areas, three National Parks and a multiplicity of other categories of protection. These areas are closer to each other, facilitating the movement of species across the surface covered by protected areas. One of the main challenges for these regions is promoting connectivity with other areas with high biodiversity potential outside the Alps and managing the development of infrastructure in the valleys.



Map 12 Suitability for Ecological connectivity – Slovenia

In Slovenia, zones suitable for ecological connectivity are primarily concentrated in the western part of the country. This is due to the presence of Triglav National Park, as well as Biosphere Reserves and Geoparks, which highlight the value in terms of biodiversity of Slovenia's natural landscapes. Most of the surfaces under the zones 3 and 2 are in proximity of Ljubljana, the urban sprawl and the link between suitable areas from west to east are one of the main challenges to strengthen this ecological network.

4.3 Threats and barriers

The suitability analysis for ecological connectivity is complemented by a barrier analysis made with a selection of criteria that will allow to spatialize the possible disturbances, land use conflicts and the areas under anthropogenic pressure.

The procedure is an adaptation to the Alpine scale of different methodologies for the identification of local disturbances for ecological connectivity followed in some of the strategies for the implementation of green and blue infrastructure in France. (DREAL Midi-Pyrénées, 2010)

4.3.1 Urban pressure

Identifying areas under urban pressure is a key aspect for determining possible strategies and actions to implement in spatial planning, it serves as a base indicator to monitor the evolution or degradation of the ecological connectivity network. This analysis includes the impacts on large natural areas and also ecological corridors essential to connect them.

Urban areas have different effects on ecological connectivity. A key factor in analysing the effects and risks posed by urban areas and in particular, urban sprawl on natural areas is population density. Higher population concentrations lead to an increase on resources demand and widespread of artificialization. (Forman R. , 2008)

4.3.1.1 Data Processing

Corine Land Cover dataset 2021 (EEA, 2021) and population data from Eurostat are the datasources integrated on the urban barriers analysis, 11 categories representing artificialized surfaces were selected, processed accordingly to the levels of population density and compared with the case study surface.

The barrier identification is developed with the elaboration of different buffers (arbitrary threshold), the size will be determined accordingly to population density and urban surface.

The categories selected from the Corine Land Cover dataset listed above were classified through two criterions, administrative division size and population density. The administrative distribution included in the analysis is based on the DGURBA municipality division, accordingly with the surface the municipalities, three groups were created as illustrated on the table below. For the municipalities with a surface above the 5 km^2, the criteria of population density is also integrated, the buffer sizes for each case are also illustrated on the table 1.

Table 3 Buffer sizes - Artificial land

Land Cover category	Surface of the municipality				
	< 1 km^2	1 - 5 km^2	> 5 km^2		
			Population density		
			0-50	50 - 500	>500
Continuous urban fabric	No buffer	50 m	150 m	200 m	250 m
Discontinuous urban fabric	No buffer	50 m	150 m	200 m	250 m
Industrial or commercial units and public facilities	No buffer	50 m	150 m	200 m	250 m
Road and rail networks and associated land	No buffer	50 m	150 m	200 m	250 m

Land Cover category	Surface of the municipality				
	< 1 km²	1 - 5 km²	> 5 km²		
			Population density		
			0-50	50 - 500	>500
Port areas	No buffer	50 m	150 m	200 m	250 m
Airports	No buffer	50 m	150 m	200 m	250 m
Mineral extraction sites	No buffer	50 m	150 m	200 m	250 m
Dump sites	No buffer	50 m	150 m	200 m	250 m
Construction sites	No buffer	50 m	150 m	200 m	250 m
Green urban areas	No buffer	50 m	150 m	200 m	250 m
Sport and leisure facilities	No buffer	50 m	150 m	200 m	250 m

The selected land use data is buffered accordingly with the surfaces indicated on table 1 and compared with the 4 zones layer from the previous analysis, the map from Map 13 is an overview of the main disturbed spaces and also those areas most under pression from urban sprawl.

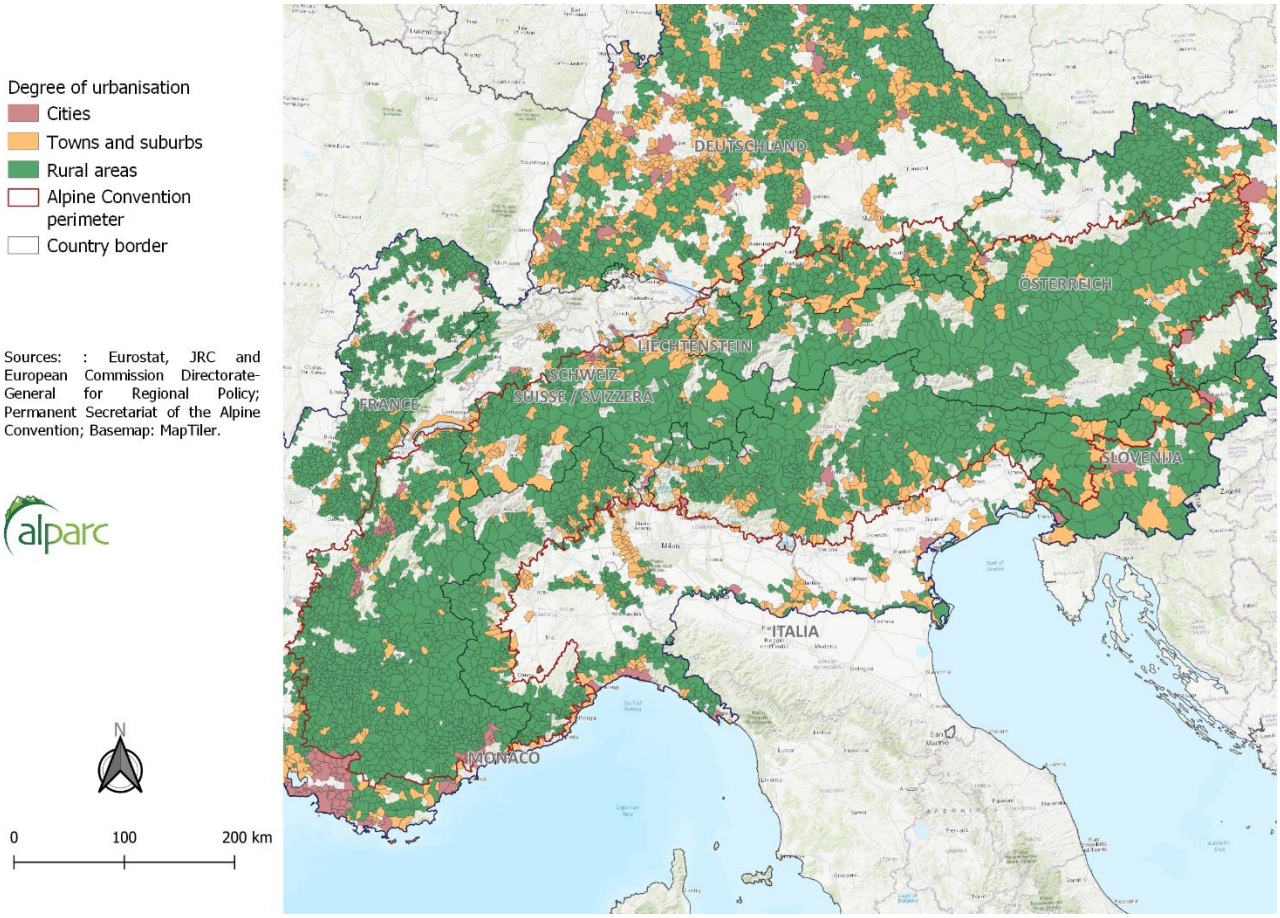
4.3.1.2 Urban barriers in Alpine space

Urbanisation in the Alpine space is mainly characterised by the development of human settlements and major infrastructure in the valleys which complexifies and intensifies the land use conflicts in areas that connect the Alps with the surfaces around and also increases fragmentation inside the region. (Perrin, Bertrand, & Kohler, 2019)

The location of places presenting a higher human population density often leads to urban sprawl, which fragments natural habitats, creates obstacles to species movement and disrupts ecological connectivity. As population pressure increases on urban areas and its surroundings, the importance of maintaining ecological connectivity becomes even more critical for the resilience of ecosystems.

Three categories of urbanisation are described on the following map, the degree of urbanisation is an indicator that *“combines the population size and the population density thresholds”.* (EUROSTAT, 2018) It allows to have a quick overview of the development of urban infrastructures inside the Alpine space, the map only includes municipalities that overlay with the Spatial Areas for Spatial Development.

The first signs of fragmentation can be seen mainly around the Alpine Convention perimeter where most of the towns and suburbs are located, these municipalities are often located around cities. Another particularity that can be observed on the map is the link between the degree of urbanisation and transboundary areas, this aspect is quite important as most of the areas identified on the case study are also transboundary which explains the importance of international cooperation for the preservation of the Alpine ecological network.

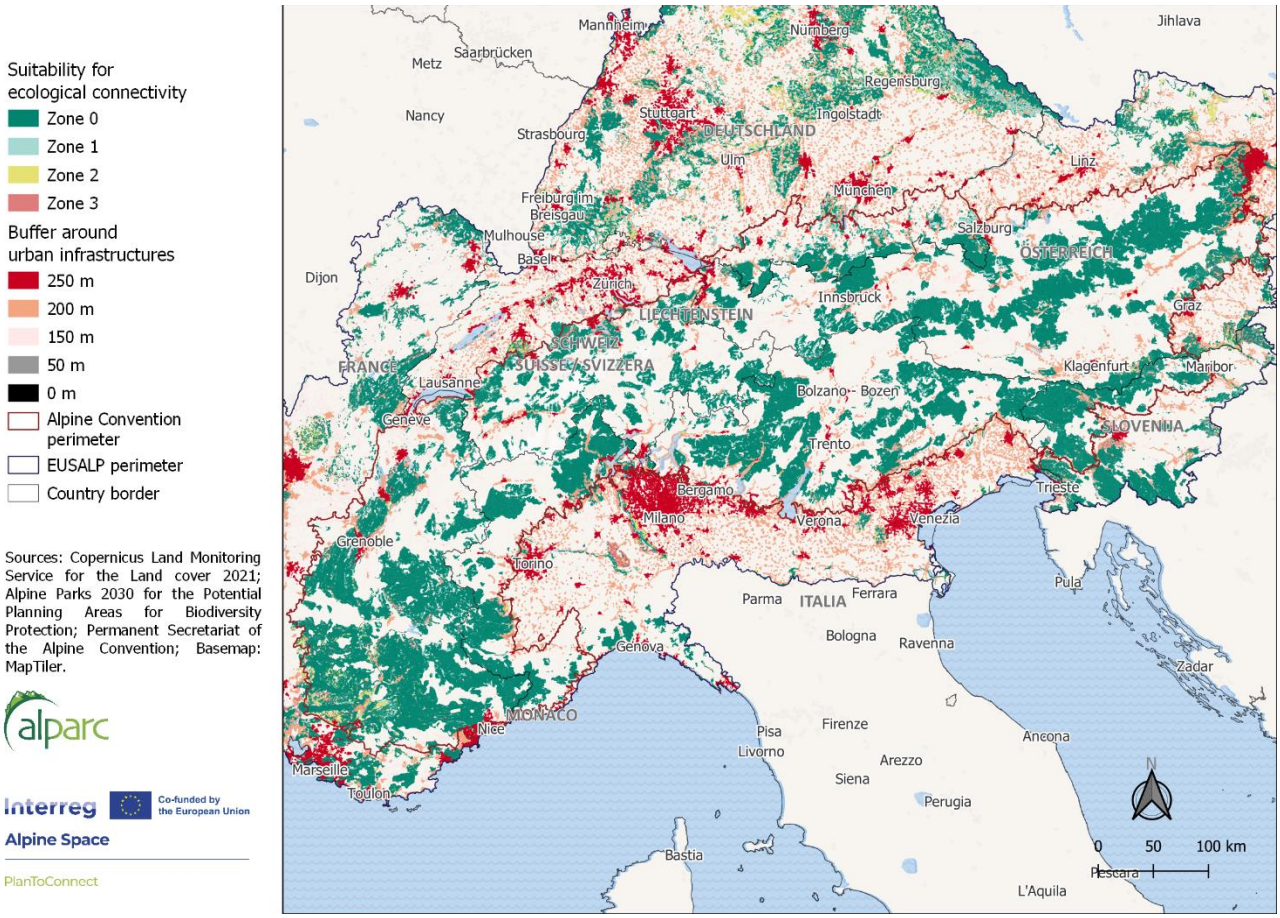


Map 13 Degree of urbanisation Alpine space

Human settlements are often associated with habitat fragmentation, one of the main threats for biodiversity preservation. The negative effects such as reduction of habitat area and quality, species isolation and other disturbances associated with artificialisation, can be addressed by implementing measures to maintain and restore connectivity. (Tabor, et al., 2019)

