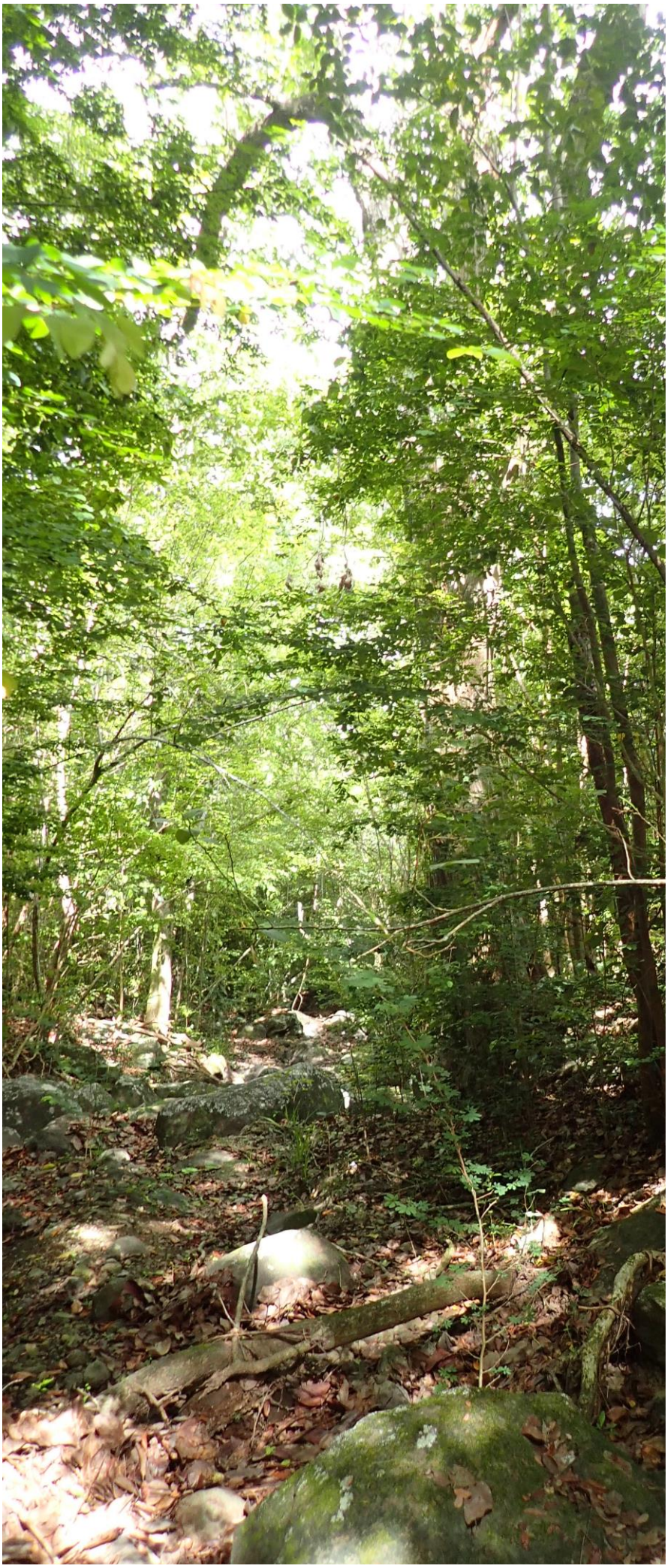

Research study on Ecological Network Restoration in Meuse-Rhine Euroregio

April 2020

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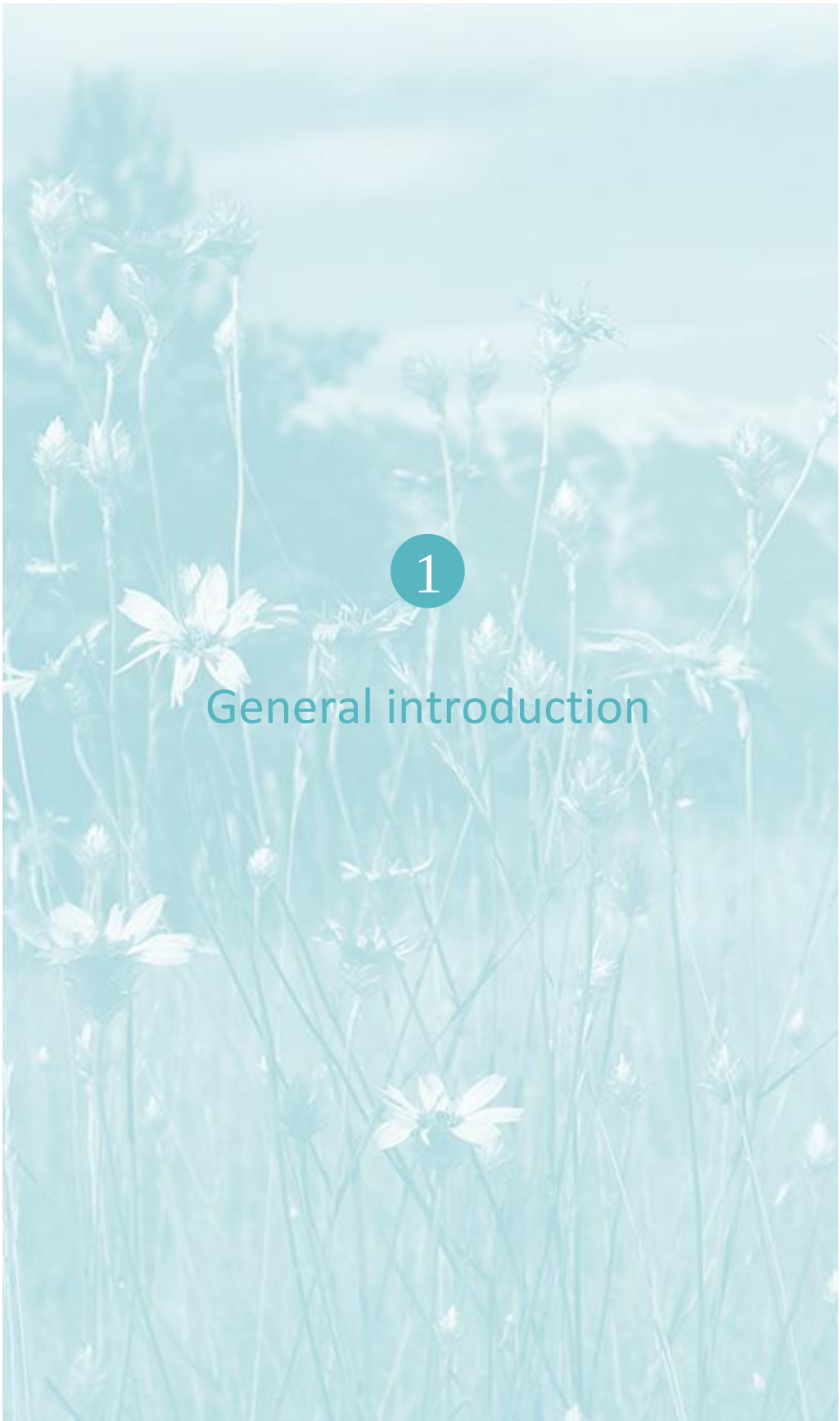


1

General introduction

1 General introduction

WWF Belgium is currently working to encourage the return of wildlife to one of the most fragmented landscape in Europe. To pursue this objective, WWF Belgium works on four iconic umbrella species: the wolf, the black grouse, the otter and the wildcat. The recent recovery of otter and wildcat populations is promising and is a sign that protective measures at the European scale can be successful.

The Meuse–Rhine Euroregion (hereafter, Euregio) is located between the cities of Aachen, Hasselt, Liège and Maastricht and encompasses 4 administrative units (The Netherlands, Germany and the Belgian Walloon and Flemish regions) (see figure 1). Due to intense industrial activities and high human population density, main threats to biodiversity include urbanization, agricultural intensification and industrial development.

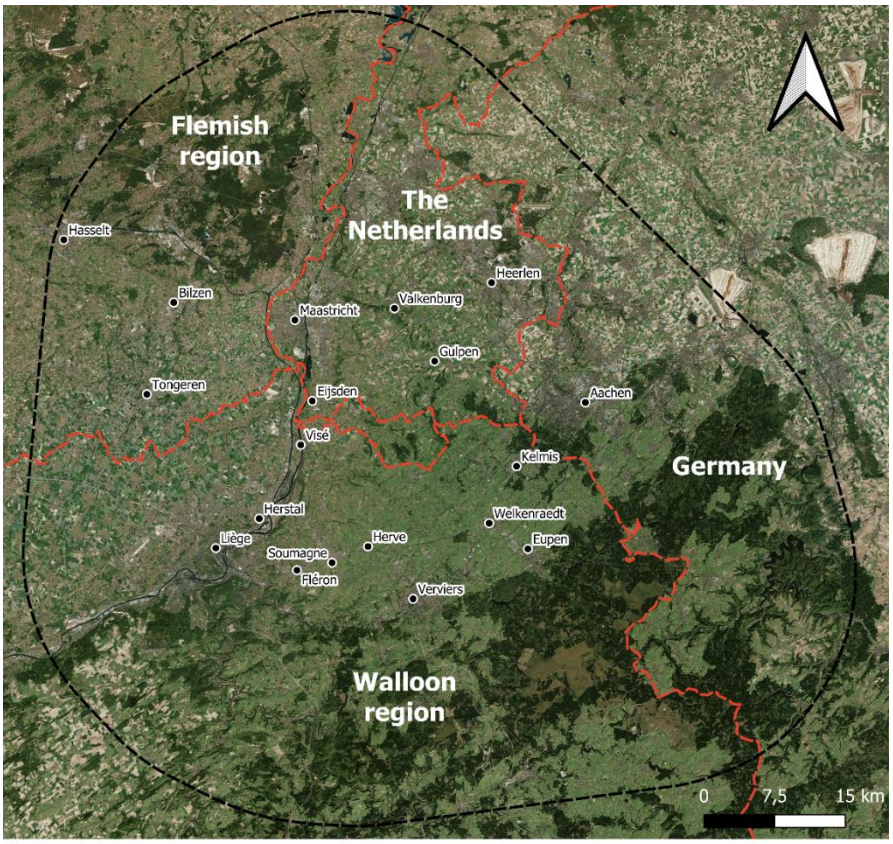


Figure 1: General map of the study region

1 General introduction

The Euregio is of crucial importance for large-scale connectivity of several iconic species and to connect animal populations from the Netherlands, Germany and Belgium. This is the case for the otter, for which the Meuse and its tributaries are projected to act as corridors for connecting Dutch and Ardenne populations (figure 2), and for the wildcat as the Euregio lies between the Hoge Kempen and Ardenne populations (figure 3).

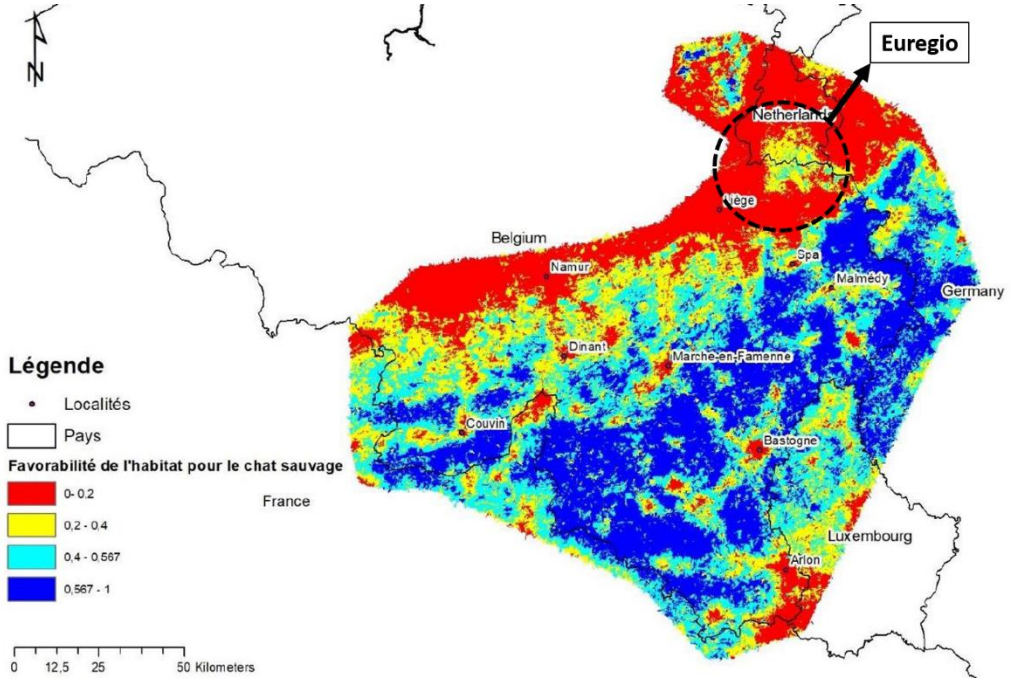


Figure 2: Suitable habitats for the wildcat in SE Belgium and neighbouring regions, showing the strategic position of the Euregio for this species (modified from Delangre et al., 2019)

1 General introduction

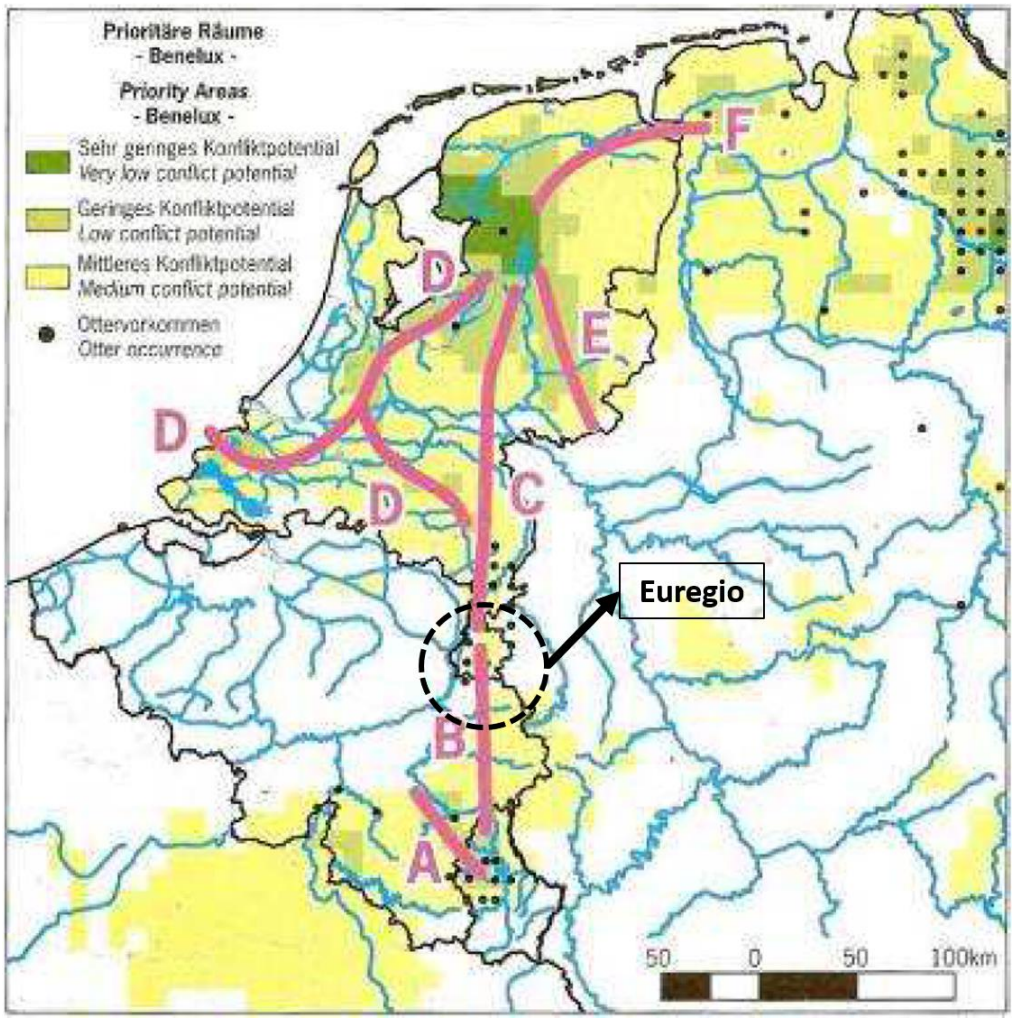


Figure 3: Projected recolonization routes for the otter in Western Europe (modified from Reuther & Krekemeyer, 2004)

Using the otter and the wildcat as examples, the general objectives of this study are to analyze the opportunities and obstacles for green and blue connectivity in the central part of Euregio. This study aims to (1) identify gaps where general landscape connectivity should be better protected and restored in the central part of Euregio, (2) which species of Community Interest could benefit from protection and restoration of landscape connectivity in this area and (3) define a catalogue of measures aiming at enhancing landscape connectivity.

WWF Belgium, together with Three Land Park Belgium, has pre-identified corridors on which the analyses should focus.

1 General introduction

The study mainly consisted in collecting and compiling cartographic information, bibliographic data, and the interview of stakeholders in order to identify in a cartographic way the areas presenting a deficit of protection and/or restoration in the defined of ecological corridors

1.1 General approach

The general approach applied in this study is summarized in figure 4 and is further described in the next pages.

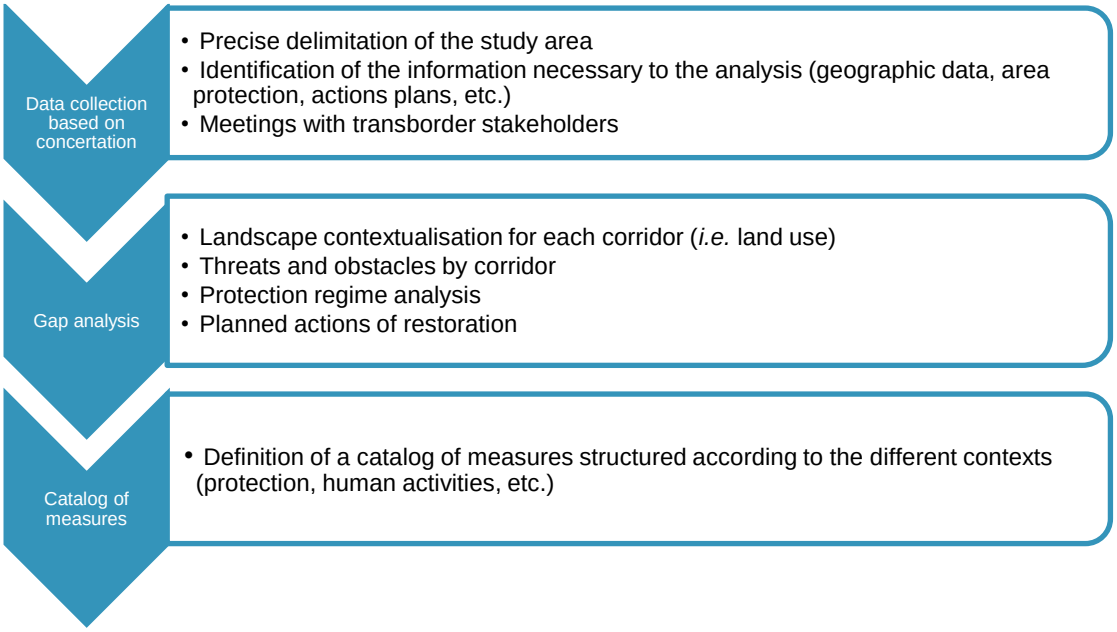


Figure 4: General approach of the study

1.1.1 Data collection based on meeting with stakeholders in the different administrative regions

Biotope Environnement took part to a workshop organized by the Three Land Park (3LP in the rest of the document) held in Eupen on 6th March 2020. It provided the opportunity to meet with stakeholders from each administrative regions (Wallonia, Flanders, the Netherlands and Germany).

