Report, database and maps of ecosystem services analysis of the pre-selected pilot areas including a list, description, assessment, and ranking concerning the demands and supplies

WP	WP 4: Flood prevention pilots
Activity	Activity 4.2
Activity-Leader	CUEI and TUM
Number and name of deliverable	D 4.2.2 Report, database and maps of ESS analysis of the pilot areas including a list, description, assessment, and ranking concerning the demands and supplies as input for D 4.2.3 and part of output 5.1.
Participating partners	All partners from countries with pre-selected pilot areas, TUM, CUEI
Connection with other deliverables/ outputs	D 4.2.3; D 4.3.1; output 5.1

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1. Introduction

In the Danube Floodplain project five pre-selected pilot areas were select to implement measures which will improve flood protection and/or naturalness of the floodplains. For this purpose, workshops were held in each pilot area to identify and evaluate the ecosystem services (ESS) and the planned measures for each area. Recording and evaluating the ecosystem services of the affected area is a good measure to be able to assess the effects of planned measures. With the help of ecosystem services, extensive information about the current situation of a region can be captured. Ecosystem services provide information about nature's regulatory services like nutrient retention, about the supply of natural products like water and also about the cultural uses within an area. Furthermore, the consideration of the ecosystem services used can help to identify all interests of Stakeholders. In this way it can be ensured that all affected Stakeholders will be taken into account in an implementation project. In addition, by applying the ecosystem services approach, the impact of the planned measures on the ecosystem of an area can be estimated. This helps to adjust the measures to the desired result during planning. The ecosystem services, their application in the project and their analysis are described in more detail below.

2. Pre-selected pilot areas

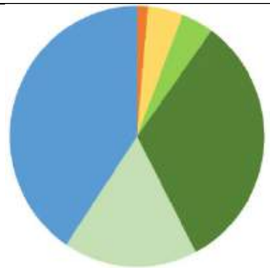
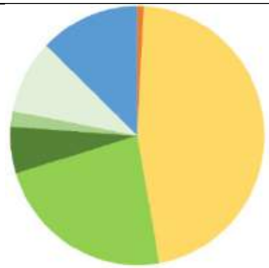
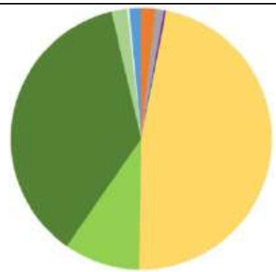
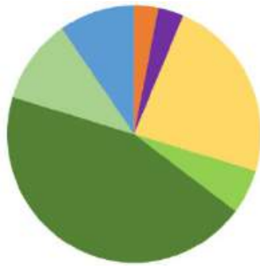
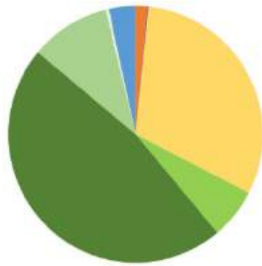
2.1 Characteristics of pre-selected pilot areas

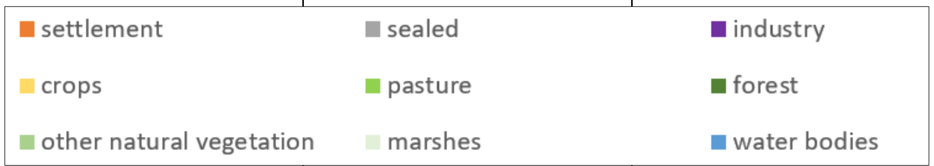
The assessment of ESS focussed on the areas in which the restoration or flood risk measures are planned. Therefore, the areas of the pre-selected pilot areas (Begečka Jama, Middle Tisza and Krka) differ in their extent from the areas of the 2D flood modelling. The pre-selected pilot areas are also different in their land use, in their geographical characteristics as well as in the aim of the planned measures (see table 1). The main objective of the measures such as dike relocation, land use change and reactivation or reconnection of oxbow lakes is to increase flood retention areas and to connect river and floodplain habitats in order to improve the habitat characteristics for vegetation and fish species. In several pilot areas, habitat improvement maily addresses with the creation of fish spawning waters or of habitats for juvenile fish.

Table 1: Characteristics of the five pilot areas in the Danube Floodplain Project

Pilot Area	Begečka Jama	Bistret	Krka	Middle Tisza	Morava
River	Danube	Danube	Krka	Tisza	Morava
Country	Serbia	Romania	Slovenia	Hungary	Slovakia, Czech Republic
Responsible PP	JCI	NIHWM/NARW	DRSV	KOTIVIZIG	VUVH/MRBA
Pilot area size for ESS [km²]	5.6	176.98	41.15	15.37	147.37
Geographical / morphological characteristics	**Begečka Jama** Nature Park (BJNatP) is located in the active floodplain on the left bank of the Danube River, upstream of the City of Novi Sad. The length of the area is approx. 7,8 km (rkm 1.276+200-1284), while the central point is 45° 13' 23“N, 19° 36' 23“E. In the past, it was part of a larger floodplain, that was reduced to its current extent due to agricultural development and flood protection measures implemented as early as the 18th century. Several geomorphologic types of fluvial erosion of different ages - islands, natural levees (ridges), oxbow lakes and backwaters, mutually created by fluvial	The **Bistret** pilot area is located on the left bank of the Danube river, just upstream of the confluence with Jiu river. It has a length of approx. 24 km and an average width of about 7 km. The average altitude of the land in the Bistret enclosure is 27.50 mdMN, and the average slope is approx. 0.00833%. The Bistret area also includes the Bistret lake into which the Desnatui tributary flows. The area is delimited in the south by the Danube flood defense dikes, in the west by the compartmentalization dike between the Rast enclosure and the Bistret enclosure, in the north by	The Kostanjevica na Krki pilot area consists of the Kostanjevica na Krki town, Krakovski forest, and Šentjernej field. It is situated in the SE part of Slovenia (45°50'46'' N 15°25'29'' E, altitude 155m). The pilot area is influenced by moderate continental climates. The whole area has a natural water retention function. The main watercourse is the Krka river (94 km, 2,315 km2). In the upper part, where the river flows through a gorge, there are many karstic underground springs. The surface tributaries appear in the lower part of the Krka valley. Some of them	The **Middle Tisza** region is a meandering river section. Flood risk and vulnerability are of particular importance in the area. After the river regulation in the 19th and 20th century both river banks were proofed with dike constructions. These dike sections protect the settlements, industrial zones and the arable lands from flood event. The Middle Tisza section is the lower section of the river, which means that more sediment can accumulate on the floodplain in this area and the transport capacity between the dikes decreases.	On the **Morava River** a lowland river, that used to meander strongly in the past, extensive river works were carried out (channel straightening, cut-off meanders, uniform channel with bank protection, reduction of floodplain areas, interruption of longitudinal continuity by weirs and sills); confluence of Morava and Thaya on CZ side with large retention area to release flood discharges; several villages along the area but outside the floodplain area; modelling area delineated by present flood dykes and the retention area on the confluence with Thaya river.

Pilot Area	Begečka Jama	Bistret	Krka	Middle Tisza	Morava
	erosion and reclamation, enabled the development of a mosaic of wetland habitats at different stages of succession of floodplain vegetation, which represent a refuge for many animal and plant species. BJNatP is an important reproduction area for many fish, amphibians and bird species. The status of the wetland habitats (oxbows, backwaters, wet meadows, marshes) and the hydrological regime have significantly deteriorated over the past 30 years due to siltation and aggradation caused by both natural processes and anthro-pogenic activities (forestry, pollution from the surrounding arable land, flood protection) Intensive land use caused habitat degradation and frag-mentation. River training and flood protection	the Bistret lake and the terrace, and in the east by the magistral irrigation channel Macesu-Nedeia. In the northern terrace area are the Villages Bistret, Plosca, Dunareni, Sapata, Macesu de Jos. The average altitude of the terrace is about 31 mdMN. In the pilot area, drying and irrigation systems and pumping stations are operated. The main pumping stations ensuring the drying of the area are SP-Malaians in the upstream end, which also ensures the gravitational discharge of Lake Bistret when the Danube discharge is less than aprox. 8000 m³/s, SP-Stejaru, and SP-Nedeia located at the downstream end of the pilot area.	(Radulja, Sajovec, Lokavec, Senuša) discharge into the Krka near the pilot area. The lower part of the river is characterized by slow river flow and extensive flood plains – one of them is Krakovski forest, which represents the largest remnant of the lowland floodplain forest in Slovenia (a combination of Pseudostellario-Quercetum and Pseudostellario europaeae-Carpinetum (determining tree species are Quercus robur, Carpinus betulus, Alnus glutinosa. Apart from the Krka river itself, it is the Krakovski forest, which is important at European level due to its habitat and species diversity (covered by the Habitat and Bird directives, and Natura2000 legislation). Šentjernej field is mainly covered by meadows, farmland, and scattered settlements.	In the floodplain the main type of land use is the forest, the second is crops and we can find some other less land use type (e.g. pasture).	

Pilot Area	Begečka Jama	Bistret	Krka	Middle Tisza	Morava
	measures disrupted the dynamics of flood events. The planting and management of poplar plantations enabled the spreading of invasive plant species, whilst the backwaters, oxbows and wet meadows were filled in due to forestry activities and needs. The area lost its attractiveness for visitors, as the aesthetic and recreational value was lost.		Kostanjevica na Krki is an important cultural and historical site.Geologically and geo-morphologically it is a tectonic lowland depression on a carbonate geological basis, filled with clay-gravel sediments		
land cover (CORINE 2020) of 2D model area					



Pilot Area	Begečka Jama	Bistret	Krka	Middle Tisza	Morava
Current ecological status and deficits	The pilot area belongs to the Danube River Water Body RSD8: Danube between Novi Sad and HR-RS State border. The status assessment below is taken from the Danube RBMP update 2015, ICPDR (DanubeGIS):	3 Surface Water Bodies have been identified for the active floodplain • RORW14-1-27_B172 Desnatui -Ac. Fantanele - Ac. Bistret in moderate ecological status status (river continuity and morphological conditions in moderate status). Moderate status for fish fauna (caused by upstream river dam Fantanele) • RORW14-1-27-8_B176 Buzat - izvor - cf. Desnatui; RORW14-1-27-7_B175 Baldal (Jivan) - izvor - cf. Desnatui in good ecological status • Good chemical status with a small increase of CCOCr for all WB	General data of the Water body Krka (Otočec – Brežice) (according to RBMP for Danube basin district) • Overall ecological status evaluation: GOOD • Significant diffuse pressures: Agriculture • Significant point pressures: Communal waste waters, Industrial waste waters • Significant hydromorphological pressures: Land use in the riparian area • Other significant anthropogenic pressures: No • In almost 200 years the watercourse topology has • not changed at all nor have any dikes been constructed along the river. • The river's floodplains are connected to the river by regular flooding	The Middle Tisza River belongs to the natural category with heavily modified sections. Based on physicochemical data supporting biology, this section of the river has excellent potential and the concentrations of the hazardous substances we studied did not exceed the limits of environ-mental quality. The narrow strip of floodplains between the dams of the active Tisza floodplain plays an important role as an ecological or green corridor in the migration and spreading of aquatic species and aquatic habitats. The floodplain of the Middle Tisza is of great natural value and ecological importance, due to its function as a core area and as an ecological corridor. Unfortunately, nowadays floodplains are the most important routes and channels for the	Heavily modified water body (HMWB) • Ecological status: 3 • moderate; • Hydromophological quality: 4 - poor

Pilot Area	Begečka Jama	Bistret	Krka	Middle Tisza	Morava
		•	• Some of them are on the International Union for the Conservation of Nature and Natural Resources red list.	invasion of invasive plant species. This process could significantly reduce biodiversity in the future. In addition, floodplain management is in many cases not consistent with the requirements of natural floodplain habitats. The area is also part of the Middle Tisza (HUHN10004) Special Protection Area and the Middle Tisza - (HUHN20015) Special Area of Conservation	
Major restoration purposes	• Adequate water supply throughout the year in the Begečka Jama lake, oxbows and channel system and improving habitats for aquatic species • Increase in the water surface area and depth of the oxbows and existing channels • Increase in biodiversity and spawning areas as a result of habitat restoration	• Flood protection for population (major damages during 2006 flood) • Sustainable development and ecotourism	Improvements for: • Flood risk management • Nature protection • Forestry	• Increasing conveyance capacity/ floodplain area • Decreasing flood hazard	• Improvement of flow conditions in the river floodplains with respect to flood protection and nature protection goals • Optimization of water regime in the floodplains • Enhancement of conditions for diverse biotopes, which can be found in the area of interest

Pilot Area	Begečka Jama	Bistret	Krka	Middle Tisza	Morava
	• Increasing the types of ecosystem services, as well as improving the quality and quantity of existing ecosystem services of the area				• Improvement of conditions for fish migration
Restoration measures Scenario 1 - realistic	• Cleaning and widening of the existing connecting channel between Danube River and Begečka Jama lake and weir reconstruction which will allow fish migration • Floodplain DEM modification via the deepening of existing oxbows and channels and the excavation of new channels between the deepened oxbows, which would allow for the controlled inflow/outflow from the system • Increase the diversity of the river morphology as a result of the excavation, deepening and cleaning of oxbows, and existing and new channels.	• Construction of a recreational and fishfarming lake (200 ha) in the area of Rast • Relocation of the dikes in the confluent area of Desnaţui River with Bistret Lake • Creation of a large water drainage channel to supply Lake Bistret and to facilitate the natural flow of Desnatui River back in the Danube	Scenario 1 is a combination of a corridor SC1 enabling floodplain activation, and measures to increase water conductivity in the river bed through Kostanjevica, thus lowering water levels within the settlement. It comprises 2 measures: K1- river bed deepening of the northern stream of the Krka river through Kostanjevica, and an inundation at the bifurcation, and K3- a corridor to the floodplain, length 650 m, width 45 m.	• Enlargement of floodplain area: Dike relocation • Land use change: Arable land to pasture • Creation of fish spawning areas	• Removal of weirs • Removal or adjustment of selected barriers (weirs, sills) • Removal of levees • Relocation of flood dikes (to include the cut off sidearms in the floodplain area)

Pilot Area	Begečka Jama	Bistret	Krka	Middle Tisza	Morava
	• Creation of new fish spawning areas which contribute to the maintenance and increase of biodiversity.				
Restoration measures Scenario 2 - optimistic	• Cleaning and widening of the existing connecting channel between Danube River and Begečka Jama lake and weir reconstruction to allow fish migration • Floodplain DEM modification via the deepening of existing oxbows and channels and the excavation of new channels between the deepened oxbows, which would allow for the controlled inflow/outflow from the system • Increase the diversity of the river morphology and diversity of cross profiles of the river as a result of the excavation, deepening and cleaning of oxbows, and existing and new channels	• Additional dike relocation from the Danube close to the Villages along the alluvial terraces	Scenario 2 is a combination of 4 measures, this includes three new flood channels to enable floodplain activation and additional measures within the river bed in Kostanjevica: K1– river bed deepening of the northern stream of the Krka river through Kostanjevica, and an inundation at the bifurcation; K2– a corridor to the floodplain, length 950 m, width 30 m; K3– a corridor to the floodplain, length 650 m, width 45 m; K4– a corridor to the floodplain, length 280 m, width 60 m.	• Enlargement of the floodplain area: Dike relocation and controlled dike overtopping • Land use change: Ploughed (cultivated) land to pasture • Vegetation regulation: Controlled afforestation • Creation of wetland habitats (eg. lake)	• RS1 and additional Relocation of flood dikes (further than in RS1) • Renewal of river pattern Reconnection of oxbows with the main Morava channel (at present state they are behind the dike) Deepening of existing oxbows

Pilot Area	Begečka Jama	Bistret	Krka	Middle Tisza	Morava
	as well as the widening of the existing river channel. • Creation of new fish spawning areas which contribute to the maintenance and increase of biodiversity.				
Major recent floods	2006: HQ100	2006: >HQ100 (ICPDR 2008)	2010: HQ100	2000: ~HQ100	2010: >HQ100 (ICPDR 2012)
	2010: HQ10-20 (HIDMET 2014)	2010: >HQ20 (ICPDR 2012)			
HQs investigated	HQ2-5	HQ5	HQ2-5	HQ2, HQ5	HQ5
	HQ10-20	HQ30	HQ10	HQ10, HQ30	HQ30
	HQ100	HQ100	HQ100	HQ100	HQ100

2.2 Current state and restoration scenarios in the pre-selected pilot areas

The responsible project partners develop the two restoration scenarios individually in cooperation with national authorities as well as the identified stakeholders. The planned restoration measures are discussed at two stakeholder workshops in each of the pilot areas with all relevant stakeholders – fishery, agriculture, shipping, municipal authorities, nature protection, residents etc. The results of these stakeholder meetings are summarized in deliverable D 4.2.1.

In table 2, all restoration measures in the pilot areas for the two scenarios are summarized. There are different kinds of restoration measures – in-stream measures which change the roughness and the shape of the river bed, alterations in the size of the floodplain (e.g. dike relocation), as well as morphological and/or land cover changes in the floodplain. Of course, the main purpose of the restoration measures is to re-establish natural floodplain conditions – as far as possible – and to ensure win-win situations for the environment and flood protection.

Table 2: Restoration measures to be implemented in the pre-selected pilot areas for both scenarios. RS1 = realistic implementation scenario, RS2 = optimistic implementation scenario.

	Begečka Jama		**Bistret**		**Krka**		**Middle Tisza**		**Morava**	
	RS1	RS2	RS1	RS2	RS1	RS2	RS1	RS2	RS1	RS2
1. construction										
1.1 dike relocation			x	x			x	x	x	x
1.2 dike removal				x			x	x		
1.3 controlled dike overtopping/ gaps in dike			x		x*	x*	x	x		
1.4 removal of weirs									x	x
1.5 change of operation mode of weir	x	x								x
1.6 migration permeability of weirs	x	x								
1.7 removal of culverts										
2. land cover and lateral branches										
2.1 change of land cover towards natural conditions				x			x	x		
2,2 modify floodplain DEM	x	x			x	x	x	x	x	x
2.3 increasing the roughness of floodplain (afforestation)					x	x		x		
2.4 creation and connection of new lateral branches or pool/new water regime	x	x	x	x	x	x				
2.5 creation of retention area/flood channels			x		x	x		x		
2.6 connection of lateral branches/oxbows	x	x	x							x

	Begečka Jama		**Bistret**		**Krka**		**Middle Tisza**		**Morava**	
	RS1	RS2	RS1	RS2	RS1	RS2	RS1	RS2	RS1	RS2
2.7 deepening of lateral branches/oxbows	x	x								x
2.8 reconnection of old oxbow										x
2.9 enlargement of floodplain area				x	x	x	x	x	x	x
3. river channel geometry alteration										
3.1 increase of roughness in river channel (according to natural bedrock)										
3.2 widening of river channel		x			x	x				
3.3 increase of river bed (decrease water depth)										
3.4 increase of diversity of the river morphology; **	x	x								
3.5 removing of bank stabilizations/ embankments							x	x		
3.6 riparian vegetation (increase of roughness, stabilizes riverbank, decrease of nutrient inflow)										
3.7 implementing of groynes, boulders or dead wood to initiate meandering										
3.8 changing of course of river (meandering)										x
3.9 removing of ground sills, plunges									x	x
3.10 creation of fish spawning areas	x	x			x	x		x		
3.11 removing ofsand bars							x	x		

* installation of gaps in a road in the pilot area Krka, which serves as a dike.

** construction of riffles, pool, potholes, sand or gravel banks, cut banks and slip off slope, broader and narrower passages of the river, etc.; diversity of cross profile of the river.

3. Ecosystem services

The basic idea behind the ecosystem service approach is connecting humans and nature. Man and nature mutually influence each other. Human activities have a direct or indirect impact on nature. Conversely, natural events affect society and its well-being. Thus, ecosystem services (ESS) bring direct or indirect economic, material, health or psychological benefit to people. The aim of the ESS approach is to show the benefits and value of ecosystems to society and to improve the conditions for sustainable management of nature and ecosystems. With the help of the ecosystem service approach trade-offs between different sectoral uses can be identified. ESS can help to mediate between science and society or between different stakeholders. In addition, they are a good tool to estimate and present the impact of management measures on the ecosystem, but also on other benefits.

The term ecosystem service was defined and distinguished in the three different types of regulating, provisioning and cultural services (CICES – Haines-Young and Potschin 2013). Provisioning services provide people with products of the nature like food, drinking water and raw materials. Climate regulation, extreme water regulation and the maintaining of lifecycle are regulating services. Services that have symbolic, cultural, aesthetic or intellectual value and create a sense of well-being are considered as cultural services, e.g. recreation or sports in the landscape. The Millennium Ecosystem Assessment (MA 2005) and the UK National Ecosystem Assessment (UK NEA – Morris and Camino 2011) also defined a fourth group, the supporting services. The supporting services are defined as 'ecosystem services that are necessary for the production of all other ecosystem services, such as primary production, production of oxygen, and soil formation' (MA 2005).

3.1 Ecosystem Services in the Danube floodplain Project

Rivers and floodplains are strongly influenced by the dynamics of the water. Based on the alternating water and groundwater levels and accompanied by the relocation of bed load and deposit the watercourse and the land around the river – the floodplain – are shaped. Many different water bodies such as flood channels, backwaters and oxbow lakes as well as land habitats with different moisture gradients have been formed in natural river systems. Several organisms populate these manifold habitats. Therefore, natural floodplains belong to the most species-rich ecosystems (*Ward* et al. 1999, *Robinson* et al. 2002, *Hughe*s et al. 2005). Floodplain ecosystems are hotspots of ecosystem services (*de Groot* et al. 2010, *Sweeney* et al. 2004) based on the interaction between water and land habitats and different ongoing processes.

In the Danube Floodplain project (DFP), we refer to the classification according to CICES (Haines-Young and Potschin 2013) and consider three classes of ecosystem services: provisioning, regulating and cultural. Regulating services 'include all the ways in which ecosystems control or modify biotic or abiotic parameters that define the environment of people' (Haines-Young and Potschin 2013) such as nutrient regulation or climate regulation. Provisioning services provide us with 'material and biotic energetic outputs from ecosystems', for example water supply or the provision of renewable energetic materials (Haines-Young and Potschin 2013). Services that have symbolic, cultural, aesthetic or intellectual value and create a sense of well-being are considered as cultural services, e.g. recreation or sports in the countryside. Supporting services defined in the UK National Ecosystem Assessment (*UK NEA* 2011) and the Millennium Ecosystem Assessment (*MA* 2005) are not taken into account in the DFP. These supporting services represent processes whose products are used and not actual services. Primary production can be mentioned as an example. The process itself has no impact on human well-being, but its products can in turn be used as provisioning services.

4. Assessment of ecosystem services in pre-selected pilot areas

4.1 Assessment of ecosystem services in the pre-selected pilot areas by stakeholders

In order to get an initial overview of the ESS occurring in the pre-selected pilot areas, a list of different ESS was sent to the respective project partners. The ESS were selected on the basis of the ESS identified in the RESI project and typical for riparian and water habitats. The RESI project had identified 25 ecosystem services for German rivers and floodplains (Podschun et al. 2018). The partners reviewed the list for completeness, the presence of the ESS in their pre-selected pilot area and, where appropriate, added other ESS relevant to the area. This preparation helped the project partners, some of whom were unfamiliar with ESS, to help stakeholders gather ESS in the workshops.

The workshops for assessing ESS took place between January and February 2019. The workshops were divided into three parts. In the first part a short presentation was given. The participants were given an introduction to ESS and the aim of the workshop. In the second part, participants were asked to identify all ESS used in the pilot area and to locate the individual ESS provided on a map of the pilot area. They then estimated the extent of use of every identified ESS using a scale from 0 to 5 (see table 3) The zero is needed for the third step of the workshop. After a short presentation of the restoration measures, the stakeholders ranked the value of used ecosystem services after restoration from 0 to 5. Since the measures can also result in one of the ESS no longer being provided, the benefits must be ranked zero (no benefit). As most stakeholders find it difficult to assess the intensity of use after the implementation of restoration, it was agreed to estimate whether there will be an increase, a decrease or no change.

It turned out that the workshops were very helpful in determining the current occurrence and the benefits of different ecosystem services for the respective pilot area. The stakeholder survey was particularly well suited to identify cultural ecosystem services. Unfortunately, the results for the provisioning and regulating ESS were not detailed enough to visualize them in maps for the current situation (CS) and the restoration scenarios (RS). For the pilot area Begečka Jama, however, we received help from local researchers, so it was possible to visualize the provision of individual ESS for the current situation (see Chapter 5.1, figure 1 to figure 6). An additional method was developed to locate the provision of individual ecosystem services and to calculate the potential of further unidentified ecosystem services.

Table 3: Scale for the intensity of provided and used ecosystem services of pilot areas.

0	1	2	3	4	5
Missing	Very low	Low	Medium	High	Very high

4.2 Assessment of ecosystem services in the pre-selected pilot areas by using land cover/land use data

On the one hand, the exact measures of the scenarios had not yet been determined at the time of the workshops. On the other hand, the workshops did not determine the current provision of all ecosystem services, but only the intensity of use of the identified ecosystem services. Therefore, a further method for recording the provisioning and regulating ESS of pilot areas was developed. Following the method of Burkhard et al (2009), the amount of ecosystem services provided in the pilot areas was estimated. Burkhard et al (2009) estimated the capacities to provide ESS by using CORINE land cover data near Halle, Germany. In the DFP, ESS were assessed on the basis of land cover/land use data from Copernicus (Copernicus Land Monitoring Service - Local Component: Riparian Zones 2012) and additional CORINE land cover data (2018) with the help of experts from the project. The CORINE land cover types were reviewed in Goolge Earth and then assigned to a Copernicus land cover/land use type. The Copernicus data is available in different resolutions (MAES typology). The more detailed the ecosystem classification, the higher the MAES level (level 1 to level 4). In the pilot area Begečka Jama the MAES level 3 was used for legal reasons, in all other pilot areas the even more detailed ecosystem classification MAES level 4 could be used. However, the Serbian Project Partner had good ESS experts, so they revised the Copernicus land cover/land use data level 3. The intensity of the provision of the ESS in the pilot areas was also indicated by values between 0 and 5 (see table 3). Table 5 gives an overview of all considered ESS and their definitions. By jointly classifying all provisioning and regulating ESS, areas with a particularly high provision of ESS (so-called hot spots) and also areas with a very low provision of ecosystem services (so-called cold spots) can now be easily identified. For this purpose, the total of all values was divided into five classes (table 4). This classification was also carried out, applied for all provisioning ESS and all regulating ESS. For the classification of the intensity of the provisioning ESS only the real occurring provisioning ESS of the pilot area were considered. This means that only the sum of the intensity of the occurring ESS was used for the classification.

Table 4: Scale for the intensity of provisioning and regulating ESS together.

Class	**1**	**2**	**3**	**4**	**5**
Intensity	Missing to very low	Low	Medium	High	Very high

Table 5: All ecosystem services and their definitions that are considered in the Danube Floodplain project.

ESS class	ESS	Definition
Provisioning ESS	agricultural product	All plant foods produced by agricultural cultivation
	wood	Wood for heating or creating wood products (furniture, roof trusses)
	animal product	Meat, cold cuts, milk, butter, wool, etc.
	game meat	Game meat obtained by hunting and offered for sale, like goose, duck, deer, boar, etc.
	honey	Honey and other products from the beehive
	fish	Fish or fish products offered for sale, produced by professional fishing or aquaculture
	water	Water for drinking or irrigation from surface water bodies or groundwater bodies
Regulating ESS	local climate regulation	The ability of forests and water bodies to influence local temperatures by evaporation or storing of heat under tree crown or in water bodies. In the summer months the air is cooled by evaporation, in autumn and spring the heat is stored and slowly released into the environment.
	air purification	The ability of plants to purify air by assimilation of particulates or harmful gases.
	low water regulation	The ability of rivers and floodplains to reduce the risk of a river drying out due to the inflow from aquifers in floodplains or by stabilising the river water level through the roughness of the river.
	flood retention	The ability of rivers and floodplains to retain or flatten flood waves. The retention volume is used by overflow/flooding.
	nutrient retention	The ability of floodplains to store nutrients (N,P, C) by uptake into stationary biomass, by deposition as sediments or to decimate nutrients by microbial degradation or respiration (in case of C)
	noise regulation	Availability of forests with undergrowth to reduce noise by refraction of acoustic noise
	provision of habitats	Availability of habitats in typical functional and structural quality, which may be used by typical biotic communities of rivers and floodplains, which may then partially be used by humans.
Cultural ESS	recreational activity	All activities that take place in the area and lead to recreation or are carried out as a hobby, such as hiking, cycling, jogging, photography, mushroom picking, bird watching, hunting, etc.
	water related activity	All activities that are carried out in or on water bodies and are done as a hobby or for recreation, like swimming, canoeing, stand up paddling, sport fishing, etc.
	tourism	This can be special places that are visited by tourists or activities that are done by tourists, for example, hunting or fishing tourism, ports for cruise ships, hotels, summer cottages, thermal baths, historical places etc.
	education	All activities that lead to further education for oneself or for others, for example scientific research, cultural heritage, archaeological sites, information events, etc.

Different factors were used to identify and evaluate the individual ecosystem services. The ESS *agricultural products* were identified by means of land cover/land use classes indicating the cultivation of crops, vegetables, fruit trees, berries or wine. Different grasslands and forest types were used to define the ESS *animal products*. The localisation of the ESS *game meat* differs from one pilot area to another. In the Serbian pilot area hunting is only done for regulatory reasons. Game meat is not for sale. The provision of the ESS *honey* was mainly assigned to grassland habitats. Water bodies indicate the ESS fish. Water bodies which, due to their temporary connection with the river, only serve as spawning habitats but are nevertheless essential for fish production were also taken into account. It was assumed that rivers and lakes can be used for *water* supply (as drinking water or for irrigation).

The decisive factor for estimating the ESS *local climate regulation* of different land cover/land use types was the evaporation function. The ESS *air purification* was estimated according to the research of Vieira et al. (2017). According to this study the air purification of natural structured forests with tree, shrub and herb layers is higher in comparison to managed grasslands.

The important factors for assessing the ESS *low water regulation* were groundwater recharge and evaporation rate. The higher the groundwater recharge and the lower the evaporation, the higher the low water regulation. However, roughness caused by macrophytes also plays a role in the water. To assess the ESS *flood retention*, special attention was paid to the level of roughness of a land cover/land use type and, in the case of water bodies, to the absorption capacity of an increased runoff within the flooded area. The results of the RESI project (Podschun et al. 2018) were taken into account when assessing nutrient retention in different land use classes. According to these results, nutrient retention is higher in natural floodplain-type habitats than in heavily fertilized or sealed areas. The density and width of tree and shrub cover of a land cover/land use type is decisive for *noise regulation*. A naturally structured forest can best reduce noise, but lines of trees and shrubs also have a noise reducing effect. When assigning the value of the ESS *provision of habitats* to a habitat type, it was taken into account to which extent the habitat type is typical of riparian zones and to which extent the habitat type is close to nature. Accordingly, the highest value (5) was assigned to floodplain typical habitats, such as riparian forests and water bodies connected to the river. A medium value (3) was given to land cover/land use types that occur naturally both in and outside the floodplains and are close to nature (e.g. near-natural forests). The lowest value (0) was given to habitats that are of artificial origin and do not occur naturally in the floodplain area (e.g. sealed areas or buildings). An overview of the values of the different ESS of each single land cover/land use type occurring in the pilot area is given in Annexe table 7.

For the pilot area Bistret, a deviation from the method used in the other pre-selected pilot areas is needed to calculate the scenarios. As there was no data on the location of the measures and no spatial delineation, the flood depth from the 2D hydraulic modelling was used to delimit the areas affected by the dike relocations. The ESS of each single land cover/land use type were then either upgraded or downgraded, depending on whether the

ESS benefit or arise weakened by the increased flooding. For example, it was assumed that the ESS *agricultural product* would be reduced by frequent floods. The ESS received a malus of -1, and instead, it was assumed that the agricultural land could be converted into grassland. Thus, ESS such as animal products, game meat or local climate regulation received a bonus of +1. Annex Table 8 contains the respective land cover/land use types and the corresponding values of the intensity of the potential ESS of the pilot area Bistret.

5. Results of the assessment of ecosystem services

5.1 Results of the assessment of ecosystem services by stakeholders

During the workshops, the stakeholders identified many currently used ecosystem services and ranked their intensity of use. The results of the stakeholder assessment of ESS for the current situation are summarized in table 6. The cultural ecosystem services were grouped into three classes. All activities carried out in the countryside for recreational purposes or as a hobby belong to the 'recreational activity' class. Activities carried out in and around water bodies belong to the class 'water-related activity'. Research and educational activities or cultural heritage sites like archaeological excavations or castles and churches are grouped in the class 'education'. The class 'tourism' relates to places which are visited by tourists like cruise ports, accommodations or thermal springs, but also to different types of tourism like hunting and fishing tourism.

Begečka Jama

Stakeholders classified the ESS *game meat* as the most frequently used provisioning ESS (value of 4), followed by the ESS *wood*, ESS *fish* and ESS *water* (value of 3) (see table 5). The assessment of the intensity of the regulating ESS showed that the pilot area has, above all, a very high *provision of terrestrial habitats* (value of 5) and a high contribution to *local climate regulation* and *air purification* (each value of 4). The *provision of fish spawning habitats* was rated lower compared to the *provision of terrestrial habitats*. It is estimated at a medium level (value of 3). None of the identified ESS had a low (value of 2) or very low (value of 1) intensity of provision. Cultural ESS are strongly represented in the pre-selected pilot area Begečka Jama. Mostly the ESS of the subclass 'recreational activity' like hiking, cycling and wildlife viewing are used very commonly (each value of 5). The area is not only important for the recreation of the local residents; it is also important for tourism. Tourists especially take advantage of the possibility of *fishing* (value of 4), *swimming* or *water sport* activities (each value of 3) at the lake Begec. The restaurant near lake Begec is also used for *educational events* or *charity work* (value of 3).

*Table 6: Results of the assessment of provisioning and regulating ecosystem services by stakeholders of each pre-selected pilot area. CS = current situation, RS 1= realistic implementation scenario, RS2 = optimistic implementation scenario, * = provision of fish spawning areas. 0 = no, 1 = very low, 2 = low, 3= medium, 4 = high, 5= very high provision of ESS. + = increase, - = decrease, +/- no change of provision of ESS*

		Begečka Jama	**Bistret**	**Krka**	**Middle Tisza**	**Morava**
ESS class	**ESS**	**CS**	**CS**	**CS**	**CS**	**CS**
provisioning ecosystem services	agricultural product		4	4	2	2
	wood	5	2	3	3	4
	animal product	1	4	4	3	4
	game meat		2	2	3	
	honey		2	1		
	fish	2	3	3	0*	
	water	3		2	5	5
	gas					2
regulating ecosystem services	local climate regulation	4	2	3	3	5
	air purification	5		3	3	4
	low water regulation					3
	flood retention	3	0	4	5	1
	nutrient retention	3		3	3	
	noise regulation					5
	provision of terrestrial or	5	3	2	4	5
	aquatic habitats	3**	3	4	4	5
recreational activity	jogging				2	
	cycling	5		3	2	5
	hiking	5		4	2	
	photography				3	5
	bird-/wild life watching	5	1		3	
	mushroom picking			1	2	4
	sport hunting			2	3	4
water related activity	swimming	3	1	4	3	
	water sport	3	1	4	5	1
	sport fishing	3	2	3	4	3
educati on	cultural heritage		0	5		5
	research		0	3		5
	information events	3	0	4	3	5
tourism	fishing tourism	4	1	3		
	hunting tourism			2		
	cruise ships/ports		1		2	
	hotels/accommodations		1	3	4	5
	thermal bath			3		

*commercial fishing is prohibited in Hungary
**fish spawning areas

5.2 Results of assessment of ecosystem services of pilot area Begečka Jama by local experts

With the help of local researchers, the Serbian project partners were able to create significant and detailed shapefiles for the ecosystem services currently used in the area. It was now possible to graphically depict three provisioning ecosystem services, five regulating ecosystem services and five cultural ecosystem services.

Most of the forest areas are intensively used (value of 5) hybrid poplar plantations (figure 1).

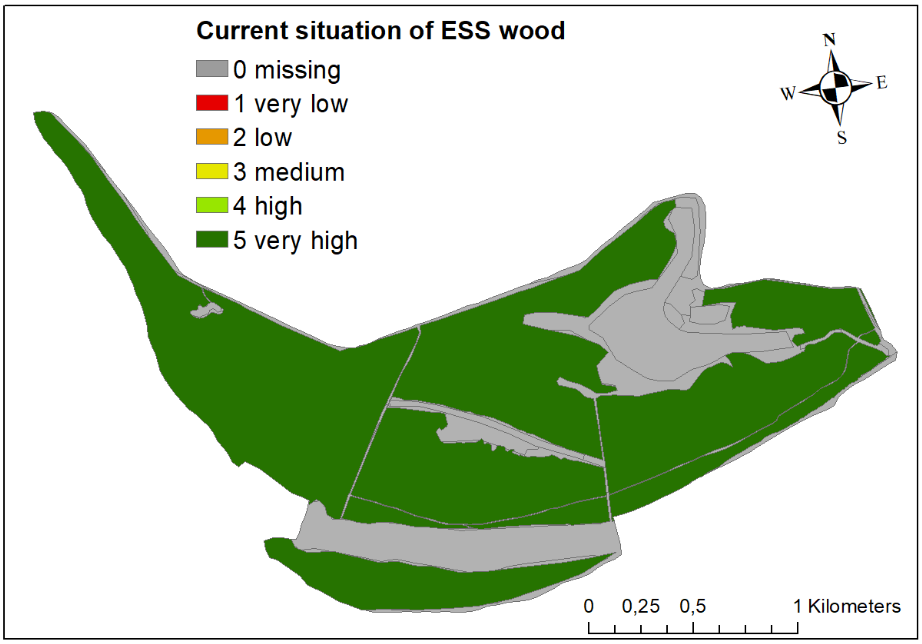


Figure 1: Intensity of the used provisioning ecosystem service wood in the pilot area Begečka Jama. The values of the intensity of use are marked in different colours.

In the current situation, the used ESS *animal product* is only represented by sheep, grazing on one part of the dike, therefore, the intensity is very low (figure 2a). Commercial fishing only takes place on the Danube. As only a small part of the Danube belongs to the pilot area, the use of the ESS *fish* is low (figure 2b).

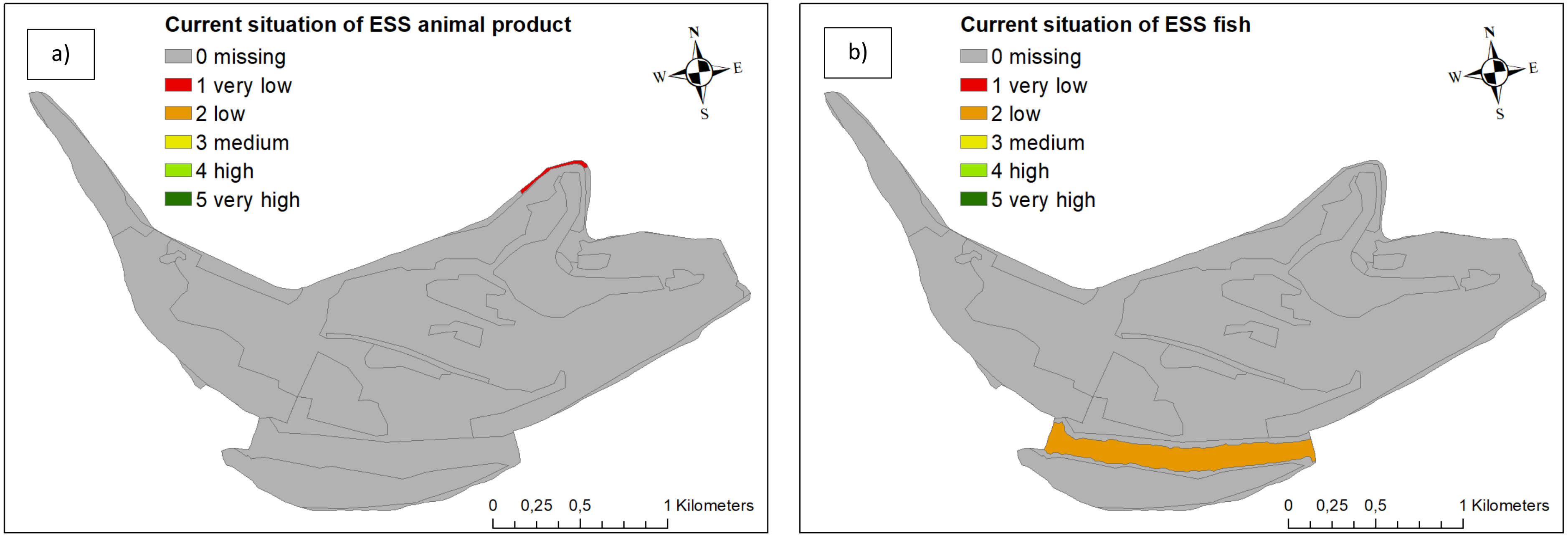


Figure 2: a) Intensity of the used ESS animal product and b) of the used ESS fish in the pilot area Begečka Jama. The values of the intensity of use are marked in different colours.