The overview obtained from the degree of urbanisation indicator is complemented with a more detailed analysis of urban infrastructures, this gives a wider perspective on the process of landscape transformation with the expansion of cities, towns and suburbs within the Alps. The analysis allows also to identify the extent of land occupation as a result of the development of human activities and particularly from urban areas.

The following map allows us to visualize both urban infrastructures and population density, the more densely populated municipalities are, the wider will be the buffer zone built around the selection of infrastructure, this procedure is made in order to illustrate the pressure of urban sprawl and how this increases with the variations on population growth.

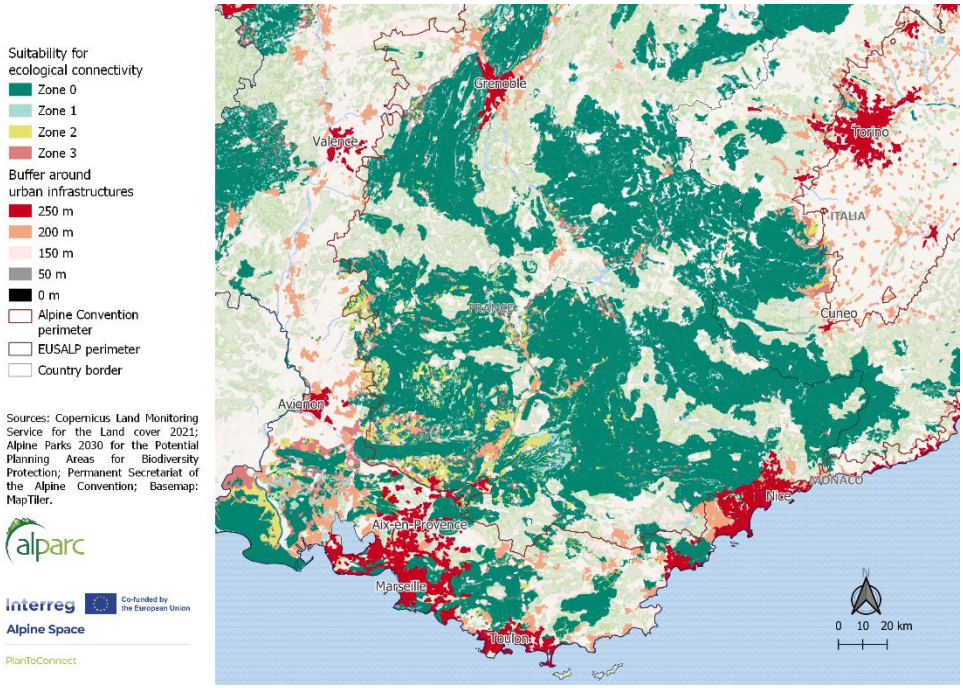


Map 14 Urban pressure Alpine Convention perimeter

The aim of this map is to highlight the differences between the disturbances and ruptures created by the artificialized surfaces and how heterogenous is the infrastructure and population repartition and in consequence, the impacts on the Alpine arc.

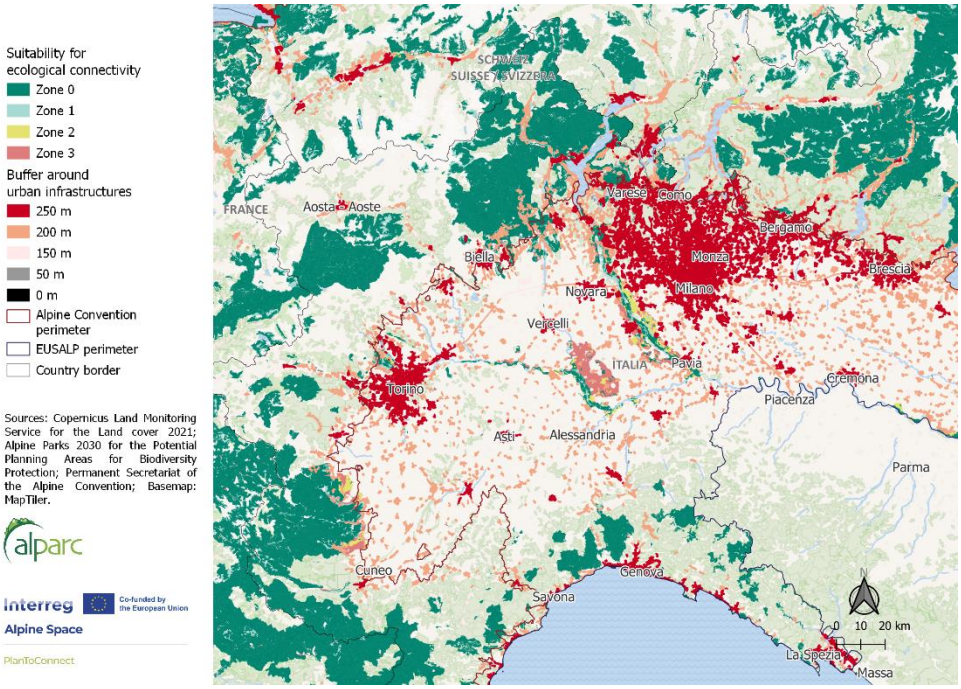
The urban infrastructures selected for the analysis include settlements, zones of economic development and the road infrastructure available on the Landcover dataset, further analysis regarding road and railway infrastructure will be included on the next section.

Buffers with different sizes are built around the infrastructure selection, this allows to identify in an early stage, the areas that may be threatened by the presence of these infrastructures. As evidenced on the map, there are areas with a biodiversity value that are more concerned by this phenomenon. Besides the visualization of the barriers around the Alpine Convention, this indicator allows to identify the possible urban sprawl trend on an early stage.



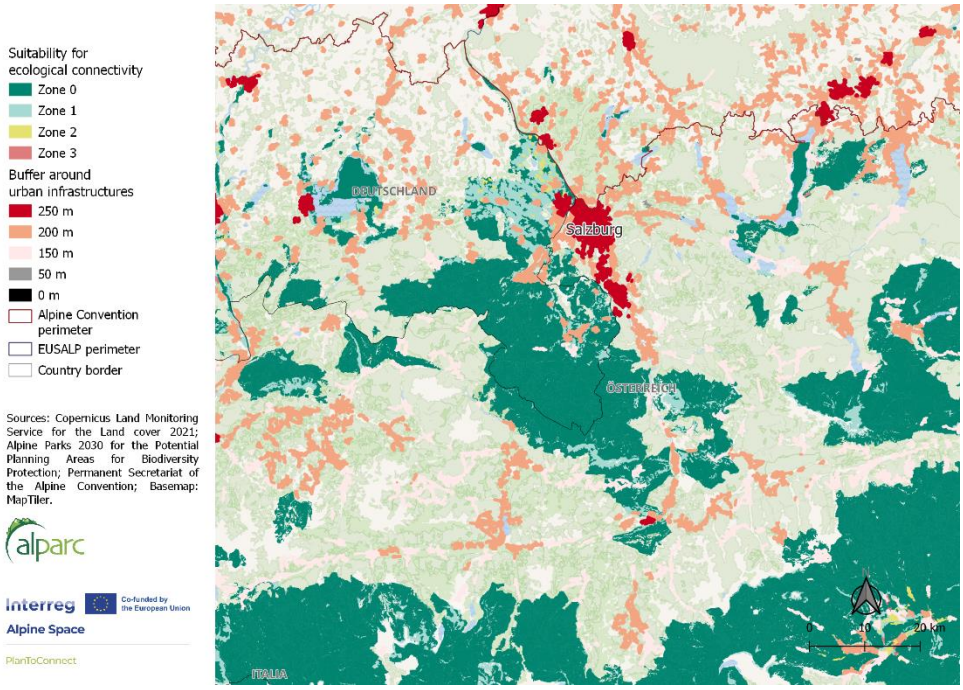
Map 15 Urban pressure - Southwestern Alps

The urban pressure within the South Western Alps is mainly related to the proximity of the Strategical Areas with some major cities on the south of the Provence Alpes Côte d'Azur region and Grenoble for the AURA region, these cities present also a high population density in comparison with other municipalities from both regions, the interface between the spaces to preserve and improve ecological connectivity and the urbanized peripheries is a major challenge in most of the examples presented on the national and also in the Alpine level.