The discussions held during this meeting allowed us to ensure the match between our methodology and conservation expectations from the stakeholders.

Following this meeting, an important amount of information was provided by some of the stakeholders, regarding :

a. “Nature zones”: Natura 2000, natural reserves, as well as other sites of biological interest with or without a legal protection status ;
b. Focal species: species of Community interest general presence and possibly for which action plans have been defined, with a particular focus on the otter and the wildcat ;
c. Land use: useful to characterize the ecological context in each country ;
d. Previous studies about the ecological network in Euregio.

1.1.2 Definition of the ecological network and gap analysis

The first step was to spatially define the ecological network based on the recommendations of WWF and previous studies in Euregio. The backbone of the ecological network in Euregio was based on the river network and terrestrial connections between main valleys. Given the short time of execution of the mission, only readily available geodata were used and analyzed in the open-source software QGIS. We then summarized collected information about nature protection, conservation and restoration in each country.

Through a combination of geoprocessing analyses and photointerpretation, we conducted three main “gap” analyses (*i.e.* identify areas where a feature of interest is lacking) in the previously defined corridors regarding :

a. The identification of the dominant land use in each corridor and main obstacles or threats to the movements of otter and wildcat (provided land use with a satisfactory precision level was available);
b. Legal protection of nature areas;
c. The planned conservation and restoration actions.

1.1.3 Selection of appropriate measures in relation with the corridors context

Based on information collected through step 2, we proposed a catalogue of measures to tackle main obstacles that have negative impacts on otter and wildcat connectivity. The measures will be selected based on the experience accumulated by Biotope Environnement and will not be precisely located on maps as this is beyond the scope of this study.

2

Ecological network and land use

This section aims at providing general information about the ecological network in the study region and the procedure that lead to the selection of ecological corridors used for subsequent analyses. We then provide a soil occupancy analysis showing the landscape context (i.e. dominant soil occupancy types) and major barriers to wildlife movement on the blue and green infrastructures, for each corridor separately.

1 Methods

1.1 Corridor selection

The ecological network presented in this report has been constructed based on (1) the information provided by WWF, (2) exchange with 3LP, and (3) previous studies identifying the ecological network in Euregio.

The network includes elements of the blue and green continuities, and more specifically:

- Major elements of the river network;
- Terrestrial connections between main valleys in the study area.

Once important landscape features have been selected, we created a buffer area of 1 km around these linear elements. This resulted in a global network of 2km-wide corridors which we then split into spatially coherent elements (e.g. a specific valley or a connection between valleys). Based on this method, we identified 14 corridors/sections for which land use and the legal protection regime is analyzed. Each corridor received a numeric code (from 1 to 14) which we will refer to throughout this report. Codes are presented in Table 1 and figure 5 shows the map of the selected corridors.

Table 1: Summary of the selected corridors

Code	Name	Approx. length
1	Vesdre valley	42 km
2	Osthertogenwald - Kelmis	9 km
3	Gueule valley	40 km
4	South of Aachen	13.5 km
5	Connection between Vesdre, Gulp and Berwinne valleys	4.5 km
6	Gulp valley	17.5 km
7	Berwinne valley	15 km
8	Remersdaal - Eijsden - Visé	15 km
9	East Maastricht	8 km
10	Connection between Vesdre and Bolland valleys	8 km
11	Bolland valley	16 km

2 Ecological network and land use

12	Meuse upstream Visé	41 km
13	Meuse downstream Visé	55 km
14	Meuse to Mechelse Heide en valley from Ziepbeek	4 km

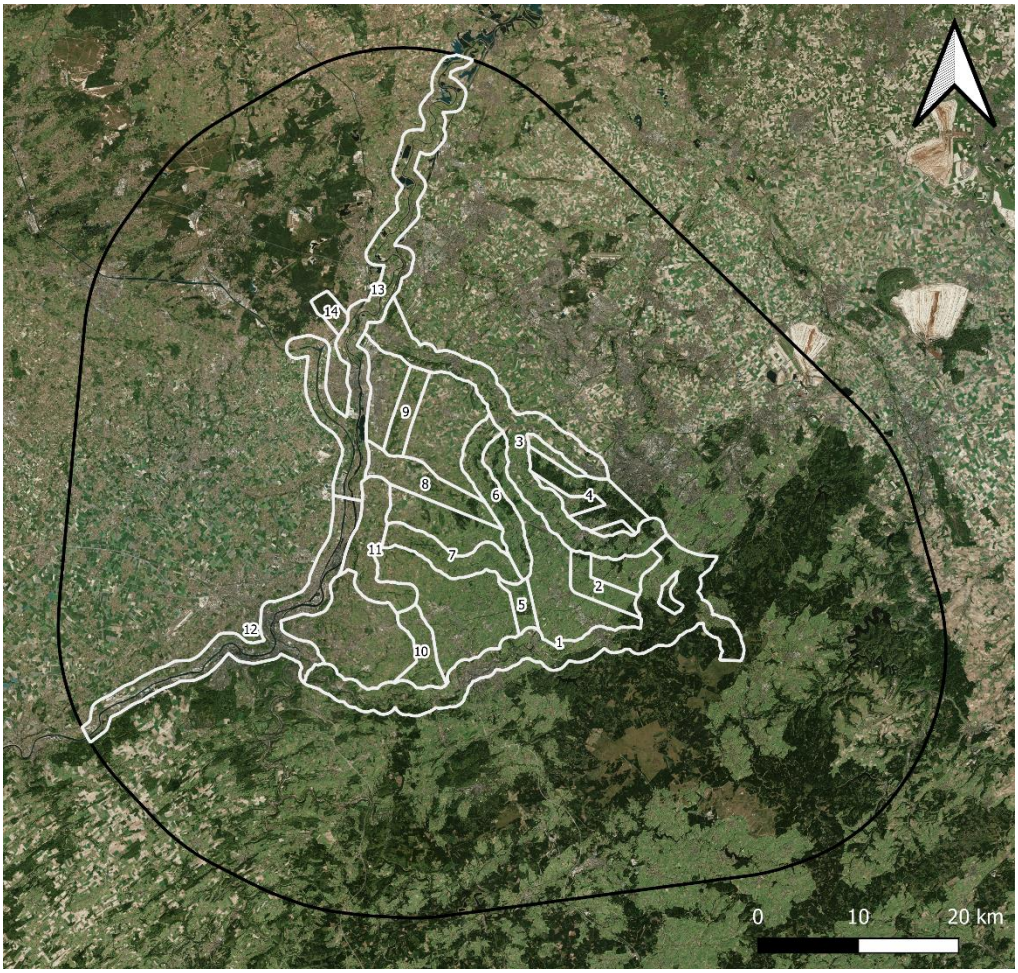


Figure 5: Selected corridors within the central part of the Euregio

1.2 Land use analysis

We characterized land use within each corridor based on a beta version of the Ecotope database (V2.10) provided by Julien Radoux (UCLouvain, Belgium) and developed within the framework of Lifewatch (http://lifewatch.be/). Its aim is to provide ecological data for biodiversity research and is available for all administrative units considered in the study. The spatial unit is the ecotope, a small polygon with largely homogeneous ecological functions. Ecotopes are based on automated delineation

taking remote sensing data and topography as input variables. More details on the methods are available in this paper (Radoux et al., 2019). The V2.10 validation has not been published but a point-based accuracy assessment was performed on the input land cover data, revealing a 94.5 percent overall accuracy (2015). More details in this technical report. While ecotopes are mapped at a coarser resolution than other datasets available in each administrative unit, they offer data of homogeneous quality and they are more readily usable at the spatial scale of the project.

Table 2 shows all land use categories mapped in the ecological network.

Table 2: List of the land use types in the ecological network

Permanent monospecific graminoids
Broadleaved trees
Mixture with plowed land
Densely artificialised area
Plowed land
Sparsely artificialised area
Non plowed land with trees
Trees with other vegetation
Needleleaved tree
Mixed forest
Plowed land with other vegetation
Permanent water
Sparse vegetation
Diversified grassland
Recently disturbed forest vegetation
Inundated grassland and shrubs
Permanent bare soil

We also mapped major roads and railways (*i.e.* high-speed railways) as barriers to animal movement based on available cartographic data and photointerpretation. Note that we did not considered “regular” railways as major barriers as they are generally not fenced and tend to be surrounded by natural vegetation. Consequently, they are rather permeable to most animal movement.

2 Results

A complete summary of the land use for each individual corridor of the network is provided in Table 3. An overview of the land use (and major barriers) within the entire network is shown in figure 6. Overall, the five land use categories mostly encountered

along the corridors of the network are (1) permanent monospecific graminoids ; (2) broadleaved forests ; (3) agricultural lands mixed with other soil occupancy ; (4) densely artificialized areas ; and (5) plowed land. For each corridor, we also provide the following information:

- General characteristics (localization, approximative length of the corridor) ;
- The dominant land use type, obtained by grouping 10 land use types into 3 broader categories: agricultural areas (permanent monospecific graminoids; plowed land; mixture with plowed land; plowed land with other vegetation), woodlands and related habitats (broadleaved trees; trees with other vegetation; needleleaved tree; mixed forest), urban and artificialized areas (densely and sparsely artificialized areas) ;
- If different from the dominant land use type, the importance of forested elements ;
- If different from the dominant land use type, the importance of artificialized surfaces ;
- A list of identified barriers to wildlife movement (bottlenecks) ;
- A map of the land use for each corridor. For the ease of visualization, we did not include the land use legend on individual maps. Please, refer to figure 6.

2 Ecological network and land use

Table 3: Land use by corridor

Land use type	1 Vesdre valley	2 Osthertogenwald - Kelmis	3 Gueule valley	4 South of Aachen	5 Connection between Vesdre, Gulp and Berwinne valleys	6 Gulp valley	7 Berwinne valley	8 Remersdaal - Eijsden - Visé	9 East Maastricht	10 Connection between Vesdre and Bolland valleys	11 Bolland valley	12 Meuse upstream Visé	13 Meuse downstream Visé	14 Meuse to Mechelse Heide en valley from Ziepbeek
Permanent monospecific graminoids	21,5%	56,7%	29,5%	12,3%	63,2%	38,7%	61,4%	34,6%	18,7%	64,1%	38,7%	12,0%	22,5%	9,4%
Broadleaved trees	20,9%	2,6%	15,2%	54,7%	11,1%	17,7%	3,0%	13,8%	29,2%	2,1%	8,0%	17,8%	8,7%	21,5%
Mixture with plowed land	1,3%	3,5%	12,7%	2,0%	6,4%	8,1%	6,5%	18,3%	17,2%	6,7%	13,7%	2,0%	13,9%	0,0%
Densely artificialised area	5,2%	0,0%	6,7%	0,2%	0,0%	0,4%	0,6%	3,5%	3,8%	2,0%	1,4%	25,8%	11,1%	5,3%
Plowed land	0,4%	2,2%	9,6%	1,4%	7,7%	9,2%	7,9%	13,0%	11,7%	4,1%	13,9%	2,6%	16,9%	0,1%
Sparsely artificialised area	6,1%	1,4%	5,1%	2,1%	3,1%	2,1%	1,7%	1,5%	1,4%	5,4%	9,3%	26,1%	6,3%	5,9%
Non plowed land with trees	7,4%	17,8%	10,6%	6,1%	4,0%	11,3%	10,4%	6,8%	7,4%	10,4%	9,9%	1,4%	2,6%	3,9%
Trees with other vegetation	7,8%	2,3%	5,7%	5,0%	2,0%	8,2%	4,9%	2,4%	5,0%	4,0%	2,1%	3,1%	1,6%	6,5%
Needleleaved tree	19,2%	0,0%	0,0%	0,9%	0,0%	0,0%	0,1%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	11,8%
Mixed forest	8,1%	10,7%	3,0%	15,1%	0,0%	1,5%	0,0%	0,0%	0,0%	0,0%	0,0%	0,1%	0,0%	32,3%
Plowed land with other vegetation	0,3%	2,7%	1,9%	0,3%	1,9%	2,8%	3,3%	6,1%	4,5%	1,2%	2,9%	0,9%	6,6%	1,1%
Permanent water	0,7%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	6,5%	8,8%	0,1%
Sparse vegetation	0,2%	0,0%	0,0%	0,0%	0,5%	0,0%	0,0%	0,0%	0,9%	0,0%	0,0%	1,3%	0,3%	0,4%
Diversified grassland	0,5%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,5%	1,7%
Recently disturbed forest vegetation	0,3%	0,2%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,1%	0,1%	0,0%
Inundated grassland and shrubs	0,1%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Permanent bare soil	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%

2 Ecological network and land use

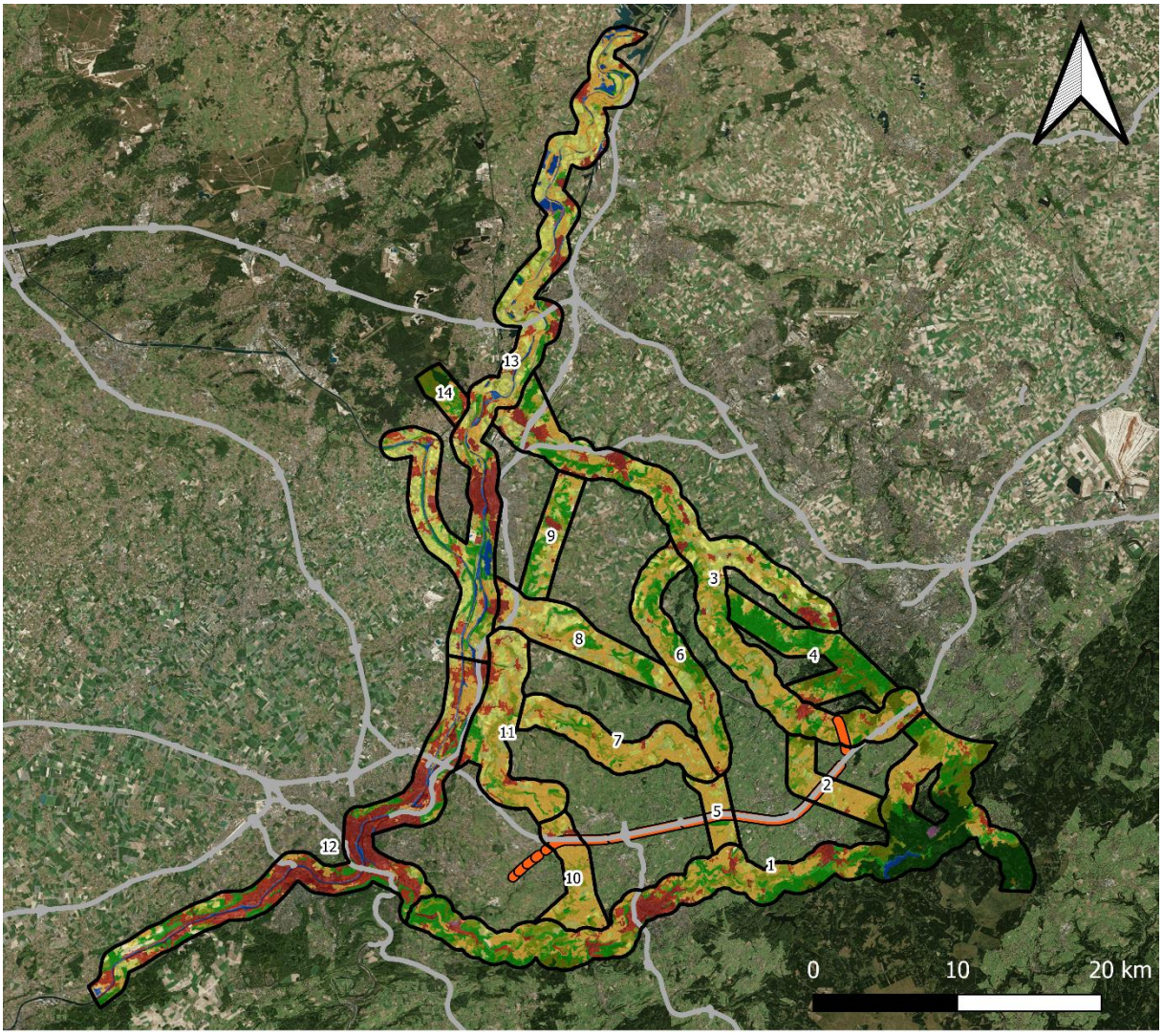
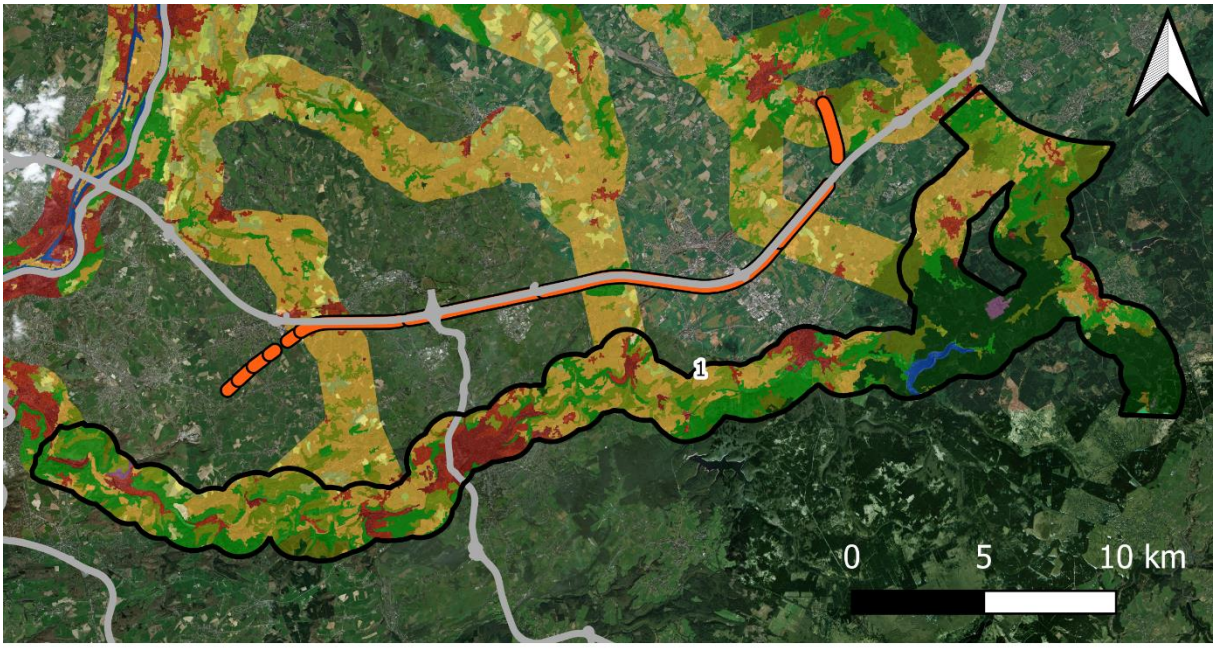


Figure 6: Overview of the land use and main barriers within the ecological network

2 Ecological network and land use

3.1 Vesdre valley

Localisation within the ecological network
Southern part of the network; along an East-West axis. The valley is steeper along the Vesdre in the western part of the section (doswnstream of Verviers).
Approximate length
Approximately 42 km long
Dominant land use type
Woodlands and forested habitats: ca. 56% of the total surface
Urban and artificial areas
11% of the corridor is classified as artificialized. The two largest cities found along the Vesdre are Verviers and Eupen. They both occupy a large portion of the corridor defined along the Vesdre. Verviers occupies approximately 5 km along the corridors, is densely artificialized and occupies both sides of the river, which might reduce connectivity for species moving along the river.
Important features impeding animal movements
YES / NO
A large dam lies along the Vesdre upstream Eupen. The surroundings are densely forested, but the connectivity for species moving along the river might be reduced. Yet the E42 highway goes through the corridor, the densely built-up area around Verviers is expected to be the main barrier for animal movement in this corridor.