The ESS *provision of habitats* actually ranges from very low (areas covered by buildings and Danube River) to high (some forest areas) and lake Begec (figure 3a). The pilot area mostly provides a very high intensity of the ESS *local climate regulation*. There are only some parts with low local climate regulation (figure 3b).

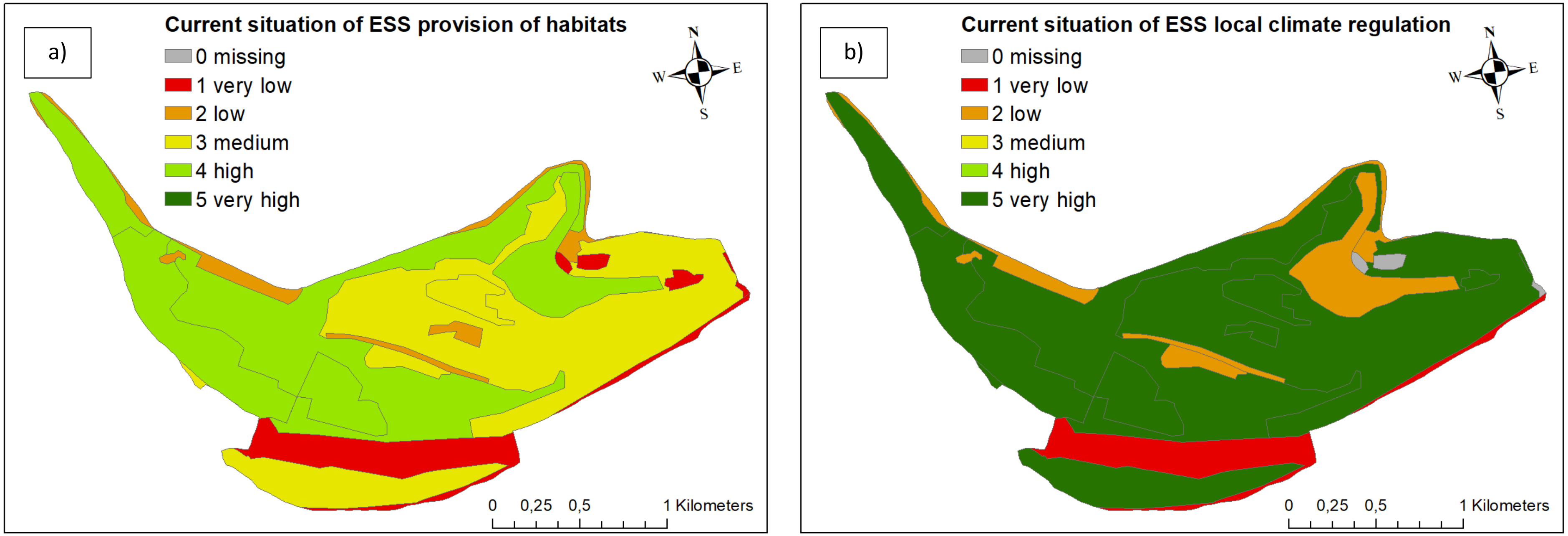


Figure 3: a) Intensity of the ESS provision of habitats and b) of the ESS local climate regulation in the pilot area Begečka Jama. The values of the intensity of use are marked in different colours.

For the assessment of the regulating ESS *flood retention* and *nutrient retention,* the spatial extent of a five-year flood event (HQ_5) was used. In the current situation almost the entire pilot area is flooded, but only for a short time. Therefore, the intensity of these ESS is medium (figure 4a). In contrast, the intensity of nutrient retention is high (figure 4b), since the frequent floods allow a high proportion of nutrients to be stored or absorbed by plants.

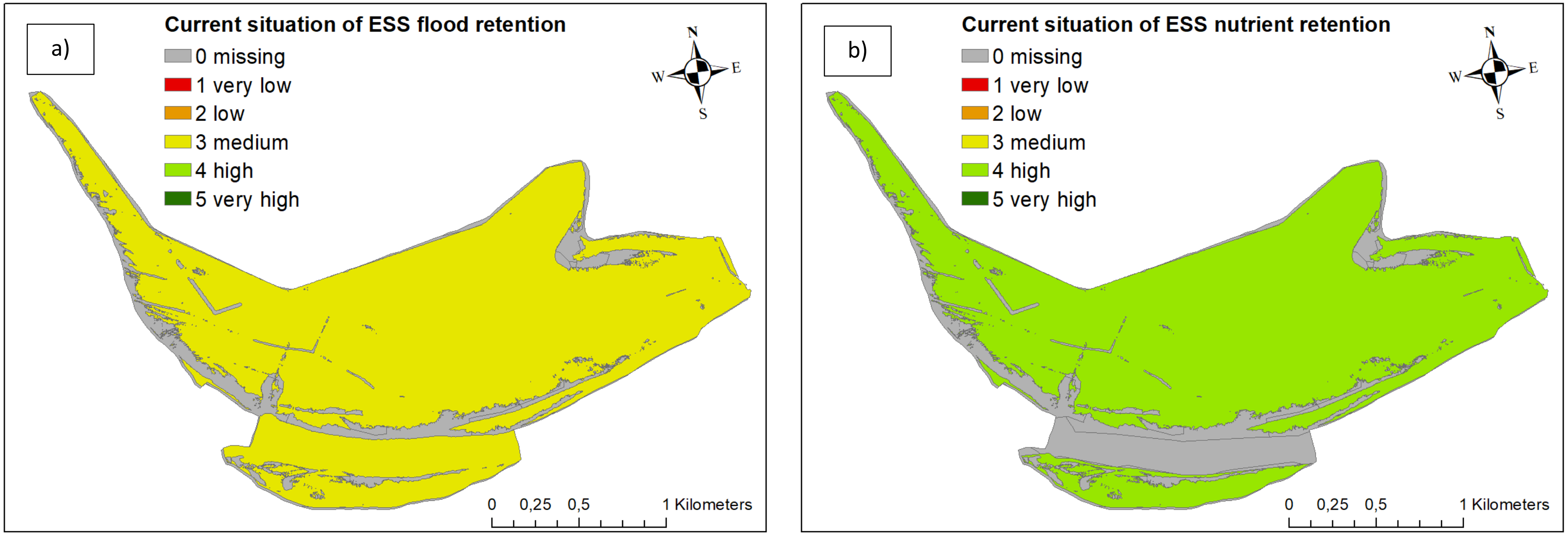


Figure 4: a) Intensity of the ESS flood retentions and b) of the ESS nutrient retention in the pilot area Begečka Jama. The values of the intensity of use are marked in different colours.

Finally, the regulating ESS *air purification* was evaluated. The value is very high, as most of the area is covered by forest (figure 5a). With the help of the Serbian project partner and local experts, it was even possible to locate and visualize the cultural ecosystem services. The ESS education reaches a medium value (3), mainly *information events* and *charity work* take place in the restaurant at the lake Begec (figure 5b).

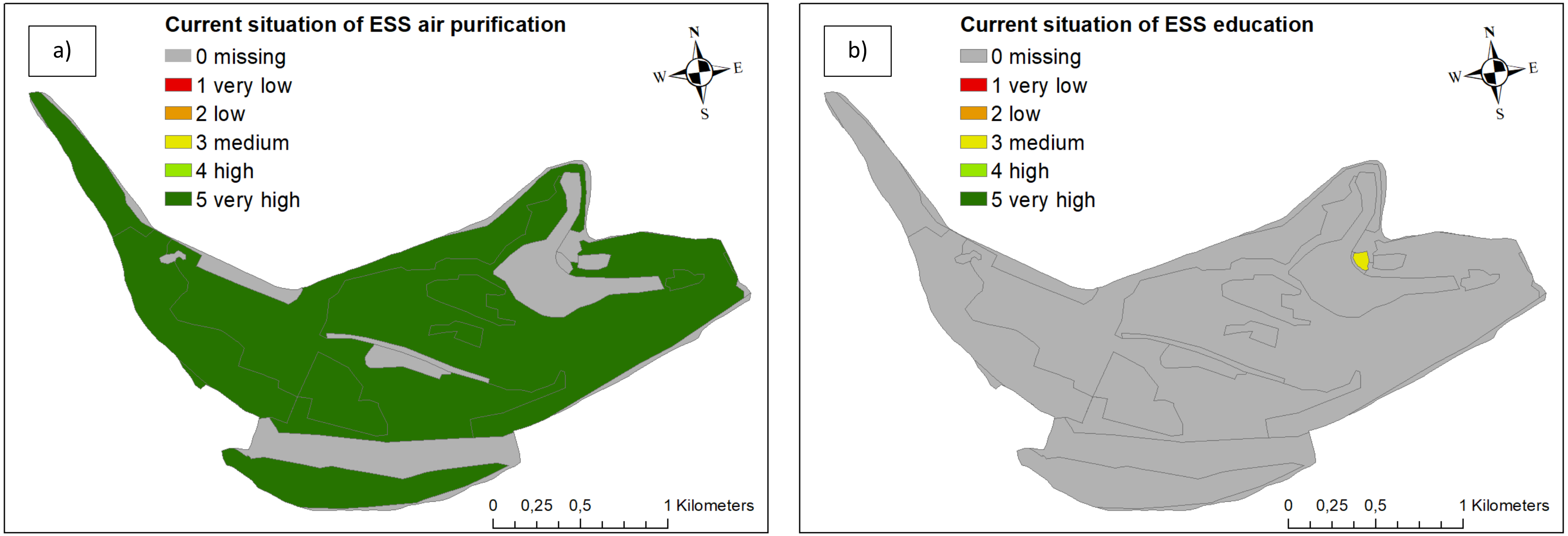


Figure 5: a) Intensity of the ESS air purification and b) of the cultural ESS education in the pilot area Begečka Jama. The values of the intensity of use are marked in different colours.

Cycling and *hiking* are very popular in the pilot area, so the recreational ESS *cycling* and *hiking* received a very high value (figure 6a). Wild animals are also often observed in the area. Depending on the location, the value of the ESS *wildlife watching* varies between 2 and 4 (figure 6b).

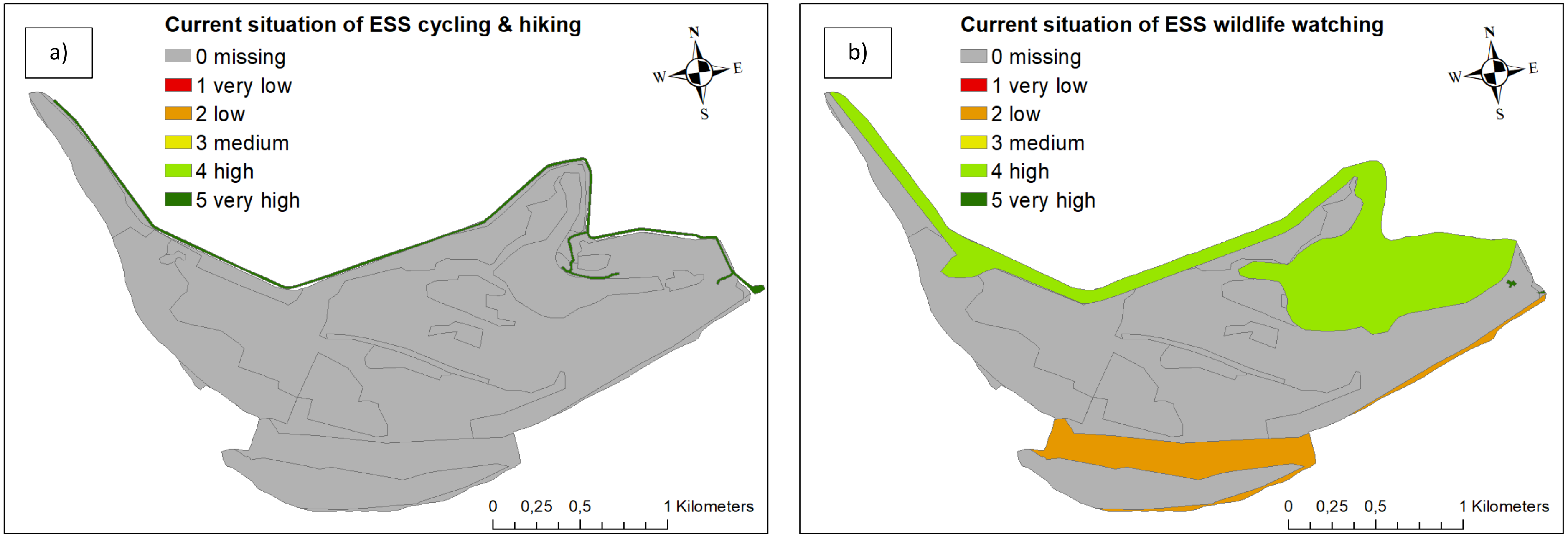


Figure 6: a) Intensity of the cultural ESS cycling and hiking and b) of the cultural ESS wildlife watching in the pilot area Begečka Jama. The values of the intensity of use are marked in different colours.

The water-related activities *sport fishing, swimming* and *water sports* at lake Begec depend on the water quality or the water depth respectively. In areas where the water is not deep enough or the bottom of the lake is covered with deposits, the value is lower than in the other used areas. The ESS *sport fishing* is also carried out along the Danube River and at a small water body in the western part of the pilot area. The use of the ESS *sport fishing* is very high on the lake and along small parts of the river bank but low in the rest of the used areas (figure 7a). *Swimming* and *water sports* are moderately exercised in the deeper parts of the lake but only very rarely practised in the shallower areas (figure 7b).

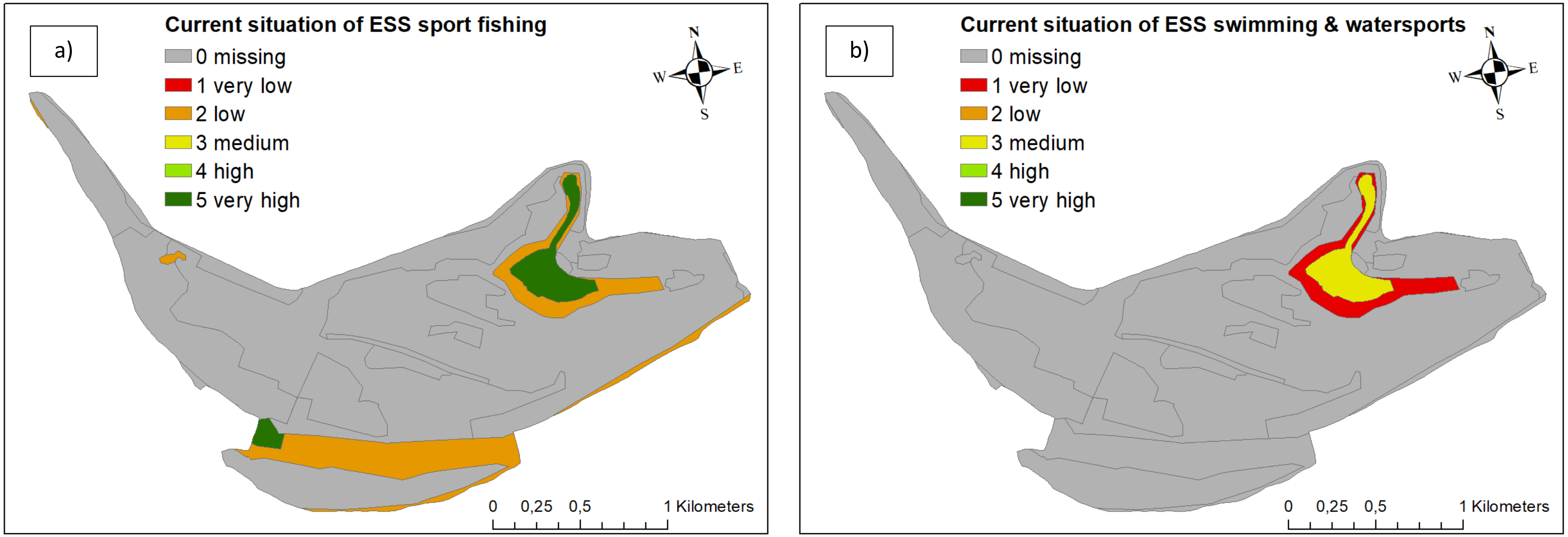


Figure 7: a) Intensity of the cultural ESS sport fishing and b) of the cultural ESS swimming and water sports in the pilot area Begečka Jama. The values of the intensity of use are marked in different colours.

5.3 Results of the assessment of ecosystem services by using land cover/land use data

Together with the responsible project partners of the pilot areas and some external experts not related to the project the intensity of each potential ESS in floodplains was assessed. The results of the current situation of the potential provisioning and regulating ecosystem services were calculated and visualized for all pilot areas. In the case of the Morava pilot area there are only results for the restoration scenario RS2, the impact of the measures of restoration scenario RS1 are not visualisable. In relation to the overall size of the pilot area, the areas of the reconnected oxbow lakes and lateral branches are too small to show discernible differences in the provision of ecosystem services between the current situation and the situation after restoration (RS1).

5.3.1 Begečka Jama

This pilot area is characterized by its large forest areas (figure 8). There are no agriculturally used areas. Different water bodies like a part of the Danube River (southern border), the lake Begec, a small lake in the western part and old oxbow channels are part of the area of which the northern border is formed by a dike with adjoining meadows.

With the implementation of the measures of restoration scenario RS1, parts of the broadleaved forest and transitional wood and scrub areas will be changed into intermittently running watercourses (figure 8). In restoration scenario RS2 interconnected watercourses connecting the Danube River with lake Begec and rewetting the forest areas will be created as well as a new sidearm of the Danube River. Thus, forest and transitional woodland scrub areas will decrease (figure 8). The land cover/land use change by both restoration scenarios has an impact on the intensity of the potentially provided ESS.

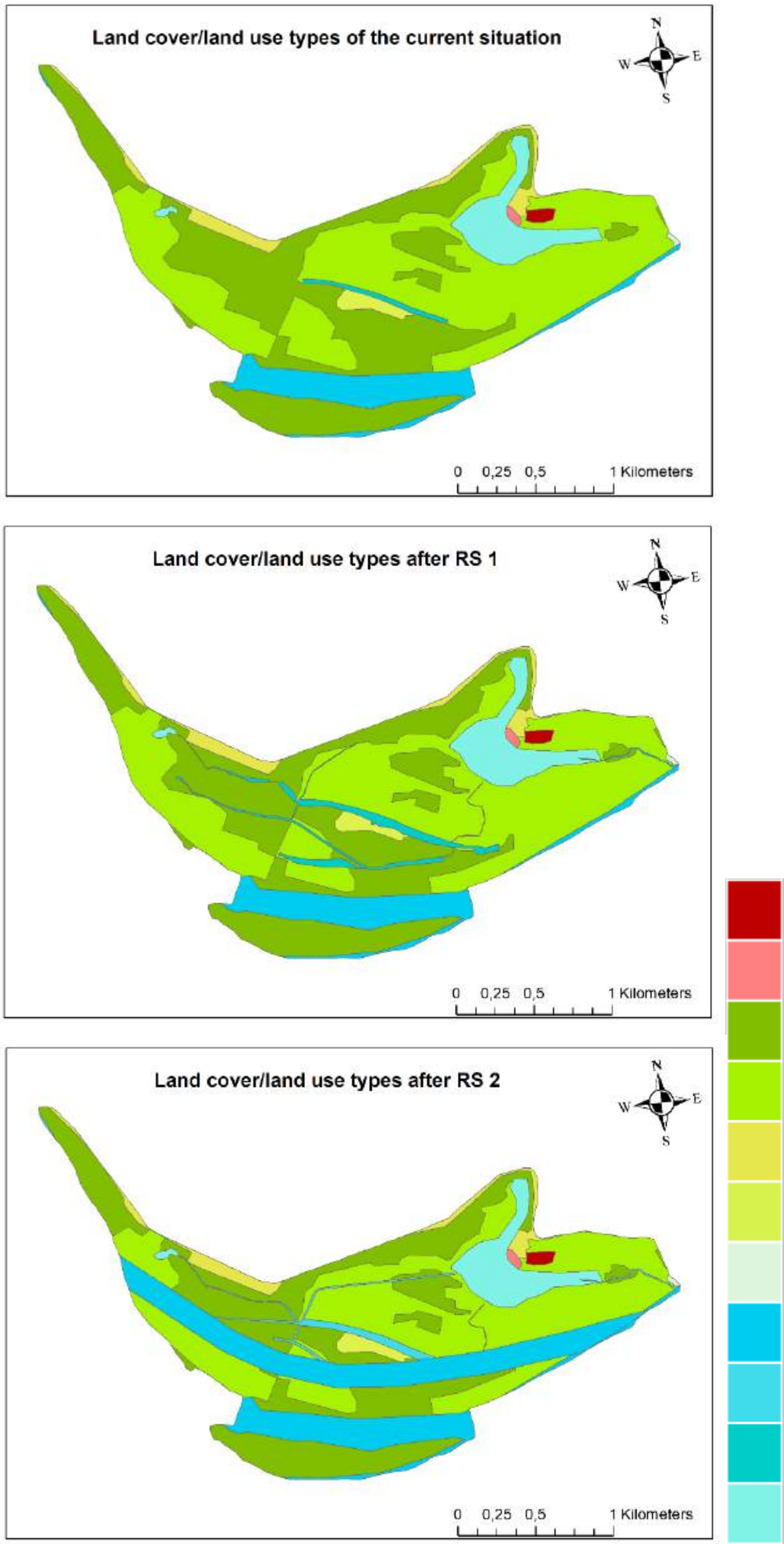


Figure 8: Land cover/land use of the current situation, after the implementation of restoration scenario 1 (RS1) and restoration scenario 2 (RS2).

Potential of the provisioning ESS

The maps of the potential of the provisioning ESS wood, ESS animal product, ESS honey, ESS fish and ESS water for the current situation and both restoration scenarios (RS1 and RS2) are shown on the following pages (figures 9-13).

The current situation of the potential to provide the ESS *woo*d is mainly high to very high (figure 9). This potential will decrease by implementing the restoration measures in the affected areas, former forest areas will be transformed into water bodies.

In contrast, the intensity of the potential to provide the ESS *animal product* is low to very low (figure 10). Only in the grassland areas is a very high potential for ESS *animal product*.

The potential to supply the ESS *fish* is very high in the oxbow lakes and the Danube River but medium or low in the disconnected oxbow channel (figure 11). This will change after implementation of the measures of RS1 from a medium provision to a high provision, and by implementing the measures of RS 2 the potential to provide ESS *fish* will increase by the reconnection of the oxbow channels to a very high level.

There is only one area (natural grassland) which provide the ESS *honey* to a very high degree (figure 12). The remaining areas have a low or medium potential to provide the ESS *honey*.

The potential to provide the ESS *water* is very high in the Danube River and the oxbow lakes but low in the disconnected oxbow channel (figure 13). After the implementation of restoration scenario 1, the potential to provide the ESS *water* will be high in the oxbow channels. Restoration scenario 2 leads to a very high potential to provide the ESS *water* at the sidearm and the connected new watercourses.

Potential of the regulating ESS

The maps of the potential to provide regulating ESS *air purification*, ESS *local climate regulatio*n, ESS *low water regulation*, ESS *flood retention*, ESS *noise regulation* and ESS *provision of habitats* for all scenarios are shown on the figures 14 to 20.

The potential to provide the ESS *air purification* is very high in the natural forests (broadleaved forest) but low in the 'transitional woodland and scrub' and grassland areas (figure 14). The provision will not increase with the implementation of the measures of RS1 and RS2. In contrast, with the transformation of natural forest into watercourses this potential will be lost in these areas.

Also, the potential to provide the ESS *noise regulation* is strongly connected to forest areas, whereas the value of the potential to provide the ESS *noise regulating* is very high (figure 18). Forests reduce noise by the refraction of sound waves. Water areas with their nearly plane surfaces do not have this effect. The sound waves can get transmitted without any restraints, thus the potential of the ESS *noise regulation* is missing. It can thus be said that the potential for providing the ESS *noise regulation* in the action areas is disappearing.

In contrast, the potential supply of ESS *local climate regulation* (figure 15), ESS *low water regulation* (figure 15), ESS *flood retention* (figure 17), ESS *nutrient retention* (figure 19) and ESS *provision of habitats* (figure 20) benefits from the restoration measures. The potential of all these ESS increases with the cleaning, widening and reconnecting of oxbow channels and

the formation of new watercourses, through the improvement of lateral connectivity and the creation of habitats that are typical of floodplains and not artificially influenced.
The potential of the ESS *local climate regulation* is mainly high or very high in the current situation (figure 15). This is based on the forest and water areas which cover almost the entire pilot area. The potential ESS *local climate regulation* intensifies with the increase of the water surface.
The intensity of the potential ESS *low water regulation,* which is on a high level in the Danube River or on a very high level in the two lakes, will increase after the implementation of RS1 and RS2 (figure 16).
The ESS *flood retention* shows a high potential to retent water in natural forest areas and a very high potential in the watercourses but a low possibility to retent water during a flood in the rest of the pre-selected pilot area (figure 17). The intensity of the ESS *flood retention* will increase in RS1 and RS2 by creating new watercourses and deepening and widening the existing oxbow channel.
The ESS *nutrient retention* also has its highest potential in the water bodies (value of 5) and the near-natural forest and grassland areas (value of 4) (figure 19). Otherwise, the potential to provide the ESS *nutrient retention* is medium or very low. After the implementation of RS1 and RS2, the potential for nutrient retention will increase.
The potential provision of the ESS *provision of habitats* is very differentiated depending on the land cover/land use type in the current situation. Floodplain typical land cover/land use types have the highest potential (value of 5) to provide habitats (figure 20). These land cover/land use types are 'natural and semi-natural broadleaved forest' and 'interconnected running watercourses'. Restoration scenario 1 will improve the ESS *provision of habitats* by cleaning and widening the oxbow channel and creating of new natural water channels on. Restoration scenario RS2 will significantly increase the potential of the ESS *provision of habitats* by creating a new sidearm and new natural watercourses.

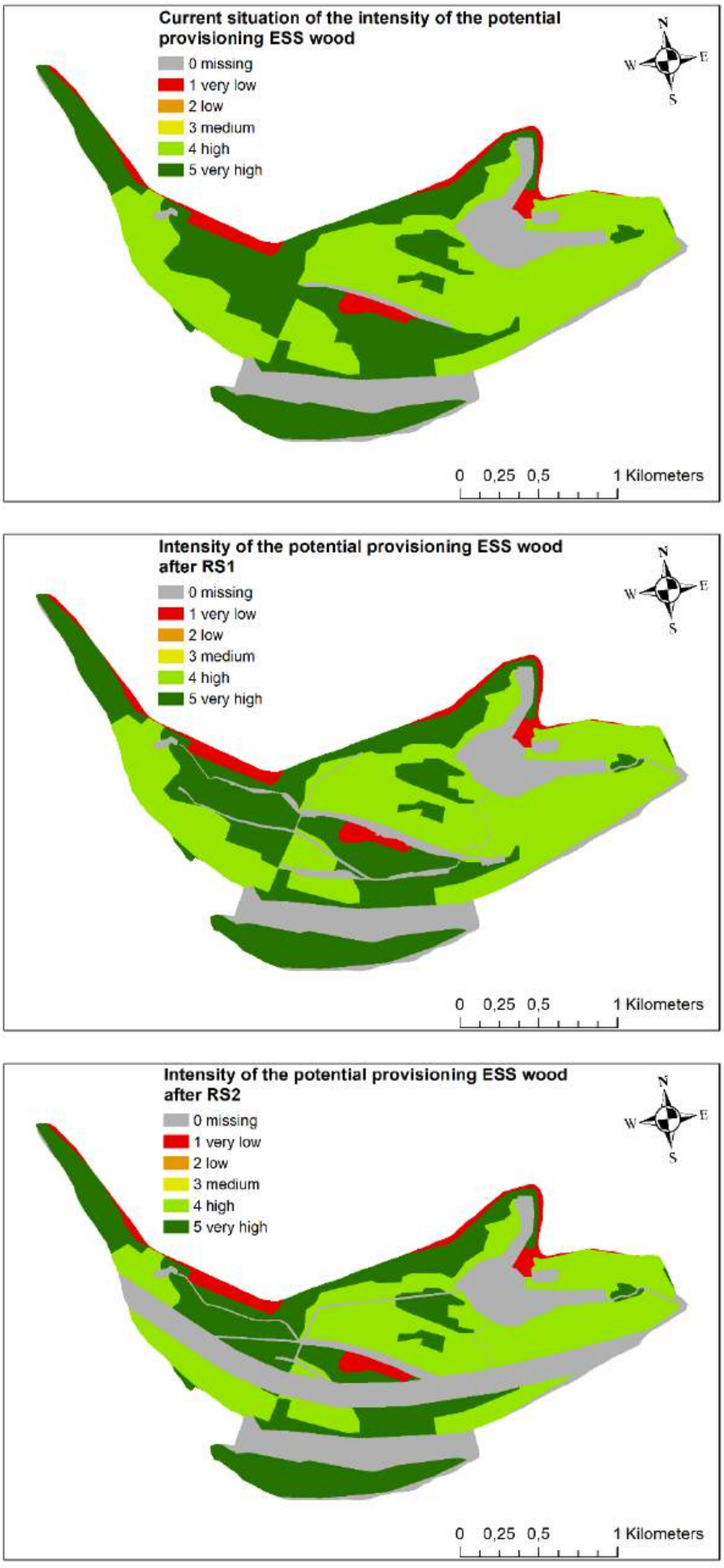


Figure 9: Intensity of the potential of the provisioning ESS wood in the current situation, the restoration scenario RS1 and the restoration scenario RS2. The values of the intensity of the potential ESS are marked in different colours.

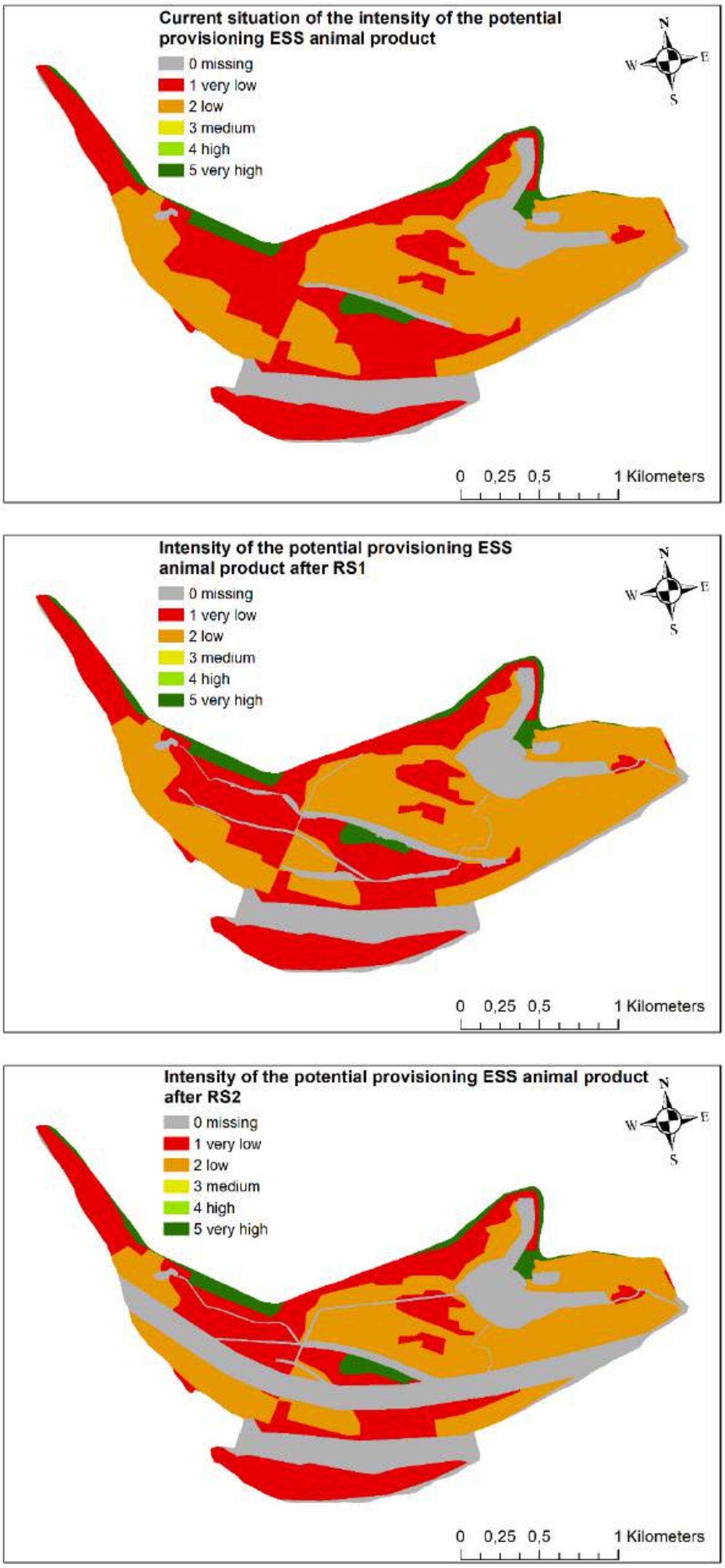


Figure 10: Intensity of the potential of the provisioning ESS animal product in the current situation, the restoration scenario RS1 and the restoration scenario RS2. The values of the intensity of the potential ESS are marked in different colours.

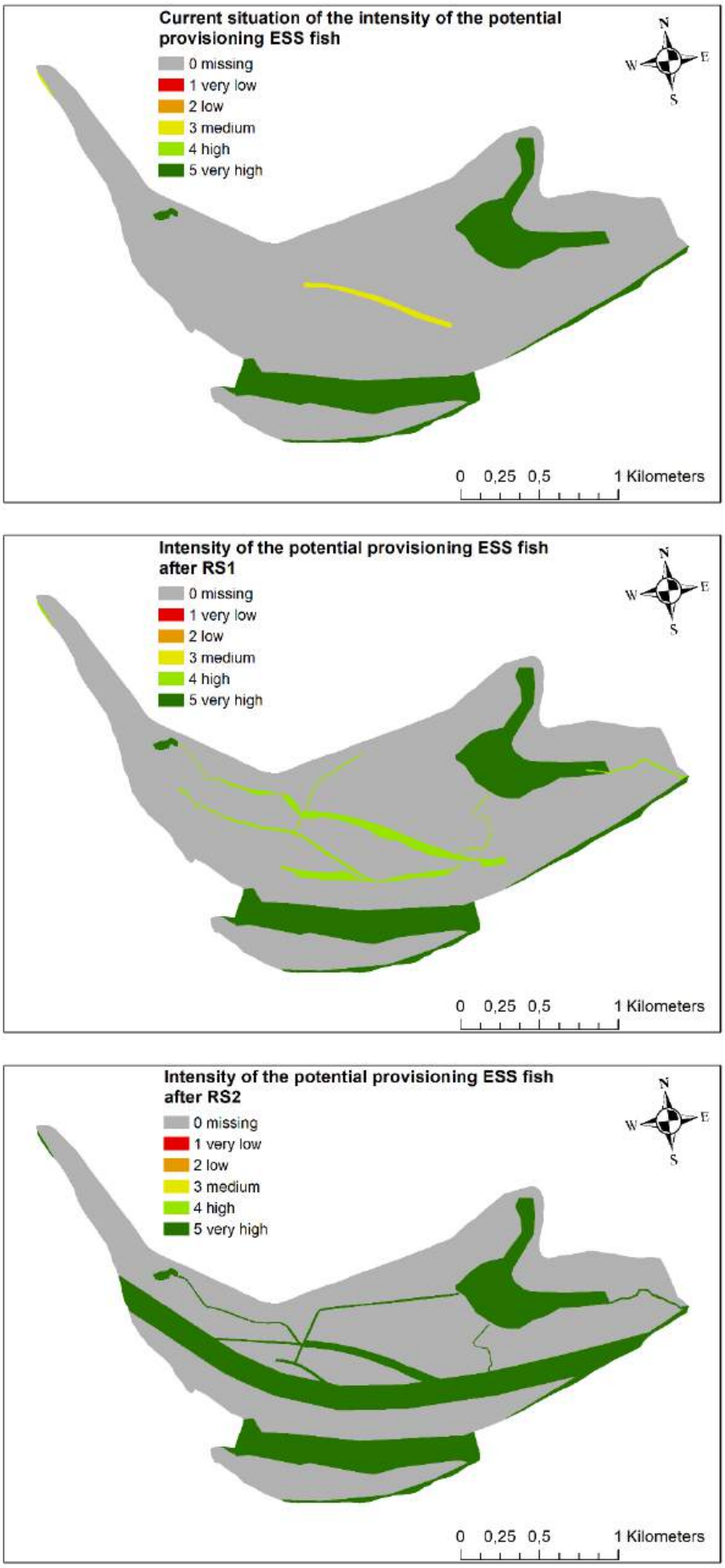
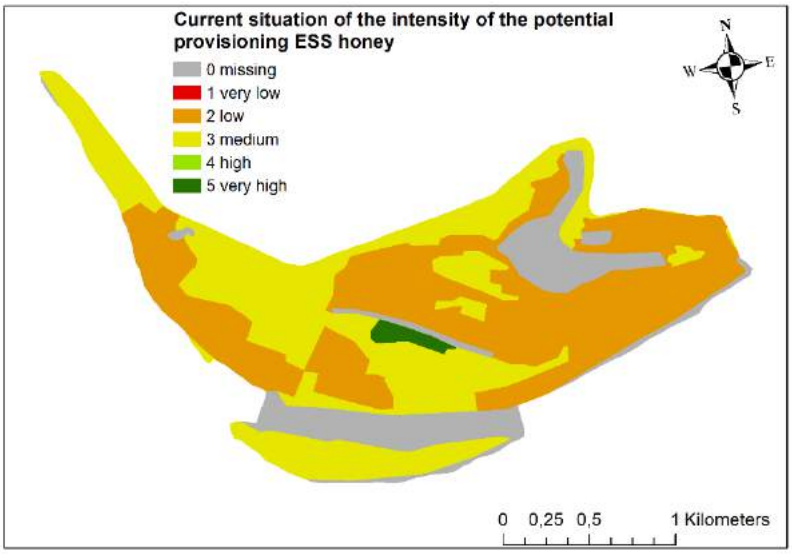
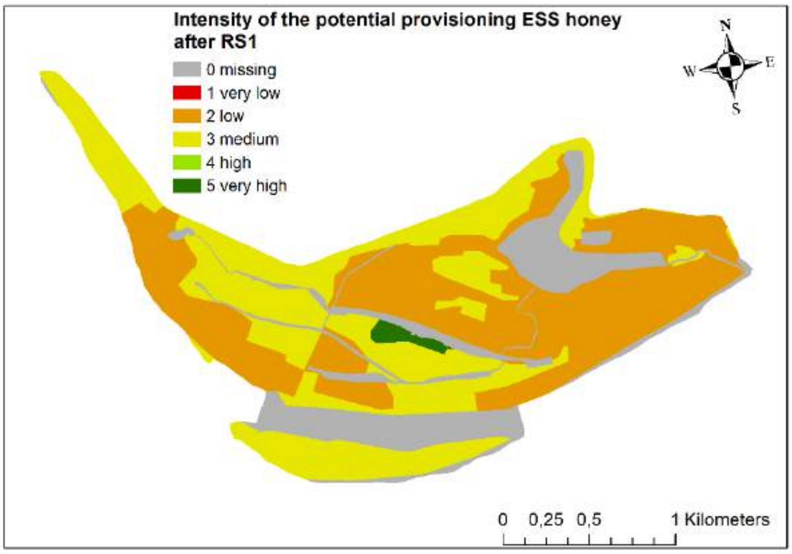


Figure 11: Intensity of the potential of the provisioning ESS fish in the current situation, the restoration scenario RS1 and the restoration scenario RS2. The values of the intensity of the potential ESS are marked in different colours.