Map 16 Urban pressure - Piemonte / Vallée d'Aosta

Piemonte and Vallée d'Aosta regions have large urban patches located within and in proximity to the Alpine Convention perimeter, the variation of the suitability can be explained by the proximity of valuable areas with urban, densely populated areas surrounding the Ticino valley for instance. These areas have an important value for biodiversity preservation, the Biosphere Ticino Val Grande Verbano regroups different categories of protected areas and around 48 Natura 2000, the mission of raising awareness about the importance of preserving this natural heritage with highly urbanized surroundings is one of the main challenges particularly on the transition zone. (Ticino Val Grande Verbano Biosphere Reserve, 2024)

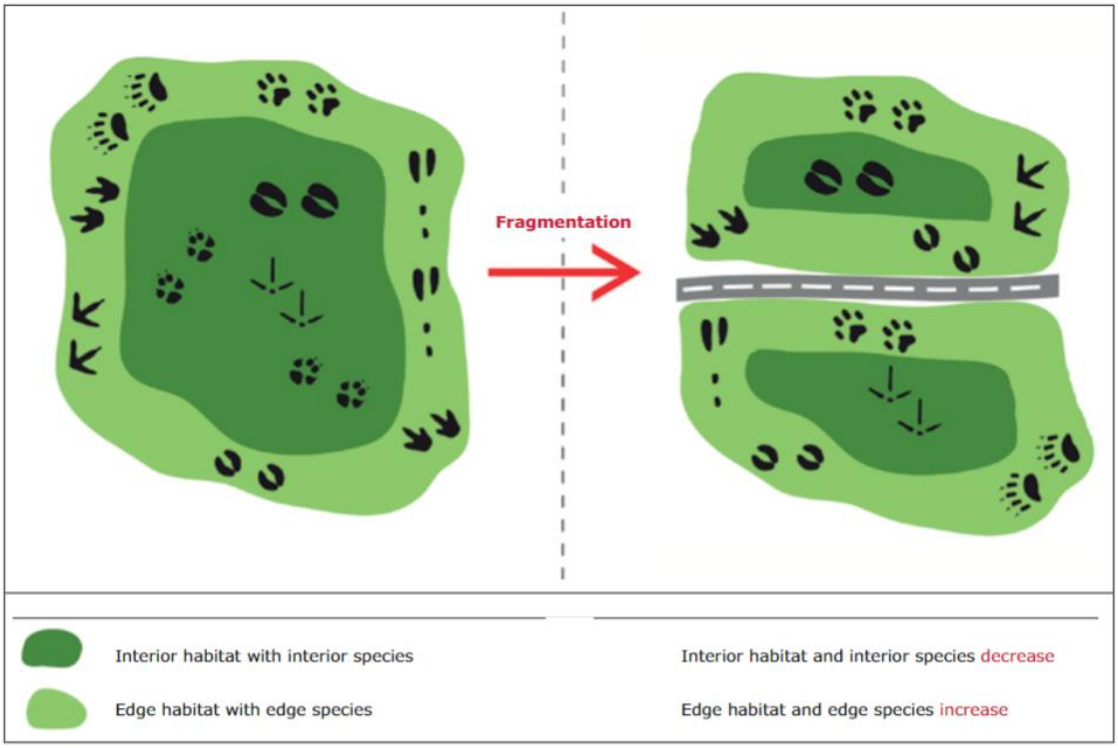


Map 17 Urban pressure - Eastern Bavaria

The areas located on zone 0 from the Easter Bavaria region are less threatened for the presence of urban infrastructures, the municipalities with high population density are located with a considerable distance from protected areas. Some early-stage fragmentation can be visualized on some patches in pink, even though the density of these areas is not as high of those identified on red, it is important to monitor the evolution of these patches and the possible landscape modification.

4.3.2 Road and railway infrastructure barriers

Landscape fragmentation is associated to different factors, the artificialisation of the land involves also the development of linear infrastructures that produce different disturbances and ruptures on natural landscapes. (European Environment Agency; Federal Office for the Environment FOEN , 2011) In order to identify additional factors that may impact or disturb ecological connectivity in the case study area, an analysis of rail and road infrastructure was integrated.



Source: Die Geographen schwick+spichtin, (European Environment Agency; Federal Office for the Environment FOEN , 2011)

Illustration 1 Loss of core habitat (or interior habitat) caused by road construction cutting through a patch of habitat

4.3.2.1 Data processing

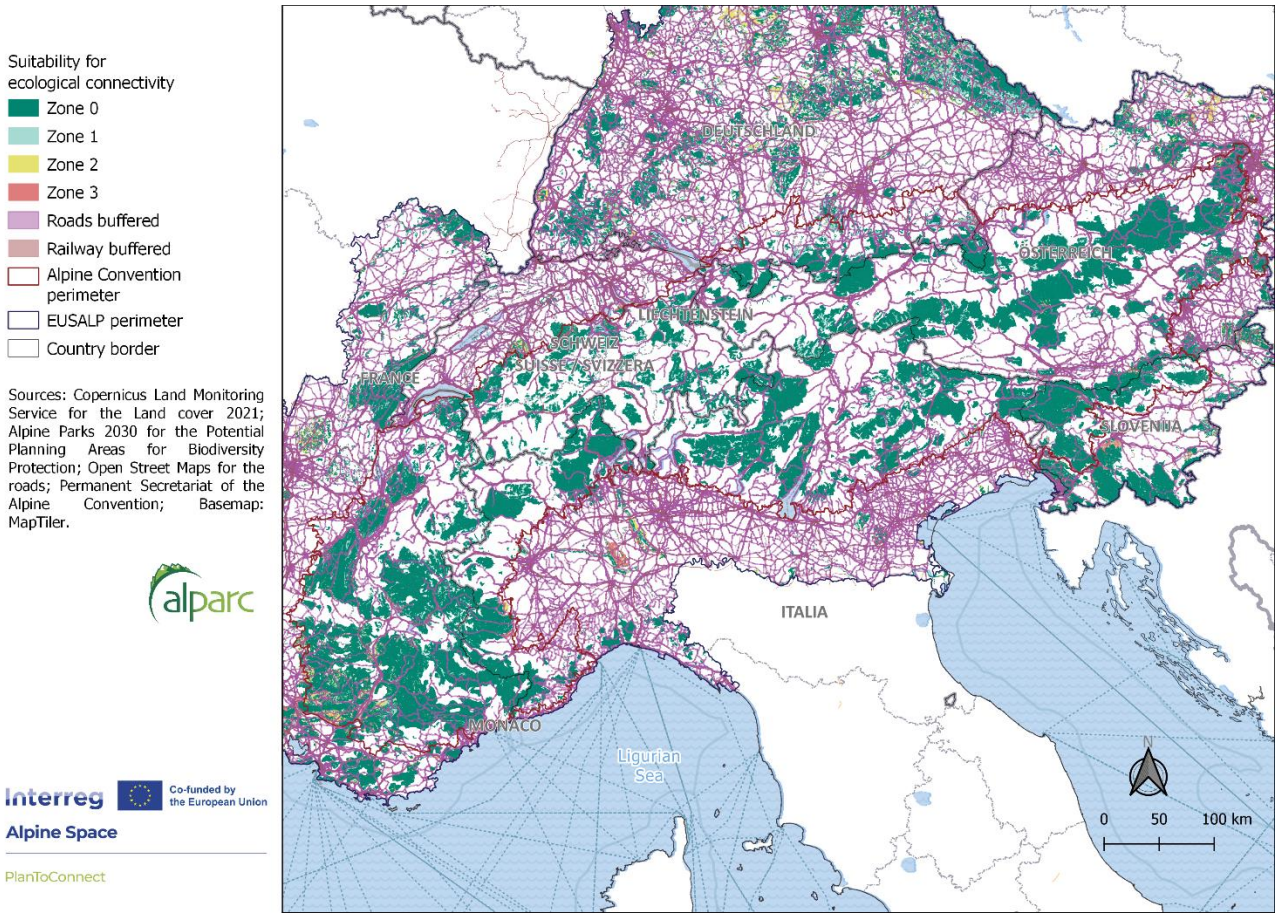
The main datasource used for this analysis are the road categories and railways layers from Open Street Maps database.

The size of buffer built around the road and railway infrastructure considered the noise pollution, different datasources were consulted in order to have an overview of the noise disturbance produced by each infrastructure, the table below resumes the buffer sizes considered in the analysis. (Martinelli, 2016) (Federal Office for the Environment FOEN, 2024)

Noise pollution is also an effect of the presence of road infrastructure. The selection focused only on the road categories with the highest traffic to clearly identify the most significant disruptions, the convergence points of these infrastructures, and their connection to the urban barriers identified in the previous analysis.

Table 4 Buffer sizes - Roads and railway

Road infrastructure	Buffer size	Db aprox
Motorway	300 m	≥ 65
Trunk	200 m	45 - > 65
Primary	150 m	45 - > 65
Secondary	70 m	45 - < 65
Railway	150 m	45 - > 65



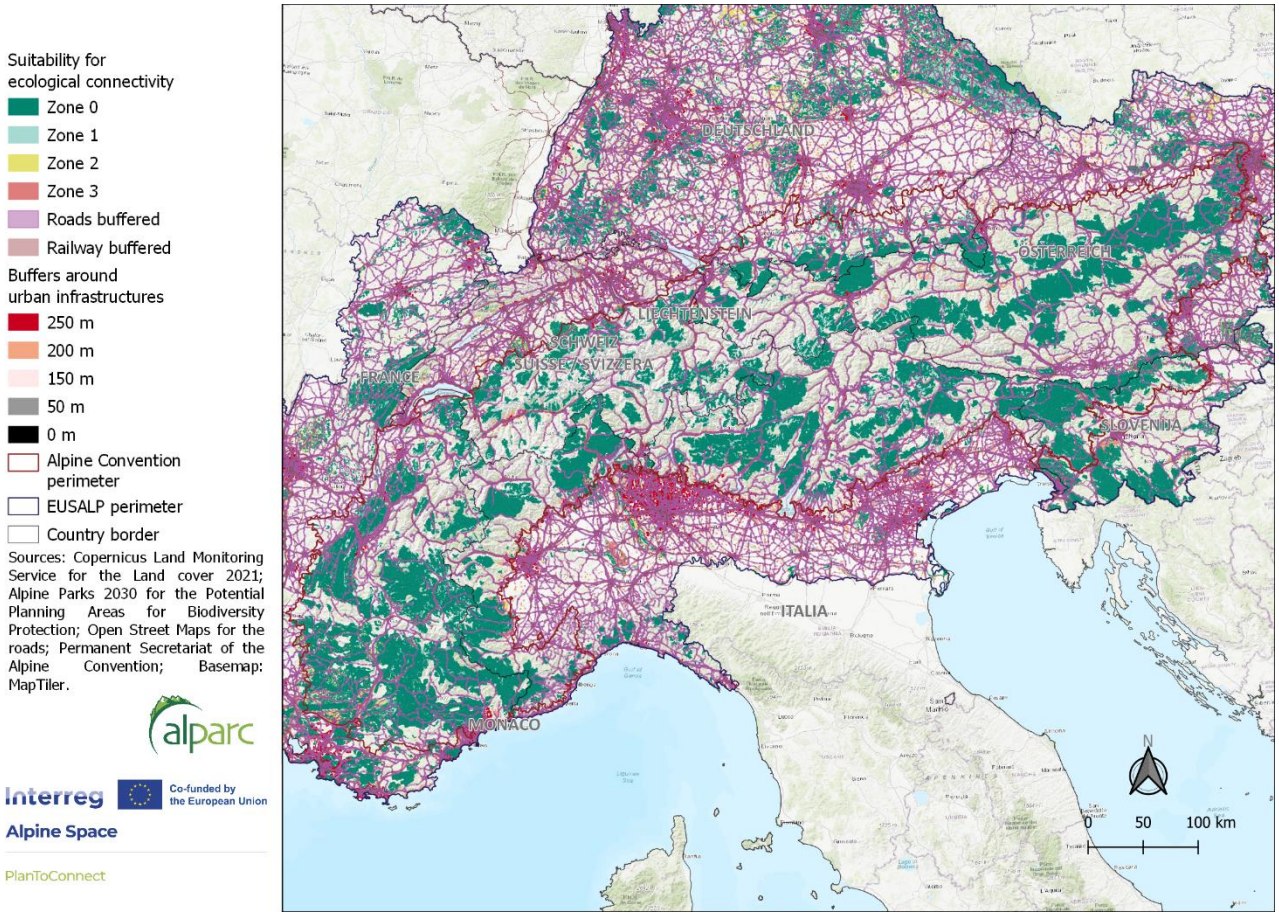
Map 18 Road and railway infrastructure barriers

The identification of linear infrastructure is essential to monitor the state of valuable natural patches and core habitats in the Alps, the presence of roads and railways modify the movement and available surface for species disturbing their life cycle. (Forman, et al., 2003)

On the Alpine scale, it is possible to visualize the fragmentation on inner valley municipalities, the barrier analysis is fundamental as these urban ruptures must be addressed in order to accomplish the protection objectives not only in terms of coverage but also in the aim to develop well-connected areas.