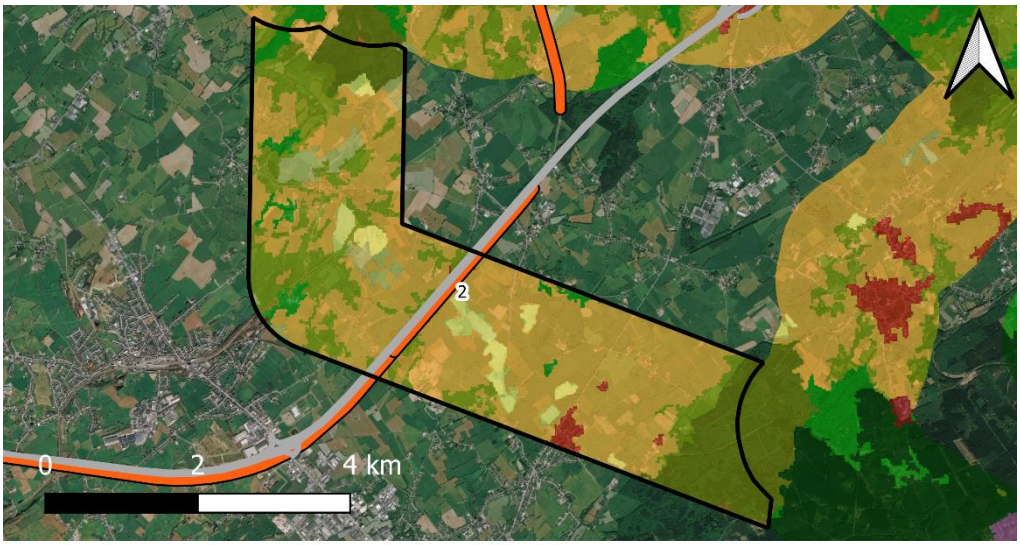


Sources : beta versions of ecotopes : LifeWatch ; aerial pictures : Bing ; Map creation : Biotope Environnement, 2020

Figure 7: Land use in the Vesdre valley

3.2 Osthertogenwald – Kelmis

Localisation within the ecological network
Southern part of the network; along an NW-SE axis
Approximate length
Approximately 9 km long
Dominant land use type
Agricultural areas: ca. 65% of the total surface
Importance of woodlands and other types of forested habitats
Approximately 16% of the corridor mainly located at the Northern and Southern edges of the corridor. A fairly dense network of hedgerows and trees (bocage) is present North of the highway/railway, but is far less developed in the Southern part.
Urban and artificial areas
1.5% of the corridor is classified as artificialized, which include the section of highway/railway
Important features impeding animal movements
YES / NO
The E40 highway and a high-speed railway cut the corridor in the middle and there are few opportunities for wildlife to cross these infrastructures: we identified 2 under- or overpasses that could be adapted to serve as wildlife passes.

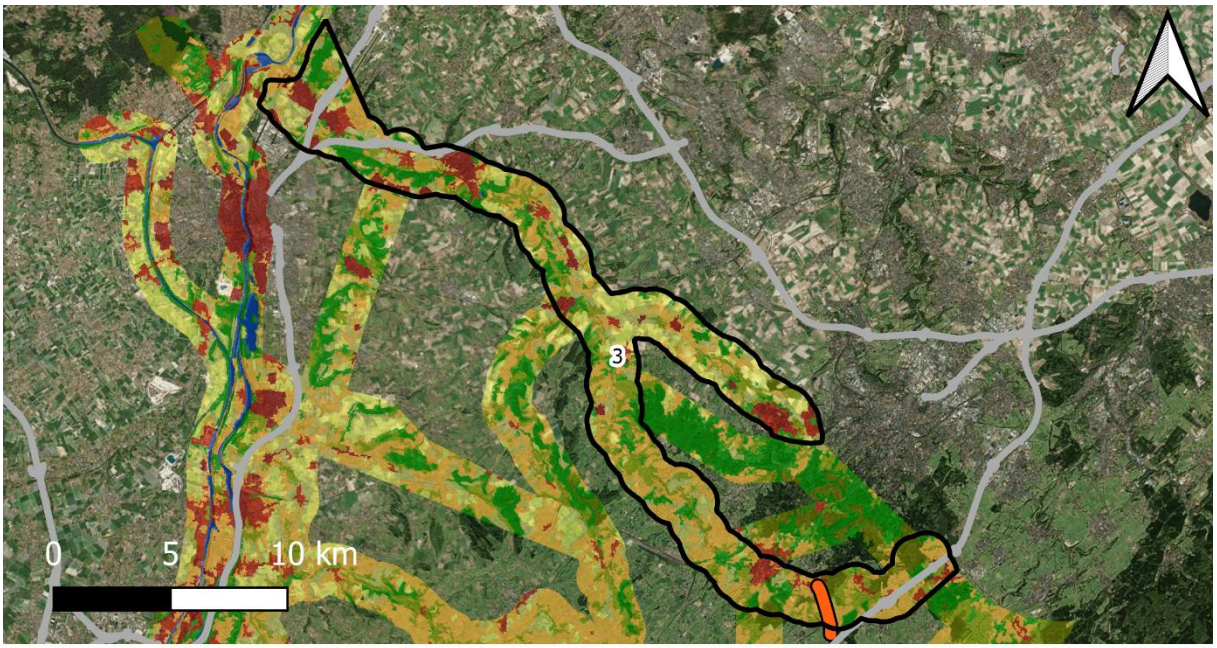


Sources : beta versions of ecotopes : LifeWatch ; aerial pictures : Bing ; Map creation : Biotope Environnement, 2020

Figure 8: Land use in the "Osthertogenwald – Kelmis" corridor

3.3 Gueule valley

Localisation within the ecological network
Eastern part of the network; along an NW-SE axis
Approximate length
Approximately 40 km long
Dominant land use type
Agricultural areas: ca. 54% of the total surface
Importance of woodlands and other types of forested habitats
Approximately 24% of the corridor
Urban and artificial areas
12% of the corridor is classified as artificialized. Urbanization is locally important close to the cities of Kelmis, Vaals and at the NW edge (between Valkenburg and Bunde).
Important features impeding animal movements
YES / NO
3 major highways (2 located at the NW edge and 1 at the SE edge) and a high-speed railway (SE edge), all of which offer very few opportunities for animal crossing. 2 underpasses could be adapted to serve as wildlife passes. Additionally, an ecoduct is located on the A2 highway (East of the village of Bunde).

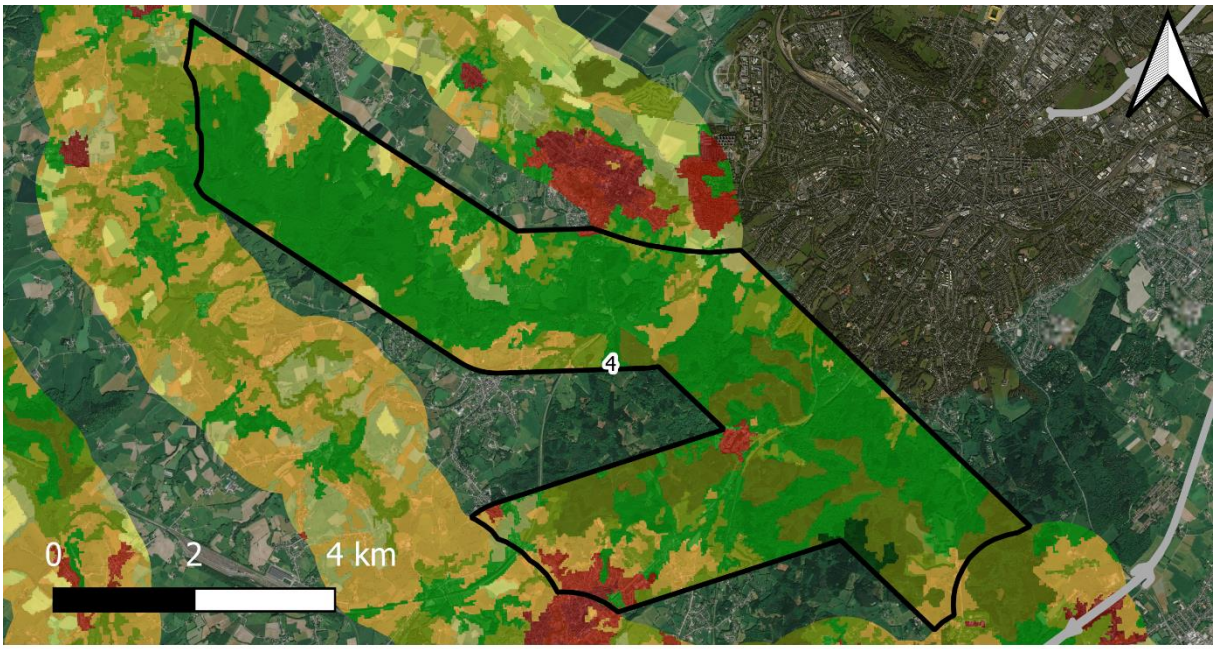


Sources : beta versions of ecotopes : LifeWatch ; aerial pictures : Bing ; Map creation : Biotope Environnement, 2020

Figure 9: Land use in the Gueule valley

3.4 South of Aachen

Localisation within the ecological network
Eastern part of the network; along an NW-SE axis
Approximate length
Approximately 13.5 km long
Dominant land use type
Woodlands and forested habitats: ca. 76% of the total surface
Urban and artificial areas
2% of the corridor is classified as artificialized, clustered in the Southern part of the corridor, close to the town of Kelmis
Important features impeding animal movements
YES / **NO**

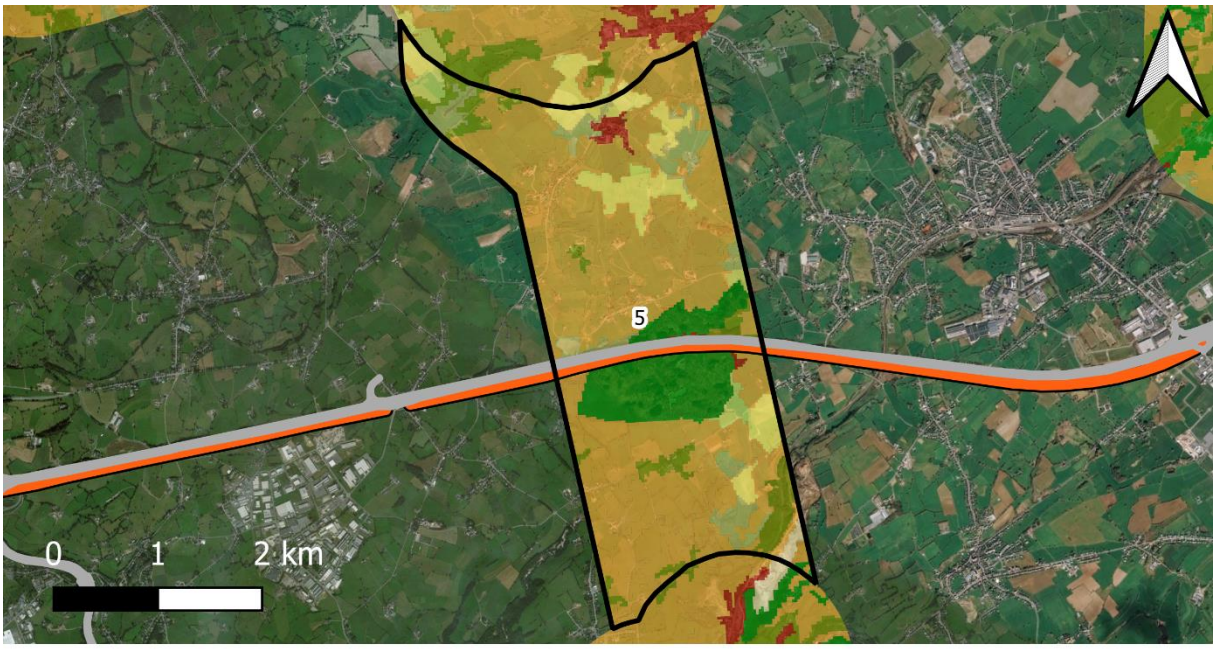


Sources : beta versions of ecotopes : LifeWatch ; aerial pictures : Bing ; Map creation : Biotope Environnement, 2020

Figure 10: Land use in the "South of Aachen" corridor

3.5 Connection between Vesdre, Gulp and Berwinne valleys

Localisation within the ecological network
Southern part of the network; along an North-South axis
Approximate length
Approximately 4.5 km long
Dominant land use type
Agricultural areas: ca. 80% of the total surface
Importance of woodlands and other types of forested habitats
Approximately 13% of the corridor, mainly in the central part of the corridor.
Urban and artificial areas
3% of the corridor is classified as artificialized, which include the section of highway/railway
Important features impeding animal movements
YES / NO
The E40 highway and a high-speed railway cut this corridor in the middle, but an ecoduct is present which helps connecting forest patches on each side. This ecoduct makes this section of the ecological network important as it allows the crossing of the highway/railway otherwise almost impermeable.

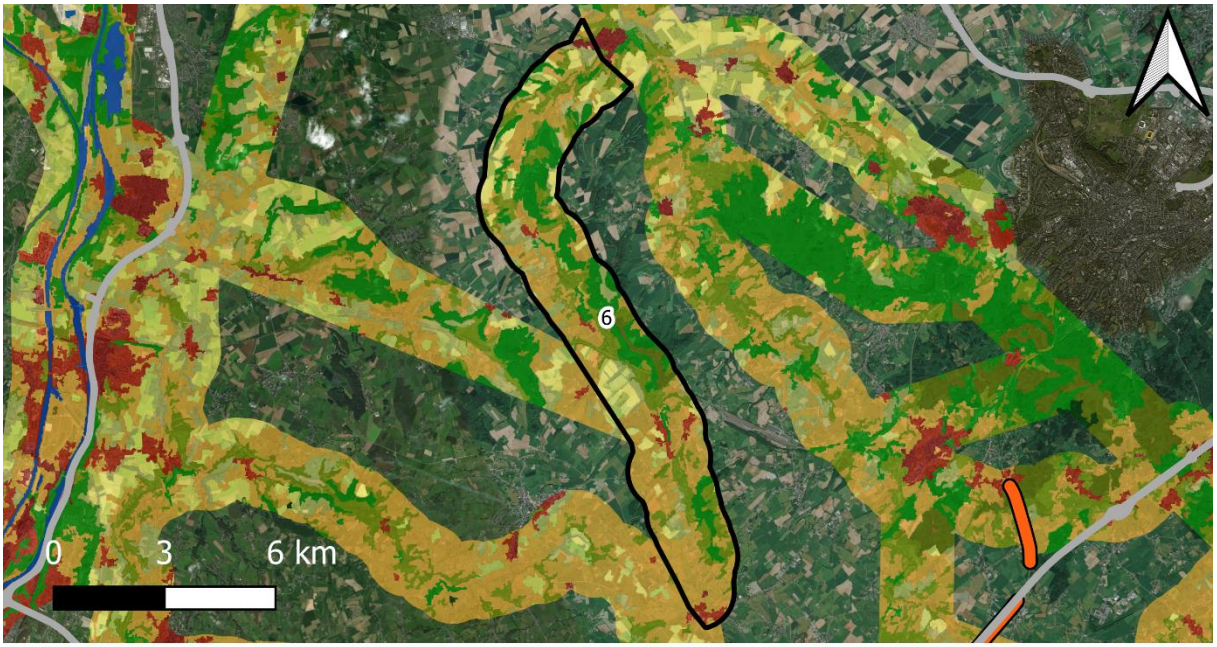


Sources : beta versions of ecotopes : LifeWatch ; aerial pictures : Bing ; Map creation : Biotope Environnement, 2020

Figure 11: Land use in the "Connection between Vesdre, Gulp and Berwinne valleys" corridor

3.6 Gulp valley

Localisation within the ecological network
Central part of the network; along an North-South axis
Approximate length
Approximately 17.5 km long
Dominant land use type
Agricultural areas: ca. 59% of the total surface
Importance of woodlands and other types of forested habitats
Approximately 28% of the total surface; hedgerows, small woodlots and isolated trees also contribute to the network in agricultural areas, but mainly so in the Southern part of the corridor
Urban and artificial areas
2.5% of the corridor is classified as artificialized
Important features impeding animal movements
YES / **NO**

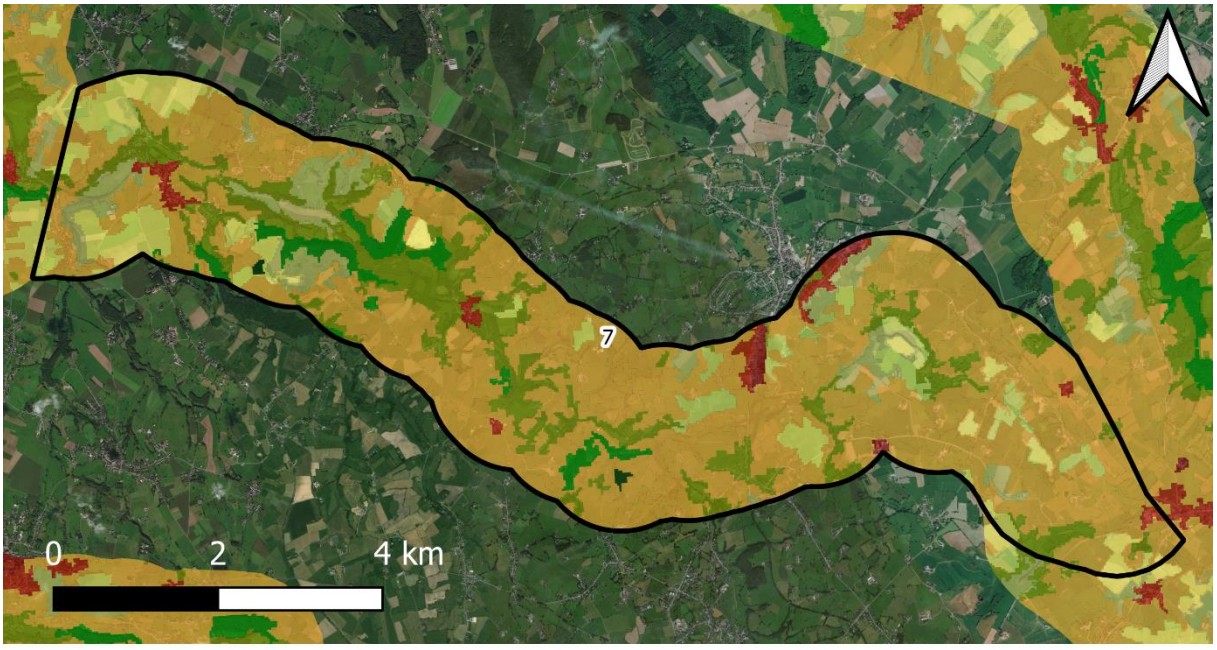


Sources : beta versions of ecotopes : LifeWatch ; aerial pictures : Bing ; Map creation : Biotope Environnement, 2020