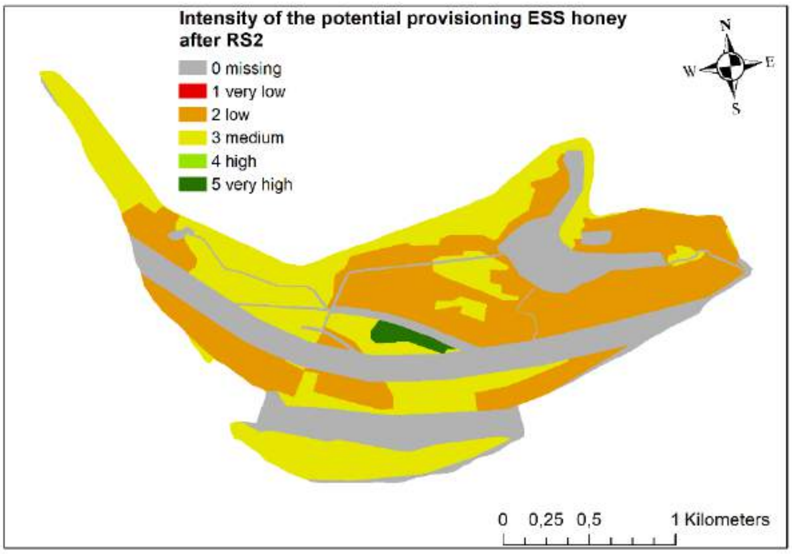


Figure 12: Intensity of the potential of the provisioning ESS honey in the current situation, the restoration scenario RS1 and the restoration scenario RS2. The values of the intensity of the potential ESS are marked in different colours.

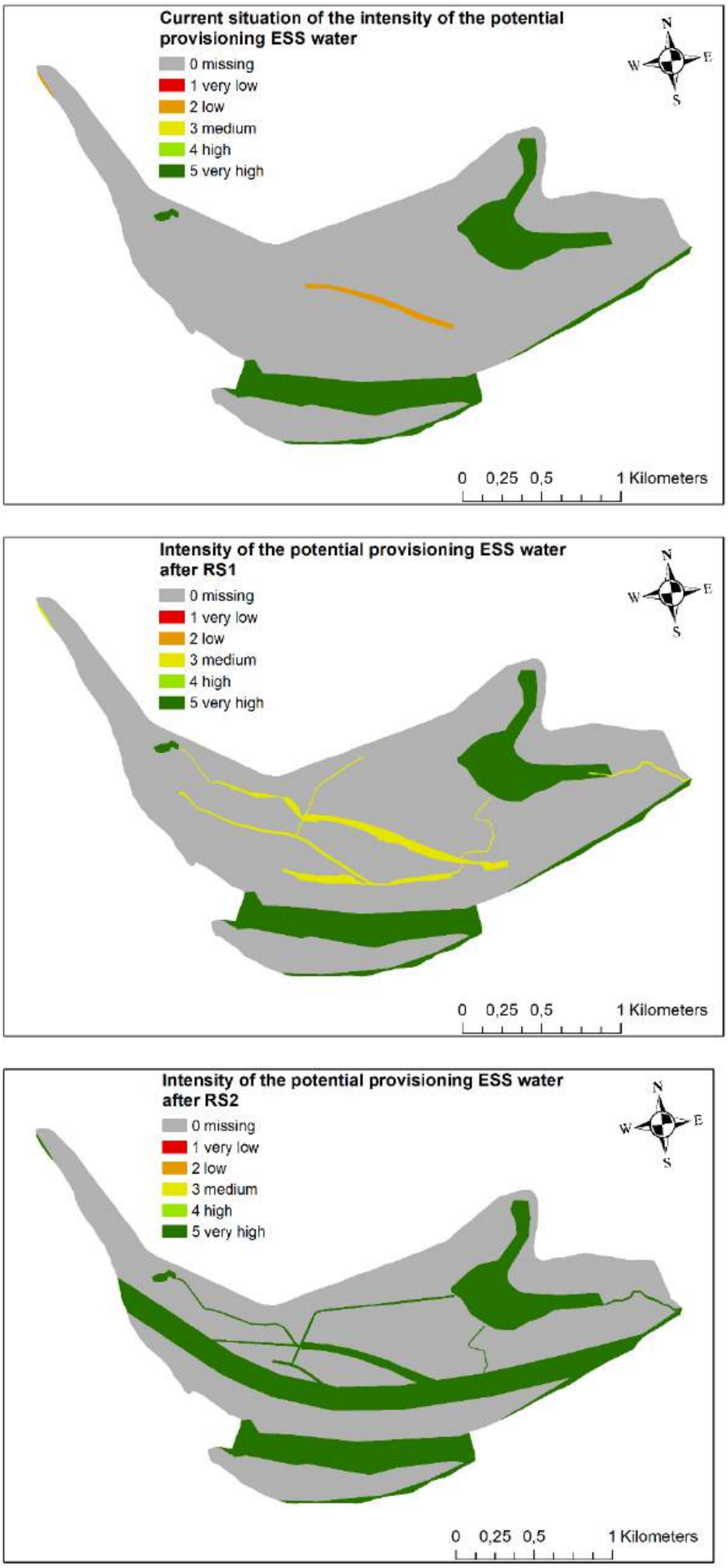
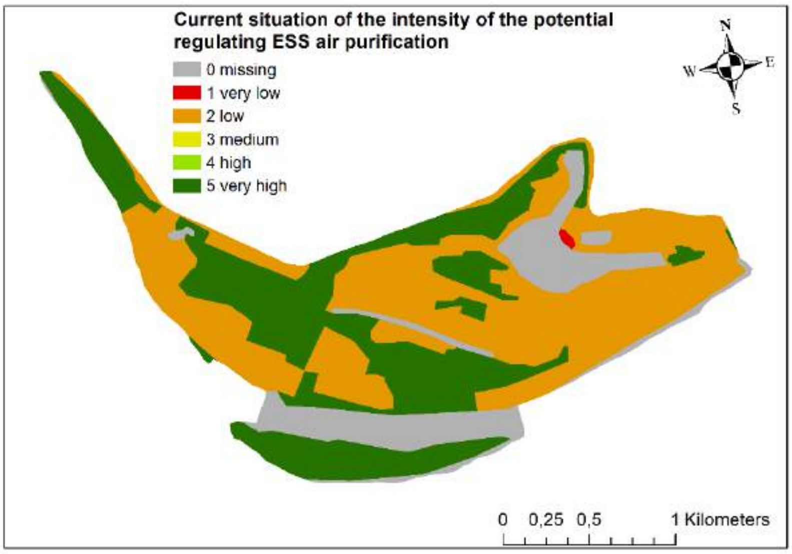
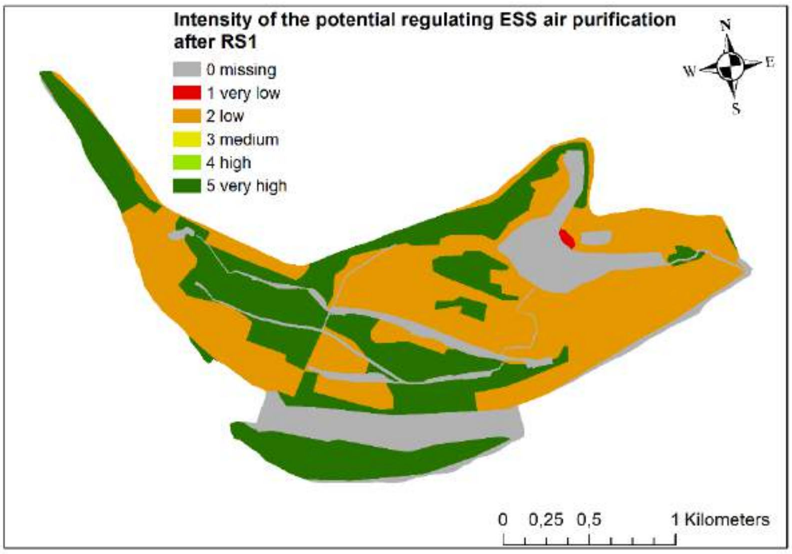


Figure 13: Intensity of the potential of the provisioning ESS water in the current situation, the restoration scenario RS1 and the restoration scenario RS2. The values of the intensity of the potential ESS are marked in different colours.





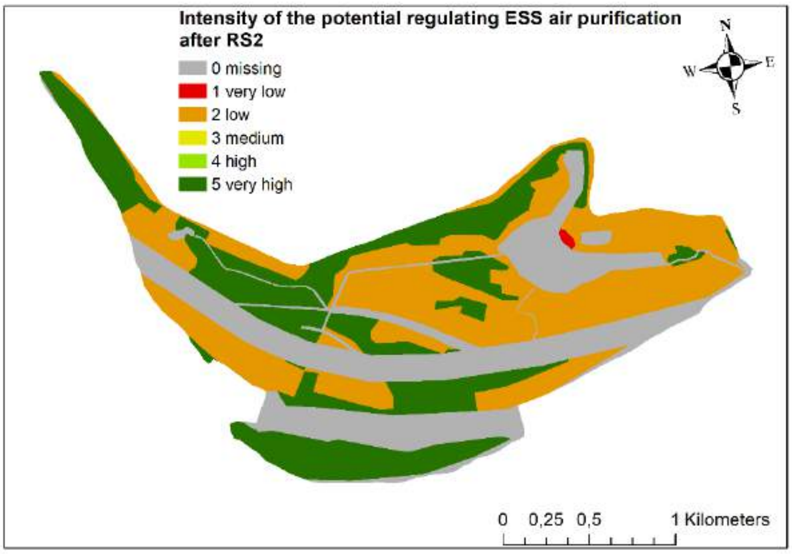
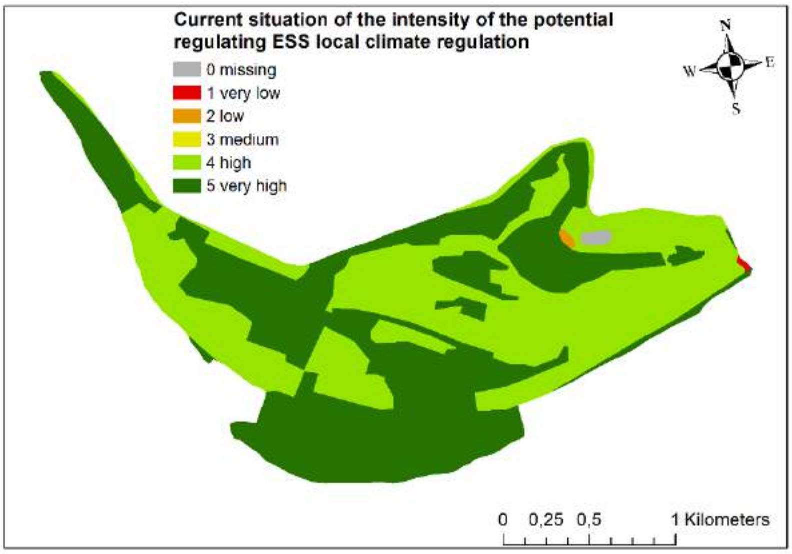
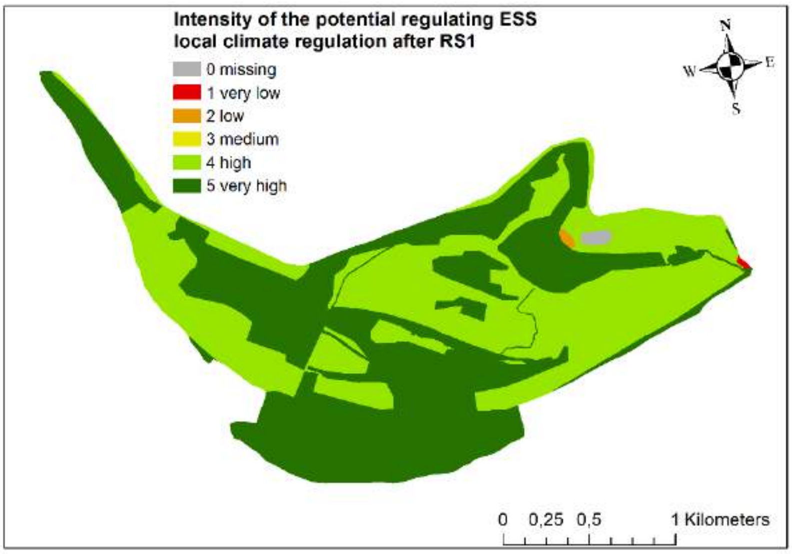


Figure 14: Intensity of the potential of the provisioning ESS air purification in the current situation, the restoration scenario RS1 and the restoration scenario RS2. The values of the intensity of the potential ESS are marked in different colours.





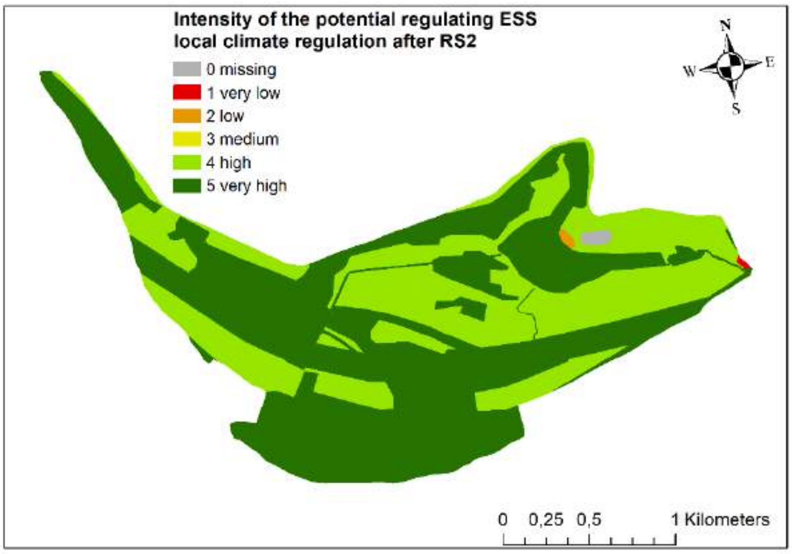


Figure 15: Intensity of the potential of the provisioning ESS local climate regulation in the current situation, the restoration scenario RS1 and the restoration scenario RS2. The values of the intensity of the potential ESS are marked in different colours.

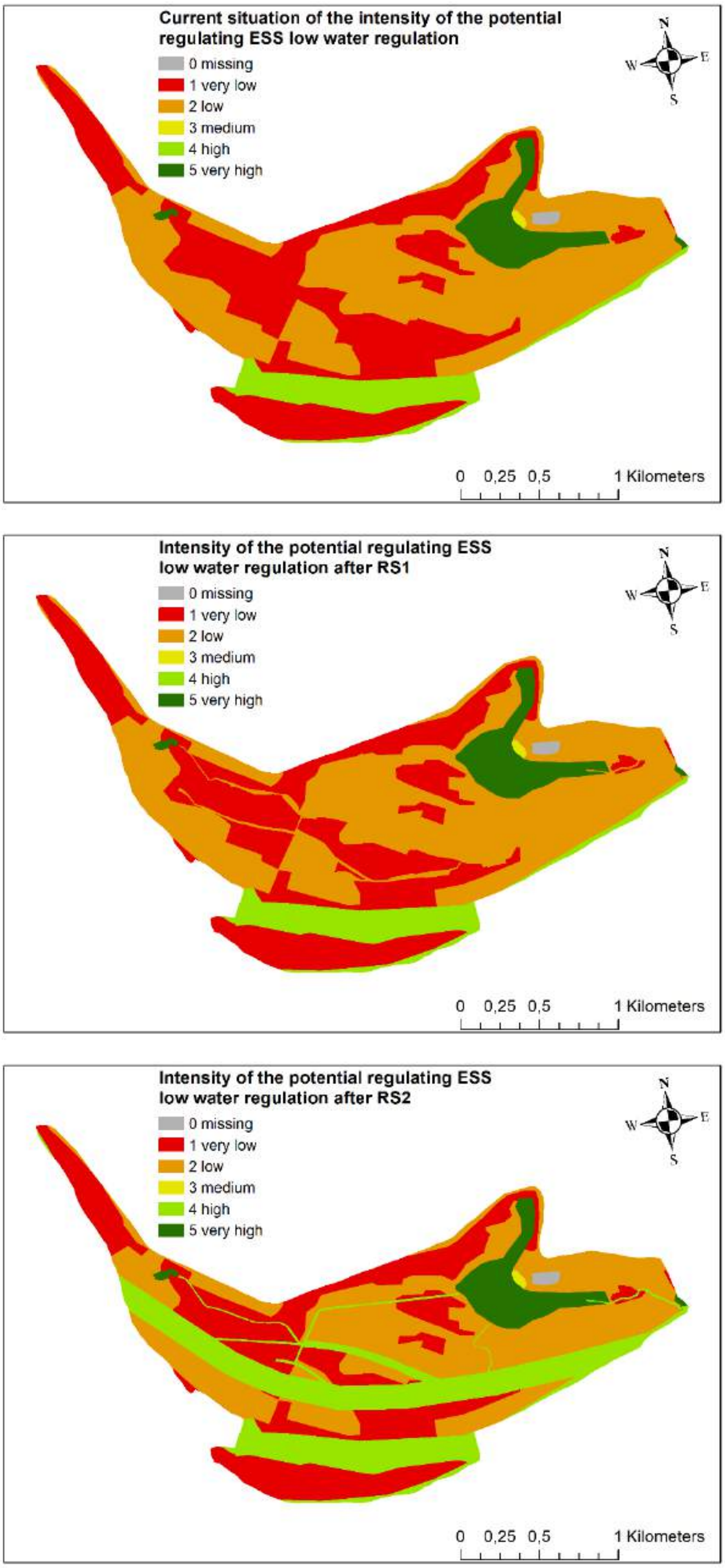


Figure 16: Intensity of the potential of the provisioning ESS low water regulation in the current situation, the restoration scenario RS1 and the restoration scenario RS2. The values of the intensity of the potential ESS are marked in different colours.

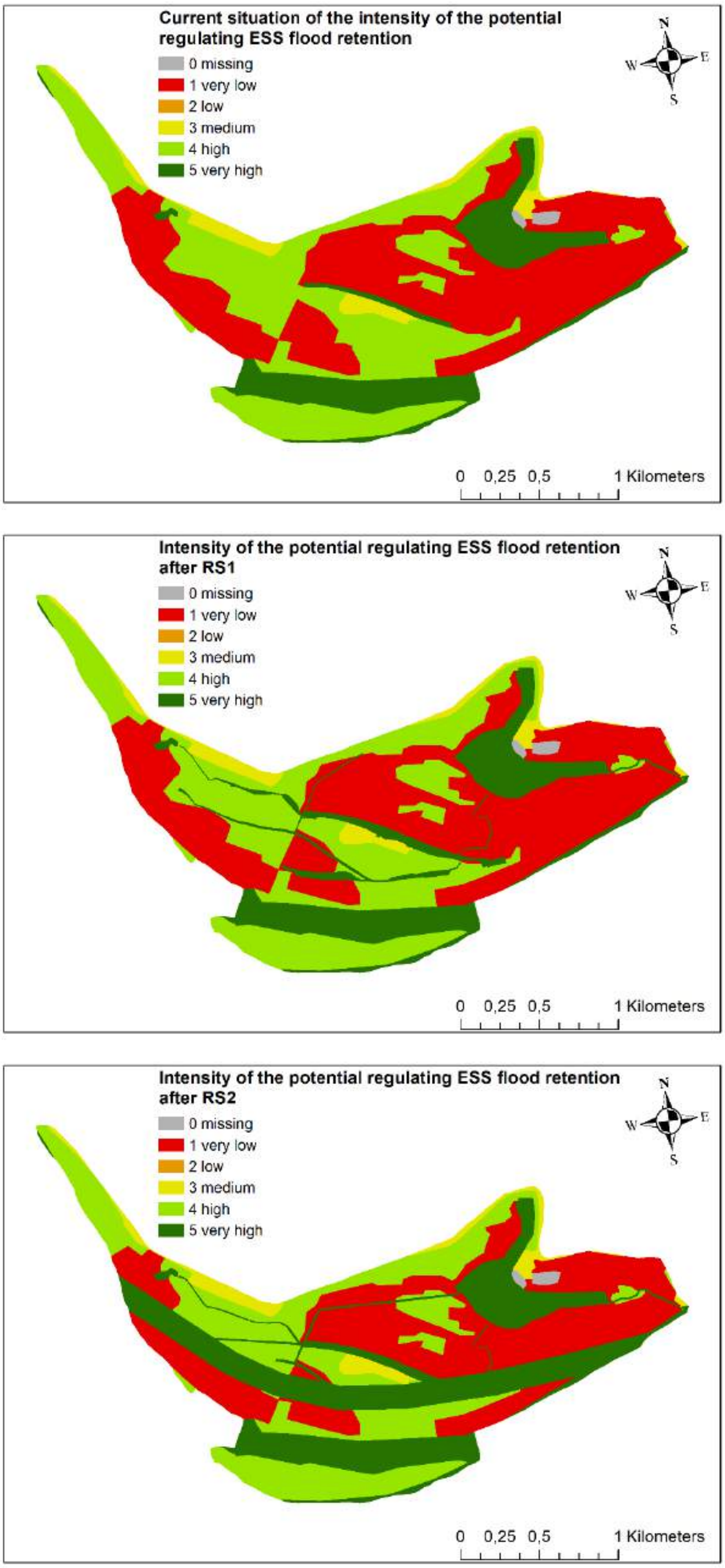


Figure 17: Intensity of the potential of the provisioning ESS flood retention in the current situation, the restoration scenario RS1 and the restoration scenario RS2. The values of the intensity of the potential ESS are marked in different colours.

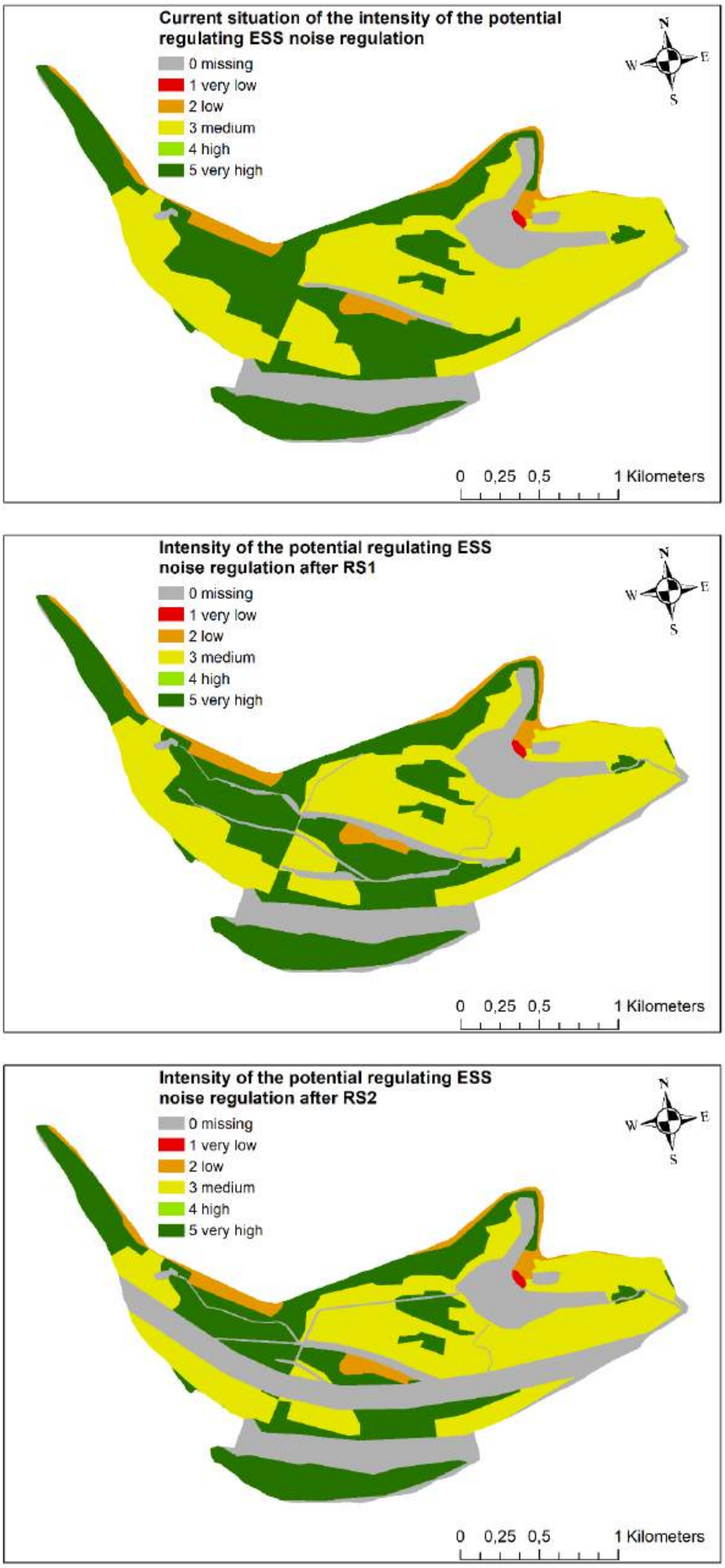
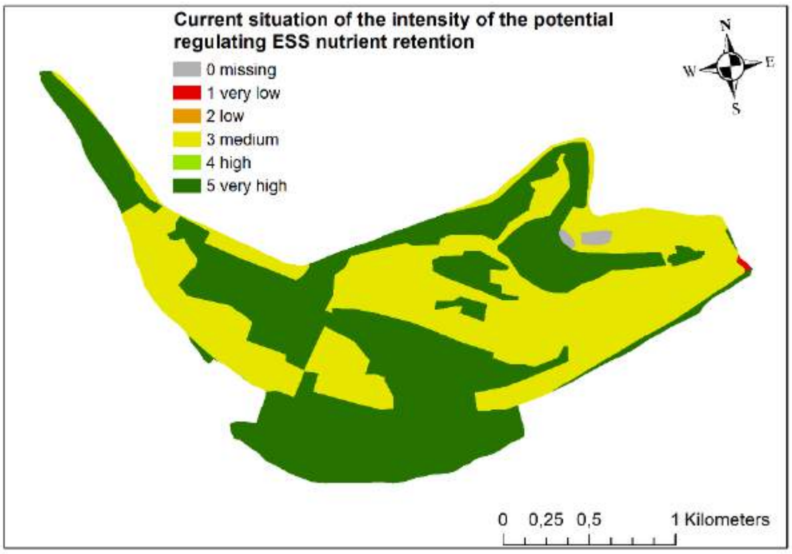
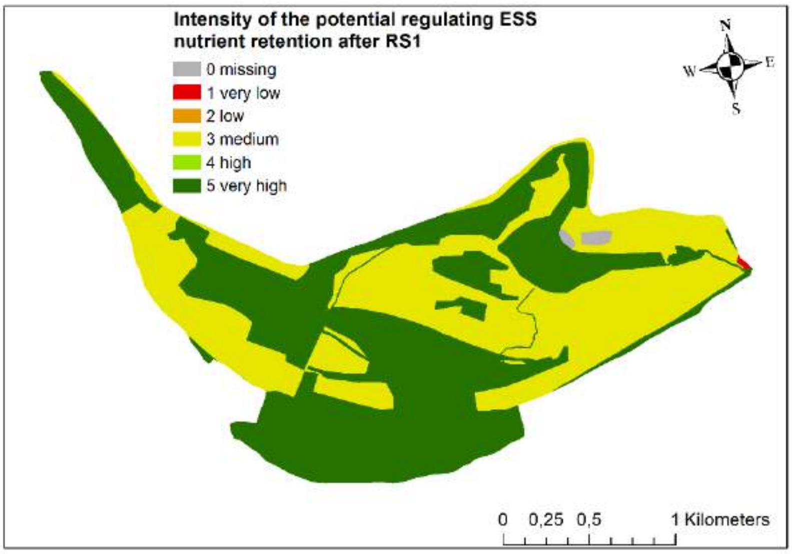


Figure 18: Intensity of the potential of the provisioning ESS noise regulation in the current situation, the restoration scenario RS1 and the restoration scenario RS2. The values of the intensity of the potential ESS are marked in different colours.





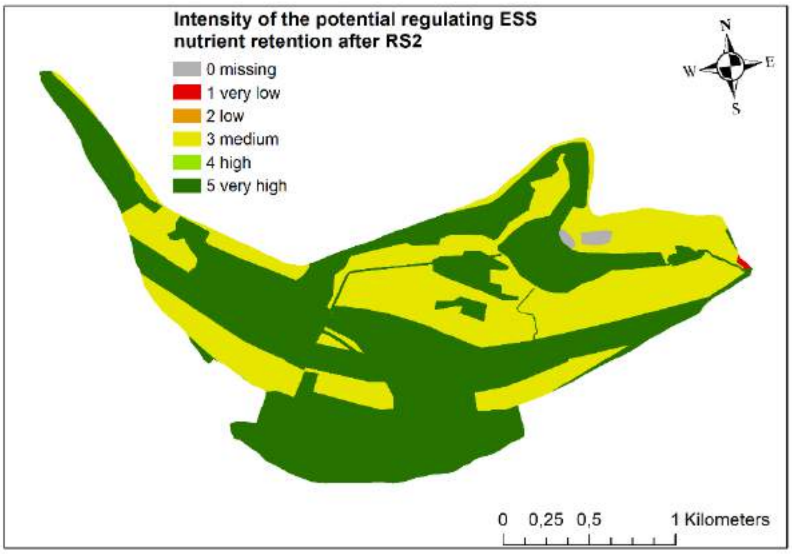
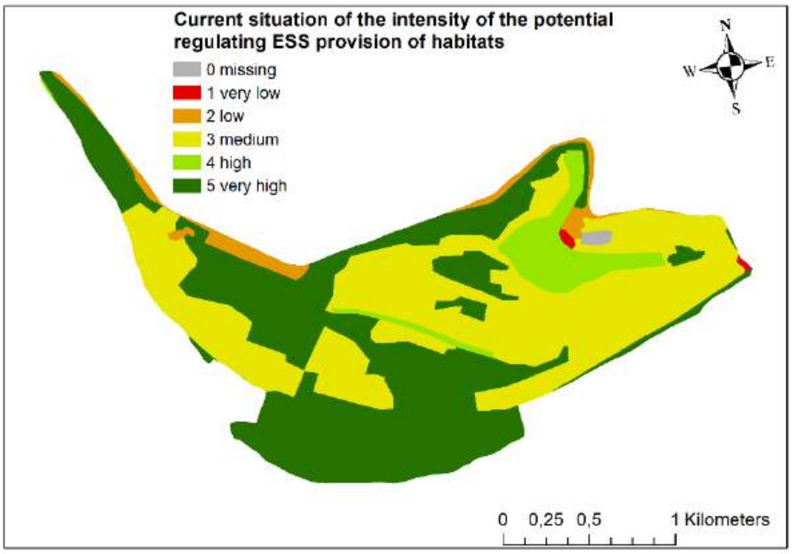
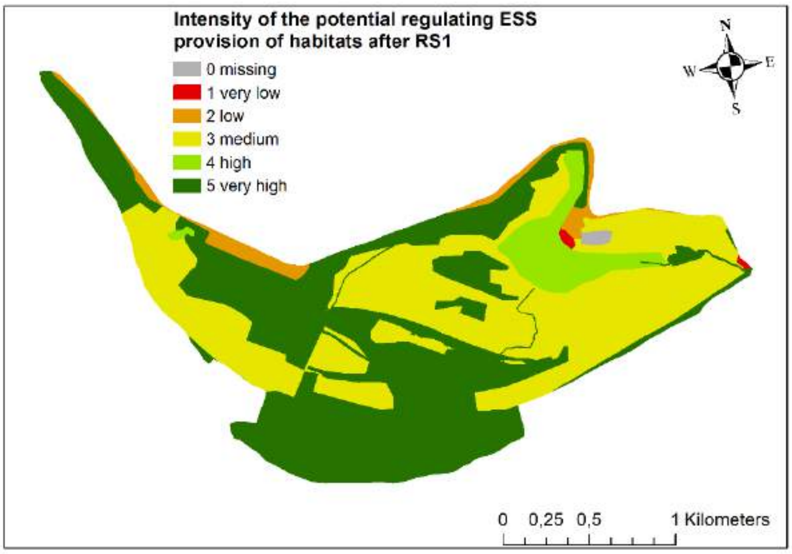


Figure 19: Intensity of the potential of the provisioning ESS nutrient retention in the current situation, the restoration scenario RS1 and the restoration scenario RS2. The values of the intensity of the potential ESS are marked in different colours.





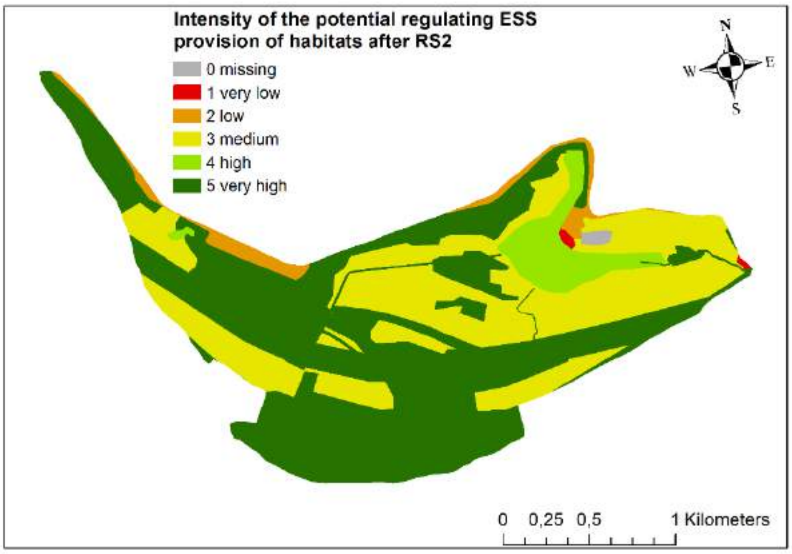


Figure 20: Intensity of the potential of the provisioning ESS provision of habitats in the current situation, the restoration scenario RS1 and the restoration scenario RS2. The values of the intensity of the potential ESS are marked in different colours.

Joint consideration of all potential provisioning ESS and all potential regulating ESS

All provisioning ESS taken together show a rather low availability of the supplying services in the current situation (figure 21). Only natural grassland has a medium potential for the provisioning of ESS. The heavily modified watercourses, on the other hand, show only a very low potential. The supply of all provisioning ESS will increase with measures of RS1 and RS2. There is no difference between the supply of all provisioning ESS after RS1 and RS2, the increase depends mainly on the improvement of the provision of ESS *water* and ESS *fish*.

The provision of all regulating ESS is mainly medium in managed forest and grassland areas or very high in near-natural forest areas in the current situation (figure 22). This will not change after the implementation of the measures of RS1 or RS2. However, the improvement of the lateral connectivity and the establishment of new floodplain habitats by the cleaning and widening of the oxbow channel and the creation of new watercourses will increase the supply of all potential regulating ESS in the water bodies.

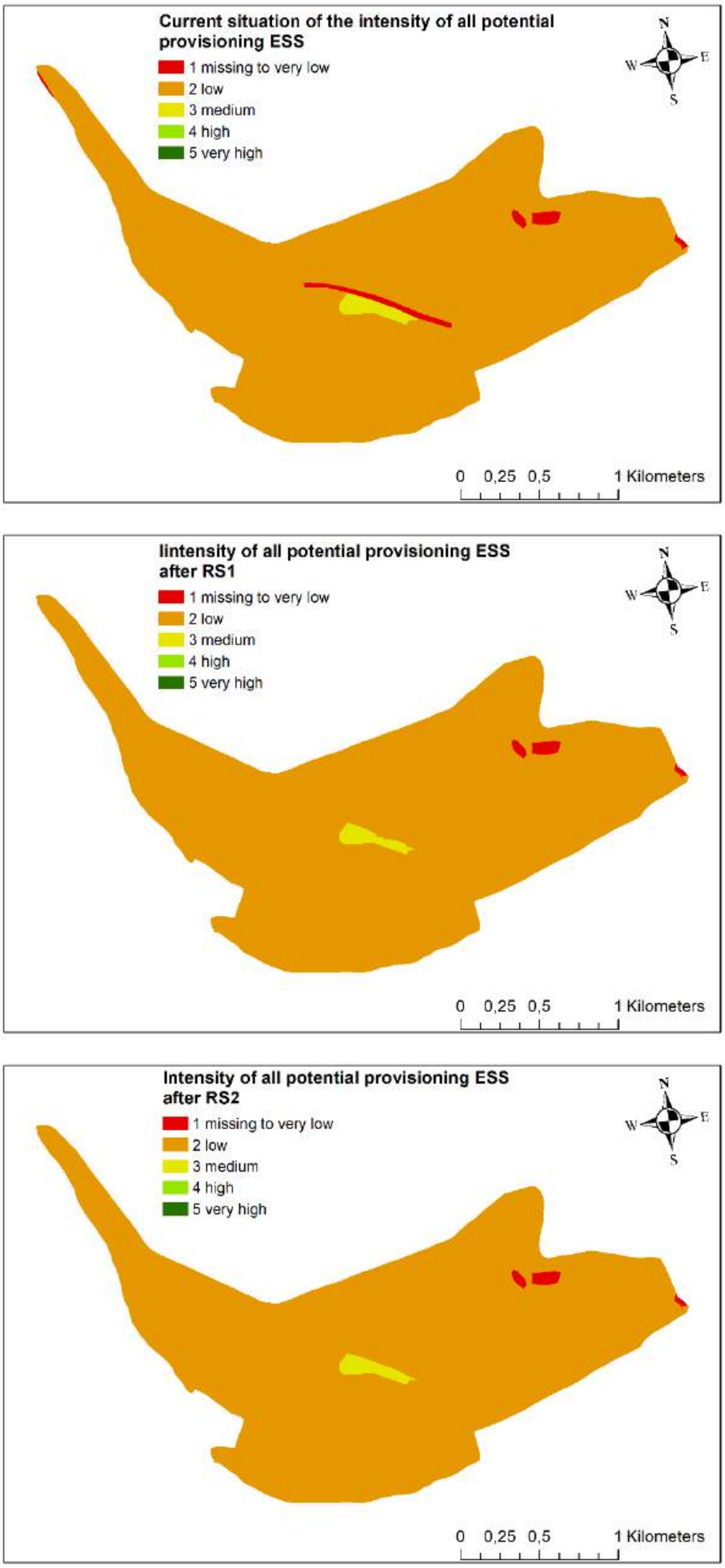
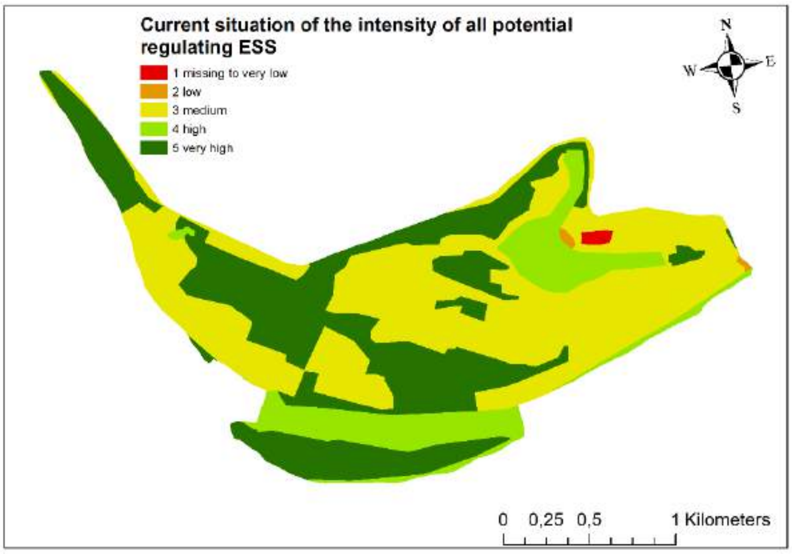
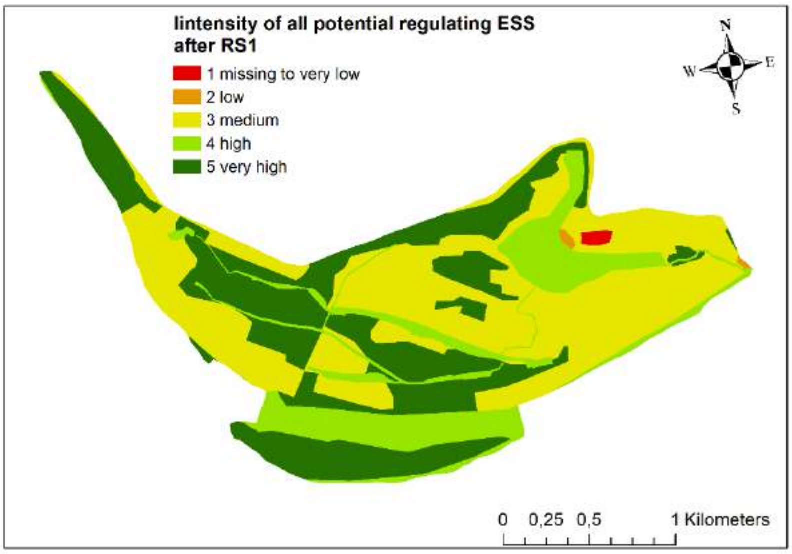


Figure 21: Intensity of all potential provisioning ESS in the current situation, the restoration scenario RS1 and the restoration scenario RS2. The values of the intensity of the potential ESS are marked in different colours.