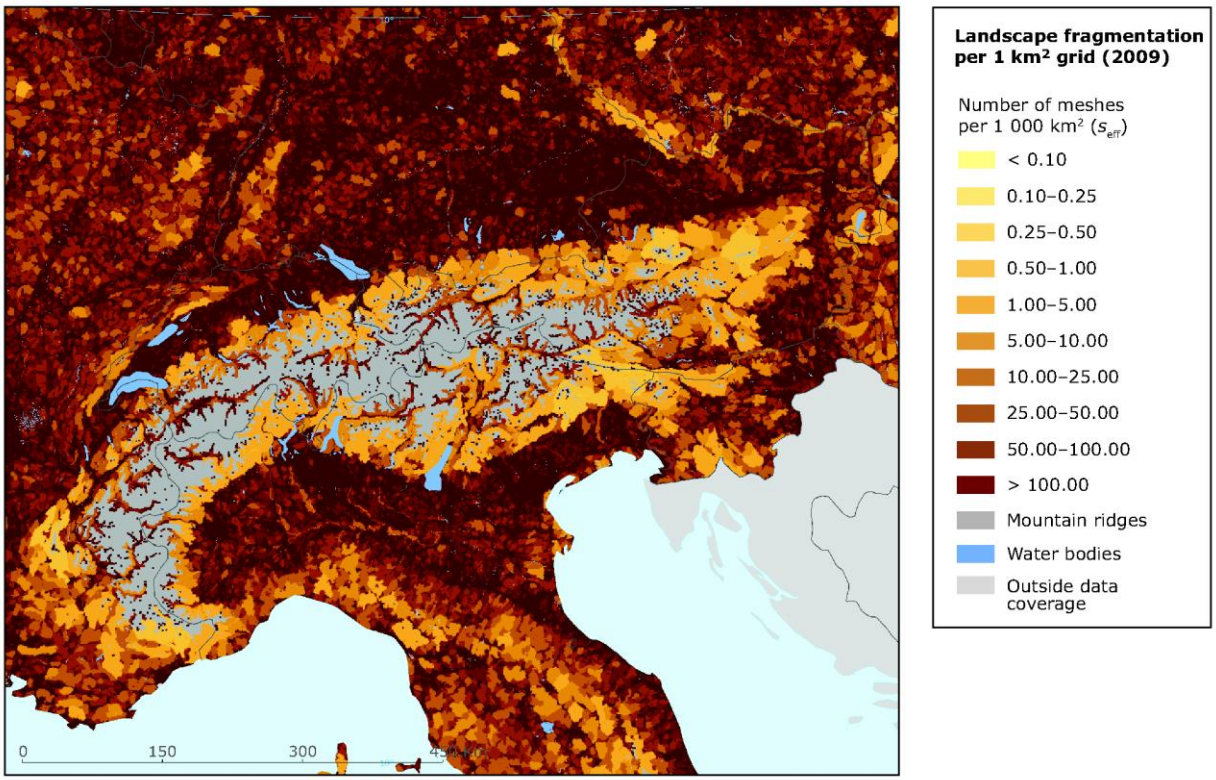
4.3.3 Landscape fragmentation

Landscape fragmentation can be measured with different methods and approaches. The following maps show the result from the barrier analysis developed on the previous steps and other fragmentation analysis elaborated by the European Environment Agency.



Map 19 Landscape fragmentation Alpine space - urban, road and railway barriers

It is important to note that the landscape fragmentation map from the Alpine space integrate areas covered by the selected infrastructures. The following two maps involve another data and methods for data processing, the result is expressed in a 1 km^2 grid. Two different years are included in order to assess any variations or changes on the results and also on the methodologies.



Map 20 Landscape fragmentation per 1 km² grid in the region around the Alps in 2009

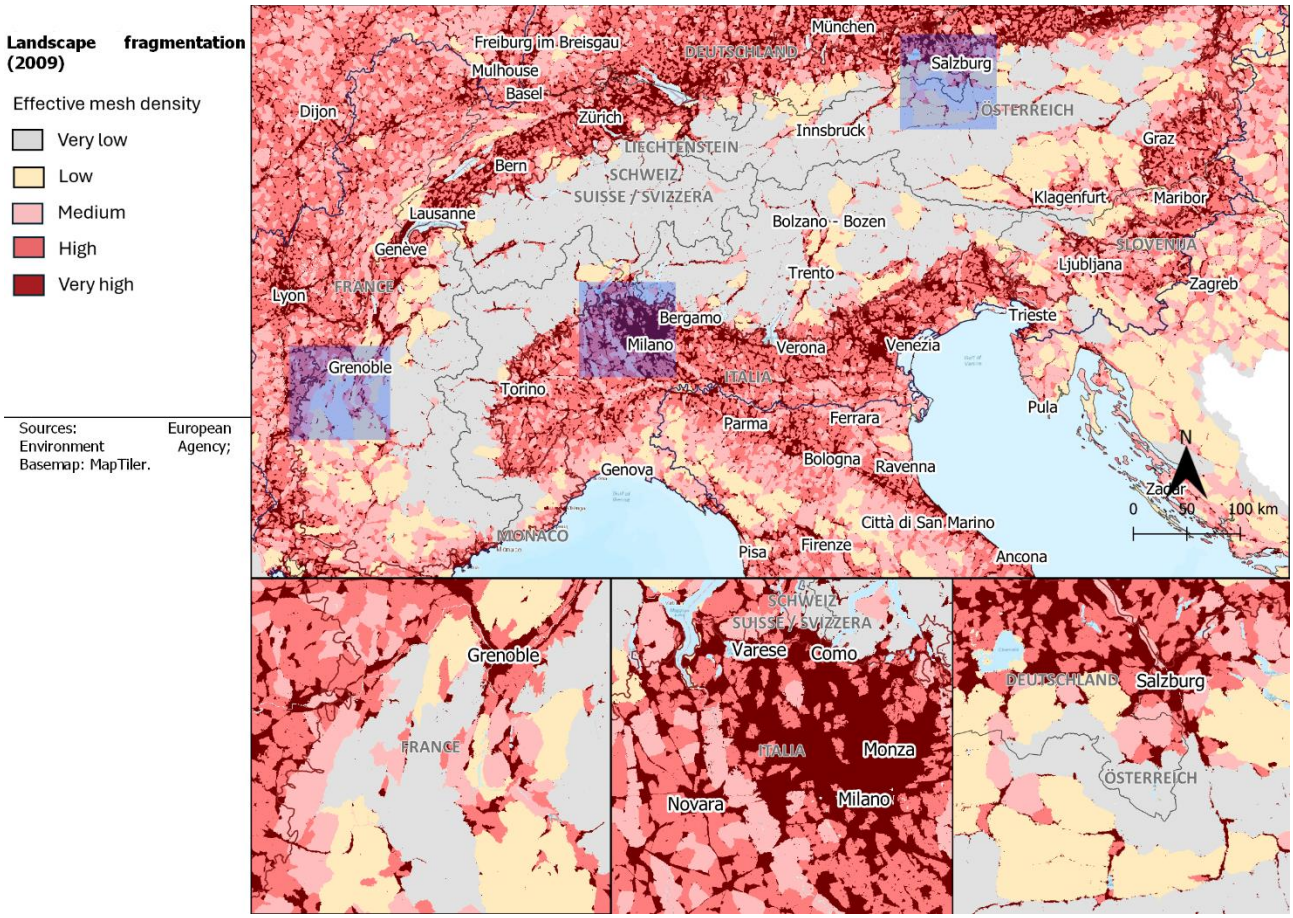
Source: European Environment Agency 2009.

Landscape fragmentation pictured on the previous map shows three main aspects. First, according to the analysis methodology, some natural features such as mountains and selected water bodies, were considered barriers and excluded from the 1 km² grid. Second, there are visible ruptures mainly located in some valleys within the Alpine arc. Third, nevertheless the results underline the importance of the Alpine Convention as a tool for preserving Alpine biodiversity. The lowest levels of landscape fragmentation are found near the borders of this perimeter, while outside this area on the interface with other protection perimeters, fragmentation levels increase dramatically.

The fragmentation map from 2009 includes different variables[1] representing barriers, the aim of this analysis is to identify the remaining non disturbed patches in the landscape and their extent. The approach of this analysis includes both natural and man-made barriers: the

[1] See annex 2

roads and built-up areas as sources of anthropogenic fragmentation, while mountains, lakes and major rivers were considered as barriers. This explains the absence of a fragmentation measure on the map for these areas, the result is a rough overview of the situation of landscape fragmentation in the Alps.



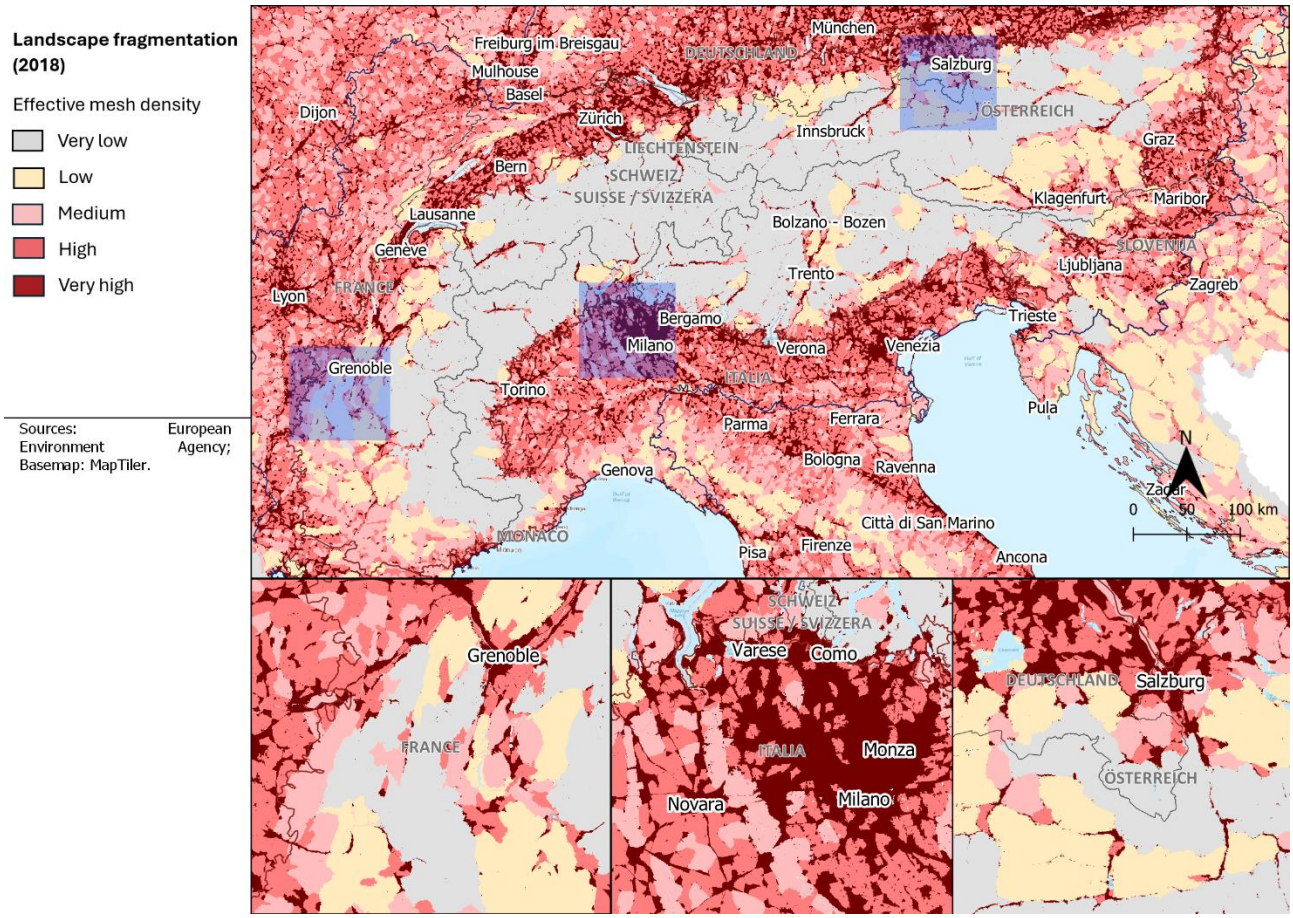
Map 21 Landscape fragmentation Effective Mesh Density 2009