Figure 12: Land use in the gulp valley

3.7 Berwinne valley

Localisation within the ecological network
Central part of the network; along an East-West axis
Approximate length
Approximately 15 km long
Dominant land use type
Agricultural areas: ca. 80% of the total surface
Importance of woodlands and other types of forested habitats
Approximately 8% of the total surface; hedgerows, orchards and isolated trees also contribute to the network in agricultural areas (i.e. bocage)
Urban and artificial areas
2% of the corridor is classified as artificialized
Important features impeding animal movements
YES / **NO**

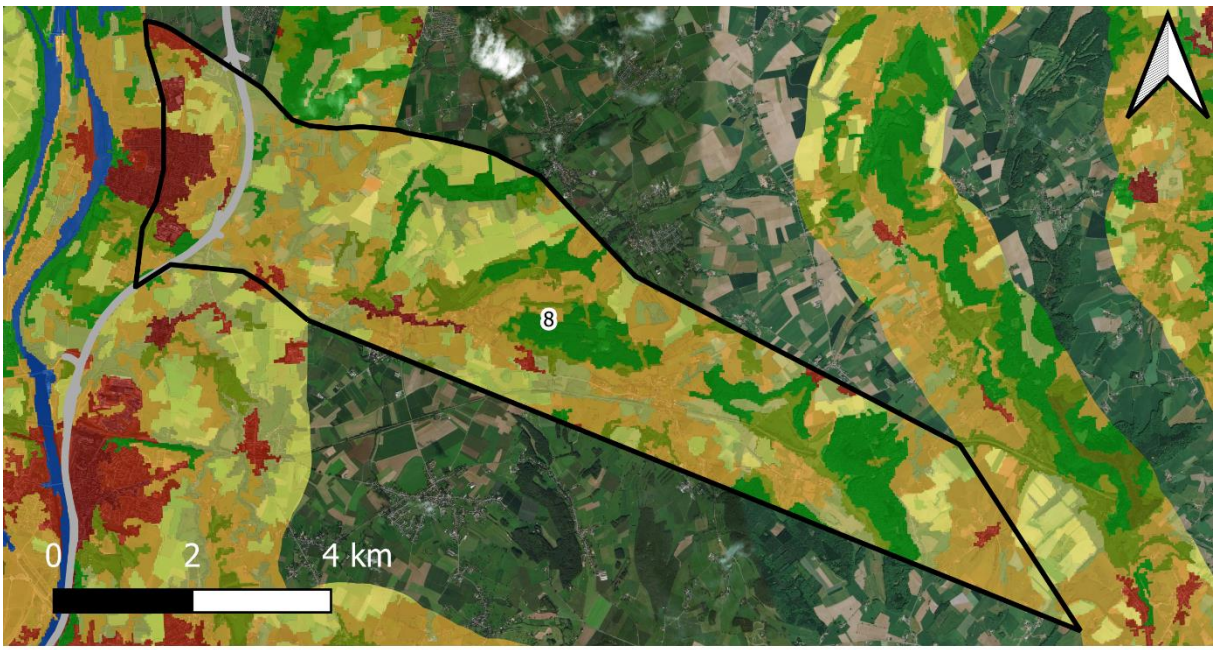


Sources : beta versions of ecotopes : LifeWatch ; aerial pictures : Bing ; Map creation : Biotope Environnement, 2020

Figure 13: Land use in the Berwinne valley

3.8 Remersdaal - Eijsden - Visé

Localisation within the ecological network
Central part of the network; along an NW-SE axis
Approximate length
Approximately 15 km long
Dominant land use type
Agricultural areas: ca. 72% of the total surface
Importance of woodlands and other types of forested habitats
Approximately 17% of the total surface
Urban and artificial areas
5% of the corridor is classified as artificialized, mainly around the village of Eijsden
Important features impeding animal movements
YES / NO
The A2 highway runs near the city of Eijsden and an existing underpass (Southern edge) could be adapted to serve as wildlife pass.

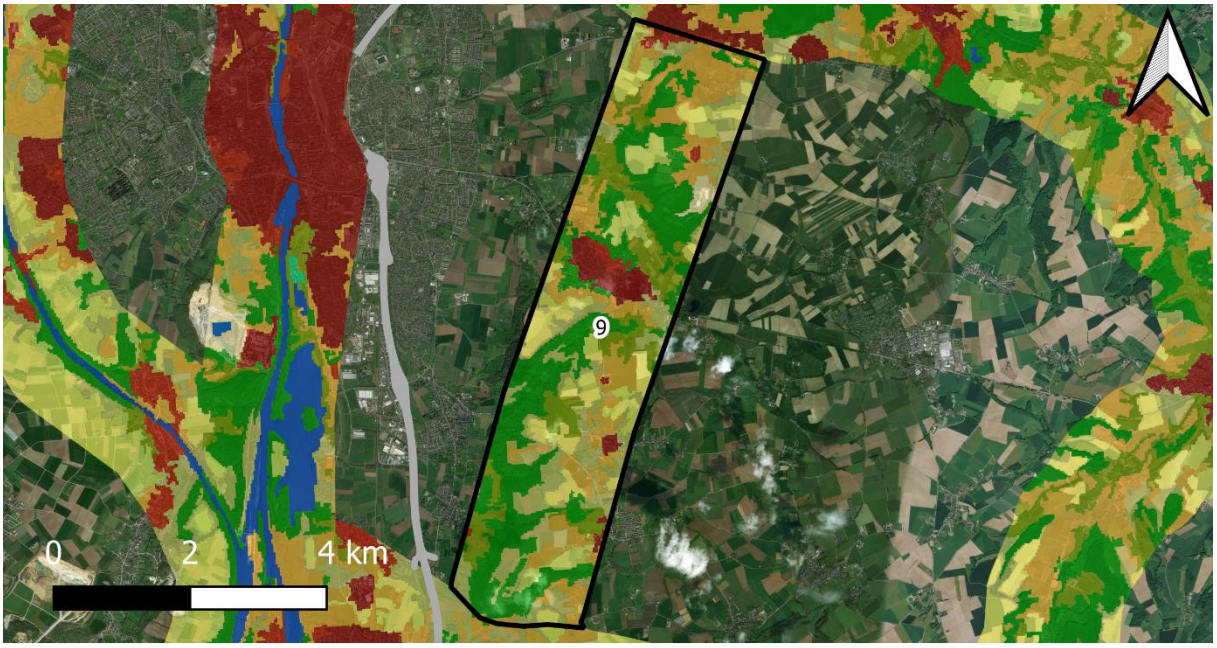


Sources : beta versions of ecotopes : LifeWatch ; aerial pictures : Bing ; Map creation : Biotope Environnement, 2020

Figure 14: Land use in the "Remersdaal - Eijsden - Visé" corridor

3.9 East Maastricht

Localisation within the ecological network
Northern part of the network; along an South-North axis
Approximate length
Approximately 8 km long
Dominant land use type
Agricultural areas: ca. 52% of the total surface
Importance of woodlands and other types of forested habitats
Approximately 34% of the total surface
Urban and artificial areas
5% of the corridor is classified as artificialized, mainly around the village of Cadeer en Keer
Important features impeding animal movements
YES / **NO**

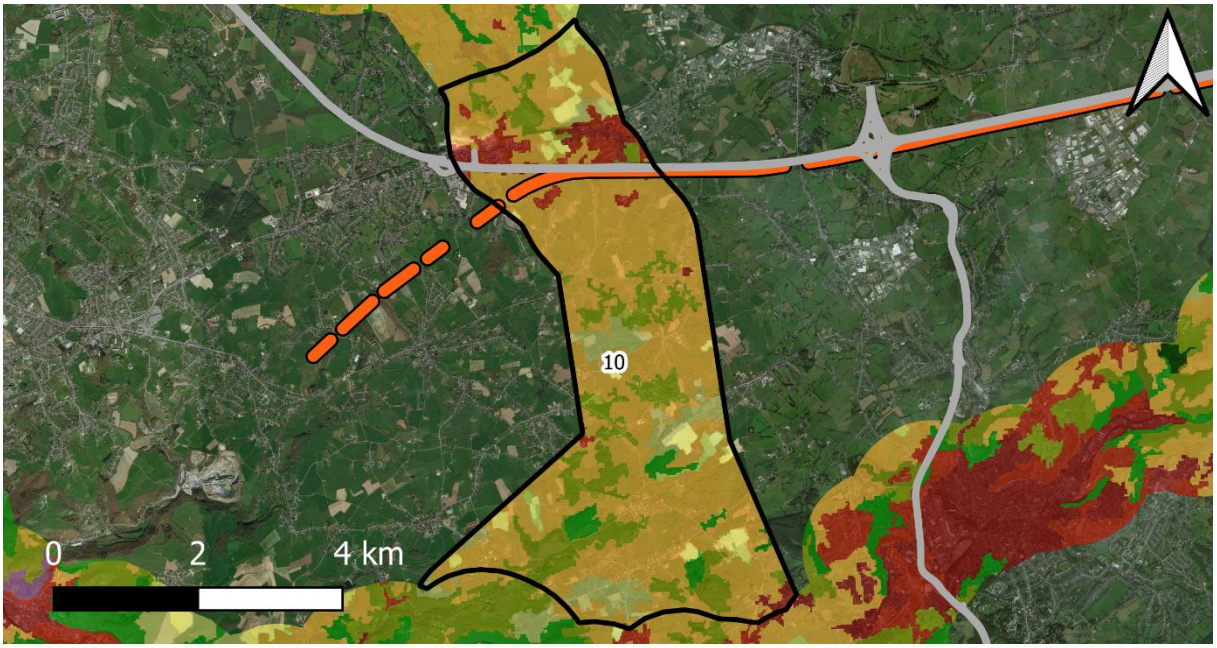


Sources : beta versions of ecotopes : LifeWatch ; aerial pictures : Bing ; Map creation : Biotope Environnement, 2020

Figure 15: Land use in the "East Maastricht" corridor

3.10 Connection between Vesdre and Bolland valleys

Localisation within the ecological network
Southern part of the network; along an North-South axis
Approximate length
Approximately 8 km long
Dominant land use type
Agricultural areas: ca. 76% of the total surface
Importance of woodlands and other types of forested habitats
Approximately 6% of the corridor; a moderately dense network of hedgerows and isolated trees may also contribute to improving connectivity
Urban and artificial areas
7.5% of the corridor is classified as artificialized, which include the section of highway/railway. Main urbanized areas are located West of the city of Herve
Important features impeding animal movements
YES / NO
A highway and a railway are located in the Northern part of the corridor, but an underpass could be adapted to serve as wildlife pass.

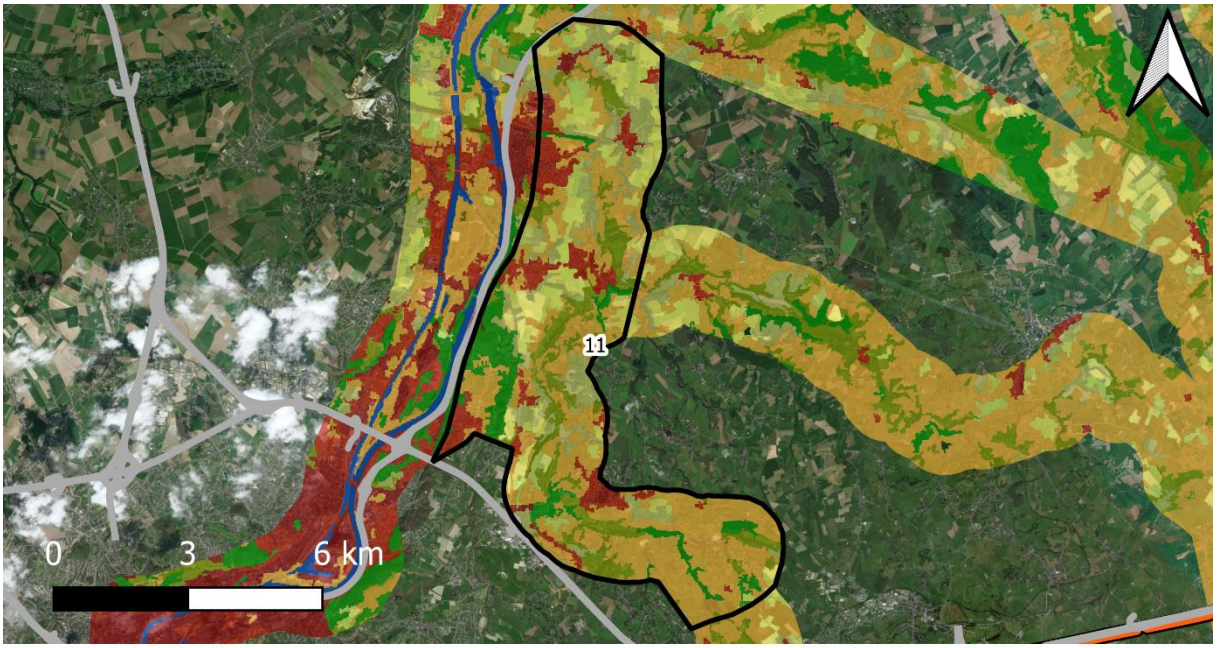


Sources : beta versions of ecotopes : LifeWatch ; aerial pictures : Bing ; Map creation : Biotope Environnement, 2020

Figure 16: Land use in the "Connection between Vesdre and Bolland valleys"

3.11 Bolland valley

Localisation within the ecological network
Western part of the network; mainly along an North-South axis
Approximate length
Approximately 16 km long
Dominant land use type
Agricultural areas: ca. 69% of the total surface
Importance of woodlands and other types of forested habitats
Approximately 10% of the corridor; a moderately dense network of hedgerows and isolated trees may also contribute to improving connectivity, but only at the Southern edge of the corridor
Urban and artificial areas
11% of the corridor is classified as artificialized. Main urbanised areas are located close to the Meuse river.
Important features impeding animal movements
YES / NO
The A2 highway runs on the Northern edge of the corridor, but an underpass could be adapted to serve as wildlife pass.

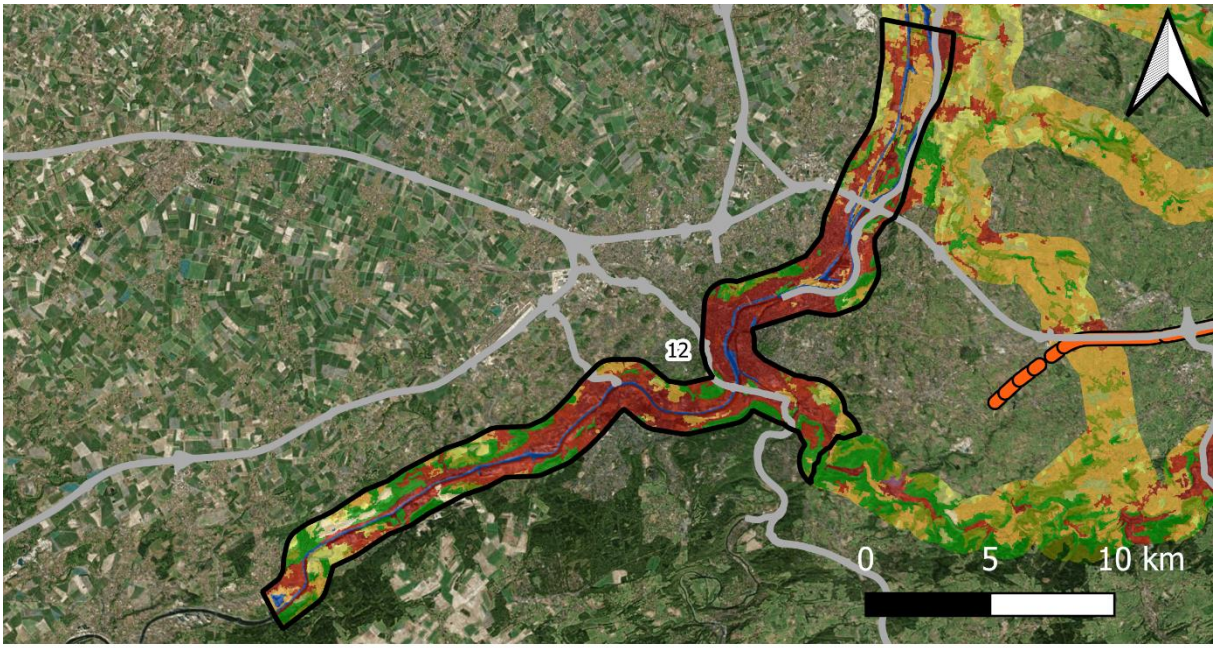


Sources : beta versions of ecotopes : LifeWatch ; aerial pictures : Bing ; Map creation : Biotope Environnement, 2020

Figure 17: Land use in the Bolland valley

3.12 Meuse upstream Visé

Localisation within the ecological network
Western part of the network; mainly along an SW-NE axis
Approximate length
Approximately 41 km long
Dominant land use type
Urban and artificial areas: ca. 52% of the total surface
Importance of woodlands and other types of forested habitats
Approximately 21% of the corridor, mainly at the Southern edge of the corridor (between Amay and Flémalle)
Important features impeding animal movements
YES / NO
This section of the ecological network is highly urbanized, a pattern that applies for both terrestrial and aquatic habitats. The cities of Flémalle, Seraing and Liège are virtually impermeable for most dispersing terrestrial animal. These cities occupy approximately 20 km along the corridors on both sides of the Meuse river. Artificialisation of the Meuse river banks are also likely to strongly reduce aquatic animal movements as they offer few resources (food, shelters, …) for such organisms. Additionally, 2 hydroelectrical power plants are located on the Meuse river, which may also act as a barrier for some aquatic taxa. Due to high urbanization rates, highways are considered as secondary barriers in this corridor.