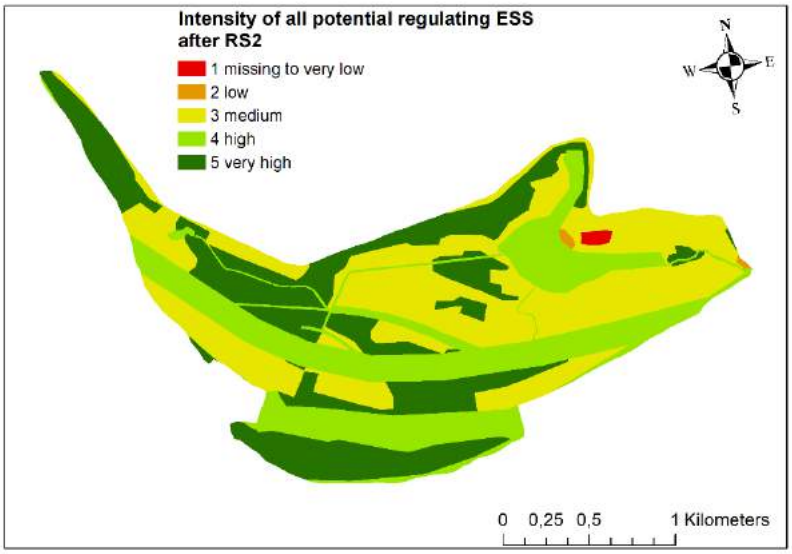


Figure 22: Intensity of all potential regulating ESS in the current situation, the restoration scenario RS1 and the restoration scenario RS2. The values of the intensity of the potential ESS are marked in different colours.

5.3.2 Bistret

The pilot area is mainly used for agriculture, in the form of arable land and grassland (figure 23). Besides inland marshes, there are also large water areas. Along the Danube River and its tributary Jiu River, there are riparian broadleaved forests. Further details about the pilot area are described in Table 1. The construction of a recreational and fish-farming lake (200 ha) in the Rast area is one of the measures foreseen in restoration scenario RS1, as well as a dike relocation and the creation of a large drainage channel between lake Bistret and the Danube. In restoration scenario RS2 an additional dike relocation from the Danube closer to the villages along the alluvial terraces is foreseen. For the calculation of the ecosystem services provided under both restoration scenarios, only the dike relocations in the form of the modelled flood areas could be taken into account with a flooding return period of HQ 2-5. There are no spatial delineations for the new lake, drainage channel and dikes.

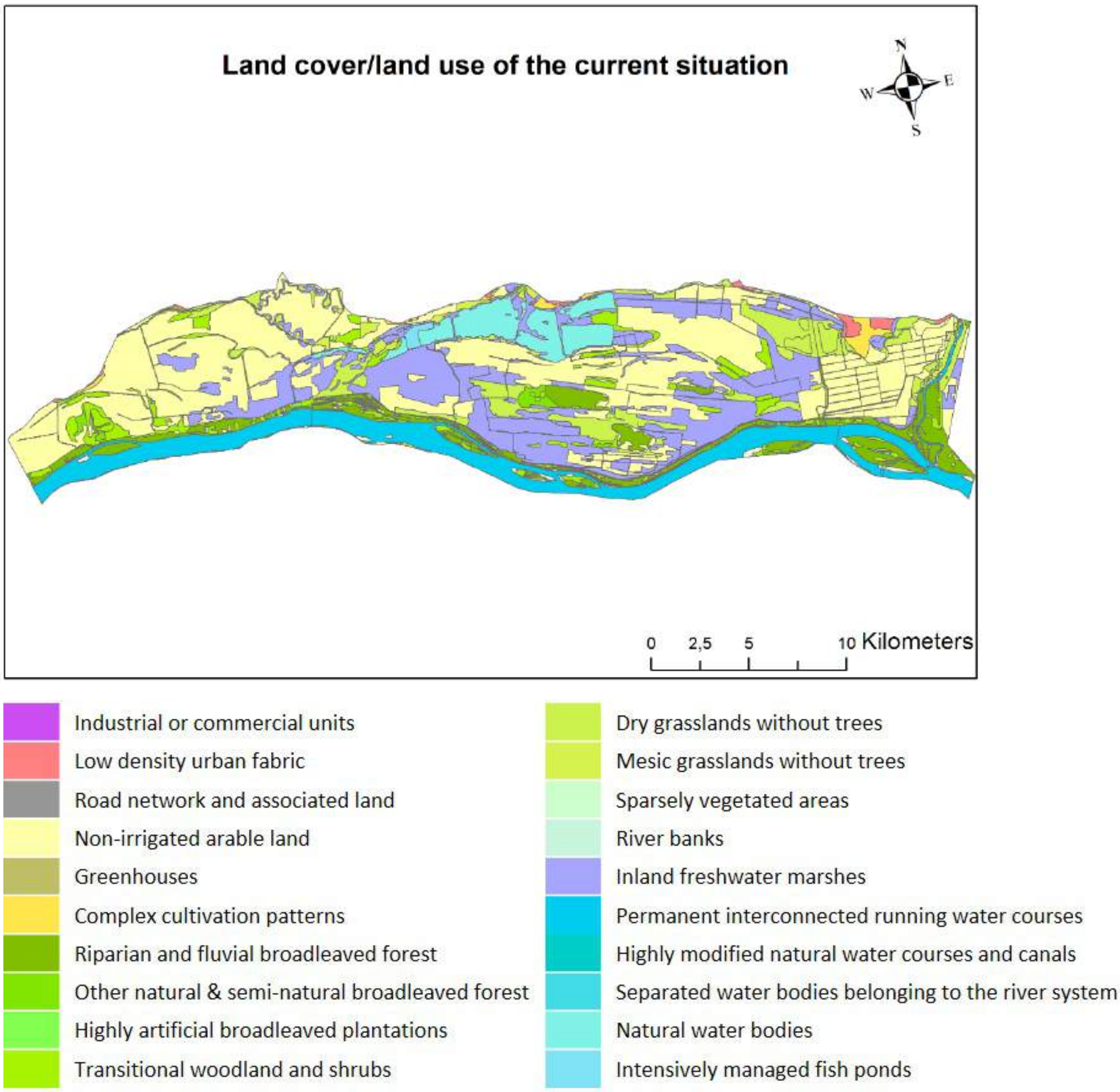
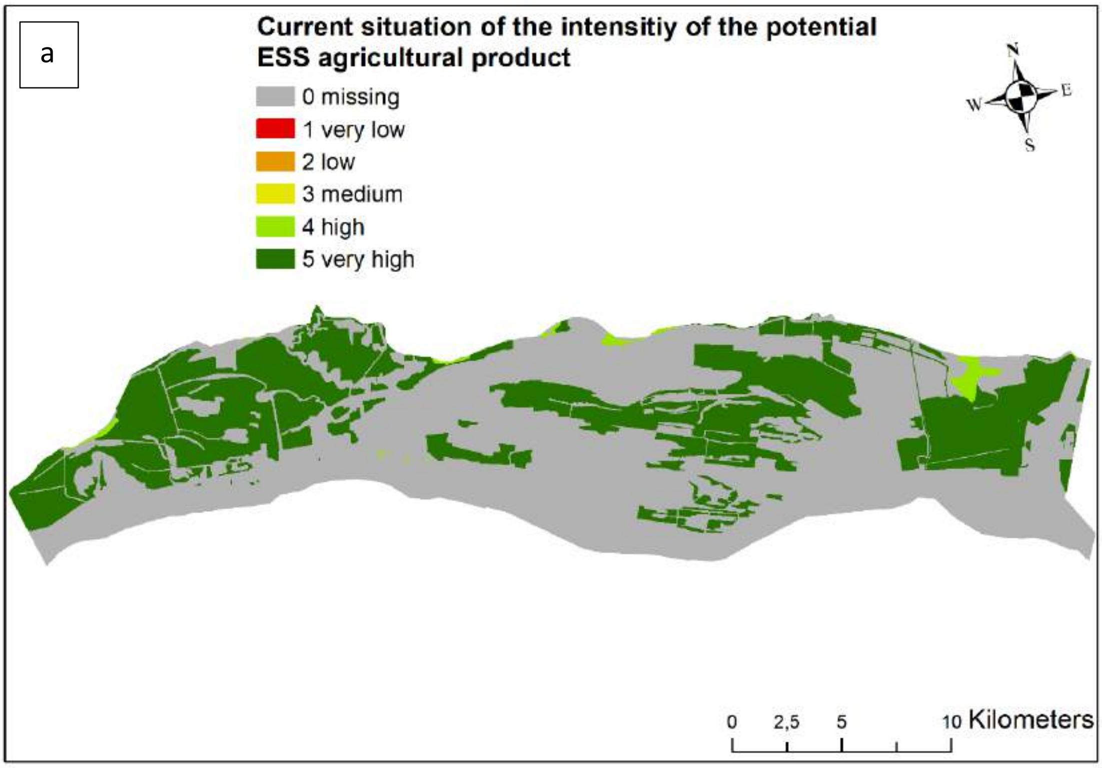


Figure 23: Land cover/land use of the current situation.

Potential of the provisioning ESS

The ESS *agricultural product* is provided by almost half of the pre-selected pilot area (figure 24). The intensity of the potential to supply this ESS is almost very high, in some areas high. The measures of restoration scenario RS1 have no impact on the level of the supply (figure 24). But with the dike relocation in restoration scenario RS2), the intensity of the potential ESS *agricultural product* decreases from a very high potential to high potential in the new floodable area (figure 25a), since the relocation of the dike is expected to lead to increased flooding of the fields. It is, therefore, to be expected that in future arable land will no longer be used as agricultural land but as grassland.
The potential of the area to supply the ESS *wood* is rather low (figure 25b). Only the few riparian forest areas in the pilot area have a very high potential to provide the ESS *wood*. The potential to supply the ESS *wood* is not influenced by either measures of RS1 or RS2 (figures 26a and b).
The pilot area mainly has a medium potential to supply the provisioning ESS *animal produc*t (figure 27a). The fact that some agricultural areas will be in the active floodplain as a result of the dike relocation in RS2, may reduce the yield of agricultural production there. Instead, these areas can be used as grassland, thereby increasing the potential for the ESS *animal product* (figure 28a). In contrast, the measures in RS1 have no impact on this ESS (figure 27b).
Approximately half of the area covered with inland marshes, riparian forests and transitional woodland and shrub is characterised by a very high intensity of the potential ESS *game meat* (figure 28b). The potential of the ESS *game meat* is very low on arable areas which are also very common. The land cover/land use type 'complex cultivation patterns' supply the ESS game meat on a medium level. As the land cover/land use will not change after the implementation of RS1, the supply of this ESS will not change (figure 29a). But the dike relocation of RS2 will increase the intensity of the potential ESS *game meat* from very low to low in the former arable land areas inside the new active floodplain (figure 29b).
The intensity of the potential ESS *honey* is in the current situation primarily medium (figure 30). Only the land cover/land use type 'complex cultivation patterns' provides it on a high level. The amount of potential ESS *honey* will not change in the new active floodplain after dike relocation in RS1 (figure 30b). However, it will increase to high intensity in the new grassland areas within the new active flood plain in RS2 (figure 31a).
Both rivers as well as the inland freshwater areas and lake Bistret provide a very high intensity of potential ESS *fish* (figure 31b). The heavily modified watercourses and canals, including those from the former irrigation system, have a medium intensity. Both restoration effects show no change in the intensity of the potential ESS *fish* (figures 32a and b).
The potential to provide the ESS *water* is very high in all water bodies but medium in the inland freshwater areas (figure 33a). The potential provision will not be impacted by both dike relocation possibilities (figure 33b and figure 34).



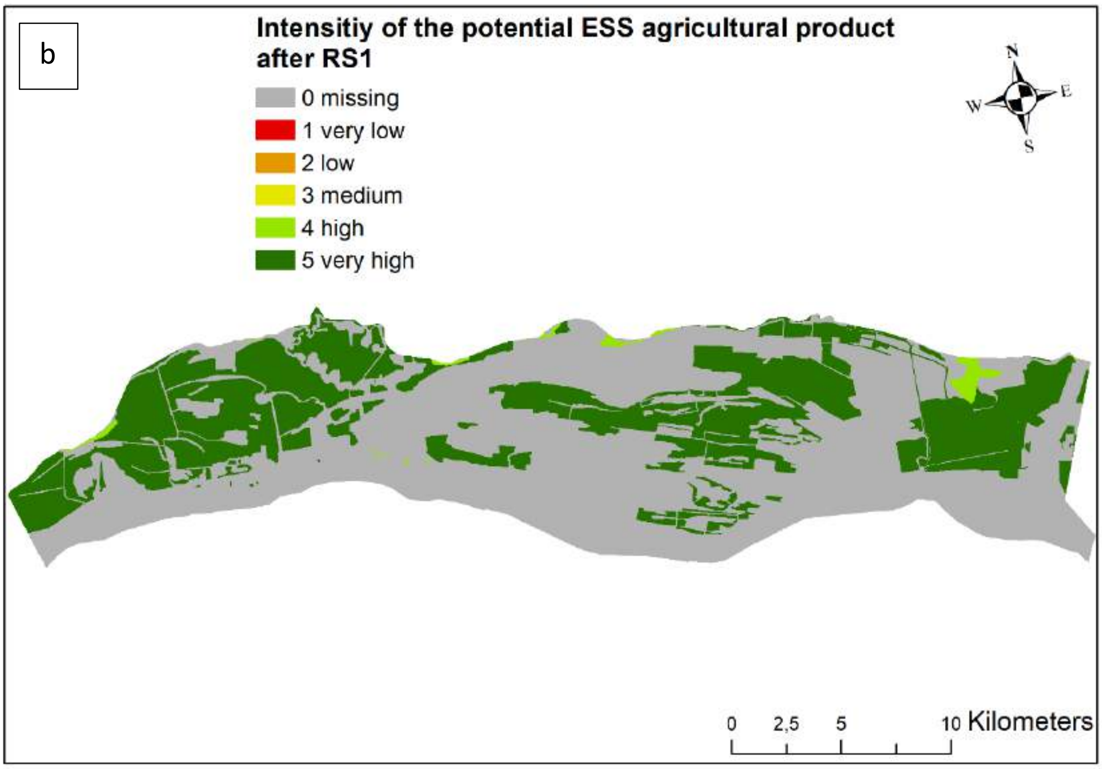
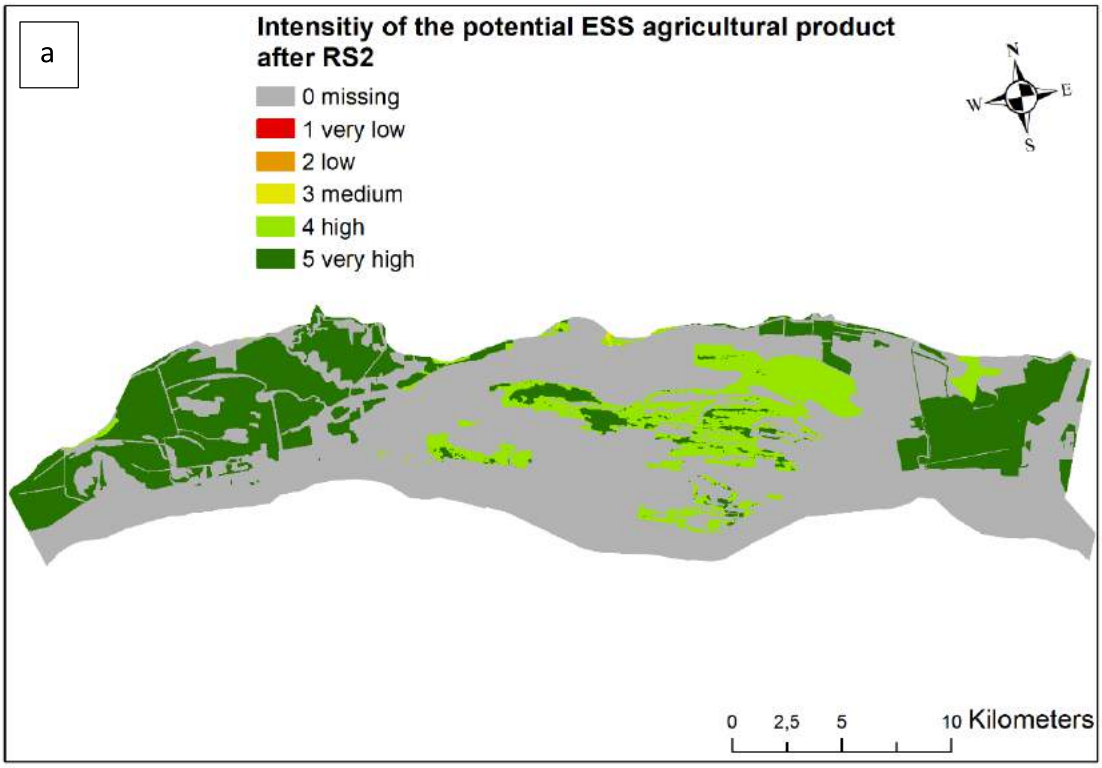


Figure 24: Intensity of the potential provisioning ESS agricultural product a) in the current situation and b) after restoration scenario RS). The values of the intensity of the potential ESS are marked in different colours.



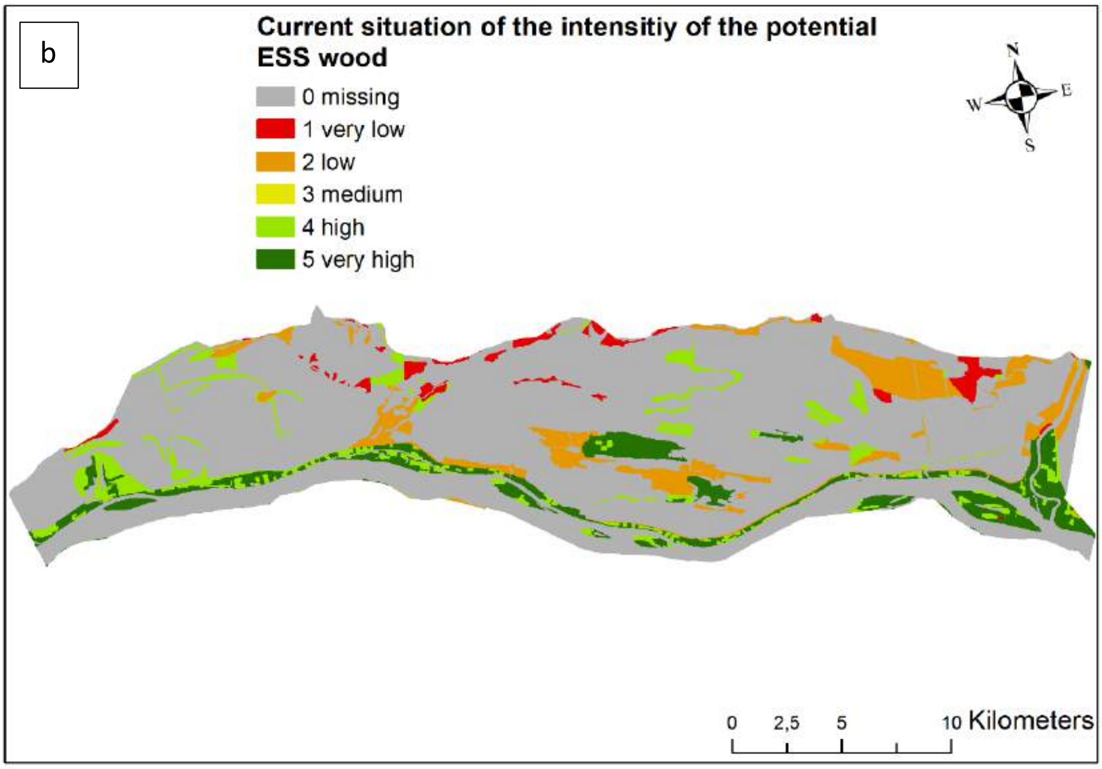


Figure 25: a) Intensity of the potential provisioning ESS wood after restoration scenario RS). b) Intensity of the potential provisioning ESS wood in the current situation. The values of the intensity of the potential ESS are marked in different colours.

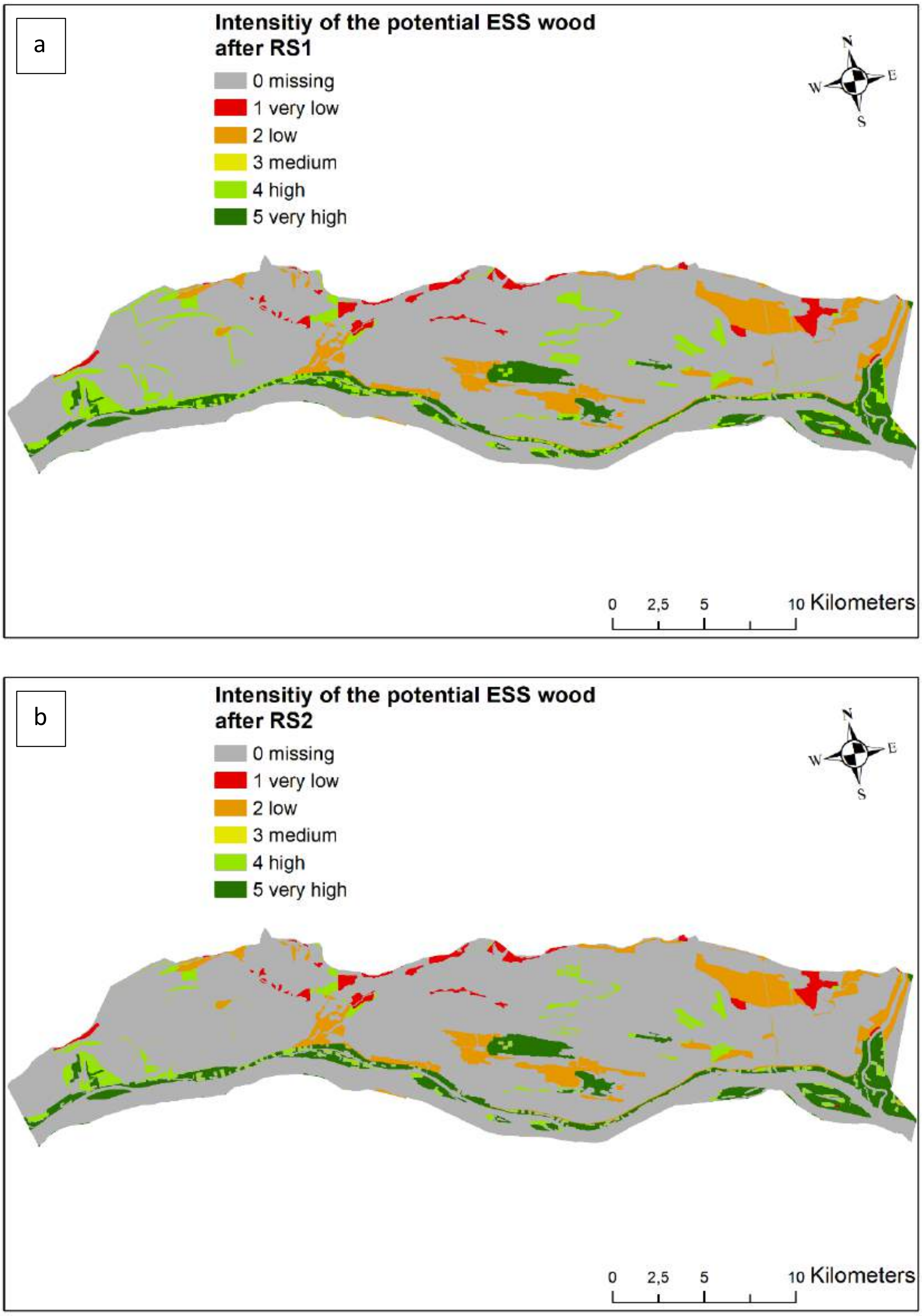


Figure 26: Intensity of the potential provisioning ESS wood a) after restoration scenario RS1 and b) after restoration scenario RS2. The values of the intensity of the potential ESS are marked in different colours.

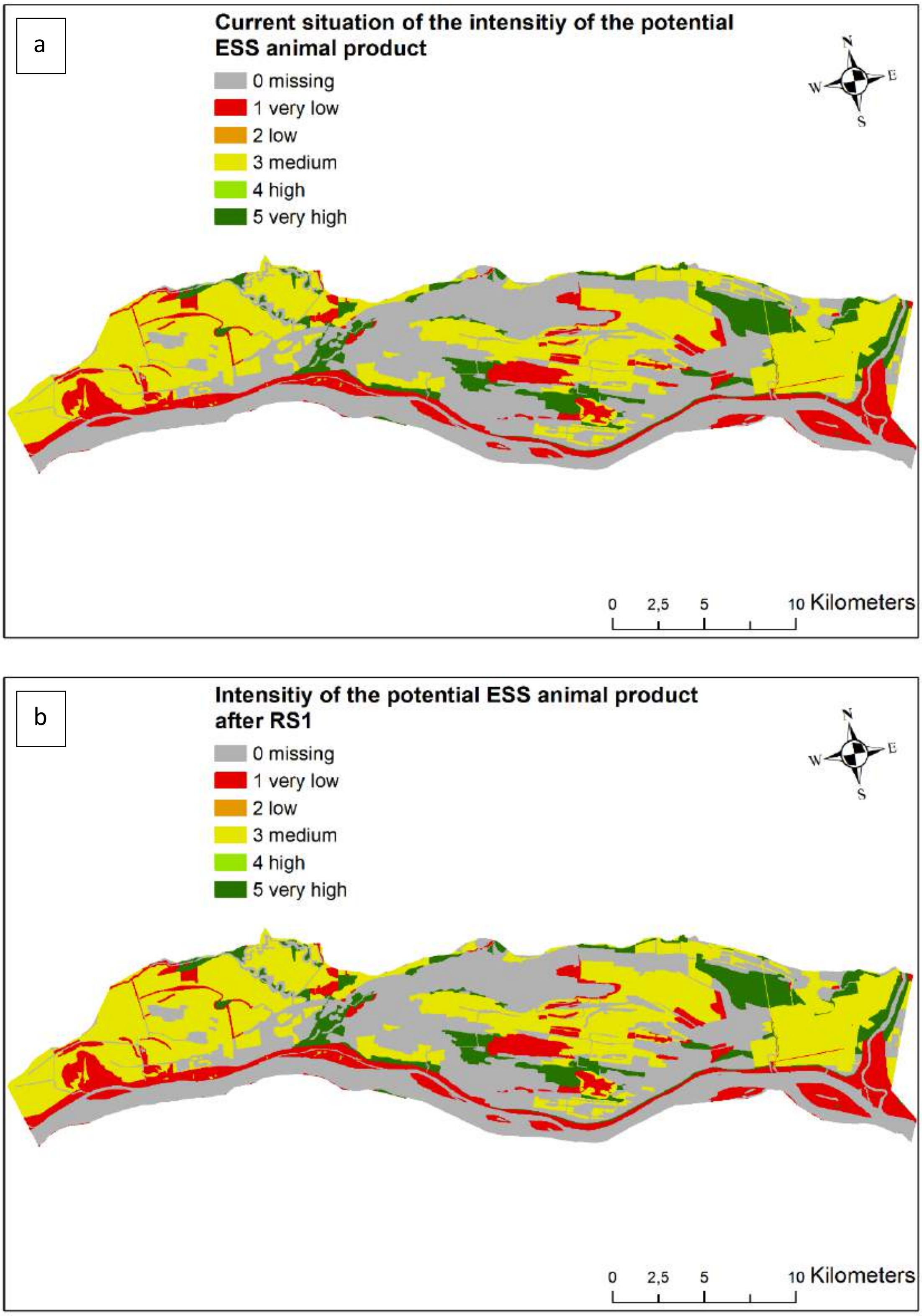
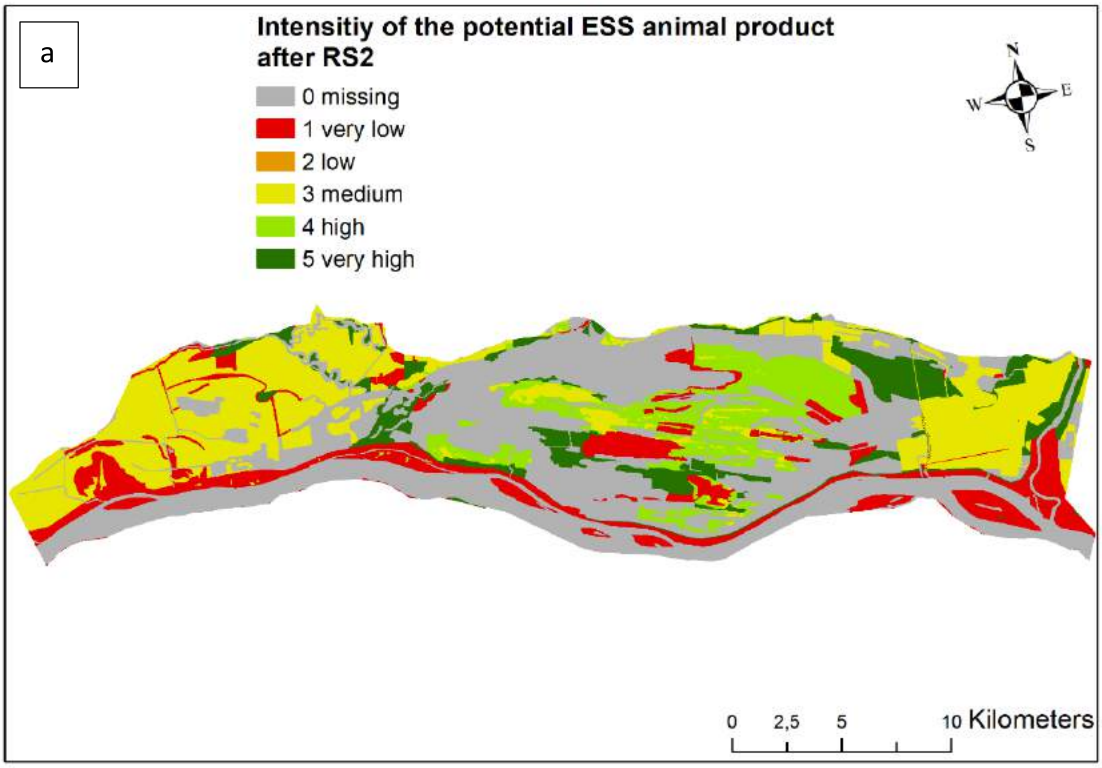


Figure 27: Intensity of the potential provisioning ESS animal product a) in the current situation and b) after restoration scenario RS1. The values of the intensity of the potential ESS are marked in different colours.



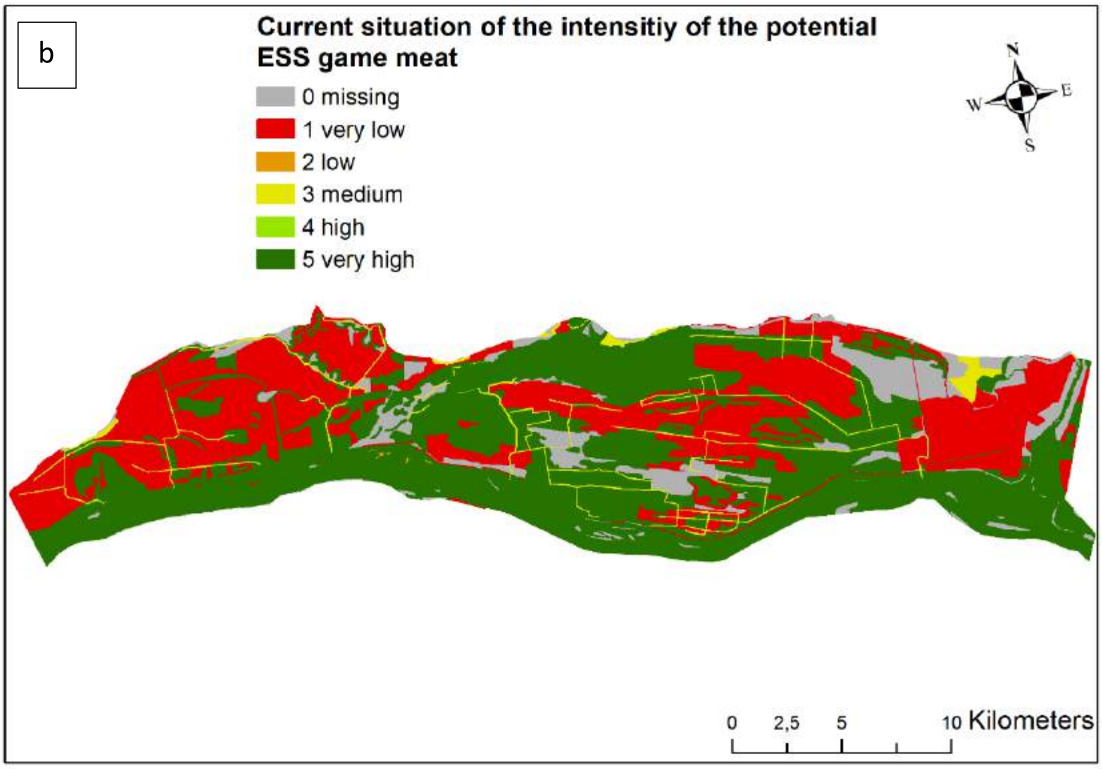
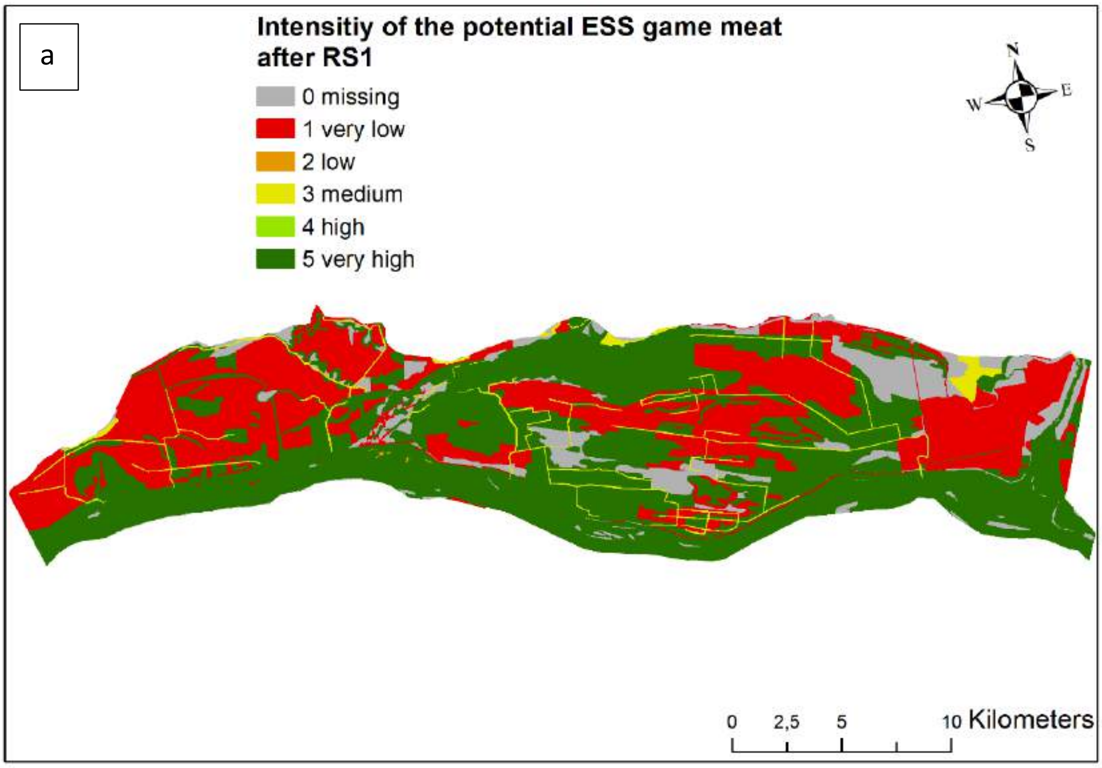


Figure 28: a) Intensity of the potential provisioning ESS animal product after restoration scenario RS2. b) Intensity of the potential provisioning ESS game meat in the current situation. The values of the intensity of the potential ESS are marked in different colours.



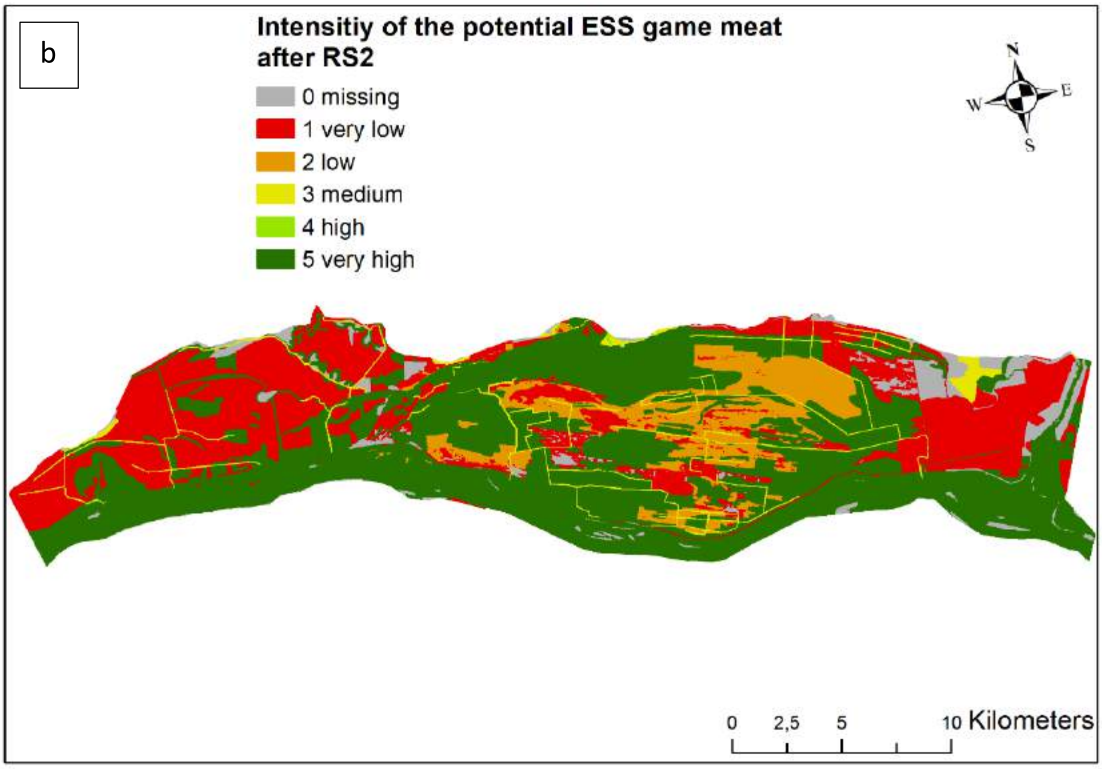
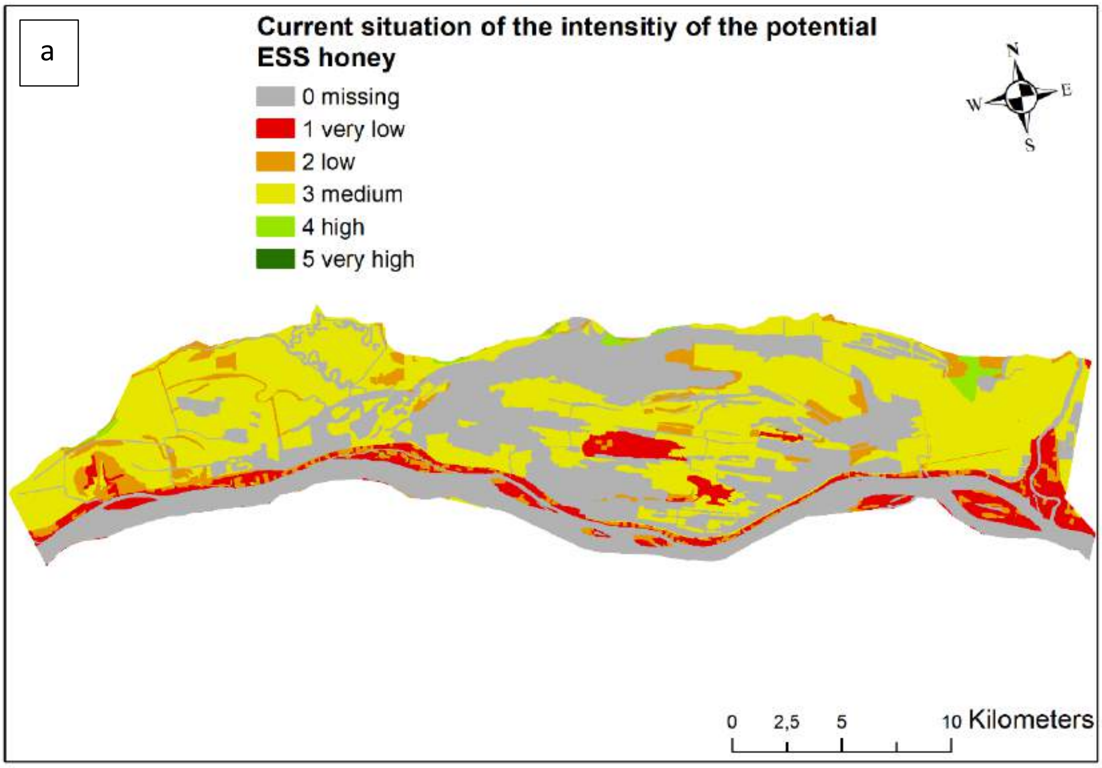


Figure 29: Intensity of the potential provisioning ESS game meat a) after restoration scenario RS1 and b) after restoration scenario RS2. The values of the intensity of the potential ESS are marked in different colours.



