Interreg
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PlanToConnect

# Project of ecological network South Tyrol

**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: D2.3.1

Laner Peter, Pilati Alessia, Vettorazzo Vittoria, Favilli Filippo

Institute for Regional Development, Eurac Research

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## Table of Contents

## List of Tables



## List of Figures

## List of Annexes



## List of Pictures

# 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)

**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)

**Ecological corridors**
"A clearly defined geographical space that is governed and managed over the long term to maintain or restore effective ecological connectivity. The following terms are often used similarly: 'linkages', 'safe passages', 'ecological connectivity areas', 'ecological connectivity zones', and 'permeability areas'." 'Clearly defined' means a spatially defined area with agreed and demarcated borders." (Hilty et al., 2020).

**Ecological conservation areas (SACA1)**
SACA1 areas will be the basis for ecological connectivity modelling in the PlanToConnect project. The term was developed in the AlpBioNet2030 project and is defined by "Areas, that still have considerable space for connectivity with non-fragmented surfaces and where connectivity should be conserved". According to Plassmann et al. 2019, currently 61% of the Ecological Conservation Areas within the Alpine Convention Perimeter are located in protected areas, which means there is a big potential for protection of these areas.

**Ecological intervention areas (SACA2)**
The main focus in the PlanToConnect project lies on areas for possible interventions to improve ecological connectivity. The AlpBioNet 2030 project simulated such areas with very large extension and developed the term "Ecological Intervention Areas". These are areas "with a high potential for connectivity in which larger, more or less natural non-fragmented zones could be created, especially by connecting protected areas, Natura2000 sites or other

precious biotopes. Ecological connectivity is currently working to some extent in these areas but would benefit from enhancements" (Plassmann et al. 2019).

**Potential ecological linkages**

'Potential ecological linkages' are geographically identified landscape elements, resulting from a connectivity model, which are connecting important ecological areas. These can be protected areas, Natura 2000 sites, or Ecological Conservation Areas (defined by AlpBioNet2030). Potential corridors are mostly a result of modelling approaches, calculated by the least cost paths, circuit theory (like SACA2), randomized shortest paths, or other methods. The term is commonly used in ecological network modelling, also in scientific literature (cf. Zhang & Song 2020)

**Ecological restoration areas (SACA3)**

The remaining areas refer to SACA3 (Ecological Restoration Areas) and are mainly areas where ecological connectivity is difficult to reestablish and act as barriers to connectivity. Mainly these are built-up areas, roads and industrial zones.

**Habitat suitability**

A Habitat Suitability Index (HSI) is a numerical index that represents the capacity of a given habitat to support a selected species. These models are based on hypothesized species-habitat relationships rather than statements of proven cause and effect relationships. HSI model results represent the interactions of the habitat characteristics and how each habitat relates to a given species (U.S. Environmental Protection Agency, 2016)

**Resistance**

Resistance models may quantify the ability of the landscape to impede species movement and represent suitable habitats (Vanderley-Silva & Averna Valente, 2023).

# EXECUTIVE SUMMARY


The study first focuses on several priority corridors, derived from a potential ecological network model at macro-regional level. These corridors are crucial for maintaining a coherent network at alpine wide level and the study revealed the ones located in South Tyrol. To validate the macroregional model, target species were selected by selecting specific habitats of which the loss is a fundamental cause of the decline in biodiversity in South Tyrol.

**Main Habitat Types and Target Species**

The primary habitat types of interest are forested areas, alpine grasslands, semi-natural grasslands, and wetlands.
The conducted connectivity analysis primarily focuses on red deer as the target species due to its need to move between forests and grasslands and its sensitivity to habitat fragmentation. Other species which would be possible to consider include black grouse for higher-altitude habitats, as well as a pollinator species for identifying missing green infrastructure elements in agricultural areas. An ecological network was modelled for red deer species using a habitat suitability (HS) and least-cost path (LCP) approach, which identifies optimal routes for wildlife based on landscape permeability.
The model identified suitable core habitats, island habitats, stepping stones, and corridors. Key factors in the model include land use, distance from human infrastructure, elevation, and slope. Corridors were described and evaluated if they are existing and should be preserved, or if they are potential and need to be restored. However, the corridors still need to be validated with additional analysis in order to confirm the model.

**Priority corridors**

Key corridors include those connecting the nature parks of Fanes-Sennes-Braies and Vedrette di Ries-Aurina in the Rasen-Antholz area, where wildlife, particularly red deer, frequently cross the State Road and where anthropogenic infrastructure is extending along the valley (see corridor n° 6). Additional priority corridors include links in the Adige Valley: A valley-crossing between the Monte Corno Nature Park and the Mendel Mountain range on the western side (n° 26) would represent one of the most important links in the Alpine region. North and south of Salorno there would be the possibility of crossing the Adige Valley with the shortest distance between the mountainsides (n° 25). A north-south connection in the Venosta Valley between the Stilfser Joch National Park and the Tessa Group is also very important for a coherent alpine-wide ecological network (n° 23). The Töllgraben river was identified as a potential option to restore and to widen the green infrastructure elements. Permeability for wildlife in Upper Venosta Valley, at the north area of Burgusio must be ensured to maintain connectivity at the alpine level (n° 4). Finally, in Isarco Valley, between Campo di Trens and Vipiteno (n° 24) the macro-regional model indicates an important corridor, and hunters' observation and animal-vehicle collisions indicate wildlife movements. The red deer model was not able to reveal the shortest path in this section, however, there

may be underpasses beneath the elevated motorway, and it would be worthwhile to investigate whether wildlife utilizes these underpasses.
Four corridors were identified as questionable in their functionality because of the presence of many barriers: Naz-Sciaves – Rio di Pusteria (n° 5), Sluderno – Prato (n° 10), Renon – Castelrotto – Laion (n° 14), and Renon – Sciliar (n° 20/21). These corridors are candidates for restoration and should be prioritized for further analysis due to their significance in the macro-regional model.

**Identified Barriers**

The report identifies several anthropogenic barriers that disrupt ecological connectivity, especially in valley bottoms. Key barriers include highways (notably the A22), railways, and intensive agricultural areas that fragment landscapes.

The study makes a focus on the corridor Percha - Rasen-Antholz where the density of incidents with wildlife along roadways is high, and checks possible alternatives, verifying the corridor widths, bottlenecks and traffic intensity. The need for connectivity measures like wildlife overpasses and underpasses is highlighted.

# ZUSAMMENFASSUNG

Die Studie konzentriert sich zunächst auf mehrere prioritäre ökologische Korridore, die aus einem potenziellen ökologischen Netzwerkmodell auf makroregionaler Ebene abgeleitet wurden. Diese Korridore sind entscheidend für die Aufrechterhaltung eines kohärenten Netzwerks auf alpenweiter Ebene, und es konnten die in Südtirol gelegenen Verbindungen aufgezeigt werden. Um das makroregionale Modell zu validieren, sind Zielarten ausgewählt worden, indem spezifische Lebensräume aus anderen Studien herangezogen wurden, die eine grundlegende Ursache für den Rückgang der Biodiversität in Südtirol darstellen.

**Hauptlebensraumtypen und Zielarten**

Die primären Lebensraumtypen von Interesse sind bewaldete Gebiete, alpine Graslandschaften, halbnatürliche Graslandschaften und Feuchtgebiete. Die durchgeführte Analyse zur Konnektivität konzentriert sich hauptsächlich auf den Rothirsch als Zielart, da er zwischen Wäldern und Graslandschaften wandern muss und empfindlich auf Habitatfragmentierung reagiert. Andere Arten, die in Betracht gezogen werden könnten, sind das Birkhuhn für höhergelegene Lebensräume sowie eine Bestäuber-Art zur Identifizierung fehlender grüner Infrastrukturelemente in landwirtschaftlichen Gebieten. Ein ökologisches Netzwerk wurde für die Rothirscharten unter Verwendung eines Habitat-Eignungsmodells (HS) und eines Ansatzes des kostengünstigsten Pfades (LCP) modelliert, welcher optimale Routen für Wildtiere basierend auf der Durchlässigkeit der Landschaft identifiziert. Das Modell identifizierte geeignete Kernlebensräume, Inselhabitate, Trittsteinhabitate und Korridore. Wichtige Faktoren im Modell umfassen Landnutzung, Entfernung von menschlicher Infrastruktur, Höhe und Steigung. Korridore wurden beschrieben und grob nach ihrer existierenden Funktionalität bewertet. Es konnten einige Rückschlüsse gemacht werden, ob sie erhalten werden sollten oder wiederhergestellt werden müssten. Die Korridore müssen jedoch noch mit zusätzlichen Analysen validiert werden, um das Modell zu bestätigen.

**Vorrangige Korridore**

Zu den wichtigsten Korridoren gehören diejenigen, die die Naturparks Fanes-Sennes-Prags und Rieserferner-Ahrn im Gebiet Rasen-Antholz verbinden. Hier überqueren Wildtiere, insbesondere Rothirsche, häufig die Staatsstraße und anthropogene Infrastrukturen breiten sich entlang des Tals aus (siehe Korridor Nr. 6). Weitere vorrangige Korridore umfassen Verbindungen im Etschtal: Eine Talquerung zwischen dem Naturpark Trudner Horn und dem Mendelkamm auf der westlichen Seite (Nr. 26) würde eine der wichtigsten Verbindungen im gesamten Alpenraum darstellen. Nördlich und südlich von Salurn gäbe es die Möglichkeit das Etschtal mit der kürzesten Entfernung zwischen den Bergseiten zu verbinden (Nr. 25). Eine Nord-Süd-Verbindung im Vinschgau zwischen dem Nationalpark Stilfser Joch und der Texelgruppe ist ebenfalls sehr wichtig für ein kohärentes alpenweites ökologisches Netzwerk (Nr. 23). Der Töllgraben wurde als potenzielle Option zur Wiederherstellung und Erweiterung der grünen Infrastrukturelemente identifiziert. Des Weiteren muss die Durchlässigkeit für Wildtiere im oberen Vinschgau, im nördlichen Bereich von Burgeis gewährleistet sein, um die Konnektivität auf alpenweiter Ebene zu erhalten (Nr.

4). Schließlich weist das makroregionale Modell im Eisacktal zwischen Freienfeld und Sterzing (Nr. 24) auf einen wichtigen Korridor hin, und Beobachtungen von Jägern sowie Wildunfälle deuten auf Wildtierbewegungen hin. Das Rothirschmodell konnte in diesem Abschnitt keinen kürzesten Weg aufzeigen. Möglicherweise gibt es jedoch Querungsmöglichkeiten unter Autobahnbrücken, und es wäre lohnenswert zu untersuchen, ob Wildtiere diese Unterführungen nutzen.

Auf vier Korridoren wurden mehrere mögliche Barrieren identifiziert, weshalb ihre Funktionalität als fraglich bewertet werden kann: Natz-Schabs – Mühlbach (Nr. 5), Schluderns – Prad (Nr. 10), Ritten – Kastelruth – Lajen (Nr. 14) und Ritten – Schlern (Nr. 20/21). Aufgrund ihrer Bedeutung im makroregionalen Modell sollten diese Korridore vorrangig weiter analysiert werden, speziell hinsichtlich möglicher Wiederherstellungsmaßnahmen.

**Identifizierte Barrieren**

Der Bericht identifiziert mehrere anthropogene Barrieren, die die ökologische Konnektivität stören, insbesondere in Talböden. Zu den wichtigsten Barrieren gehören Autobahnen (insbesondere die A22), Eisenbahnen und intensive landwirtschaftliche Gebiete, die Landschaften fragmentieren.

Die Studie konzentriert sich auf den Korridor Percha - Rasen-Antholz, wo die Dichte von Wildunfällen entlang der Straßen hoch ist, und prüft mögliche Alternativen, indem die Korridorbreiten, Engpässe und Verkehrsintensität überprüft werden. Der Bedarf an Maßnahmen für die ökologische Konnektivität wie Wildtierüberführungen und -unterführungen wird hervorgehoben.

# RIEPILOGO

Lo studio si concentra su diversi corridoi prioritari, derivati da un potenziale modello di rete ecologica a livello macroregionale. Questi corridoi sono cruciali per mantenere una rete coerente a livello alpino e questo studio ha rivelato quelli situati in Alto Adige. Per convalidare il modello macroregionale, sono state selezionate specie target scegliendo habitat specifici di cui la perdita è causa fondamentale del declino della biodiversità in Alto Adige.

**Tipi di Habitat Principali e Specie Target**

I principali tipi di habitat di interesse sono le aree forestali, i pascoli alpini, i prati semi-naturali e le zone umide.

L’analisi della connettività condotta si concentra principalmente sul cervo come specie target a causa della sua necessità di spostarsi tra foreste e pascoli e della sua sensibilità alla frammentazione dell’habitat. Altre specie che potrebbero essere considerate sono il gallo cedrone per gli habitat ad alta quota, e una specie impollinatrice per identificare le infrastrutture verdi mancanti nelle aree agricole.

È stata modellata una rete ecologica per le specie di cervo utilizzando un approccio di idoneità dell’habitat (HS) e di percorso a costo minimo (LCP), che identifica le rotte ottimali per la fauna selvatica basate sulla permeabilità del paesaggio.

Il modello ha identificato aree di habitat centrali, “isole di habitat”, *stepping stones* e corridoi. I fattori chiave nel modello includono l’uso del suolo, la distanza dalle infrastrutture umane, l’altitudine e la pendenza. I corridoi sono stati descritti ed è stata fatta una valutazione: esistono e vanno preservati, o sono potenziali e devono essere ripristinati. Tuttavia, i corridoi devono ancora essere validati tramite ulteriori analisi per confermare il modello.

**Corridoi Prioritari**

I corridoi chiave includono quelli che collegano i parchi naturali di Fanes-Sennes-Braies e Vedrette di Ries-Aurina nell’area di Rasun-Anterselva, dove la fauna selvatica, in particolare i cervi, attraversano frequentemente la strada statale e dove le infrastrutture antropiche si stanno estendendo lungo la valle (vedi corridoio n° 6). Altri corridoi prioritari includono collegamenti nella Valle dell’Adige: un attraversamento della valle tra il Parco Naturale del Monte Corno e la catena montuosa della Mendola sul lato occidentale (n° 26) rappresenterebbe uno dei collegamenti più importanti nella regione alpina. A nord e a sud di Salorno ci sarebbe la possibilità di attraversare la Valle dell’Adige con la distanza più breve tra i versanti montuosi (n° 25). È inoltre molto importante, per una rete ecologica coerente a livello alpino, una connessione nord-sud nella Val Venosta tra il Parco Nazionale dello Stelvio e il Gruppo di Tessa (n° 23). Il fiume Töllgraben è stato identificato come un’opzione potenziale per ripristinare e ampliare gli elementi di infrastruttura verde. La permeabilità per la fauna selvatica nell’Alta Val Venosta, nell’area nord di Burgusio, deve essere garantita per mantenere la connettività a livello alpino (n° 4). Infine, nella Valle Isarco, tra Campo di Trens e Vipiteno (n° 24), il modello macro-regionale indica un corridoio importante, e le osservazioni dei cacciatori e le collisioni tra animali e veicoli indicano movimenti della fauna selvatica sul luogo. Il modello non è stato in grado di rivelare il corridoio più breve in quest'area, ma potrebbero esistere dei passaggi al di sotto dei punti in cui l'autostrada è sopraelevata. Si potrebbe fare una verifica su campo per controllare se questi passaggi siano utilizzati o meno dalla fauna selvatica.

Quattro corridoi sono stati identificati come discutibili nella loro funzionalità data la presenza di molte barriere: Naz-Sciaves – Rio di Pusteria (n° 5), Sluderno – Prato (n° 10), Renon – Castelrotto – Laion (n° 14) e Renon – Sciliar (n° 20/21). Questi corridoi sono candidati per il ripristino e dovrebbero essere prioritari per ulteriori analisi a causa della loro importanza nel modello macroregionale.

**Barriere Identificate**

Il rapporto identifica diverse barriere antropogeniche che interrompono la connettività ecologica, specialmente nel fondovalle. Le barriere principali includono autostrade (in particolare l'autostrada A22), ferrovie e aree agricole intensive che frammentano i paesaggi.

Lo studio si concentra sul corridoio Percha - Rasun-Anterselva, dove la densità di incidenti con la fauna selvatica lungo le strade è elevata, e verifica possibili alternative, controllando le larghezze dei corridoi, i colli di bottiglia e l'intensità del traffico. Viene evidenziata la necessità di misure di connettività come sovrappassi e sottopassi per la fauna selvatica.

# REPORT

# 1 Introduction

The PlanToConnect project aims to develop an ecological connectivity network for South Tyrol as a proposal for new spatial planning tools. The aim of the case study is the creation of a GBI network in the Autonomous Province of Bolzano-South Tyrol, as it is the last region in the Alpine Space without a formal or informal ecological connectivity concept, or which is included in a national connectivity concept, which can be downloaded from an official website of a public authority. The network design is made on two levels: an ecological connectivity concept for the new Provincial Strategic Plan (PSP) will be proposed, using the macroregional structural model of the PlanToConnect project. At the provincial level an analysis regarding ecological connectivity for target species is made to formulate a more detailed network design proposal. This could be used for the new provincial landscape guidelines and to focus on some specific measures to implement EC in the municipal development programs, especially for the in-depth landscape analysis for some municipalities. The update of the PSP could provide the basis for the creation of a real provincial ecological network and its connection to the European ecological network and align with other regions of the EUSALP.

The following will give an overview of ecological connectivity in the case study region. Starting from chapter 3, there will be an in-depth look at the pilot area outlining and detailing where the project's specific areas of analysis and work are. Chapter 4 will provide the results of the work, and Chapter 5 will provide/give future recommendations.

## 1.1 Ecological connectivity in South Tyrol

In this case study, the connectivity to be maintained and reestablished is structural and functional. The valley bottoms in South Tyrol are a barrier for many wildlife species for what it would be useful to find possibilities for corridors consisting of natural connectivity features (hedgerows, wildlife strips, stone walls, riparian river vegetation, stepping stones of natural habitats, etc.). The structural approach can be represented by the macro-regional model, while it is necessary to conduct an analysis based on a functional approach based on target species for a detailed picture of the situation. For this, we refer to a study on which habitats are being lost that generate a cause of the decline in biodiversity in South Tyrol, published in the Landscape guidelines of South Tyrol of 2003. (see section 3.1 Methodological approach). A list of target species was deduced based on the listed habitats. We came to the conclusion that ecological connectivity in South Tyrol should be analysed at provincial-level for ungulates, species in higher altitudes, and pollinators.
In this study we focus on red deer as target species. Red deer is a generalist species that move between different areas, like grasslands and forests and feed on a wide variety of plant species, while the most important barriers are anthropogenic infrastructures.

Additionally, it would be possible to focus on black grouse, which is more specialized and concentrates along the forest line but is also able to live in habitats influenced by anthropogenic uses, such as alpine pastures. It depends on different types of local habitats during its annual life cycle. The analysis of pollinators would require more detailed data on local level and more expertise, which results in a high complexity.
The protected areas of South Tyrol are mainly located on the provincial borders. This has a positive effect on transnational and transregional connectivity, but areas with high naturalistic value located in the central area of the province are not protected. In fact, the overall ecological connectivity is given mainly within nature parks and other protected areas. All the nature parks are SACA1 areas. Not protected SACA1 areas are present mainly at the centre of South Tyrol.Connectivity must also be maintained and reestablished between state borders; in fact, numerous crossings occur between the borders connecting the Autonomous Province of Bolzano - South Tyrol with Austria and Switzerland. Therefore, it is important to create a coherent network to keep all the possible linkages connected to the inner Alpine arc with major wildlife areas outside the Alps.

Currently, there are existing passages used by the species, but they need to be prevented from being closed by anthropogenic infrastructure. Similarly, possible passages have been identified that need to be improved or restored (for example hedges, rows, shrubs, forests, natural channels with riparian vegetation, wetlands).
From an experts' point of view, ecological connectivity is mostly working on mountain slopes, covered by forests.

The pilot area has numerous physical barriers of anthropogenic origin, the main ones are present in the valley bottoms. Anthropogenic infrastructure such as residential areas, the road network, and tourism infrastructure are the main barriers immediately evident, and especially in the Adige valley. At the other hand side, there are high levels of ecological connectivity in the central and eastern areas of South Tyrol outside the large urban settlements such as Brunico and Bressanone. (Giombini et al. 2022).
The most important road barriers are the highway sections of the A22 between Campo di Trens and Sterzing, the section near Ora, and those before and after Salorno. The Merano-Bozen (MeBo) freeway represents a major barrier in the section between Gargazon and Lana. In South Tyrol, the Adige Valley is a main barrier. Intensive agriculture also causes environmental homogeneity, resulting in a shortage of shrublands or uncultivated margins.

Currently, South Tyrol is one of the last regions in the Alpine Space that doesn't yet have spatial planning that integrates a formal or informal concept of ecological connectivity at a regional level.
To be able to integrate ecological connectivity in local and provincial spatial planning instruments, it is important to support regional planning authorities and municipalities with appropriate analysis.
The municipal development programs are developed at the municipal level as long-term planning tools for land development, defining future building land and open space in a

municipality over the next ten years. The municipal plan is developed according to the guidelines of the Provincial Strategic Plan (PSP), which defines the province's land development goals in the medium and long term, the update of which is scheduled for 2024. At the same time, the Provincial Landscape Guideline needs to be revised.

# 2 Pilot region

## 2.1 General description

The geographic scope of the study includes the Autonomous Province of Bolzano-South Tyrol, with consideration for connections to surrounding regions. The area covers an area of 7,400 km² with 536,933 inhabitants (2023) and has a protected surface area of 1.867,39 km², equal to 25.24% of the total area. (Laner P., Vitangeli V., 2024). More than half of South Tyrol's territory is covered by forested areas. Most of the 14,700 animal species documented to occur in South Tyrol live permanently or partially in forests. More than 1,100 plant species also grow in the forested areas of South Tyrol, including 173 mosses, 49 tree species and 23 shrub species, as well as about 6,000 species of fungi. (Autonomous Province of Bolzano, 2023).

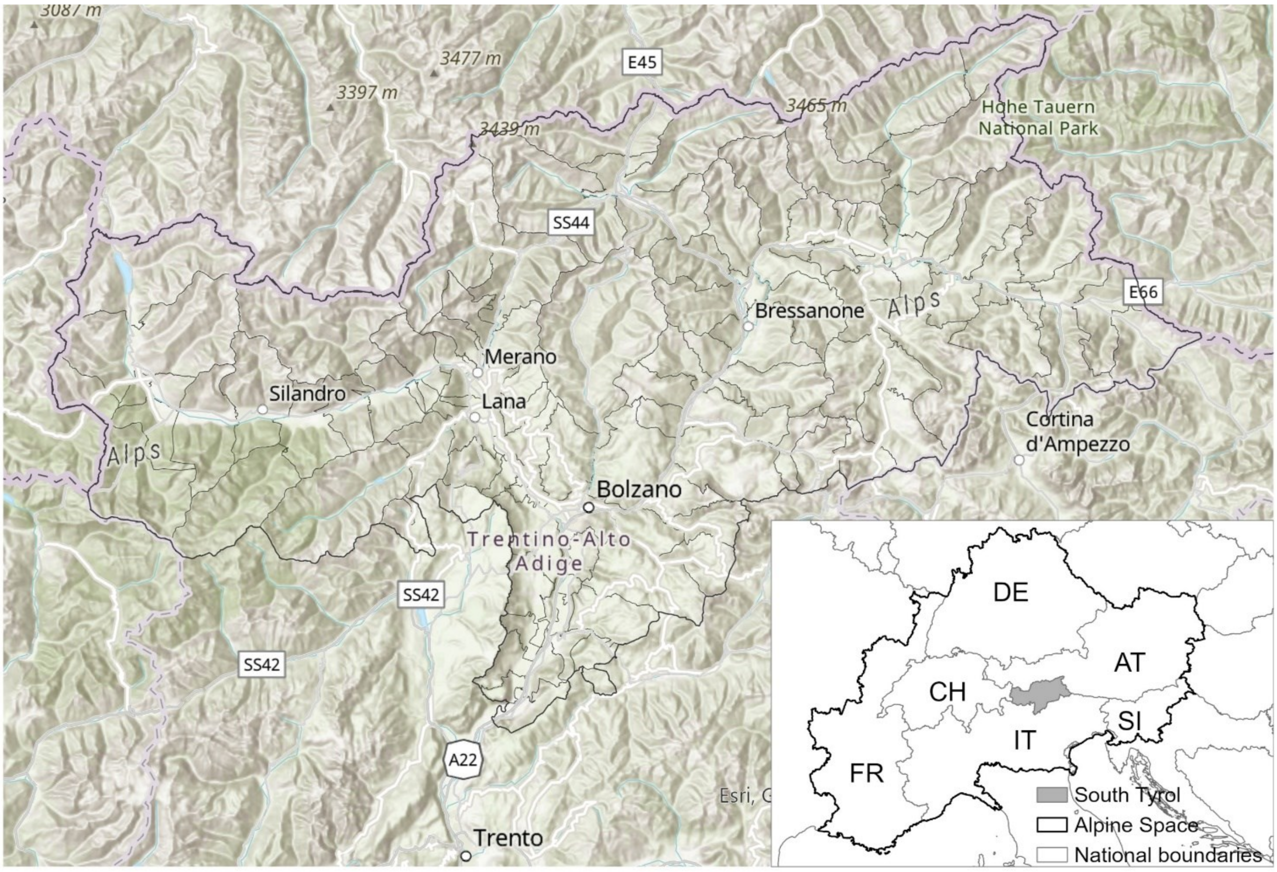


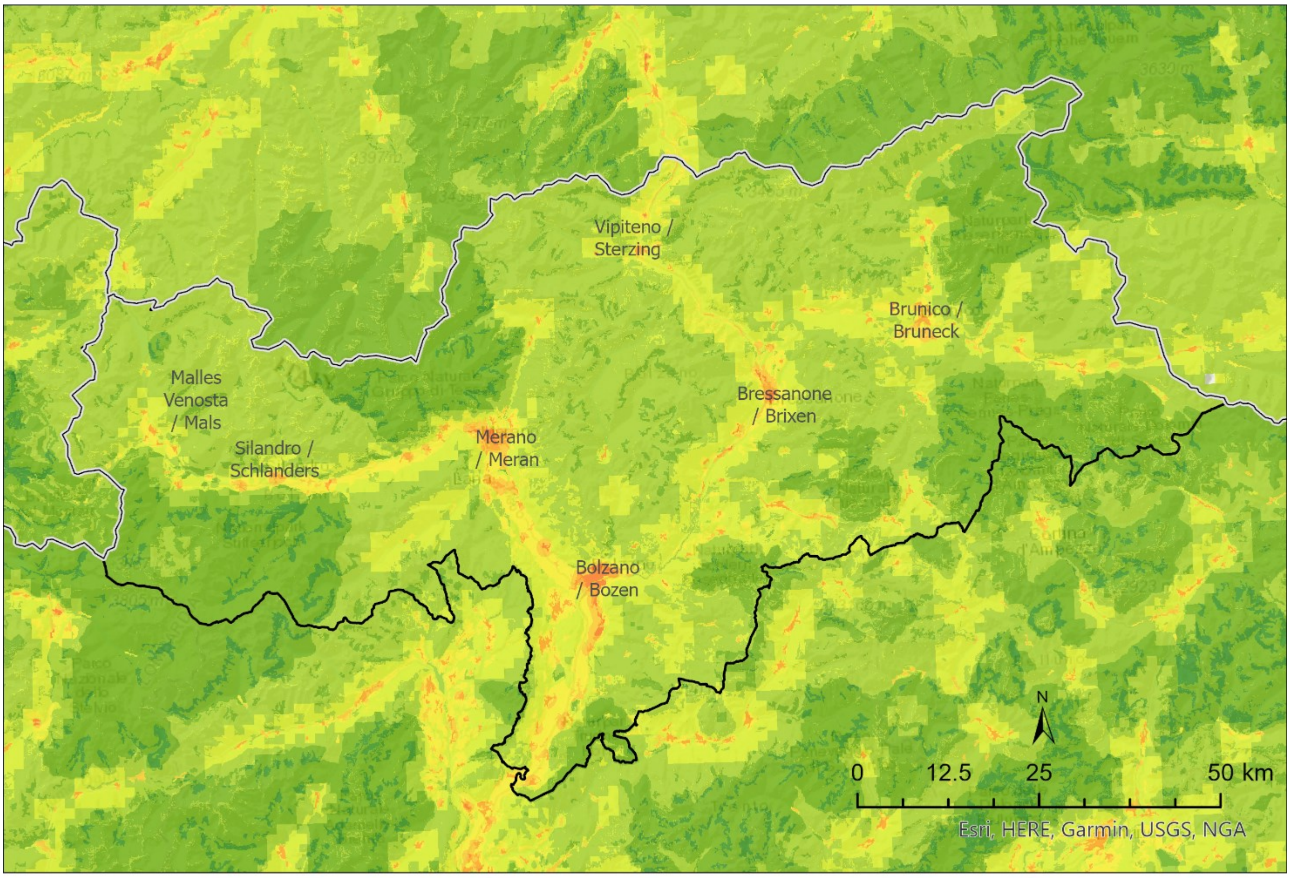

Figure 1: Overview – Location of pilot area

South Tyrol is characterized by the alternation of valleys and mountainous areas and the transition from forest associations to alpine grasslands. The uniqueness of the South Tyrolean landscape is given by the combination of strongly characterizing forms of use such as fruit growing, viticulture, and forage farming. Changing agrarian structure, intensive land use, has induced a noticeable change in the landscape. Data on the overall distribution of land types in South Tyrol show the dominance of the alpine and forested areas, which are characterized by anthropogenic use, influencing them in a pointwise manner.

