Interreg CENTRAL EUROPE

Co-funded by the European Union

ReCo

Transnational and regional GIS survey along European Green Belt in Central Europe (D.1.2.1)

31. 1. 2024

Title: GIS surveys along Green Belt

Deliverable: D.1.2.1

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Publication developed as a part of the project “ReCo – Restoring degraded eco-systems along the Green Belt to improve and enhance biodiversity and ecological connectivity” (www.interreg-central.eu/projects/reco), supported by the Interreg CENTRAL EUROPE Programme with co-financing from the European Regional Development Fund.

Contents

1. Introduction

The main aim of the ReCo project is to provide solutions to improve protection and conservation of habitats along the Central European Green Belt (CE EGB). The focus is dominantly on degraded ecosystems or ecosystems threatened by degradation, resulting from climate change, increased land use pressure or fragmentation. It is necessary to identify these ecosystems in order to target them. For this, innovated solutions using geoinformation and data processing systems are implemented. These solutions include using satellite and other available data, historical analysis, the concept of ecosystem services and broader habitat types' classification.

This report describes in detail all above mentioned innovative solutions, which were applied in ReCo's six pilot regions. By applying ecosystem services concept, the project will identify restoration hotspots along the CE EGB, hence areas with a particular need for restoration to enhance not only ecological connectivity but also to increase interconnectivity of habitats and to mitigate climate change effects. A historical analysis will help to identify areas with a high potential of success for sustainable restoration, hence promoting economic viability of public funds. Using broader habitat types' classification will ensure comparability between the pilot regions and transferability of results to other parts of Europe and world.

2. Present broader habitat types' maps

2.1. Data

The development of a comprehensive, unified map for each of the 6 pilot regions across Central Europe and the consequent translation to the BHT system required a collection of many different data sets. Depending on the available data and the covered extend in every pilot region, different methods were applied to fill the gaps in those habitat maps.

The basic data set covering the entirety of Europe is the complementation and extension of the CORINE Land Cover data: higher resolving CLC+ Backbone. It consists of an 11-class 10 m spatial resolution raster and is provided as a product of the EU Copernicus Land Monitoring Service (CLMS; ESA, 2018). The CLC+ Backbone was supposed to be applied mainly for the extended pilot regions, in case of lacking mapping data. But it also was also used for closing information gaps in the PR left by existing national and/or regional habitat maps or even provide a higher degree of detail in some cases.

For polish pilot region (PR5 - Kaszubski Park Krajobrazowy), it was necessary to integrate products of the High-Resolution Layers for forest types, grassland and waterbodies and wet land. These data were provided by the Copernicus programme since no data was available for PR5 that suited the needs of the methods and project.

Another important data source was the Sentinel-2 satellite imagery. This approach required a sound set of trainings data; thus it was not always possible to receive valid results, used for the classification of pilot region 6 (*National Park Thayatal & Podyjí*) and was attempted for pilot region 1 (*Fichtelgebirge-Smrčiny Mountains)*. Unfortunately, not all the provided trainings data for the target area suited the requirements and the approach was changed to merging the existing data for the German part with the CLC+ Backbone data. The Czech part was covered by the KVES data set.

Detailed and comprehensive habitat maps like the KVES data set were the last valuable source of information. For the pilot regions 2 (*Isonzo River Delta Nature Reserve*), 3 (*Škocjanski zatok Nature Reserve*) and 4 (*Karavanke Region*) as well as the Czech part of pilot region 1, the biotope mapping provided by the project partners were covering the whole area and had sufficient thematic and spatial detail. For this reason, they could be used as they were for the further analyses.

The combinations of the different data sources for each pilot region is shown in the table below (Table 1).

Table 1 The different data sources used in Activity 1.2 for each pilot region.

Pilot region / *Data source*	**PR1 - Fichtelgebirge -Karlovarský kraj (DE/CZ)**	**PR2 - Isonzo River Delta Nature Reserve (IT)**	**PR3 - Škocjanski zatok Nature Reserve (SI)**	**PR4 - Gorenjska region (SI)**	**PR5 - Kaszubski Park Krajobrazowy (PL)**	**PR6 - National Park Thayatal & Podyjí (AT/CZ)**
CLC+ Backbone	•	•		•	•	•
Copernicus HRL					•	
Sentinel-2 data	•					•
Regional mapping data	•	•	•	•		•

2.2. Methods

As a common classification system for the "ReCo" Interreg CE project, the broader habitat types (BHT) classification according to Bunce et al. (2008, 2011) was chosen. Also, this system was already used in the preliminary Interreg DTP project "DaRe to Connect". It is based on the EUNIS classification, a hierarchical system of habitats across the European Union. It is subdivided into several levels as depicted in Table 2.

Table 2 Hierarchical level 1-5 of the EUNIS habitat classification system.

EUNIS level	Designation	Example	
		Code	Name
1	Environment	G	Woodland, forest and other wooded land
2	Broader Habitat Types	G1	Broadleaved deciduous woodland
3	Habitat Complex	G1.1	Riparian and gallery woodland, with dominant *Alnus, Betula, Populus* or *Salix*
4	Biotope Complex	G1.11	Riverine Salix woodland
5	Biotopes	G1.111	Middle European Salix alba forests

The first step to develop a unified data set for the means of the project was to check and set up the regional and transnational data sets of the partners and products obtained from the CLMS. During this process, the literature Copernicus was to screen the reference catalogues and manuals that describe the different classification systems used in each pilot region. Based on their definitions, the habitat types were translated to the respective broader habitat types. The result was a common list of BHTs relevant for the project.

As base for the entire project area, the raster data of CLC+ Backbone was used, reclassified, vectorized and adjusted to the extent of the pilot regions separately, so the large geodata could be handle easier. Later it could be clipped as needed for the pilot regions with gaps in their BHT map.

The core area of pilot region 3 was completely covered by the provided data of the existing habitat maps of the marine and freshwater area of the Škocjanski zatok Nature Reserve near Koper. Additionally for the extended pilot region, the data sets of the Gorenjska region (PR4) could be used. They consisted of the governmental land use database and the Nature conservation atlas, which is a collection of data of:

- Natura 2000 sites
- Ecologically important areas
- Valuable natural features
- Rare, valuable, or famous natural phenomena
- Protected areas, such as natural parks (national, regional, local), natural reserves, and natural monuments

The data of pilot region 4 was merged with the High-Resolution Layer for forest types, since the thematic and spatial resolution was a significant improvement compared to the rough class of "forests" in the dataset. This covered the core area as well as the extended pilot region.

Pilot region 2 also had a sound data set for the core area available but needed to be complemented in the extended area using CLC+ Backbone data.

For pilot region 6 and 1 trainings data derived from the provided biotope mappings and other data sets was prepared for further analysis. This approach uses machine learning to classify Sentinel-2 satellite imagery via the programme Automap (Sassik, 2020). This method depends on high-quality, solid trainings data that is also available in sufficient quantities within the study area, to give valid results. Various mappings of biotope types, habitats, vegetation recordings, etc. are required, so they can serve as a reverence for the analysis. These trainings data sets should ideally be well distributed throughout the area and as up to date as possible. By recognizing the characteristic, phenological patterns of multi-spectral information, each pixel with a resolution of 10m is categorized according to the given classes of the trainings data.

For pilot region 5, as by far the largest of the 6 pilot regions, the approach of using Sentinel-2 data to classify the core area was not an option. Although the project partners of GAIA (PP0%) were diligent in send all the databases and sources they could gather, no feasible trainings data in the form of digitized mapping data of habitats or biotope types as a shapefile could be acquired. Therefore, we were not able to use Automap.
The solution was the use of other sources provided by the CLMS that were directly derived from the Sentinel-2 satellite data (CLC+ Backbone) or were other products (HRL for forest types, grassland, water & wetness). These data sets cover information not older than the last 3-5 years and have a resolution of 10m. To elaborate the most detailed BHT map possible, those data sets were merged for PR5 to improve the information of the CLC+ Backbone data.

The result of this preparational work was the unified geodata set containing the broader habitat types as detailed as possible. The legend in Figure 1 shows the occurring BHTs of the exemplary maps of PR 2 (Figure 2), PR 3 (Figure 3) and PR4 (Figure 4).

Figure 1 Legend of all broader habitat types of pilot region 2.