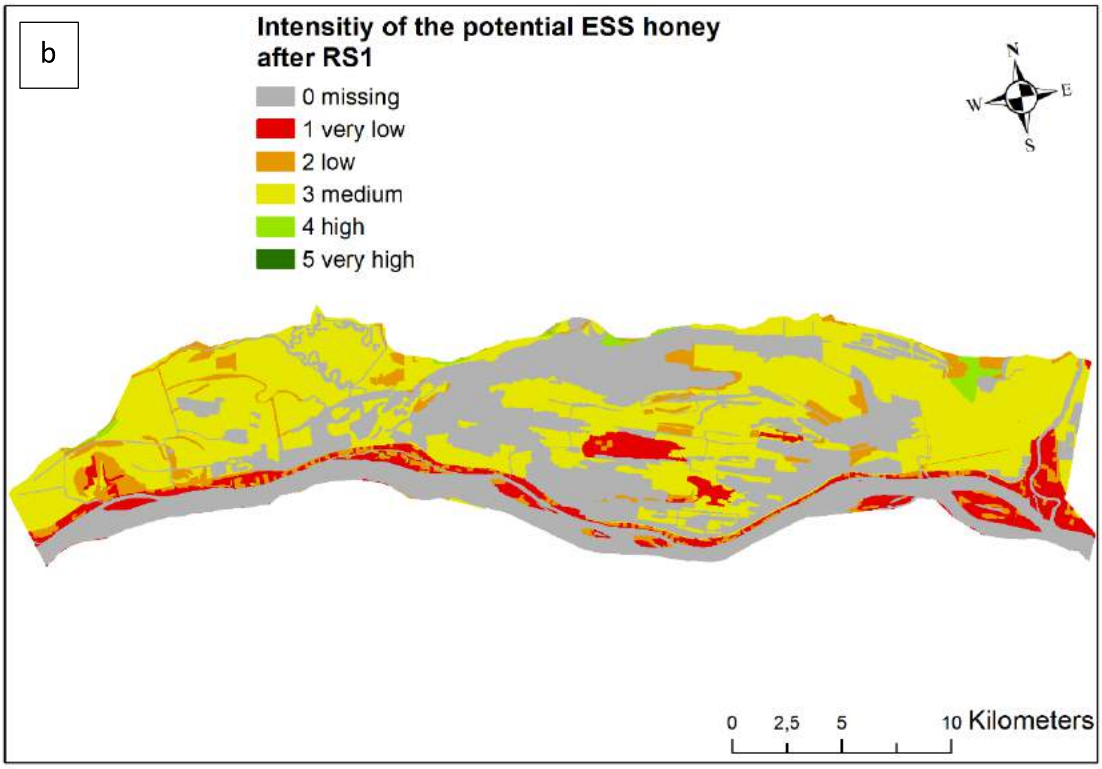
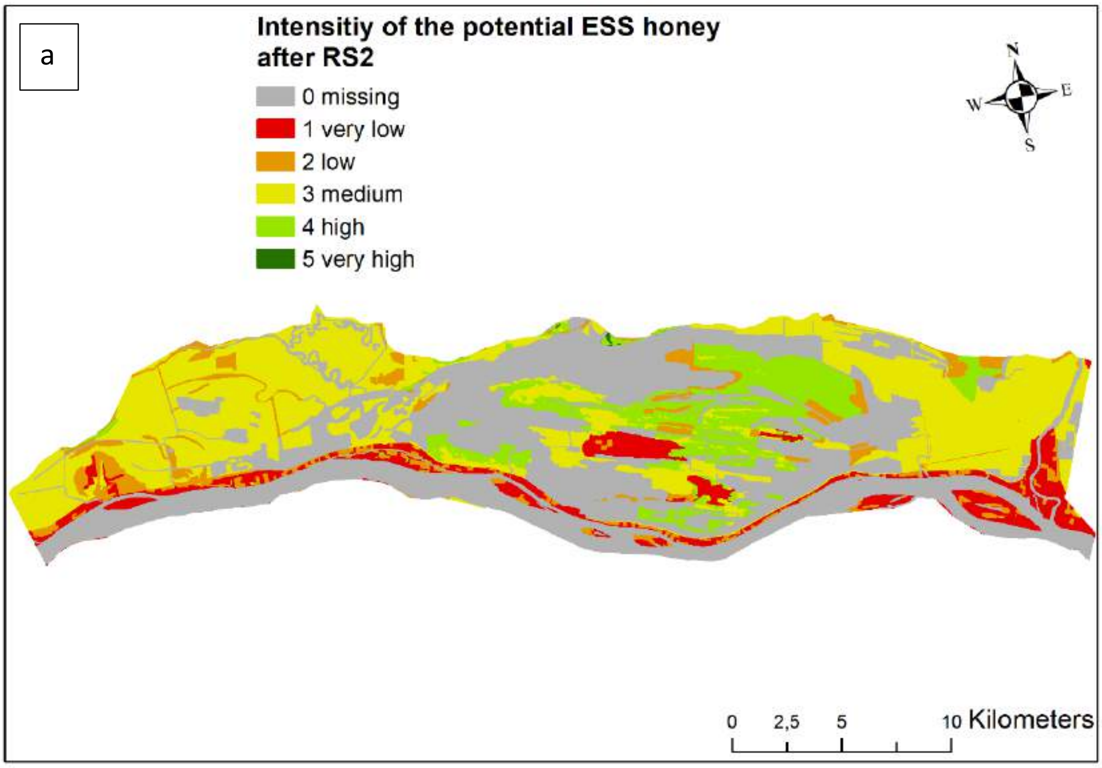


Figure 30: Intensity of the potential provisioning ESS honey a) in the current situation and b) after restoration scenario RS1. The values of the intensity of the potential ESS are marked in different colours.



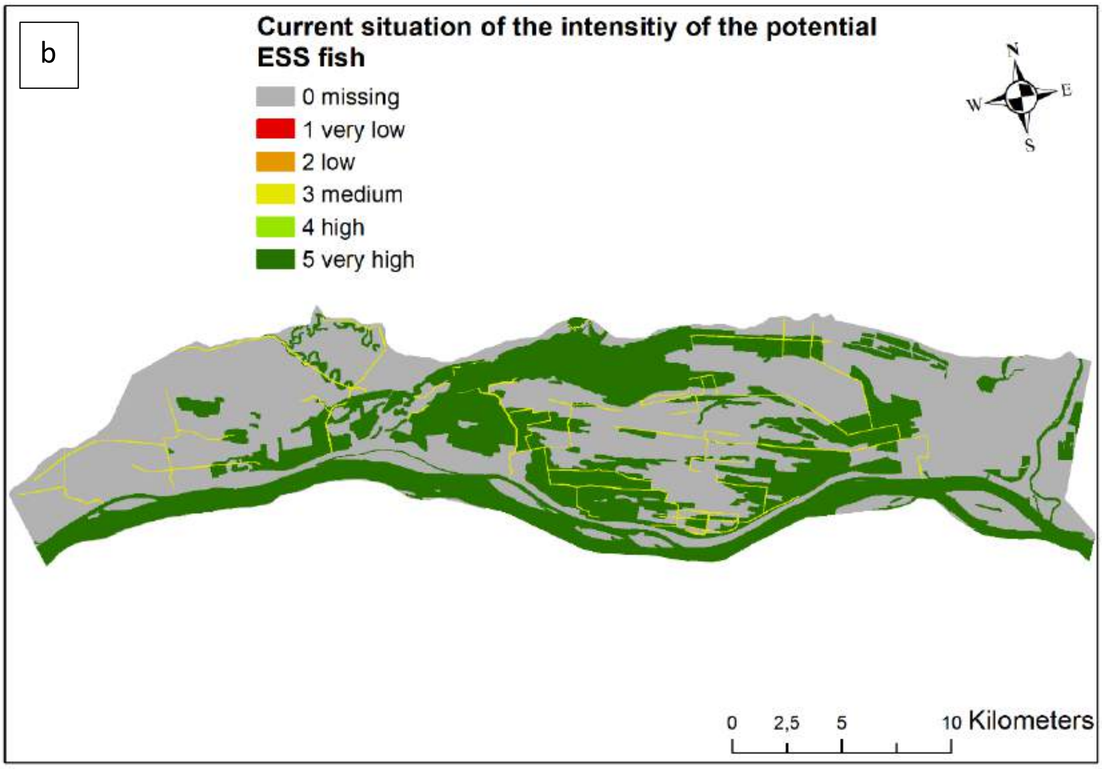


Figure 31: a) Intensity of the potential provisioning ESS honey after restoration scenario RS2. b) Intensity of the potential provisioning ESS fish in the current situation. The values of the intensity of the potential ESS are marked in different colours.

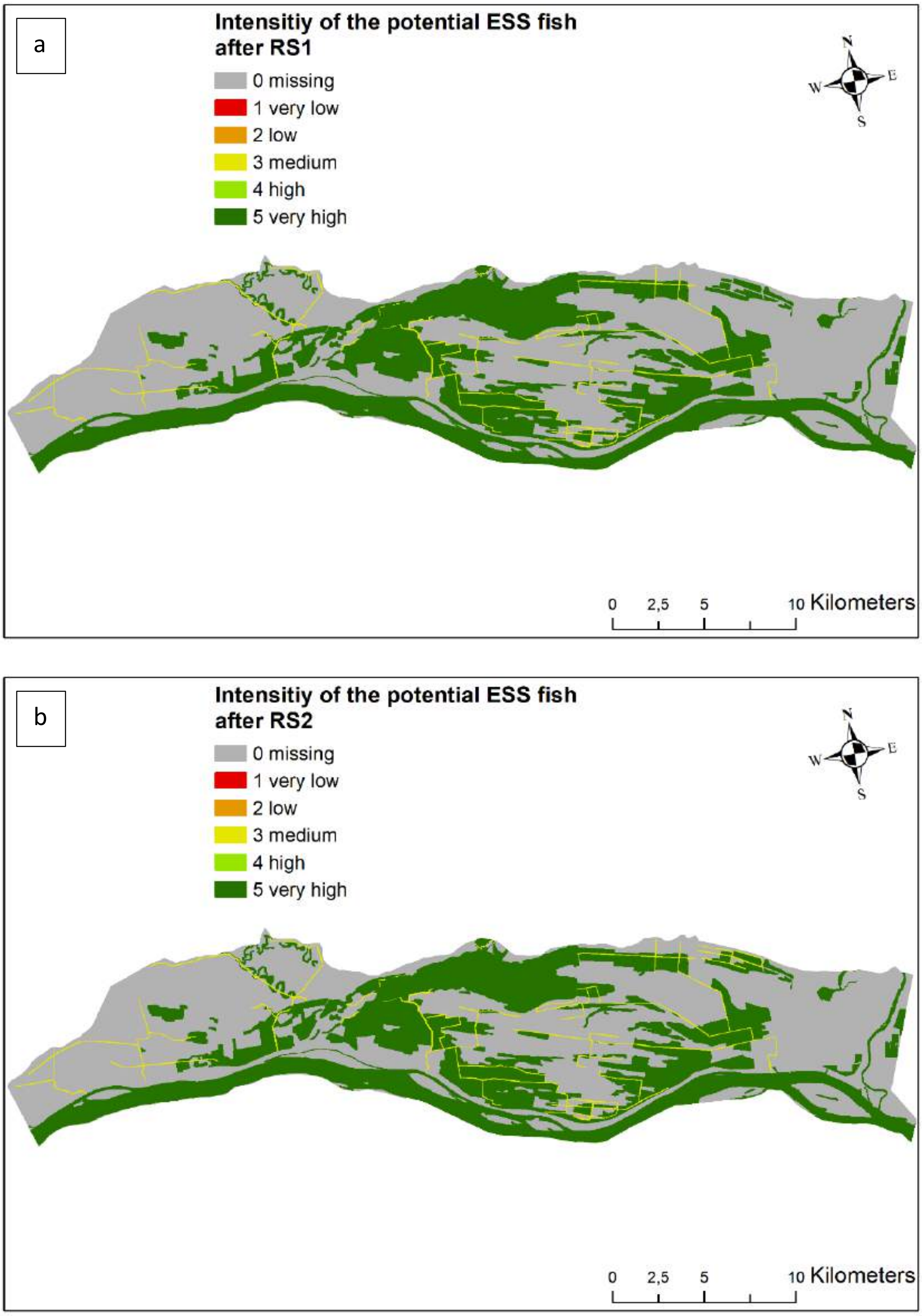


Figure 32: Intensity of the potential provisioning ESS fish a) after restoration scenario RS1 and b) after restoration scenario RS2. The values of the intensity of the potential ESS are marked in different colours.

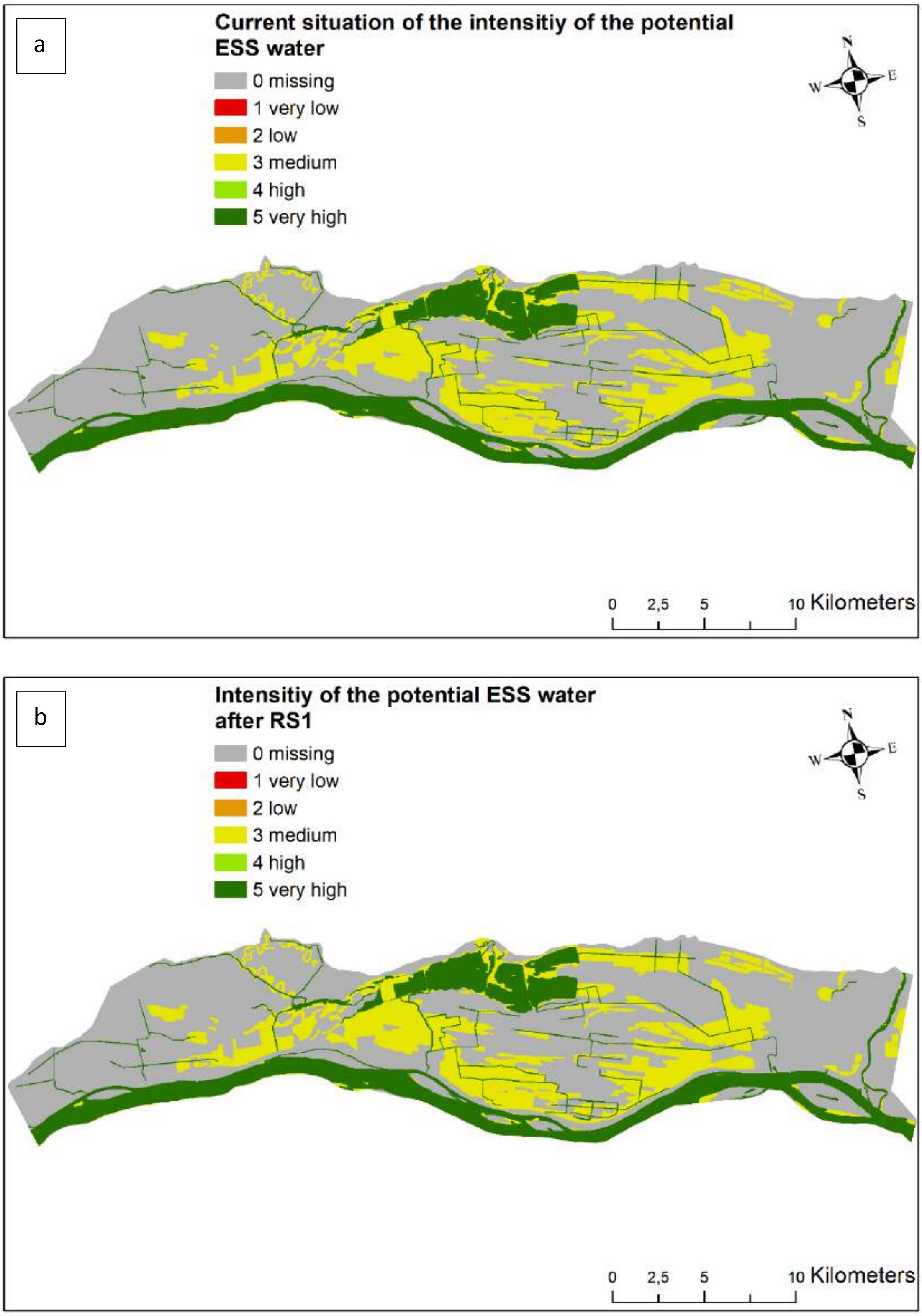


Figure 33: Intensity of the potential provisioning ESS water a) in the current situation and b) after restoration scenario RS1. The values of the intensity of the potential ESS are marked in different colours.

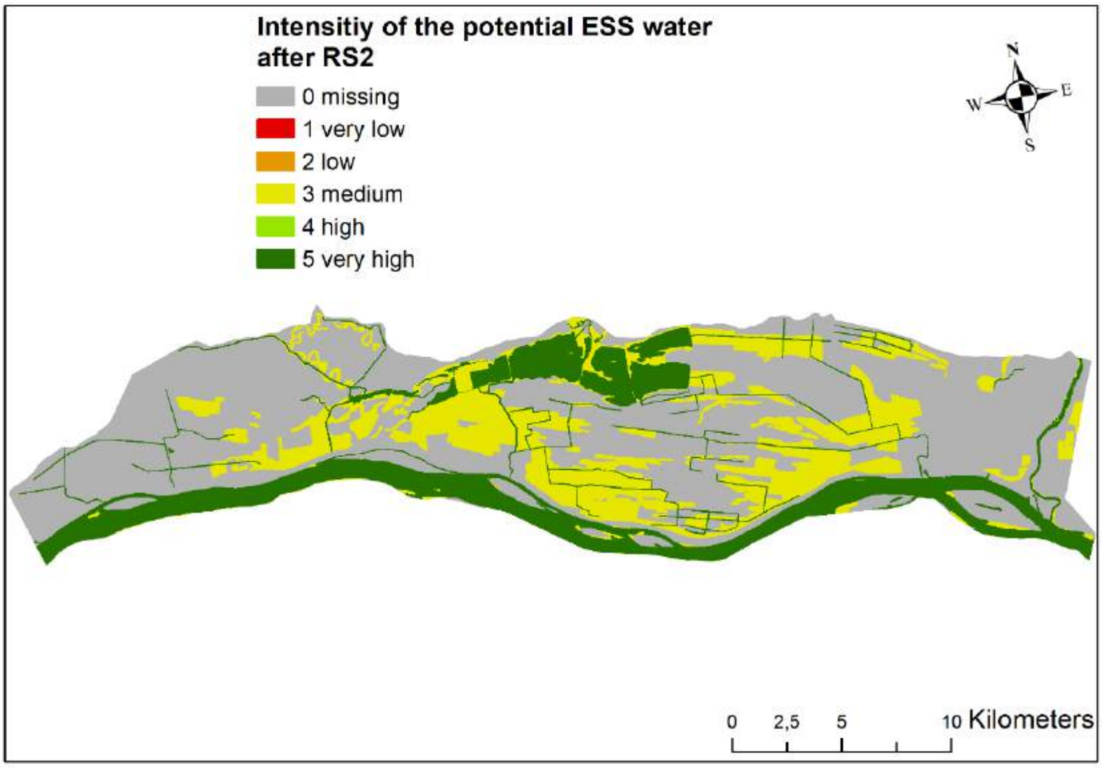


Figure 34: Intensity of the potential provisioning ESS water after restoration scenario RS2. The values of the intensity of the potential ESS are marked in different colours.

<u>Potential of the regulating ESS</u>

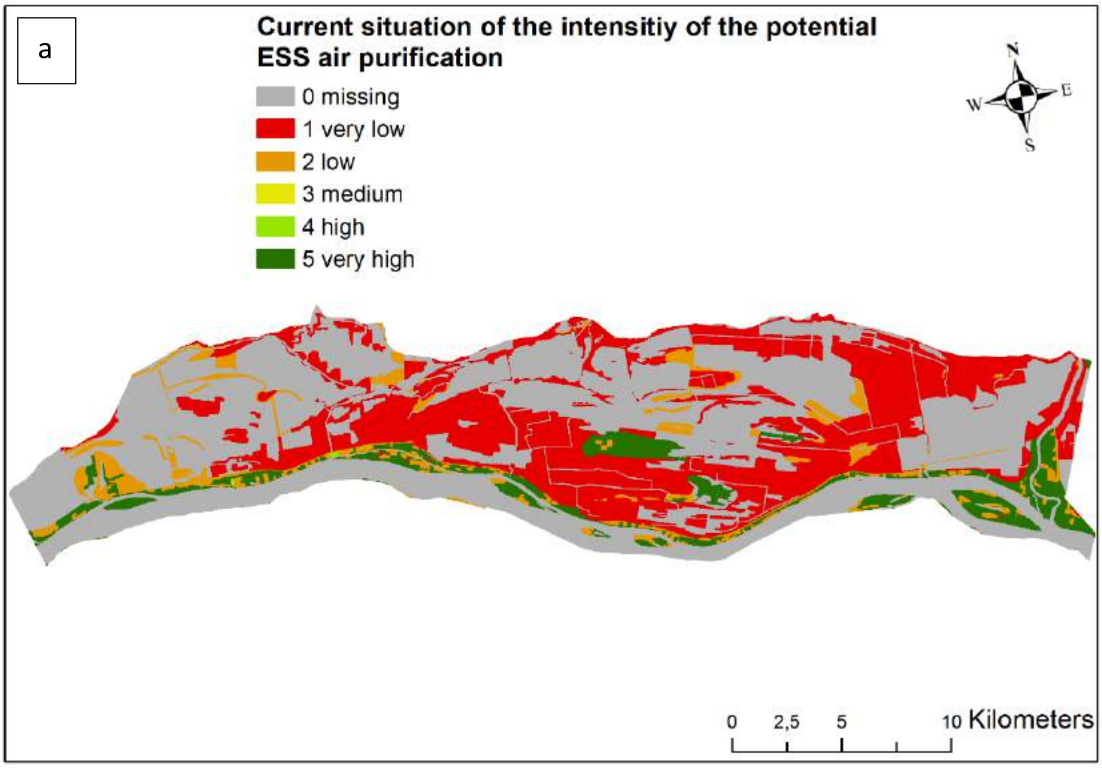
The intensity of the potential ESS *air purification* is mainly very low (figure 35a). Only the riparian forests provide this ESS on a very high level. The dike relocation planned in RS1 (figure 35b) has no impact on the provision of the ESS *air purification* but the dike relocation of RS 2 (figure 36a) increases the intensity from very low to low in the former dry grassland areas inside the new active floodplain.

The level of the provision of the potential ESS *local climate regulation* varies from very low to very high in the current situation (figure 36b). The provision of the ESS *local climate regulation* will increase in some of the areas reconnected by dike relocation in both RS1 and RS2 (figures 37a and b).

The level of the intensity of the potential ESS *low water regulatio*n also varies between very low and very high (figure 38a). It is not affected by the dike relocation in RS1 (figure 38b) but will decrease in some areas within the reconnected floodplain with the dike relocation in RS2 (figure 39a).

The potential ESS *flood retention* is provided at a very high intensity by the water bodies and on a high level by the inland freshwater areas and mesic grassland areas within the pilot area (figure 39b). All other areas, except river banks, have a very low water retention potential. River banks provide a medium intensity of the potential ESS *flood retention*. The land

cover/land use types within the new recent floodplain created by the dike relocation in RS1 will not change their potential to provide the ESS *water retention* (figure 40a). In contrast, some of the formerly dry grassland areas will become wetter as a result of the dike relocation in RS 2, leading to an increase in the provision of the ESS *water retention* (figure 40b).
ESS *noise regulation* plays a subordinate role in this pilot area (figure 41). On the one hand, only a few of the existing land cover/land use types are suitable for noise regulation, and on the other hand, there are hardly any major noise sources. Both dike relocation scenarios do not impact the ESS noise regulation (figure 41b and figure 42a).
The ESS *nutrient retention* occurs in varying intensity in the pilot area (figure 42b). There are many land cover/land use types (water bodies and inland freshwater areas) with a very high potential to provide the ESS *nutrient retention*. However, there are also many areas (non-irrigated arable land) with a very low intensity of this ESS. The increase of the active floodplain in both restoration scenarios leads to an increase in the provision of the ESS *nutrient retention*. The intensity of the potential ESS increases more in RS2 than in RS1 (figures 43a and b).
The intensity of the potential ESS *provision of habitats* for floodplain typical species is highly variable in the current situation (figure 44). While arable land does not provide habitats for floodplain species, riparian forests, freshwater areas and both rivers have a very high potential to provide the ESS *provision of habitats*. Natural still waters have a high intensity, other forest types and grassland areas have a medium intensity, urban areas, complex cultivation pattern and highly modified natural watercourses and canals a very low intensity of the ESS provision of habitats. Since in RS1 mainly forests are located in the dike relocation area, no changes in the provision of the ESS *provision of habitats* are to be expected (figure 44b). In RS2, on the other hand, some areas that have provided no or very few floodplain typical habitats to date will be affected by the measure to relocate the dikes, thus increasing this ESS (figure 45).



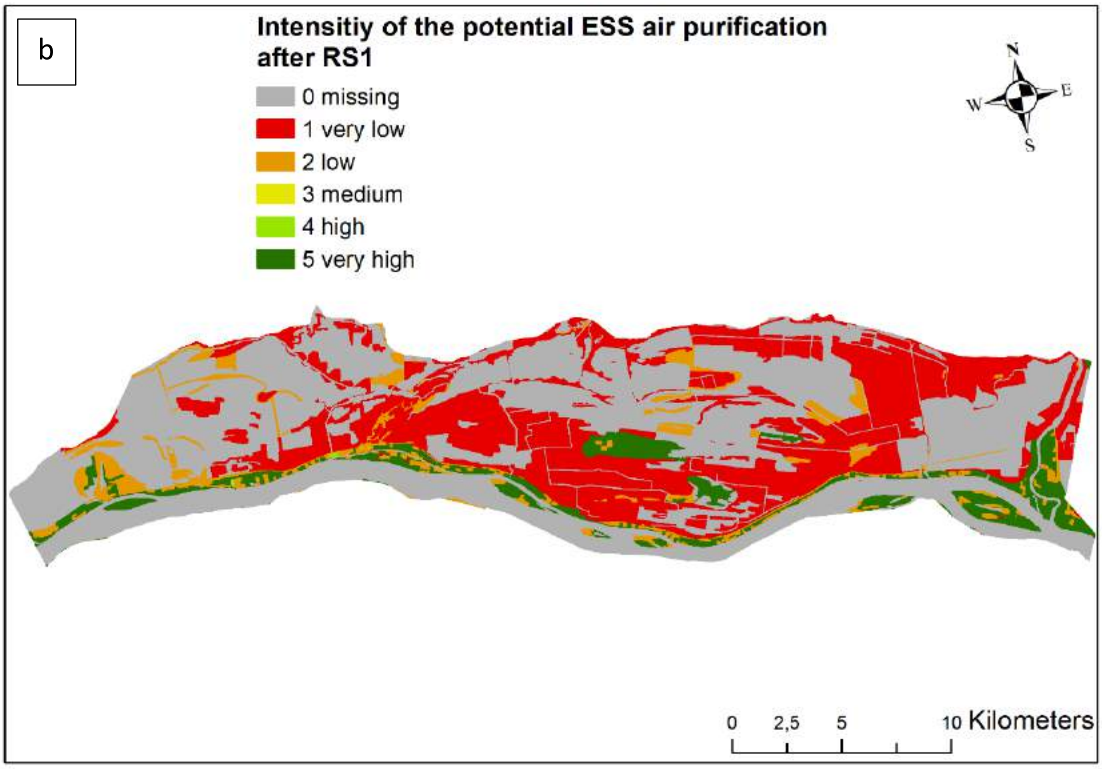
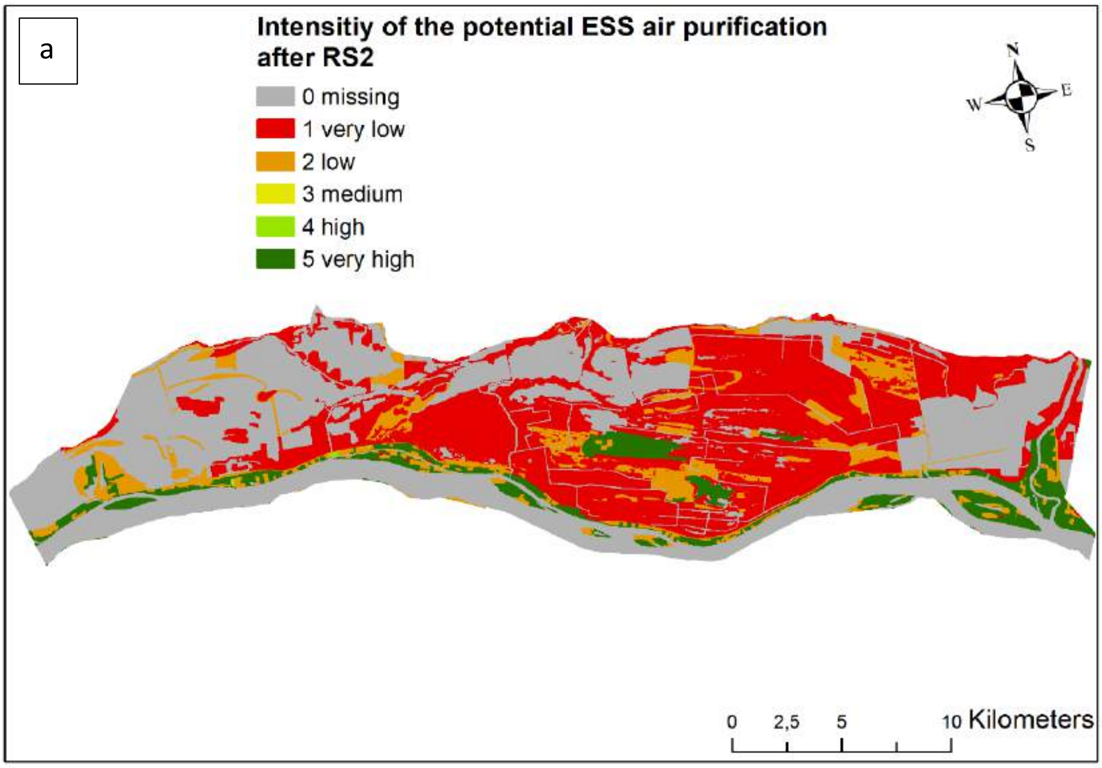


Figure 35: Intensity of the potential regulating ESS air purification a) in the current situation and b) after restoration scenario RS1. The values of the intensity of the potential ESS are marked in different colours.



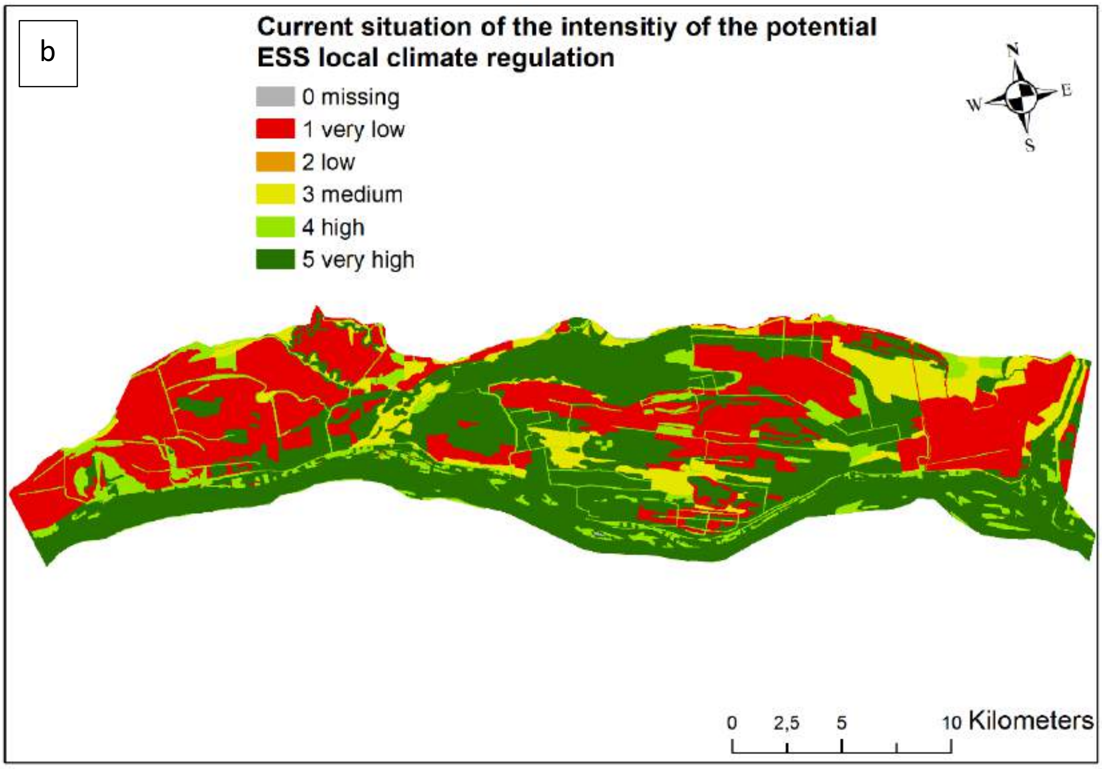
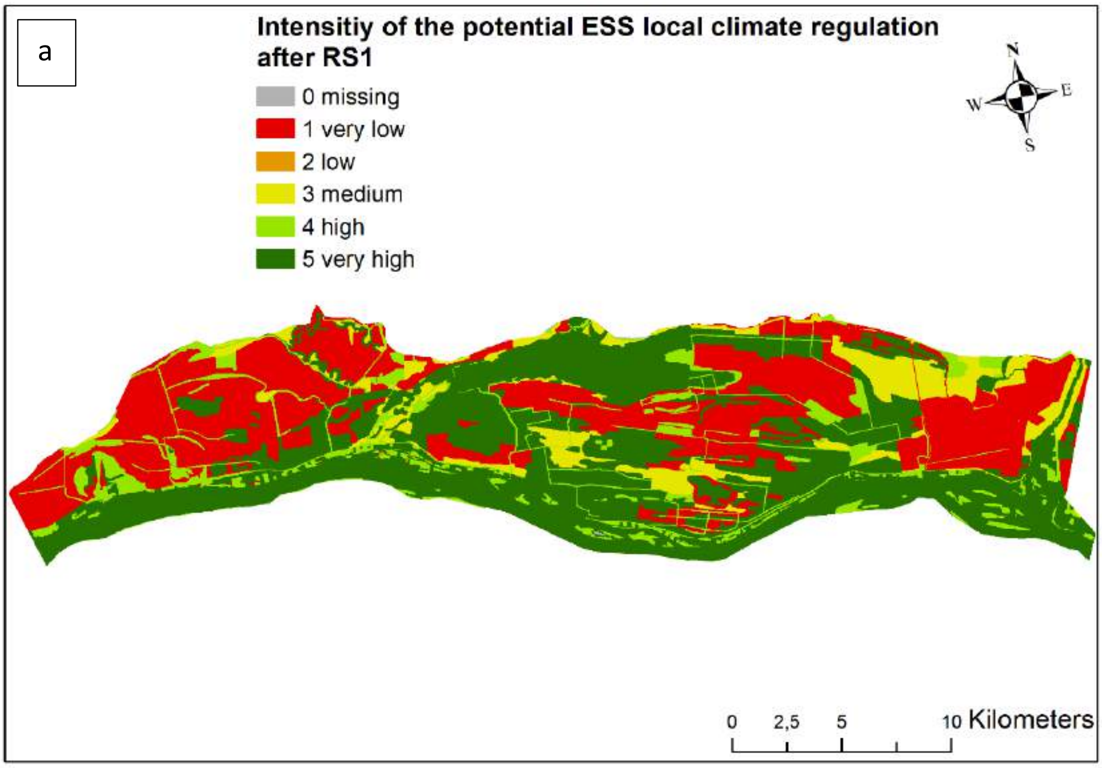


Figure 36: a) Intensity of the potential regulating ESS air purification after restoration scenario RS2. b) Intensity of the potential regulating ESS local climate regulation in the current situation. The values of the intensity of the potential ESS are marked in different colours.



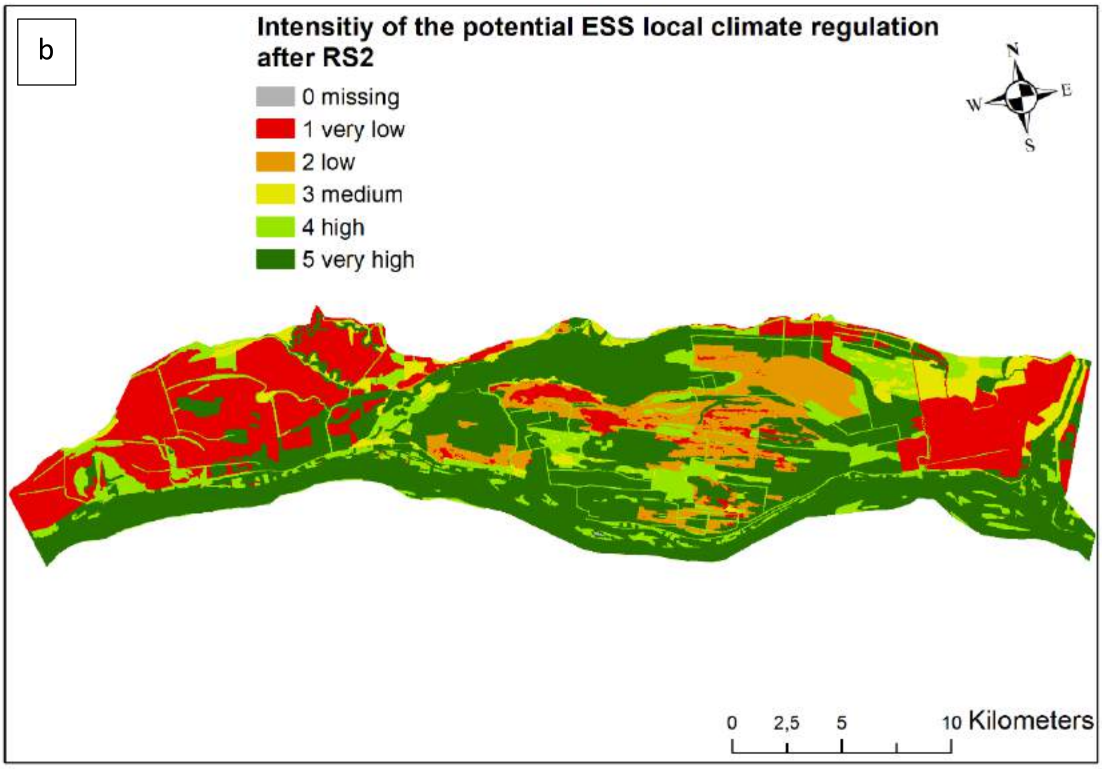
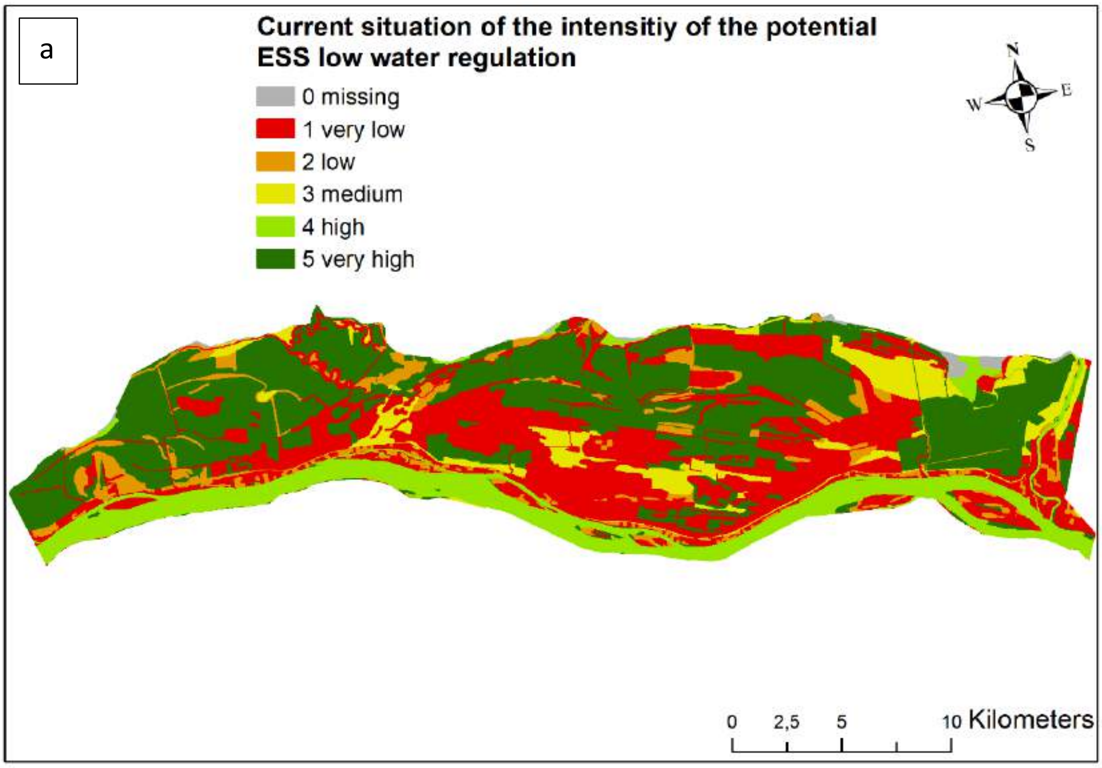


Figure 37: Intensity of the potential regulating ESS local climate regulation a) after restoration scenario RS1 and b) after restoration scenario RS2. The values of the intensity of the potential ESS are marked in different colours.