The Map 21 is an updated version of the 2009 landscape fragmentation analysis, it contains more precise data that provide a clearer view of the location of the major and medium anthropogenic fragmenting elements.[2] This map, along with the following one, concern these kinds of barriers to have a more comparable elements to the GIS analysis elaborated for the case study.

As explained on the methodology followed for the elaboration of the Landscape fragmentation maps, *"The Effective Mesh Density (seff) is a measure of the degree to which*

[2] See annex 3

movement between different parts of the landscape is interrupted by a Fragmentation Geometry (FG).” (European Environment Agency, 2019)



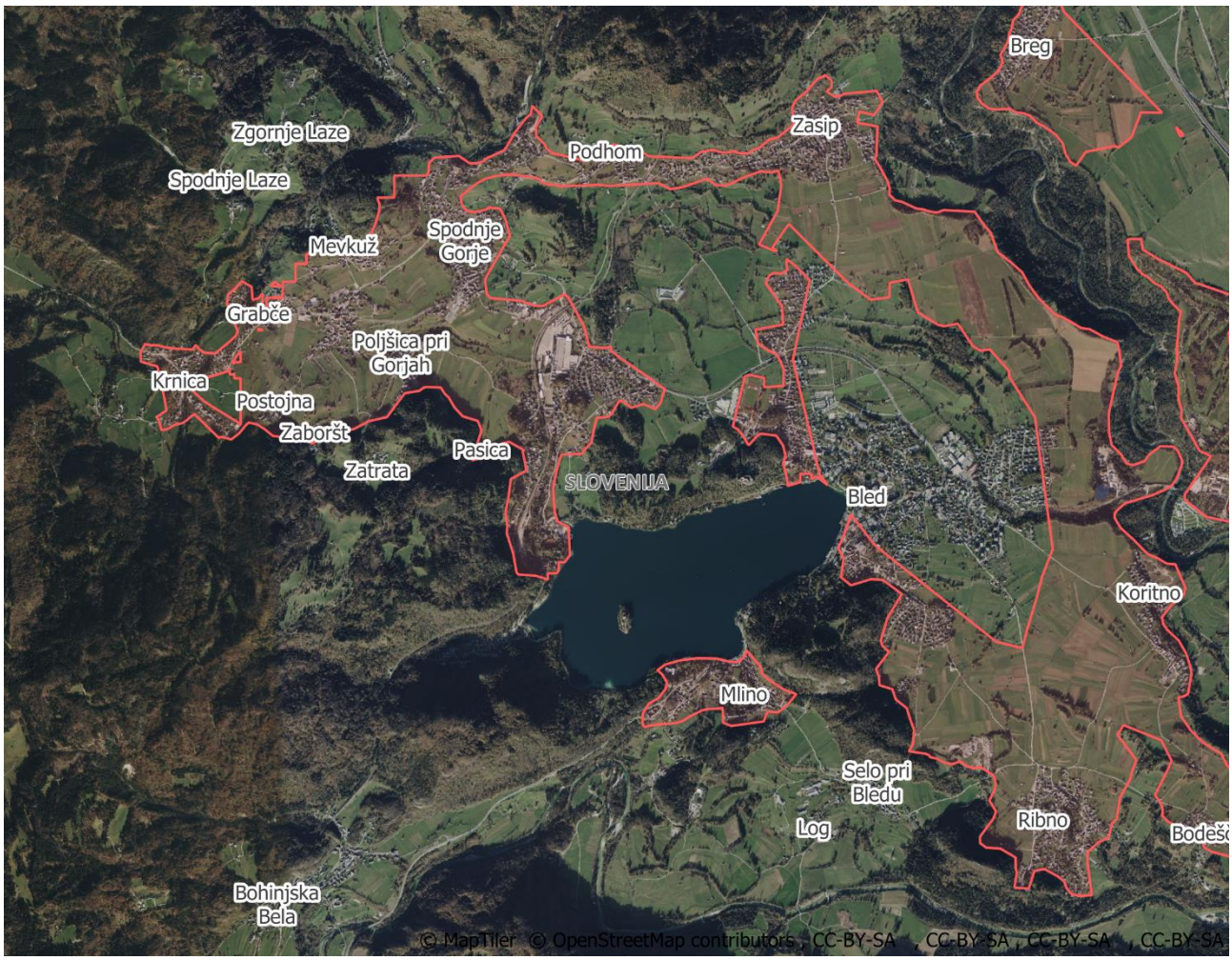
Map 22 Landscape fragmentation Effective Mesh Density 2018

The map of Landscape fragmentation from 2018 shows different elements to be analysed. First, there is a slight variation on the fragmentation levels, some of the already consolidated large urban areas, showing high fragmentation from the 2009 map, have expanded to reach more surface. Second, the major road barriers identified in some parts of the inner Alpine arc remain consistent on both timeframes, these areas represent obstacles to ecological connectivity.

4.4 Results and Evaluation of Data Analysis

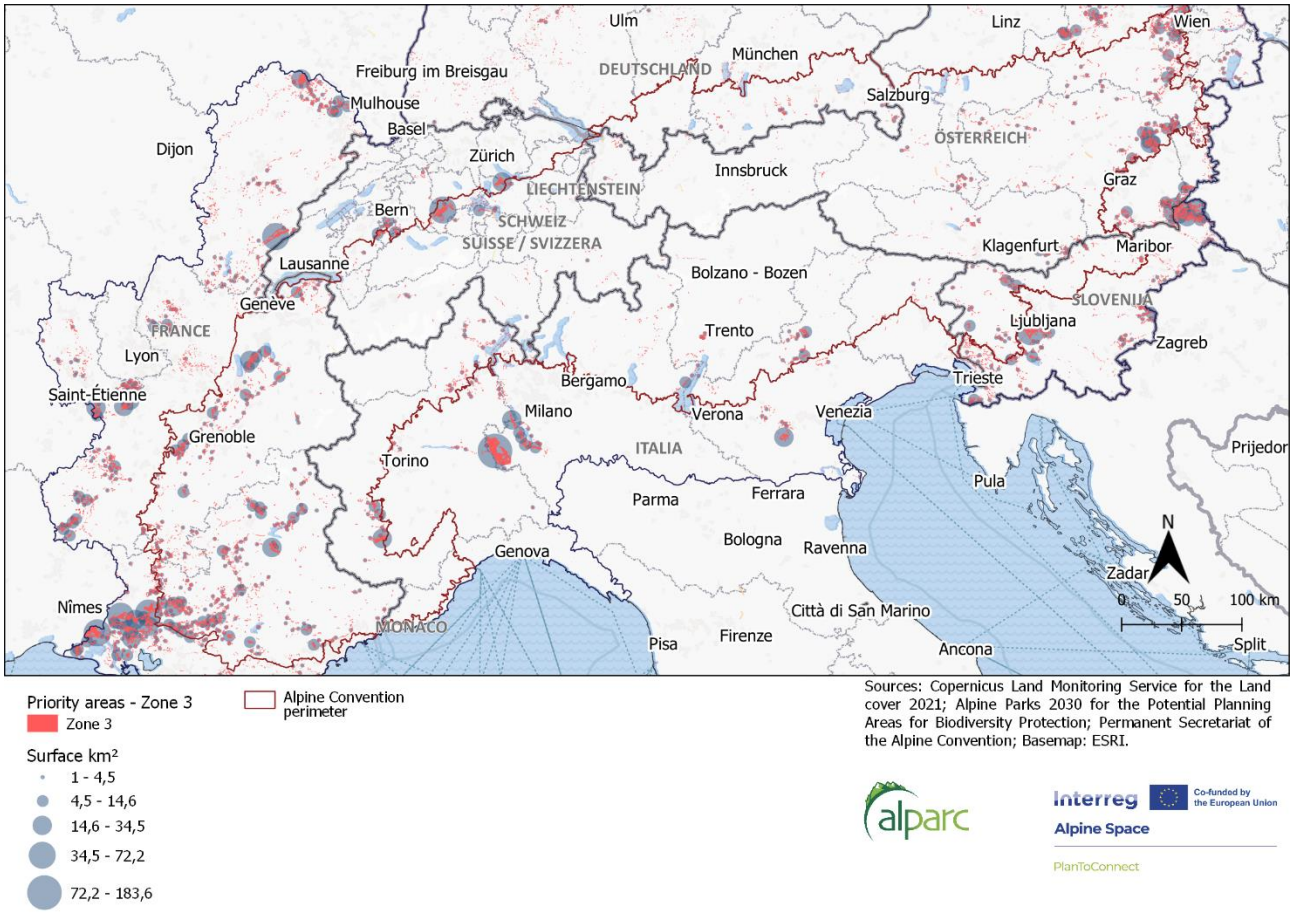
Covering around 37.7% of the surface of the Alpine Convention, the classification of these areas into 4 zones allows to propose 4 mainly types of actions:

Zone 3: These areas have urban development, and actions to improve ecological connectivity should be focused on preventing the expansion to the other zones, less modified and in some cases, untouched landscapes.