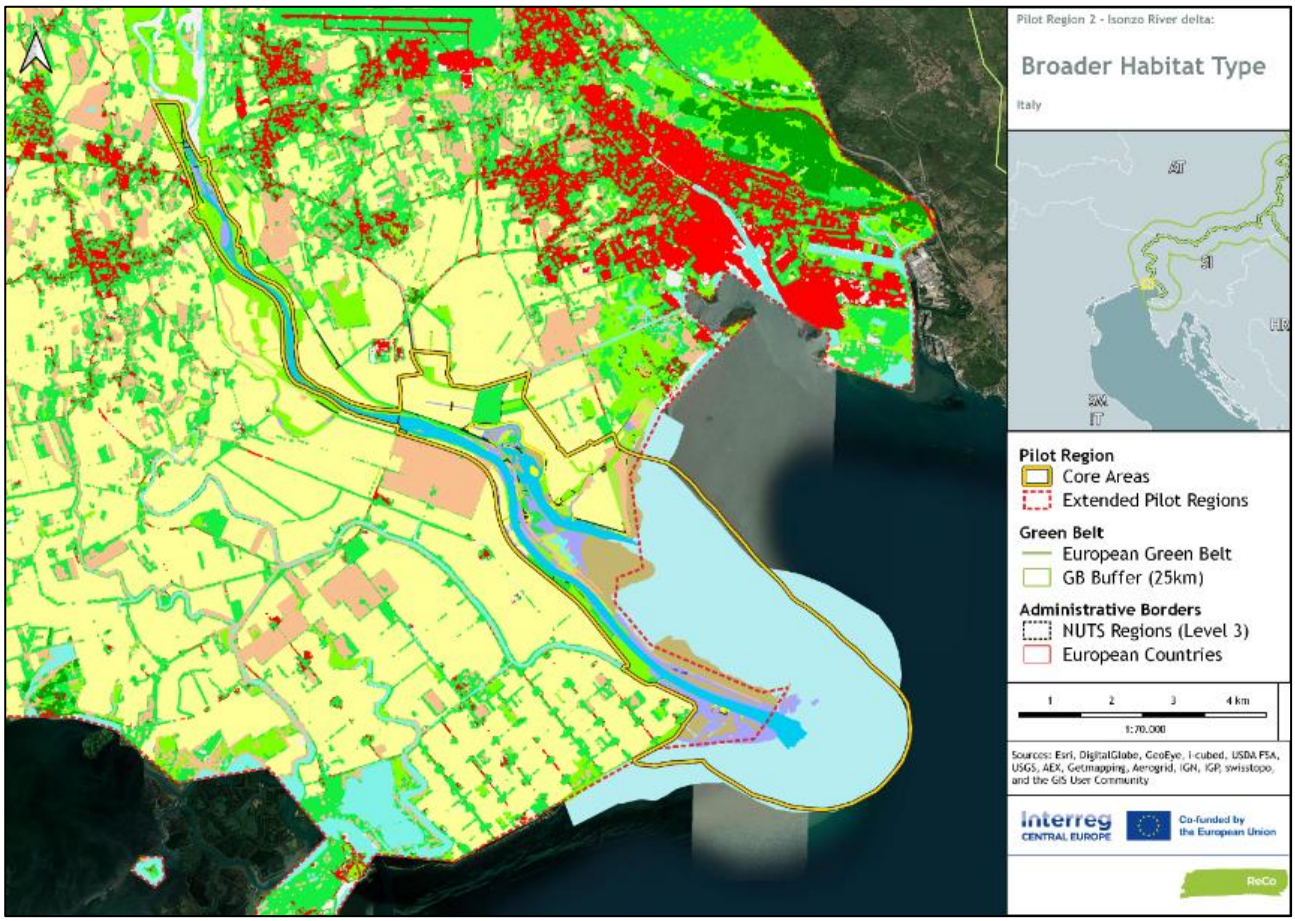


Figure 2 Broader habitat types of the core area of pilot region 2.

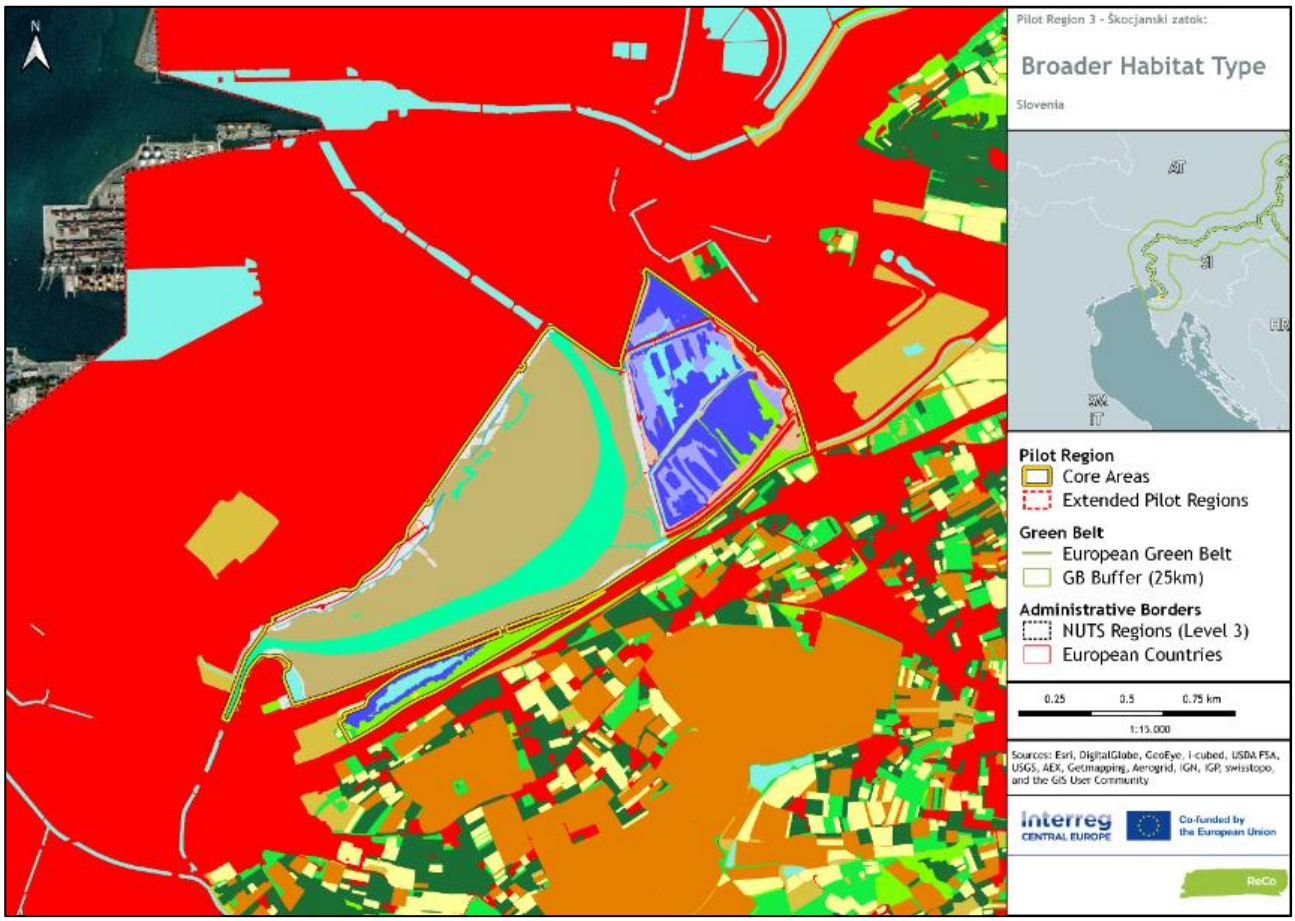


Figure 3 Broader habitat types of the core area of pilot region 3.