Table 1: Classification of landscape typology of South Tyrol

| |
|---|
| **Landscape type A - Valley bottoms and major basins** |
| Landscape belt A1 - Valley bottoms and low slopes with fruit specialization |
| Landscape belt A2 - Valley bottoms and low slopes with viticultural specialization |
| Landscape belt A3 - Valley bottoms and adjacent areas with predominantly forage and arable crops |
| Landscape belt A4 - Settlements |
| **Landscape type B - Slopes** |
| Landscape belt B1 - Valley slopes with sub-Mediterranean vegetation |
| Landscape belt B2 - Inner alpine dry valley slopes |
| Landscape belt B3 - Mountain agricultural areas |
| **Spatial typology C - Forest** |
| **Spatial typology E - Alpine and high-altitude environment** |

From the landscape permeability map (Figure 2) it is possible to observe the distribution of areas from the most artificial to the least artificial areas. In this way, the valley bottom of the pilot area is easily visible as influenced by man-made infrastructure. The rest is occupied by semi-natural areas (areas with predominantly forage, arable and fruit culture) and natural areas (forest, alpine environment). The central and eastern areas of South Tyrol have high levels of ecological connectivity outside the large urban settlements (Giombini et al. 2022).




Landscape permeability

- 1 - highly artificial areas, very high barrier effect
- 2 - artificial areas, very high barrier effect
- 3 - artificial areas, high barrier effect
- 4 - artificial areas, barrier effect
- 5 - semi-natural areas, high antropogenic influence
- 6 - semi-natural areas, important for connectivity
- 7 - natural areas, important for ecological connectivity
- 8 - natural areas, ecological value
- 9 - natural areas, high ecological value
- 10 - highly natural areas, very high ecological value
- National boundaries
- Boundary South Tyrol

Eurac Research
Institute for Regional Development.
Cartography: Peter Laner.
July 2023

Sources: Values for landscape permeability from ALPARC (AlpBioNet2030 project). Eurostat/ GISCO 2021 for administrative boundaries.

Figure 2: Assessment of landscape permeability in South Tyrol

## 2.2 Alpine-wide structural potential network in South Tyrol

Within the pilot area all three SACA areas are included, with the largest distribution being in SACA 2 areas, which have a big potential for ecological connectivity. SACA3 areas are easily visible along the settlements of the Adige valley. Figure 4 represents the potential ecological network of South Tyrol, outlining whether the level of barriers is high, intermediate or low; the level of connectivity of the landscape; potential regional connections; and the width of the connections.

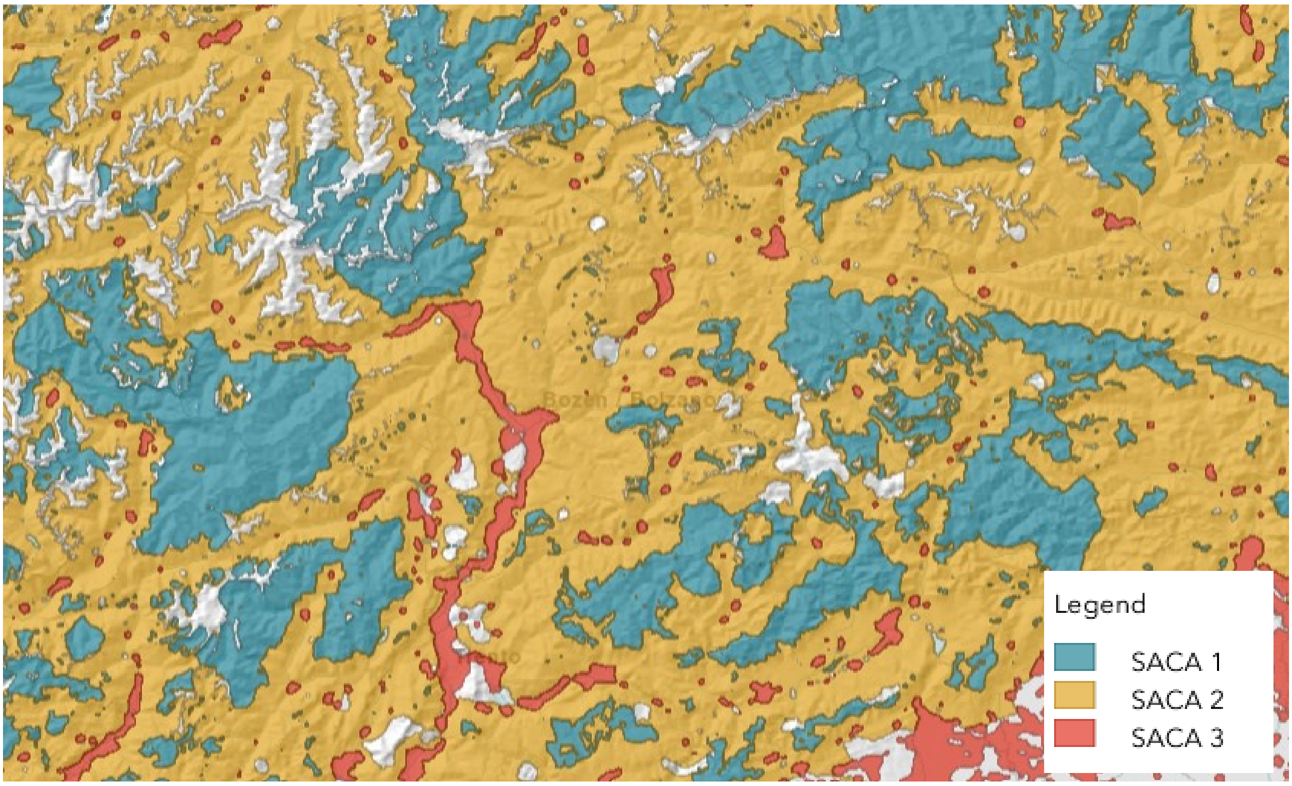



Figure 3: Overview – Location of pilot area and SACA areas

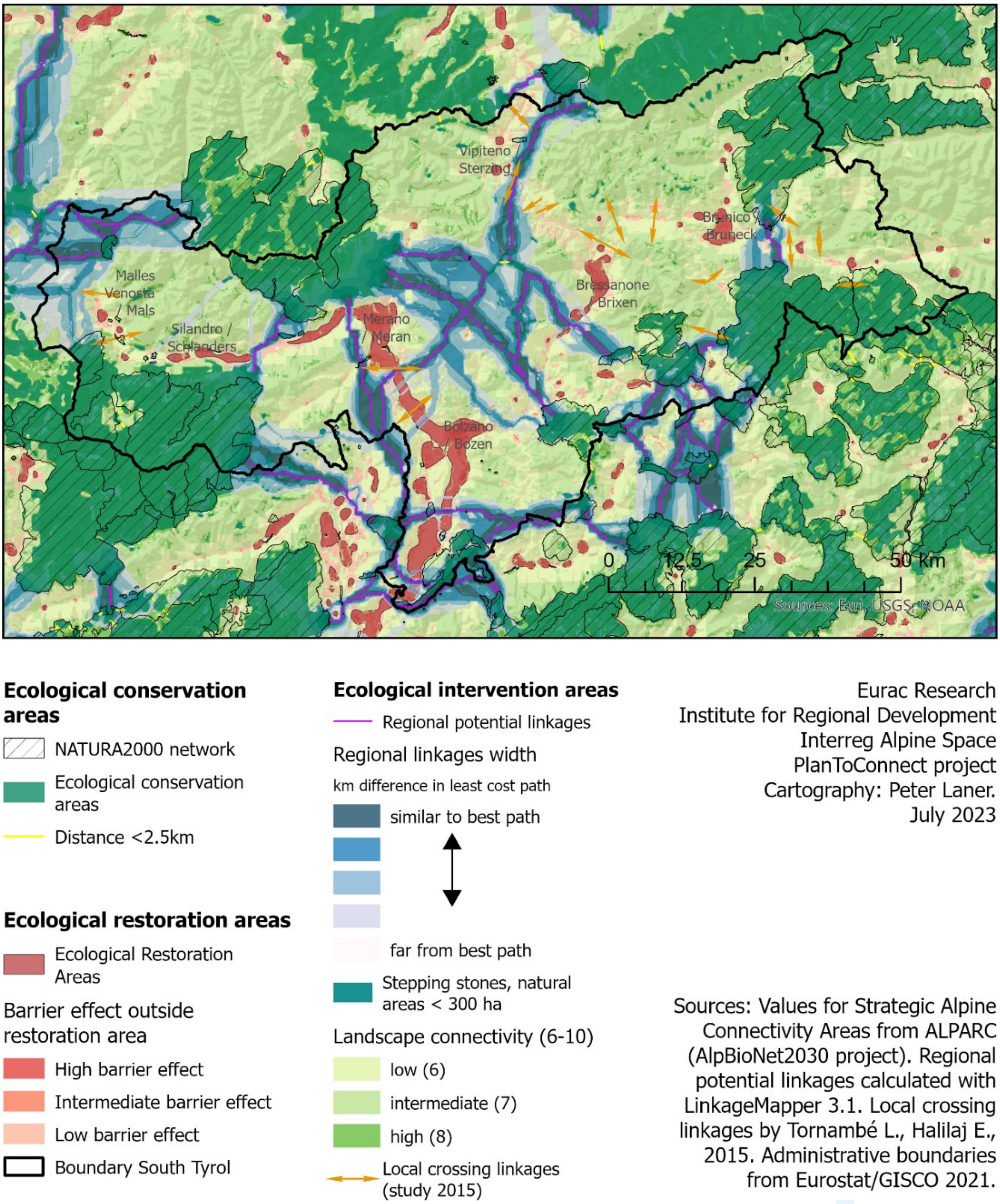



Figure 4: Potential ecological connection of South Tyrol

The coloured arrows in the map (Figure 5) identify the selected links, in red the one with the highest priority in the Alpine region, in purple the potential linkages and in green the existing ones.

For priority connectivity areas at the transnational and regional levels, the goal is to preserve the existing highly permeable landscapes in the regions and identify ecological connections important for the creation of a coherent Alpine network for a true transnational ecological network.
The connection between the nature parks of Fanes - Sennes - Braies and Vedrette di Ries - Aurina has been classified one of the highest priorities in the Alps. On the highway east of Brunico, incidents with wildlife are very frequent, confirming the presence of a migratory route. This route is affected by urban development and should be preserved soon.
A valley-crossing between the Monte Corno Nature Park and the Mendel Mountain range on the western side would represent one of the most important links in the Alpine region. North and south of Salorno there would be the possibility of crossing the Adige Valley with the shortest distance between the mountainsides.
A north-south connection in the Venosta Valley between the Stilfser Joch National Park and the Tessa Group is also very important for a coherent alpine-wide ecological network. Permeability for wildlife in the north area of Burgusio must be ensured to maintain connectivity at the alpine level.
In summary, while the presence of transregional nature parks such as the Stelvio National Park is positive for ecological connectivity, additional protection and conservation measures, especially in the central areas of the province, are needed to ensure an effective ecological network. In addition, the slopes on the north side of the Aurina valley are not protected and constitute a break in the network of protected areas from North Tyrol to the south.
As potential corridors with lower importance, the connections between the Tessa Group and the Sciliar-Catinaccio Nature Park, as well as the Stelvio National Park have been identified. A potential connection between Val Sarentino and Val di Vizze is interrupted by the A22 motorway.
Finally, for local priority connectivity areas the goal is to link ecological conservation areas to avoid their fragmentation and possibly increase the size of existing protected areas by building a kind of “buffer zone.”

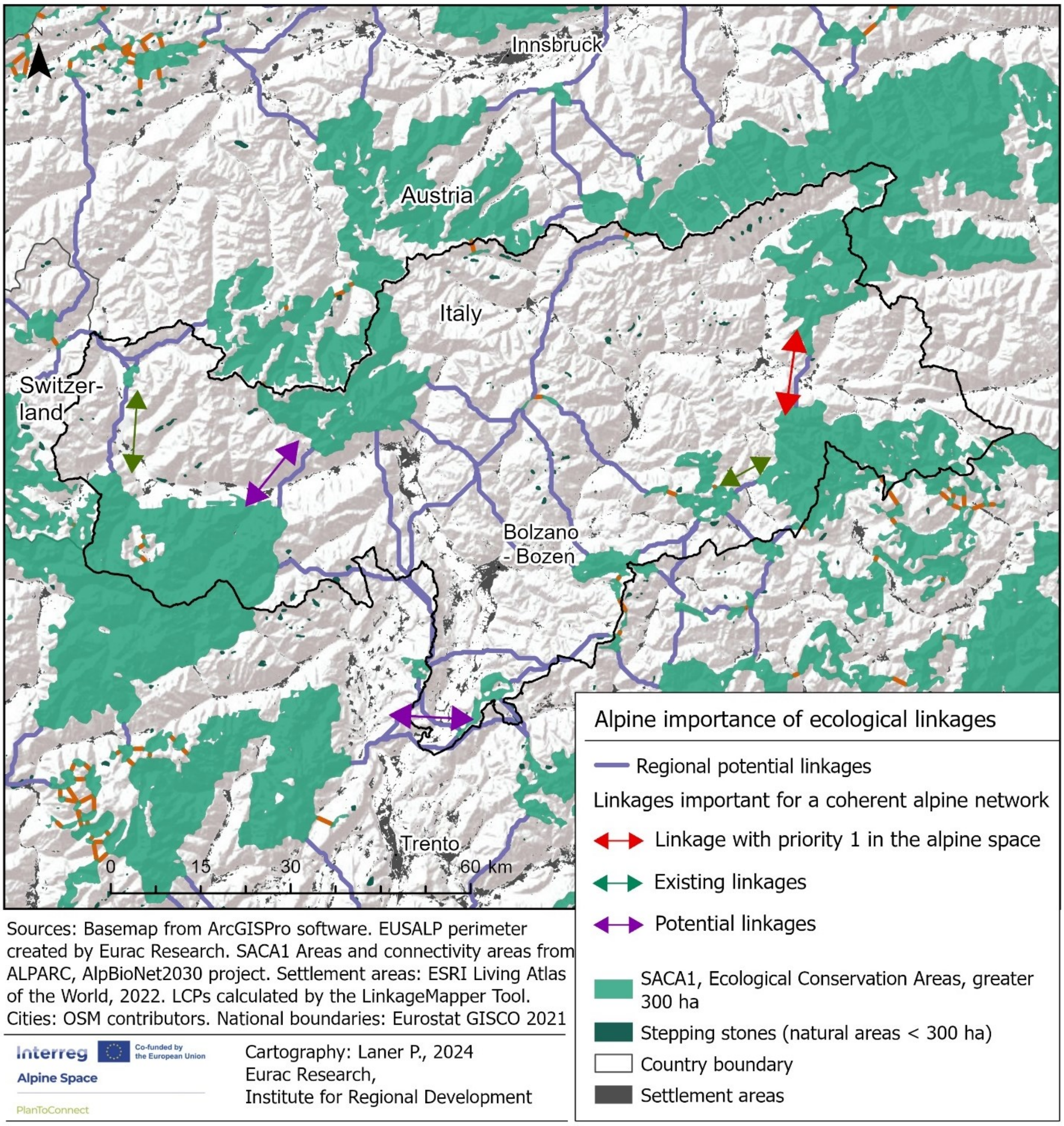



Figure 5: Important linkages for an Alpine-wide coherent ecological network

## 2.3 Main barriers

Picture 1: Adige Valley bottom from Bolzano towards the south.

Source: Laner P., (2020).

The image (Picture 1) above shows the main barriers in the pilot area. The conformation of the Adige valley has allowed the construction of numerous urban settlements, which are an obstacle for animals that need to move from one slope to another. Highways and train lines connecting different settlements also contribute to land fragmentation, dividing possible ecological corridors. The valley bottom in South Tyrol is often the most significant barrier, not only because of infrastructure barriers, but also because of intensive agriculture. Linear semi-natural structures in the valley bottom such as for example hedges, rows, shrubs, forests, natural channels with riparian vegetation, or wetlands are very important for habitat connectivity for a wide variety of species but tend to decline (Autonomous Province of Bolzano-South Tyrol, 2003), as do semi-arid grasslands. Intensive agriculture has certainly optimized economic productivity, but at the same time it has severely compromised the natural diversity present on the sites. This has reflexively caused a decrease in the variety of animal and plant species. The use of fertilizers and pesticides further contributes to the naturalistic depletion of cropland areas.
The solar panel fields (not visible in the photo) can represent an additional barrier on ecological linkages and are an upcoming threat for the connectivity of green and blue infrastructure, in South Tyrol possibly by agro-photovoltaic installations. At higher altitudes there is pressure from tourism and ski resorts.

## 2.4 Land ownership patterns

In South Tyrol, forests are owned by a total of about 23,300 landowners, who often own only a few hectares and, in some cases, live far away and are disinterested in their forests.
More than 60% of the forest is privately owned (individual owners and private co-ownerships) and is mostly represented by individual owners (53%) (Autonomous Province of Bolzano - South Tyrol, 2024).
The second category is public entities (municipalities and hamlets) with 28%. Private entities, such as interests and vicinities, own more than 7% of the forested area. Forest belonging to entities is mainly concentrated in areas characterized by Rhaeto-Romanic settlements, such as the Venosta and Ladin valleys.
State forests, managed by the Provincial Forestry and State Property Agency and the Laimburg Agricultural and Forestry Experimentation Center, have a 1% share. Two percent of the forest area is owned by the church.
South Tyrol's forests are intimately linked to traditional mountain agriculture, and not only for scenic reasons. In fact, in addition to agricultural land, 13.450 farms (out of a total of 20.247) also own forests. Often these are just a few hectares of forest that have been managed by the farm for several generations (Provincia Autonoma di Bolzano - Alto Adige, 2023).

# 3 Methodical approach in the pilot area

## 3.1 Methodological approach

### 3.1.1 General approach

The identified five linkages from the alpine-wide potential network model are indicating the highest priorities for improving ecological connectivity in South Tyrol (see 2.2 Alpine-wide structural potential network in South Tyrol). To analyse these corridors in detail, a habitat suitability (HS) model for the target species was developed.

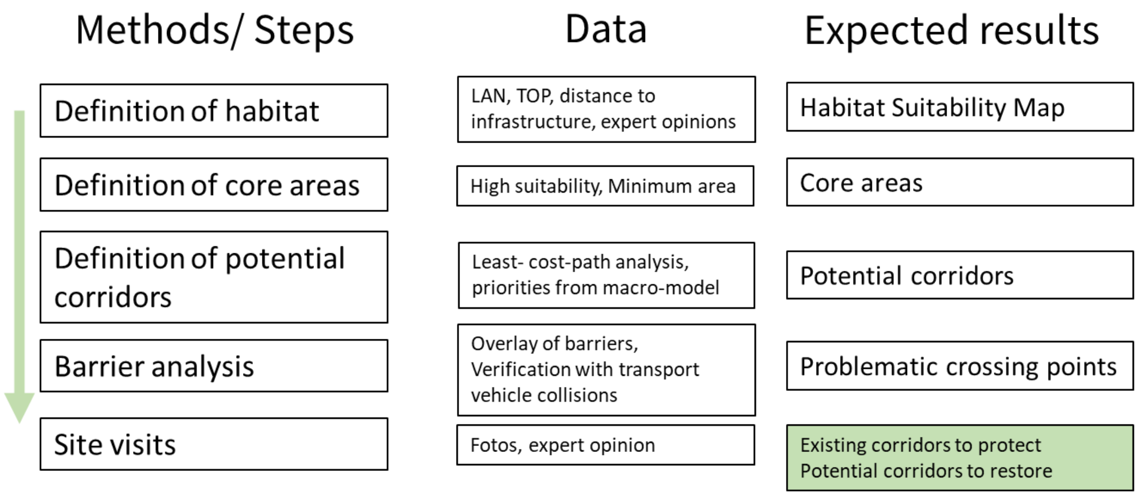



Figure 6:Scheme for general approach.

The need to develop a concept for an ecological network in South Tyrol can already be deduced from the Guidelines Nature and Landscape in South Tyrol, published in 2003, which explains the reasons why species on the Red List in South Tyrol are threatened:

– "almost one-third of Red List species are affected by habitat restriction (due to urbanization and expansion of the road network)"
– "about 40 percent of Red List species are affected by the effects of intensive cultivation"

(Autonomous Province of Bolzano-South Tyrol, 2003)

In order to identify target species for mapping a regional ecological network in South Tyrol, a review of the criteria for identifying target species according to ISPRA, a screening of European projects on ecological connectivity in the Alps and in various Italian regions that are part of the Alps, the list of species listed in the Natura2000 lists of South Tyrol, and a compilation of targets and possible measures for spatial and landscape planning were done.

This resulted in a proposal of various target species to be analysed to identify an ecological network at the provincial level.

In the Italian alpine regions, the methodology used to create the regional ecological network varies between using a species-specific model at the provincial level, then extended through environment-species affinity for the entire regional territory (as in the case of Piedmont), and between using species-target environments of interest (wetlands, open and forested environments) to model connectivity at the regional level in an integrated manner (Lombardy, Friuli-Venezia Giulia, Trentino).

The criteria for identifying target species according to ISPRA are as follows:

1. The conservation criterion: the species is listed on national, regional, local red lists.
2. The biogeographic criterion: the species is present in the area with disjunct, relict populations or has other peculiarities.
3. The ecological criterion: the species, although not listed on red lists has, locally or in general, its own intrinsic vulnerability to fragmentation and isolation.

(ISPRA, 2003)

The landscape guidelines identified the destruction of specific habitats as a fundamental cause of the decline in biodiversity in South Tyrol, which resulted through an evaluation of data on the spread of Red List species. These habitats are:

- Extent of the different forest types, particular types of grassland and pasture associations (the arid and semi-arid meadows and pastures, the rough meadows and pastures, the litter meadows and wet meadows),
- biotopes formed by shrub species and the shrublands of the cultural landscape especially those characterized by a high proportion of old tree and shrub vegetation (oak and chestnut forests, riparian forests, hedgerows and forest margins)
- habitats at bogs and riparian zones

(Autonomous Province of Bolzano-South Tyrol, 2003)

These important habitats in South Tyrol are in line with structural models that mainly follow three macro-types of green infrastructure, such as Germany's national green infrastructure concept (Bundesamt für Naturschutz, 2017): forested areas, semi-arid grasslands, and wetlands. In Austria, ecological network modelling at the national and some federal state levels focuses on target species of large wild mammals that prefer forests (Leitner et al., 2018).

A comparison with the ecological network of the Friuli - Venezia Giulia region shows that in mountainous areas, topography must be considered. The distinction to which habitats and target species were attributed was made through geographic area and domains, including, for example, the alpine and prealpine zone, the high plains, the low plains, or hill systems.

Considering this approach, four spatial typologies can be considered in South Tyrol, which are listed in the landscape guidelines: Forest, Alpine environment and high altitudes, Slopes

(Valley slopes and sub-Mediterranean vegetation, inner alpine dry valley slopes and mountain agricultural areas), and valley floors.

(Autonomous Province of Bolzano-South Tyrol, 2003)

### 3.1.2 Selection of target species

Ungulates such as deer and roe deer, but also tetraon species which present umbrella species because they need diversified habitat, can be considered to identify the forest habitat network. Not all ungulates are protected, however, as already described in other studies, from a cultural-economic and wildlife incident perspective they are important to consider in South Tyrol (Schwingshackl, 2019; Alejandra et al., 2021).
Tetraon habitats cover forest-covered mountain areas, but also semi-open areas, as does that of chamois. These species often conflict with ski areas or ski touring routes that are located at the same altitudes. The advantage of choosing grouse would be that there is already a model of habitat potential at the provincial level, however, as data are sensitive it is considered useful to map the network for grouse where publication of data is a less sensitive issue (Autonomous Province of Bolzano-South Tyrol, 2022). For black grouse, there is a model at the Alpine level, developed in the Interreg Alpine Space Econnect project (Füreder et al., 2011), which can be a starting point.
Linear semi-natural structures in the valley bottom are important for a wide variety of pollinators, which also support the productivity of intensive fields.
The last habitat type that needs to be considered to cover the most important structures for South Tyrol are wetlands. A wide variety of birds and amphibians can be considered to identify their ecological network. A selection of certain species must be based on their local occurrence. However, the Yellow-bellied Ululon can be considered as an umbrella species for less mobile organisms in wetlands (Aletsee, 2016). Due to an ongoing investigation and mapping of existing wetland habitats in South Tyrol, it might be better to wait for updated geographical data to model connectivity areas at the moment (2024).

To give concreteness on how a study of the regional ecological network could serve land-use planning, and vice versa, which land-use and landscape planning tools can help maintain and improve the regional ecological network, the overview in Table 2-3 was created. Therefore, the ecological objectives for each habitat of interest were transformed into objectives for spatial planning, at the same time considering possible intervention measures that could be handled by spatial and landscape planning tools. In this way, the study can help fulfil one of the most important tasks of planning, which is the avoidance of land use conflicts, which in this case are expressed through human-wildlife conflicts, i.e., human-wildlife.
It is concluded that for the regional level, a proposal was arrived at to analyse the ecological network of red deer.

At the inter-municipal/local level, a wide variety of pollinators and birds is possible to consider, which needs to be evaluated with additional experts.