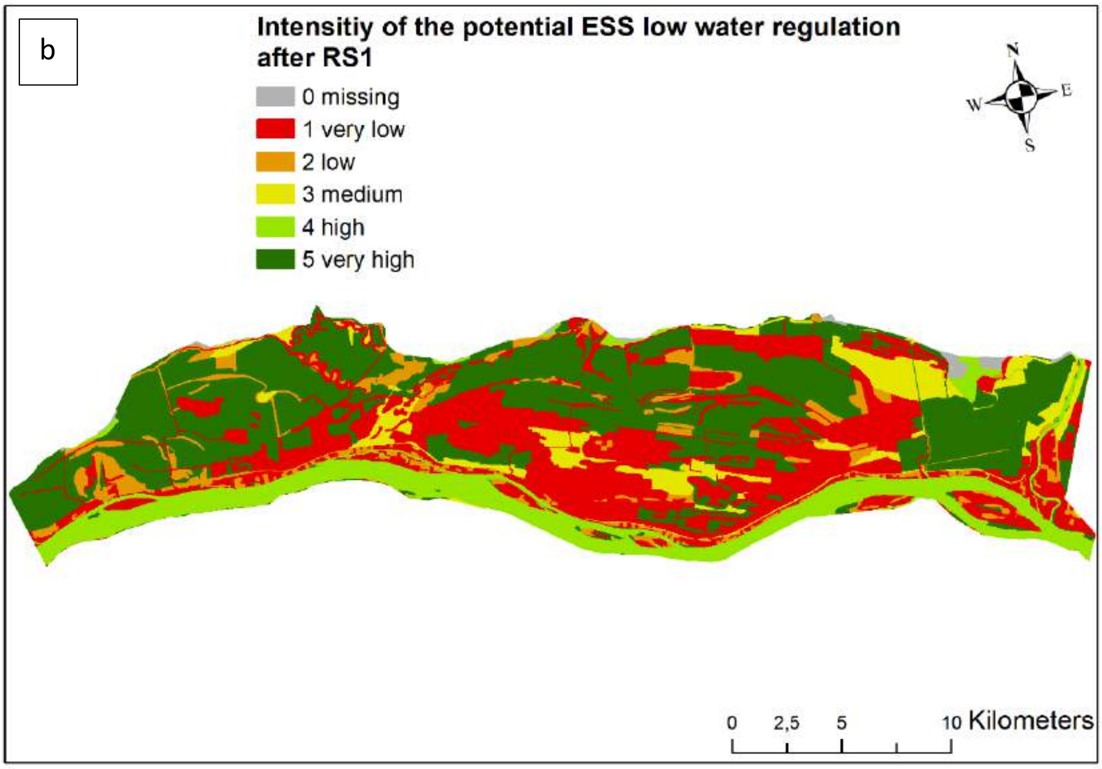


Figure 38: Intensity of the potential regulating ESS low water regulation a) in the current situation and b) after restoration scenario (RS1. The values of the intensity of the potential ESS are marked in different colours.

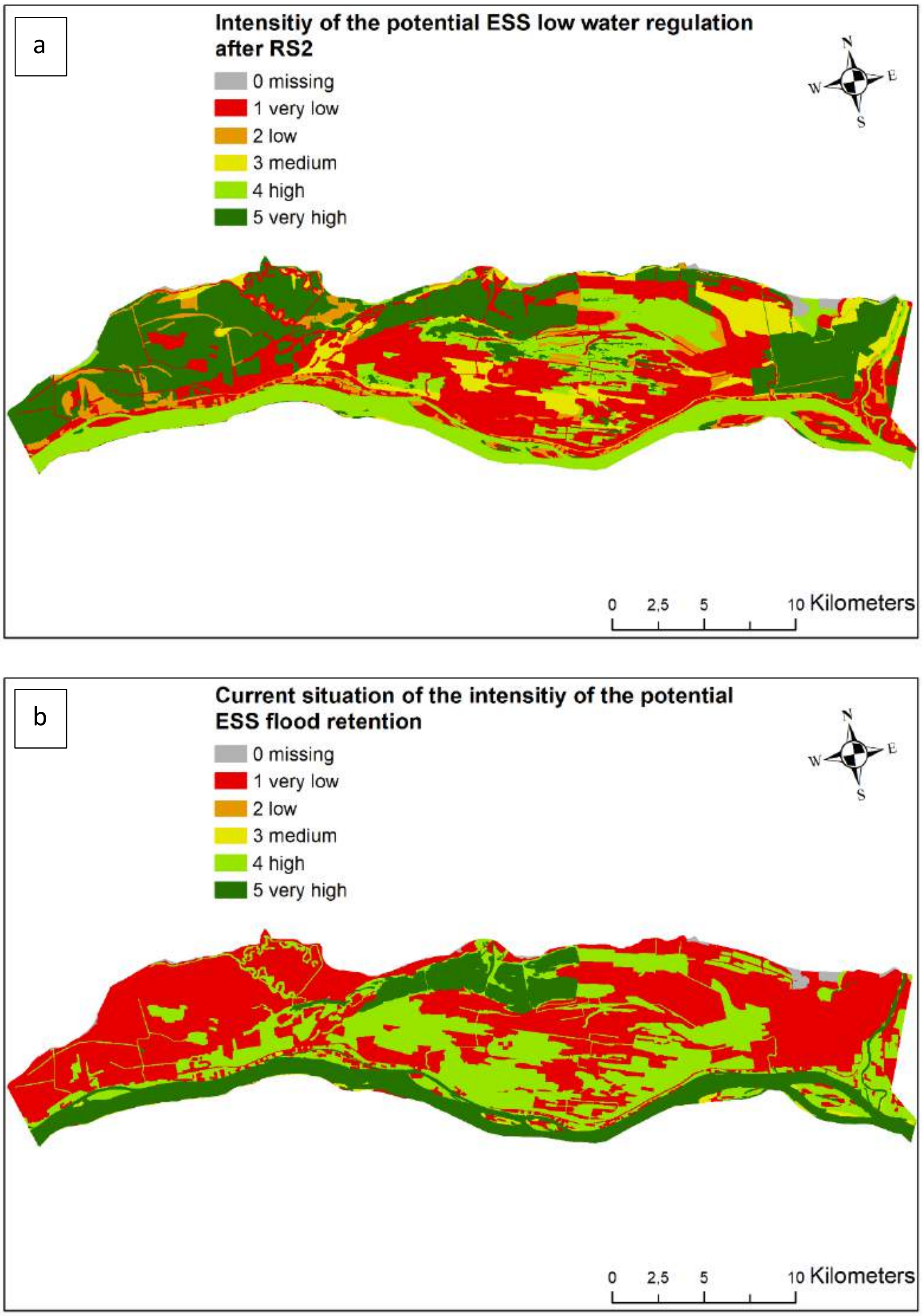
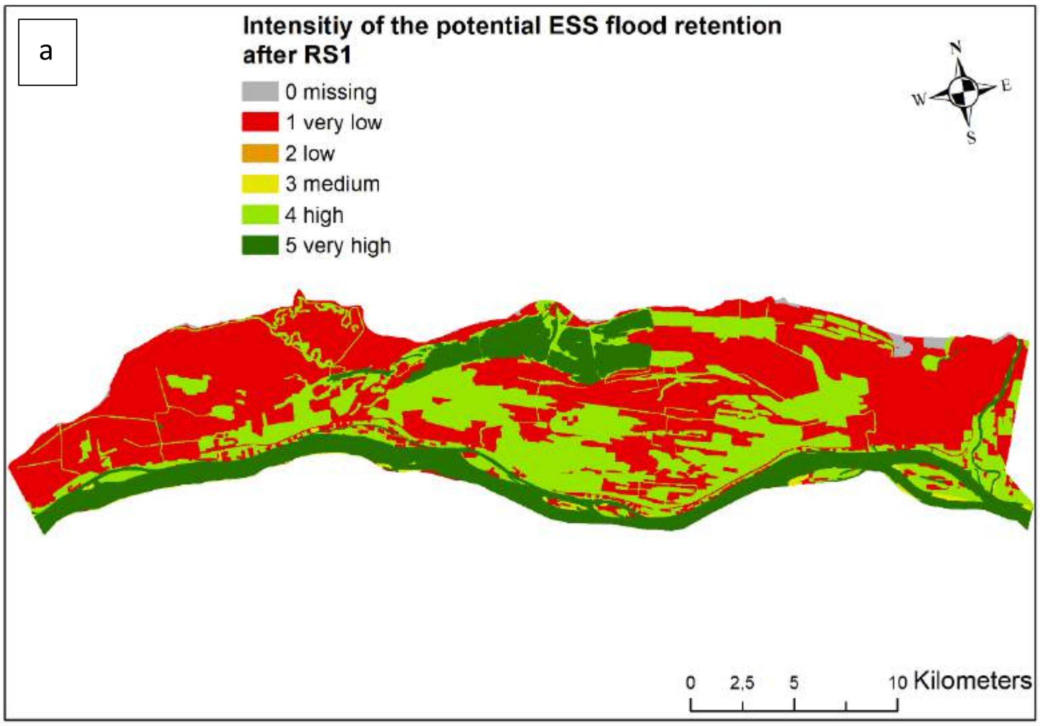


Figure 39: a) Intensity of the potential regulating ESS low water regulation after restoration scenario RS2. b) Intensity of the potential regulating ESS flood retention in the current situation. The values of the intensity of the potential ESS are marked in different colours.



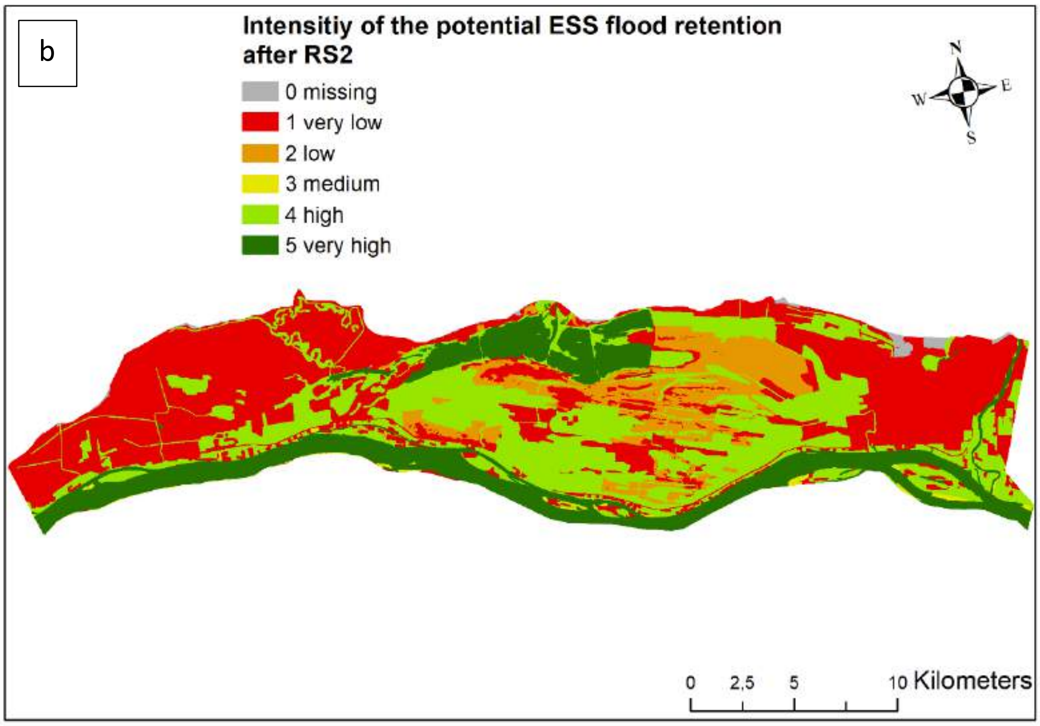
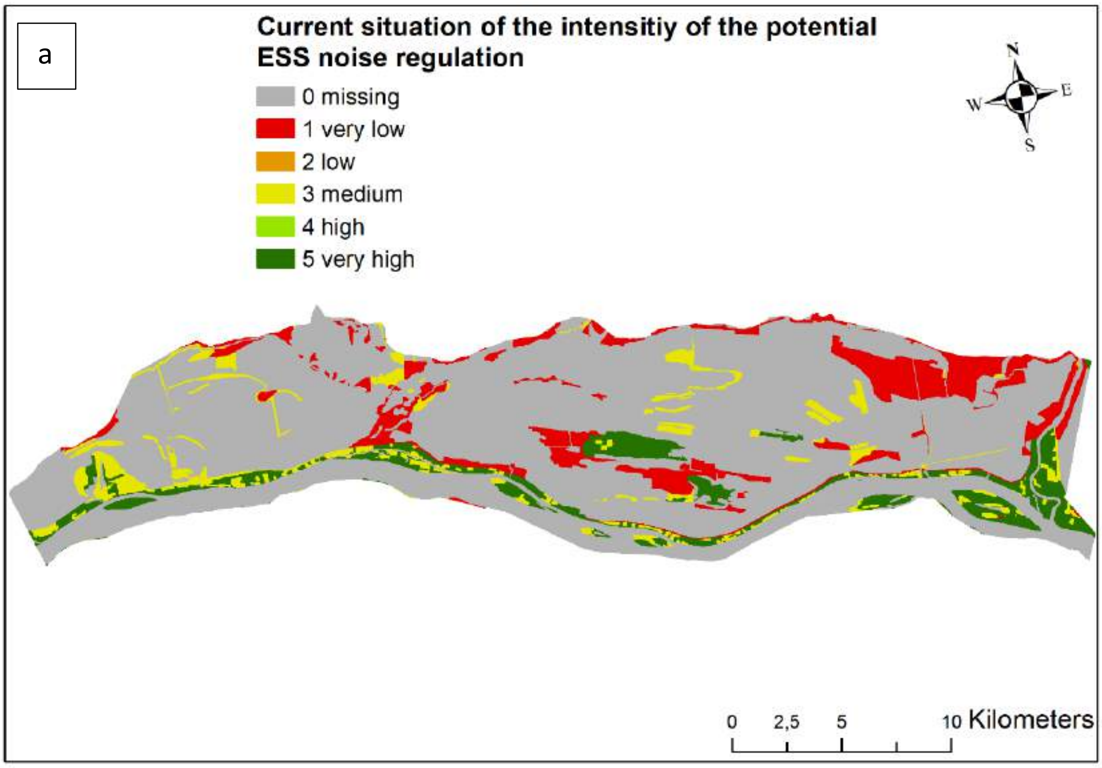


Figure 40: Intensity of the potential regulating ESS flood retention a) after restoration scenario RS1 and b) after restoration scenario RS2. The values of the intensity of the potential ESS are marked in different colours.



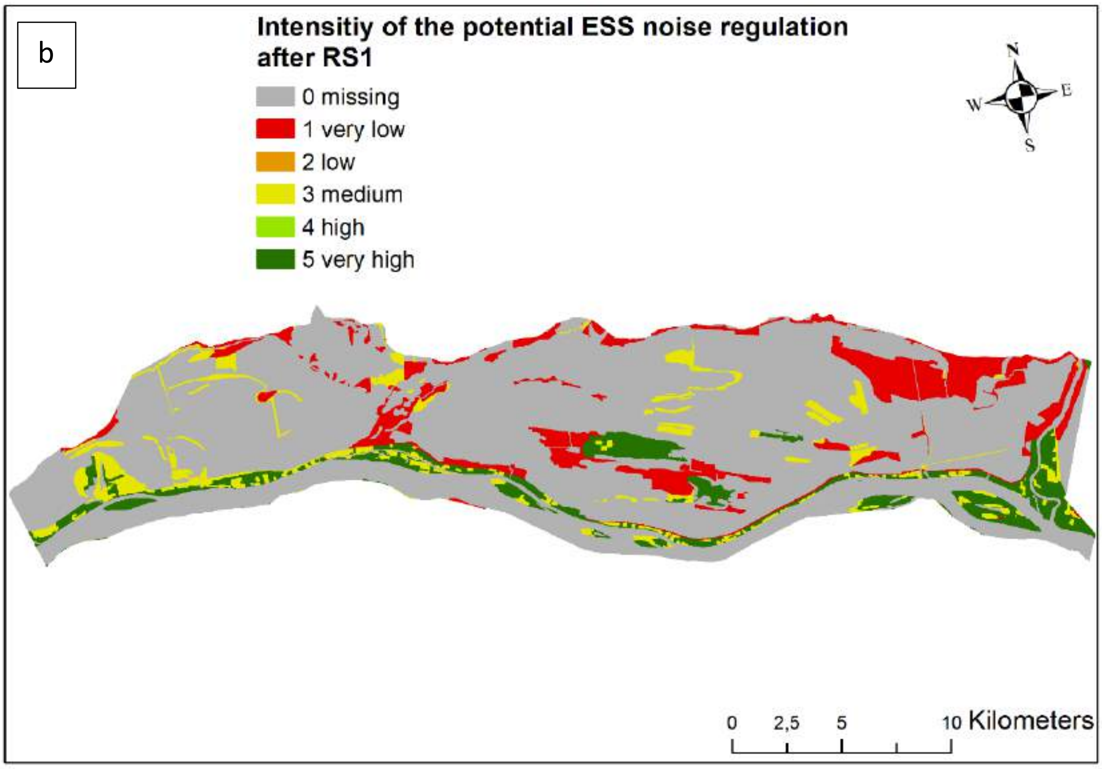
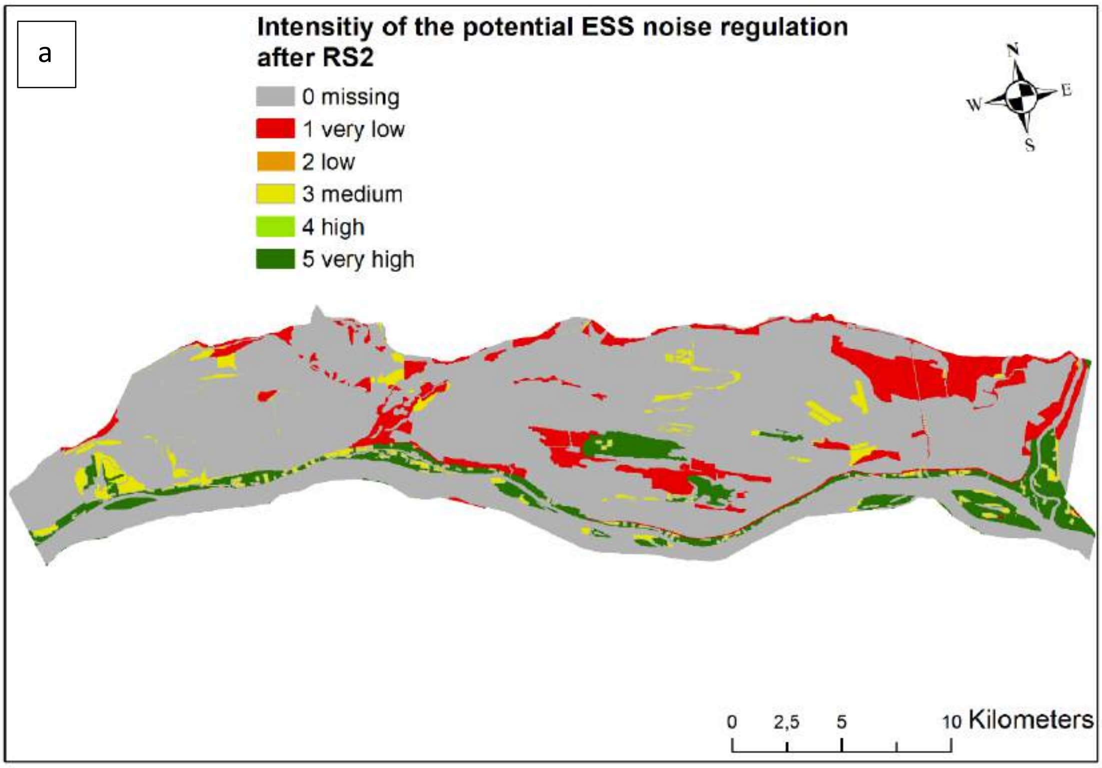


Figure 41: Intensity of the potential regulating ESS noise regulation a) in the current situation and b) after restoration scenario RS1. The values of the intensity of the potential ESS are marked in different colours.



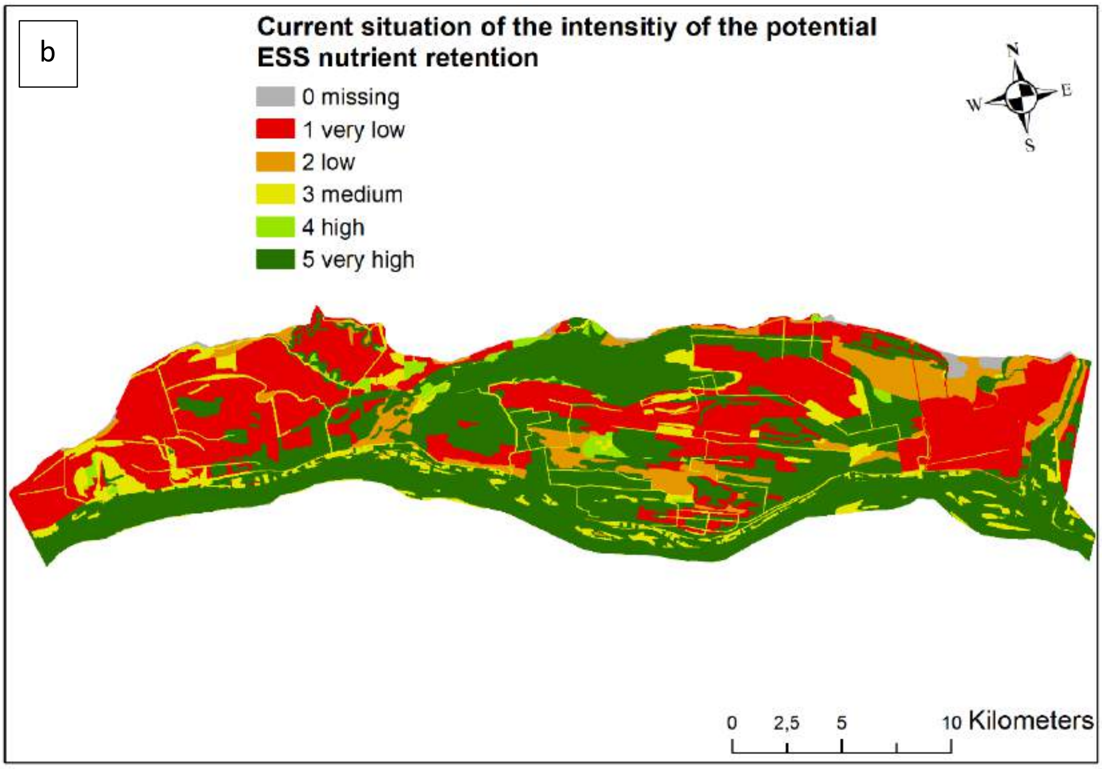
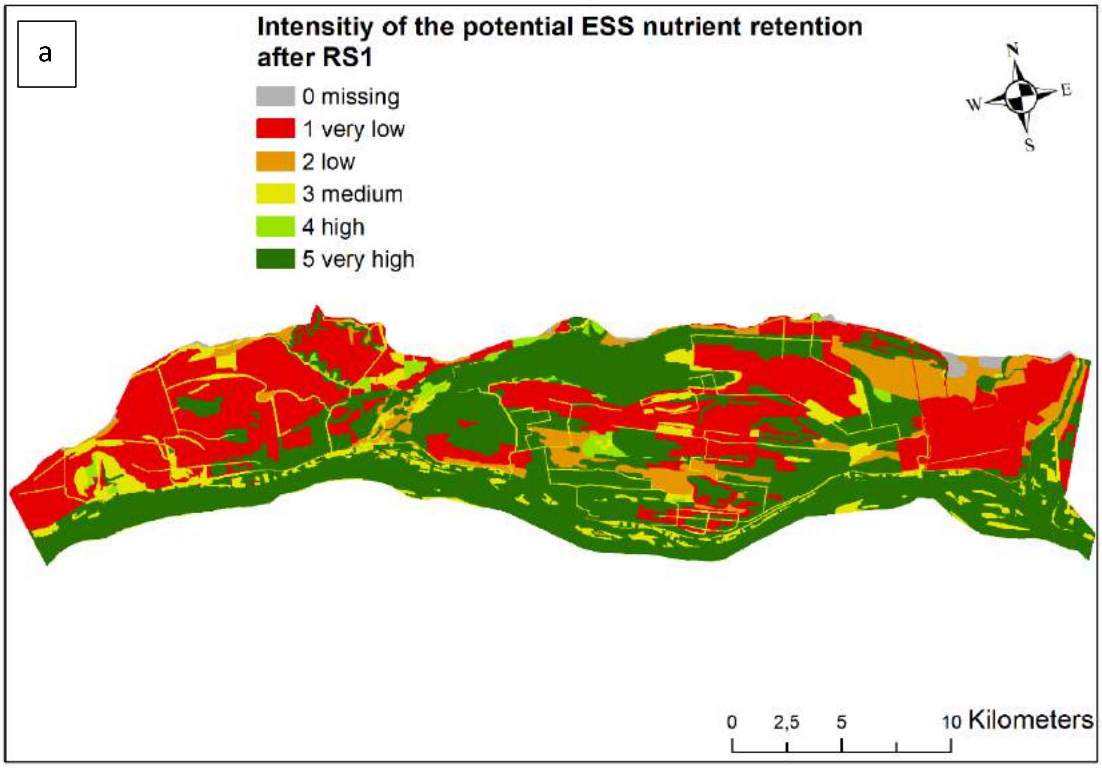


Figure 42: a) Intensity of the potential regulating ESS low water regulation after restoration scenario RS2. b) Intensity of the potential regulating ESS flood retention in the current situation. The values of the intensity of the potential ESS are marked in different colours.



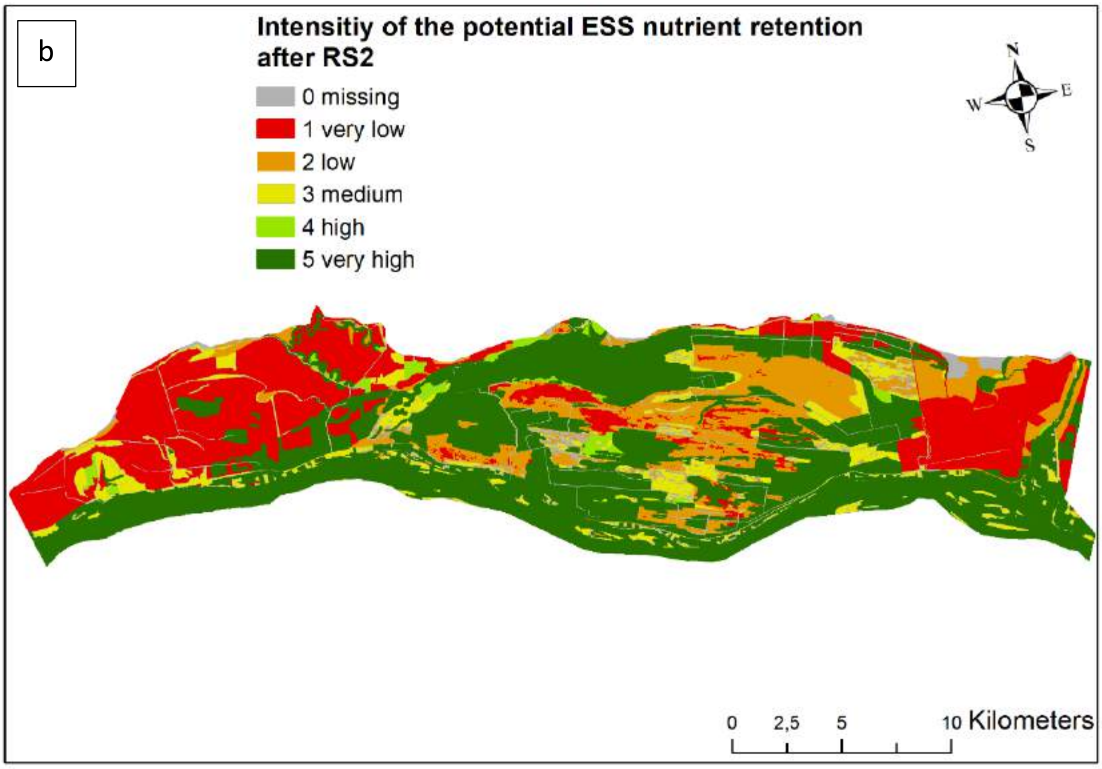
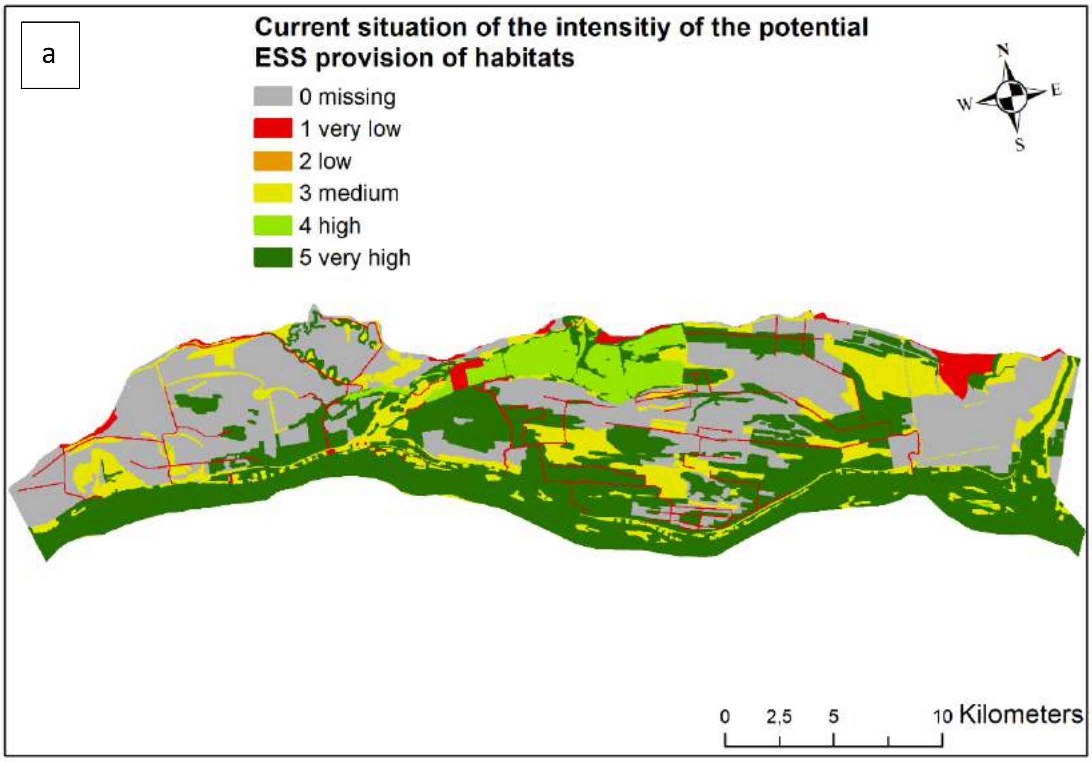


Figure 43: Intensity of the potential regulating ESS nutrient retention a) after restoration scenario RS1 and b) after restoration scenario RS2. The values of the intensity of the potential ESS are marked in different colours.



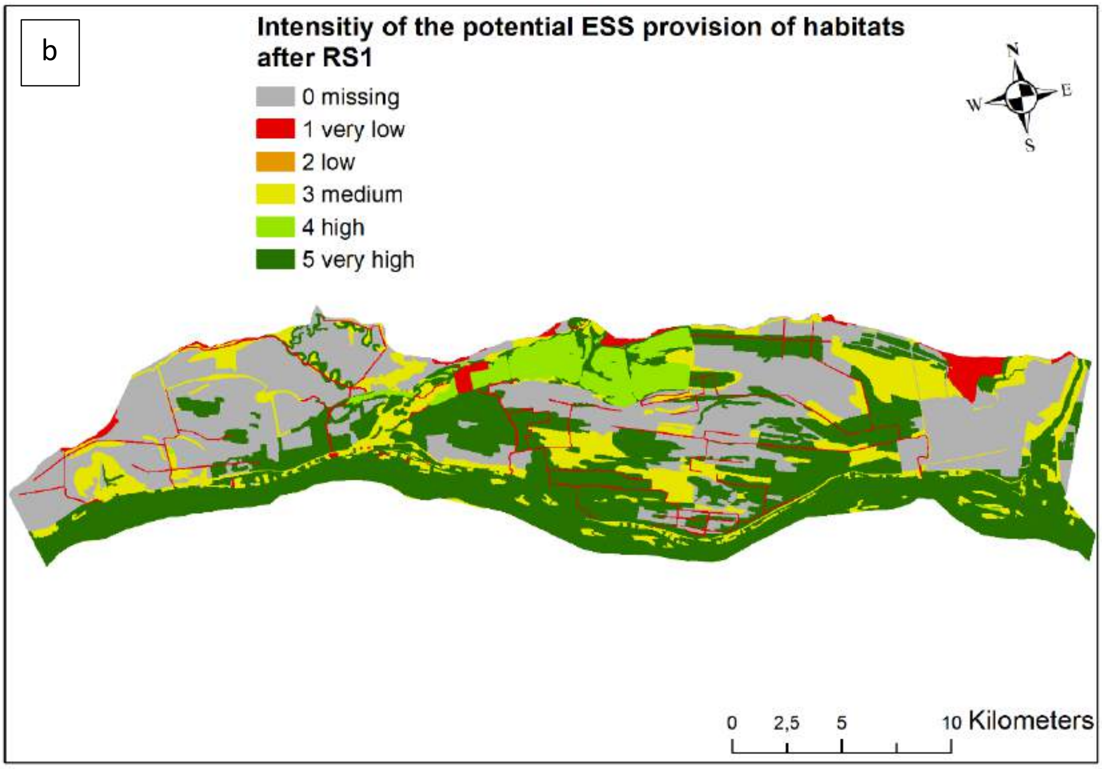


Figure 44: Intensity of the potential regulating ESS provision of habitats a) in the current situation and b) after restoration scenario RS1. The values of the intensity of the potential ESS are marked in different colours.

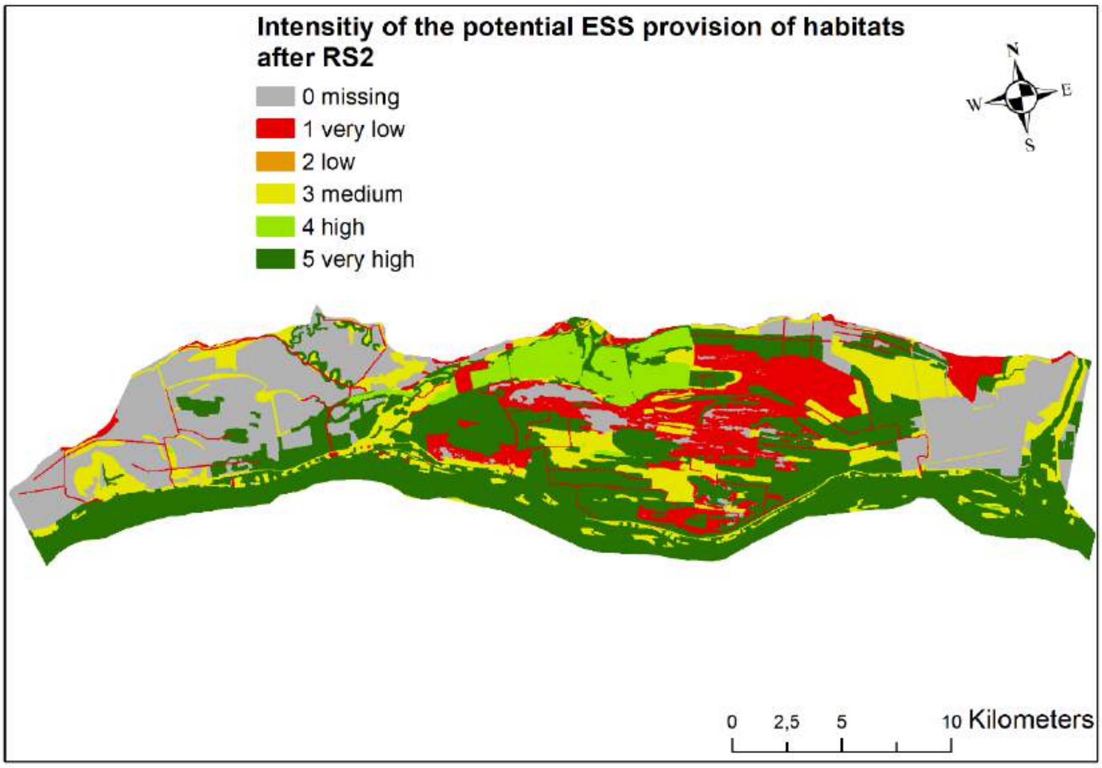
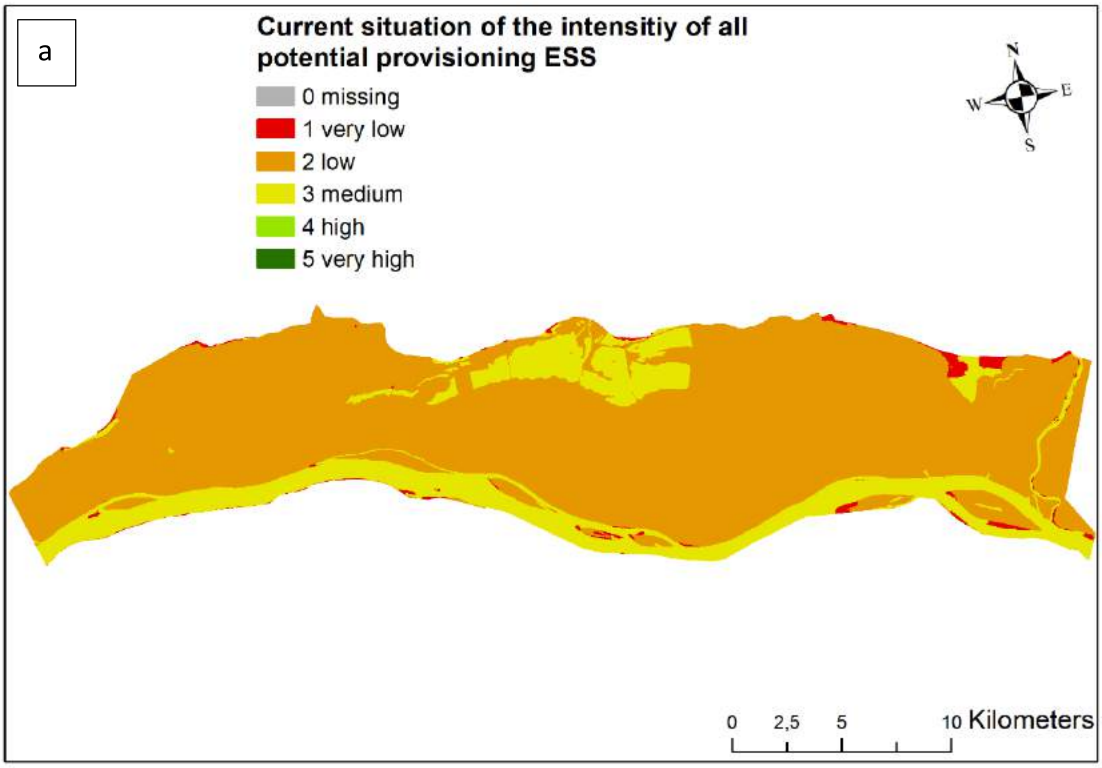


Figure 45: Intensity of the potential regulating ESS provision of habitats after restoration scenario 2 (RS2). The values of the intensity of the potential ESS are marked in different colours.