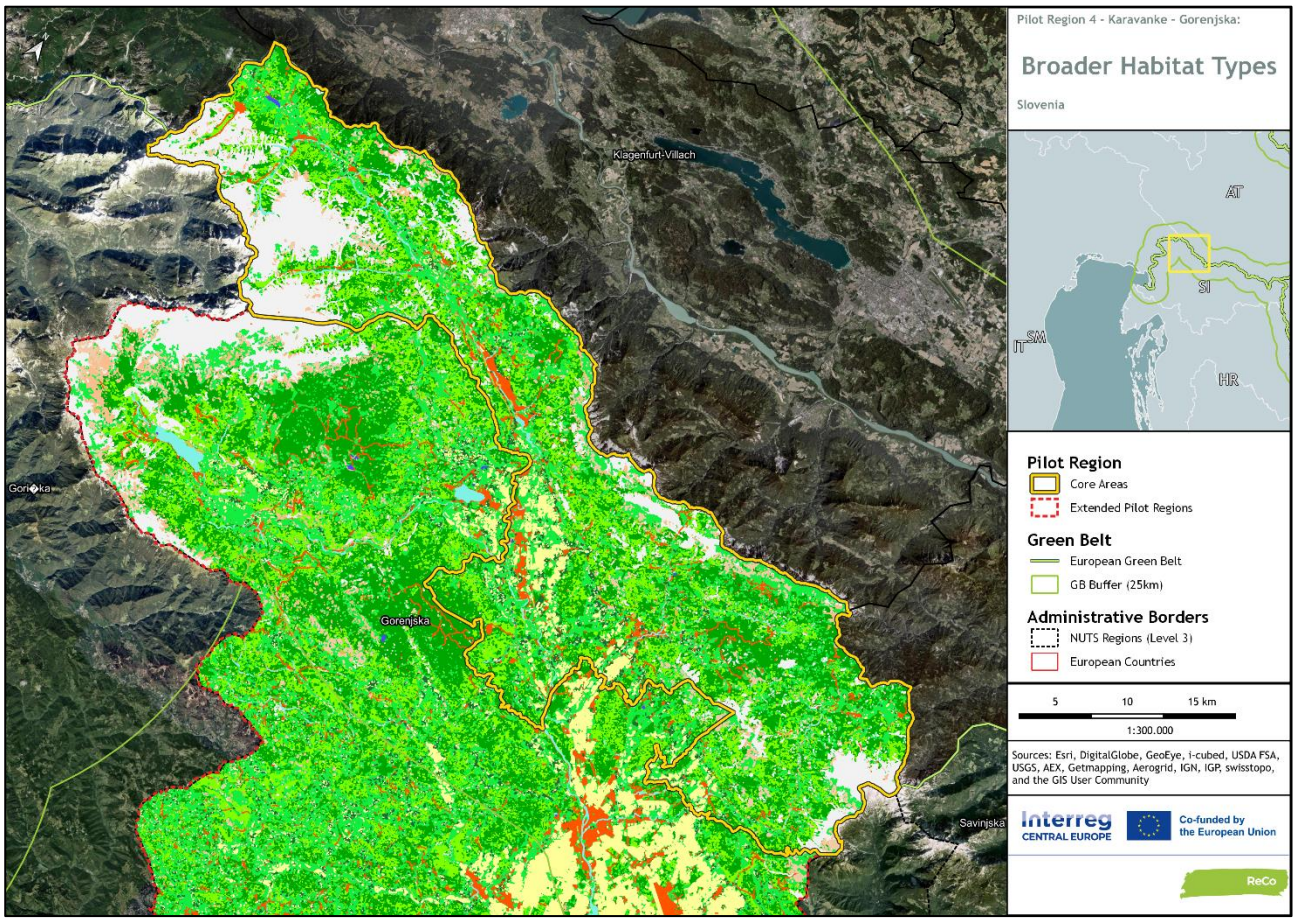


Figure 4 Broader habitat types of the core area of pilot region 4.

3. Historical land cover maps

3.1. Data

For the historical analysis, the maps from the second half of the 19th century were used. These maps show relatively well-preserved landscape structure without large-scale human interventions. All maps were created at the scale of 1:25 000. Different pilot regions were covered by maps from different mapping surveys: pilot regions 2 (Isonzo River delta, IT), 3 (Škocjanski zatok, SI), 4 (Karavanke – Gorenjska, SI), 6 (Podyjí/Thayatal, CZ/AT) and Czech part of pilot region 1 (Smrčiny – Karlovarský kraj) were covered by maps from 3rd Austrian military survey; German part of pilot region 1 (Fichtelgebirge) was covered by maps from Königreichs Bayern survey; and pilot region 5 (Ińsko lakeland, PL) was covered by maps from Prussian military survey. All maps were provided by Arcanum maps (https://maps.arcanum.com/en/) in the form of wmts or obtained from Österreichisches Staatsarchiv as digitized raster map sheets. More detail about the surveys is given in the following text.

3rd Austrian military survey

3rd Austrian military survey was carried out in the late 19th century, in case of the pilot regions, the maps were produced between 1870 and 1877. They recorded quite precise topography, including different types of land cover/land use types, as well as elevation data. While the land use/land cover classes were captured by a combination of colour, the elevation was captured by combination of spot heights, hatches and contour lines (Figure 5).

The maps can be sometimes harder to read due to faded colours and hatches. The main land cover/land use types that can be distinguished on these maps include arable land, pastures, meadows, vineyards, orchards and gardens, parks, hop-fields, rice-fields, forests, water bodies and water streams, sea, wetlands, swamps, peatbogs, wet grasslands, wet forests and individual trees.

Figure 5 Example of map from 3rd Austrian military survey (surroundings of Hnanice, CZ; Pilot region 6 – Podyjí – Thayatal).

Königreich Bayern maps

Maps for the German/Bavarian part of pilot region 1 were based on the topographic survey that stemmed from the cadastral survey from the 1808-1864. The cadastral maps at scale 1:5 000 were generalized to scale 1:25 000. Maps used in the Pilot region 1 were from 1848. The maps were black and white and showed main land cover/land use types recorded by symbols as well as elevation captured by hatches (Figure 6).

The land cover/land use types included buildings, arable fields, forests, meadows, pastures, wetlands, gardens, vineyards, hop-fields, peatbogs, water bodies and individual trees.

Figure 6 Example of map from Königreich Bayern survey (surroundings of Reichenbach, DE; Pilot region 1 – Fichtelgebirge – Smrčiny).

Prussian military survey

Prussian military survey was carried out in the second half of the 19th century. The maps used for capturing land cover for Polish pilot region (5) were from 1877. They were black and white with blue water bodies. The land cover/land use types were distinguished by symbols, elevation by contour lines, making the maps easily readable (Figure 7).

The land cover/land use types included different types of forest (deciduous, coniferous, mixed), shrubs, pastures, meadows, sand or gravel, swamps, wetlands, peatbogs, vineyards, hop-fields, wet ground, buildings, water bodies and rivers.

Figure 7 Example of map from Prussian military survey (surroundings of Kozy, PL; Pilot region 2 – Ińsko Lakeland).

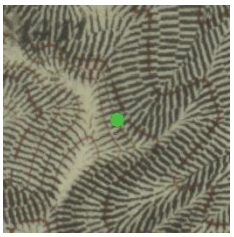
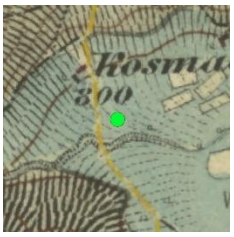
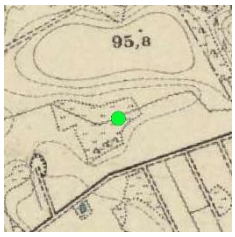
3.2. Creating historical land cover maps

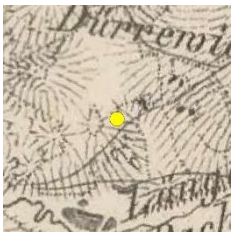
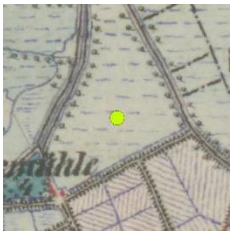
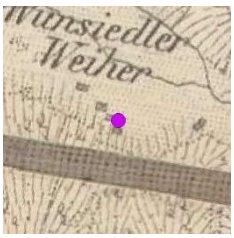
Thanks to the size of individual pilot region, technical complexity of map processing and simultaneous time restriction related to delivering this output, historical land cover maps were in some cases made only for core areas, in other cases for the whole extended areas. Historical land cover maps were generated for core areas of pilot region 1 (Fichtelgebirge – Smrčiny), pilot region 4 (Karavanke – Gorenjska) and pilot region 5 (Ińsko Lakeland). Regarding extended areas, the historical land cover maps were made for pilot region 2 (Isonzo River delta), pilot region 3 (Škocjanski zatok) and pilot region 6 (Podyjí – Thayatal).