Table 2: Proposal for objectives, measures and target species for an ecological network in South Tyrol for regional planning.

| Level | Ecological and cultural-economic objective, habitats of interest | Spatial planning objective | Target species | Possible measures and instruments | Example |
|---|---|---|---|---|---|
| Regional | Ensuring passages for highly mobile land species (ungulates)<br><br>Habitats of interest: "Semi-open wooded areas and alpine grasslands. From broadleaf forests to the upper edge of the forest'. | Preventing existing free passages from being closed by infrastructure | Red Deer<br><br>(Alternatively: Roe Deer) | Designating areas as ecological corridors that cannot lose their functionality (municipal development programms) | Salzburg - Oberpinzgau |
| Regional | | Improving and restoring possible passages | Red Deer<br><br>(Alternatively: Roe Deer) | Using compensation measures to restore passages following the provincial concept of an ecological network | Green bridge Pusteria Valley (South Tyrol) |
| Regional | Reduction of road accidents with wildlife (mainly ungulates)<br><br>Habitat di interesse: Bosco | Planning of transport infrastructure that respects ecological requirements | Red Deer<br><br>(Alternatively: Roe Deer) | Underpasses, Overpasses, traffic reduction, Limitation of speed in critical points | |
| Regional | Ensuring connectivity in the high mountains (habitats), avoiding conflicts with ski areas.<br><br>Habitats of interest: High Mountain areas, "Areas close to the upper edge of the forest, strip of twisted shrubs". | Avoiding conflicts between important wildlife areas and ski resorts/ intensive tourism areas/ ski mountaineerin g routes | Black grouse<br><br>(Alternatively: Chamois, or Capercaillie) | Concepts for controlling visitor flows.<br><br>Respect the corridors in the 'Ski Lift and Ski Slope Sector Plan'. | Black grouse protection system in ski areas in Vanoise, (FR),<br><br>Freedom and Respect' Project (South Tyrol) |

Table 3: Proposal for objectives, measures and target species for inter-municipal spatial and landscape planning

| Level | Ecological and cultural-economic objective, habitats of interest | Spatial planning objective | Target species | Possible measures and instruments | Example |
|---|---|---|---|---|---|
| Intermunicipal | Ensure ecological connection elements in agricultural areas and reduce the impact of the agricultural environment.<br><br>Habitats of interest: Semi-arid grasslands, wooded structures in agricultural areas in valley bottoms | Landscape planning of agricultural environments that respects ecological needs | Pollinators (wild bees)<br><br>(difficult to define) | Protection of linear semi-natural structures in the valley bottom (hedges, rows, shrubs, forests, etc.).<br><br>Instrument: municipal landscape plans | Restoring pollinator habitats across European agricultural landscapes |
| Intermunicipal | Habitats of interest: Wetlands | Ensure the ecological connectivity of wetlands at the municipal or inter-municipal level | Birds and Amphibian, for example, the yellow-bellied toad | Protection of linear semi-natural structures in the valley bottom (natural channels with riparian vegetation, wet areas) through municipal landscape plans | Implementation of reconstruction interventions of microhabitats suitable for the yellow-bellied toad (Bombina variegata), in agricultural and former quarry contexts located along the Adige Valley |

## 3.2 Data used

Land use/ land cover:

- EUSALP LULC map 2020. Marsoner, T., Simion, H., Giombini, V. et al. (2023). A detailed land use/land cover map for the European Alps macro region. Sci Data 10, 468. https://doi.org/10.1038/s41597-023-02344-3

Roads and motorways:

- GeoCatalogo Provincia Autonoma di Bolzano. Elementi della rete di trasporto: vestizione ufficiale. http://geokatalog.buergernetz.bz.it/geokatalog/#
- EuroGlobalMap. European global map for highways from Eurogeographics updated 2024.

Topography:

- EEA, (2020). European Environmental Agency. European Digital Elevation Model (EU-DEM), version 1.1. https://land.copernicus.eu/imagery-in-situ/eu-dem/eu-dem-v1.1

Cable cars:

- GeoCatalogo Provincia Autonoma di Bolzano. Elementi della rete di trasporto: vestizione ufficiale. http://geokatalog.buergernetz.bz.it/geokatalog/#

## 3.3 Working steps

### 3.3.1 Calculation of suitability score of factors' classes for provincial model

For each class of the habitat factors (such as forest or grassland within land cover) a particular suitability score is assigned. Meaningful thresholds are set to allocate appropriate HS scores to the categories, whereby the defined thresholds are related to the habitat requirements of breeding sites. A score of zero is assigned when a particular class of a habitat factor does not correspond to the ecological requirements of the species considered. To assign a suitability score to each class within each factor, we use a fixed scale between 0 (no suitability) and 100 (maximum suitability) having in mind the following biological interpretation:

- 100: best habitat, highest survival and reproductive success
- 50: sub-optimal habitat, food availability and passage
- 25: occasional use and passage
- 0: avoided/barrier

Habitat suitability is limited by its worst factor

***Suitability =*** $\prod_{i=1}^{n}(S_i^{W_i})$

LAN$^w$ x ELE$^w$ x SLOPE$^w$ x DIST road$^w$ x DIST motorway$^w$ x DIST settl$^w$

Table 4: Weights used for the single habitat factors

| Habitat factor | LAN | ELE | SLOPE | DIST road | DIST motorway | DIST settl |
|---|---|---|---|---|---|---|
| Weight | 50 | 10 | 10 | 10 | 10 | 10 |

Where Π indicates the product to combine the n habitat factor classes (i) with their scores ($S_i$) and their habitat factors weight ($W_i$). Following that procedure, it is necessary to create suitability classes to simplify the model approach. Therefore, the obtained pixel values are divided in 4 suitability classes (Beier et al., 2008) accordingly:

1- Suitability > 50 – 100% = Appropriate for an optimal habitat, core areas, highest survival and reproductive success (CORE AREAS)
2- Suitability > 25 - < 50% = Sub-optimal habitat, food availability, passage sites (low resistance areas – optimal for least-cost paths)
3- Suitability > 0 - < 25% = Occasional habitat, stepping stones
4- Suitability 0 = Avoided, non-habitat (Barrier)

(Favilli et al., 2012)

### 3.3.2 Indicators and data processing for provincial model

The coordinate reference system (CRS) used for all data is ETRS89-LAEA Europe, also known in the EPSG Geodetic Parameter Dataset under the identifier: EPSG:3035.

**Land use/cover**

The HS values used in the model are shown in table 5. The description of each attribute can be found in Annex 1. Land use resistance values for red deer are based on the table "Widerstandswerte der Eingangsdaten für die Costgrid-Analyse – SINUS Datensatz" from the study of Leitner et al. (2014), and on a study Habitat Suitability Based Models for Ungulate Roadkill Prognosis in Lithuania according to Balčiauskas et al. (2020), using a detailed land use/cover map of the European Alps macro region of Marsoner et al. (2023).

In the EUSALP LULC map 2020 data (Marsoner et al., 2023) the attribute "Artificial surfaces and constructions" refers to "impervious elements with a density greater than 50%. Airports, construction sites, mineral extraction and greenhouses. The build-up areas adjacent to small farms are included in this class". In the attribute there is an error, showing a large amount of these elements in the north-east part of South Tyrol, in a mountainous area.

Consequently, it was decided to exclude it from the dataset regarding the "Distance to human impact facilities" layer and to give a small HS to the "land use/land cover" layer.

Table 5: Habitat suitability values used for the single land use/land cover attributes.

| Code | EUSALP LULC Label | HS value |
|---|---|---|
| 11000 | Artificial surfaces and constructions | 0,10 |
| 11100 | Dense settlement area | 0 |
| 11200 | Low density settlement area | 0 |
| 11300 | Built-up area | 0 |
| 11400 | Open settlement area | 0 |
| 12100 | Industrial and commercial zones | 0 |
| 12210 | Roads, motorways and trunks | 0 |
| 12220 | Roads primary and secondary | 0 |
| 12221 | Roads, tertiary and others | 0 |
| 12230 | Railways train tracks | 0 |
| 12240 | Unpaved Roads and Tracks | 0 |
| 14100 | Green urban areas | 0 |
| 21000 | Cultivated areas - Arable Land - Annual Crops | 0,25 |
| 21211 | Common wheat | 0,25 |
| 21213 | Barley | 0,25 |
| 21214 | Rye | 0,25 |
| 21215 | Oats | 0,25 |
| 21216 | Maize | 0,25 |
| 21218 | Triticale | 0,25 |
| 21219 | Other cereals | 0,25 |
| 21221 | Potatoes | 0,25 |
| 21222 | Sugar beet | 0,25 |
| 21223 | Other root crops | 0,25 |
| 21230 | Other non permanent industrial crops | 0,25 |
| 21231 | Sunflower | 0,25 |
| 21232 | Rape and turnip rape | 0,25 |
| 21233 | Soya | 0,25 |
| 21240 | Dry pulses | 0,25 |
| 21250 | Fodder crops | 0,25 |
| 21290 | Bare arable land | 0,25 |
| 22000 | Permanent Crops | 0,25 |
| 22100 | Vinyard | 0,25 |
| 22200 | Orchard | 0,25 |
| 23100 | Managed grassland - Pastures - | 0,50 |
| 23200 | Seminatural grassland - Meadows | 0,50 |
| 31100 | Broadleaf tree cover | 0,95 |
| 31102 | Broadleaf tree cover 30-60% | 0,95 |

| Code | EUSALP LULC Label | HS value |
|---|---|---|
| 31103 | Broadleaf tree cover 60-100% | 0,95 |
| 31200 | Coniferous tree cover | 0,85 |
| 31202 | Coniferous tree cover 30-60% | 0,85 |
| 31203 | Coniferous tree cover 60-100% | 0,85 |
| 31300 | Mixed tree cover | 1,00 |
| 31400 | Tree cover in agricultural context | 0,50 |
| 31450 | Tree cover in urban context | 0 |
| 31500 | Green linear elements - linear woody features | 0,25 |
| 31600 | Patchy woody features | 0,25 |
| 31610 | Additional woody features | 0,25 |
| 32000 | Scrub and shrubland | 0,60 |
| 32100 | Alpine and sub-alpine natural grassland | 1,00 |
| 32200 | Moors and Heathland - other scrubland | 0,40 |
| 32300 | Sclerophyllous vegetation | 0,40 |
| 33100 | Beaches, dunes, sands | 0,10 |
| 33200 | Bare rocks and rock debris | 0,10 |
| 33300 | Sparsely vegetated land | 0,25 |
| 33500 | Permanent snow-covered surfaces | 0,10 |
| 41000 | Wetland (permanent wet areas) - inland marshes | 0,10 |
| 51000 | Water bodies | 0,10 |
| 51100 | River network | 0,10 |

### Elevation

In South Tyrol, forests above 2.100 m. a.s.l. are rare (Südtiroler Landesverwaltung, 2024), and the habitat mapping of the provincial wildlife management office considered 2.100 to 2.300 m a.s.l. as threshold for red deer habitat. The maximum altitude of red deer according to Sedy & Hölzl (2011) is 2750 m a.s.l. For high altitudes, Leitner et al. (2014), considered an area outside a 500-metre buffer around the tree line, which in South Tyrol is approximately at 2.000 m a.s.l.. In the PlanToConnect model, the altitude range from 2.300 to 2.900 m a.s.l. was therefore considered occasional use for red deer, and altitudes higher than 2.900 m a.s.l. were considered not suitable. The altitude ranges were categorized based on the above cited literature and the insights of local ungulate experts; the used values are shown in table 6. It was decided to assess the suitability of the red deer during the winter season, when they typically reside at lower elevations than in summer. Further tests with varying elevation ranges and values were performed, revealing that the model's sensitivity to these changes was minimal.

Table 6. HS values (scores) used for four different elevation ranges.

| Classes (m a.s.l.) | Scores (% suitability) |
|---|---|
| 0-1500 | 100 |
| 1.500-2.300 | 50 |
| 2.300-2.900 | 25 |
| >2.900 | 0 |

(Favilli et al. 2012, modified according to Sedy & Hölzl 2011, Leitner et al. 2014 and expert opinion)

**Slope**

According to Sedy & Hölzl (2011) the maximum slope lies below 55°. According to Zweifel-Schielly et al., (2009), slopes lower than 30° are considered as flat terrain and, within home ranges, deer selected flat terrain in summer, while it preferred steep terrain in winter. The HS values utilized were categorized into three slope ranges: Bottom-gentle (0-30°), Steep (30-55°), and Ridge top (55-90°), as illustrated in Table 7.

Table 7. HS values (scores) used for three slope classes.

| Classes (degree) | Scores (% suitability) |
|---|---|
| Bottom-gentle 0-30° | 100 |
| Steep 30-55° | 75 |
| Ridge top 55 - 90° | 0 |

(Favilli et al. 2012, modified according to Sedy & Hölzl 2011)

**Distance to human impact facilities**

For distance to human impact facilities, settlement areas, including the classes “dense settlement areas” (11100), “low density settlement area” (11200), “open settlement areas” (11400) and “industrial and commercial zones” (12100) were selected. In this way smaller built-up areas (11300), which can represent farms in agricultural landscape, were excluded. According to Sedy & Hölzl (2011), the minimum distance to settlements is 200 m, other studies are defining 250 meters for small towns. The used HS values are divided into three categories based on the distance from settlement areas: 0-100 m, 100-250 m , and greater than 250 m, as shown in table 8. These distance ranges and HS values were chosen to balance the impact of larger settlements, which have a greater influence on red deer presence, and isolated settlements, which may be more easily approached by the animals, especially if food sources are nearby.

Table 8. HS values (scores) used for three classes representing the distance to settlement areas.

| Settlement areas | |
|---|---|
| Classes | Scores (% suitability) |
| 0-100 m | 0 |
| 100-250 m | 25 |
| > 250 m | 100 |

(Favilli et al., 2012, Balčiauskas et al. 2020)

**Distance to transport infrastructure (roads and cable cars)**

National and provincial roads and cable cars were considered. Only roads located on the ground surface were considered. Tunnels and elevated roads were excluded from the dataset. Hiking trails, agricultural roads, forest roads and municipal roads were not considered here. Also, single trails for mountain bikes do not represent a wide extension in the dataset and were not considered. According to Sedy & Hölzl (2011), the minimum distance to roads is 100 m. The same suitability values were assigned to roads and cable cars due to their variable impact from inconsistent usage and tourism flows; the values used for the calculations of the HS are shown in table 9. Areas adjacent to roads and beneath cable car lines often feature open clearings in the forest, where habitats with leaf production and small fruits like blackberries thrive. These food sources attract red deer. Consequently, a minor impact was attributed to both roads and cable cars, reflected in the factor weight and HS values.

Table 9. HS values (scores) used for three classes representing the distance to roads and cable cars.

| **Roads and cable cars** | |
|---|---|
| Classes | Scores (% suitability) |
| 0-100 m | 25 |
| 100-200 m | 50 |
| >200 m | 100 |

(Favilli et al., 2012, Sedy & Hölzl 2011)

The biggest disturbance (smallest suitability values) among roads and cable cars was considered as the determining factor.

**Distance to motorways**

For the distance to motorways, the A22 highway and the fast line road “Superstrada MeBo” between Merano and Bolzano were considered. The values were assigned based on our own evaluation. The used ranges and related HS values are shown in table 10.

Table 10. HS values (scores) used for three classes representing the distance to the motorways.

| **Classes** | **Scores (% suitability)** |
|---|---|
| 0 - 200 m | 0 |
| 200 - 300 m | 50 |
| > 300 m | 100 |

**Selection of core areas**

According to the study of Salzburg, suitable habitats for red deer can be classified according to following patch sizes:

- *Core habitat: Definition of year-round habitats (source and target areas) with a minimum size of 5,000 hectares of suitable habitat.*
- *Island habitat: Definition of habitats with a size of between 2,000 and 5,000 hectares of suitable habitat. These habitats may or may not be year-round habitats.*
- *Stepping stone habitat: Definition of suitable habitats with a size of 2 to 2,000 hectares. They are not suitable as year-round habitats.*

*For the network model, the focus was on the connectivity of the core habitats. Where core habitats were missing, island habitats were used as a substitute* (Leitner et al., 2014).

The dispersal distance of red deer to construct the network between core areas in former network models was equal to 30 km (Urbina et al., 2023), which reflects the maximum distance of a corridor. Migratory distances for Alpine red deer are mostly between 5 and 30 km (Haller 2002 in Zweifel-Schielly et al., 2009).

For the model in PlanToConnect project, suitable habitat sizes were defined in the same way as in the study of Salzburg. Patches smaller than 4 hectares were not considered as stepping stones. The areas with HS values greater than 75 and an extension larger than 5000 ha were considered as core areas.

### 3.3.3 Calculation of corridors at provincial level

**Resistance**

To calculate the potential corridors for the red deer in South Tyrol, a resistance raster was created, through which the model finds the least cost path to connect two core areas. The HS values were transferred to resistance values ranging from 1 to 1046 by a data transformation to get linear resistances (see table 11 and figure 7), using the following rule:

*RES geom* = `1.072^(100-HS)`

Table 11. Conversion table of the HS values in linear resistance (RES lin) values and geometric resistance (RES geom) values.

| HS | RES lin | RES geom |
|---|---|---|
| 0 | 100 | 1.046 |
| 10 | 90 | 522 |
| 20 | 80 | 260 |
| 30 | 70 | 130 |
| 40 | 60 | 65 |
| 50 | 50 | 32 |
| 60 | 40 | 16 |
| 70 | 30 | 8 |
| 80 | 20 | 4 |
| 90 | 10 | 2 |
| 100 | 0 | 1 |

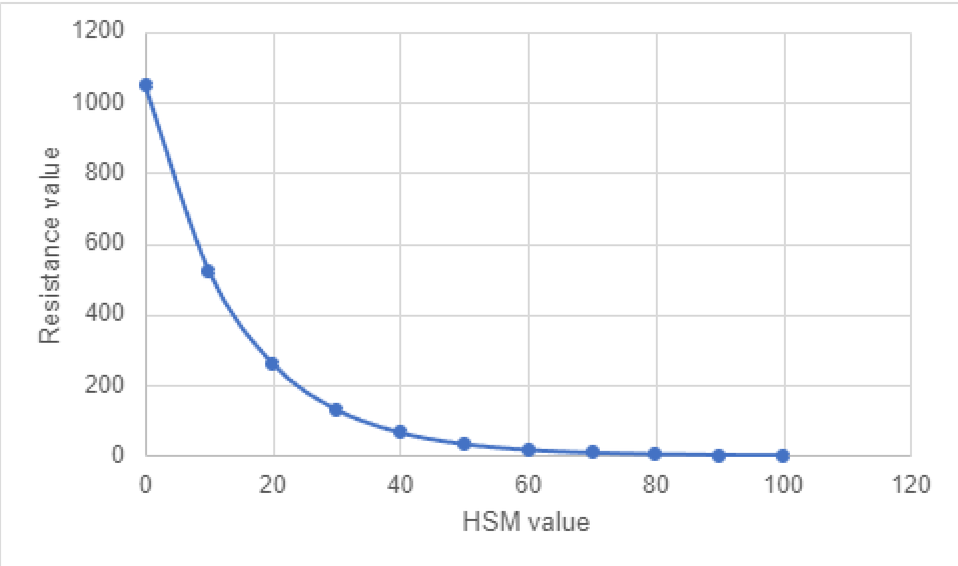



Figure 7:Graph showing the relation between the HSM values and the geometric resistance values.

In the resistance surface, settlements were given the highest resistance value of 1.046, since there is a very low probability that existing buildings will be displaced because of the needs for ecological connectivity. This is coherent with the ALPBIONET2030 methodology in which these kinds of barriers were totally excluded as potential connecting elements (Lüthi & Costes, 2019).

For calculation processing time and storage, the resistance surface was resampled to a resolution of 20 m.

The identification of the potential corridors was based on the least-cost path (LCP) approach and was conducted with the Linkage Mapper Toolset and its Linkage Pathways Tool

(LinkageMapper.org). LCP (or “the best path”) represents the route along which the minimum resistance, given by the landscape matrix to the red deer movements, occurs. It identifies the route of least cumulative resistance for a species moving between two core areas (McRae & Kavanagh 2012).

### 3.3.4 Analysis focusing on single corridors (local level)

Table 6: Working steps focusing on single corridor sections

| Working Step | Description |
|---|---|
| 1 | Compilation of the protected areas within the corridor |
| | In a first step, the known protected areas are described, that the corridor connects. Then, the corridor itself will be checked on existing protected areas, which can be “Protected Landscape Elements”, “Respect Zones” “Biotopes” as stepping stones, or Protected Landscapes or other protected areas by the landscape plans. |
| 2 | Compilation and analysis of GBI elements within the corridor (connectivity evaluation) |
| | In a second step, all GBI elements (based on detailed landcover data) within the corridor are listed and summarised according to the main categories, e.g.:<br>• Natural/ Semi-natural grassland<br>• Sparsely vegetated areas<br>• Forests and other wooded lands (shrubs, hedges, trees)<br>• Water bodies (flowing and standing water)<br>• Wetland (marshes, peatbogs) |
| 3 | Barrier Analysis |
| | Based on species- or habitat- specific handbooks and other literature, a descriptive barrier analysis is made to reveal the major problems in the corridor section. |
| 4 | Compilation of local and provincial data to reveal priority areas for interventions |
| | Based on more detailed provincial data regarding animal- vehicle collision and traffic flows, more detailed intervention options can be revealed. |
| 5 | Distance analysis of areas of high nature conservation value |
| | A more precise surveying of the corridor width and length should reveal the corridors importance (macro-regional, regional, local) and should find out if bottlenecks exist. |

| Working Step | Description |
|---|---|
| **6** | Identification of priority areas for conservation and restoration |
| | Definition and refinements of intervention options for improving the ecological network can be deduced from the importance of the width, but also the macro-regional model. |
| **7** | Recommendations for possible restoration areas |
| | Recommendations can be given based on existing handbooks, for example:<br><br>Rosell et al. (2023). ***IENE Biodiversity and infrastructure. A handbook for action***. https://www.biodiversityinfrastructure.org/<br>Leitner H., Leissing D., Grillmayer R., (2023). ***Leitfaden zur Bewertung der wildökologischen Durchlässigkeit von Lebensraumkorridoren für wildlebende Säugetiere ab Hasengröße***. https://lebensraumvernetzung.at/de/publications<br>Trocmé M., Righetti A., Wegelin A. (2014). ***Querungshilfe für Wildtiere.*** Richtlinie. ASTRA 18008. Bern: Bundesamt für Straßen ASTRA. file:///C:/Users/PLaner/Downloads/astra_18008_querungshilfefuerwildtiere2014v101-1.pdf |

# 4 Results

## 4.1 Species network model on provincial level

**Overall characteristics of the network:**

The ecological network model for red deer identified 26 core habitats, 23 island habitats, and nearly 2000 stepping stones. Some stepping stones are situated within a natural matrix in mountainous regions, while others are found in the valleys. These elements are crucial for conservation as they enhance ecological connectivity in the most affected areas of South Tyrol. As an example, the Monticolo/Monitggl forest is an isolated habitat and could be an important stepping stone between the natural park Monte Corno and Mendola/ Mendel pass.

In the whole Adige Valley from Salorno/Salurn to Lasa/Laas, no functional existing corridors were identified. The hunter's association informed about a wildlife fence to protect apple orchards and vineyards at the Valley bottom of Venosta Valley. It extends from Upper Valley to the Adige Valley. This area is also imposed with a "no go zone" for red deer, which means they can be hunted with less restrictions in this area. A potential corridor at the border between Parcines and Lagundo along the river (Töllgraben - Tovo di Tel) would be an option for a corridor restoration. A potential corridor (focus area 25) between the Magrè municipality and the Piana Rotaliana in Trentino (municipalities around Mezzocorona) is emerging from 3 different studies:

1) *Red* Deer model designs a corridor with low connectivity around Mezzocorona
2) Alpine-wide analysis is indicating a corridor at the level of Magré
3) The network concept of Trentino is showing an existing corridor based on a statistical evaluation of species movement.

In this study, a total of 45 corridors have been identified. However, 18 of them are located in the 15 km buffer outside the provincial borders. In South Tyrol, 27 corridors have been identified, including three that are transboundary with Veneto and Austria. These three corridors traverse mountain areas that remain unaffected by anthropic activity. In fact, some corridors are the result of the modelling approach but do not need further investigation on site, because no threats or barriers were identified on them. Mostly they are corridors of very short distances. Most of the network corridors are crossing valley bottoms. For a detailed description of the corridor locations refer to the list of focus areas.

The animal – vehicle collisions in the following map sections represent collisions of various animals: roe deer, red deer, badger, wild boar, chamois, fox, eagle owl, mountain hare, marmot and other, not identifiable game species. A validation with only red deer species will be elaborated in the technical proposal (Deliverable D.2.5.1).

## Workshop results

On November 8th a workshop with the regional connectivity working group discussed the creation of the ecological connectivity concept in South Tyrol.

The workshop was attended by participants chosen for their expertise in the territory:

- Office for municipal planning
- Office for road constructions North/east
- Association of biologists
- Conservator zoology section (Naturmuseum Südtirol)
- Provincial landscape planning office
- Office for forest management
- Office for Wildlife Management
- Institute for Alpine Environment (Eurac Research)
- Hunter association South Tyrol
- Provincial Spatial planning

The main objectives were the presentation and validation of the model and its possible integration or modification, the collection of possible future threats for connectivity (Deliverable 2.4.1) in the pilot site and a discussion of the next phases of the project.

During the workshop, it emerged that the model is a good start for the creation of the provincial ecological connectivity concept. The methodology used to create the potential ecological connectivity linkages, was approved by all participants. For the model's applicability and its integration into provincial and municipal plans a validation of the corridors is necessary. The validation of the corridors is still in progress, and it was proposed to monitor the identified locations using camera traps, and to analyse the movements of radio-collared red deer and/or the footprints on the snowpack. The approaches suggested by the participants to validate the use of a corridor are explained in the Table 7. The organisation of field research is still required for this aspect.