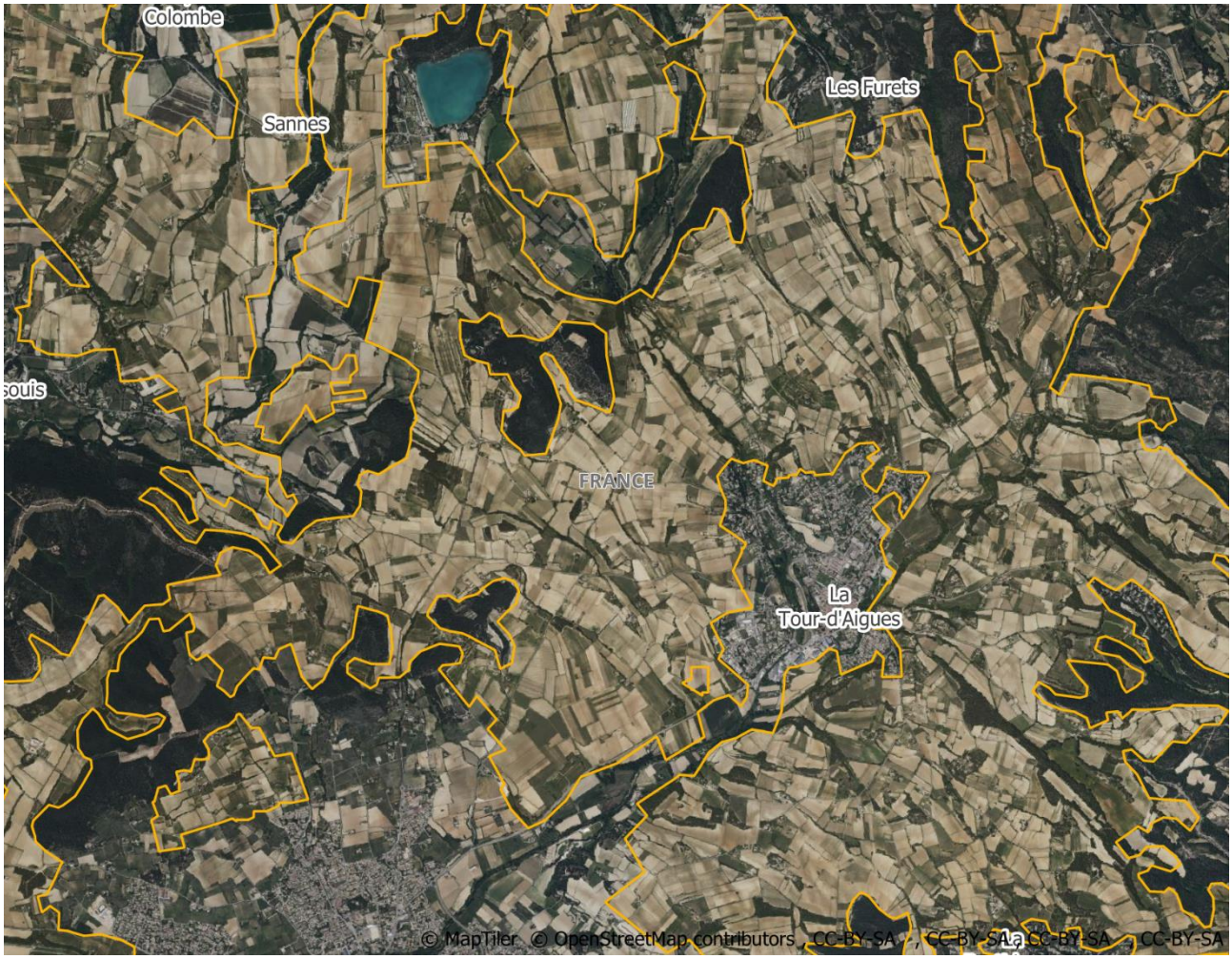
Map 23 Zoom Zone 3 at Upper Carniola region - Slovenia

The map highlights a selection of patches (575) from zone 3 larger than 1km², the extension of the patch is indicated with the size of the symbol in blue. Special attention should be given to the larger patches, mostly located on the interface between the Alpine Convention and the EUSALP space. Within the Alps, the western and southwestern regions are more threatened by the presence of intermediate cities and urban barriers, which block ecological connectivity within and between areas of high ecological potential, including in some cases already established protected areas.



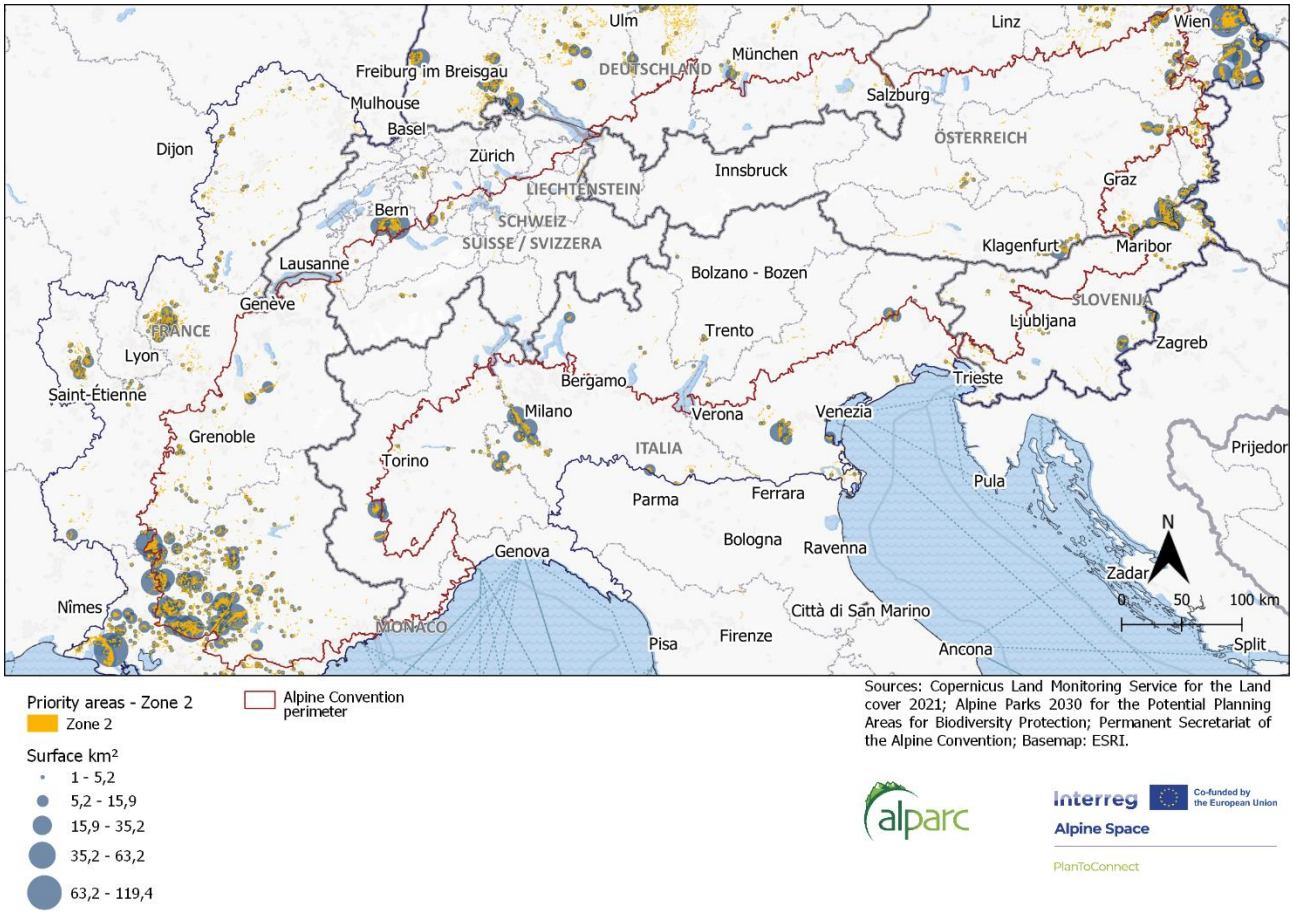
Map 24 Priority areas - Zone 3

Zone 2: Some high impact agricultural activities are developed in these areas, in some cases the ecological potential of the surface is higher than the average, nevertheless in terms of priority for preservation these areas have less range of preservation actions to implement. Close monitoring should be implemented in order to guarantee that these activities remain on the current limits, that there are not additional major changes caused by intensive agriculture on the neighboring landscapes and promote agricultural practices with lower environmental impact.



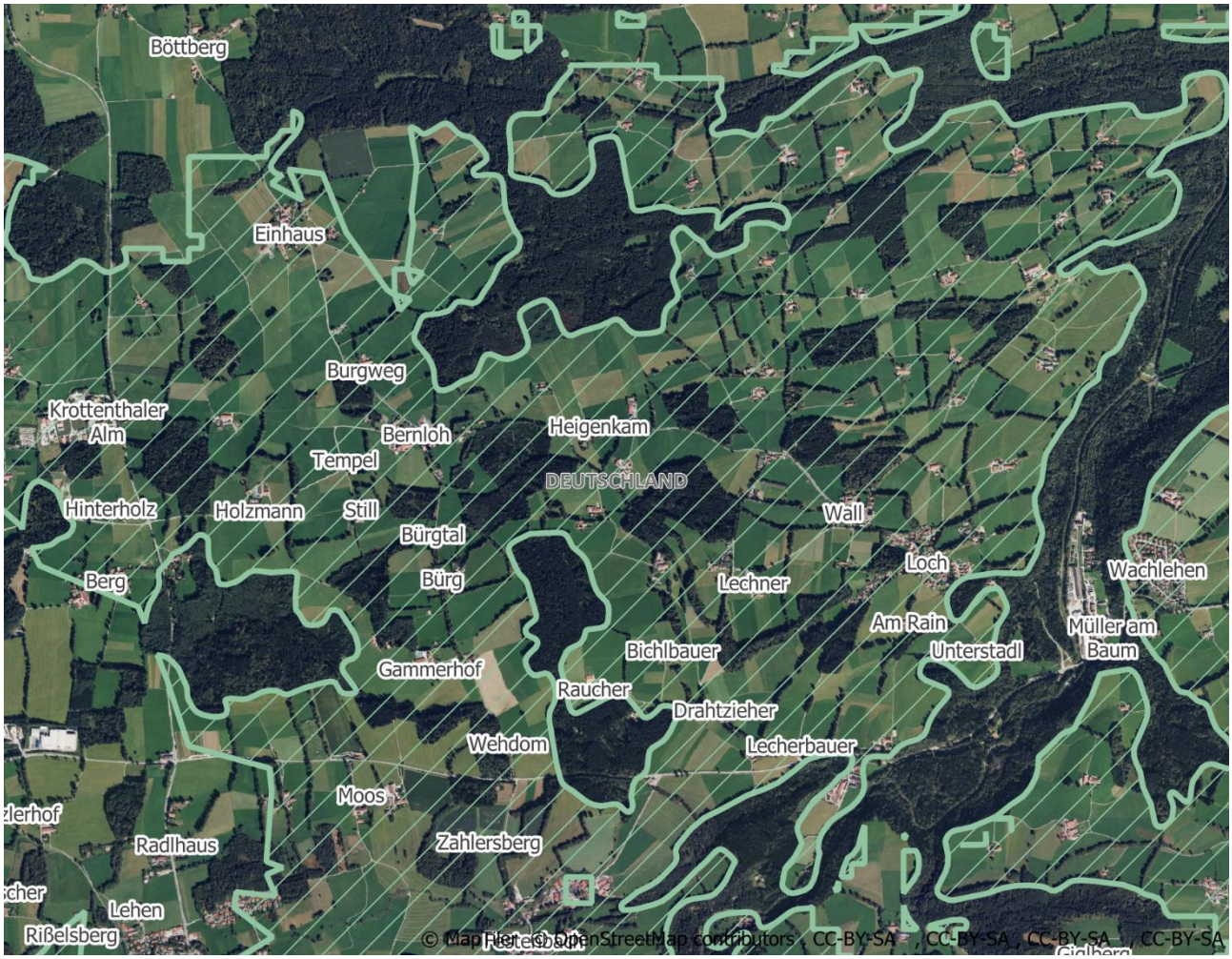
Map 25 Zoom Zone 2 - Vaucluse region France

The map has a selection of (413) patches from zone 2 larger than 1km². The importance on identifying these areas lays on the incompatibility of some agricultural activities that create significant impacts on the natural landscapes. As we can appreciate on the map, there are some small patches within the territory of the Alpine Convention. However, the areas more concerned by these activities are located on the Southwestern Alps, the interface with the Jura Massif and the Northeastern Alps.