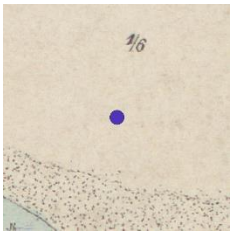
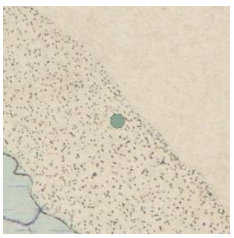
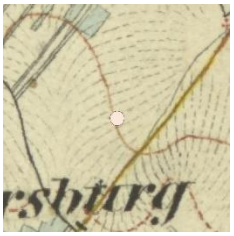
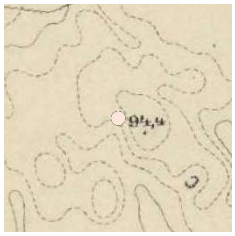
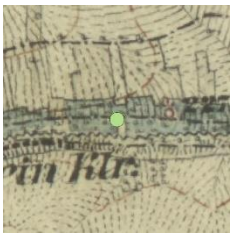
To capture historical land cover, we combined all land cover/land use types from used military surveys and distinguished 18 land cover classes: Arable land, Orchard, Vineyard, Meadow, Pasture, Wet grassland, Grassland with trees, Forest, Wet forest, Wetland, Peatbog, Salt marsh, River, Water body, Sea, Settlement, Bare surface – rock, Bare surface – gravel bar, Bare surface – beach.

Due to the different quality of the historical maps and time restriction, the historical land cover was captured in the form of regular grid, with the minimum size of 250 m. From the grid, we extracted centroid/point and visually assigned land cover class, from the underlying map, i.e. if a point laid in an area symbolized as forest, the corresponding land cover class was forest. Examples of captured individual land cover classes in used historical maps are shown in Table 3 Examples of capturing historical land cover classes on used historical maps. This table shows examples only from pilot regions.

Table 3 Examples of capturing historical land cover classes on used historical maps.

Land cover class	Austrian military survey	Prussian military survey	Königreichs Bayern survey
Forest			
Wet forest			
Meadow			

Pasture			
Grassland with trees			
Wet grassland			
Wetland			
Peatbog			
Salt marsh			
River			

Water body			
Sea			
Bare surface – rock			
Bare surface – gravel bar			
Bare surface - beach			
Arable land			
Orchard			

Vineyard			
Settlement			

Not all land cover classes occurred in every pilot region. Therefore

Table 4 shows, which land cover classes could be found in which pilot region. From this table, it is clear that some land cover classes are unique only for several pilot regions (like sea or salt marshes for sea-bound pilot regions of Isonzo River delta and Škocjanski zatok, or vineyards for warm pilot regions of Isonzo River delta, Škocjanski zatok and Podyjí - Thayatal), while other can be found in all pilot regions regardless their location.

Table 4 Presence of historical land cover in pilot regions (PR)

Land cover class	PR 1 Fichtelgebirge - Smrčiny	PR 2 Isonzo River delta	PR 3 Škocjanski zatok	PR 4 Karavanke - Gorenjska	PR 5 Ińsko lakeland	PR 6 Podyjí - Thayatal
Forest	X	X	X	X	X	X
Wet forest		X			X	
Meadow	X	X	X	X	X	X
Pasture	X	X	X	X	X	X
Grassland with trees	X	X	X	X	X	X
Wet grassland	X	X	X	X	X	X
Wetland	X	X			X	
Peatbog	X				X	
Salt marsh		X	X			

River	X	X		X	X	X
Water body	X	X			X	X
Sea		X	X			
Bare surface – rock				X		
Bare surface – gravel bar		X		X		
Bare surface - beach		X				
Arable land	X	X	X	X	X	X
Orchard		X		X		X
Vineyard		X	X			X
Settlement	X	X	X	X	X	X

Example of the historical land cover map is shown in the following Figure 8.

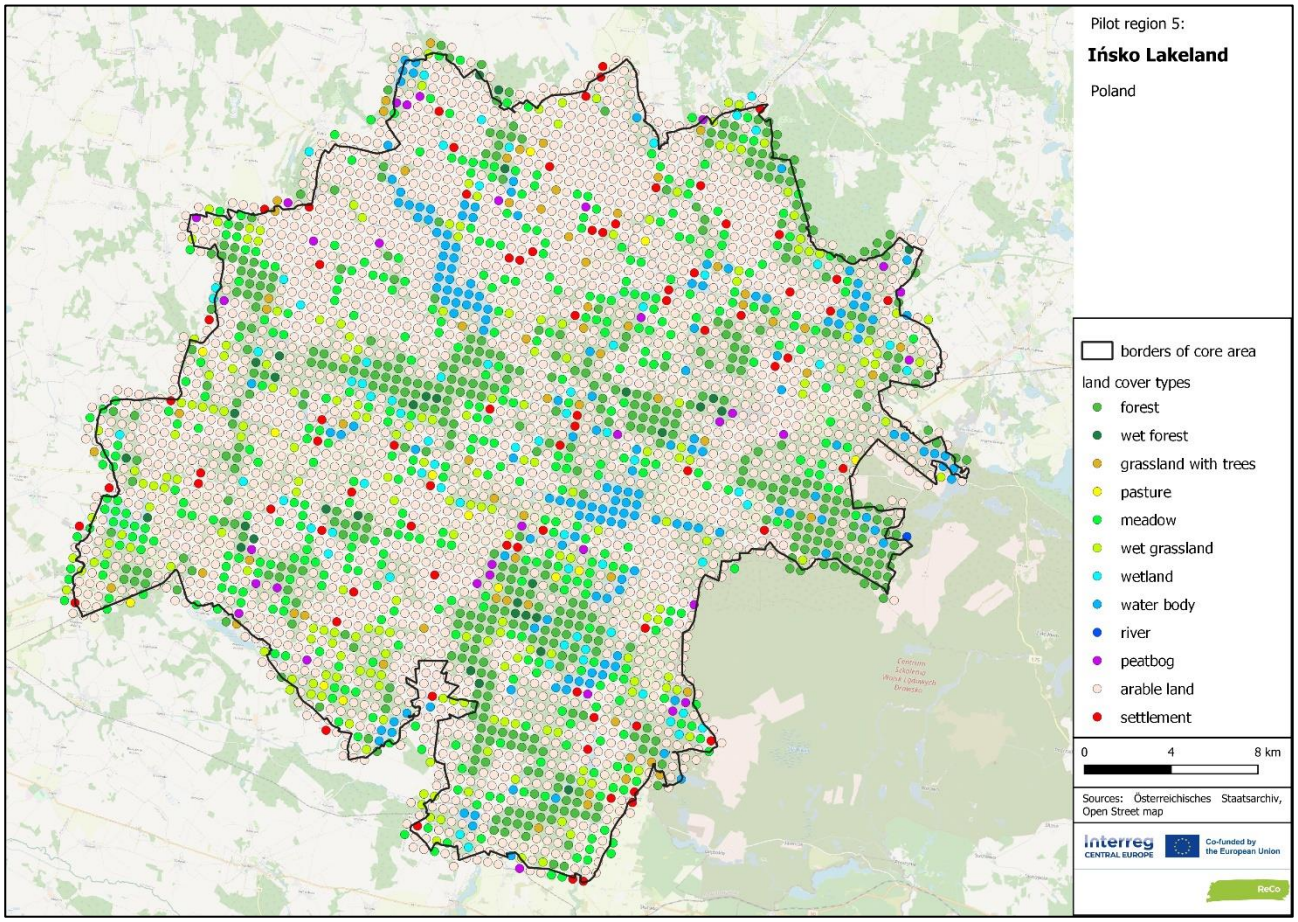


Figure 8 Historical land cover map of pilot region 5.

4. Analysis of land cover change

Historical maps due to their purpose (mainly for military use) and generalization cannot capture individual habitats or broader habitat types described in chapter 2. Therefore, we assigned historical land cover classes to broader habitat types (see Table 5). That enabled us to analyse habitat changes between 19th century and present situation and therefore capture hotspots in terms of significant changes from natural/semi-natural habitats to degraded habitats as well as changes of ecosystem services.