Table 7: Possible methods to validate a corridor

| Methods | Definition/description | Pros and cons |
|---|---|---|
| Camera traps | Remote cameras with sensor that capture images of wildlife. | This is not very effective for red deer because the corridors are large; many traps camera would be needed, and it would be difficult to individuate where to locate them. Additionally, it would be extremely difficult to understand if the animal had actually passed through the entire corridor. |
| Radio collars | Tracking collars with a radio transmitter that record and send location. | It is a useful method through which animal movement, position, and behavior can be studied, confirming the usage and passage of a linkage. It requires more time to capture the animals. |
| Snow tracking | During winter, animals move across the snow-covered ground and leave their footprints. | It is a useful method, but it is necessary to wait for a snowfall and then go out the following day to see the tracks. The efficiency depends on weather conditions, experience and knowledge. Training is necessary. |


Picture 2: Discussion and interactive map work during the workshop

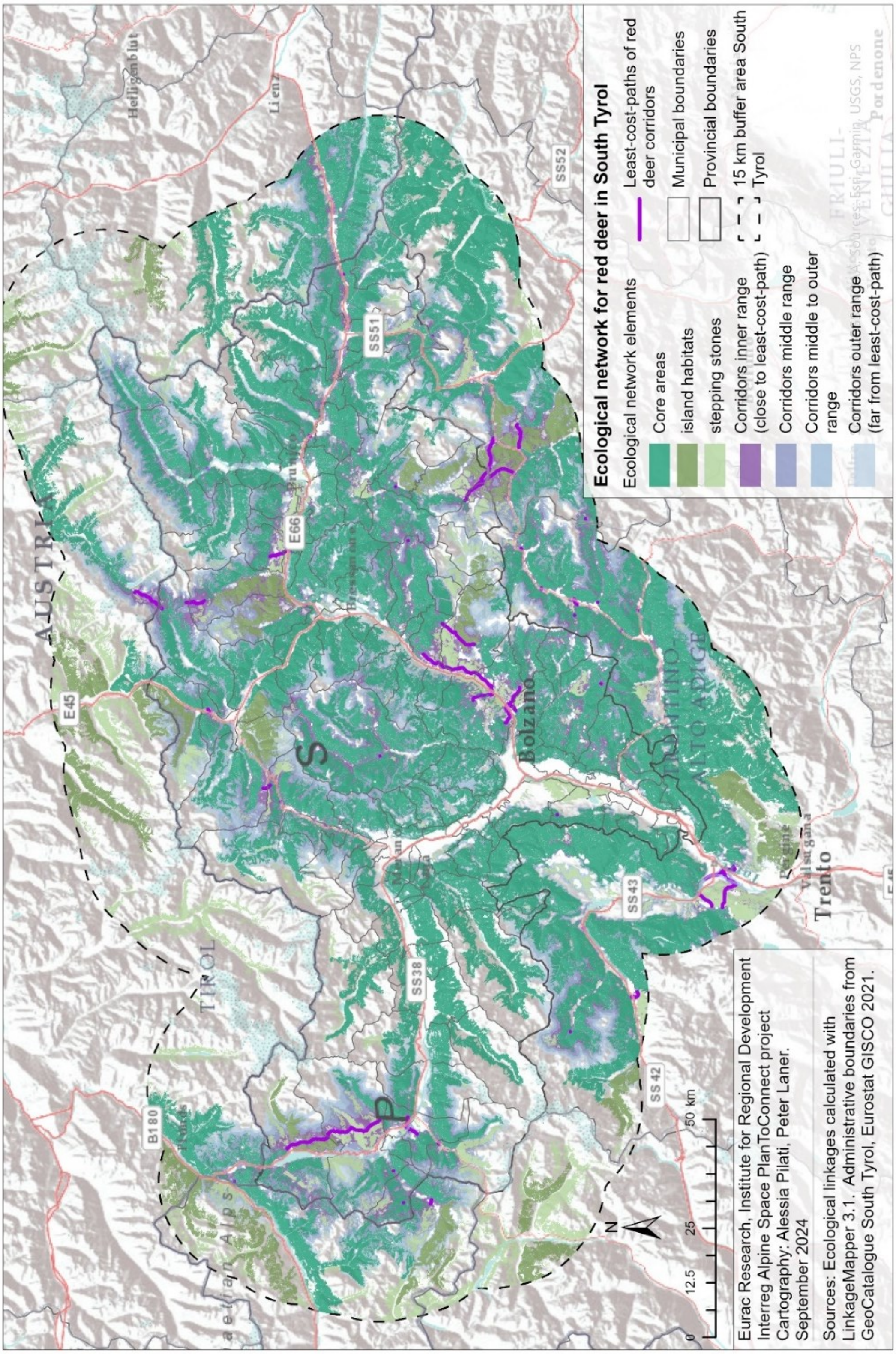



Figure 8: Ecological network for red deer in South Tyrol

Based on an evaluation by aerial images, 26 corridors were identified which should be analysed in detail to guarantee their preservation using spatial planning instruments and additional measures on transport infrastructure. Among them, four are potential corridors that would need to be restored (see number 23 to 26). The ten corridors highlighted in yellow resulted as a priority from the macro-regional model and should be maintained or restored.

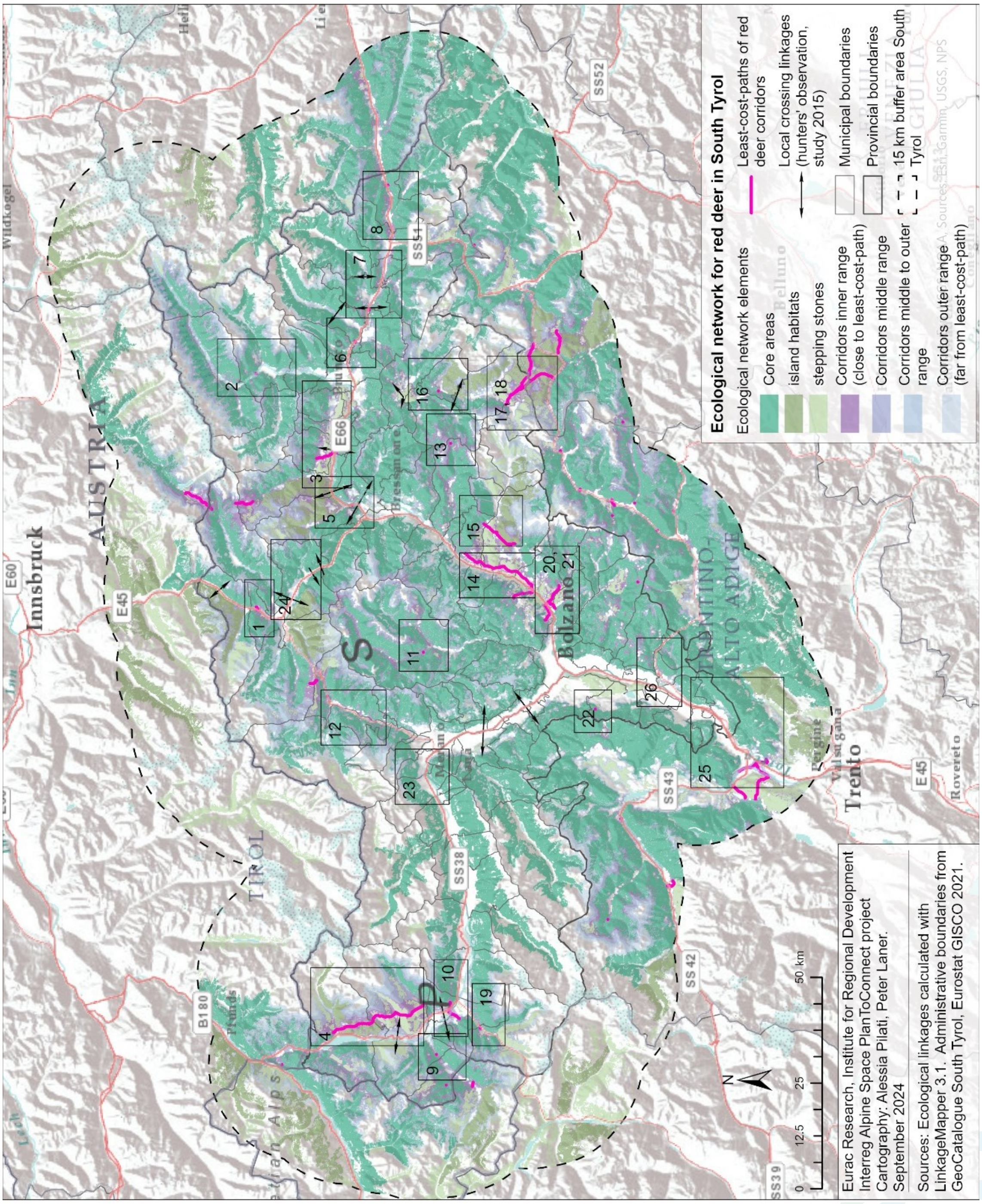
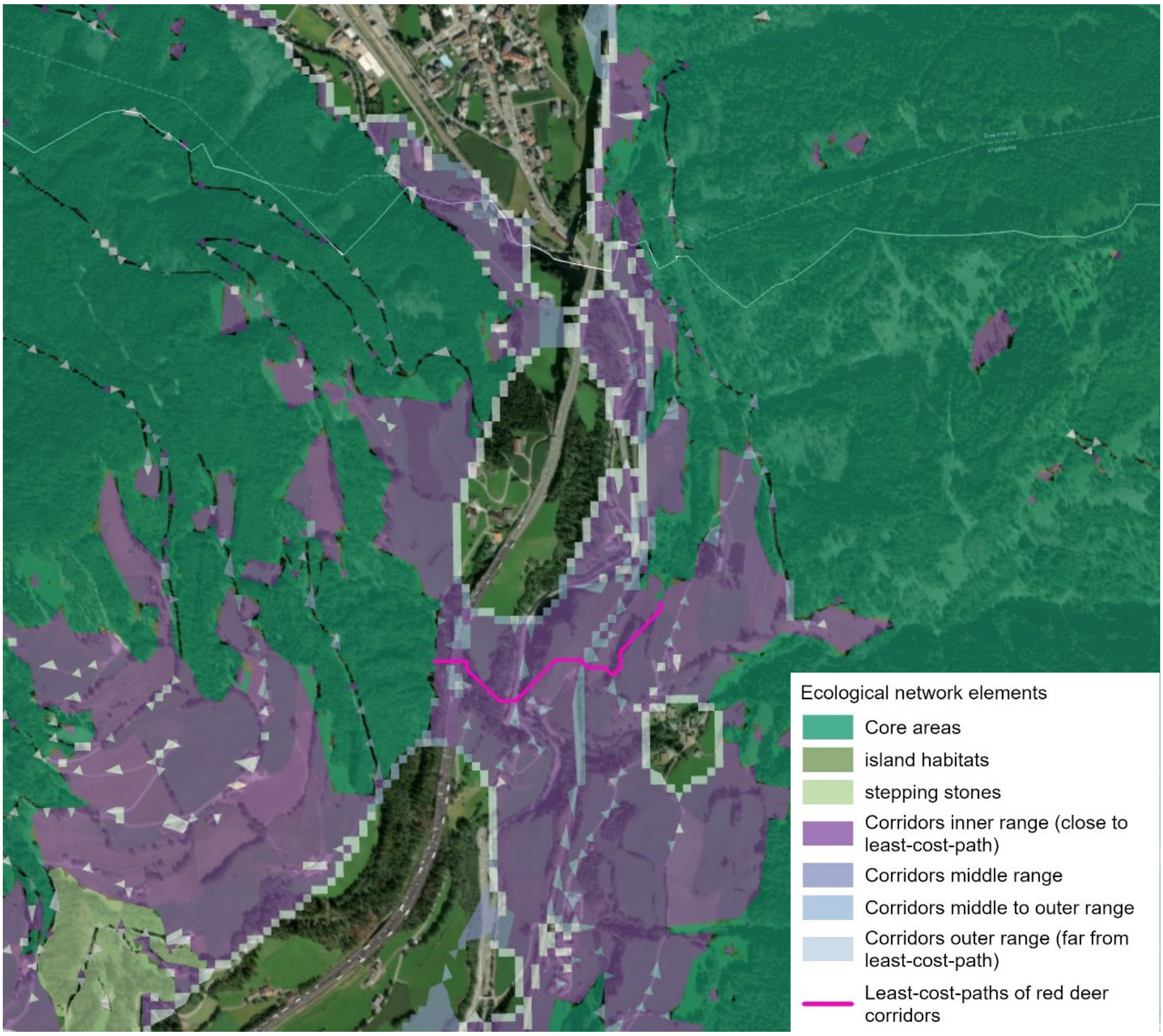


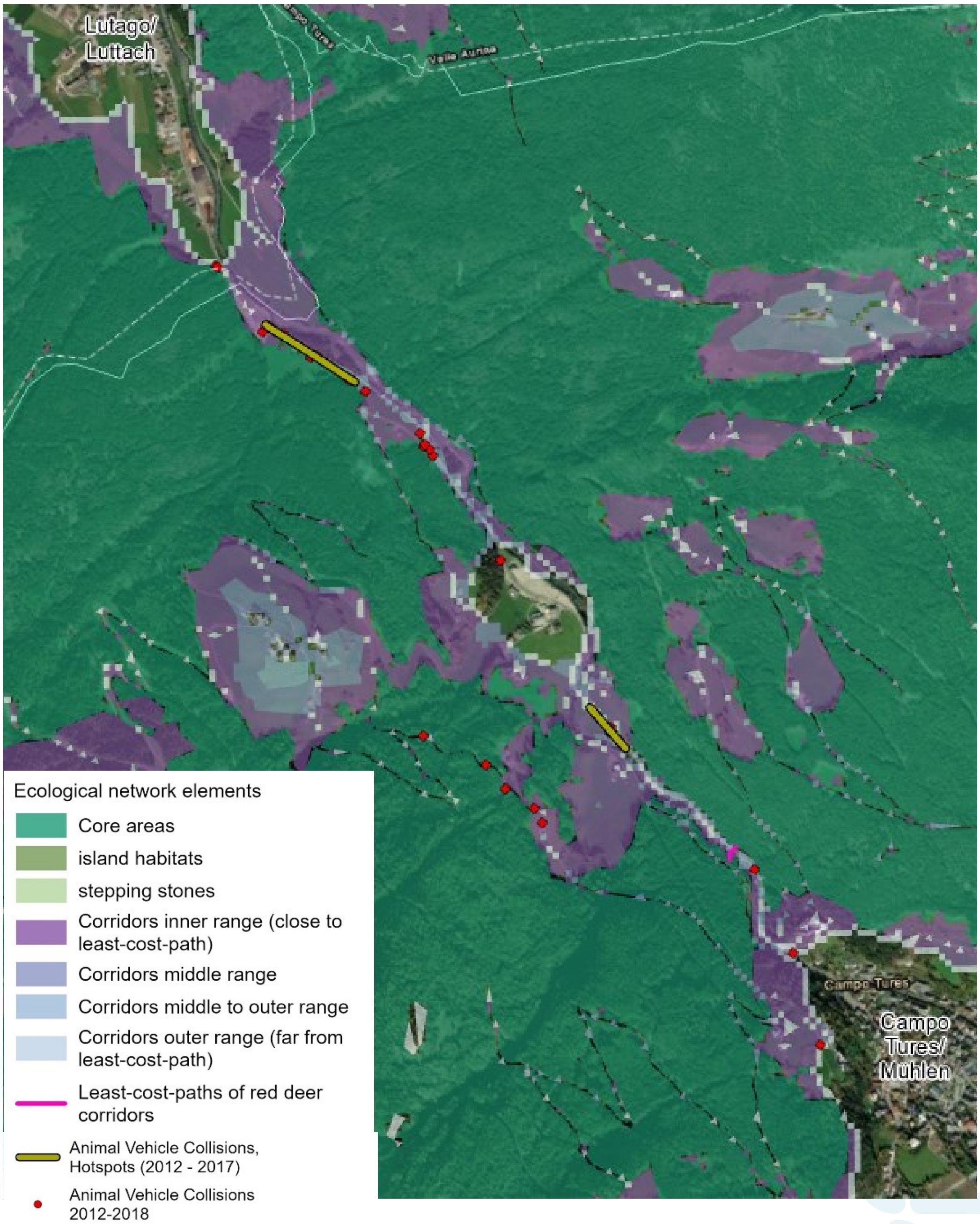

Figure 9: Ecological network for red deer in South Tyrol, highlighting focus areas for detailed corridor analysis

## Focus areas (n°), corridor names and description

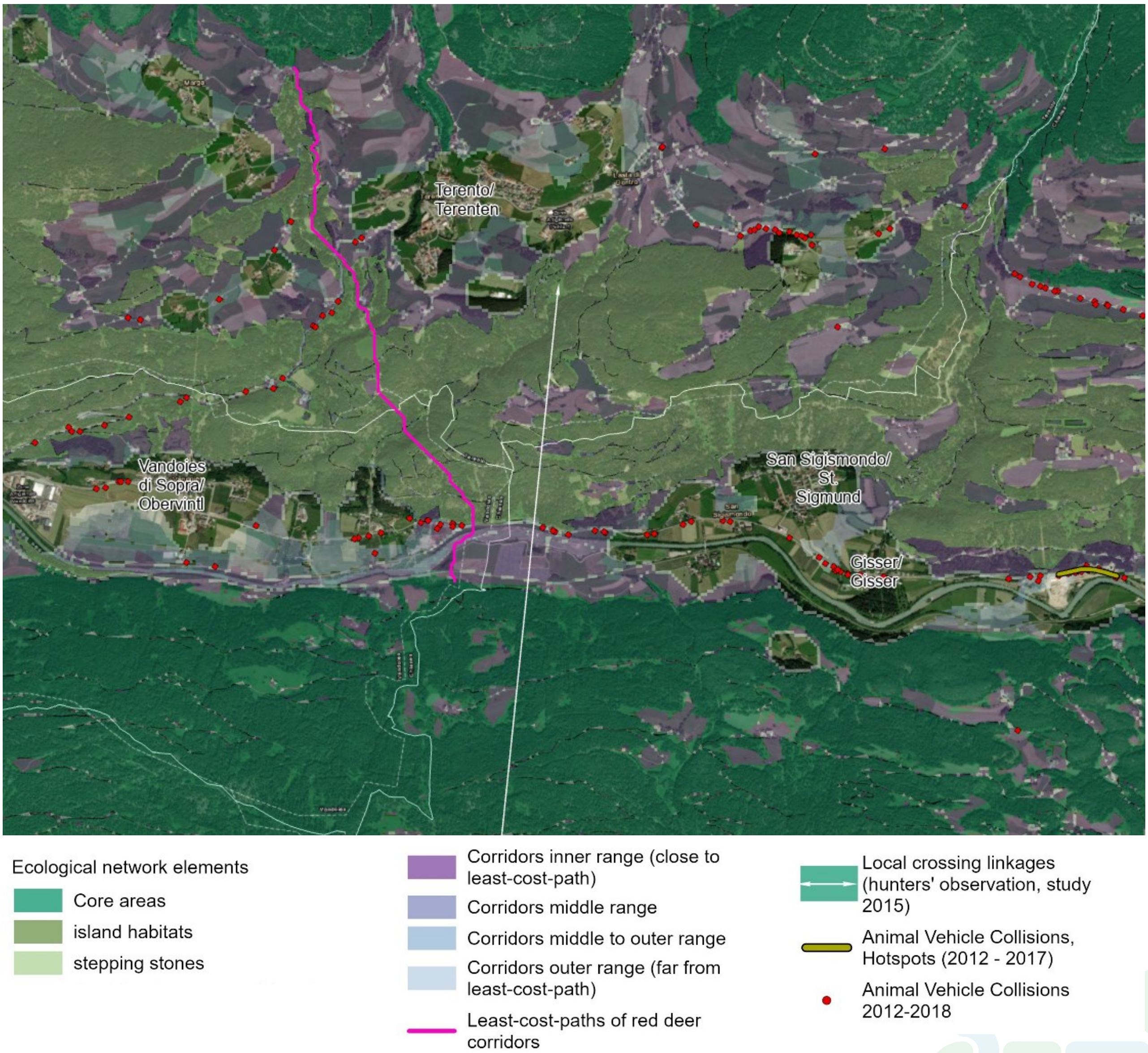
| n° | Corridor name | Location: Valley/ district, municipality | Existing/ potential | Description of GBI elements/ barriers/ alternatives |
|---|---|---|---|---|
| 1 | Vipiteno/ Sterzing north | Municipality of Vipiteno/ Sterzing | Existing | The corridor connects the mountain ranges between the settlements Colle Isarco and Vipiteno. It is an existing wildlife corridor with motorway bridges, a tunnel for the road with national importance and linear forest patches. A possible barrier is the railway line. |



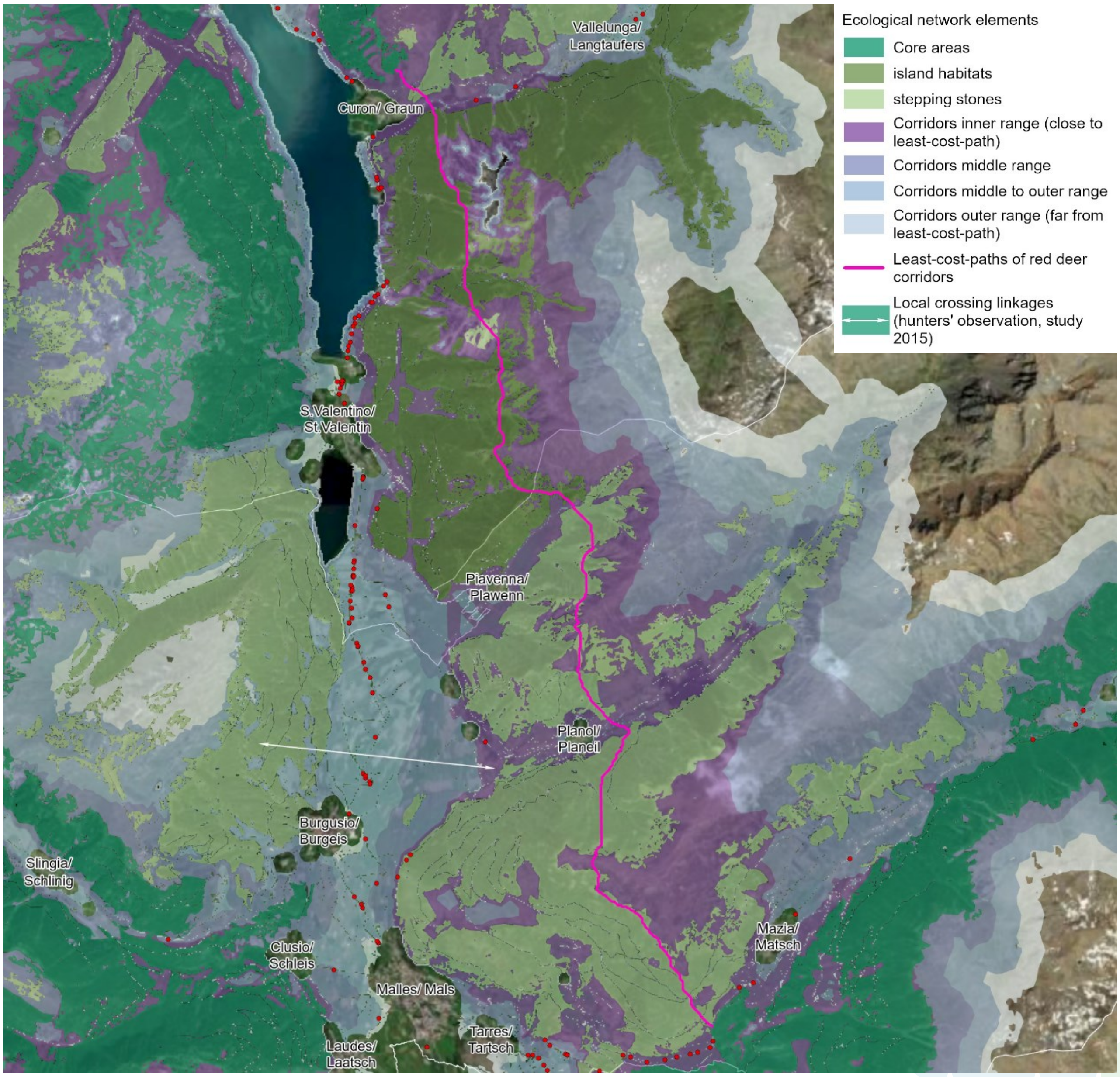
| n° | Corridor name | Location: Valley/ district, municipality | Existing/ potential | Description of GBI elements/ barriers/ alternatives |
|---|---|---|---|---|
| 2 | Campo Tures/ Sand in Taufers | Municipality of Campo Tures/ Sand in Taufers, between the main village and Lutago/ Luttach. | Existing | The east-west corridor passes through the valley bottom, connects two mountain ranges and is confirmed by seasonally recurring animal – vehicle collisions (yellow lines). |



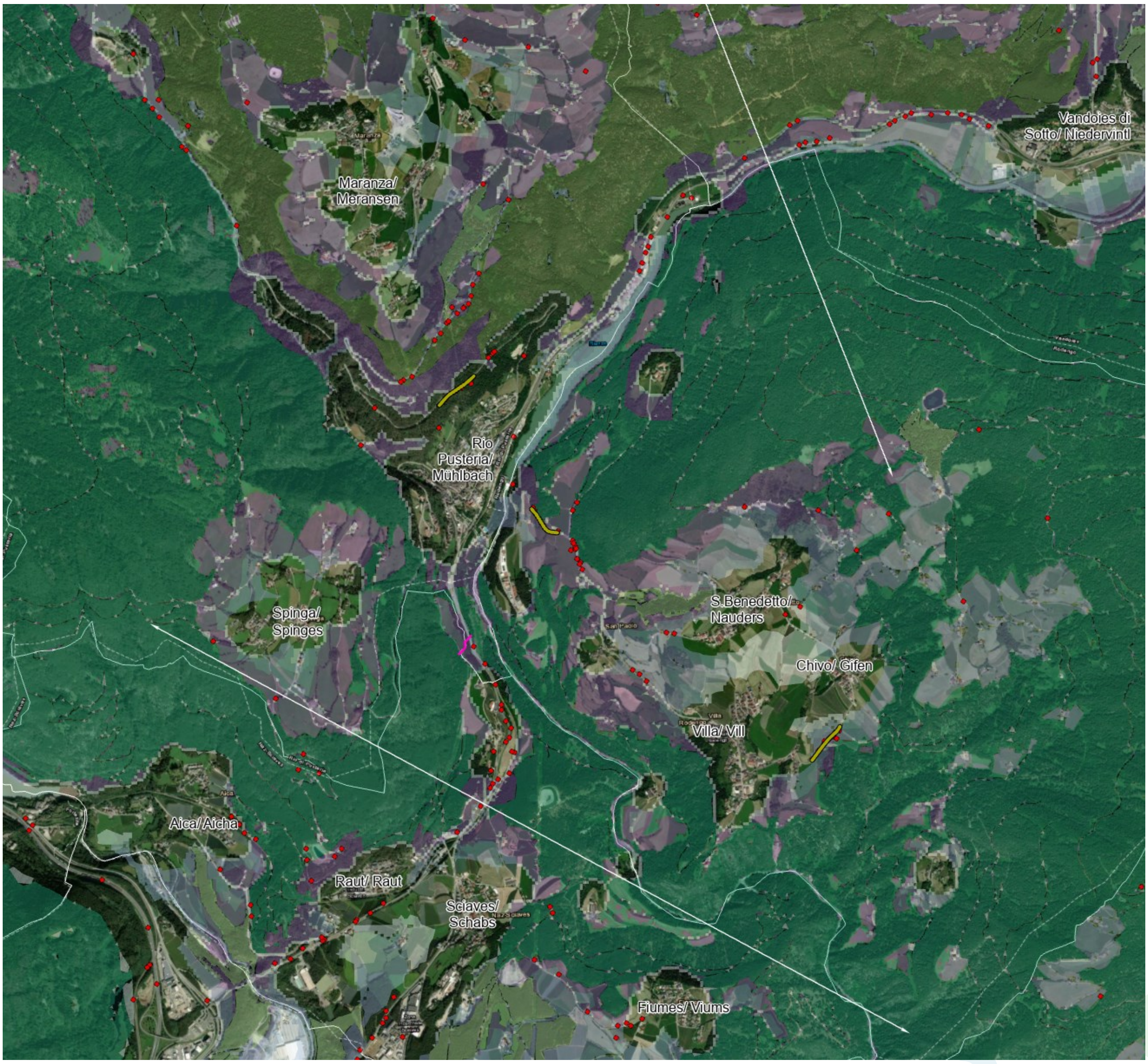
| n° | Corridor name | Location: Valley/ district, municipality | Existing/ potential | Description of GBI elements/ barriers/ alternatives |
|---|---|---|---|---|
| 3 | Lower Pusteria Valley | Municipalities between Vandoies/ Vintl and Brunico/ Bruneck | Existing | The south-north corridor passes through the valley bottom of Pusteria Valley. Possible barriers are the State Road SS49 (also numbered as E66), intensive agricultural areas, and the rectified Rienza river. A lot of alternative passages are possible along the valley bottom, however, settlement development is a risk for wildlife passages. The least-cost-path is confirmed by dispersed animal-vehicle collisions and observations of hunters (see Tornambé & Halilaj, 2015), signed as white arrow in the map. |



| n° | Corridor name | Location: Valley/ district, municipality | Existing/ potential | Description of GBI elements/ barriers/ alternatives |
|---|---|---|---|---|
| 4 | Upper Val Venosta | Malles/ Mals and Curon Venosta/ Graun im Vinschgau | Existing | The Planai Valley and the Mazia Valley are island habitats for red deer. They are important connections on the path from core areas of the northern slopes of the Venosta Valley towards Austria. An east- west connection is currently existing between Burgusio/ Burgeis and the Haider Lake/ Resia Lake. |