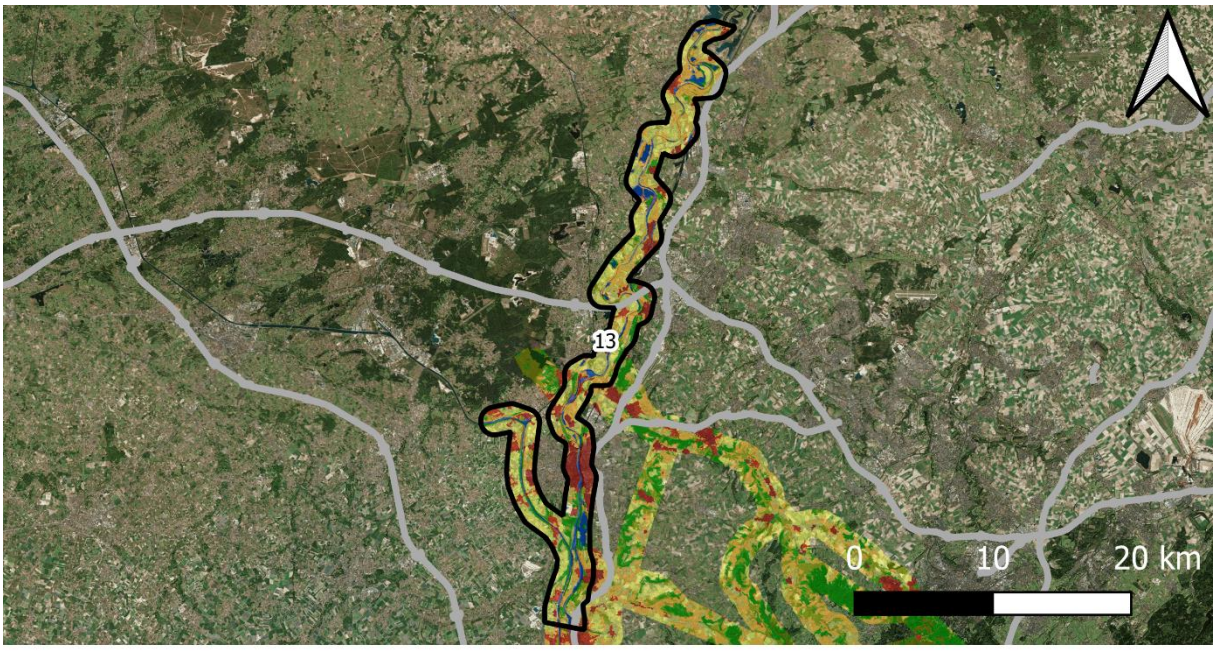


Sources : beta versions of ecotopes : LifeWatch ; aerial pictures : Bing ; Map creation : Biotope Environnement, 2020

Figure 18: Land use in the "Meuse upstream Visé" corridor

3.13 Meuse downstream Visé

Localisation within the ecological network
Western and Northern parts of the network; along an North-South axis
Approximate length
Approximately 55 km long
Dominant land use type
Agricultural areas: ca. 60% of the total surface
Importance of woodlands and other types of forested habitats
Approximately 10.5% of the corridor
Urban and artificial areas
17.5% of the corridor is classified as artificialized. Main urbanized areas include the city of Maastricht and various villages in the Netherlands, upstream Maastricht (e.g. Elsoo, Urmond).
Important features impeding animal movements
YES / NO
The major obstacle to wildlife dispersal is urbanization around the city of Maastricht which occupies approximately 3 km along the corridors on both sides of the Meuse river. Within the Maastricht, river banks are artificial, although locally vegetalized. Outside of the agglomeration, Meuse banks have a natural pattern and several waterbodies (e.g. swamps, large ponds) are located near the Meuse river, which may act as steppingstones for dispersing animals. The sluice near Borgharen and the hydro-electrical power plant of Lixhe may act as a barriers for some aquatic taxa. The major highway near Stein is not expected to be a major barrier to animal dispersal as an underpass along the Meuse can be used by wildlife (but its attractivity to wildlife could be improved).

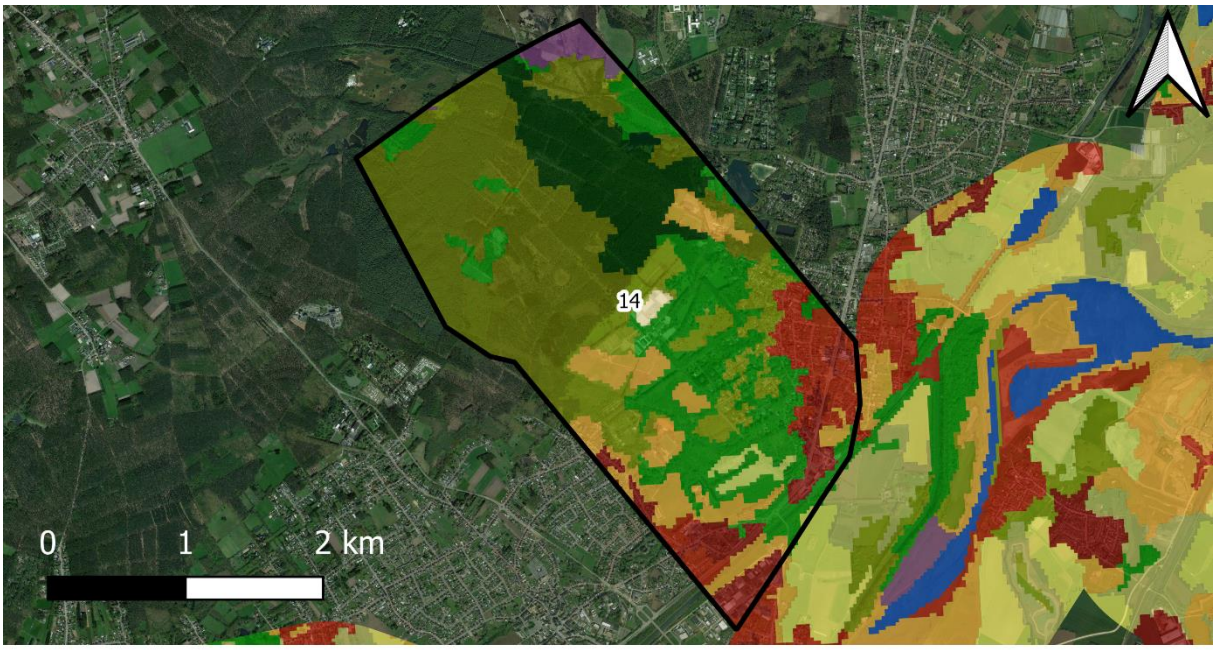


Sources : beta versions of ecotopes : LifeWatch ; aerial pictures : Bing ; Map creation : Biotope Environnement, 2020

Figure 19: Land use in the "Meuse downstream Visé" corridor

3.14 Meuse to Mechelse Heide and valley from Ziepbeek

Localisation within the ecological network
Western part of the network; along an NW-SE axis
Approximate length
Approximately 4 km long
Dominant land use type
Woodlands and forested habitats: ca. 72% of the total surface
Urban and artificial areas
11% of the corridor is classified as sparsely artificialized, mainly close to the Albert Canal
Important features impeding animal movements
YES / **NO**
While we did not identify any major obstacle to animal movements, it should be noted that high urbanization rates are observed close to the Albert Canal. High densities of buildings and roads in this area are thus expected to reduce suitability for terrestrial animal movements. Similarly, banks of the Briegden-Neerharen Kanaal are highly artificial and unlikely to promote movements of aquatic taxa.



Sources : beta versions of ecotopes : LifeWatch ; aerial pictures : Bing ; Map creation : Biotope Environnement, 2020

Figure 20: Land use in the "Meuse to Mechelse Heide and valley from Ziepbeek" corridor

3 Summary

The pre-selected corridors exhibit a wide range of lengths, land use and several bottlenecks to animal movement. Yet, some general conclusions can be drawn :

- The project take place in region mainly dominated by agricultural activities or, locally, by woodlands and other types of forested habitats. In some of the corridors, these two dominant land uses are intermixed in bocage-like landscapes.
- All corridors are affected by urbanization (*i.e.* sparsely and densely artificialized areas) to some extent. While urban areas are not dominant landscape features in most corridors, some major cities (Liège, Verviers, Maastricht) are located within the ecological network and are likely to act as barriers to wildlife dispersal.
- In addition to urban areas, other types of terrestrial barriers include highways and railways (*i.e.* high-speed rail). On the one hand, these infrastructures increase the risk of collision. On the other hand, they are frequently fenced, which make them impermeable to animal movement. Barriers on aquatic systems include artificialized river banks, dams, sluices and hydro-electrical power plants, which act as direct (stopping movements) and indirect (*i.e.* reduced habitat quality) barriers. We have summarized the information about major bottlenecks in Table 4 and Figure 21. This information will be used to identify key-actions listed in section 6 (Catalogue of recommended actions).

2 Ecological network and land use

Table 4: Summary of the main barriers and existing mitigation infrastructures

Bottleneck type	Impacted continuity	Impacted corridors	Existing mitigation
Highways	Green	Osthertogenwald – Kelmis	None
		Gueule valley	Existing ecoduct
		Connection between Vesdre, Gulp and Berwinne valleys	Existing ecoduct
		Remersdaal - Eijsden - Visé	None
		Connection between Vesdre and Bolland valleys	None
		Meuse downstream Visé	Existing underpass to be improved
High-speed railway	Green	Osthertogenwald – Kelmis	None
		Gueule valley	None
		Connection between Vesdre, Gulp and Berwinne valleys	Existing ecoduct
		Connection between Vesdre and Bolland valleys	None
Major cities	Green	Vesdre valley	None
		Meuse upstream Visé	
		Meuse downstream Visé	
Dam	Blue	Vesdre valley	Check if existing passes are present
Sluice	Blue	Meuse downstream Visé	
Hydro-electrical plants	Green	Meuse upstream Visé	
		Meuse downstream Visé	
Artificialized river banks	Green	Meuse upstream Visé	None
		Meuse to Mechelse Heide and valley from Ziepbeek	

2 Ecological network and land use

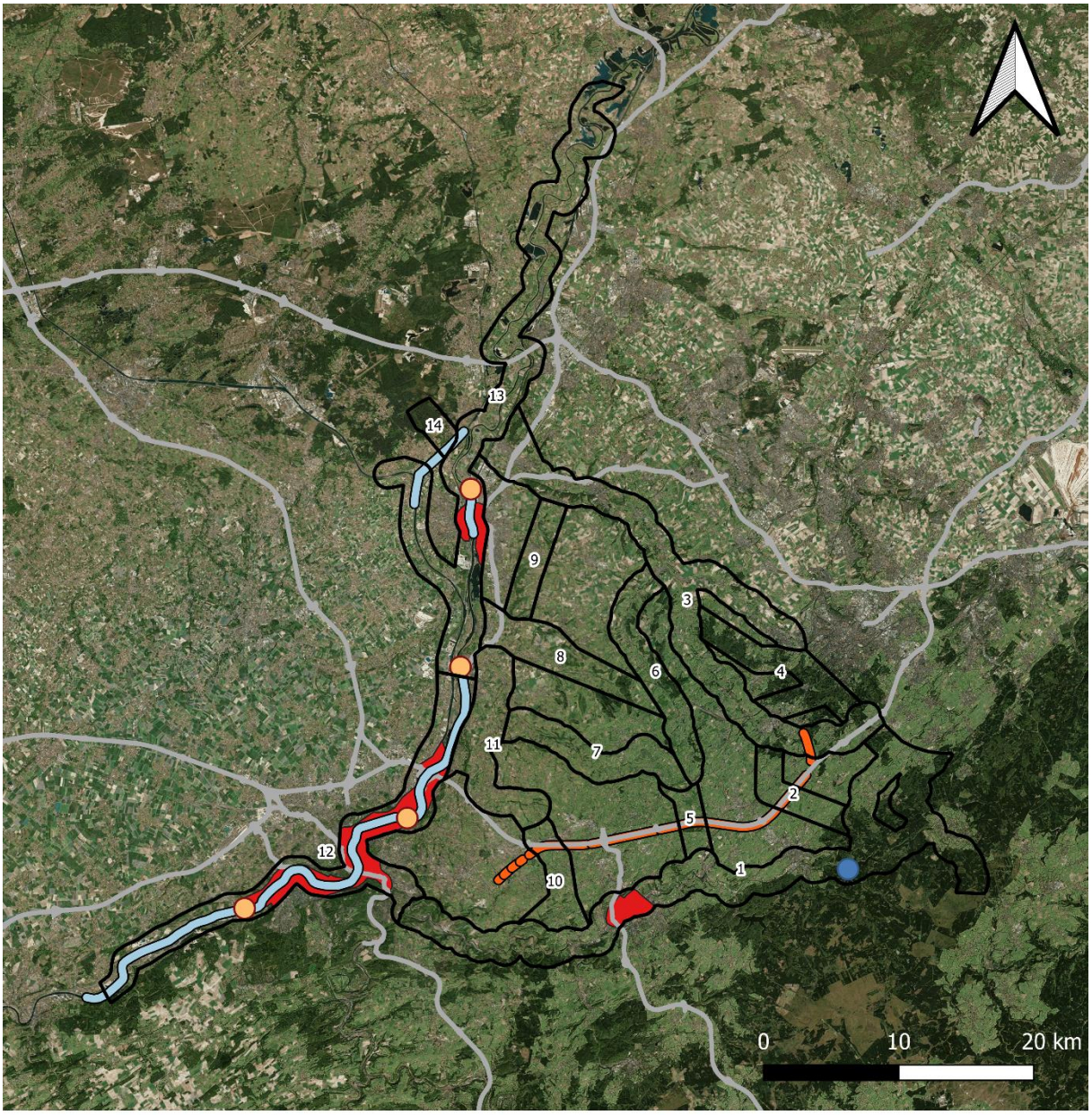


Figure 21: Overview of the main ecological barriers

3

Analysis of the protection context

3 Analysis of the protection context

1 Introduction

Implementation of conservation measures at the landscape scale can be greatly facilitated if it is based on a legal ground. Such a legal framework can be used to engage in and facilitate discussions with private land owners and stakeholders. Identifying areas with a protection regime is thus a crucial step within the framework of this project as it is expected to guide where conservation measures should be undertaken in priority.

Here, we conducted an analysis of the protection context, separately for each of the 14 pre-selected corridors, and we highlight areas that offer promising opportunities for ecological improvements based on the overlap with the Natura 2000 network.

2 Methods

As the present study takes place on several administrative units (countries and regions), several types of regionally protected areas where available (non-exhaustive list):

- Walloon Region: Réserves naturelles domaniales (RND), Réserves naturelles agréées (RNA), Réserves forestières (RF), Sites de grand intérêt biologique ;
- Flemish Region: Vlaamse natuurreservaten, Erkende Natuurreservaten ;
- The Netherlands: Natuur in goudgroene natuurzone, Verplichte zeer kwetsbare gebieden;
- Germany: Naturschutzgebiete, Nationalparke, Biosphärenreservate.

In practice, those sites were selected based on specific legal tools and purposes that cannot be easily transposed to other administrative units. Additionally, most of these regional/national protected areas overlap at least partly (and sometimes totally) with the Natura 2000 network. For instance, 96% of combined surface of Walloon RND, RNA and RF within the study area overlap with the Natura 2000 network. Consequently, we decided to focus on the Natura 2000 network which provides a common ground based on European Directives that apply to all administrative units considered here. Our analysis thus provides a broad picture of the protection context in the Euregio. We acknowledge that protected areas outside the Natura 2000 network could also be considered based on specific purposes as they can contribute to some extent to improving ecological connectivity and they may benefit from management plans which promote and localize ecological restoration/priority conservation areas. However, their contribution to ecological connectivity is expected to be marginal compared to the Natura 2000 network.

Based on an accurate mapping of the Natura 2000 sites located within the whole area covered by this project, we identified sites located in each corridor of the ecological network. For each of the 14 pre-selected sectors, we report :

- The number of Natura 2000 sites within the corridor and their code ;
- The proportion (%) of the sector within the Natura 2000 network ;
- The spatial distribution of the Natural 2000 sites (clustered or spread) based on visual inspection.

3 Results

Figure 22 provides an overview of the Natura 2000 network in the central part of the Euregio. Table 5 summarizes information about the overlap between Natura 2000 sites and each corridor.

3 Analysis of the protection context

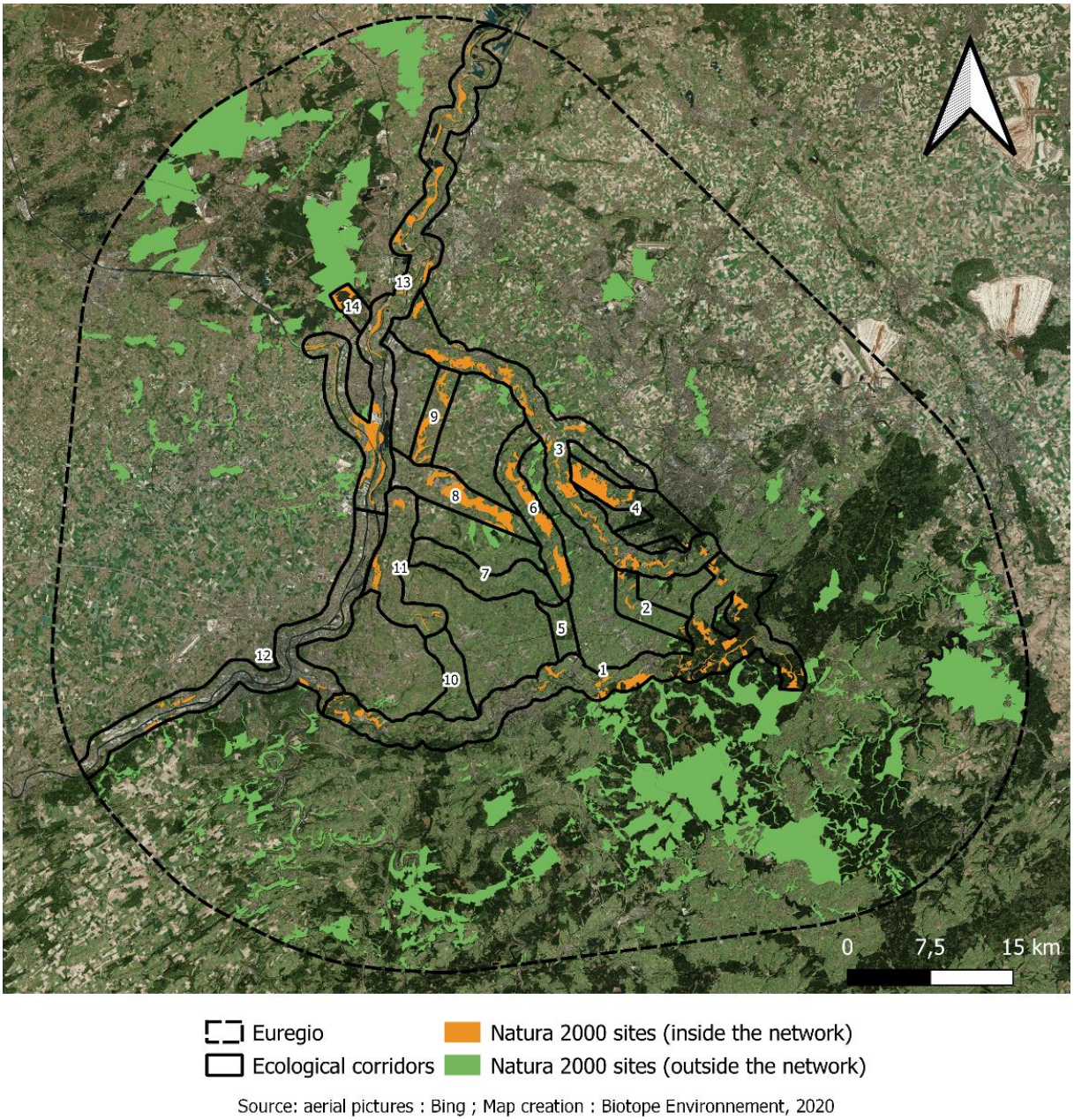


Figure 22: Overview of the Natura 2000 network in the study region

3 Analysis of the protection context

Table 5 : Summary of the protection context within each pre-selected corridors

1. Vesdre valley			
Number of Natura 2000 sites within the sector	Natura 2000 sites within the sector	Distribution	Proportion of the sector within the Natura 2000 network
8	BE33025C0 BE33019C0 BE33023C0 BE33022C0 BE33016C0 BE33066B0 BE33020C0 BE33021C0	Spread, but missing in the central part (near Verviers)	10%
2. Osthertogenwald - Kelmis			
Number of Natura 2000 sites within the sector	Natura 2000 sites within the sector	Distribution	Proportion of the sector within Natura 2000 network
2	BE33007C0 BE33020C0	Spread	6%
3. Gueule valley			
Number of Natura 2000 sites within the sector	Natura 2000 sites within the sector	Distribution	Proportion of the sector within Natura 2000 network
6	BE33006C0 BE33007C0 BE33021C0 NL2003012 NL9801041 NL9801076	Spread	14%
4. South of Aachen			
Number of Natura 2000 sites within the sector	Natura 2000 sites within the sector	Distribution	Proportion of the sector within Natura 2000 network
3	BE33006C0 BE33007C0 NL9801041	Clustered	20%
5. Connection between Vesdre, Gulp and Berwinne valleys			
Number of Natura 2000 sites within the sector	Natura 2000 sites within the sector	Distribution	Proportion of the sector within Natura 2000 network