Table 5 Relationship between historical land cover classes and broader habitat types

Land cover class	Broader habitat type
Forest	Broadleaved deciduous woodland Coniferous woodland Mixed deciduous and coniferous woodland Line of trees, small anthropogenic woodlands, recently felled woodland, early-stage woodland and coppice
Wet forest	Broadleaved deciduous woodland Coniferous woodland Mixed deciduous and coniferous woodland
Meadow	Dry grasslands Mesic grasslands, intensively managed Mesic grasslands, medium intensive Alpine and subalpine grasslands Woodland fringes and clearings, tall forb stands
Pasture	Dry grasslands Mesic grasslands, intensively managed Mesic grasslands, medium intensive Alpine and subalpine grasslands Inland salt steppes Tundra
Grassland with trees	Sparsely wooded grasslands Arctic, alpine and subalpine scrub Temperate and Mediterranean-montane scrubs and heathland Maquis, arborescent matorral and thermo-Mediterranean brushed Spiny Mediterranean heaths (prygana, hedgehog-heaths and related coastal cliff vegetation) Riverine and fen scrubs

	Hedgerows
Wet grassland	Seasonally wet and wet grasslands
Wetland	Littoral zone of inland waterbodies
Peatbog	Mires, bogs and fens
Salt marsh	Saline coastal lagoons
River	Inland surface waters - watercourses
Water body	Inland surface waters - waterbodies Highly artificial man-made waters and associated structures
Sea	Marine habitats Estuaries
Bare surface - rock	Littoral rock Rock cliffs, ledges and shores Inland unvegetated or sparsely vegetated habitats
Bare surface - gravel bar	Inland unvegetated or sparsely vegetated habitats
Bare surface - beach	Littoral sediment Coastal dunes and shingle
Arable land	Arable land and market gardens - intensive Arable land and market gardens - low intensity Cultivated areas of gardens and parks
Orchard	Fruit and nut tree orchards
Vineyard	Shrub plantations
Settlement	Extractive industrial sites Transport networks and other constructed hard-surface areas Waste deposits Constructed, industrial and other artificial habitats - with significant green spaces Constructed, industrial and other artificial habitats - high imperviousness

We are aware that combining historical land cover and broader habitat types can lead to quite big simplification and that not all changes might be real. A clear example is meadows and pastures that are assigned to all grassland BHT, since we are comparing the habitat composition with habitat management. However, we believe that information about historical management, i.e. if the respective grassland was grazed or mowed, can be inspiring for present management plans.

The change analysis was done by overlaying both maps, i.e. historical land cover and broader habitat types. The changes were calculated as changes between these two maps and were grouped into six main groups, showing a broad overview of the changes. These groups included two groups of unchanged habitats and four groups of changed habitats:

a) unchanged – (semi)natural habitats: all (semi)natural habitats, like different types of grasslands, forests or water affected habitats

b) unchanged – anthropogenic habitats: all anthropogenic habitats related to settlements as was as agricultural habitats like arable fields, orchards or shrub plantations in the form of vineyards

c) change to anthropogenic habitats

d) change to (semi)natural habitats

e) change to permanent crops

f) change between (semi)natural habitats

Furthermore, other types of changes could be distinguished, based on the needs of pilot regions, or rather focus of the restoration habitat efforts. We have highlighted two main types of changes, the first related to drying out (semi)natural habitats and the second to overgrowing by woody vegetation. Unlike the five groups of changed habitats, which are clearly distinguished from each other and can therefore be easily depicted in one map (Figure 9), drying out (semi)natural habitats or overgrowing by woody vegetation can overlap and therefore should be depicted as features in individual maps (Figure 9).

The two main types of changes are showing different interpretations of the 6 change groups listed above. An example for historical habitats drying out would be a riparian forest or wet grassland got drained for a facilitated management or even sealed. Previously managed arable land or extensively or intensively used pastures were put out of use and became fallow land, being ultimately populated by shrubs and trees would be depicted as an overgrowing habitat.

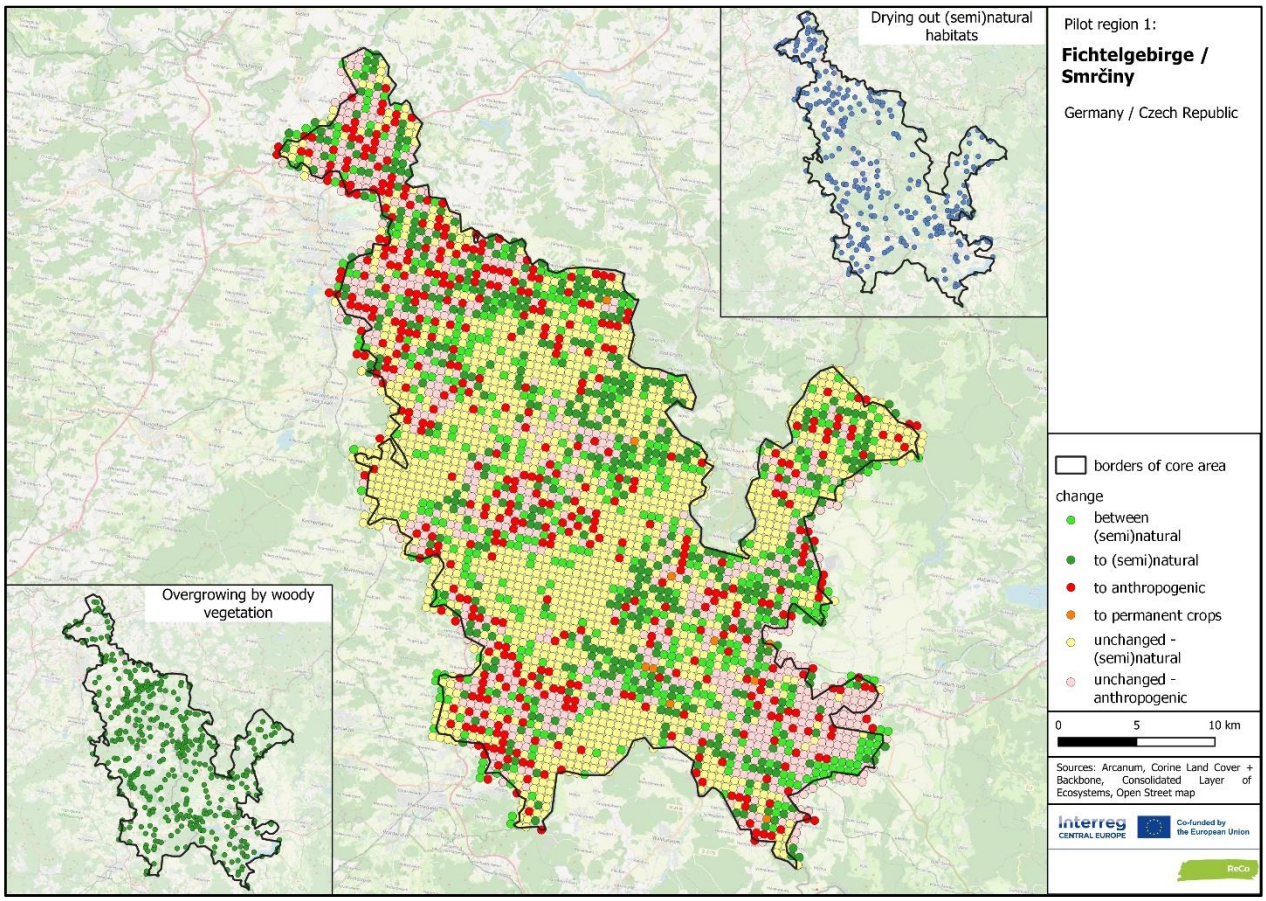


Figure 9 Change analysis of habitat types in pilot region 1. The main map shows six main groups while the smaller maps show drying out (semi)natural habitats (top right) and overgrowing by woody vegetation (bottom left).

5. Ecosystem services

Ecosystem services (ESS) are usually measured using capacity matrices that assign a certain value to each referenced land cover type – in the case of ReCo BHTs – depending on the potential amount of provided ESS. Following an approach that was introduced in 2009 by Burkhard et al. this apporach has been further developed and applied in many studies (Campagne et al. 2017).