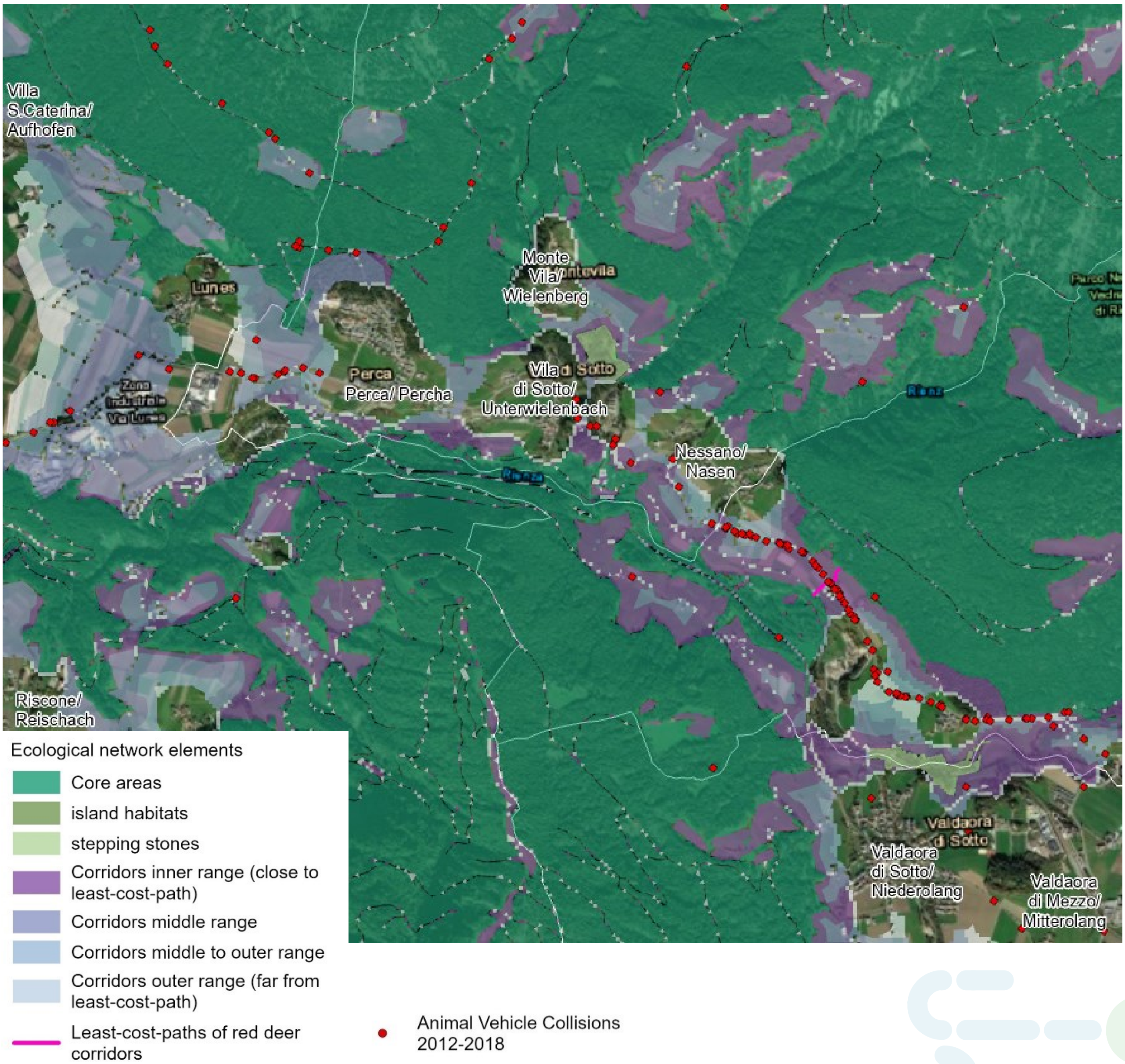


| n° | Corridor name | Location: Valley/ district, municipality | Existing/ potential | Description of GBI elements/ barriers/ alternatives |
|---|---|---|---|---|
| 5 | Naz-Sciaves – Rio di Pusteria | Naz-Sciaves/ Natz-Schabs, Rio di Pusteria/ Mühlbach | Question-able | Observations by hunters (see Tornambé & Halilaj, 2015) and animal-vehicle collisions are indicating that wildlife species are moving between Luson/ Lüsen and Spinga/ Spinges. The corridor passes in between the main villages of the two municipalities. However, the State Road SS49 and the regional railway line could potentially constitute significant barriers. A High number of collisions with wildlife species is identified on this road section. Bottlenecks need to be investigated. |

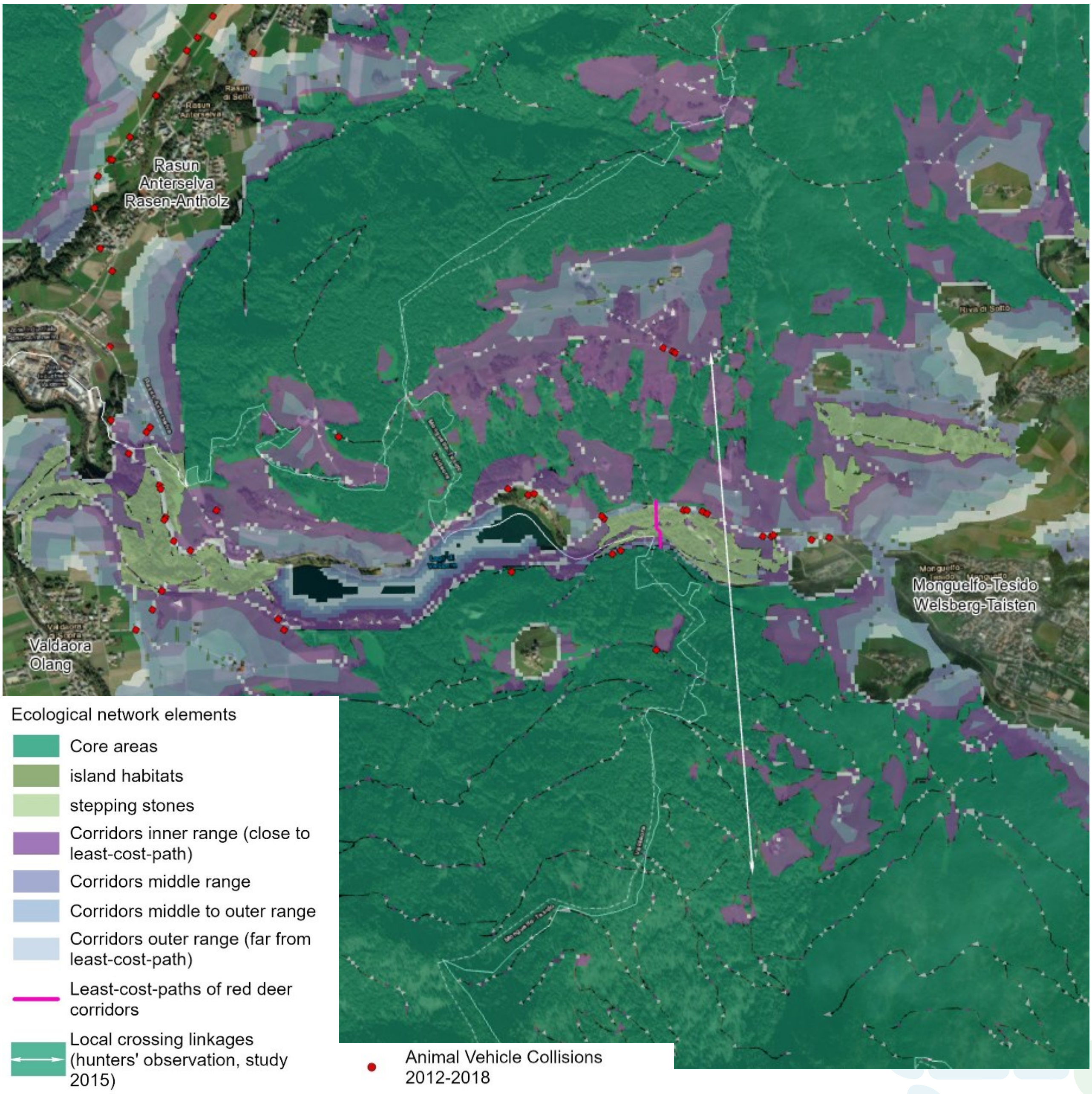



Legend: see focus area n°3

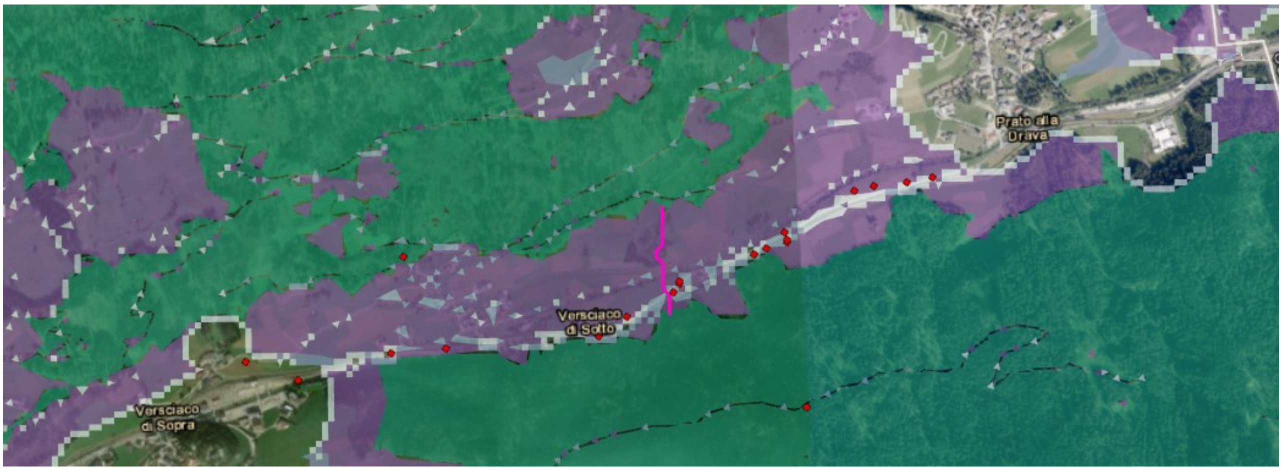
| n° | Corridor name | Location: Valley/ district, municipality | Existing/ potential | Description of GBI elements/ barriers/ alternatives |
|---|---|---|---|---|
| 6 | Perca - Rasun Anterselva / Percha - Rasen-Antholz | Brunico/ Bruneck, Perca/ Percha, Rasun Anterselva/ Rasen-Antholz, Valdaora/ Olang | Existing, Problem-atic | The corridor connects the nature parks of Fanes - Sennes - Braies and Vedrette di Ries – Aurina.<br>The road section where this corridor passes is one of the most frequently involved in accidents with red and roe deer in the whole province.<br>In the macro-regional model this linkage was evaluated with **priority 1** because of the importance for the overall network coherency and potential risks of getting lost. |

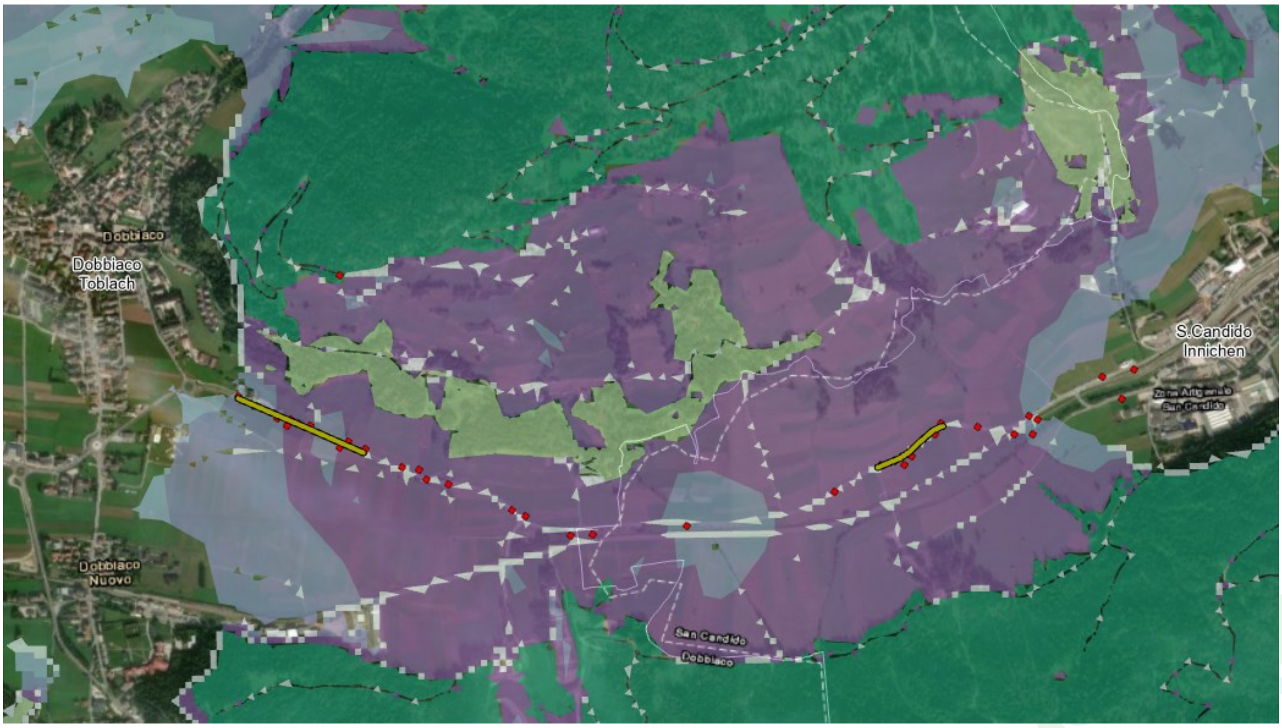


| n° | Corridor name | Location: Valley/ district, municipality | Existing/ potential | Description of GBI elements/ barriers/ alternatives |
|---|---|---|---|---|
| 7 | Braies - Vedrette di Ries/ Prags-Rieserferner | Anterselva/ Rasen-Antholz, Valdaora/ Olang, Monguelfo-Tesido/ Welsberg-Taisten | Existing | The corridor is part of the connection between the two nature parks Fanes - Sennes - Braies and Vedrette di Ries – Aurina.<br>Wildlife movements are confirmed by observations of hunters (see Tornambé & Halilaj, 2015). |



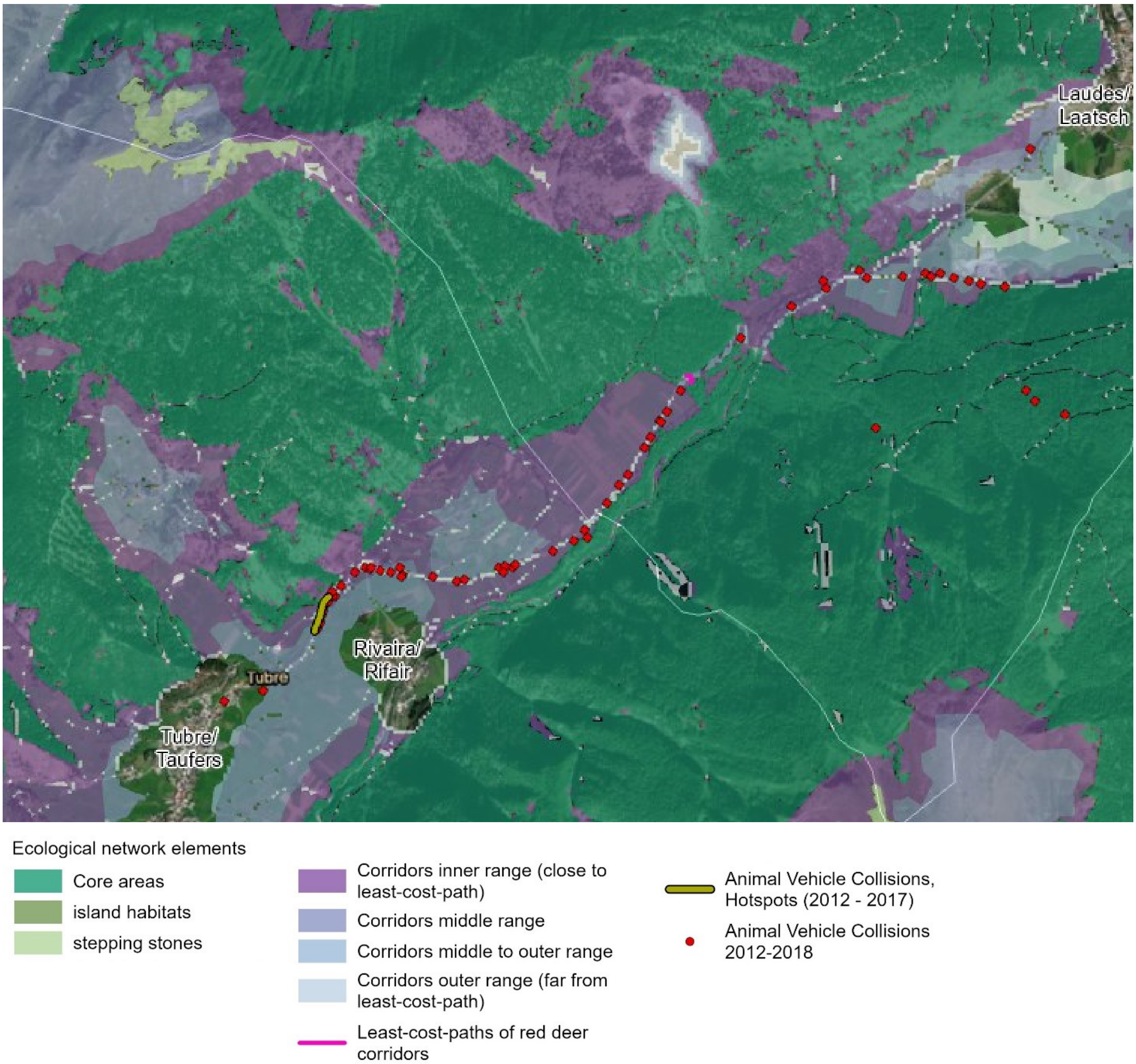
| n° | Corridor name | Location: Valley/ district, municipality | Existing/ potential | Description of GBI elements/ barriers/ alternatives |
|---|---|---|---|---|
| 8 | Tre cime – Valle Silvestro/ Drei Zinnen - Silvestertal | Upper Pusteria Valley, municipalities of Dobiacco/ Toblach and San Candido/ Innichen | Existing | The south - north corridor between the Tre Cime nature park and the Valle Silvestro has three sections of a width of more than 2 km and constitutes rather a permeable area with mostly semi-natural grassland between the two mountain slopes. An important corridor section is recognisable by seasonally recurring animal – vehicle collisions between the two main villages Dobiacco/ Toblach and San Candido/ Innichen which has a width of approximately 2.8 km. Barriers might be the train line and the State Road SS49. |



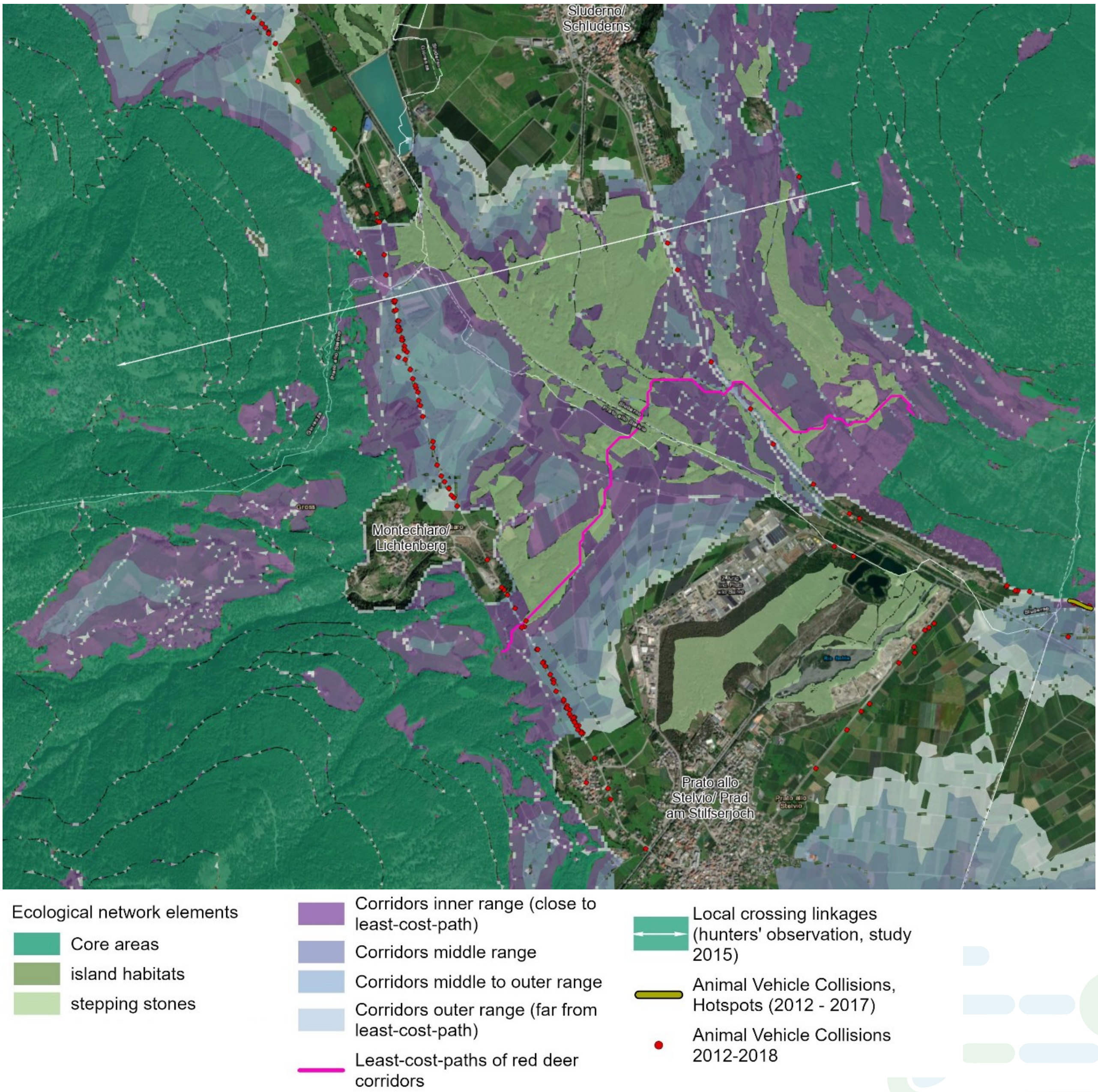




Legend: see area

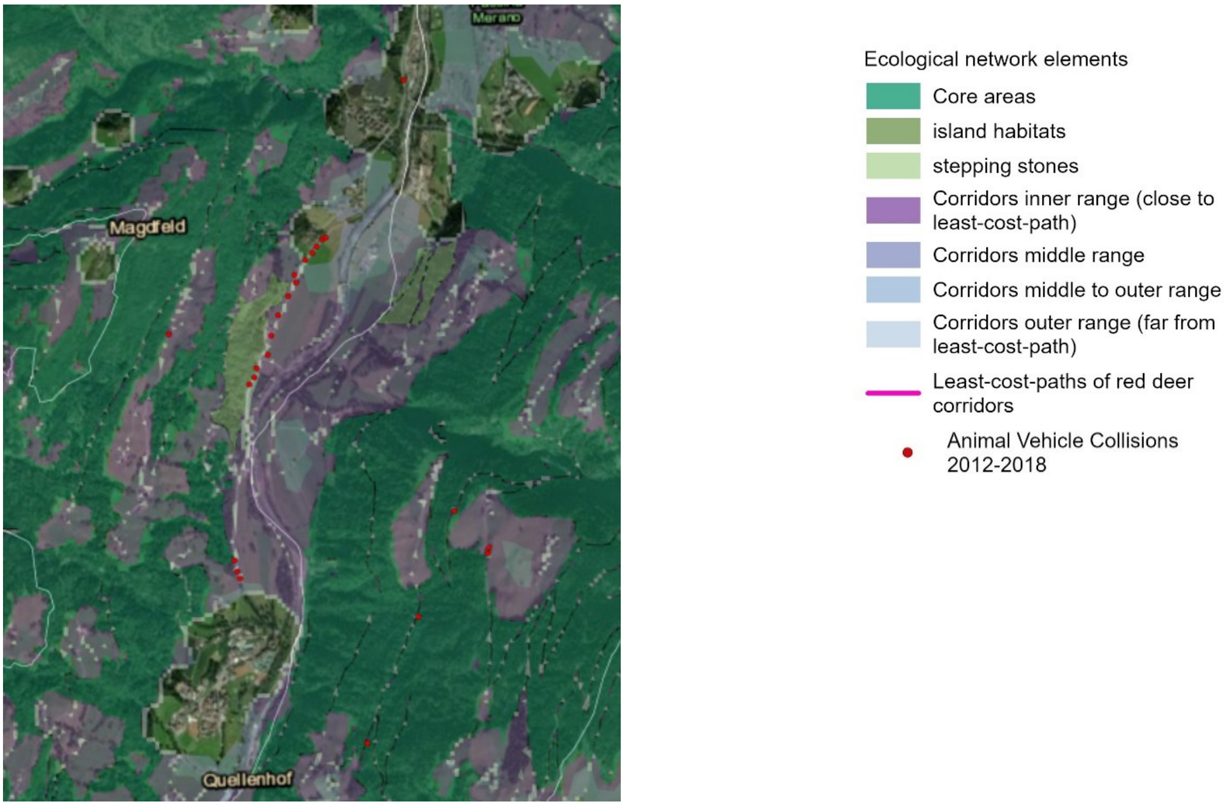
| n° | Corridor name | Location: Valley/ district, municipality | Existing/ potential | Description of GBI elements/ barriers/ alternatives |
|---|---|---|---|---|
| 9 | Tubre/ Taufers im Münstertal | Municipalities of Tubre/ Taufers im Münstertal and Malles/ Mals | Existing | The corridor constitutes rather a permeable area for red deer species. Seasonally recurring animal – vehicle collisions are present near the main village Tubre/ Taufers. |



| n° | Corridor name | Location: Valley/ district, municipality | Existing/ potential | Description of GBI elements/ barriers/ alternatives |
|---|---|---|---|---|
| 10 | Sluderno – Prato/ Schluderns - Prad | Upper Venosta Valley, Sluderno/ Schluderns, Prato/ Prad, Lasa/ Laas | Existing/ Question-able | The corridor is confirmed by observations of hunters (see Tornambé & Halilaj, 2015). However, it passes through some extensive but also intensive agricultural areas. It is questionable if the connection is functional for red deer on the whole corridor width. The existing forest patches in the valley bottom are important to guarantee the functionality. Potential barriers are the State Road SS40 and the train line (high mortality rate). |