Map 26 Priority areas - Zone 2

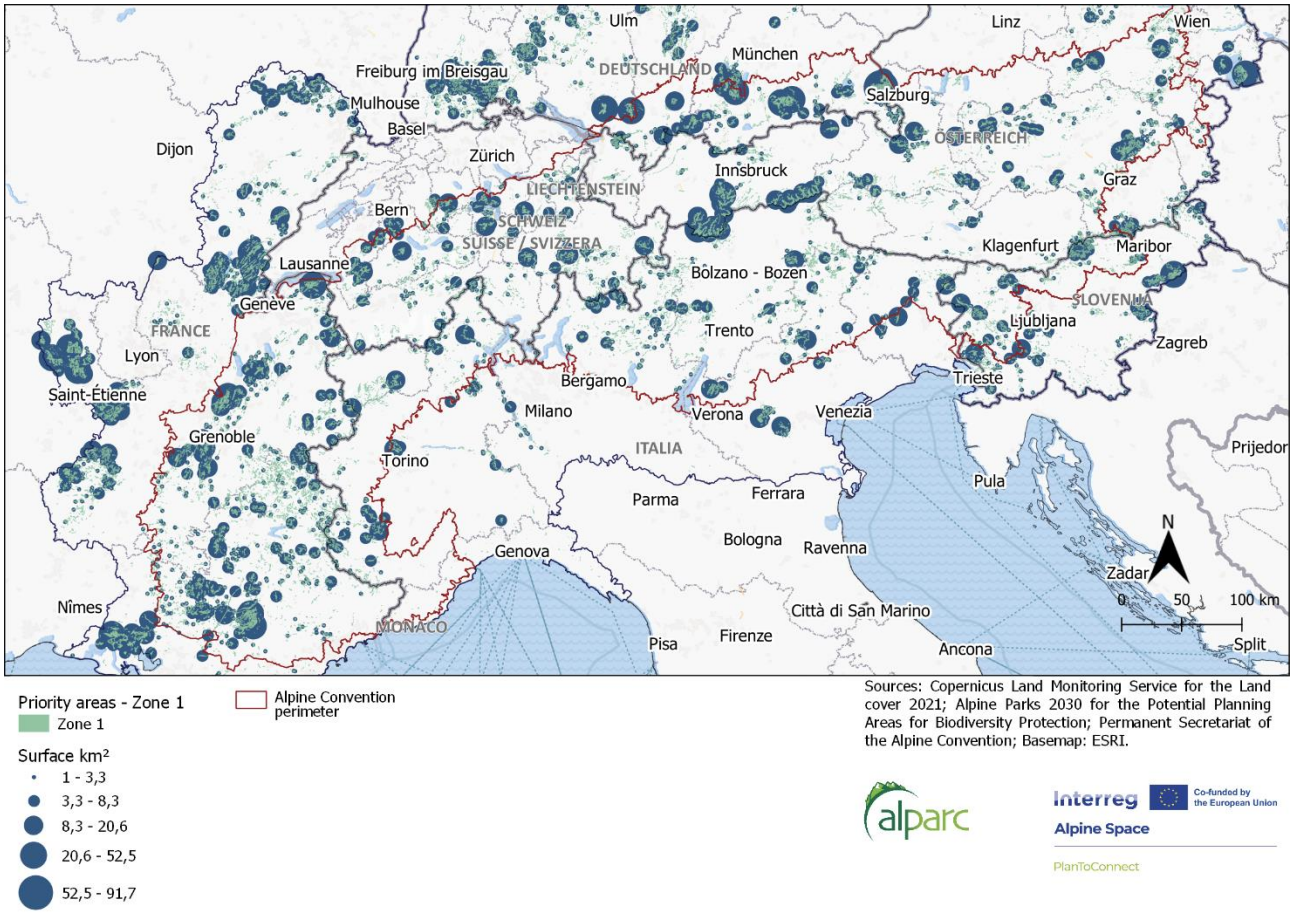
Zone 1: These areas include agricultural activities developed in surfaces with a high ecological potential. The coverage of these areas is less representative than the coverage on zone 0, nevertheless their importance is explained by their role in enabling the continuities and their partial compatibility with the establishment of nature preservation measures.



Map 27 Zoom Zone 1 - Warngau Upper Bavaria – Germany

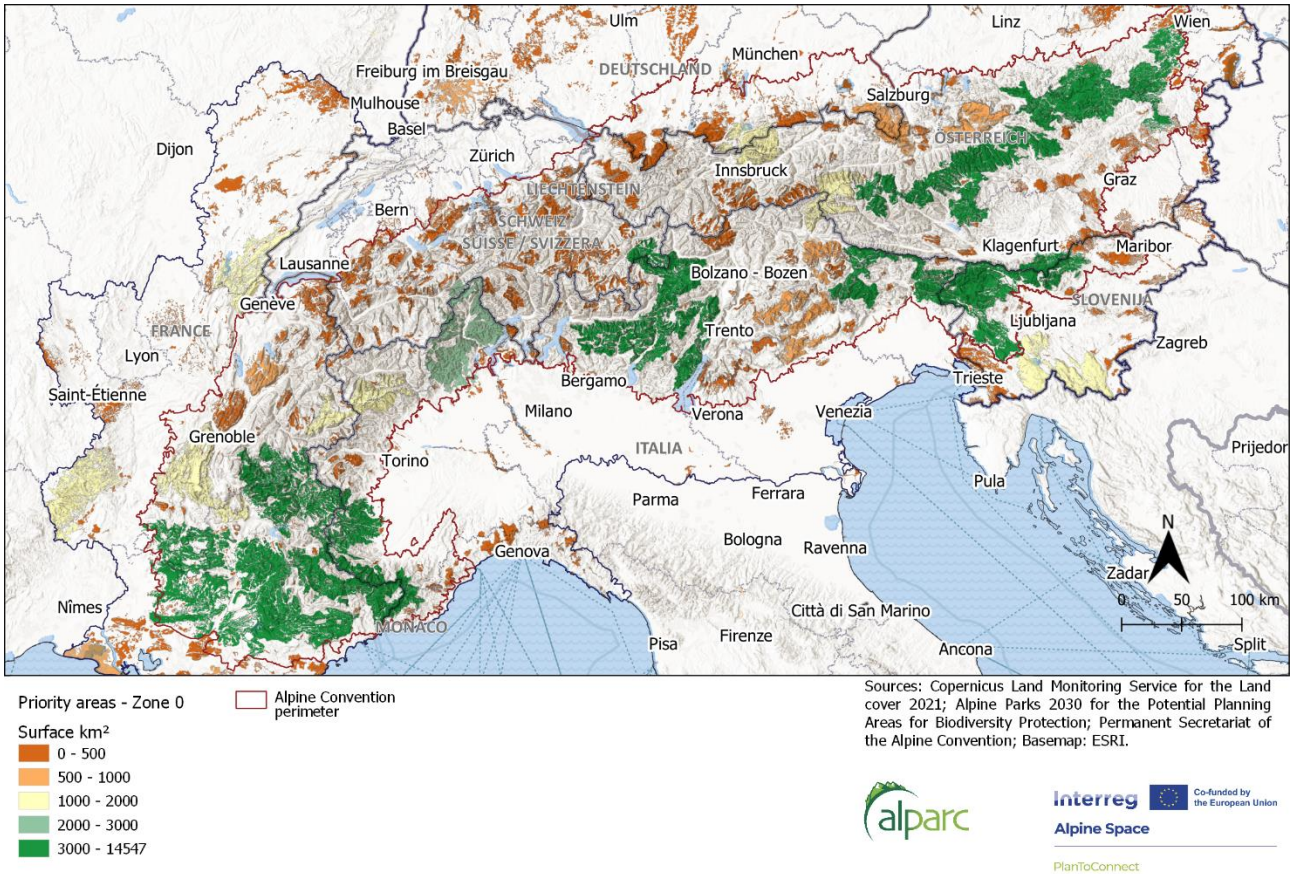
The map has a selection of (1373) patches from zone 1 larger than 1km². The implementation of effective conservation measures is expected at this category, further efforts are needed to monitor and designate these areas, as only a small proportion (36,5% of the areas in zone 1) are recognised under the Natura 2000 and Emerald network sites.

The preservation of these areas can help to connect and create larger continuities. The distribution of the areas from zone 1 is dispersed all along the Alpine region, which is quite beneficial given that the patches from zone 0 will need these connexions in order to reduce the threats



Map 28 Priority areas - Zone 1

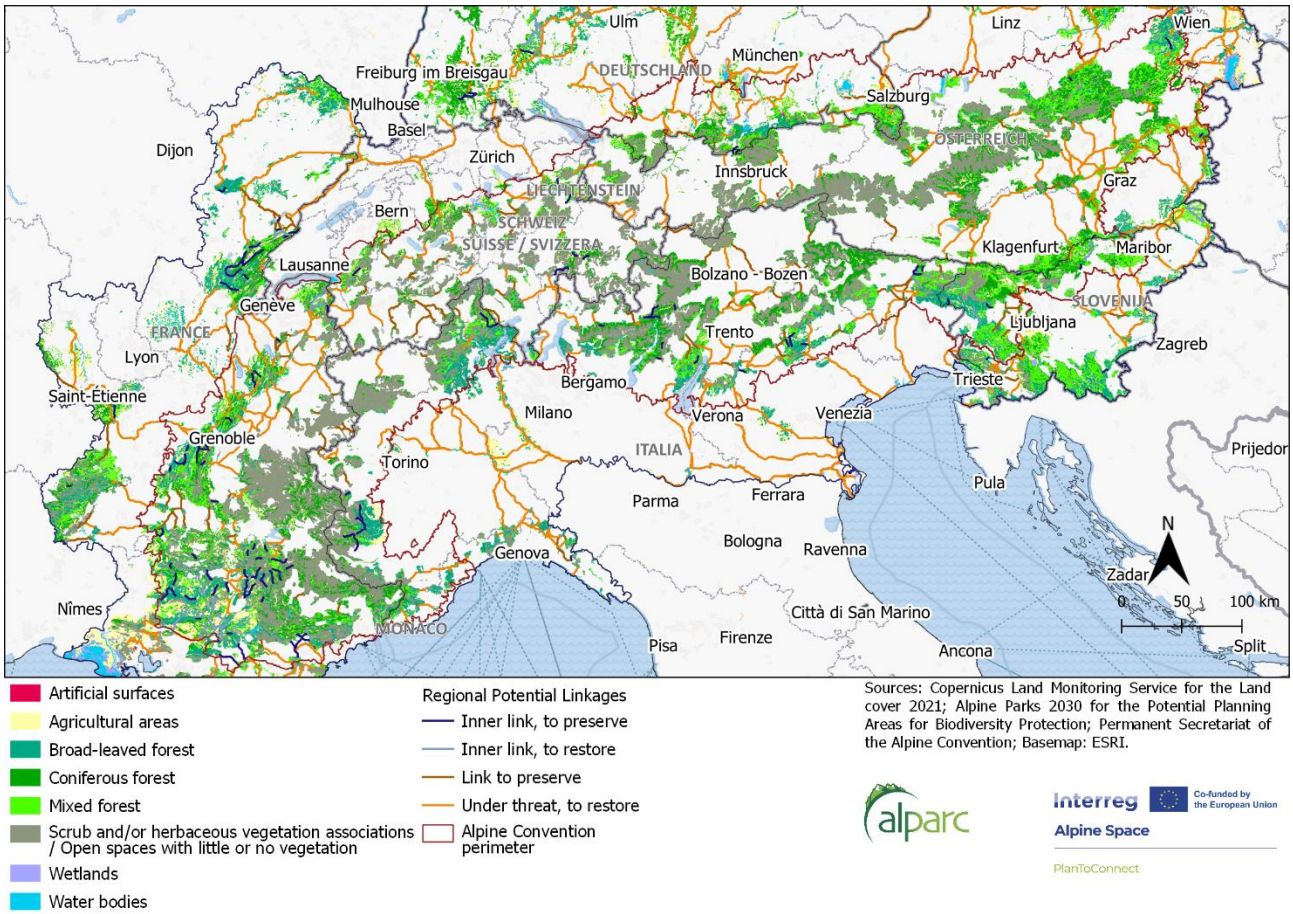
Zone 0: These areas have the highest ecological potential and the most compatible land uses. As highlighted in the habitat relevance section, many of these areas are already part of the Natura 2000 and Emerald Network sites. Several of the identified areas are also under national nature protection designations. However, due to the presence of infrastructure barriers some of these continuities are being fragmented. It is crucial to make every effort to prevent any artificialization within Zone 0 to preserve its ecological integrity.