0	None	/	0%
6. Gulp valley			
Number of Natura 2000 sites within the sector	Natura 2000 sites within the sector	Distribution	Proportion of the sector within Natura 2000 network
3	BE2200039 BE33006C0 NL9801041	Spread	23%
7. Berwinne valley			
Number of Natura 2000 sites within the sector	Natura 2000 sites within the sector	Distribution	Proportion of the sector within Natura 2000 network
0	None	/	0%
8. Remersdaal - Eijsden - Visé			
Number of Natura 2000 sites within the sector	Natura 2000 sites within the sector	Distribution	Proportion of the sector within Natura 2000 network
2	BE2200039 NL2003033	Spread	28%
9. East Maastricht			
Number of Natura 2000 sites within the sector	Natura 2000 sites within the sector	Distribution	Proportion of the sector within Natura 2000 network
2	NL9801040 NL9801076	Spread	25%
10. Connection between Vesdre and Bolland valleys			
Number of Natura 2000 sites within the sector	Natura 2000 sites within the sector	Distribution	Proportion of the sector within Natura 2000 network
0	None	/	0%
11. Bolland valley			
Number of Natura 2000 sites within the sector	Natura 2000 sites within the sector	Distribution	Proportion of the sector within Natura 2000 network
3	BE2200039 BE33004C0 BE33005C0	Clustered	6%
12. Meuse upstream Visé			

Number of Natura 2000 sites within the sector	Natura 2000 sites within the sector	Distribution	Proportion of the sector within Natura 2000 network
5	BE33004C0 BE33012C0 BE33013C0 BE33014C0 BE33016C0	Clustered	2%
13. Meuse downstream Visé			
Number of Natura 2000 sites within the sector	Natura 2000 sites within the sector	Distribution	Proportion of the sector within Natura 2000 network
10	BE2200036 BE2200037 BE2200042 BE33002B0 BE33003C0 BE33004C0 NL2003012 NL2018167 NL9801025 NL9801075	Spread	11%
14. Meuse to Mechelse Heide and valley from Ziepbeek			
Number of Natura 2000 sites within the sector	Natura 2000 sites within the sector	Distribution	Proportion of the sector within Natura 2000 network
2	BE2200035 BE2200727	Clustered	21%

4 Summary

Our analysis of the protection context of the pre-selected ecological network reveals strong differences among corridors. While 5 out of the 14 corridors have relatively high overlap (≥20%) with the Natura 2000 network, 3 corridors have no Natura 2000 site within their limits.

These figures should also be seen in light of the dominant land use type and spatial distribution of the Natura 2000 sites. For instance, the “Meuse upstream Visé”

corridor has one of the highest number of Natura 2000 sites, but they only marginally overlap with the corridor (ca. 2%) and they are located at the Southern margin of the corridor. As such, this corridor offers few opportunities to implement effective conservation measures in order to increase ecological connectivity (at least, when considering the Natura 2000 network only).

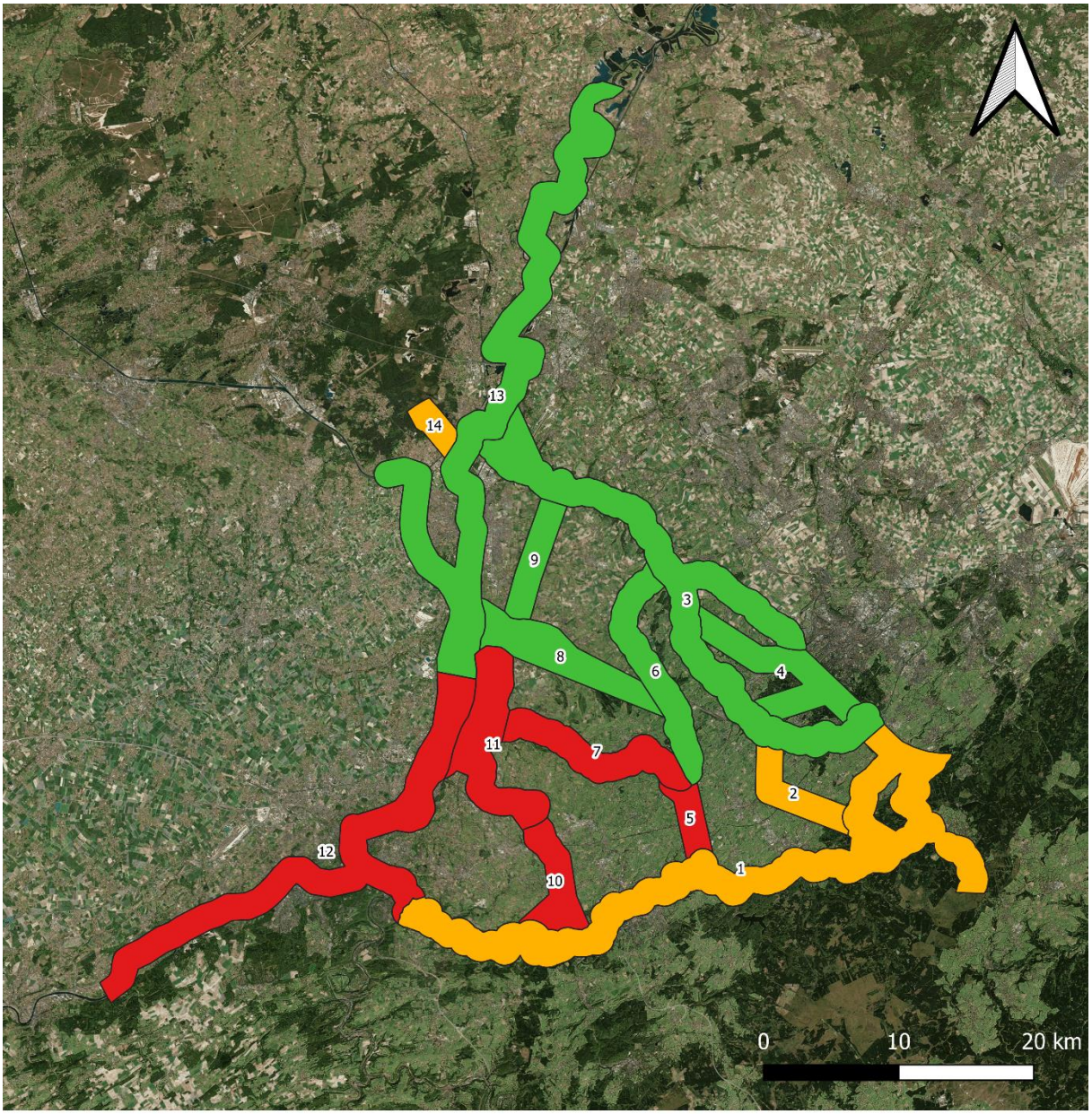
Based on the proportion of Natura 2000 sites and their spatial distribution (current situation), we propose the following ranking for **assessing opportunities to implement ecological restoration and habitat quality improvement**, should such measures be required (Table 6 and figure 23).

Table 6 : Summary of existing opportunities to implement ecological restoration through the Natura 2000 network

Many opportunities	Some opportunities	Few opportunities
Corridors 3, 4, 6, 8, 9, 13	Corridors 1, 2, 14	Corridors 5, 7, 10, 11, 12

We should also stress that there are opportunities to implement restoration actions outside the Natura 2000 network. For instance, pond creation and hedgerow planting can be implemented in corridors dominated by agricultural areas where few Natura 2000 sites are present (*e.g.* corridors 5, 7 and 10). While these actions do not take place within areas under a protection regime, they are supported by financial incentives through agri-environmental schemes and are thus useful in promoting biodiversity-friendly practices among farmers.

3 Analysis of the protection context



Opportunities for ecological restoration through the Natura 2000 network

- Many opportunities
- Some opportunities
- Few opportunities

Sources : aerial pictures : Bing ; Map creation : Biotope Environnement, 2020

Figure 23: Existing opportunities for ecological restoration through the Natura 2000 network

4

Synergies with restoration and conservation plans

4

Synergies with restoration and conservation plans

1 Background

The Euregio is expected to be of crucial importance for otter and wildcat conservation as the region is strategically located between remaining populations or along potential (re-)colonisation routes. While the implementation of regional nature conservation actions will be important to improve ecological connectivity, we have identified several projects that have similar goals and that create opportunities to develop a large-scale approach to conserve the otter and the wildcat.

We have listed the most relevant projects that take place within the study region (or in close proximity). Those projects can be integrated in a global conservation strategy that would benefit the otter and the wildcat.

2 List of synergic nature conservation projects

2.1 LIFE Patches and corridors

Project name
LIFE Patches & Corridors - LIFE15 NAT/DE/000745
Objectives
Development of a habitat network for the Violet Copper to promote a sustainable metapopulation
Target species/group
Violet Copper (*Lycaena helle*)
Examples of relevant actions
Restoration of valleys through fir removal, selective forestry and alluvial forest initialization
Project location
Nordrhein-Westfalen (DE), Natura 2000 site “Oberlauf der Rur”
Duration
2017 - 2022
Website
https://life-patchesandcorridors.de/en/

4

Synergies with restoration and conservation plans

2.2 LIFE Amphibienverbund

Project name
LIFE Amphibienverbund - LIFE15 NAT/DE/000743
Objectives
Improvement of habitats and population connectivity for endangered amphibians in the cityregion of Aachen
Target species/group
Yellow-bellied, Midwife and Natterjack toads (*Bombina variegata*, *Alytes obstetricans, Epidalea calamita*)
Examples of relevant actions
Creation of 600 ponds, reintroduction of the Yellow-bellied toad at two protected sites
Project location
Seven Natura 2000 sites around Stolberg
Duration
2017 - 2025
Website
https://life-amphibienverbund.de/

2.3 LIFE BOVAR

Project name
LIFE BOVAR - LIFE16 NAT/DE/000660
Objectives
Management of yellow bellied toad and other amphibians in dynamic habitats
Target species/group
Yellow-bellied, Midwife and Natterjack toads (*Bombina variegata*, *Alytes obstetricans, Epidalea calamita*) and Great crested newt (*Triturus cristatus*)
Examples of relevant actions
Creation of 3000 ponds, extensive grazing of terrestrial and aquatic habitats
Project location
Germany (Lower Saxony and North Rhine-Westphalia) and The Netherlands (Limburg)
Duration
2018 - 2026
Website
https://www.life-bovar-en.com/the-project/

4

Synergies with restoration and conservation plans

2.4 LIFE Pays Mosan

Project name
LIFE Pays Mosan - LIFE13 NAT/BE/001067
Objectives
Improving connectivity between the dry grasslands of the Natura 2000 network of the Dutch and the Belgian Meuse basin
Target species/group
Myotis and *Rhinolophus* bats
Examples of relevant actions
Planting of 40 km of hedgerows, creation of orchards, creation or management of 50 ponds
Project location
40 Natura 2000 sites along the Meuse in the Walloon and Flemish regions and in the Netherlands
Duration
2014 - 2020
Website
https://www.lifepaysmosan.eu/index.php?id=3434&L=1

2.5 LIFE Ardenne liégeoise

Project name
LIFE Ardenne liégeoise - LIFE10 NAT/BE/000706
Objectives
Restoration of natural habitats in the Ardenne ligeoise region
Target species/group
Violet Copper (*Lycaena helle*) and peatbog specialist species
Examples of relevant actions
Alluvial forest restoration through fir removal and broadleaf tree planting, pond creation
Project location
18 Natura 2000 sites in Wallonia (Province of Liège)
Duration
2012 - 2020
Website
http://biodiversite.wallonie.be/fr/life-ardenne-liegeoise-2012-2020.html?IDC=3590

4

Synergies with restoration and conservation plans

2.6 Belgian Nature Integrated Project

Project name
BNIP - Belgian Nature Integrated Project - LIFE14 IPE/BE/000002
Objectives
Developing and implementing an operational framework, to provide expertise and to support Natura 2000 projects in the field
Target species/group
Several amphibian and bird species, thick shelled river mussel (*Unio crassus*) and Barbastelle (*Barbastella barbastellus*); several habitats of community interest
Examples of relevant actions
Establishing action plans for community interest species, creation or restoration of 500 ponds, translocation of crested newts, restoration of alluvial forests through planting and fencing
Project location
Flemish and Walloon regions
Duration
2015 - 2023
Website
https://www.life-bnip.be/

2.7 Action plan for the common dormouse

Project name
Actieplan hazelmuis
Objectives
Action plan for the conservation of the common dormouse
Target species/group
Hazel dormouse (*Muscardinus avellanarius*)
Project location
Tri-Country Park
Duration
2019-2021
Link
Link to the report

4

Synergies with restoration and conservation plans

2.8 Action plan for the otter

Project name
Plan loutre 2011-2021 en Wallonie et au Grand-Duché de Luxembourg
Objectives
Action plan for the conservation of the otter in Wallonia and the grand Duchy of Luxembourg
Target species/group
European Otter (L*utra lutra*)
Project location
Wallonia and the grand Duchy of Luxembourg
Duration
2011-2021
Link
Link to the report

2.9 Former restoration and actions plans

In addition to the running projects and action plans listed above, several other projects took place within the Euregio and neighbouring regions, including (non-exhaustive list):

- LIFE Loutre (2005-2011): restoration of European otter habitats in Belgium and the Grand Duchy of Luxembourg ;
- LIFE Tourbières Hautes-Fagnes (2007-2012): restoration of heaths and mires on the Hautes-Fagnes Plateau ;
- LIFE ELIA (2011-2017): creation of green corridors under overhead lines in Belgium and France ;
- Action plan for the wildcat in Germany (2009-2019): identifying threats and minimizing them ;
- Action plan for the conservation of the Crested Newt *Triturus cristatus* species complex in Europe.

These projects are important as they provide useful information about techniques that could be used for future restoration actions. The restoration work undertaken during these projects created areas where good quality habitats are available, which are expected to play a role for the otter and wildcat connectivity outside the Euregio.

5 Target species

5 Target species

1 Introduction

Within the framework of this study, the otter and the wildcat are the focus species which should primarily guide ecological restoration actions. Yet, these species can be considered as "flagship" or "umbrella" species, which means implementing conservation measures targeting them and their habitats may in turn benefit other species that share (at least partly) similar ecological requirements.

The European Birds and Habitats Directives list some of the most threatened species for which urgent actions should be taken in order to reverse current negative populations trends. In this context, measures aiming at restoring ecological connectivity and improving habitat quality based on habitat requirements of umbrella species may significantly contribute to achieving conservation goals for threatened and protected species.

This section thus aims to identify species under the Birds and Habitats Directives that are likely to benefit from measures based on otter and wildcat ecological requirements.

2 Methods

We used information available in the Standard Data Form (SDF; accessed from the Natura 2000 Network Viewer - European Environment Agency, 2019) of the Natura 2000 sites that overlap with at least one of the 14 pre-identified corridors to list all potential species that would benefit from ecological improvement measures. As the pre-selected corridors did not overlap any Natura 2000 sites in Germany, we used all Natura 2000 sites located in Germany within the study area, as well as a set of German nature reserves (*Naturschutzgebiete*). Together, these sites provide the backbone of the German ecological network in the study area. The summary of the information used for species selection (number of sites) is presented in Table 7.

Table 7: Summary of the Natura 2000 sites and nature reserves used for species selection

	Wallonia	Flanders	The Netherlands	Germany
Natura 2000 sites	27	6	8	32
German nature reserves	/	/	/	18

5 Target species

For each species reported in at least one of the SDF, we calculated the following metrics:

- The proportion of sites at which the species occurs, separately for each administrative unit ;
- An index of commonness, obtained by summing up proportions from all administrative units. While we acknowledge that this metric as no strong biological or statistical meaning, it is helpful to rank species and identify those that would benefit most from ecological improvements ;
- The number of administrative units in which the species occurs.

We then sorted species according to the number of administrative units where they occur, and we kept only species occurring in at least two units. This resulted in 3 groups of species (*i.e.* occurrence in 4, 3 or 2 administrative units). Within each group, we then sorted species according to the commonness index described above. Consequently, species occurring in many administrative units and with the highest commonness index are those that are expected to benefit most from ecological restoration.

The ecological network can be divided in sub-networks as exemplified in figure 24. Within the study region, we decomposed the general network into 4 sub-networks :

- Rivers and wetlands ;
- Woodlands ;
- Bocage and semi-open habitats ;
- Open habitats

We selected species (or groups of species) that are the most representative of the general network and each sub-network, based on the previously described metrics. We also gave more weight to species listed on the Annex I of the Bird Directive, to species listed on the Annexes II and IV of the Habitat Directive and to species targeted by recent action plans *sensu lato* (e.g. LIFE projects, specific action plans).