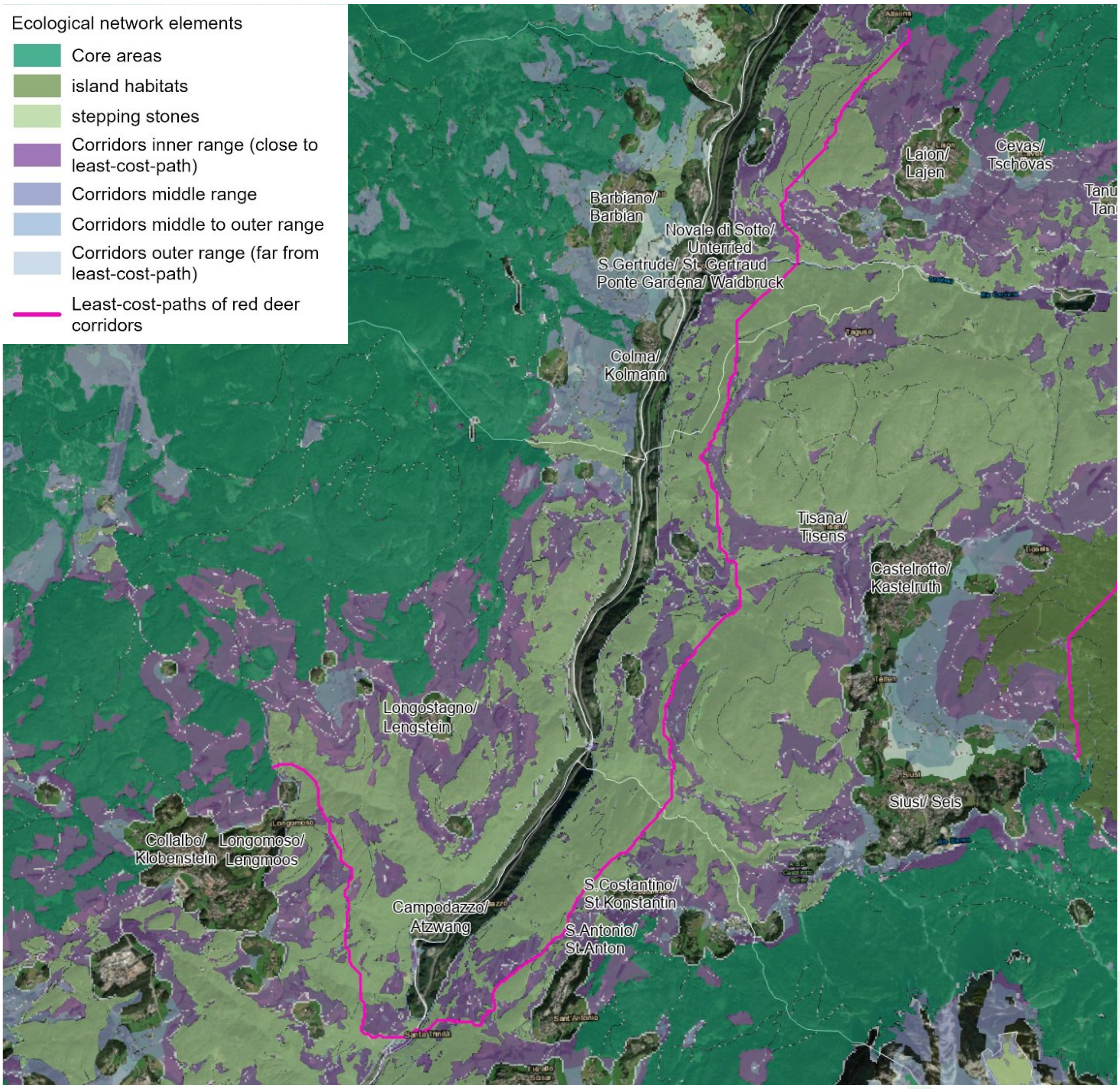


| n° | Corridor name | Location: Valley/ district, municipality | Existing/ potential | Description of GBI elements/ barriers/ alternatives |
|---|---|---|---|---|
| 11 | Sarentino/ Sarnthein | Municipality of Sarentino/ Sarntal | Existing | The east-west corridor constitutes rather a permeable area in the north of the main village of the valley. The valley bottom has rather a low barrier effect, showing some small semi-natural grassland areas with a width of 200 to 700 m.<br>Major intervention measures for improving ecological connectivity seems not to be necessary at the moment, at least not for red deer. |
| 12 | Passiria | S. Martino in Passiria/ St. Martin in Passeier S.Leonardo in Passiria/ St.Leonhard in Passeier, | Existing | The corridor represents an alternative of many possibilities for crossing the Passiria Valley, passing between the mountains of Val Sarentino and the Nature Park Gruppo di Tessa. Wildlife incidents are relatively concentrated on the road section between Quellenhof and the S. Matino, main village of the municipality. The section is located right on the border between the municipalities S. Martino and St. Leonardo. |

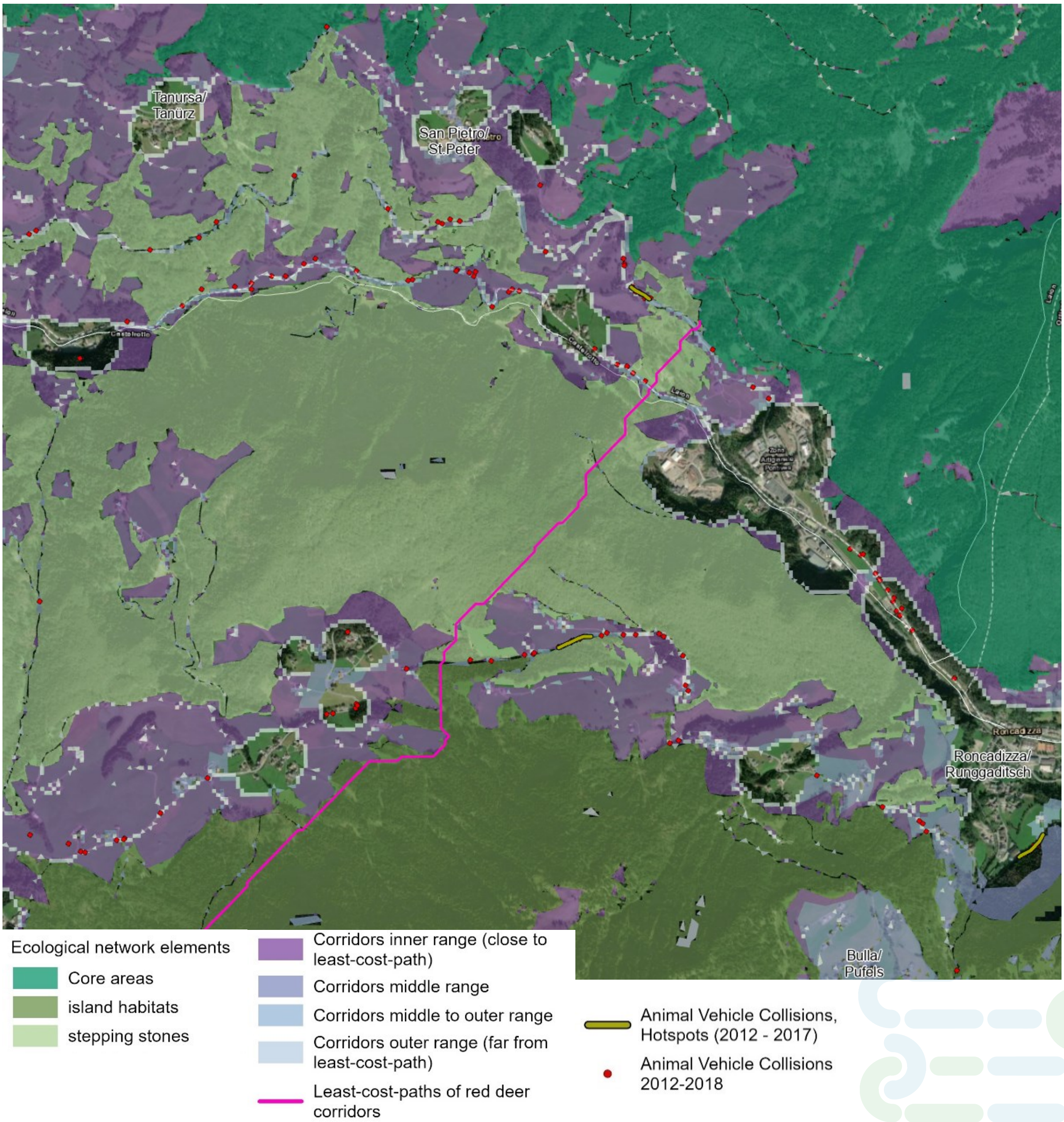



| | | | | |
|---|---|---|---|---|
| 13 | Villnöss - Badia | Funes/ Villnöss, S.Martino in Badia/ St. Martin in Thurn | Existing | The permeable area lies in the nature park Puez-Odle/ Puez-Geisler and has no major barriers. The corridor is in high altitudes above 1.900m. A potential disturbance factor can be extensive agriculture. |

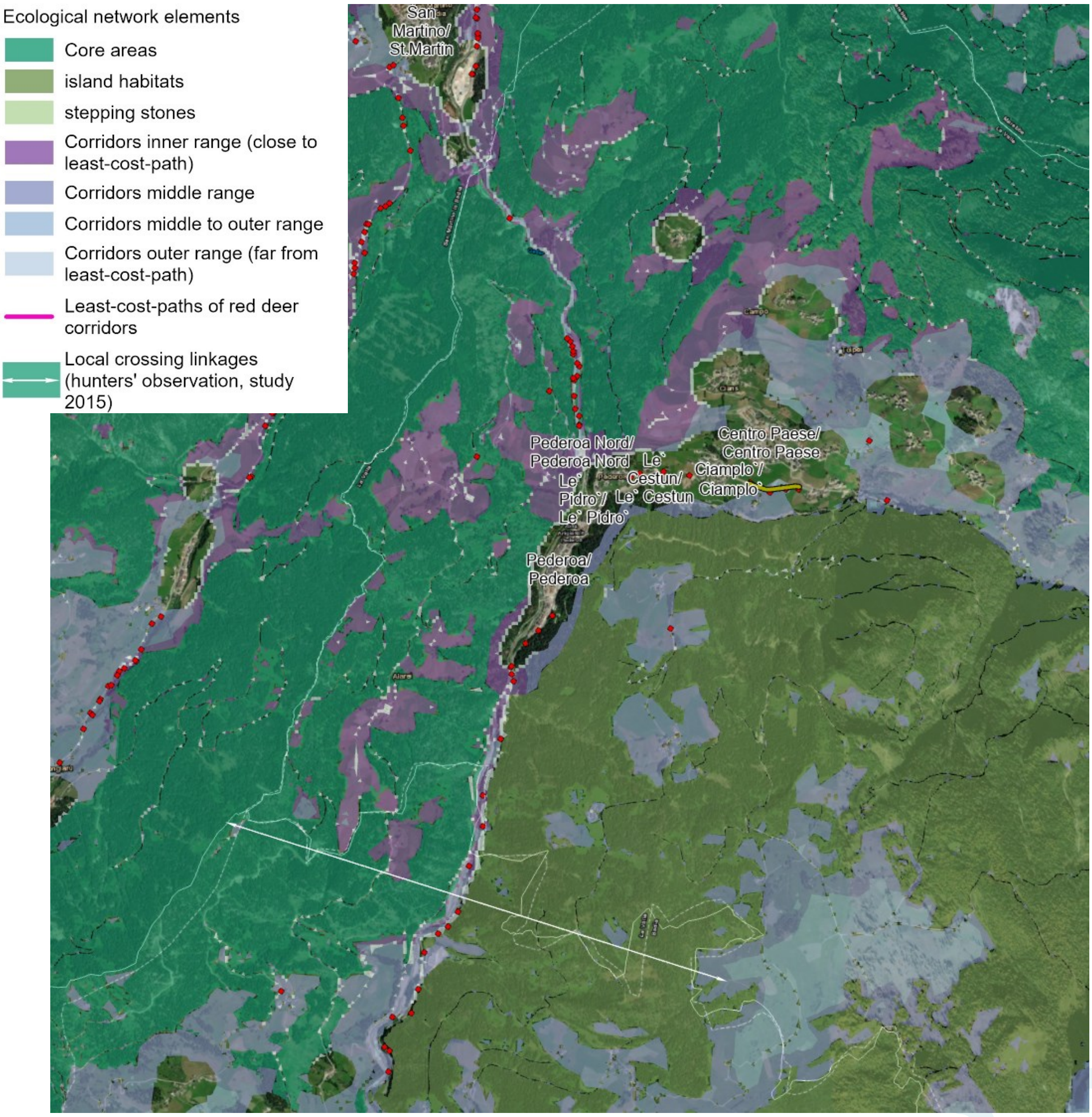
| n° | Corridor name | Location: Valley/ district, municipality | Existing/ potential | Description of GBI elements/ barriers/ alternatives |
|---|---|---|---|---|
| 14 | Renon – Castelrotto – Laion, Ritten – Kastelruth - Lajen | Renon/ Ritten, Castelrotto/ Kastelruth, Fie'/ Völs, Laion, Lajen | Question-able | The corridor connects the high plateaus of Renon, Sciliar and Laion. With almost 20 km, it is one of the longest corridor sections, connecting several stepping stone areas of a large surface extent. It overpasses the motorway tunnel in the south of Campodazzo/ Atzwang and a tunnel of the State road SS12 in the Isarco Valley. It must be verified if red deer and other species can overcome the steep slopes and the Isarco River in exactly this location. |



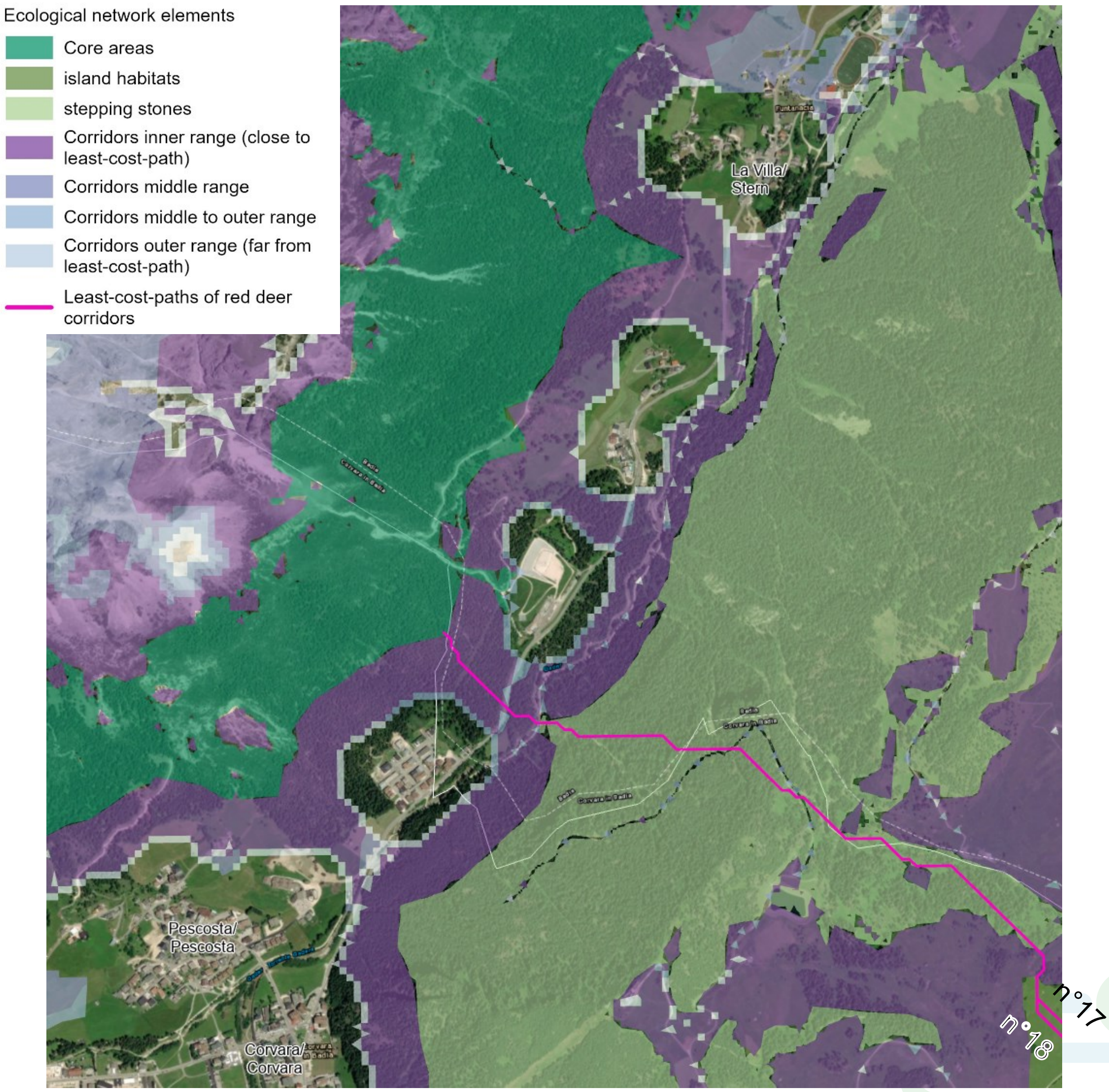
| n° | Corridor name | Location: Valley/ district, municipality | Existing/ potential | Description of GBI elements/ barriers/ alternatives |
|---|---|---|---|---|
| 15 | Sciliar-Laion, Schlern-Lajen | Castelrotto/ Kastelruth, Laion, Lajen | Existing | The corridor connects the forests above the villages Siusi and Castelrotto, which are classified as an island habitat for red deer, with the core area at the northern side of Val Gardena. Wildlife is passing in the western part of the industrial zone Pontives, where seasonally recurring animal – vehicle collisions are happening. |

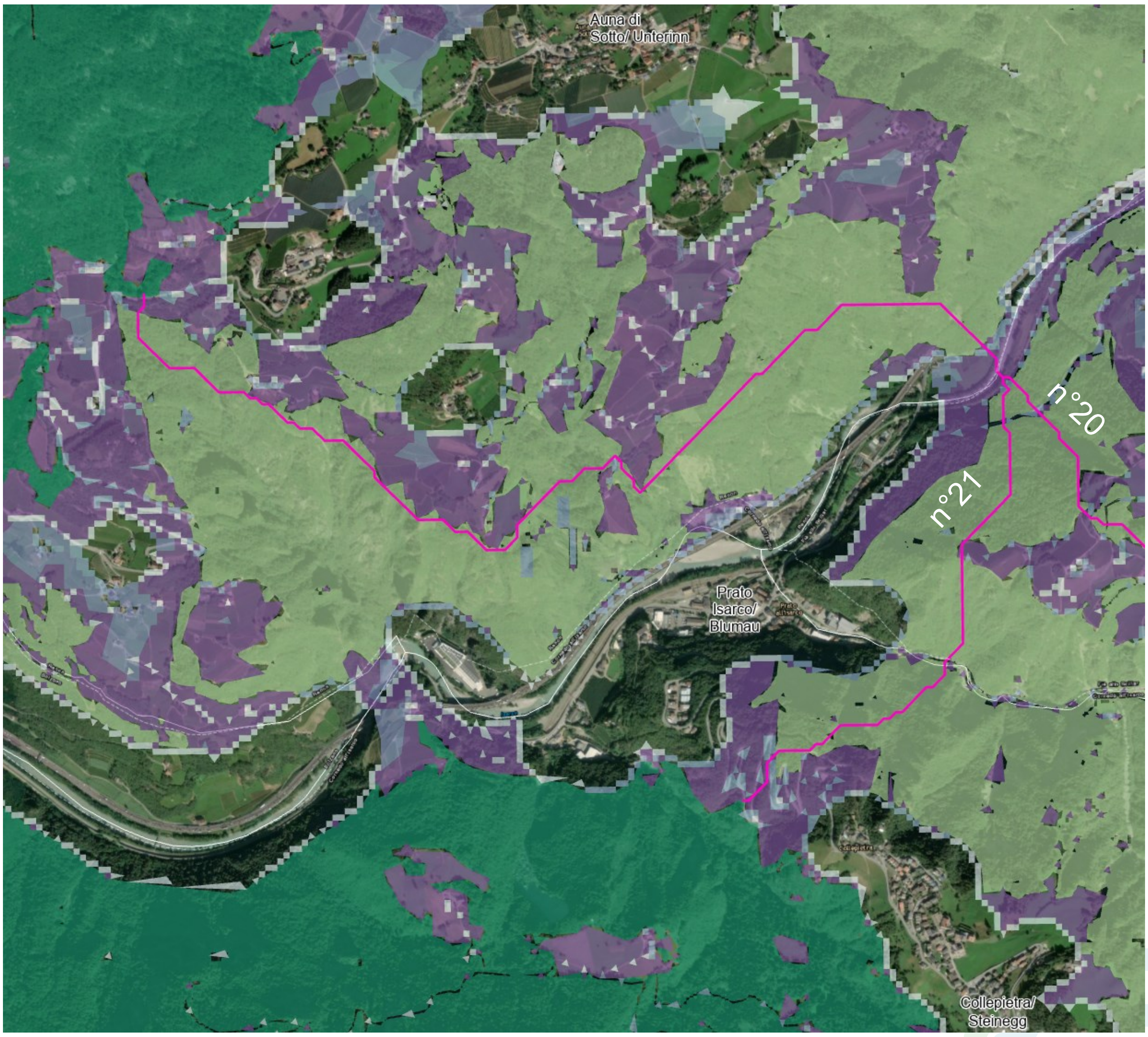


| n° | Corridor name | Location: Valley/ district, municipality | Existing/ potential | Description of GBI elements/ barriers/ alternatives |
|---|---|---|---|---|
| 16 | Pederoa | S. Martino in Badia/ St. Martin in Thurn, Badia/ Abtei | Existing | On the State Road SS244 between S. Martino in Badia and Pederoa, animal – vehicle collisions are concentrated next to the least-cost-path pf the network model. Towards the south of Pederoa, animal movements across the State Road SS244 are confirmed by hunter observations. (see Tornambé & Halilaj, 2015) |

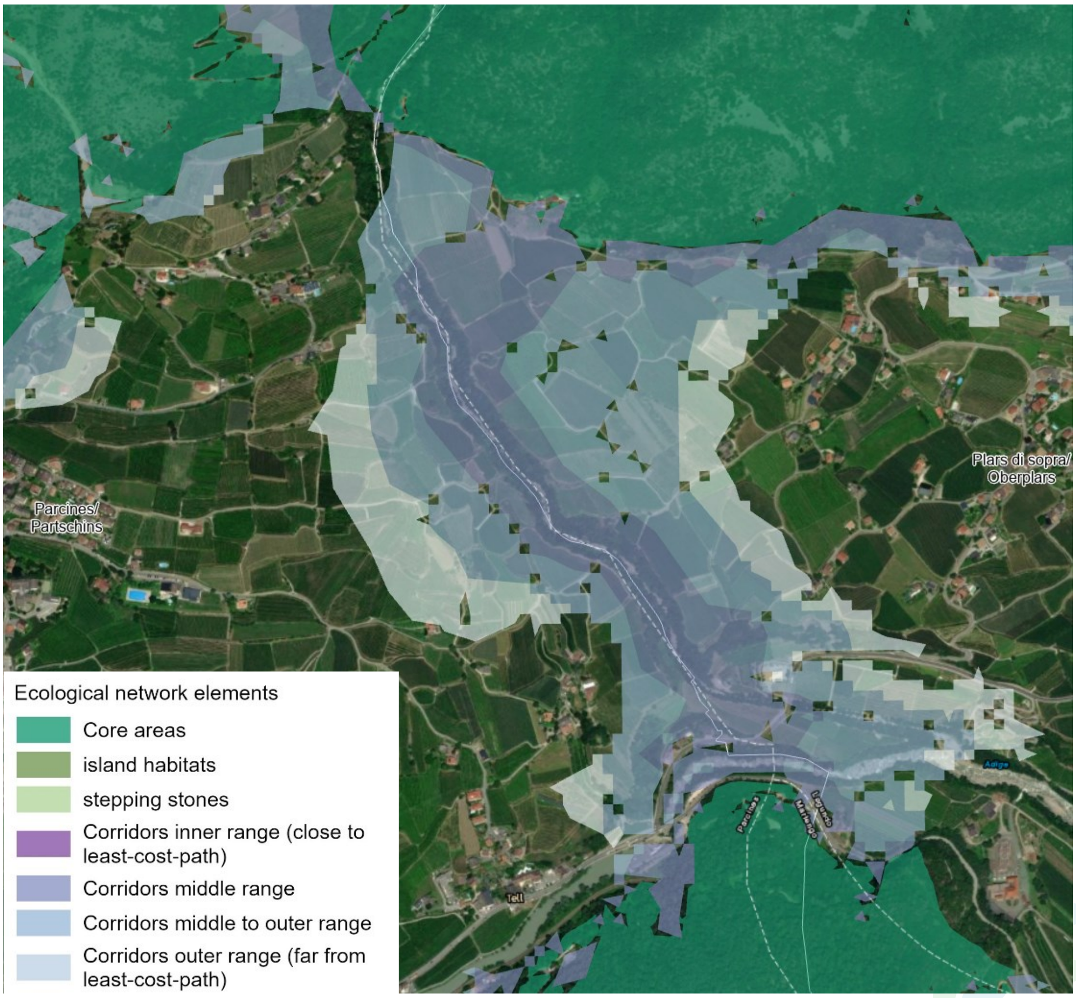


| n° | Corridor name | Location: Valley/ district, municipality | Existing/ potential | Description of GBI elements/ barriers/ alternatives |
|---|---|---|---|---|
| 17<br>18 | Corvara | Corvara, Badia/ Abtei | Existing | The Least-cost-path is crossing the State Road SS244 in a forested area at the north of Corvara. It is a remaining forest patch of approximately 350 meters between the industrial zone and a landfill site. Two alternatives for this corridor are visible toward the north. The first one is also structured by forests but has only a width of 280 meters, the second one is structured by natural grassland with a width of approximately 450 metres. |