Map 29 Priority areas - Zone 0

The map shows the areas of zone 0 organised by surface area. his representation highlights potential connections for creating large connectivity patches, including both protected and unprotected areas. The type of connection may vary depending on the surface area of the priority zone. For larger patches, actions should focus on preserving these significant areas, while for smaller surfaces, establishing ecological corridors becomes essential to ensure the movement of species and preserving habitats.

5 Recommendations for possible connectivity measures



Map 30 Ecological network Spatial Planning Areas for Biodiversity Protection

The following general measures are recommended in order to fulfil the ecological connectivity objectives inside the Alpine region:

- Protection of Spatial Planning Areas, finding mechanisms to ensure the protection of these landscapes should prioritise the areas integrating Zone 0 and Zone 1.
- Implementation of restauration measures for areas located on Zone 2 and Zone 3.
- Implementation of the potential links to integrate core zones and stepping stones into the ecological connectivity network.

The actions to be implemented concerning the categorisation of zones have been described in the previous chapter. Regarding the potential links, the map shows the Spatial Planning Areas for Biodiversity Protection, categorised by land use, along with the potential corridors proposed on the analysis of the PlanToConnect project.

Several regional potential linkages (461) were integrated into this analysis. The selection focused on those links that connect a patch, the links are illustrated in dark and light orange

for those connecting two or more Spatial Planning Areas for Biodiversity Protection, and in dark and light blue for those creating inner connexions inside these areas.

The presence of inner connexions is due to the potential linkage's goal to connect Ecological Conservation Areas (SACA1), some of which are located within the Spatial Planning Areas for Biodiversity Protection. It is important to remind that Ecological connectivity is one of the criteria integrated to identify these zones. This approach also allows to identify the challenges for ecological connectivity inside larger continuities beyond those identified with the Ecological Conservation Areas.

The surface covered by the Spatial Planning Areas for Biodiversity Protection extends to surfaces with different states of development concerning ecological connectivity. Identifying inner connexions is quite important, as these links are located in near natural areas with fewer land use conflicts and are already implementing actions aimed at nature preservation.

The links that connect the Spatial Planning Areas contribute to integrating and addressing the isolation of areas important for biodiversity protection but that currently are covering smaller surfaces.

The recommendations for integration into spatial planning vary accordingly to the barriers and current situation of the area. The recommendation of action (To preserve, to restore) is given accordingly to the current situation of the corridor regarding the barriers identified into the analyses, if the link intersects with more than two barriers (urban, road or railway) a restoration action will be privileged.

Restoring, protecting and preserving of the Spatial Planning Areas for Biodiversity Protection is one aspect of the strategy to guarantee ecological connectivity of natural areas of high ecological value in the Alps. Isolated patches are vulnerable to fragmentation, making it essential to analyze the possible synergies between the identified continuities. To create a more comprehensive approach, the potential regional linkages were incorporated into the analysis.

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ANNEXES

Annex 1 Classification scheme

Corine Code	Description (Corine Code/EFA)	Suitability class	Ecological connectivity suitability level			
			0	1	2	3
111	Continuous urban fabric	111_65				X
111	Continuous urban fabric	111_75				X
112	Discontinuous urban fabric	112_65				X
112	Discontinuous urban fabric	112_75				X
121	Industrial or commercial units and public facilities	121_65				X
121	Industrial or commercial units and public facilities	121_75				X
122	Road and rail networks and associated land	122_65				X
122	Road and rail networks and associated land	122_75				X
123	Port areas	123_65				X
123	Port areas	123_75				X
124	Airports	124_65				X
124	Airports	124_75				X
131	Mineral extraction sites	131_65				X
131	Mineral extraction sites	131_75				X
132	Dump sites	132_65				X
132	Dump sites	132_75				X
133	Construction sites	133_65				X
133	Construction sites	133_75				X
141	Green urban areas	141_65				X
141	Green urban areas	141_75				X
142	Sport and leisure facilities	142_65				X
142	Sport and leisure facilities	142_75				X
211	Non-irrigated arable land	211_65			X	

Corine Code	Description (Corine Code/EFA)	Suitability class	Ecological connectivity suitability level			
			0	1	2	3
211	Non-irrigated arable land	211_75		X		
212	Permanently irrigated land	212_65				X
212	Permanently irrigated land	212_75			X	
213	Rice fields	213_65				X
213	Rice fields	213_75			X	
221	Vineyards	221_65				X
221	Vineyards	221_75			X	
222	Fruit trees and berry plantations	222_65				X
222	Fruit trees and berry plantations	222_75			X	
223	Olive groves	223_65				X
223	Olive groves	223_75			X	
231	Pastures, meadows and other permanent grasslands under agricultural use	231_65		X		
231	Pastures, meadows and other permanent grasslands under agricultural use	231_75	X			
241	Annual crops associated with permanent crops	241_65			X	
241	Annual crops associated with permanent crops	241_75		X		
242	Complex cultivation patterns	242_65				X
242	Complex cultivation patterns	242_75			X	
243	Land principally occupied by agriculture, with significant areas of natural vegetation	243_65		X		
243	Land principally occupied by agriculture, with significant areas of natural vegetation	243_75	X			
244	Agro-forestry areas	244_65		X		
244	Agro-forestry areas	244_75	X			
311	Broad-leaved forest	311_65	X			
311	Broad-leaved forest	311_75	X			

Corine Code	Description (Corine Code/EFA)	Suitability class	Ecological connectivity suitability level			
			0	1	2	3
312	Coniferous forest	312_65	X			
312	Coniferous forest	312_75	X			
313	Mixed forest	313_65	X			
313	Mixed forest	313_75	X			
321	Natural grasslands	321_65	X			
321	Natural grasslands	321_75	X			
322	Moors and heathland	322_65	X			
322	Moors and heathland	322_75	X			
323	Sclerophyllous vegetation	323_65	X			
323	Sclerophyllous vegetation	323_75	X			
324	Transitional woodland-shrub	324_65	X			
324	Transitional woodland-shrub	324_75	X			
331	Beaches, dunes, sands	331_65		X		
331	Beaches, dunes, sands	331_75	X			
332	Bare rocks	332_65		X		
332	Bare rocks	332_75	X			
333	Sparsely vegetated areas	333_65	X			
333	Sparsely vegetated areas	333_75	X			
334	Burnt areas	334_65	X			
334	Burnt areas	334_75	X			
335	Glaciers and perpetual snow	335_65	X			
335	Glaciers and perpetual snow	335_75	X			
411	Inland marshes	411_65	X			
411	Inland marshes	411_75	X			
412	Peat bogs	412_65	X			

Corine Code	Description (Corine Code/EFA)	Suitability class	Ecological connectivity suitability level			
			0	1	2	3
412	Peat bogs	412_75	X			
421	Coastal salt marshes	421_65	X			
421	Coastal salt marshes	421_75	X			
422	Salines	422_65	X			
422	Salines	422_75	X			
423	Intertidal flats	423_65	X			
423	Intertidal flats	423_75	X			
511	Water courses	511_65	X			
511	Water courses	511_75	X			
512	Water bodies	512_65	X			
512	Water bodies	512_75	X			
521	Coastal lagoons	521_65	X			
521	Coastal lagoons	521_75	X			
522	Estuaries	522_65	X			
522	Estuaries	522_75	X			
523	Sea and ocean	523_65	X			
523	Sea and ocean	523_75	X			

Annex 2 Landscape fragmentation elements 2009

Dataset	**Fragmenting elements**
Corine Land Cover (CLC)	1.1: Continuous urban fabric, discontinuous urban fabric 1.2: Industrial and commercial units, road and rail networks and associated land, port areas, and airports 1.3: Mineral extraction sites, dump sites, and construction sites 1.4.1: Green urban areas

	1.4.2: Sport and leisure facilities (only included as a barrier if they were completely surrounded by the previous classes) 4.2.2: Salines 5.1.2: Water bodies
TeleAtlas Multinet	Class 00 'Motorways' (buffer 2 × 15 m) Class 01 'Major roads' (buffer 2 × 10 m) Class 02 'Other major roads' (buffer 2 × 7.5 m) Class 03 'Secondary roads' (buffer 2 × 5 m) Class 04 'Local connecting roads' (buffer 2 × 2.5 m) Railroads (buffer 2 × 2 m
Nordregio	Criterion 1: Elevation is higher than 2 500 m Criterion 2: Elevation is higher than 1 500 m and the slope is steeper than 2
WorldClim	Mean July temperature < 9.5 °C (mean 1950–2000, 30 '')
CCM2 : Catchment Characterisation and Modelling version 2.1	Catchment areas greater than 3 000 km^2

Annex 3 Landscape fragmentation elements time series 2009 - 2019

Dataset	**Fragmenting elements**
Copernicus High Resolution Layer	Imperviousness degree (30% of IMD)
TeleAtlas Multinet TeleAtlas Connect and Connect Plus	Tele Atlas road class Buffer size [m] Buffer width [m] motorways, freeways 15 30 major roads less important than a motorway 10 20 other major roads 7,5 15 secondary roads 5 10 local connecting roads 2,5 5 railroads 2 4

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PlanToConnect

Project of local ecological network - Alpine space

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Veneto Region (IT)
ALPARC – the Network of Alpine Protected Areas (FR)
Asters, organisation for the conservation of natural areas in Upper Savoy (FR)
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