The capacity matrix used in the project was derived from an existing matrix for the entirety of Europe by Stoll et al. (2015), which then was assigned to the definitions of landscape services by de Groot et al. (2002, 2006 and 2010). It consists of 5 main services, that can be subdivded into a total of 30 single ESS (e.g. Clime regulation or water retention for the main service "Regulation function"). As an indicator for the sum of the functionality of a BHT, all the values can be aggregated to the total function value (TFV). The TFV is the aggregation of the weighted values for each function group. They are calculated by dividing the actual sum of the capacity score within the main service by the highest possible score. Eventually, the total function value is the mean of the 5 weighted main service values, scaled on a basis from 0 to 100, where 0 means no capacity at all and 100 hypothetically represents land cover classes providing full capacity in each single service. This way the total function value represents the total amount of capacity of all landscape services. (Danzinger et al. 2020)

The Millennium Ecosystem Assessment (MEA) defines "ecosystem services" to comprise various benefits for human well-being that are provided by ecosystems. They can be divided into four categories:

- Provision services (e.g. food, fresh water)
- Regulating services (e.g. climate regulation, pollination)
- Cultural services (e.g. recreation, education)
- Supporting services (e.g. soil formation, photosynthesis)

Furthermore, these services of ecosystems also consitute a high economical value, besides sustaining fundamental needs of mankind (MEA, 2005; TEEB, 2010).

The capacity matrix tries to quantify this provision of benefits by assigning capacities values to each single ESS, ranging from a value of 0 to 5 as described below:

- 0 - no relevant capacity of providing this ESS,
- 1 - low relevant capacity,
- 2 - relevant capacity,
- 3 - medium relevant capacity,
- 4 - high relevant capacity and
- 5 - very high relevant capacity

Based on the approach of MaGICLandscapes' 'Green Infrastructure Handbook - Conceptual & Theoretical Background, Terms and Definitions' (John et al., 2019) we also applied the concept of ESS into the 5 main categories (de Groot 1992 and de Groot et al. 2002):

- **Regulation functions**: This group of functions relates to the capacity of natural and semi-natural ecosystems to regulate essential ecological processes and life support systems through biogeochemical cycles and other biospheric processes. Regulation functions maintain a "healthy" ecosystem on different scales and, at the biosphere level, provide and maintain the conditions for life on earth. In many ways, these regulation functions provide the necessary pre-conditions for all other functions. Thus, care should be taken not to double count their value in economic analysis. In

theory, the number of regulation functions would be almost unlimited, but for landscape planning, only those regulation functions are considered that provide services, which have direct and indirect benefits to humans (such as maintenance of clean air, water and soil, prevention of soil erosion and biological control services).” (de Groot 2006, p. 177)

- **Habitat functions**: Natural ecosystems provide refuge and reproduction-habitat for wild plants and animals and thereby contribute to the (in situ) conservation of biological and genetic diversity and evolutionary processes. As the term implies, habitat functions relate to the spatial conditions needed to maintain biotic (and genetic) diversity and evolutionary processes. The availability, or condition, of this function is based on the physical aspects of the ecological niche within the biosphere. These requirements differ for different species groups, but can be described in terms of the carrying capacity and spatial needs (minimum critical ecosystem size) of the natural ecosystems which provide them.” (De Groot 2006, pp. 177-178)
- **Production functions**: Photosynthesis and nutrient uptake by autotrophs converts energy, carbon dioxide, water and nutrients into a wide variety of carbohydrate structures, which are then used by secondary producers to create an even larger variety of living biomass. This biomass provides many resources for human use, ranging from food and raw materials (fibre, timber, etc.) to energy resources and genetic material.” (De Groot 2006, p. 178)
- **Information functions**: Because most of human evolution took place within the context of undomesticated habitat, natural ecosystems provide an essential ‘reference function’ and contribute to the maintenance of human health by providing opportunities for reflection, spiritual enrichment, cognitive development, re-creation and aesthetic experience.“ (De Groot 2006, p. 178)
- **Carrier functions**: Most human activities (e.g. cultivation, habitation, transportation) require space and a suitable substrate (soil) or medium (water, air) to support the associated infrastructure. The use of carrier functions usually involves permanent conversion of the original ecosystem. Thus, the capacity of natural systems to provide carrier functions on a sustainable basis is usually limited (exceptions are certain types of shifting cultivation and transportation on waterways, which, on a small scale, are possible without permanent damage to the ecosystem).” (De Groot 2006, p. 178)

The final matrix used for the current project can be seen in Figure 10. It includes the total function value and its mains services as well as the single ESS.