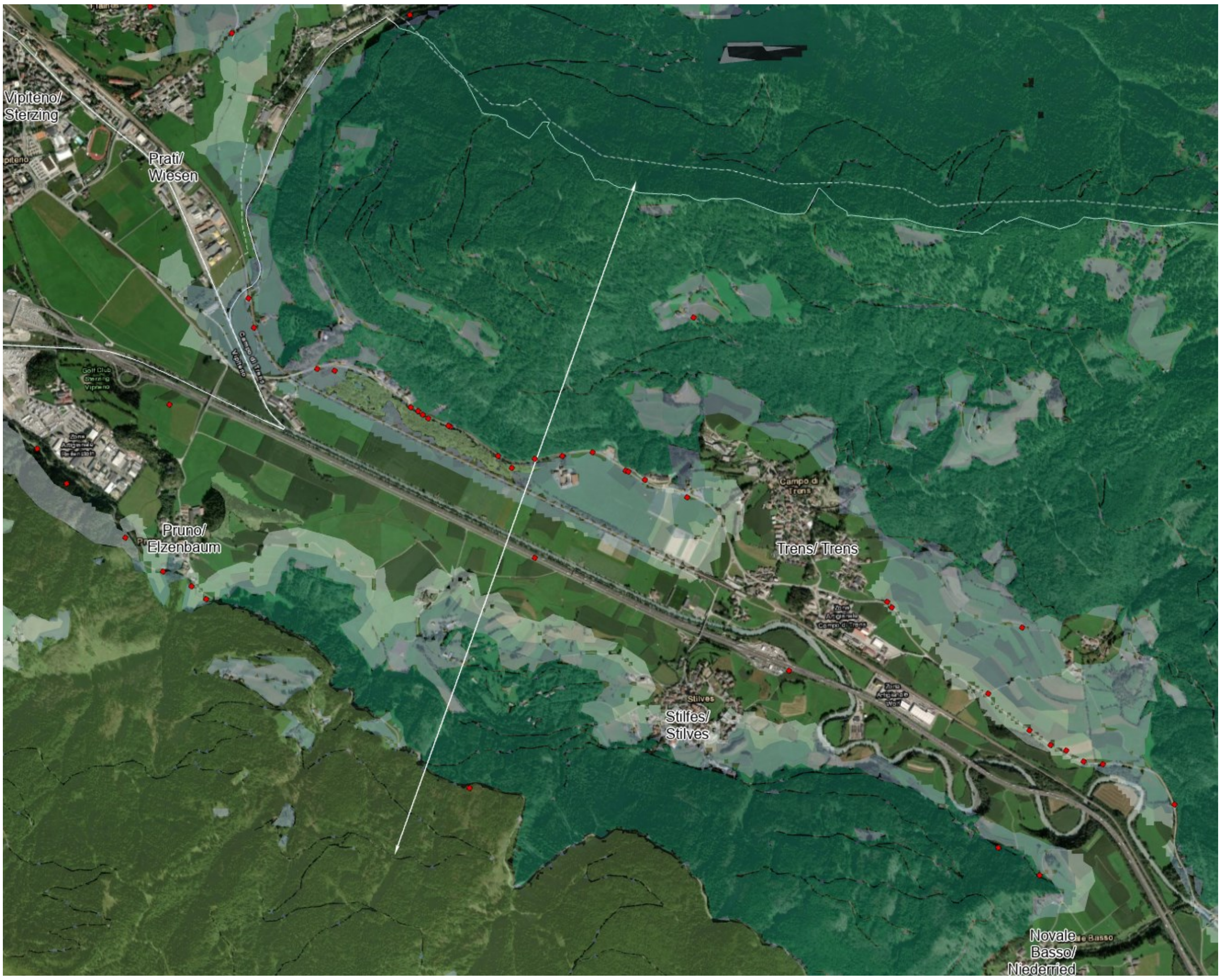


| n° | Corridor name | Location: Valley/ district, municipality | Existing/ potential | Description of GBI elements/ barriers/ alternatives |
|---|---|---|---|---|
| 19 | Stelvio | Prato/ Prad, Stelvio/ Stilfs | Existing | The corridor between the main villages of Prato/ Prad and Stelvio/ Stilfs is representing a permeable area. It connects the Natura 2000 sites Alpe di Cavallaccio with Ultimo – Solda in the National Park Stelvio. |
| Aereal image of corridor not provided | | | | |
| 20<br>21 | Renon – Sciliar | Renon/ Ritten, Fie'/ Völs, Cornedo all'Isarco/ Karneid | Question-able | The modelled corridors connect the core area of the Renon with the corridor around nature park Sciliar and the core area of the Eggen Valley, passing below Collepietra/ Steinegg. It is questionable if these corridors are functional for red deer. They are overpassing a motorway tunnel, but the Eisack Valley with the State Road SS12 and some intensive agricultural areas could constitute a barrier. |
|  | | | | |
| Legend: see focus area n°3 | | | | |

| n° | Corridor name | Location: Valley/ district, municipality | Existing/ potential | Description of GBI elements/ barriers/ alternatives |
|---|---|---|---|---|
| 22 | Mendel | Appiano/ Eppan, caldaro/ Kaltern | Existing | This corridor results from the modelling approach and highlights the Mendel pass road as fragmenting element. However, with the existing Animal-vehicle collision data, a major barrier effect of the road cannot be confirmed. |
| Aereal image of corridor not provided | | | | |
| 23 | Töllgraben | Parcines/Partschins and Lagundo | Potential | The model is defining an alternative south-north-connection in the Vinschgau Valley at the border between Parcines and Lagundo along the river Töllgraben/ Tovo di Tel. At the moment, the GBI elements are not enough established. The forested area along the river is just 70 m wide, and constitutes an option for a corridor restoration, extending its width for red deer species to reduce the high barrier effect of the valley bottom. |

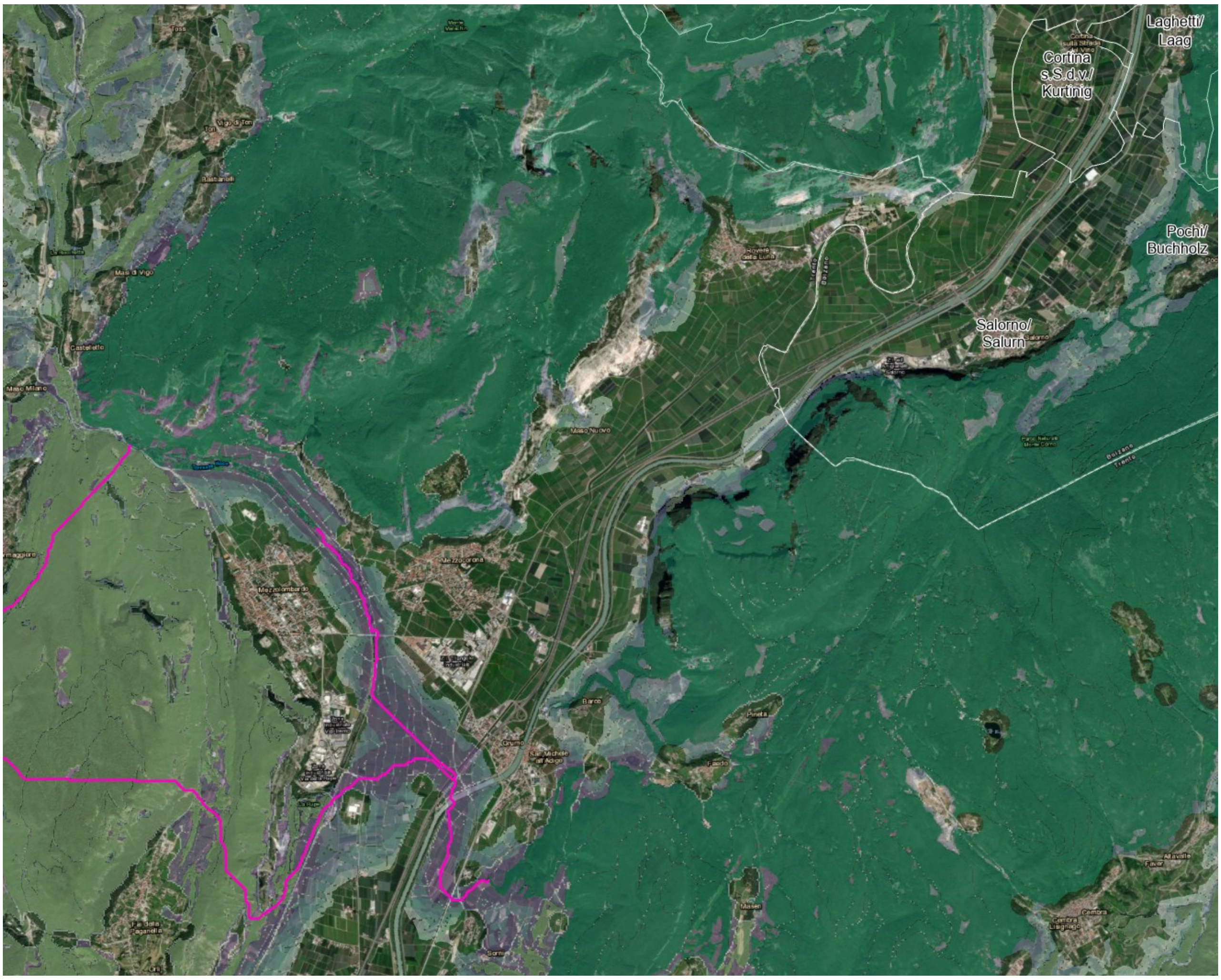


| n° | Corridor name | Location: Valley/ district, municipality | Existing/ potential | Description of GBI elements/ barriers/ alternatives |
|---|---|---|---|---|
| 24 | Campo di Trens | Campo di Trens/ Freienfeld | Potential | Between Campo di Trens and Vipiteno hunters' observations are indicating animal movements passing the motorways. However, at the south-east of the main village, there exist several motorway bridges because of the Isarco River. The model was not able to reveal a possible connection there, but it would be worth to check vehicle collisions, also with trains to verify the corridor. |




Ecological network elements
- Core areas
- island habitats
- stepping stones
- Corridors inner range (close to least-cost-path)
- Corridors middle range
- Corridors middle to outer range
- Corridors outer range (far from least-cost-path)
- Local crossing linkages (hunters' observation, study 2015)
- Animal Vehicle Collisions 2012-2018

| n° | Corridor name | Location: Valley/ district, municipality | Existing/ potential | Description of GBI elements/ barriers/ alternatives |
|---|---|---|---|---|
| 25 | Piana Rotaliana | Trentino/ municipalities around Mezzocorona | Potential | The model is designing a potential corridor in the Piana Rotaliana in Trentino, which crosses the Adige Valley. The network concept of Trentino is defining a potential corridor at the north of Mezzocorona.<br>However, the designed corridor is passing through intensive agriculture for 1,5 km, which is not very realistic. |




Ecological network elements
- Core areas
- island habitats
- stepping stones
- Corridors inner range (close to least-cost-path)
- Corridors middle range
- Corridors middle to outer range
- Corridors outer range (far from least-cost-path)
- Least-cost-paths of red deer corridors

| n° | Corridor name | Location: Valley/ district, municipality | Existing/ potential | Description of GBI elements/ barriers/ alternatives |
|---|---|---|---|---|
| 26 | Mitterberg/ Montiggl | Caldaro/ Kaltern, Vadena/ Pfatten, Ora/ Auer | Potential | A potential corridor between the mountain ridge of the Mendola and the nature park Monte Corno was revealed in other studies on ecosystem services (see LUIGI project). This corridor, crossing the Adige Valley would be highly important to mitigate the barrier effect of intensive agriculture. It would connect the biotopes Castelfeder, Caldaro Lake, and the protected landscape of the Montiggl forest on its' path. However, it was not designed in the red deer model, therefore could be an important connection for other species, which needs to be investigated. |


Ecological network elements

- Core areas
- island habitats
- stepping stones
- Corridors inner range (close to least-cost-path)
- Corridors middle range
- Corridors middle to outer range
- Corridors outer range (far from least-cost-path)

## 4.2 Focus on corridor Perca - Rasun Anterselva/ Percha - Rasen- Antholz

In the following paragraphs we focus on the corridor “Perca - Rasun Anterselva / Percha - Rasen- Antholz” (focus area n°6), since it has a high priority based on PlanToConnect macro model and local experts' evaluation.

### 4.2.1 Identification of protected areas and GBI elements in focus area

Figure 12 depicts the Least Cost Path (LCP) in bright pink, connecting both sides of the Pusteria Valley/Pustertal. To the north-east lies the Vedrette di Ries-Aurina/Rieserferner-Ahrn natural park, while the south-west features the Plan de Corones/ Kronplatz Mountain, which is not a protected area and includes ski infrastructure such as runs, resorts, and cable cars. As previously noted, such openings in the forest often lead to the creation of grassland habitats, producing leaves and small fruits that benefit red deer during periods and times when these areas are not frequented by people. The LCP crosses cultivated lands and the State Road linking Brunico/ Bruneck and San Candido/ Innichen. Within focus area 6, there are alternative potential corridors that traverse the valley, showing either similar or higher resistance compared to the LCP. The violet gradient in figure 10 represents the resistance gradient, with darker shades indicating lower resistance and lighter shades indicating higher resistance.

In general, the corridor is located in areas which are covered by various existing landscape and nature protection designations (see Figure 12):

The nature park Rieserferner-Ahrn starts only 1,6 km from the valley bottom and protects the core areas at the northern mountain slope. Two wetland areas are located at the southern side of the valley bottom (Fuchsnau and Rienzau Percha), which are protected as biotopes. Wide areas of the corridor are designated as respect zone, where soil sealing and constructions of new buildings is prohibited. Landscape protected elements in the area are mainly archeological sites.

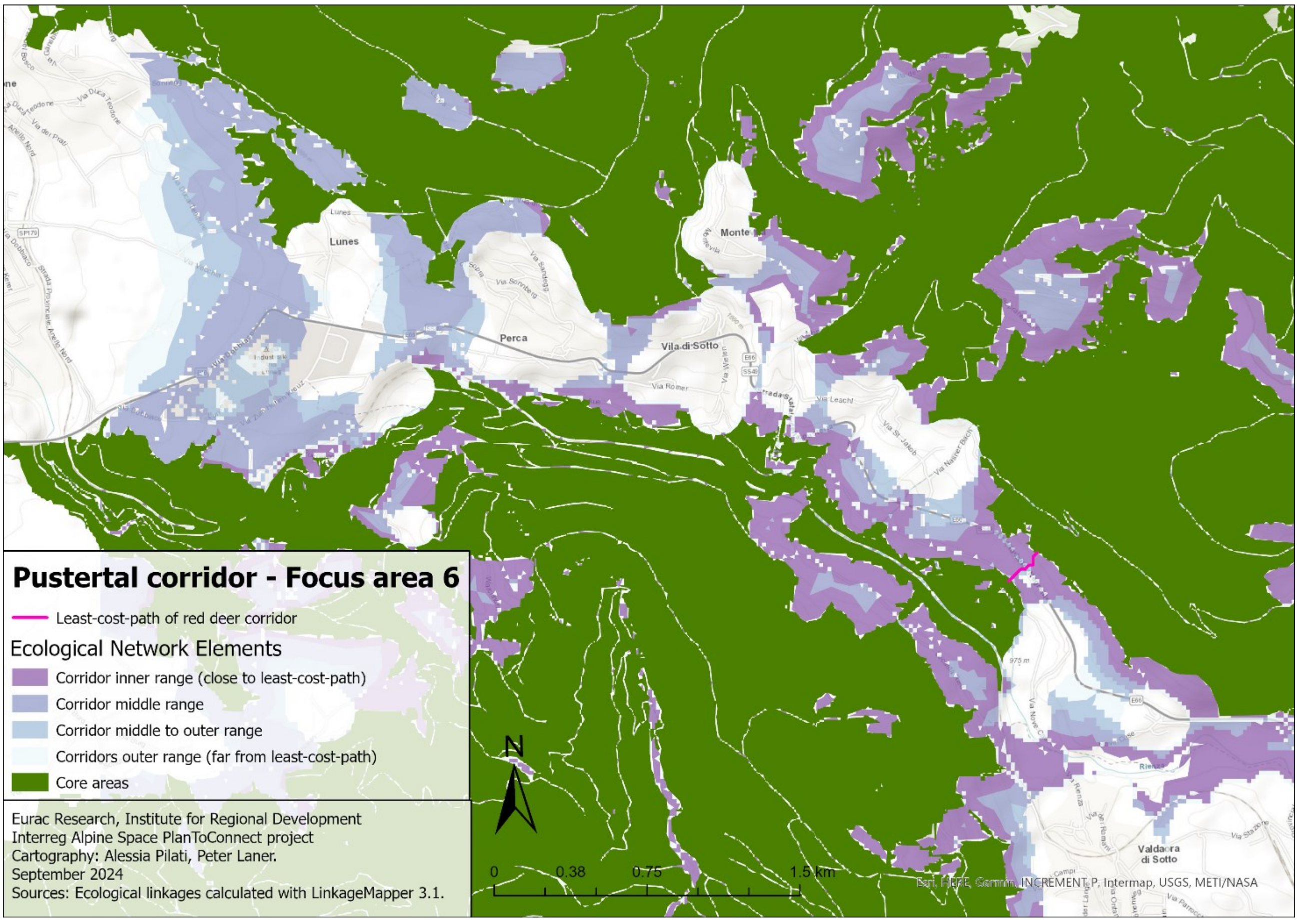



Figure 10: Ecological network for red deer in South Tyrol, detail on focus area 6.

In the heavily cultivated valley, small patches of tree cover and green linear elements may facilitate the movement of red deer across the valley. In Table 8 there is the list of the land use/land cover attributes present within the corridor, and Figure 6 clearly shows that the valley is intensively cultivated (cultivated areas for 65.7% of the corridor area), with the presence of few patches of natural elements, such as tree covered areas or green linear elements.

Table 8: Percentages of land use/land cover attributes in the corridor

| LULC attribute | Percentage (%) |
|---|---|
| Artificial surfaces and constructions | 4.7 |
| Road networks | 2.9 |
| Railways train tracks | 0.6 |
| Unpaved roads and tracks | 1.9 |
| Cultivated areas | 65.7 |
| Managed grassland - Pastures | 2.5 |
| Seminatural grassland - Meadows | 0.8 |
| Tree cover | 18.5 |
| Green linear elements | 1.9 |
| Patchy woody features | 0.5 |

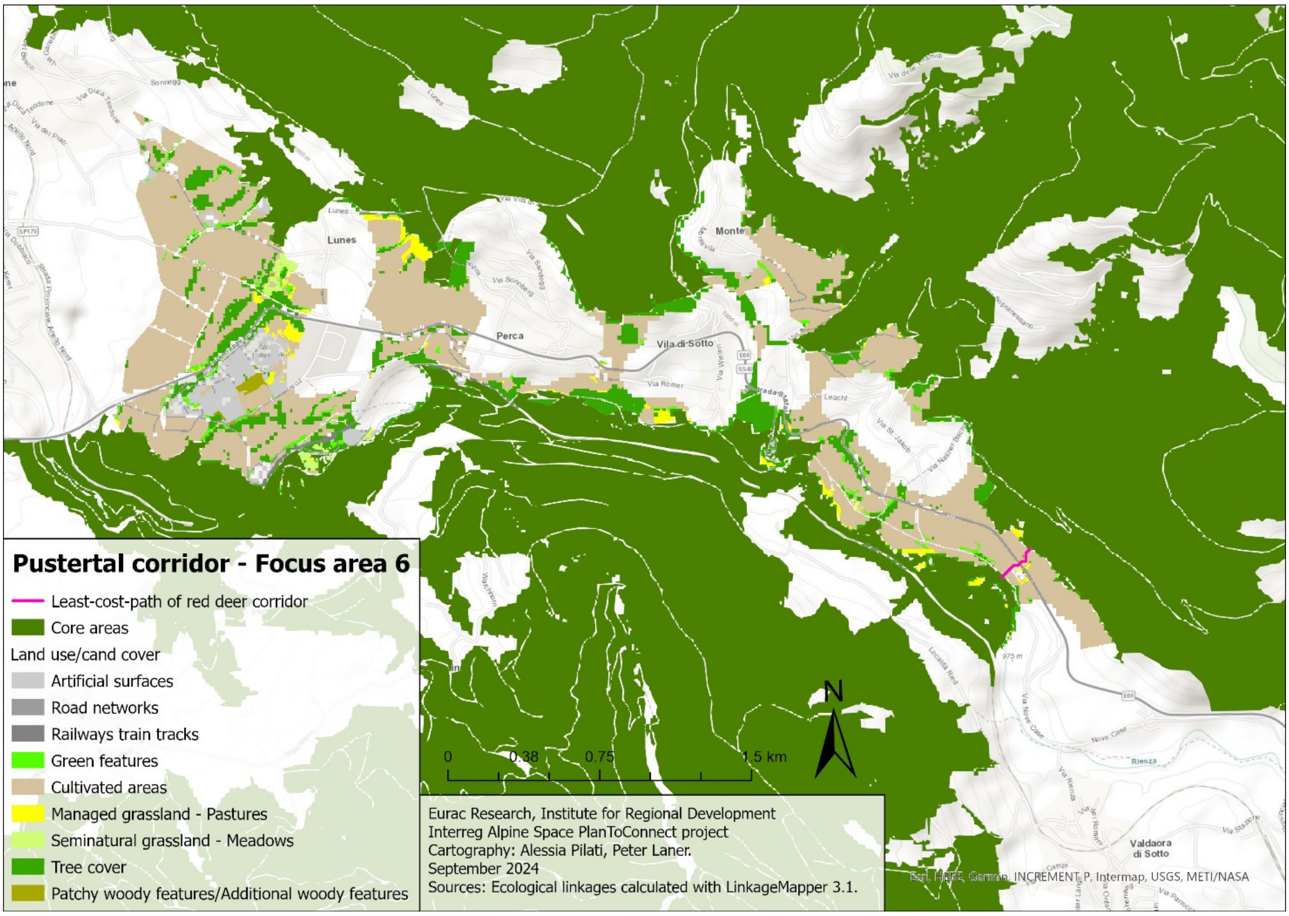



Figure 11: Land use/land cover of the ecological network for red deer in South Tyrol, detail on focus area 6.

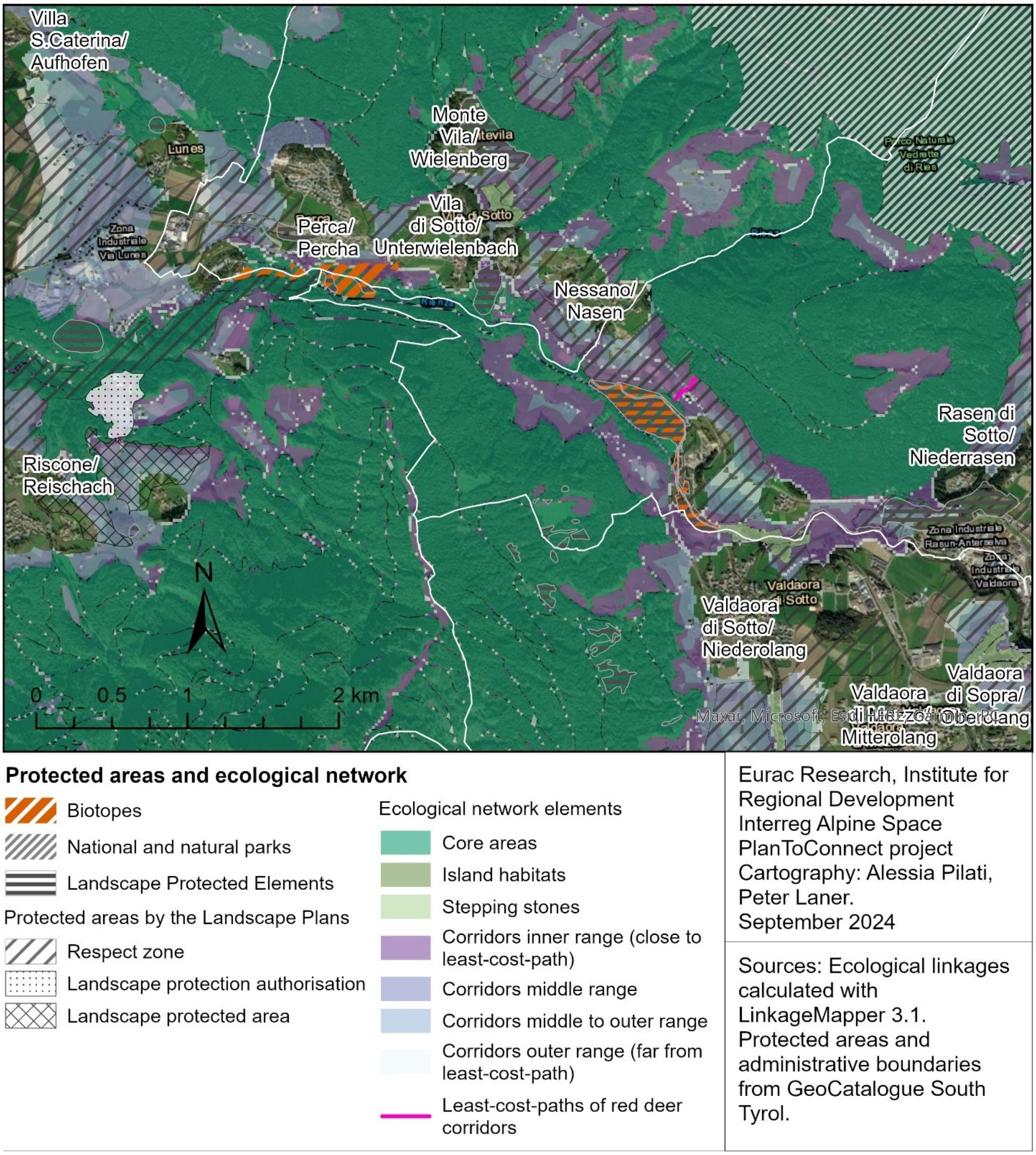



Figure 12: Protected areas and ecological network elements on the corridor Percha - Rasen-Antholz

### 4.2.2 Barriers and threats in focus corridor

The passage of the red deer across the valley is hindered mainly by cultivated areas, urbanized areas and the State Road. Although cultivated areas attract animals as a food source, particularly when natural forage is limited, these regions can serve as barriers for red deer. This is especially true for large monoculture fields with minimal tree cover or hedgerows that provide shelter, and where human presence is significant.

Between Rasen-Antholz and Percha, a major problem are animal-vehicle incidents on the State Road SS49, which is confirmed by a Kernel Density analysis of accidents from 2015 to 2020, visible on the map in Annex 2 – “Wildlife accidents - priority road sections”. This road section is one of the most dangerous areas in the whole province in terms of animal-vehicle collisions. Additionally, the gravel mill in the industrial zone “Strabit” is a major barrier for wildlife species in general and is reducing the corridor width. Most collisions happened between the gravel mill and the Nasen village.

The railway line could potentially be another transport barrier. It must be verifyed if the railway line is fenced. A railway tunnel is present between the area of Nasen and Unterwielenbach. However, existing scattered settlements on the northern side of the valley seems to hinder this wildlife passage. Data for railway accidents are not known at the moment and must be collected by the Transport Agnecy of South Tyrol (STA).

### 4.2.3 Evaluation of data analysis and priority areas for interventions

Verification of traffic flow:

According to the flow map of the provincial mobility plan 2023 (see Figure 13), the State Road SS49 apparently is used by more than 10.000 vehicles per day in the section between Bruneck and Olang. Even though more precise data must be checked, an international handbook on road ecology (IENE handbook “Biodiversity & Infrastructure: a Handbook for action”) states that the effect of such an amount of vehicles for most species is that the road is not permeable, and a very high death risk exists for them (see Table 9 in general recommendations). A wildlife underpass or overpass would be needed at the core-axis of the corridor. According to the IENE handbook, the focus for such road sections is to provide safe passages, and to fully separate wildlife and traffic.

Verification of corridor width:

The corridor at the main axis has a width of approx. 600 m, which corresponds to a regional corridor. The alternative between Bruneck and Percha corresponds also to a regional corridor, because of the width of more than 300 m. The alternative between Percha and Unterwielenbach has a width of about 130 m and is not appropriate. The alternative between Unterwielenbach and Nasen has a width of approx. 170 m and could constitute a local corridor. The alternative crossing section between the “Strabit” cave and Olang corresponds also to a regional corridor width of more than 300m.

Verification of bottlenecks:

A bottleneck is not present on the main axis of the corridor. The corridor has a length of approximately 200-300 meters from the two core areas and a width of approx. 600 m. The local corridor between Unterwielenbach and Nasen has a bottleneck of 80 m, which is still in an acceptable range for local corridors. The alternative between Bruneck and Percha has a bottleneck of 200 m, which is acceptable.

Priority areas for interventions:

1) The corridor at the main axis between Nasen and the “Strabit” cave
2) The alternative crossing section between the “Strabit” cave and Olang
3) The alternative between Bruneck and Percha
4) The alternative between Unterwielenbach and Nasen

# 5 Recommendations for possible connectivity measures

## 5.1 General recommendations

First of all, the red deer ecological network model should be complemented 1) by an analysis on species for higher altitudes (black grouse) and 2) by an analysis on pollinators to investigate options for network improvements in the valley bottoms on a more detailed level.

**Existing corridors:** Regarding the red deer model, site visits are necessary together with experts, for an expert evaluation of the functionality of so far classified "existing" corridors and those with a "questionable" functionality. With the elaborated red deer model, corridors number 1-22 should be maintained by spatial planning instruments. Recommendations from a spatial planning point of view will be provided in the next report.