5 Target species

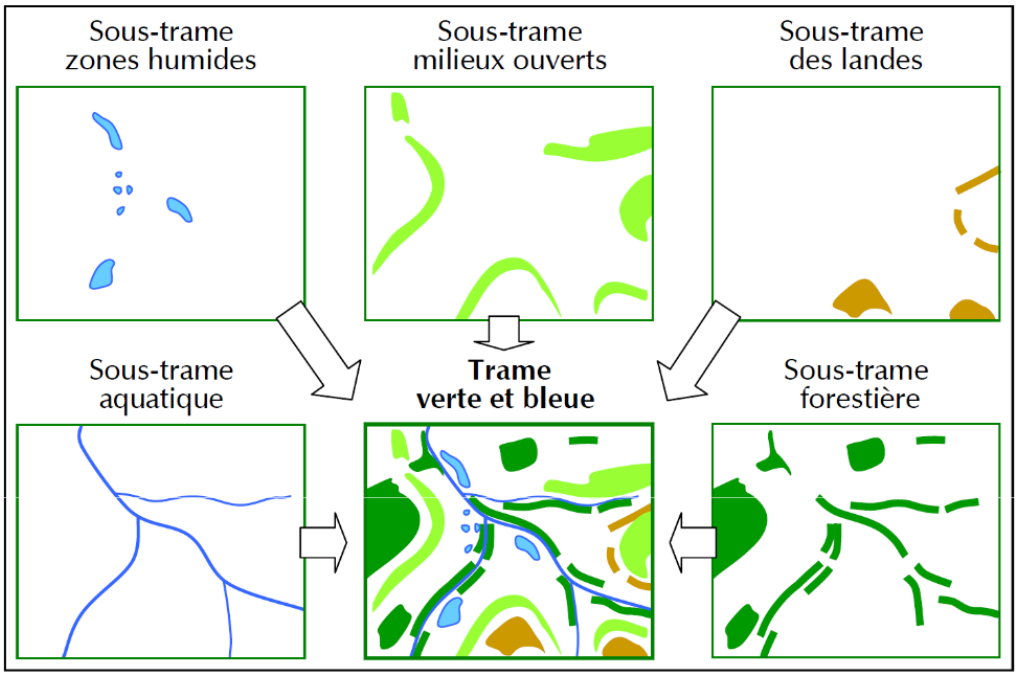


Figure 24 : Example of ecological sub-networks (source: Allag-Dhuisme et al., 2010)

3 Results and summary

A total of 68 species were identified according to the method presented above. They are listed in Table S1 of the Appendix. Only a subset of species occurred in the majority of administrative units, as shown in Table 8.

Table 8: Distribution of species between administrative units

	Occurrence in 2 administrative units	Occurrence in 3 administrative units	Occurrence in 4 administrative units
Number of species	41	17	10

Within this list, we selected a subset of species that are associated with the main sub-networks in the study region (Table 9). While most of the species occur in a restricted range of habitats and they are therefore typical of one sub-network only, some species rely on several habitats type to complete their life-cycle. This is the case of *Myotis* bats, for instance, which nest in woodlands and may hunt insects in more open areas. These species integrate several features from different sub-networks and they will thus benefit from having an ecological network of good overall quality.

5 Target species

Table 9: Species of community interest and their association with pre-identified sub-networks

Sub-network	Species (or group)	European Directive / Annex	Existing action plan[a]
Rivers and wetlands	Eurasian otter (*Lutra lutra*)	DH / II + IV	X
	Crested newt (*Triturus cristatus*)	DH / II + IV	X
	European beaver (*Castor fiber*)	DH / II + IV	
	Violet Copper (*Lycaena helle*)	DH / II + IV	X
	Common midwife toad (*Alytes obstetricans*)	DH / IV	X
	Common kingfisher (*Alcedo atthis*)	DO / I	
Woodlands	Wildcat (*Felis silvestris*)	DH / IV	X
	Stag beetle (*Lucanus cervus*)	DH / II	
	Black stork (*Ciconia nigra*)	DO / I	
	Black woodpecker (*Dryocopus martius*)	DO / I	
Bocage and semi-open habitats	Red-backed shrike (*Lanius collurio*)	DO / I	
	Hazel dormouse (*Muscardinus avellanarius*)	DH / IV	X
Open habitats	Wood lark (*Lullula arborea*)	DO / I	
	Smooth snake (*Coronella austriaca*)	DH / IV	
	European nightjar (*Caprimulgus europaeus*)	DO / I	
General network	Bats (*Myotis* sp.)		X

[a] Based on collection information on running LIFE projects and regional/national action plans.

6

Catalogue of recommended restoration actions

6 Catalogue of recommended restoration actions

Based on the land use context prevailing in each corridor, major barriers to wildlife movement and opportunities offered by the overlap between corridors and the Natura 2000 network, we propose a list of recommended actions aiming at improving landscape connectivity in the Euregio. This list provides a general roadmap of actions which should be adapted to meet specific challenges and opportunities that may apply locally.

For each of these actions, we report:

- The type of barrier targeted by the action ;
- Which sub-network is primarily related to the action ;
- An overview of how this action can be implemented in the study region ;
- The corridors to which the action should be implemented in priority.

The proposed actions are framed within the specific context of the Otter and Wildcat conservation. Yet, because they share some ecological requirements with other species, we expect such actions to benefit biodiversity in general in the study region. Wherever relevant, we try to exemplify how these actions can benefit other species, especially species of community interest.

1 Forest management

Targeted barrier
No specific barrier, but aims at improving connectivity in general
Sub-network
Woodlands
Overview
Some parts of the network were heavily planted with exotic needleleaf tree species such as the spruce (*Picea abies*). While needleleaf tree plantations are not barriers *per se* to otters and wildcats, they are supposed to be non-optimal habitats for these species. On the one hand, the wildcat inhabits forests with a dense undercover vegetation which generally lacks in needleleaf tree plantations. On the other hand, needleleaf tree plantations tend to replace other types of vegetation (*e.g.* riparian forests) that provide suitable habitats for the otter. As forests are of crucial importance for both species and natural broadleaf forests are overall more species-rich and tend to provide more ecosystem services than exotic needleleaf plantations, restoration of indigenous broadleaf forests should be undertaken wherever possible, including riparian forests along degraded streams (in and/or in the vicinity of Otter's potential habitats).
Relevant corridors
May apply to all corridors, based on the distribution of spruce and other needleleaf tree plantations. Corridors with important areas covered by needleleaf and mixed forests include the Vesdre valley (downstream Eupen) and "Meuse to Mechelse Heide en valley from Ziepbeek" corridors.

2 Hedgerows plantations

Targeted barrier
No specific barrier, but aims at improving connectivity in general
Sub-network
Bocage and semi-open habitats
Overview
In areas dominated by agricultural activities and where natural forest restoration is impossible, planting hedgerows should be considered to increase the amount of forested habitats and the ecological continuity. Indeed, hedgerows provide diversified habitats for species through the “edge effect” and contribute to connectivity between woodland patches. Planting hedgerows in fragmented, agricultural landscapes can provide an effective alternative to habitat restoration for conservation of the Hazel dormouse : in Italy, creating new corridors by planting hedgerows resulted in a 38% gain in landscape connectivity, while restoring existing corridors increased connectivity by 11% only (Dondina et al., 2018). The contribution of hedgerows to local biodiversity and to connecting wooded elements ultimately depends on their management : diversified multi-species hedgerows and those with a wildlife-friendly management (*e.g.* reduced frequency of cutting, no spraying) are likely to harbour more species. As hedgerow plantation incurs low costs to agricultural yields and is supported by subsidies issued under the Rural Development Regulation, this action provides a useful tool to enhance connectivity in agricultural areas, even outside the Natura 2000 network.
Relevant corridors
May apply to all corridors, but mainly those dominated by agricultural activities. **Priority corridors**: “Osthertogenwald – Kelmis”, “Connexion between Vesdre, Gulp and Berwinne valleys” and “Connexion between Vesdre and Bolland valleys” ; **Non-priority corridors**: Gueule valley (E and SE parts), Berwinne valley

3 Pond creation and wetland restoration

Targeted barrier
No specific barrier, but aims at improving connectivity in general
Sub-network
Rivers and wetlands
Overview
This action aims to improving wetland connectivity by creating aquatic habitats of various sizes. The creation of a network of small- to medium-size ponds in agricultural areas will benefit species of community interest such as the Great crested newt and the Common midwife toad whose habitats are threatened by agricultural intensification and urbanization. As for the plantation of hedgerows, pond creation is supported by subsidies issued under the Rural Development Regulation and can be implemented on private land parcels. Restoration of large-scale wetlands is a complementary action where such a measure is possible, especially near large rivers and canals. This includes restoration of marshes and large ponds and creating a mosaic of wetland habitats at different levels of vegetation development. These sites represent important stopover sites for migrating birds and aquatic animal species during dispersal.
Relevant corridors
Pond creation: Vesdre valley, “Osthertogenwald - Kelmis”, Gueule valley, “Connexion between Vesdre, Gulp and Berwinne valleys”, Gulp valley, Berwinne valley, “Remersdaal - Eijsden – Visé”, “East Maastricht”, “Connexion between Vesdre and Bolland valleys”, Bolland valley Wetlands restoration: Vesdre valley, Meuse upstream Visé, Meuse downstream Visé

4 River bank restoration

Targeted barrier
Artificialized river banks, aquatic barriers (sluices, hydro-electrical power plants)
Sub-network
Rivers and wetlands
Overview
Upstream Lixhe, the Meuse banks have been heavily artificialized due high urbanization rates and intense industrial activities in this region. Consequently, the section of the Meuse offers few natural habitats left for aquatic species. Additionally, other infrastructures such as hydro-electrical power plants are located on this section of the Meuse and may at least partly reduce dispersal success of aquatic species. Renaturation measures will be inspired by a LIFE project ('Grensmaas') that successfully restored sites of the Meuse river along the Belgian/Dutch border. Those measures include, for instance, remeandering, extensive grazing of alluvial meadows and riparian rehabilitation. Wetland and pond creation is a complementary action. Presence of passes for aquatic taxa at hydro-electrical power plants and sluice should be checked or installed/adapted if not present or inappropriate for the focus species.
Relevant corridors
Meuse upstream Visé

5 Highway and railway passes

Targeted barrier
Highways and railways
Sub-network
General network
Overview
Highways and railways are major barriers in the study as they have both direct (i.e. collision) and indirect (e.g. through light and noise pollution) impacts on animal movement. In the study region, 5 major highways and 1 high-speed railway have been identified as major barriers (see Table 4 and Figure 21). The most impermeable infrastructures are European E40 route and the adjacent high-speed railway, both of which cut 4 corridors in a perpendicular way. An ecoduct is present in corridor 5 and this passage is of crucial importance at the moment for increasing their permeability to wildlife movement. Yet, no such structure is present in the other terrestrial corridors. In order to significantly increase connectivity in this region, other over- or underpasses should be installed especially because these roads are presumed to play a major role in preventing Northwards dispersal by wildcats and connections with the Hoge Kempen. In this context, ecoducts and similar landscape bridges appear as the most effective infrastructures when it comes to crossing highways and railways. However, they are costly and require frequent management so as to ensure that they are suitable for the target species. We suggest to adapt existing over – and underpasses as suitable alternatives for increasing connectivity. At the moment, there a several bridges and underpasses that are used as local roads and agricultural tracks. Most of them are covered with concrete or asphalt-like surfaces and are hardly used by animals. Adding earth-covered or vegetated strips may already increase attractiveness to animals at a low cost. We have identified several existing structures which could be adapted to increase permeability of highways and railways to animal movement (Table 10). Some tips on designing and adapting passes can be found here. **Importantly, animals should be guided towards over- and underpasses once these infrastructures have been adapted for wildlife. Consequently, the plantation of hedgerows that guide and canalize animals from the surrounding landscape is a complementary action**.
Relevant corridors

"Osthertogenwald – Kelmis", Gueule valley, "Remersdaal - Eijsden – Visé", "Connexion between Vesdre and Bolland valleys", Bolland valley

Table 10: List of existing structures to create wildlife passes.

Corridor	Bottleneck type	Geographic coordinates (Lat ; Long)	Type of pass
Osthertogenwald - Kelmis	Highway and railway	50.670469, 6.033104	Overpass
		50.666502, 6.027705	Underpass
Gueule valley	Railway	50.697915, 6.049680	Underpass
	Highway	50.877914, 5.749791	Underpass
	Highway	50.876610, 5.769796	Underpass
Remersdaal - Eijsden - Visé	Highway	50.765577, 5.714037	Underpass
Connexion between Vesdre and Bolland valleys	Highway and railway	50.633572, 5.775223	Underpass
Bolland valley	Highway	50.762146, 5.704793	Underpass

6 Urban green belts

Targeted barrier
Densely urbanized areas
Sub-network
General network
Overview
A large-scale strategy might be to implement green belts around cities that represent impermeable barriers to animal movement. In the study region, this applies more specifically to **Liège**, **Verviers** and **Maastricht**. Practically, the creation of green belts requires to set some land aside that would be devoted to nature. This strategy may prove to be difficult to be implemented on the short term as it requires extensive discussion between stakeholders at different levels and it needs to be included in mid- to long-term sub-regional development plans. Yet, it would create and secure ecological corridors that would benefit to the regional species pool on the long-term. In addition to enhancing connectivity, green belts contribute to achieving other societal goals such a providing sustainable transport alternatives, improving air quality and connecting people living in large cities with nature. They also offer opportunities for companies to engage in nature conservation through compensatory measures and biodiversity-friendly management of their land parcels. There is now a growing interest from the European Commission for developing urban green belts all across Europe and to support such projects (see this report). This is also mirrored at the national level, for instance in Belgium where several initiatives are taking place in order to improve ecological continuity in urban areas (see this link). Additionally, a recent LIFE+ project (LIFE GREEN4GREY - LIFE13 ENV/BE/000212) developed green and blue infrastructures for grey peri-urban landscapes around Brussels and Hasselt. Therefore, there are opportunities to develop a network of semi-natural areas around cities of the studied region that would benefit to biodiversity in general.
Relevant corridors
Around major cities: Vesdre valley (Verviers), Meuse upstream Visé (Liège and its surroundings), Meuse downstream Visé (Maastricht) Actions would take place both within and outside the corridors

7 Restoration of the otter habitat

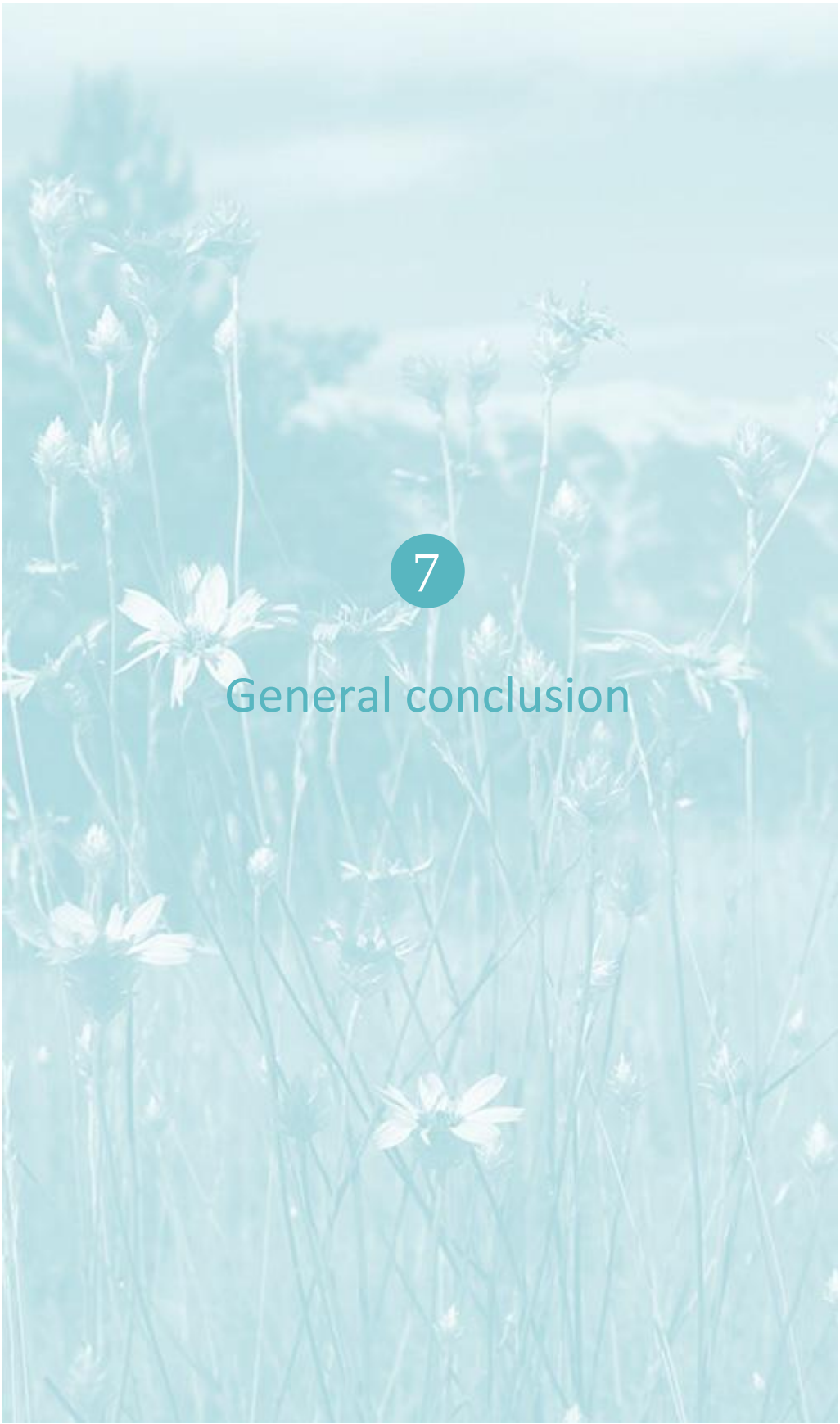
Targeted barrier
No specific barrier, but aims at improving connectivity in general
Sub-network
Rivers and wetlands
Overview
In addition to general measures such as forest management, pond creation and river bank restoration, some actions focusing on the otter habitat should be undertaken. Based on the action plan for the otter in Belgium and the Grand Duchy of Luxembourg, 4 types of actions can be implemented: (1) securing high quality habitats by creating a network of protected areas along rivers; (2) restoration of rivers and valleys through fir removal, riparian and alluvial forest restoration, exclusion of cows and other domestic animals from river banks by fencing, invasive species management; (3) increasing fish stocks through removal of barriers to fish movement and restoration of reproductive habitats; (4) improvement of water quality by removal aquatic pollutant sources. The creation of a few artificial otter holts may also increase the local attractiveness where few suitable habitats are available. Field visits should be conducted to identify areas that are the most suitable for the otter and areas where ecological restoration should be undertaken in priority.
Relevant corridors
Gueule valley, Gulp valley, Berwinne valley, “Remersdaal - Eijsden – Visé”, Bolland valley

8 Funding opportunities

The proposed actions will generate financial costs that could be covered by several funding opportunities:

- European LIFE programmes, especially the environment sub-programme which funds nature conservation projects that target habitats and species ;
- Agri-environmental schemes (AES) for the integration of environmental concerns into the common agricultural policy ;
- Local and regional funds for nature conservation.

Because ecological connectivity improvement in the Euregio would require large-scale actions to be achieved, launching **a LIFE programme, as planned by 3LP, represents the best option**. Several projects have been conducted in neighbouring regions and successfully created and restored natural habitats. If a LIFE project would be submitted, it could build on existing knowledge acquired by previous LIFE and related projects in the region. AES and local funds are complementary to a larger-scale funding and can help achieving specific goals. For example, AES directly target farmers and they offer opportunities to implement environmentally-friendly agricultural techniques in areas under intensive agricultural management (*e.g.* outside the Natura 2000 network) through financial incentives.