BHT_Code	BHT_Name	Regulation functions	Gas regulation	Climate regulation	Disturbance prevention	Water regulation	Water supply	Soil retention	Soil formation	Nutrient regulation	Waste treatment	Pollination	Biological control	Habitat functions	Refugium function	Nursery function	Production functions	Food	Raw material	Genetic resources	Medicinal resources	Ornamental resources	Information functions	Aesthetic information	Recreation	Cultural and artistic inf	Spiritual and historic ir	Science and educatio	Carrier functions	Habitation	Cultivation	Energy conversion	Mining	Waste disposal	Transportation	Tourism-facilities	Total Function Value
A	Marine habitats	3	3	5	2	4	5	3	1	1	5	5	0	3	5	5	5	5	3	5	5	5	5	5	5	5	5	5	1	0	2	0	0	4	3	1	77
A1	Littoral rock	2	0	3	5	3	0	1	1	1	3	0	2	5	5	4	2	3	0	3	3	2	4	4	4	2	4	4	0	0	0	0	0	0	1	0	49
A2	Littoral sediment	3	1	3	3	4	3	4	4	3	3	2	1	5	4	5	2	1	1	4	3	2	4	4	3	3	4	5	0	0	0	0	0	0	0	0	53
B1|2	Coastal dunes and shingle	2	1	2	5	5	2	2	2	1	1	1	1	5	4	5	2	0	1	4	2	3	4	5	5	2	4	4	0	0	1	0	0	0	0	2	52
B3	Rock cliffs, ledges and shores	0	0	0	1	1	1	0	0	0	0	0	1	3	4	4	1	2	0	3	2	3	3	4	4	0	5	4	0	0	0	0	0	0	0	2	33
C1	Inland surface waters - standing	3	2	4	3	4	5	3	4	3	5	0	3	5	5	5	3	3	2	5	3	3	5	4	5	5	4	5	1	0	0	3	0	0	3	3	69
C2	Inland surface waters - watercourses	3	2	4	3	4	5	2	1	3	5	2	1	5	5	5	3	3	2	5	4	2	5	4	5	5	4	5	1	0	0	4	0	0	3	3	70
C3	Littoral zone of inland waterbodies	4	4	4	4	5	4	5	5	4	4	2	1	5	5	5	3	1	2	5	4	2	4	4	4	4	4	5	0	0	0	2	0	0	0	1	63
D	Mires, bogs and fens	4	4	4	5	3	4	4	5	5	4	4	1	3	5	5	4	2	0	4	4	3	4	4	4	4	4	4	0	0	0	1	0	0	0	1	60
E1	Dry grasslands	4	3	3	3	3	4	4	5	5	4	3	4	4	5	5	3	2	1	5	3	4	5	5	5	4	4	5	0	0	0	1	0	0	0	1	67
E1	Dry grasslands	4	3	3	3	3	4	4	5	5	4	3	4	4	5	5	3	2	1	5	3	4	5	5	5	4	4	5	0	0	0	1	0	0	0	1	67
E2a	Mesic grasslands, intensively managed	3	1	3	1	3	1	4	4	2	3	3	3	4	4	3	3	5	2	3	3	1	3	4	4	3	1	3	1	0	0	5	0	0	0	1	51
E2a	Mesic grasslands, intensively managed	3	1	3	1	3	1	4	4	2	3	3	3	4	4	3	3	5	2	3	3	1	3	4	4	3	1	3	1	0	0	5	0	0	0	1	51
E2b	Mesic grasslands, medium intensive	4	3	3	3	4	4	5	5	4	3	4	4	5	5	5	3	2	1	5	3	4	5	5	5	4	4	5	1	0	0	1	0	0	0	1	67
E2b	Mesic grasslands, medium intensive	4	3	3	3	4	4	5	5	4	3	4	4	5	5	5	3	2	1	5	3	4	5	5	5	4	4	5	1	0	0	1	0	0	0	1	67
E3	Seasonally wet and wet grasslands	4	3	3	3	4	4	5	5	4	3	4	4	5	5	5	3	2	1	5	3	4	5	5	5	4	4	5	0	0	0	1	0	0	0	1	67
E4	Alpine and subalpine grasslands	1	1	1	1	1	2	1	1	1	1	2	1	4	4	4	2	0	0	3	2	3	3	4	4	3	1	4	0	0	0	0	0	0	0	0	40
E4	Alpine and subalpine grasslands	1	1	1	1	1	2	1	1	1	1	2	1	4	4	4	2	0	0	3	2	3	3	4	4	3	1	4	0	0	0	0	0	0	0	0	40
E5	Woodland fringes and clearings, tall forb stands	4	3	4	4	3	4	5	5	4	3	4	4	5	5	5	3	2	3	4	3	3	4	5	5	4	4	5	0	0	1	0	0	0	0	0	63
E6	Inland salt steppes	3	3	3	3	4	3	4	4	4	3	4	4	5	5	5	3	2	2	1	5	3	4	5	5	4	4	5	1	0	0	1	0	0	0	1	67
E7	Sparsely wooded grasslands	3	3	4	1	4	3	4	4	2	3	3	2	4	4	4	3	3	5	3	3	2	3	3	4	3	1	4	0	0	0	1	0	0	0	1	54
F1	Tundra	1	1	1	1	1	2	1	1	1	1	2	1	4	4	4	2	0	0	3	2	2	3	3	4	3	1	4	0	0	0	0	0	0	0	0	40
F2	Arctic, alpine and subalpine scrub	1	1	1	1	1	2	1	1	1	1	2	1	4	4	4	2	0	0	3	2	2	3	3	4	3	1	4	0	0	0	0	0	0	0	0	40
F3|4	Temperate and mediterranean-montane scrubs and heathland	4	3	4	4	4	4	5	5	4	3	3	4	5	5	5	3	2	3	5	3	4	5	5	4	4	5	5	0	0	0	0	0	0	0	1	69
F5	Maquis, arborescent matorral and thermo-Mediterranean brushes	4	3	4	4	3	3	5	5	4	3	4	4	5	5	5	4	3	3	5	3	4	4	4	5	4	3	4	0	0	0	0	0	0	0	1	67
F7	Spiny Mediterranean heaths (phrygana, hedgehog-heaths and related coastal cliff vegetation)	4	3	4	4	3	3	5	5	4	3	4	4	5	5	5	4	3	3	5	3	4	4	5	5	4	3	4	0	0	0	0	0	0	0	1	67
F9	Riverine and fen scrubs	4	3	4	4	4	4	5	5	4	3	3	4	5	5	5	3	2	3	5	3	4	5	5	5	4	4	5	0	0	0	1	0	0	0	1	69
FA	Hedgerows	4	3	4	4	3	4	5	5	4	3	4	4	5	5	5	3	2	3	4	3	3	4	5	5	4	4	5	0	0	0	1	0	0	0	0	63
FB	Shrub plantations	3	2	3	1	2	3	1	2	3	2	5	3	2	2	1	2	5	2	2	2	1	3	3	3	2	2	2	1	0	0	1	0	0	0	1	40
G1	Broadleaved deciduous woodland	5	5	5	5	5	5	5	5	5	4	4	5	5	5	5	3	5	5	5	5	5	5	5	5	5	5	5	1	0	0	1	0	0	0	2	79
G1	Broadleaved deciduous woodland	5	5	5	5	5	5	5	5	5	4	4	5	5	5	5	3	5	5	5	5	5	5	5	5	5	5	5	1	0	0	1	0	0	0	2	79
G1|D	Fruit and nut tree orchards	3	2	3	2	3	1	2	3	2	2	5	3	2	2	1	2	5	2	2	2	1	3	3	3	2	2	2	1	0	0	1	0	0	0	1	40
G3	Coniferous woodland	5	5	5	5	4	4	5	5	5	5	4	4	5	5	5	4	3	5	5	5	4	5	5	5	4	5	5	1	0	0	1	0	0	0	2	78
G3	Coniferous woodland	5	5	5	5	4	4	5	5	5	5	4	4	5	5	5	4	3	5	5	5	4	5	5	5	4	5	5	1	0	0	1	0	0	0	2	78
G4	Mixed deciduous and coniferous woodland	5	5	5	5	4	4	5	5	5	5	4	4	5	5	5	4	3	5	5	5	4	5	5	5	4	5	5	1	0	0	1	0	0	0	2	77
G4	Mixed deciduous and coniferous woodland	5	5	5	5	4	4	5	5	5	5	4	4	5	5	5	4	3	5	5	5	4	5	5	5	4	5	5	1	0	0	1	0	0	0	2	77
G5	Lines of trees, small anthropogenic woodlands, recently felled woodland, early-stage woodland and coppice	4	3	4	4	4	5	5	4	4	4	5	4	4	5	5	3	2	3	4	3	3	4	4	4	3	2	5	0	0	0	0	0	0	0	0	63
H	Inland unvegetated or sparsely vegetated habitats	1	1	1	1	1	2	1	1	1	1	2	1	1	4	4	2	0	0	3	2	2	3	3	4	3	1	4	0	0	0	0	0	0	0	0	40
H	Inland unvegetated or sparsely vegetated habitats	1	1	1	1	1	2	1	1	1	1	2	1	1	4	4	2	0	0	3	2	2	3	3	4	3	1	4	0	0	0	0	0	0	0	0	40
I1a	Arable land and market gardens - intensive	1	1	1	3	1	1	3	0	1	1	2	1	1	2	2	2	5	2	2	2	1	2	1	1	2	1	3	0	1	0	0	0	0	0	0	37
I1b	Arable land and market gardens - low intensity	2	2	3	1	3	2	3	3	2	2	3	3	4	3	4	3	3	2	3	2	2	3	3	3	3	3	3	1	1	0	0	0	0	0	2	49
I2	Cultivated areas of gardens and parks	2	1	3	1	3	1	2	3	1	2	3	3	4	3	3	2	4	2	1	2	2	3	2	3	3	2	2	1	1	4	0	0	0	1	0	39
J3	Extractive industrial sites	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	1	0	0	0	5	2	0	0	4
J4	Transport networks and other constructed hard-surfaced areas	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	1	1	0	0	0	1	0	0	0	0	5	2	0	8
J5	Highly artificial man-made waters and associated structures	3	2	4	3	4	5	2	1	3	5	0	0	3	5	5	5	3	3	2	5	3	4	5	5	5	4	5	1	0	0	4	0	0	3	3	70
J6	Waste deposits	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	0	0	0	0	5	0	0	3
Ja	Constructed, industrial and other artificial habitats - with significant green spaces	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	2	3	3	4	2	0	1	4	0	1	0	0	3	2	18
Jb	Constructed, industrial and other artificial habitats - high imperviousness	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	3	3	4	2	0	2	5	0	1	0	3	2	16
X1	Estuaries	3	3	5	3	4	4	3	3	3	5	0	4	5	5	5	4	4	2	5	3	4	5	5	4	4	5	4	1	0	3	1	0	0	2	1	70
X2|3	Saline coastal lagoons	4	3	5	4	4	4	4	4	4	5	2	3	5	5	5	3	4	1	5	3	4	5	5	5	4	5	4	0	0	0	0	0	0	0	1	68

Figure 10 Capacity matrix for the provided ecosystem services for each broader habitat type in the 6 pilot regions.

After joining the capacity matrix with the geodata set of the broader habitat types, maps of every ESS can be provided. The following figures show two examples for each main service, covering the core areas of pilot region 3 and 4.

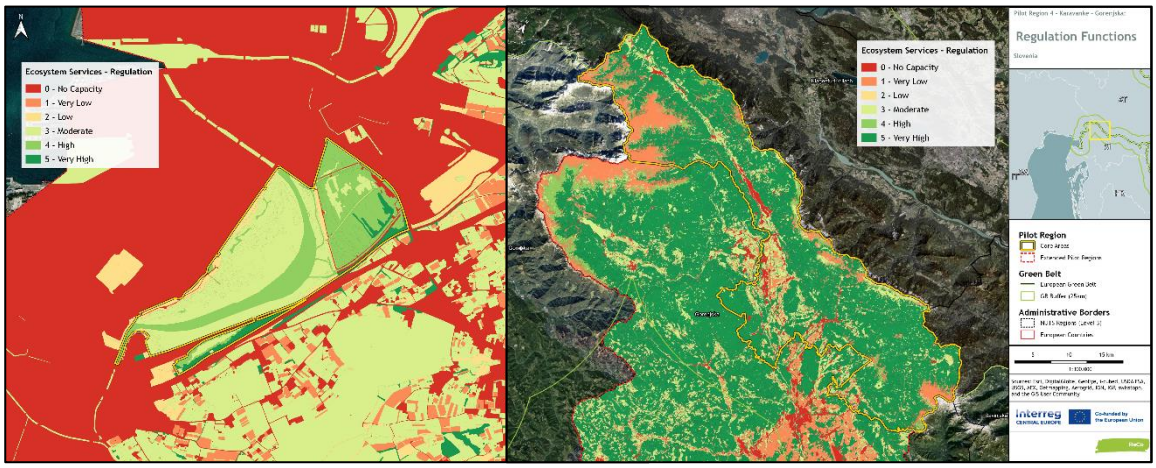


Figure 11 Maps of the regulation functions of pilot regions 3 and 4.