<u>Joint consideration of all potential provisioning ESS and all potential regulating ESS</u>

In the current situation, all provided potential provisioning ESS have a very low, low or medium level of their intensity of provision (figure 46a). Only urban areas and river banks have a very low potential to provide provisioning ESS. Jointly considering the provision of all provisioning ESS, it seems that the dike relocations in RS1 and RS2 do not influence their intensity (figure 46b and figure 47a). However, as described in the sub-chapter 'Potential of the provisioning ESS', the intensity of individual provisioning ESS increases or decreases as a result of the measures.

In the pre-selected pilot area, all values of the intensity of the provided potential regulating ESS are represented (figure 47b). With the implementation of the dike relocation in both restoration scenarios the intensity of all jointly provided regulating ESS increases in the new active floodplains (figures 48a and b). RS2 shows more areas with a higher provision of regulating ESS than RS1.



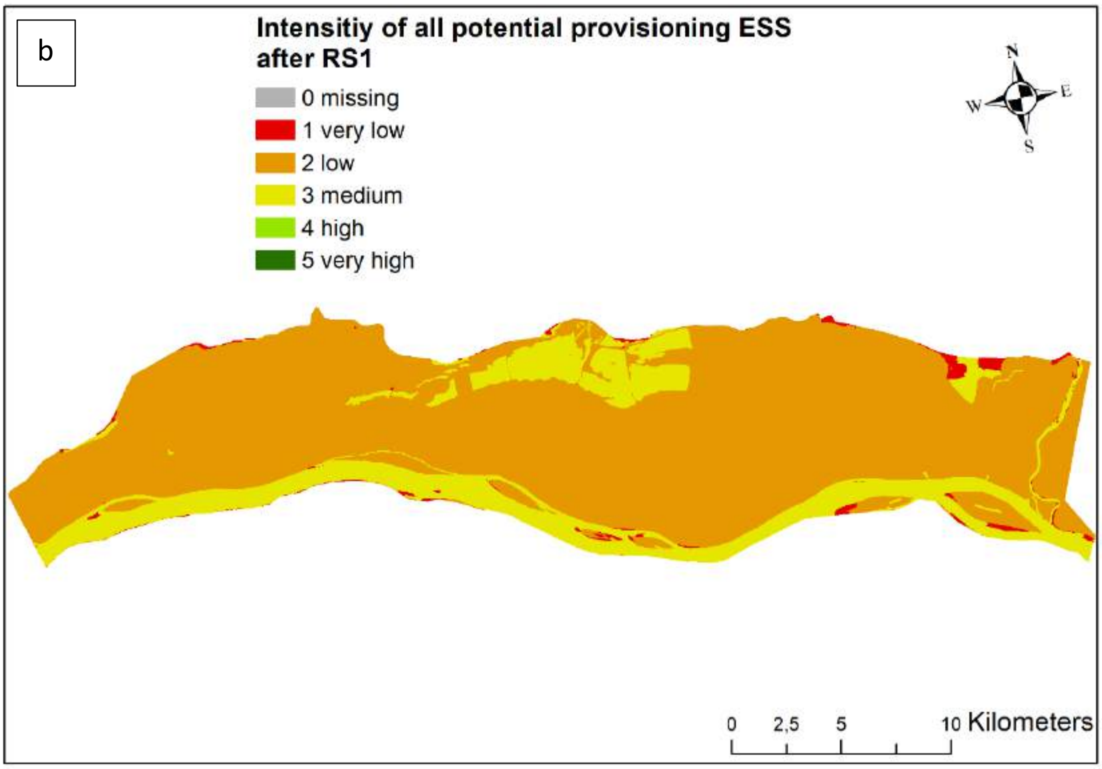


Figure 46: Intensity of all potential provisioning ESS a) in the current situation and b) after restoration scenario RS1. The values of the intensity of the potential ESS are marked in different colours.

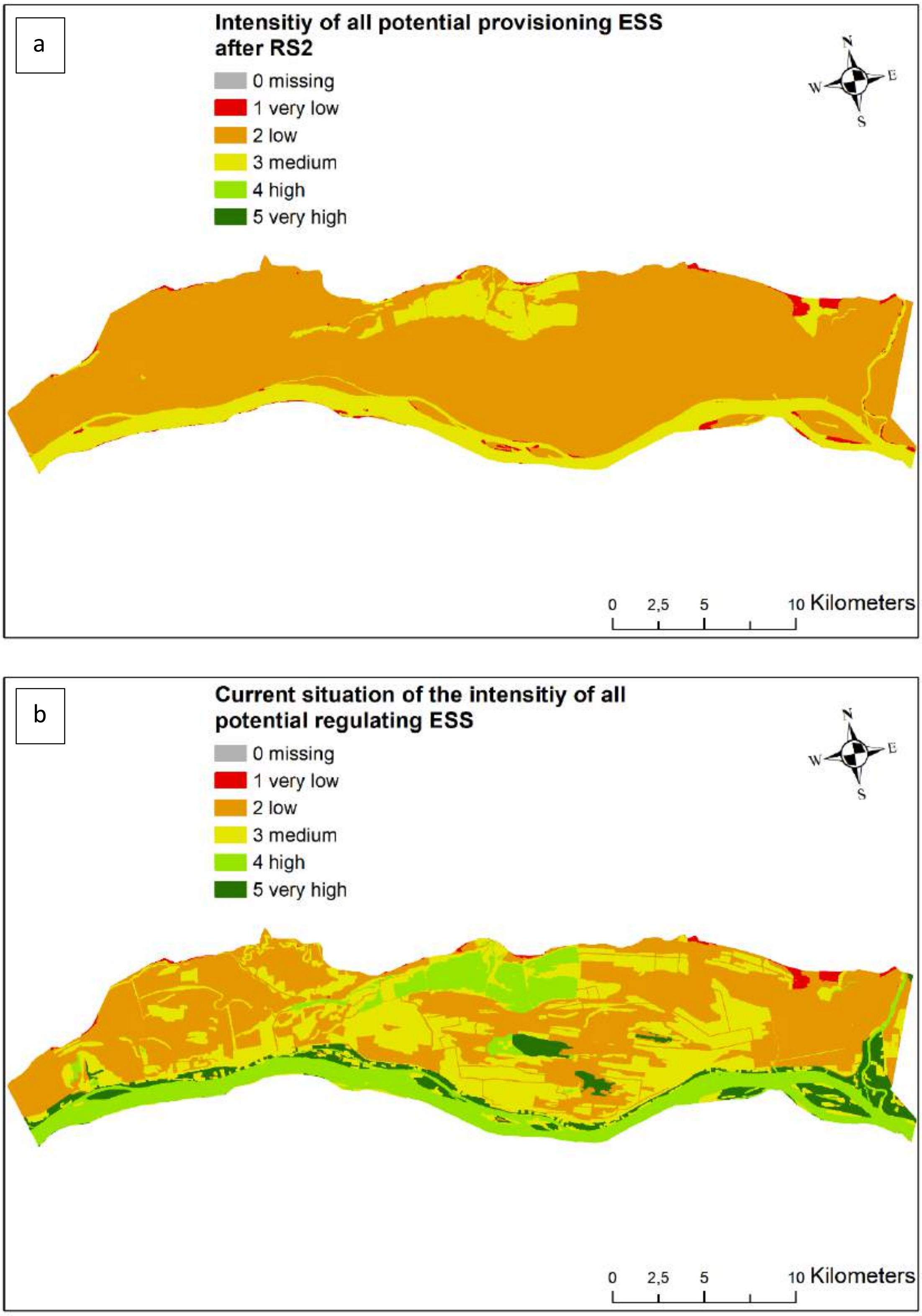
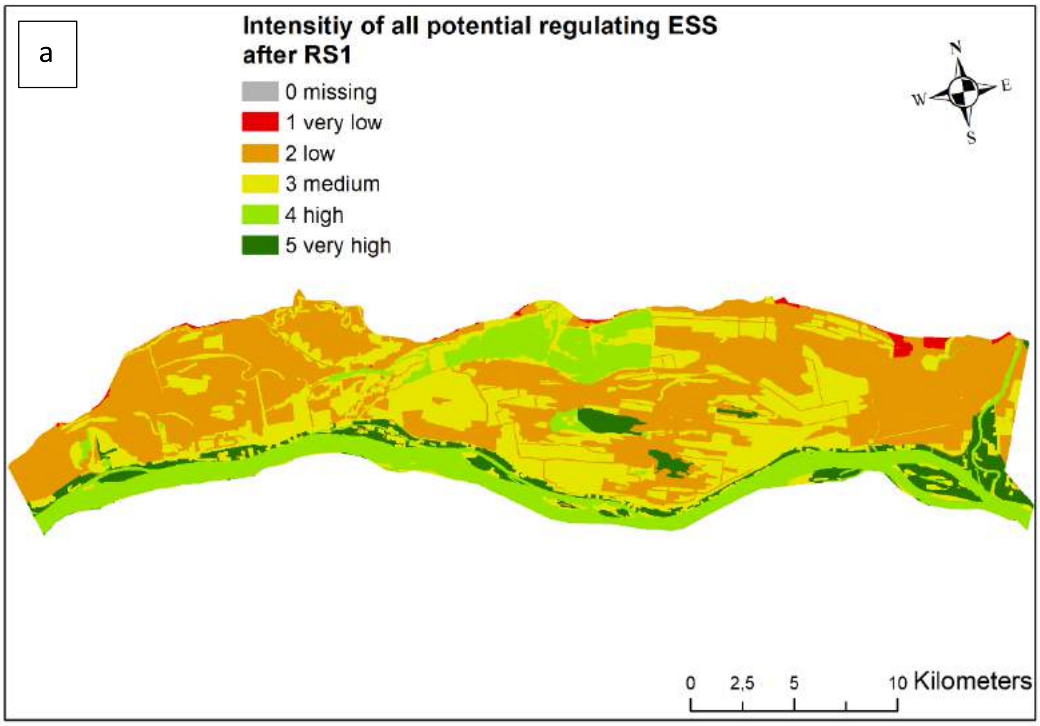


Figure 47: a) Intensity of all potential provisioning ESS after restoration scenario RS2. b) Intensity of all potential regulating ESS in the current situation. The values of the intensity of the potential ESS are marked in different colours.



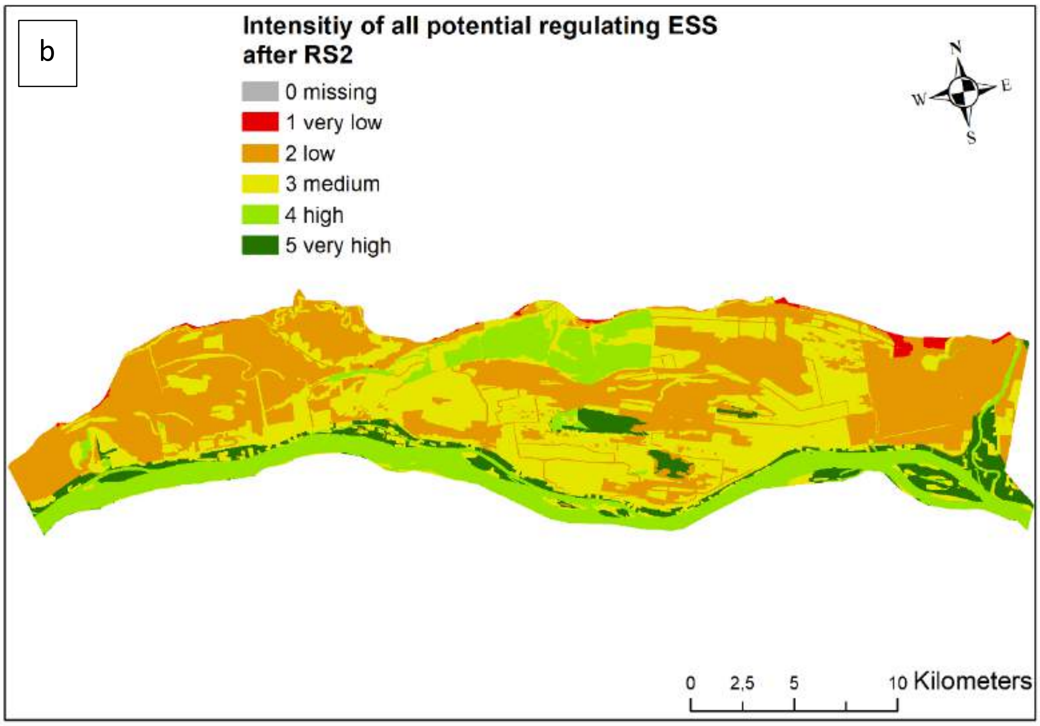


Figure 48: Intensity of all potential regulating ESS a) after restoration scenario RS1 and b) after restoration scenario RS2. The values of the intensity of the potential ESS are marked in different colours.

5.3.2 Krka

The pilot area Krka is characterized by a large forest area, the Krakovski forest (figure 49). Fields of arable land, grassland and greenhouses are located directly on the Krka River and are flooded several times a year during floods. The town of Kostanjevica na Krki, which is surrounded by a bend of the Krka river, is also affected by the floods. In contrast, most of the forest is currently suffering from increasing drought. The annual floods only reach a small part of the forest. Several measures are planned to reduce the risk of flooding in the town and to connect the forest to the Krka river. A new flood channel and the excavation and widening of the Krka river at the west side of Kostanjevica na Krki is planned in restoration scenario RS1 (figure 50a). In restoration scenario RS2, two more flood channels are to be created in addition to the measures planned in RS1 (figure 50b).

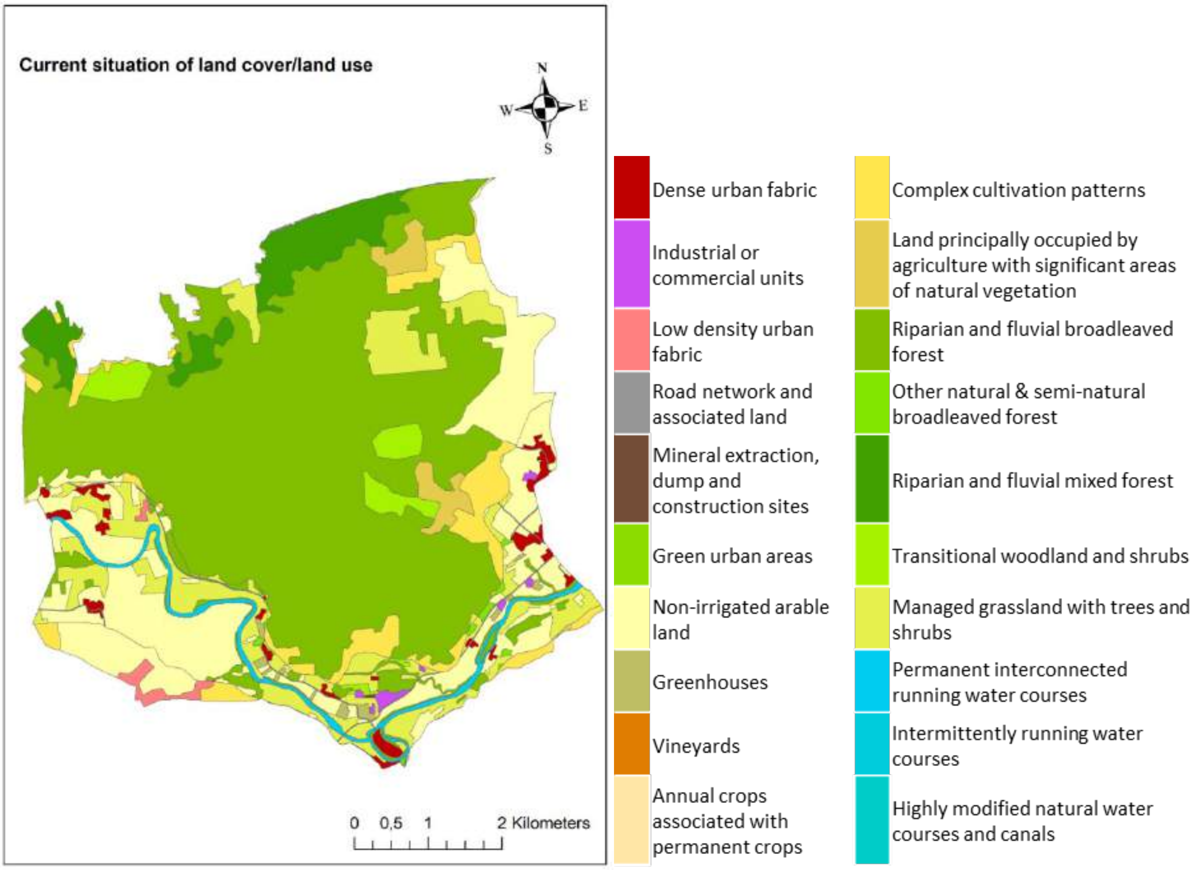


Figure 49: Land cover/land use types of pre-selected pilot area Krka in the current situation.

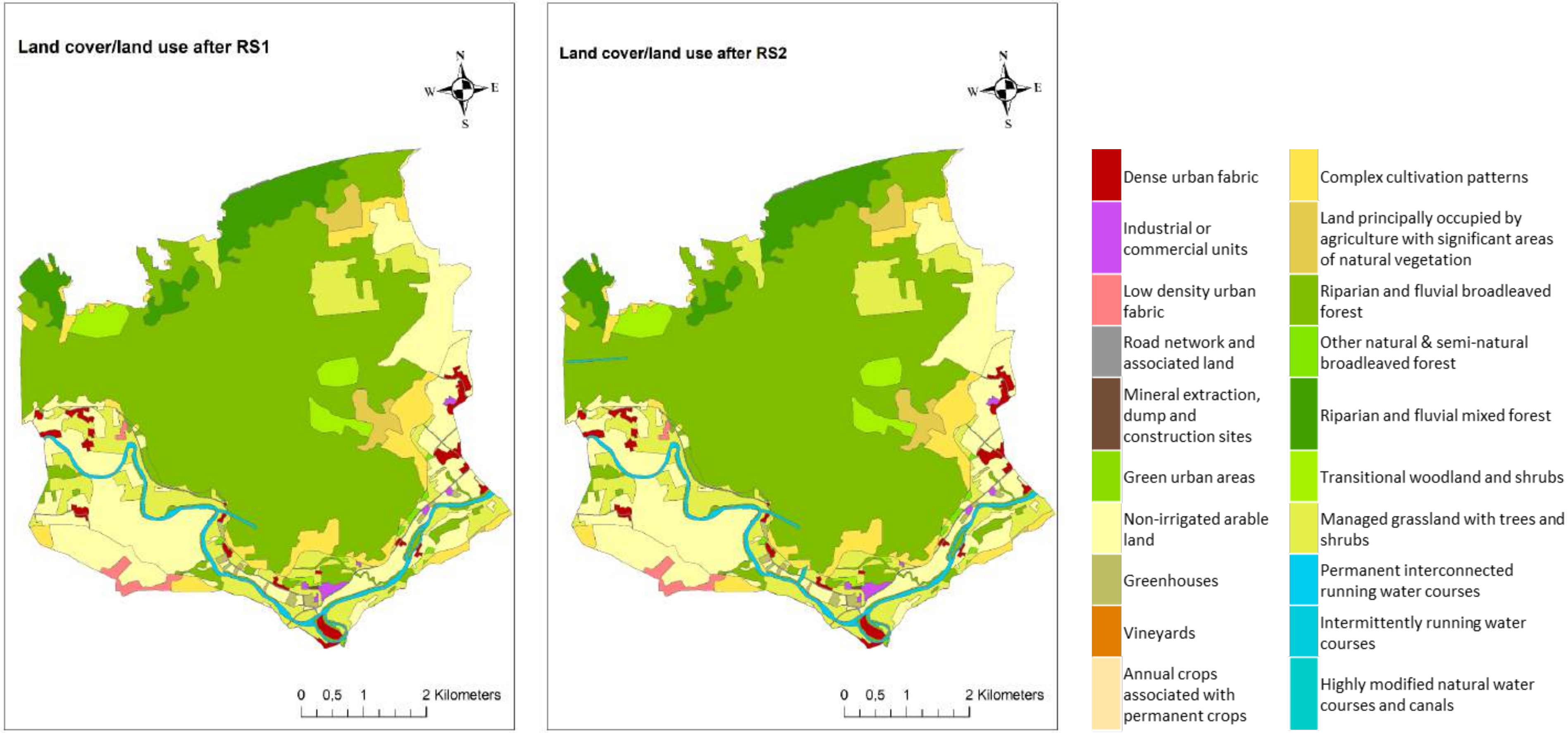


Figure 50: Land cover/land use types of pre-selected pilot area Krka after restoration scenarios RS1 and RS2.

Potential of the provisioning ESS

The intensity of the provided potential ESS *agricultural product* varies between medium to very high in the current situation and both restoration scenarios (figure 51 and figure 52). As a result of the creation of one of the three flood corridors in RS2, a small agricultural area with a very high potential to provide the ESS *agricultural product* will be lost (figure 52b).

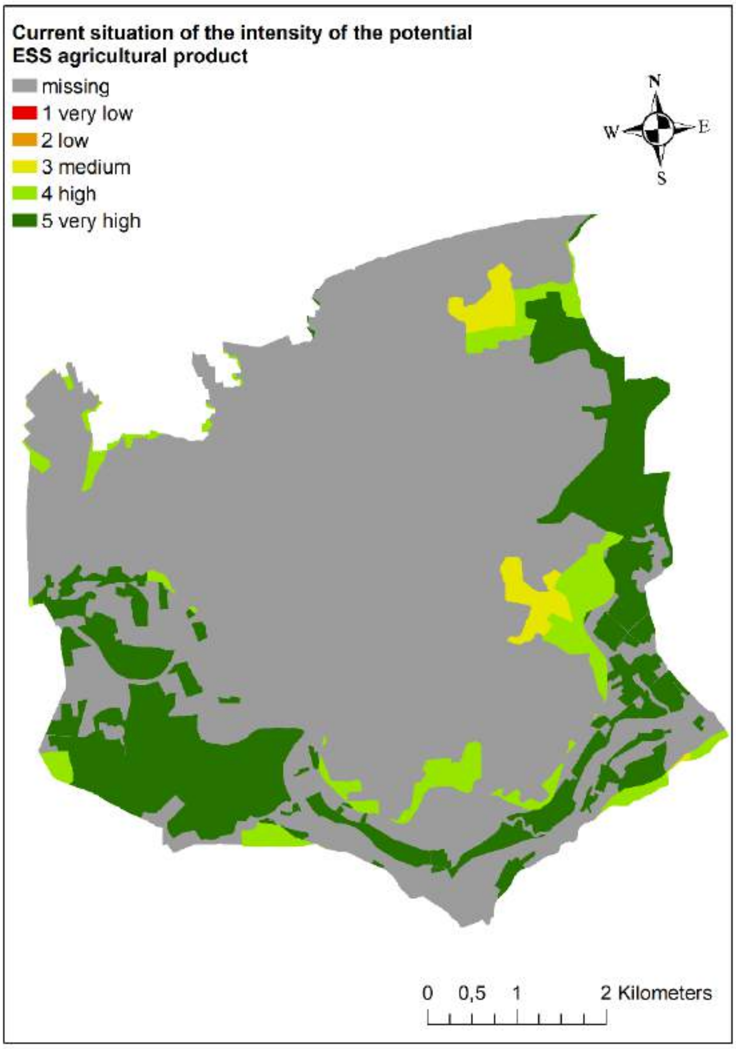


Figure 51: Intensity of the potential provisioning ESS agricultural product in the current situation. The values of the intensity of the potential ESS are marked in different colours.

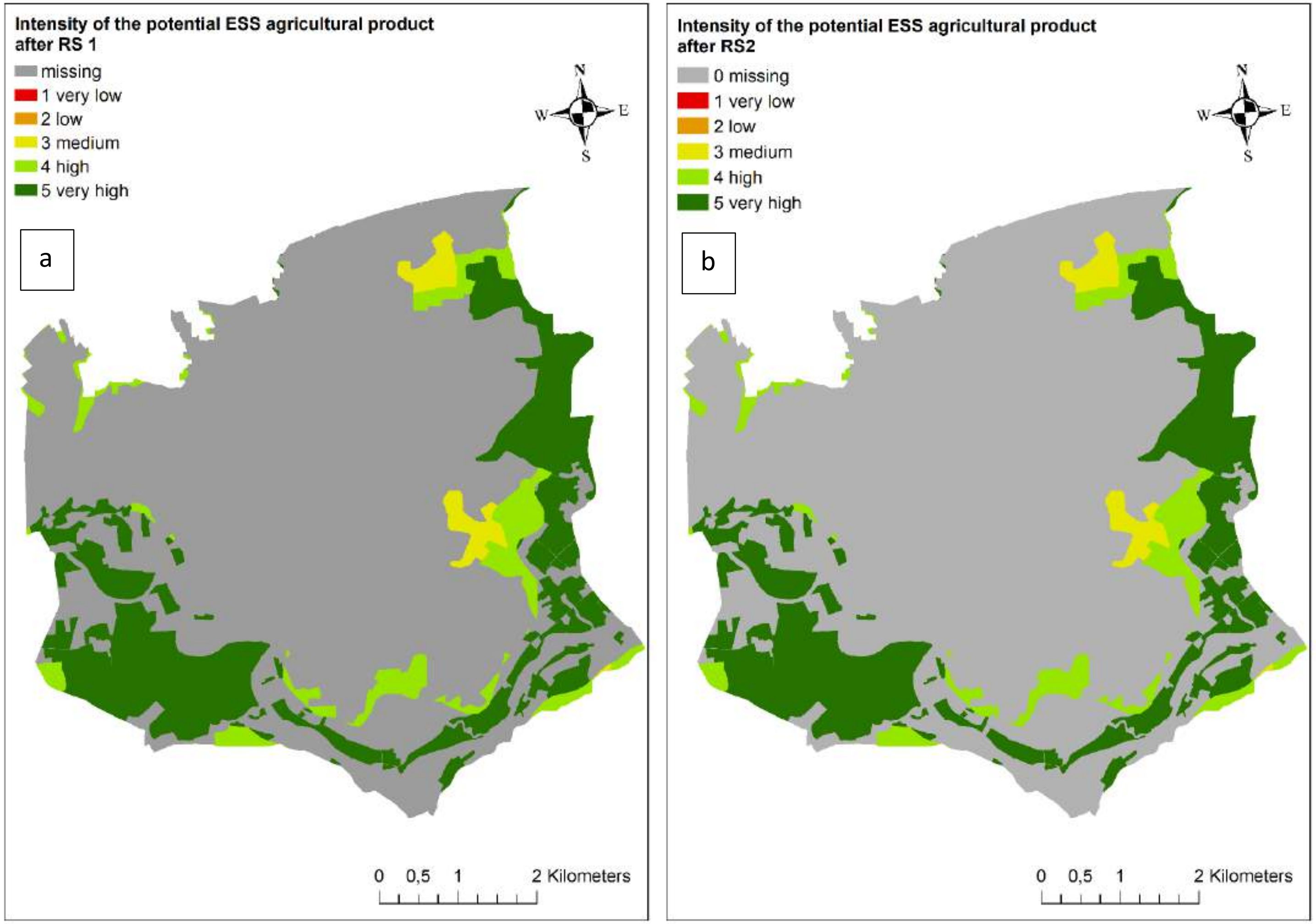


Figure 52: Intensity of the potential provisioning ESS agricultural product a) after restoration scenario RS1 and b) after restoration scenario RS2. The values of the intensity of the potential ESS are marked in different colours.

The potential to provide the provisioning ESS *wood* is mainly very high because of the large Krakovski forest (figure 53). The transitional woodland and shrub areas have a high potential to provide the ESS *wood*. However, there are also grassland areas with trees that have a medium potential. Complex cultivation patterns provide the ESS *wood* on a very low level and other agricultural areas do not provide wood at all. The supply of the ESS *wood* will decrease to a very small amount in restoration scenario RS1 due to the created flood corridor from the Krka river into the forest (figure 54a). In restoration scenario RS2, this decrease is intensified by two further flood corridors (figure 54b).

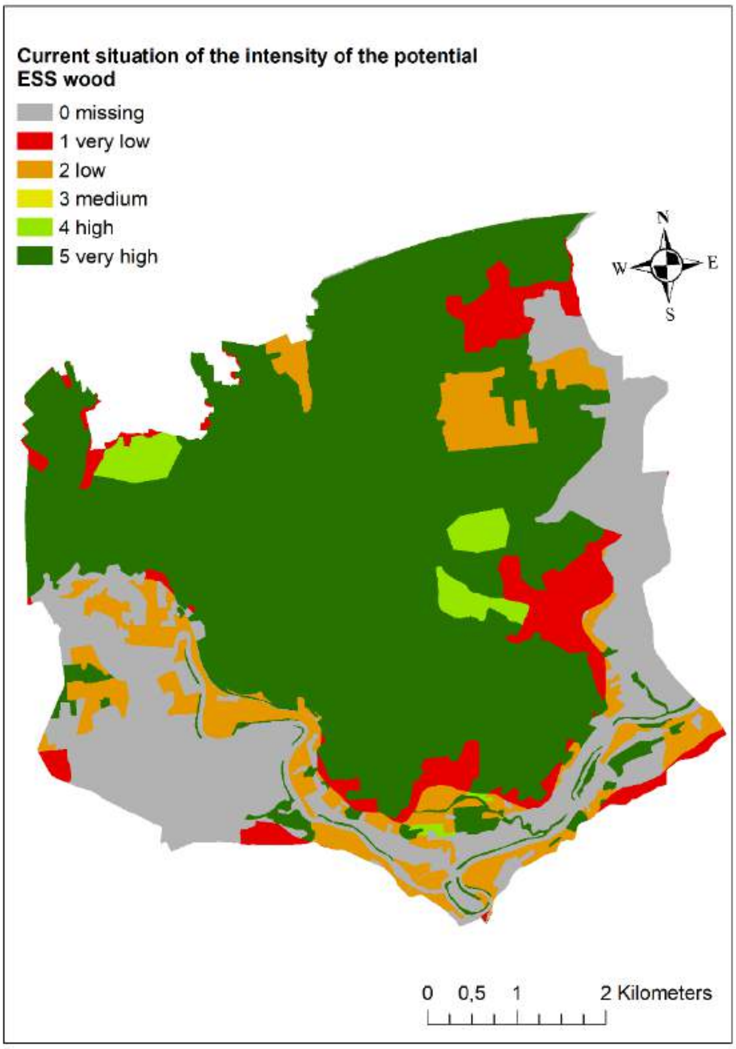


Figure 53: Intensity of the potential provisioning ESS wood in the current situation. The values of the intensity of the potential ESS are marked in different colours.

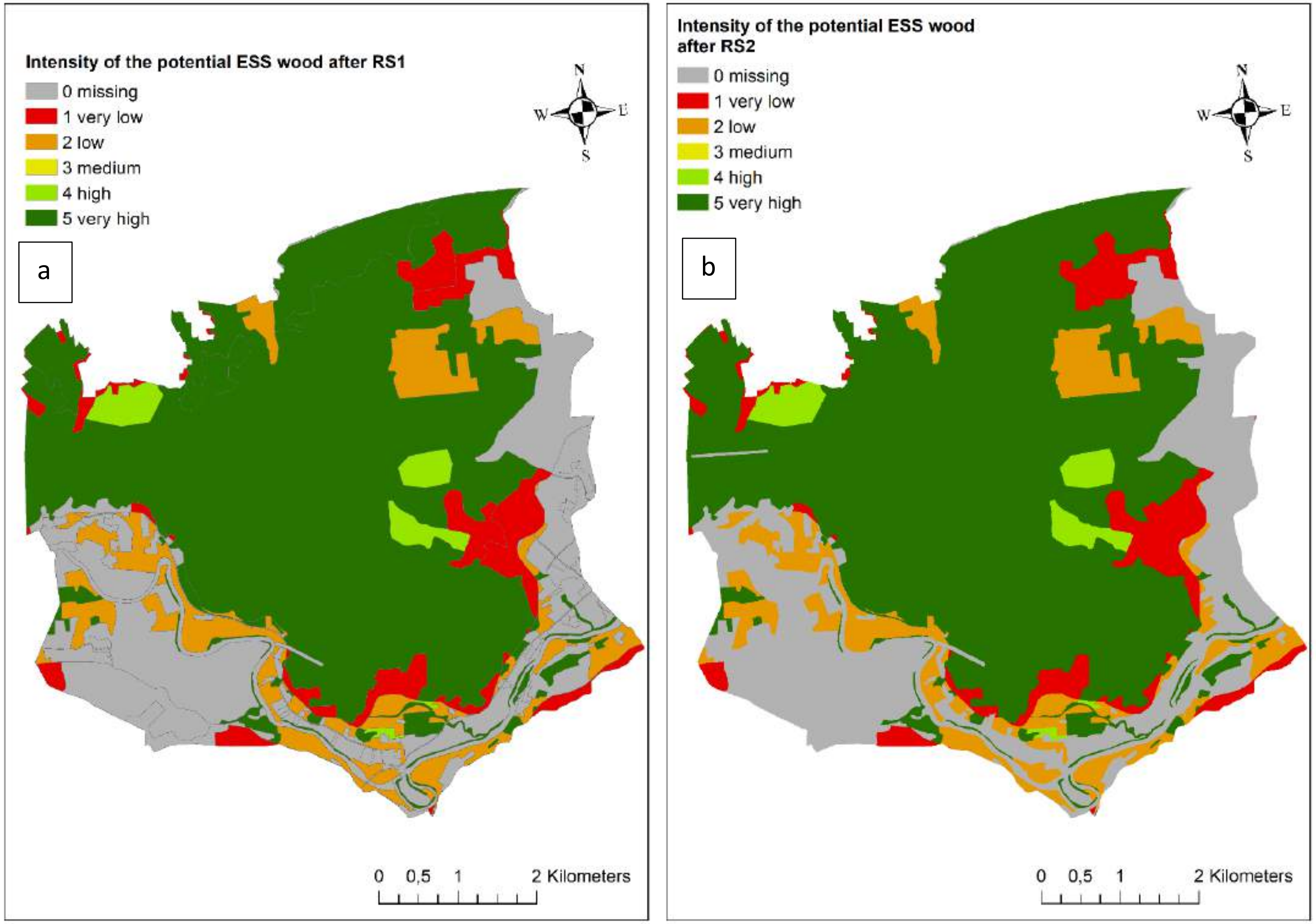


Figure 54: Intensity of the potential provisioning ESS wood a) after restoration scenario RS1 and b) after restoration scenario RS2. The values of the intensity of the potential ESS are marked in different colours.

In the current situation, the intensity of the provided potential ESS *animal product* is mainly very low (figure 55). There are only a few areas with a high or very high potential to provide this ESS. Therefore, the loss of the ESS *animal product* through the measures is minimal. This applies to both restoration scenarios RS1 and RS2 (figures 56a and b).

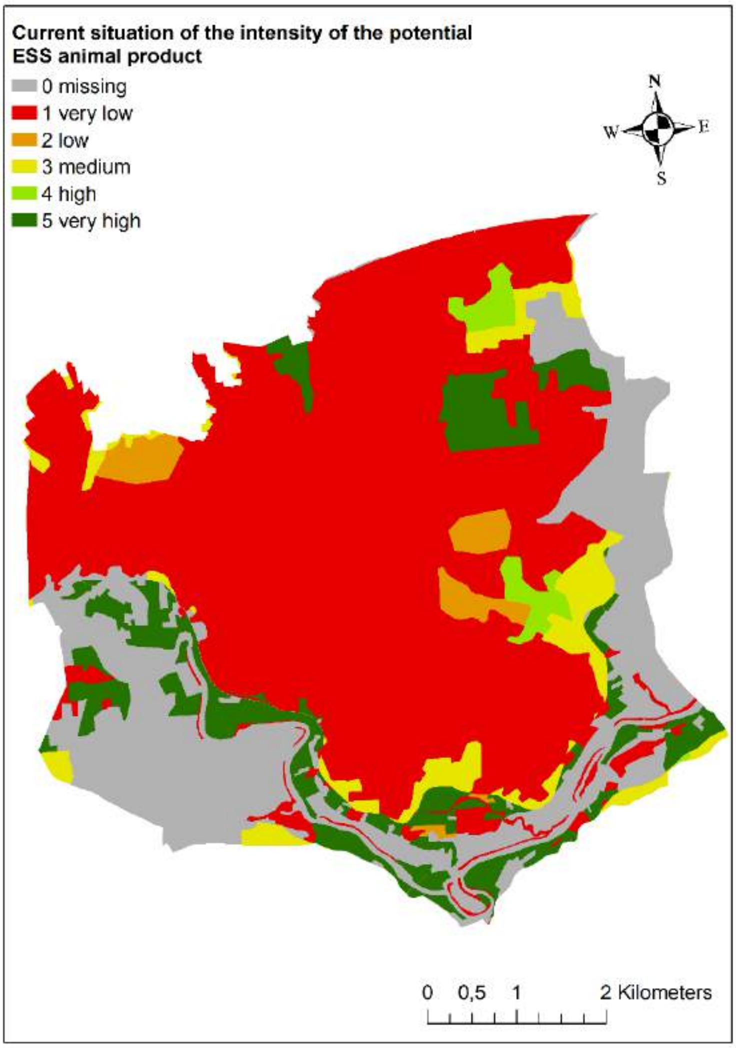


Figure 55: Intensity of the potential provisioning ESS animal product in the current situation. The values of the intensity of the potential ESS are marked in different colours.

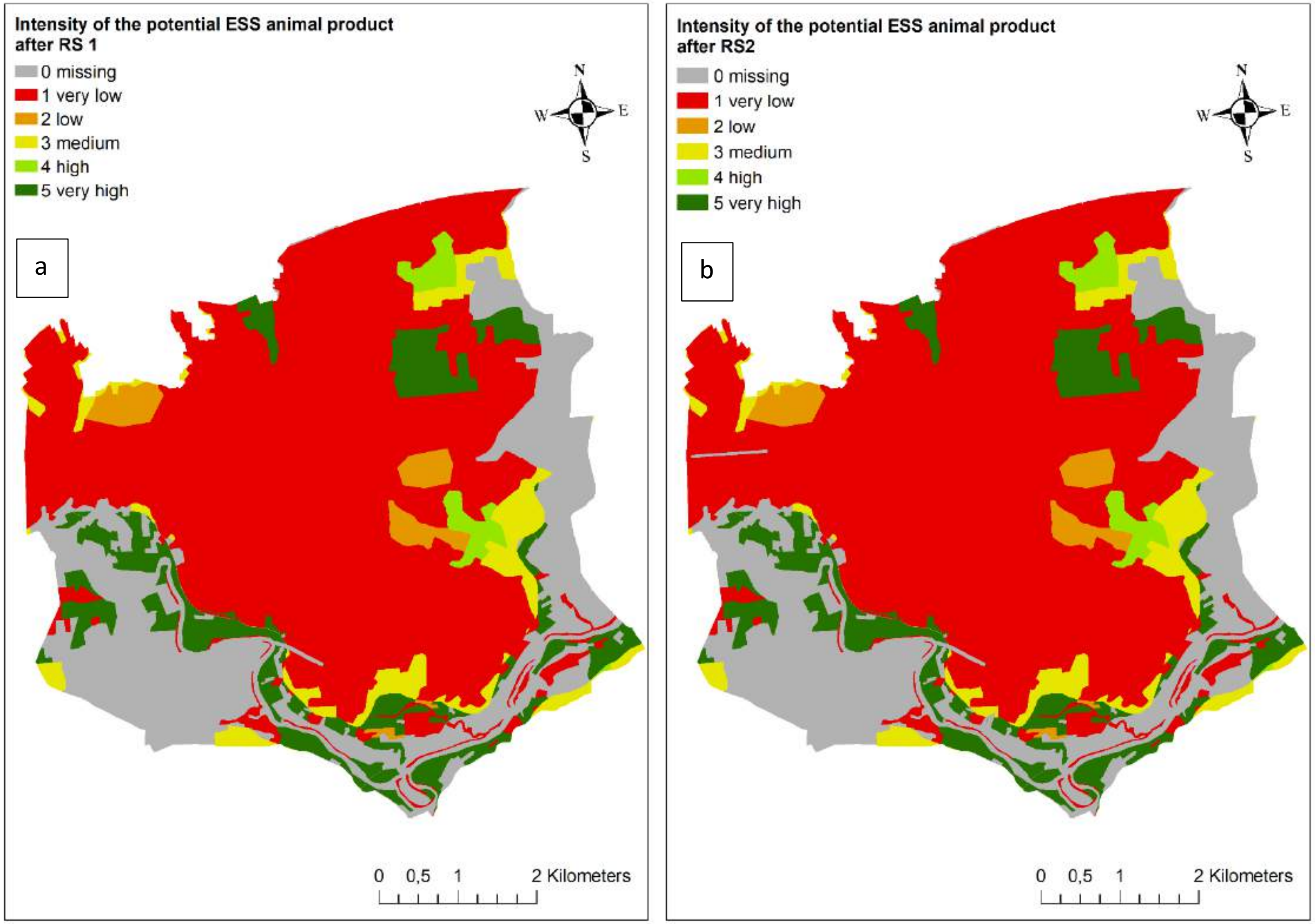


Figure 56: Intensity of the potential provisioning ESS animal product a) after restoration scenario RS1 and b) after restoration scenario RS2. The values of the intensity of the potential ESS are marked in different colours.