7 General conclusion

7 General conclusion

Human activities such as urbanization and agriculture intensification have disrupted movement and gene flows for several animal and plant taxa (Beier & Gregory, 2012). This has resulted in smaller and more isolated populations that become more susceptible to stochastic events and reduced genetic diversity via drift and inbreeding. Consequently, human-mediated habitat fragmentation is considered as major threat to biodiversity and actions are taking place worldwide to improve ecological connectivity.

Using the otter and the wildcat as flagship species, WWF Belgium is currently working to promote the return of wildlife to the Euregio, one of the most urbanized and fragmented landscape of Europe. This region, which covers parts of Belgium, The Netherlands and Germany, has been shown to be crucial for connecting existing populations and is a key area along the re-colonization routes in Western Europe. Based on 14 pre-identified ecological corridors that encompass the blue and green continuities, the aim of this report was to:

- Identify the dominant land use in each corridor and main obstacles or threats to animal movement ;
- Analyse the protection regime within each corridor ;
- Provide a list of planned conservation and restoration actions ;
- Identify species of community interest that would benefit from implementing ecological restoration actions focused on the otter and the wildcat ;
- Propose a catalogue of recommended actions.

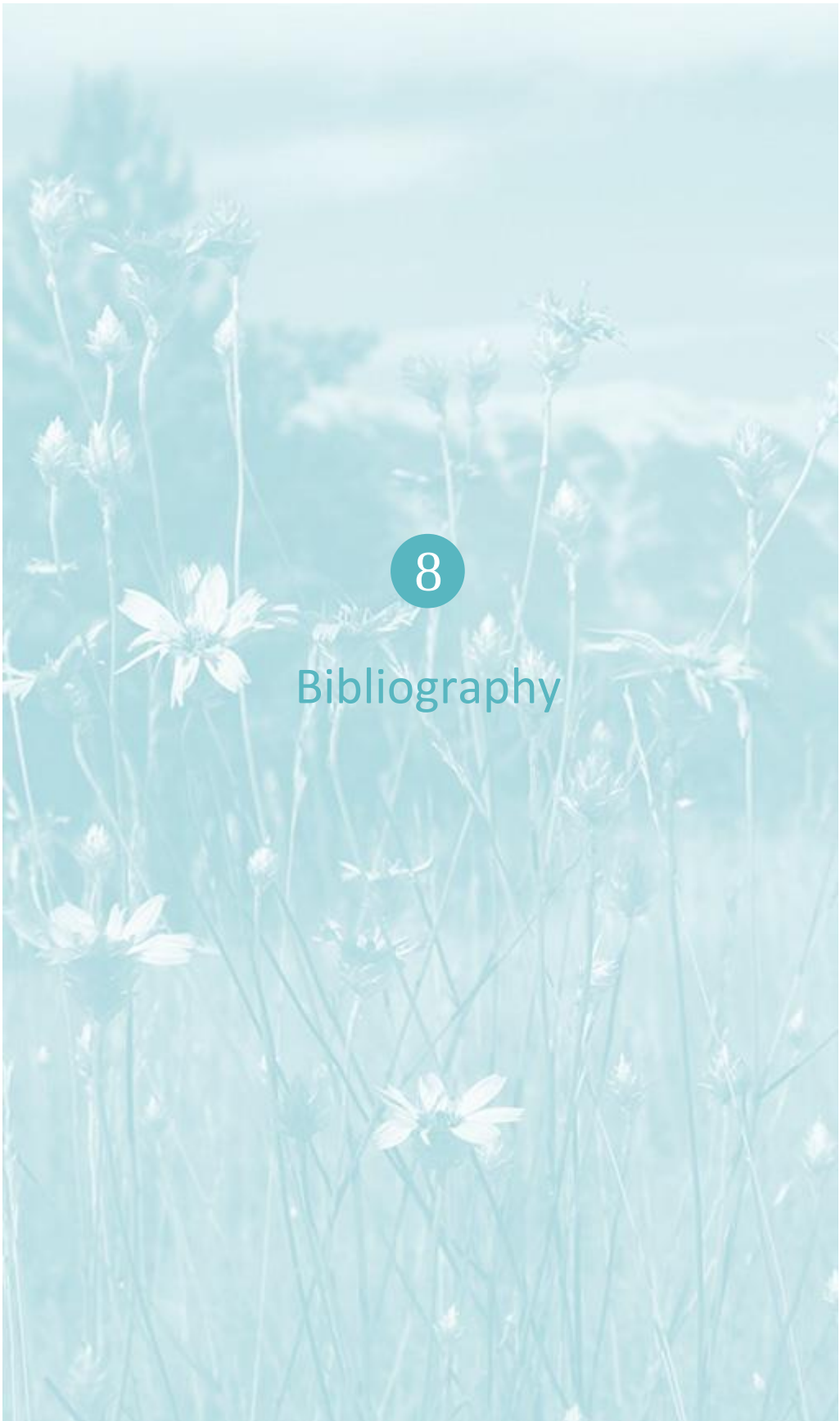
Through geoprocessing analyses, photointerpretation and literature review, we aimed to fill the existing gaps in order to facilitate the implementation of conservation measures in the Euregio.

Our analyses show that the ecological network in the Euregio is highly heterogeneous. While agricultural areas are the dominant land use overall, some corridors are dominated by woodlands, bocage-like landscapes or by artificialized areas. Urban areas and human-built structures (highways and high-speed railways) are the main barriers related to the green continuity, while hydro-electrical power plants, dams, sluices and artificialized river banks are the main bottlenecks to the blue continuity. Yet, there are opportunities to improve the ecological connectivity in the Euregio through the Natura 2000 network and existing LIFE projects and local action plans whose actions would indirectly benefit the otter and the wildcat. We also listed species of community interest that are present within the ecological network of the Euregio and we have identified a subset of species that would benefit the most from ecological restoration. Within the framework of the otter and wildcat conservation, we then proposed 7 broad restoration actions (themselves including multiple actions) that target the habitats of these species. The proposed actions include large-scale (*i.e.* wetland and river bank restoration, urban green belts) and small- to medium-scale

7 General conclusion

(*i.e.* forest management, planting of hedgerows, pond creation, highway and railway passes, restoration of the otter habitat) restoration actions that are expected to improve ecological connectivity for the focus species as well as other species of community interest. In order to achieve this goal, a close coordination of regional and local partners in the 4 administrative units is essential.

While these restoration actions should now be translated operationally on the field, this work focused on the otter and the wildcat shows that there are opportunities to improve the blue and green continuities in the Euregio, to connect distant animal populations and to facilitate the (re-)colonization of Western Europe by iconic and community interest species. In parallel to these restoration actions, the monitoring effort should be increased in order to better document the ecological requirements of the focus species. While a recent report shed light on the habitat requirements of the wildcat in Wallonia (Delangre et al., 2019), some aspects of the ecology of the otter and the wildcat remain poorly studied. Such information (including intra-specific variation; see Oliveira et al., 2018 for a wildcat example) is crucial in order to identify key areas to preserve and where restoration actions are most needed.



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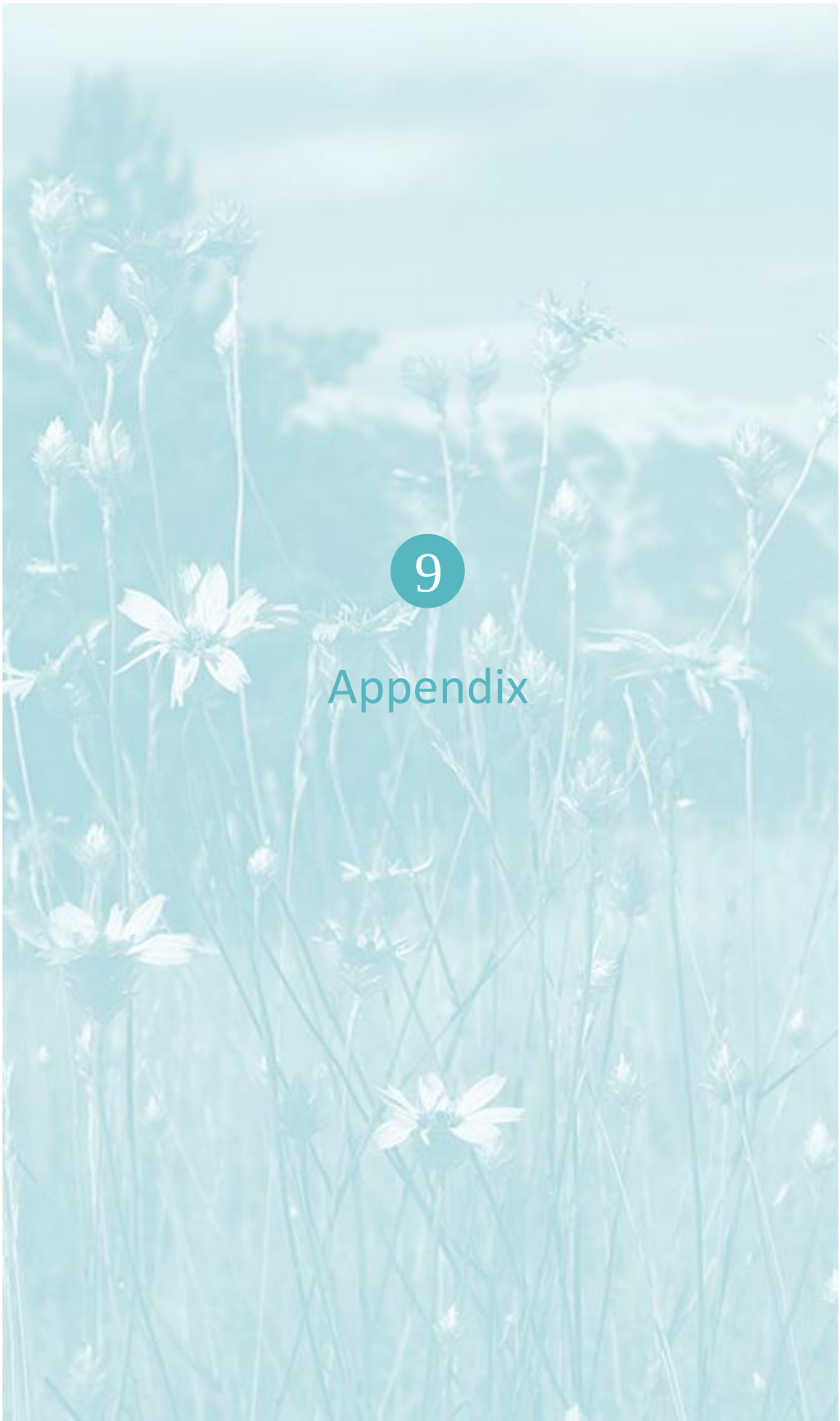

9 Appendix

9 Appendix

Table 11: Species of community interest within the studied ecological network

N2000 code	Group	Species	RW	RF	NL	DE	Index[a]	Nb[b]	Directive / Annex[c]	Prio[d]
1166	Amphibians	*Triturus cristatus*	14,8	50,0	37,5	10,0	112,3	4	DH / II + IV	*
1163	Fishes	*Cottus gobio*	63,0	33,3	37,5	20,0	153,8	4	DH / II	
1096	Fishes	*Lampetra planeri*	25,9	50,0	25,0	12,0	112,9	4	DH / II	
1078	Insects	*Callimorpha quadripunctaria*	22,2	33,3	38,0	4,0	97,6	4	DH / II	
1083	Insects	*Lucanus cervus*	14,8	33,3	37,5	2,0	87,6	4	DH / II	*
1324	Mammals (Bats)	*Myotis myotis*	40,7	33,3	50,0	12,0	136,1	4	DH / II + IV	*
1309	Mammals (Bats)	*Pipistrellus pipistrellus*	48,1	50,0	12,5	8,0	118,6	4	DH / IV	
1318	Mammals (Bats)	*Myotis dasycneme*	22,2	16,7	50,0	4,0	92,9	4	DH / II + IV	*
1331	Mammals (Bats)	*Nyctalus leisleri*	11,1	16,7	12,5	2,0	42,3	4	DH / IV	
1337	Mammals (Non-flying)	*Castor fiber*	51,9	16,7	37,5	14,0	120,0	4	DH / II + IV	*
1191	Amphibians	*Alytes obstetricans*	40,7	16,7	0,0	8,0	65,4	3	DH / IV	*
1202	Amphibians	*Bufo calamita*	14,8	16,7	0,0	6,0	37,5	3	DH / IV	
A236	Birds	*Dryocopus martius*	66,7	16,7	0,0	22,0	105,3	3	DO / I	*
A072	Birds	*Pernis apivorus*	66,7	16,7	0,0	14,0	97,3	3	DO / I	
A338	Birds	*Lanius collurio*	51,9	16,7	0,0	28,0	96,5	3	DO / I	*
A246	Birds	*Lullula arborea*	33,3	16,7	0,0	18,0	68,0	3	DO / I	*
A030	Birds	*Ciconia nigra*	44,4	16,7	0,0	6,0	67,1	3	DO / I	*
A224	Birds	*Caprimulgus europaeus*	11,1	16,7	0,0	6,0	33,8	3	DO / I	*
1321	Mammals (Bats)	*Myotis emarginatus*	33,3	33,3	50,0	0,0	116,7	3	DH / II + IV	*
1314	Mammals (Bats)	*Myotis daubentonii*	37,0	33,3	0,0	6,0	76,4	3	DH / IV	
1327	Mammals (Bats)	*Eptesicus serotinus*	22,2	50,0	0,0	2,0	74,2	3	DH / IV	
1330	Mammals (Bats)	*Myotis mystacinus*	25,9	33,3	0,0	6,0	65,3	3	DH / IV	
1320	Mammals (Bats)	*Myotis brandtii*	7,4	50,0	0,0	4,0	61,4	3	DH / IV	
1326	Mammals (Bats)	*Plecotus auritus*	14,8	33,3	0,0	8,0	56,1	3	DH / IV	
1312	Mammals (Bats)	*Nyctalus noctula*	14,8	33,3	0,0	4,0	52,1	3	DH / IV	
1323	Mammals (Bats)	*Myotis bechsteinii*	7,4	33,3	0,0	2,0	42,7	3	DH / II + IV	*
1283	Reptiles	*Coronella austriaca*	18,5	16,7	0,0	14,0	49,2	3	DH / IV	*
1213	Amphibians	*Rana temporaria*	88,9	0,0	0,0	22,0	110,9	2	DH / V	
1207	Amphibians	*Rana lessonae*	7,4	33,3	0,0	0,0	40,7	2	DH / IV	
2353	Amphibians	*Triturus alpestris*	25,9	0,0	0,0	6,0	31,9	2	-	
5916	Amphibians	*Triturus helveticus*	18,5	0,0	0,0	6,0	24,5	2	-	
1203	Amphibians	*Hyla arborea*	0,0	16,7	0,0	4,0	20,7	2	-	

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2361	Amphibians	*Bufo bufo*	3,7	0,0	0,0	12,0	15,7	2	-	
A234	Birds	*Picus canus*	55,6	0,0	0,0	16,0	71,6	2	DO / I	
A238	Birds	*Dendrocopos medius*	51,9	0,0	0,0	12,0	63,9	2	DO / I	
A229	Birds	*Alcedo atthis*	37,0	0,0	0,0	18,0	55,0	2	DO / I	*
A074	Birds	*Milvus milvus*	25,9	0,0	0,0	16,0	41,9	2	DO / I	
A215	Birds	*Bubo bubo*	22,2	0,0	0,0	18,0	40,2	2	DO / I	
A052	Birds	*Anas crecca*	29,6	0,0	0,0	6,0	35,6	2	DO / Art. 4.2	
A275	Birds	*Saxicola rubetra*	22,2	0,0	0,0	8,0	30,2	2	DO / Art. 4.2	
A059	Birds	*Aythya ferina*	0,0	16,7	0,0	2,0	18,7	2	DO / Art. 4.2	
A073	Birds	*Milvus migrans*	7,4	0,0	0,0	8,0	15,4	2	DO / I	
A082	Birds	*Circus cyaneus*	11,1	0,0	0,0	4,0	15,1	2	DO / I	
A103	Birds	*Falco peregrinus*	7,4	0,0	0,0	4,0	11,4	2	DO / I	
A055	Birds	*Anas querquedula*	7,4	0,0	0,0	2,0	9,4	2	DO / Art. 4.2	
A222	Birds	*Asio flammeus*	7,4	0,0	0,0	2,0	9,4	2	DO / I	
A068	Birds	*Mergus albellus*	3,7	0,0	0,0	2,0	5,7	2	DO / I	
A094	Birds	*Pandion haliaetus*	3,7	0,0	0,0	2,0	5,7	2	DO / I	
1400	Bryophytes	*Leucobryum glaucum*	25,9	0,0	0,0	2,0	27,9	2	DH / V	
1106	Fishes	*Salmo salar*	0,0	16,7	25,0	0,0	41,7	2	DH / II + V	
1134	Fishes	*Rhodeus sericeus amarus*	11,1	16,7	0,0	0,0	27,8	2	DH / II	
4038	Insects	*Lycaena helle*	44,4	0,0	0,0	8,0	52,4	2	DH / II + IV	*
1042	Insects	*Leucorrhinia pectoralis*	14,8	16,7	0,0	0,0	31,5	2	DH / II + IV	
1322	Mammals (Bats)	*Myotis nattereri*	37,0	33,3	0,0	0,0	70,4	2	DH / IV	
1304	Mammals (Bats)	*Rhinolophus ferrumequinum*	18,5	33,3	0,0	0,0	51,9	2	DH / II + IV	
1317	Mammals (Bats)	*Pipistrellus nathusii*	7,4	33,3	0,0	0,0	40,7	2	DH / IV	
1363	Mammals (Non-flying)	*Felis silvestris*	85,2	0,0	0,0	6,0	91,2	2	DH / IV	*
1358	Mammals (Non-flying)	*Mustela putorius*	59,3	16,7	0,0	0,0	75,9	2	DH / V	
1341	Mammals (Non-flying)	*Muscardinus avellanarius*	40,7	16,7	0,0	0,0	57,4	2	DH / IV	*
1355	Mammals (Non-flying)	*Lutra lutra*	3,7	16,7	0,0	0,0	20,4	2	DH / II + IV	*
1357	Mammals (Non-flying)	*Martes martes*	3,7	16,7	0,0	0,0	20,4	2	DH / V	
1026	Molluscs	*Helix pomatia*	29,6	0,0	0,0	8,0	37,6	2	DH / V	
1029	Molluscs	*Margaritifera margaritifera*	3,7	0,0	0,0	6,0	9,7	2	DH / II + V	
5191	Pterydophytes	*Lycopodiella inundata*	11,1	0,0	0,0	2,0	13,1	2	DH / V	
5910	Reptiles	*Zootoca vivipara*	44,4	0,0	0,0	14,0	58,4	2	-	

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1256	Reptiles	*Lacerta muralis*	37,0	0,0	0,0	10,0	47,0	2	DH / IV	
2432	Reptiles	*Anguis fragilis*	22,2	0,0	0,0	10,0	32,2	2	-	
2469	Reptiles	*Natrix natrix*	3,7	0,0	0,0	18,0	21,7	2	-	

[a] Index of commonness ; [b] Number of administrative units were the species is present; [c] Status according to the European Directives and Annexes (DH = Habitat Directive; DO = Bird Directive); [d] Species selected in Table 8 are indicated with an asterisk.