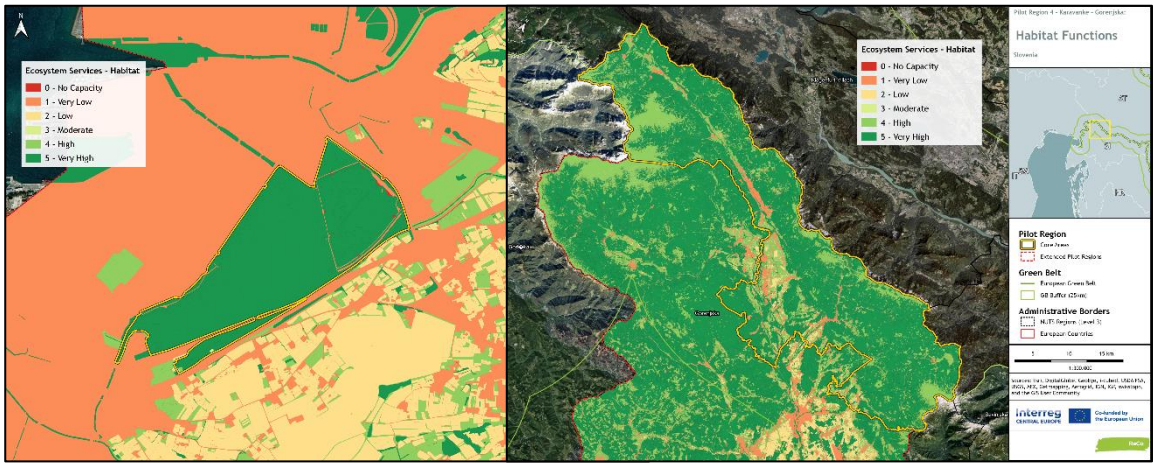


Figure 12 Maps of the habitat functions of pilot regions 3 and 4.

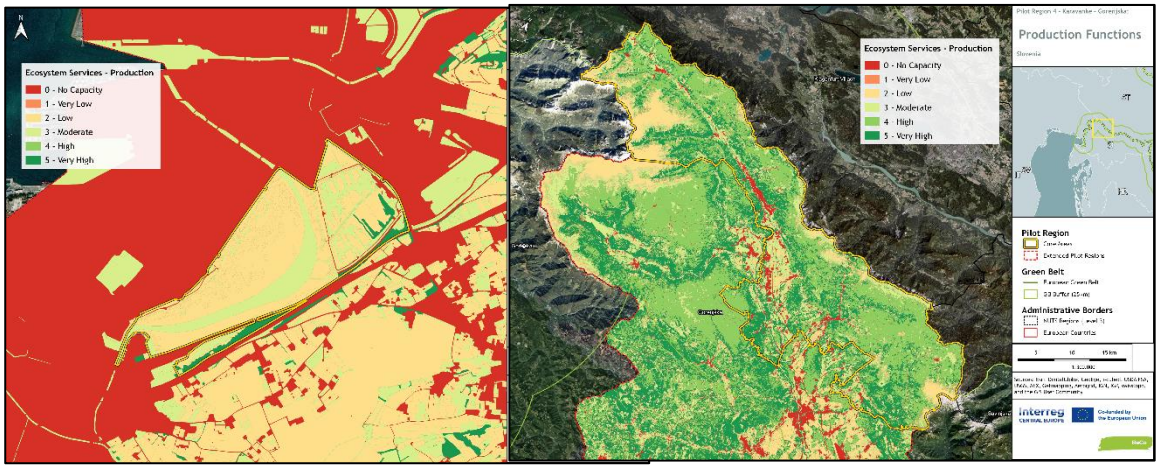


Figure 13 Maps of the production functions of pilot regions 3 and 4.

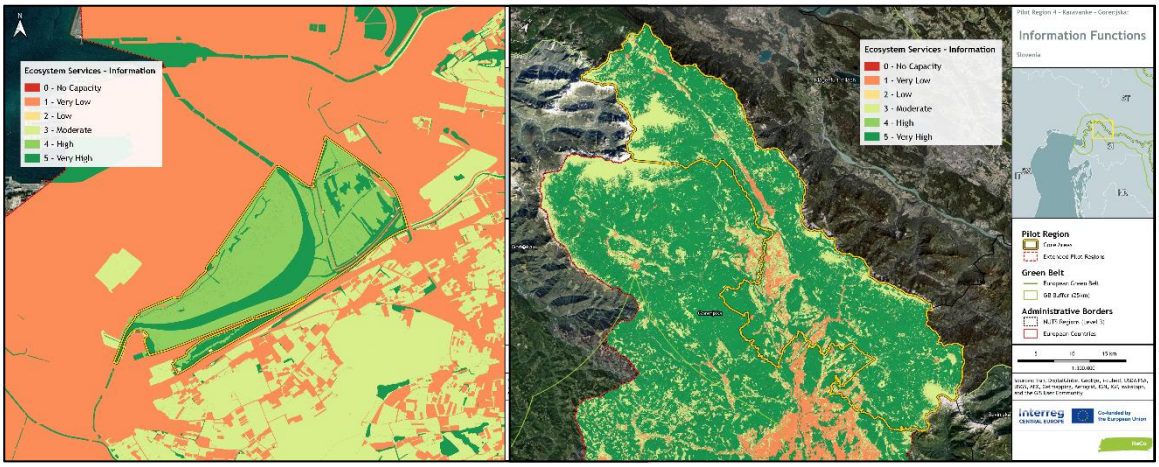


Figure 14 Maps of the information functions of pilot regions 3 and 4.

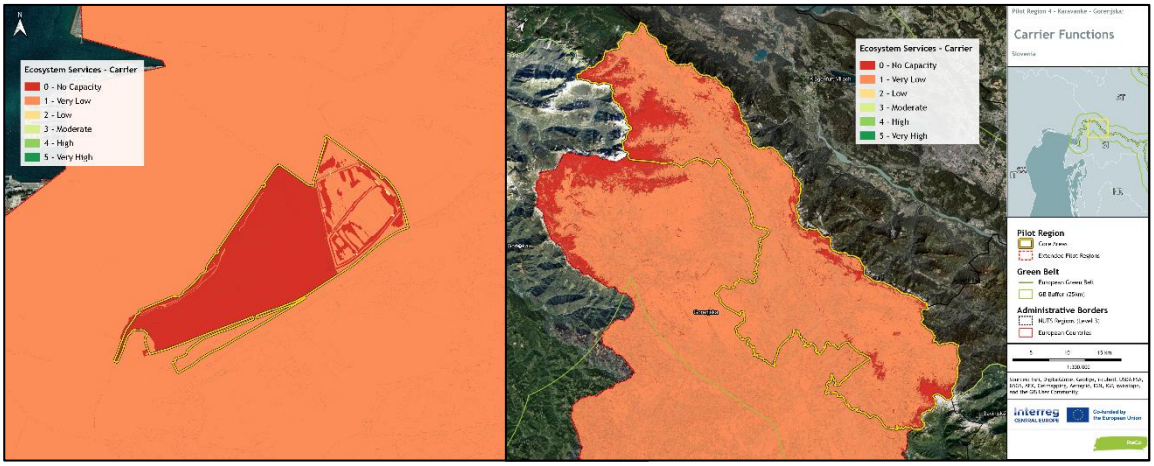


Figure 15 Maps of the carrier functions of pilot regions 3 and 4.

Depending on the needs for restoration and the required management of the area, maps can be customized. The hot and cold spots of those functionalities indicate target areas for future restoration. In combination with the results of the analyses of the BHT and historical land cover as well as the change analysis help to localize hot spots for restoration actions in the pilot regions.

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