A wildlife corridor for red deer should have green infrastructure elements like hedge rows and woody features. "*Dense planting on both outer edges of the corridor with a minimum width of ten meters is recommended for small corridor sections. These help to shield against external interference. Avoidance of disturbance factors like noise and light from outside"* is recommended according to Austrian handbooks (Leitner et al. 2022). Rectified rivers could be a potential barrier for wildlife passages. Riverbeds could be opened to reduce the water flow speed and naturalized to provide a possible passage.

Road barriers with more than 10.000 vehicles per day are widely existing on red deer corridors in South Tyrol (see Figure 13). Mitigation measures of road infrastructure should be implemented according to the following table:

Table 9: Relationship between road and rail traffic density and the risk for mortality and barrier effects on mammals

| Road Traffic intensity | Railway traffic intensity | Effect on permeability | Mitigation approach |
|---|---|---|---|
| < 1000 vehicles per day | < 100 trains per day | High permeability for most mammalian species, but smaller species may still experience mortality and barrier effect | Mitigation may not be required for larger wildlife, but smaller species may need special solutions |
| 1000 – 4000 vehicles per day | 100 – 200 trains per day | Reduced permeability for most species, increased mortality | Focus on accident prevention, smaller species may need special solutions |
| 4000 – 10000 vehicles per day | 200 – 400 trains per day | Limited permeability for most species, high death risks | Mitigation must balance barrier and mortality effects |
| > 10000 vehicles per day or fenced | > 400 trains per day or fenced | No permeability for most species, very high death risk | Focus on providing safe passages, fully separate wildlife and traffic |

Source: (Rosell 2023). IENE Biodiversity and infrastructure - Handbook.

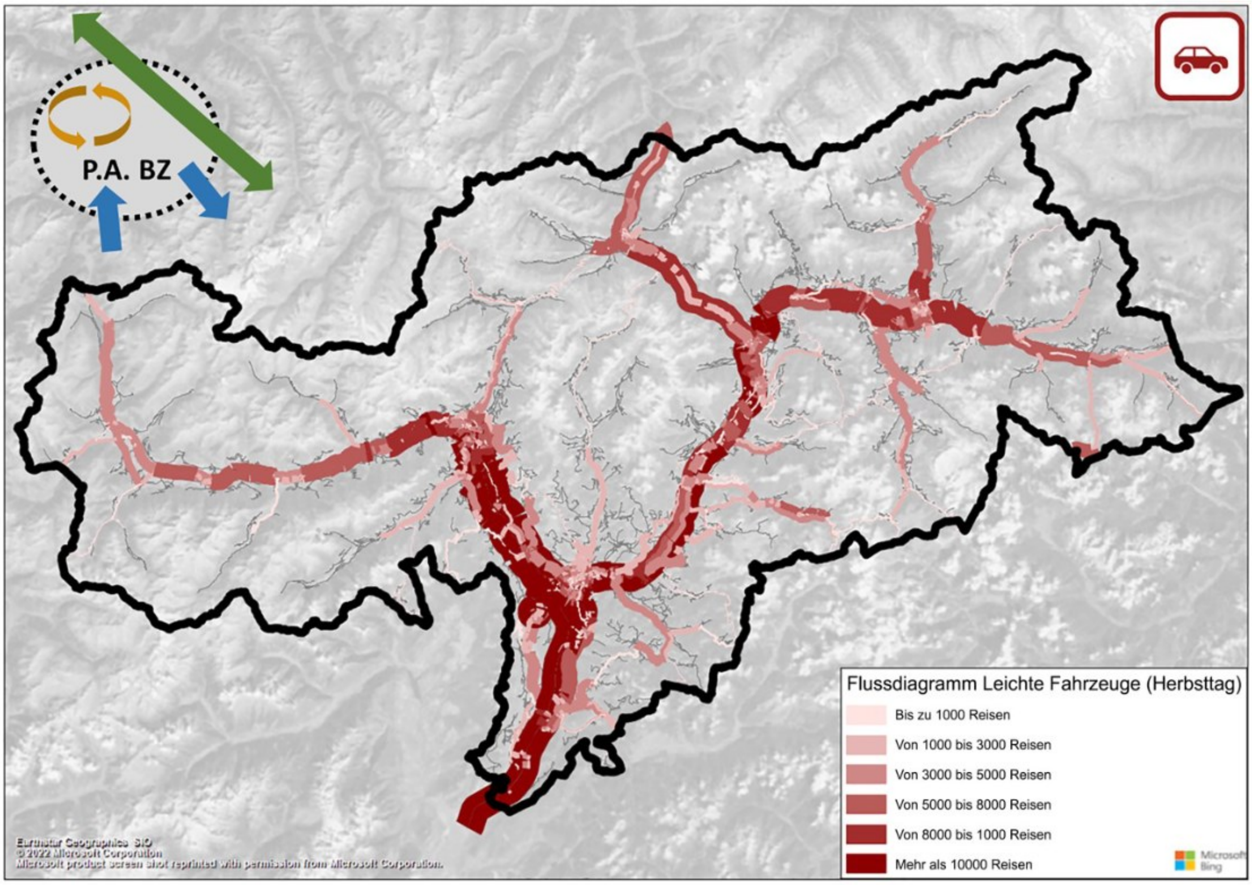


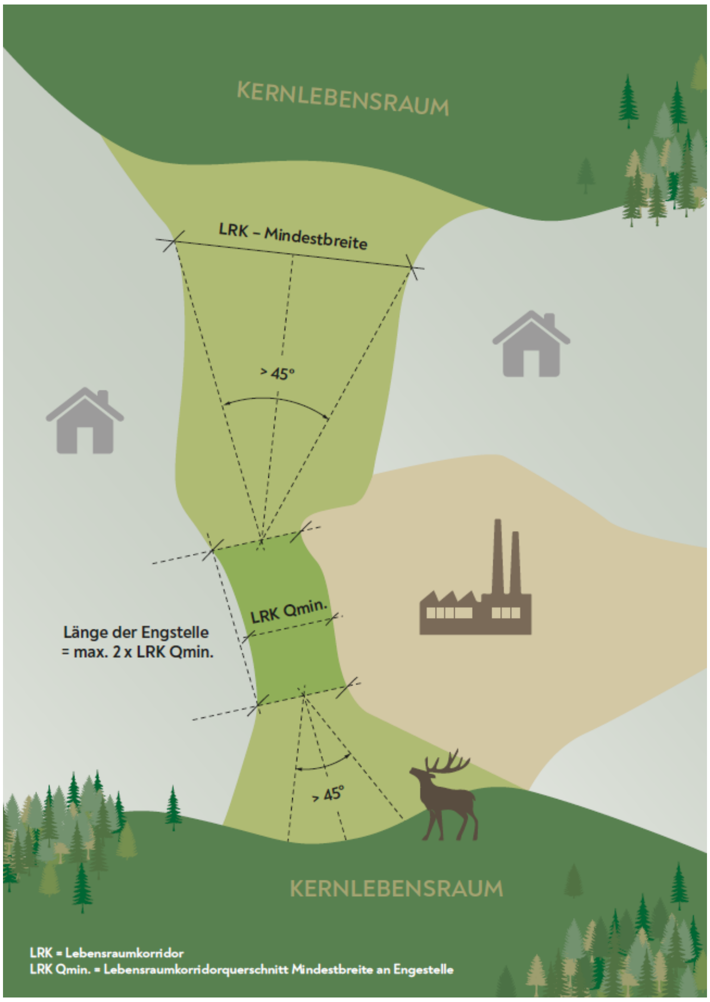

Figure 13: Car flow diagram of inter-municipal traffic in autumn on a working day

Source: Autonomous Province of South Tyrol (2023).

Recommendations for bottlenecks and width of wildlife corridors can be found in the Guidelines for the assessment of wildlife ecological permeability of habitat corridors of Austria (Leitner et al. 2022):

- *“Transregional corridors: They serve the migratory needs and genetic exchange of wild animals. In most cases, they are also used for seasonal migration and for moving between grazing areas and home ranges. The minimum width for supra-regional habitat corridors is 800 meters.“* (ibid.)
- *“Regional corridors: They are primarily used to find seasonally different habitats (e.g. sunny side vs. shady side). They are usually also used to move between grazing areas and home ranges. The minimum width is 300 meters.”* (ibid.)
- *Local corridors: These are used for frequent (daily) changes between grazing areas and home ranges. The minimum width is 150 meters* (ibid.)

*The respective habitat corridor bottleneck for corridors of local, regional and supra-regional importance must not be less than 25, 50 or 80 meters respectively.*




*The length of the minimum cross-section of the habitat corridor that is not reached, i.e. the length of the bottleneck, should not extend over more than twice the width of the bottleneck. Depending on the type of corridor, this would mean a maximum length of 50, 100 or 160 meters for the minimum width of the bottleneck.* (ibid.)

**Potential corridors:** Four corridors (see numbers 23 to 26) could be potentially established. In the macro-regional model, all of them resulted as highly important to establish a coherent alpine-wide ecological network. Three of them would cross the Adige Valley, which is one of the biggest barriers in the whole Alps. The most “realistic” one for restoration measures is probably corridor n°23 along the Töllgraben River between Parcines/Partschins and Lagundo/ Algund. In this case, a linear forest corridor should be established along the river with a width of at least 300 m, which would mean to widen the forest for approximately 120 m each side. Given that these areas are currently intensively cultivated with permanent crops, i.e. mostly apple orchards, it is quite unrealistic to implement, especially from a political point of view, unless the farmers are willing to sell their properties, and the provincial administration finds mechanisms to compensate the private owners. Furthermore, a wildlife underpass or overpass needs to be established on the State Road SS38 in the east of the dam wall Tel/ Töll of the Adige River.

Between Campo di Trens and Vipiteno the macro-regional model, hunters' observation and wildlife incidents indicate wildlife movements. The red deer model could not reveal a possible crossing in this area because the motorway bridges were not inserted, however they should be checked for a technical proposal of a wildlife crossing.

**Corridors with questioning functionality for wildlife crossings:** Four corridors were identified with questioning functionality. Those are the corridors n° 5 Naz-Sciaves – Rio di Pusteria, corridor n°10 Sluderno – Prato, corridor n° 14 Renon – Castelrotto – Laion, and corridor n°20/21 Renon – Sciliar. They are candidates for restoration measures and should be analysed with a higher priority because the macro-regional model is indicating their importance.

## 5.2 Recommendations for corridor 6 – "Percha - Rasen- Antholz":

We provide a list with possible recommendations from a nature protection perspective.

- Over - or underpass construction: To reduce frequent wildlife-vehicle collisions, construct wildlife overpasses or underpasses at key locations, based on movement patterns and traffic density. Generally, overpasses, are often preferred by larger animals like red deer because they provide a more open and natural environment. However, underpasses can also be effective, especially when they are designed to be spacious.
- Implement woody features: Establish native hedgerows along roads and railways to guide wildlife, providing shelter and improving connectivity through fragmented landscapes.
- Promote low - intensity agriculture: Encourage less intensive farming practices that maintain natural grasslands, avoiding permanent crops to support habitat connectivity for red deer and other species.
- On-site evaluation with wildlife experts: Conduct field evaluations to prove the identified critical crossing points and assess infrastructure and natural features that impact wildlife movement, especially for red deer.
- Monitor railway accidents: Set up a monitoring program to track wildlife - railway collisions and implement mitigation measures such as fencing or wildlife crossings where needed.

Recommendations from a planning point of view will be provided in technical proposal for ecological network improvements (coming soon).

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# ANNEXES

## Annex 1: Land use classifications of the EUSALP LULC map 2020

| Code | Description |
|---|---|
| 11000 | Imperviousness Layer > 50% density. Airports, Construcion sites, Mineralextraction and Greenhouses. The build-up areas adjacent to small farms will be included in this class. |
| 11100 | Buildings and its associated land together with artificial surfaced areas covers more than 30% of the total surface. Non-linear areas of vegetation and bare soil are exceptional. The average degree of soil sealing is high |
| 11200 | Low density urban fabric contains residential buildings, roads and other artificially surfaced areas. The vegetated areas are predominant, but the land is not dedicated to forestry or agriculture. The average degree of soil sealing is < 30% for the whole compound. |
| 11300 | This class is comprised of Buitup areas of the Imperviousness Layer and Buildings out of OpenStreet Map |
| 11400 | This class contains areas within settlements with no soil sealing (grass, very small green spaces between buildings) |
| 12100 | This class contains industrial, commercial and military units. The administrative border and associated areas, such as roads, sealed areas and vegetated areas are included, if these areas are below the MMU. It also contains public, military and private services. At least 30% of the ground is covered by artificial surfaces. More than 50% of those artificial surfaces are occupied by buildings and/or artificial structures with non-residential use, i.e. industrial, commercial or carriage related uses are dominant. The texture is homogenous with large buildings, car parks and sheds representing industrial or commercial complexes. Industrial or commercial units located in urban fabric are only taken into account if they are clearly distinguishable from residential areas. |
| 12210 | This class includes Motorways and Trunks and associated land created by an applied Buffer of 10m on OSM vectorlines. Tunnels where excluded. |
| 12220 | This class includes Primary and Secondary Roads and associated land created by an applied Buffer of 5m on OSM vectorlines Tunnels where excluded. |
| 12221 | This class includes Tertiary and Private and Unclassified Roads and associated land created by an applied Buffer of 3m on OSM vectorlines Tunnels where excluded. |
| 12230 | This class includes Traintracks (applied buffer 6m) and Tram- and Subwaytracks and associated land (applied buffer 3m) created by an applied buffer on OSM vectorlines. Tunnels where excluded. |
| 12240 | This class includes Tracks (grade 1-5) and bridleways and associated land created by an applied buffer of 3m on OSM vectorlines. Tunnels where excluded. |
| 14100 | All sports and leisure facilities including associated land, whether public or commercially managed. Public arenas for any kind of sports including associated green areas, parking places, etc. Usually near to human settlements. Vegetation is often planted and regularly worked by humans; strongly human-influenced. Public green areas such as gardens, zoos, parks, castle parks with predominantly recreational use and sporting facilities independent of being non-sealed, sealed or built-up, are entirely included on this category. OSM parks and recreational grounds. |
| 21000 | Arable Land is land under a rotation system used for annually harvested plants and fallow lands. The land is permanently or not irrigated. It includes cereals, oil seed plants, vegetables, beets, fodder and flooded crops such as rice and other inundated croplands. The PLOUGH High resolution layer (HRL) was assigned to this category |
| 21211 | Arable land with main crop: Common wheat |
| 21213 | Arable land with main crop: Barley |
| 21214 | Arable land with main crop: Rye |

| | |
|---|---|
| 21215 | Arable land with main crop: Oats |
| 21216 | Arable land with main crop: Maize |
| 21218 | Arable land with main crop: Triticale |
| 21219 | Arable land with main crop: Other cereals |
| 21221 | Arable land with main crop: Potatoes |
| 21222 | Arable land with main crop: Sugar beet |
| 21223 | Arable land with main crop: Other root crops |
| 21230 | Arable land with main crop: Other non permanent industrial crops |
| 21231 | Arable land with main crop: Sunflower |
| 21232 | Arable land with main crop: Rape and turnip rape |
| 21233 | Arable land with main crop: Soya |
| 21240 | Arable land with main crop: Dry pulses |
| 21250 | Arable land with main crop: Fodder crops (cereals and leguminous) |
| 21290 | Arable land with main crop: Bare arable land |
| 22000 | Permanent crops are surfaces that are not under a rotation system but last for many seasons and need not to be replanted after harvest. Included are ligneous crops of standard cultures for fruit production such as extensive fruit orchards, olive groves, chestnut groves, walnut groves, shrub orchards such as vineyards and some specific low-system orchard plantation, espaliers and climbers. In the case of irrigated permanent crops, the qualification of irrigation prevails over permanent, thus, all the irrigated permanent crops are classified as 2.1.1.0 Arable irrigated and non-irrigated land. |
| 22100 | Piece of land where grapes are grown. Only datasource OSM landuse |
| 22200 | Intentional planting of trees or shrubs maintained for food production, including orchards and similar plantations. Orchards usually comprise fruit or nut-producing trees grown for commercial production. Applies to fruit and berry gardens, generally synonymous with an orchard, but on a smaller scale and may emphasize berry shrubs in preference to fruit trees. Only datasource OSM landuse. |
| 23100 | Managed grasslands are considered intensively managed areas for the production of grass. From a land use point of view, in the case of these agricultural grasslands, grass is a crop in the same way as cereals or others. Managed grasslands could be divided into improved and semi-improved grasslands according to their management. --> An additional spatial model was used to identify these areas on all not better defined Herbaceous Vegetation (including HRL Grasslandlayer) 3 Conditions where applied Grassland below 1600m elevation, below 26° slope (usually threshold for mowing with tractor <50%). |
| 23200 | Semi-natural grasslands are areas where the herbaceous plants are natural but are created and maintained as permanent grasslands by less intensive agricultural activities. Here are also included marginal grasslands: abandoned crop invaded by grasses; areas near roads and other infrastructures; abandoned dumping sites, etc. --> An additional spatial model was used to identify these areas on all not better defined Herbaceous Vegetation (including HRL Grasslandlayer) 2 Conditions where applied Grassland below 2000m elevation, more than 26° slope (usually treshhold for mowing with tractor <50%). |

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| 31100 | Broadleaved forest: Vegetation formation composed principally of trees, including shrub and bush understoreys, where broadleaved species predominate and represent more than 75% of the pattern. |
| 31102 | Broadleaved forest: Vegetation formation composed principally of trees, including shrub and bush understoreys, where broadleaved species predominate and represent more than 75% of the pattern with a tree cover density 30-60% |
| 31103 | Broadleaved forest: Vegetation formation composed principally of trees, including shrub and bush understoreys, where broadleaved species predominate and represent more than 75% of the pattern with a tree cover density 60-100% |
| 31200 | Coniferous forest: Vegetation formation composed principally of trees, including shrub and bush understoreys, where coniferous species predominate and represent more than 75% of the pattern |
| 31202 | Coniferous forest: Vegetation formation composed principally of trees, including shrub and bush understoreys, where coniferous species predominate and represent more than 75% of the pattern with a tree cover density 30-60% |
| 31203 | Coniferous forest: Vegetation formation composed principally of trees, including shrub and bush understoreys, where coniferous species predominate and represent more than 75% of the pattern with a tree cover density 60-100% |
| 31300 | Mixed forest: Vegetation formation composed principally of trees, including shrub and bush understoreys, where neither broadleaved nor coniferous species predominate. The share of coniferous or broad-leaved species does not exceed 75% in the canopy closure. |
| 31400 | Trees for agricultural use (fruit trees) or trees within agricultural areas. |
| 31450 | Trees within urban areas (usually outside parks and green urban areas) |
| 31500 | Small woody landscape features are important vectors of biodiversity and provide information on fragmentation of habitats with a direct potential for restoration while also providing a link to hazard protection and green infrastructure, amongst others. Linear SWF: represent landscape features such as hedgerows or tree alignments that are defined by a compactness criterion less or equal to 0.75, up to 30m width and at least 50m length. They are only distinguished as separate attributes in the vector layer |
| 31600 | Patchy SWF: represent areas of isolated and scattered patches of trees or scrubs defined by a compactness criterion greater than 0.75, at least 10m width and with an area greater than 200m² and less than 5,000m². They are only distinguished as separate attributes in the vector layer |
| 31610 | Woody features that are neither linear nor patchy SWF, but which are connected to linear or patchy SWF and isolated woody features that are not linear nor patchy SWF, but which present an area above 1500m² (linear features wider than 30m, and out-of-specifications patches). |
| 32000 | Mix of small clusters of plants or single plants dispersed on a landscape that shows exposed soil or rock; scrub-filled clearings within dense forests that are clearly not taller than trees; examples: moderate to sparse cover of bushes, shrubs and tufts of grass, savannas with very sparse grasses, trees or other plants |
| 32100 | By Alpine and sub-alpine natural grassland we mean areas where the herbaceous plants are natural and Geographical limitations prevent other natural landcover. --> An additional spatial model was used to identify these areas on all not better defined Herbaceous Vegetation (including HRL Grasslandlayer) 3 Conditions where applied Grassland between 1600m and 2000m elevation, more than 26° slope (usually threshold for mowing with tractor <50%), and farther than 500m distant to access road. |
| 32200 | Areas with low and closed cover, dominated by brush, bushes and herbaceous vegetation or dwarf shrubs. They are mostly secondary ecosystems with unfavourable natural conditions. The field layer has a cover > 50 % and tree cover < 10 %. |

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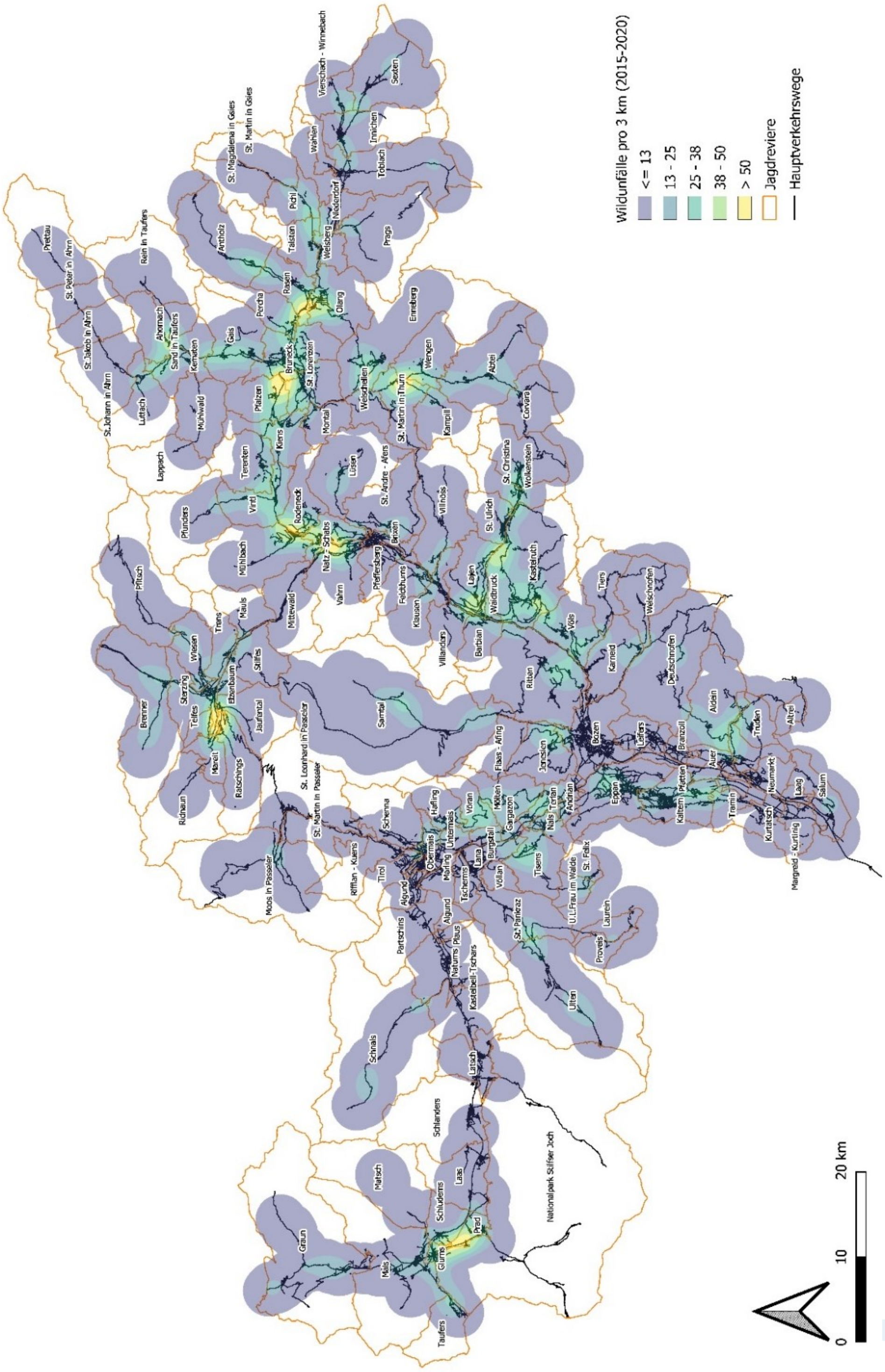
| 32300 | This class includes evergreen sclerophyllous bushes and scrubs, also includes maquis, garrigue and phrygana. It corresponds to CLC class 323 and characterized by hard, leathery, evergreen foliage that is adapted to prevent moisture loss. |
| 33100 | This class includes dunes (above the drift line that means above the high point of material deposited by water) as well as beaches (up to the drift line that means up to the high point of material deposited by water) with sand, gravel, shingle, pebbles or cobblestones along lakes, rivers or sea and also artificial “beaches” in urban areas. Trees or shrub should cover < 10%. The dunes and sand plains can be partly vegetated with grass. |
| 33200 | Bedrock outcrops and blocky areas with little or no high vegetation (< 10 %) but can be moss or lichen covered. |
| 33300 | Natural areas covered with little or no vegetation, including open thermophile formations of sandy or rocky grounds distributed on calcareous or siliceous soils frequently disturbed by erosion, sparsely vegetated areas of stones on steep slopes, screes, cliffs, rock fares, limestone pavements with plant communities colonising their tracks, beaches, sand dunes and plains, riverbanks, perpetual snow and ice, and burnt areas (other than forest areas). Sparsely vegetated areas have less than 50 % field cover (herb, grass and/or scrub) at the phenological mature stage and less than 10 % tree cover. Areas affected by recent fires, still mainly black, not in forest. |
| 33500 | Land covered by glaciers or permanent snowfields. |
| 41000 | Inland wetlands without a direct connection to the open ocean with significant content of water, which is influenced by a certain seasonal fluctuation. Permanent Wet areas out of Water and Wetness HRL |
| 51000 | Natural permanent and temporary lakes, including reservoirs. Included are also lakes with artificial origin in urban environments and lakes resulting from former extractive industries (gravel mining, open cast pit) after restoration. Ponds with completely man-made structure. Water reservoirs, especially in Mediterranean countries, used for irrigation and located in agricultural surroundings. This category includes ponds and water basins for industrial use/sewage not connected with building and other facilities as buildings and storage tanks. |
| 51100 | Natural stream of water that empties into another body of water or into the sea. Also water courses that cease to flow for part of the year, leaving a partially dry bed or water pools (EUNIS definition class C2.5) are included here. Different classes of temporary rivers are considered: snowmelt and glacier meltwater; perched and semi-perched alluvial; and karstic non-permanent streams. |

## Annex 2: Wildlife accidents - Priority road sections




Source: Hunter’s association South Tyrol

**Project of ecological network South Tyrol**

**Author(s)**
Peter Laner, (peter.laner@eurac.edu),
Vittoria Vettorazzo (vittoria.vettorazzo@eurac.edu)
Alessia Pilati, (alessia.pilati@eurac.edu)
Filippo Favilli, (filippo.favilli@eurac.edu),

Eurac Research – Institute for Regional Development

**Layout**
UIRS

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**Plan to Connect project partners:**

Urban Planning Institute of the Republic of Slovenia (SI)
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ALPARC – the Network of Alpine Protected Areas (FR)
Asters, organisation for the conservation of natural areas in Upper Savoy (FR)
Eurac Research (IT)
ifuplan - Institute for Environmental Planning and Spatial Development (DE)
University of Würzburg (DE)
Salzburg Institute for Regional Planning and Housing (AT)
E.C.O. Institute of Ecology Ltd. (AT)
Fondazione Politecnico di Milano (IT)