Also, the intensity to provide the potential ESS *honey* is very low in more than half of the area (figure 57). The potential is only very high in areas with natural vegetation and high in grassland areas. Flood corridors will lead to a loss of the supply of the potential ESS *honey*, but this will mainly affect forests with a very low potential for this ESS (figures 58a and b).

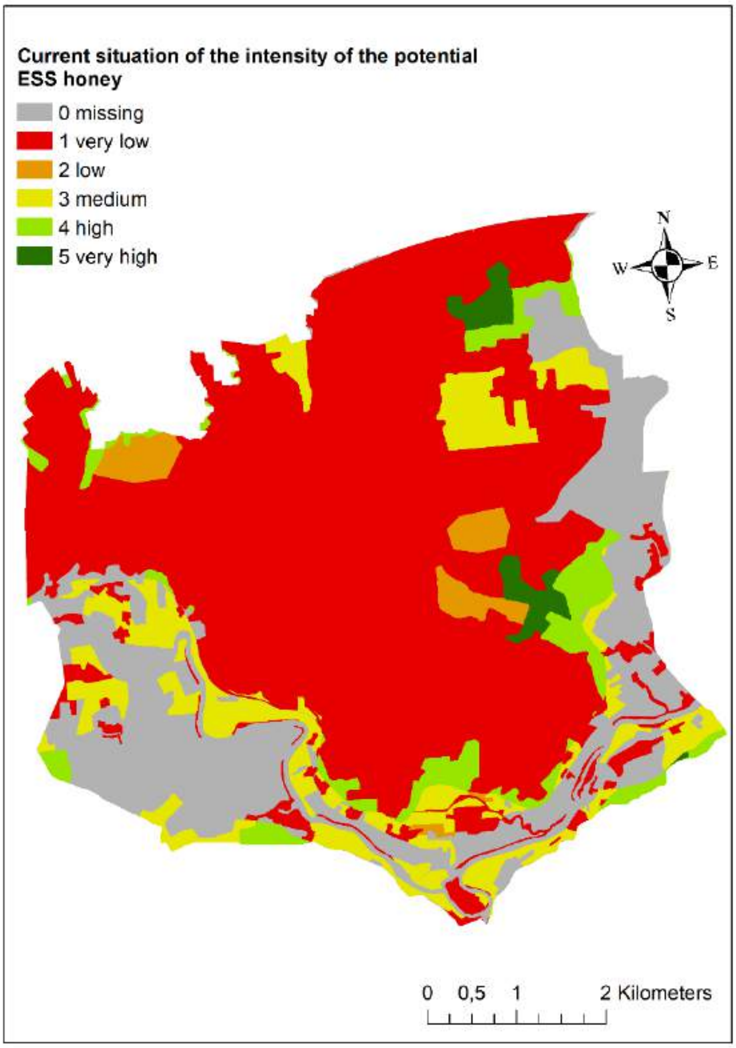


Figure 57: Intensity of the potential provisioning ESS honey in the current situation. The values of the intensity of the potential ESS are marked in different colours.

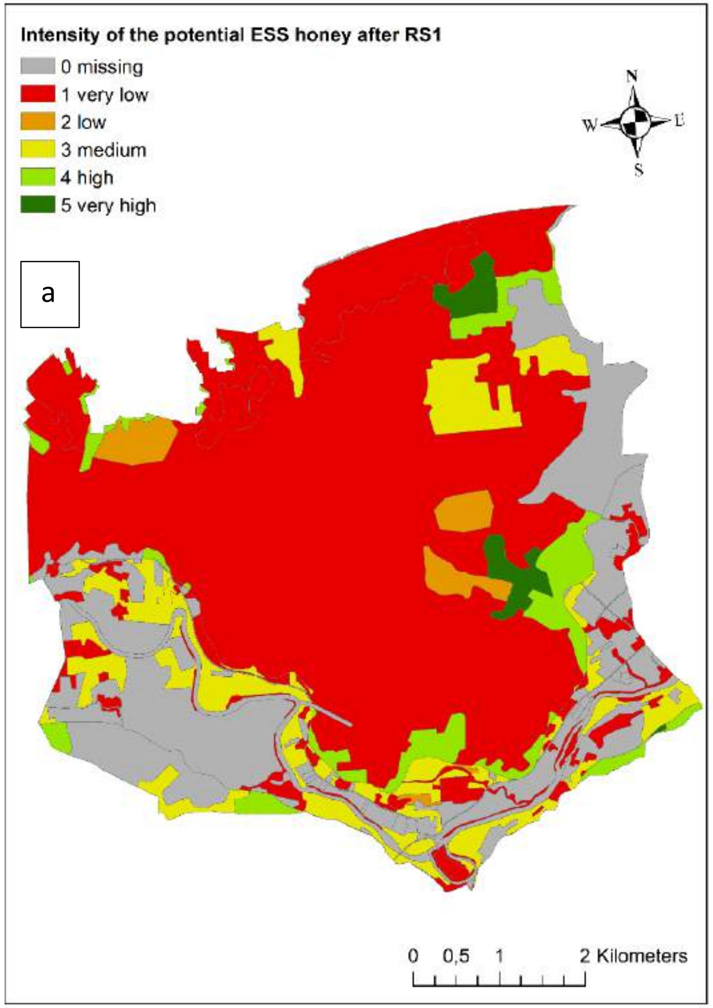


Figure 58: Intensity of the potential provisioning ESS animal product a) after restoration scenario RS1 and b) after restoration scenario RS2. The values of the intensity of the potential ESS are marked in different colours.

Due to the large forest area, the intensity of the provided ESS *game mea*t is very high (figure 59), whereas in agricultural areas the intensity is only at a very low level. This potential ESS will disappear with the restructuring of forests in the areas of the flood corridors (figures 60a and b).

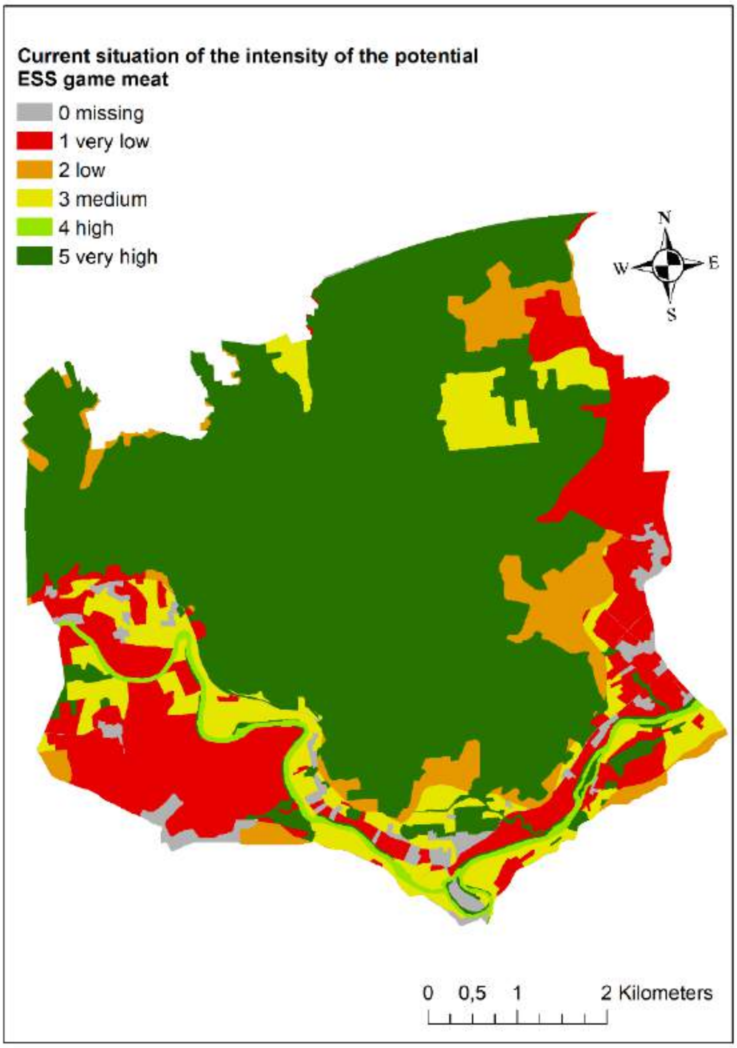


Figure 59: Intensity of the potential provisioning ESS game meat in the current situation. The values of the intensity of the potential ESS are marked in different colours.

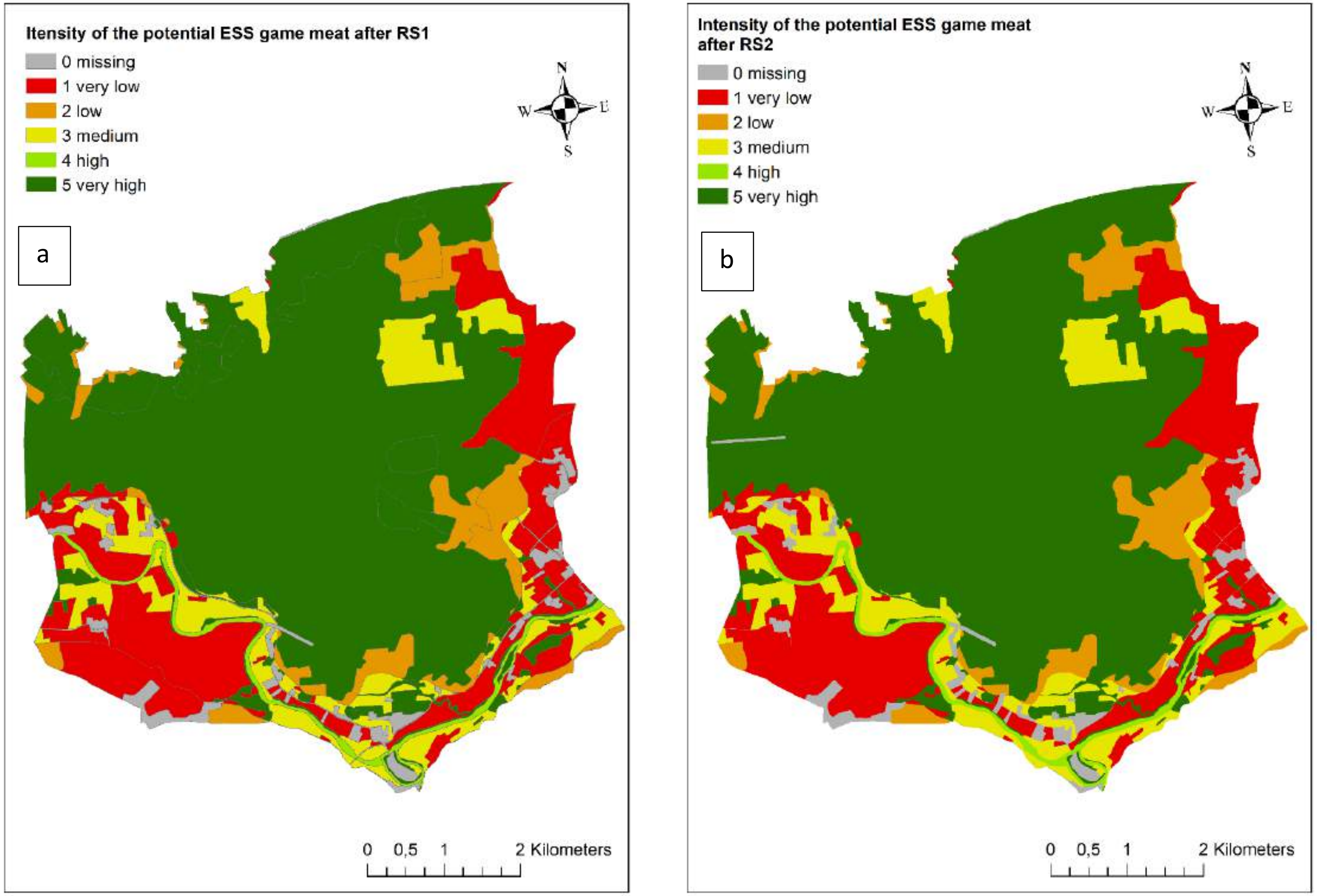


Figure 60: Intensity of the potential provisioning ESS game meat a) after restoration scenario RS1 and b) after restoration scenario RS2. The values of the intensity of the potential ESS are marked in different colours.

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Only the river Krka can provide *fish* as a potential ecosystem service, but at a very high level (figure 61). In the future, flood corridors can also contribute to the provision of the ESS *fish* in times of flooding (figures 62a and b).

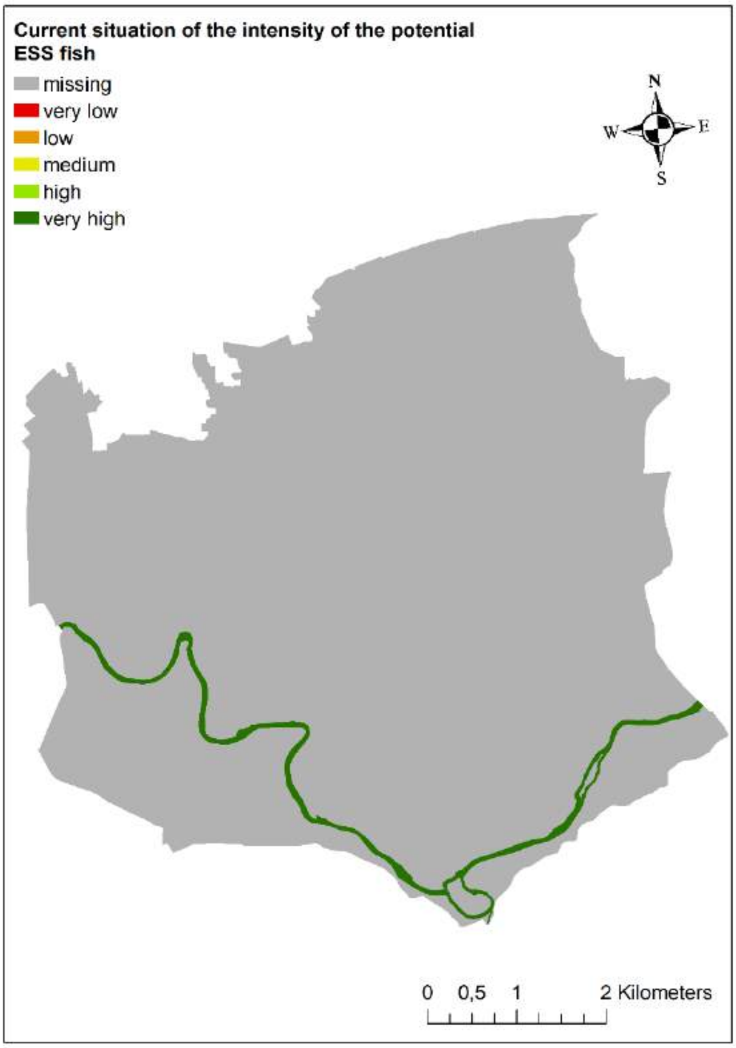

Figure 61: Intensity of the potential provisioning ESS fish in the current situation. The values of the intensity of the potential ESS are marked in different colours.

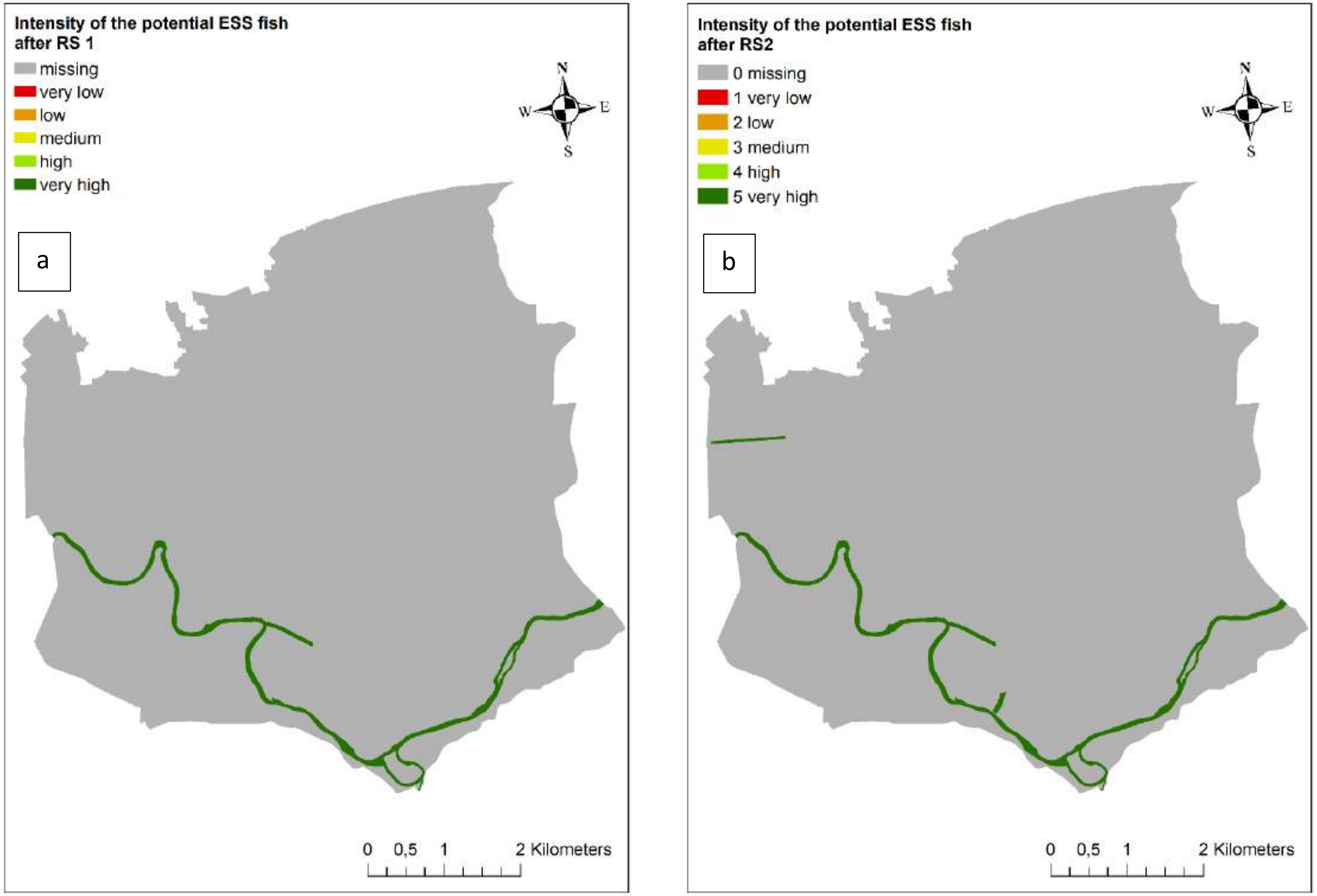

Figure 62: Intensity of the potential provisioning ESS fish a) after restoration scenario RS1 and b) after restoration scenario RS2. The values of the intensity of the potential ESS are marked in different colours.

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The provision of the potential ESS *water* as an ecosystem service is limited to a minimum (figure 63). There is also no improvement through the measures in RS1 or RS2 (figures 64a and b).

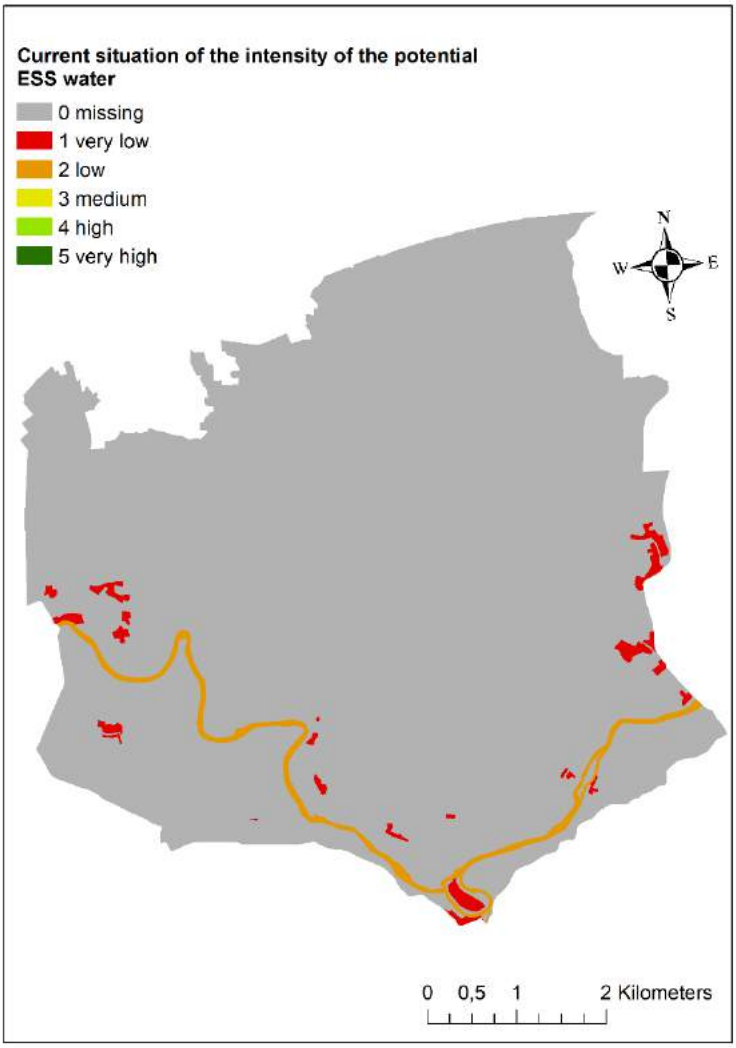


Figure 63: Intensity of the potential provisioning ESS water in the current situation. The values of the intensity of the potential ESS are marked in different colours.

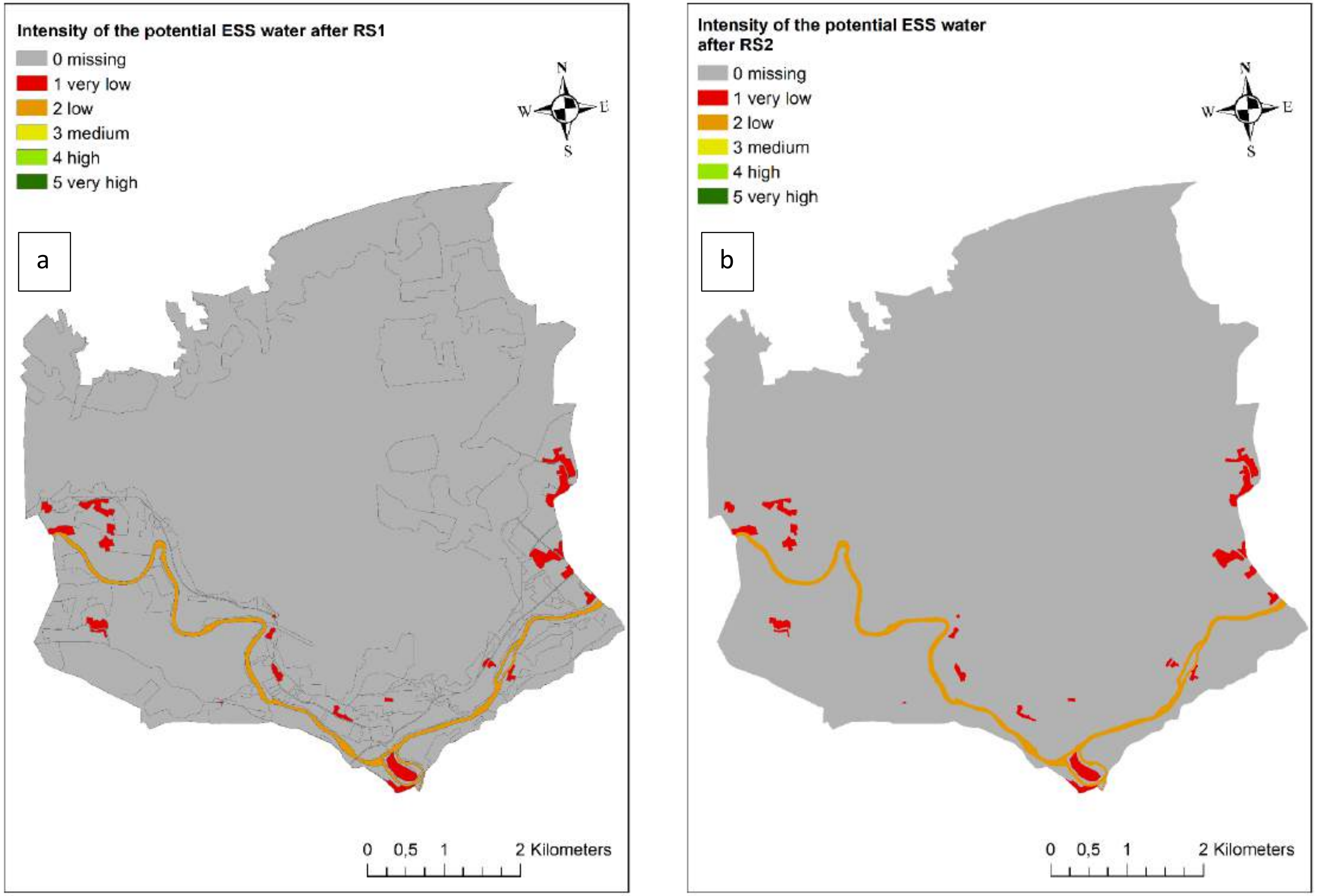


Figure 64: Intensity of the potential provisioning ESS water a) after restoration scenario RS1 and b) after restoration scenario RS2. The values of the intensity of the potential ESS are marked in different colours.

Potential of the regulating ESS

The potential to provide the ESS *air purification* is very high due to the Krakovski forest (figure 65). In contrast, areas without trees have only a very low intensity of the provided ESS *air purification*. The creation of the flood corridors into the forest will eliminate the potential to filter the air by trees in the affected areas (figures 66a and b). This loss is more significant in RS2 than in RS1.

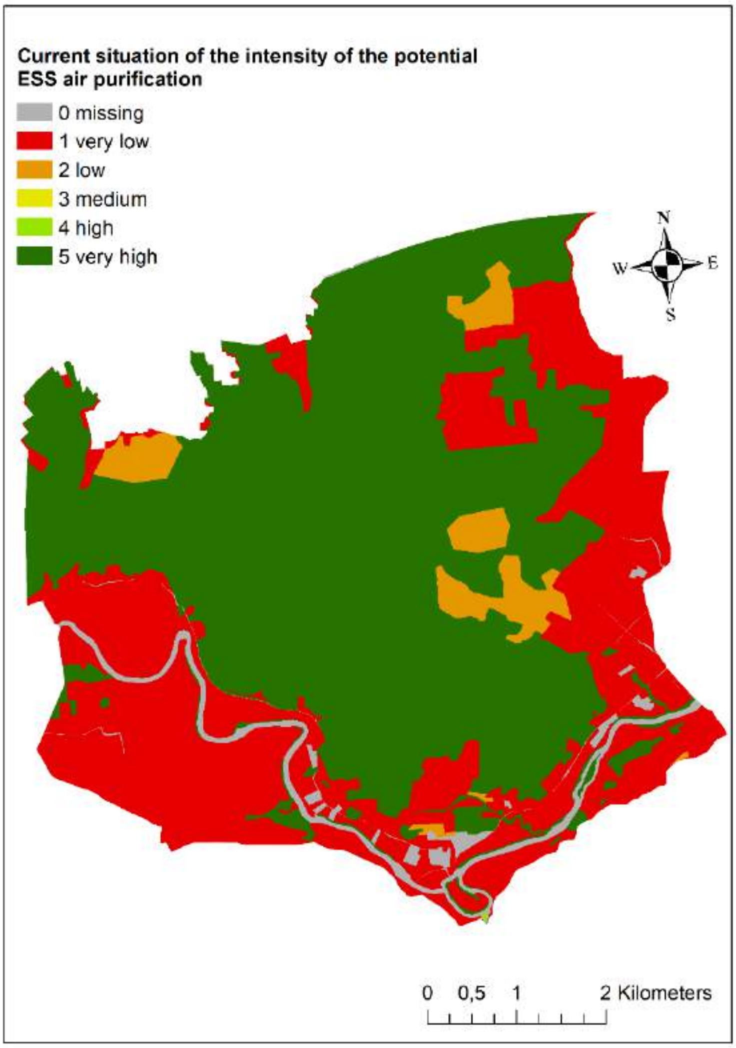


Figure 65: Intensity of the potential regulating ESS air purification in the current situation. The values of the intensity of the potential ESS are marked in different colours.

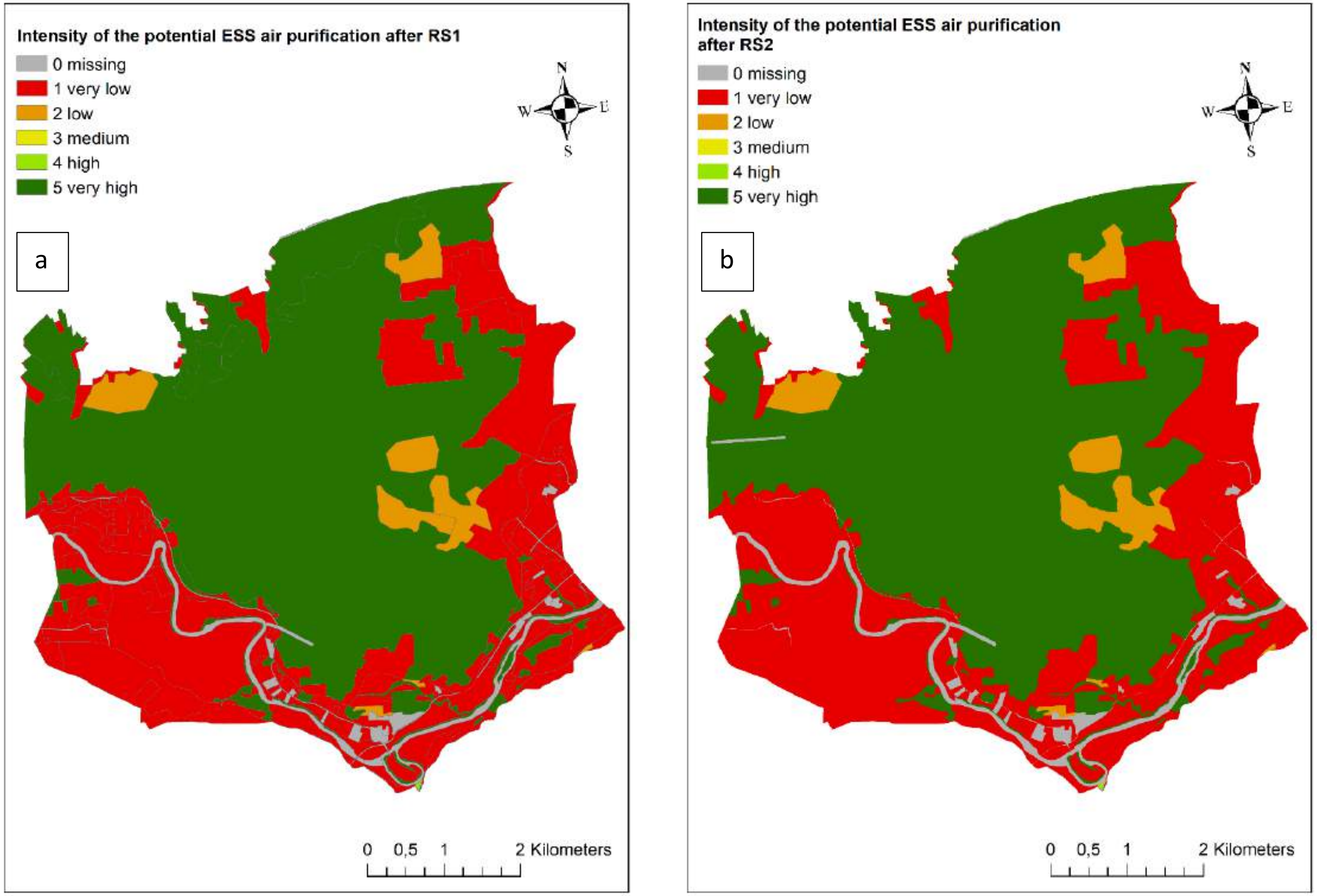


Figure 66: Intensity of the potential regulating ESS air purification a) after restoration scenario RS1 and b) after restoration scenario RS2. The values of the intensity of the potential ESS are marked in different colours.

The potential to provide the ESS l*ocal climate regulation* is also very high (figure 67). Contrary to the ESS *air purification*, this ESS is provided by grassland and even agricultural land, although only to a very limited extent. The new flood corridor in restoration scenario RS1 and the same one in RS2 increase the intensity of the potential ESS local climate regulation (figures 68a and b). In RS2, another flood corridor improves this ESS by two levels within areas of medium intensity.

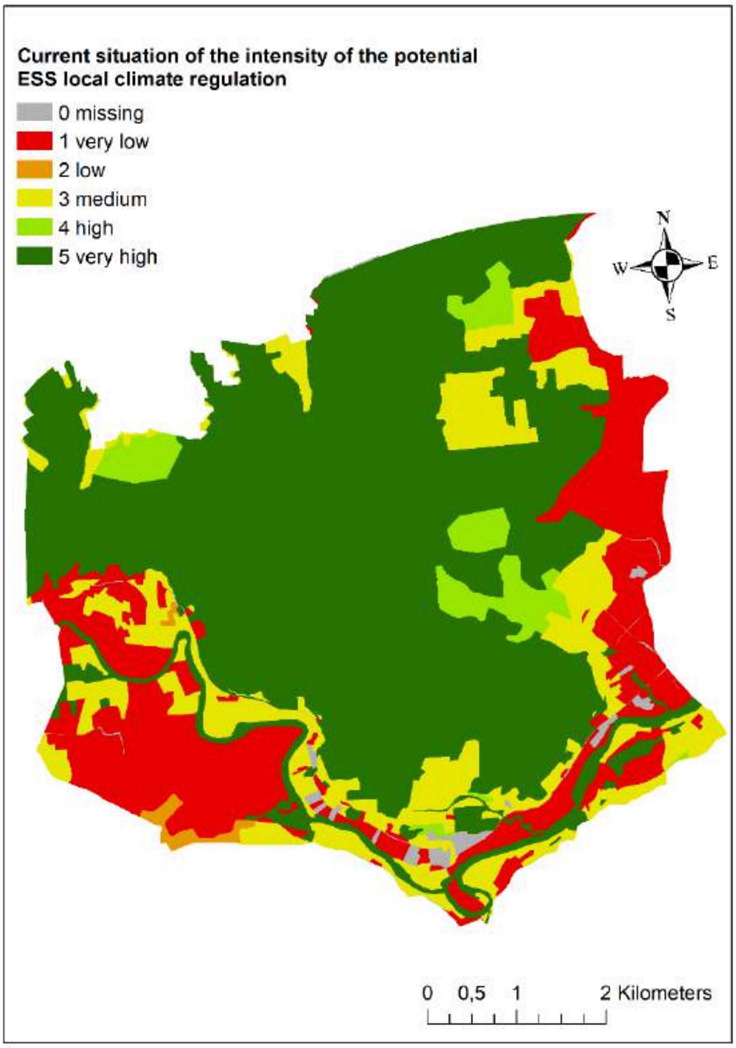
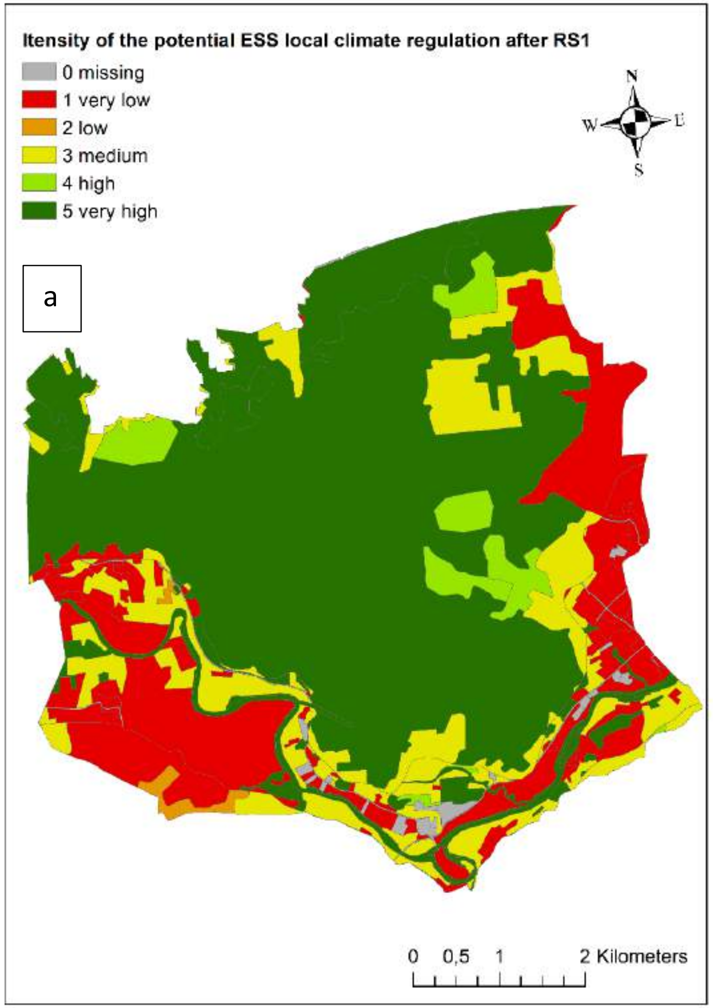


Figure 67: Intensity of the potential regulating ESS local climate regulation in the current situation. The values of the intensity of the potential ESS are marked in different colours.



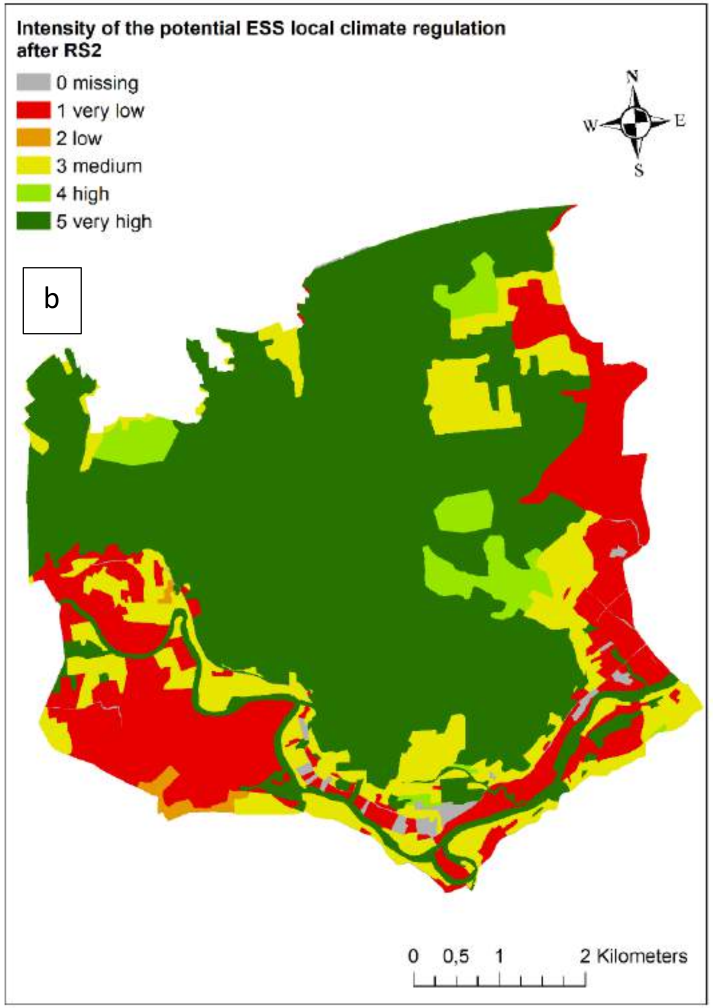


Figure 68: Intensity of the potential regulating ESS local climate regulation a) after restoration scenario RS1 and b) after restoration scenario RS2. The values of the intensity of the potential ESS are marked in different colours.

In contrast, the supply of the potential ESS *low water regulation* is usually very low due to the large forest area in the pre-selected pilot area (figure 69). The intensity of the ESS l*ow water regulation* increases in the areas of the established measures (figures 70a and b). The flood corridors can upgrade the potential ESS *low water regulation* to a high level.

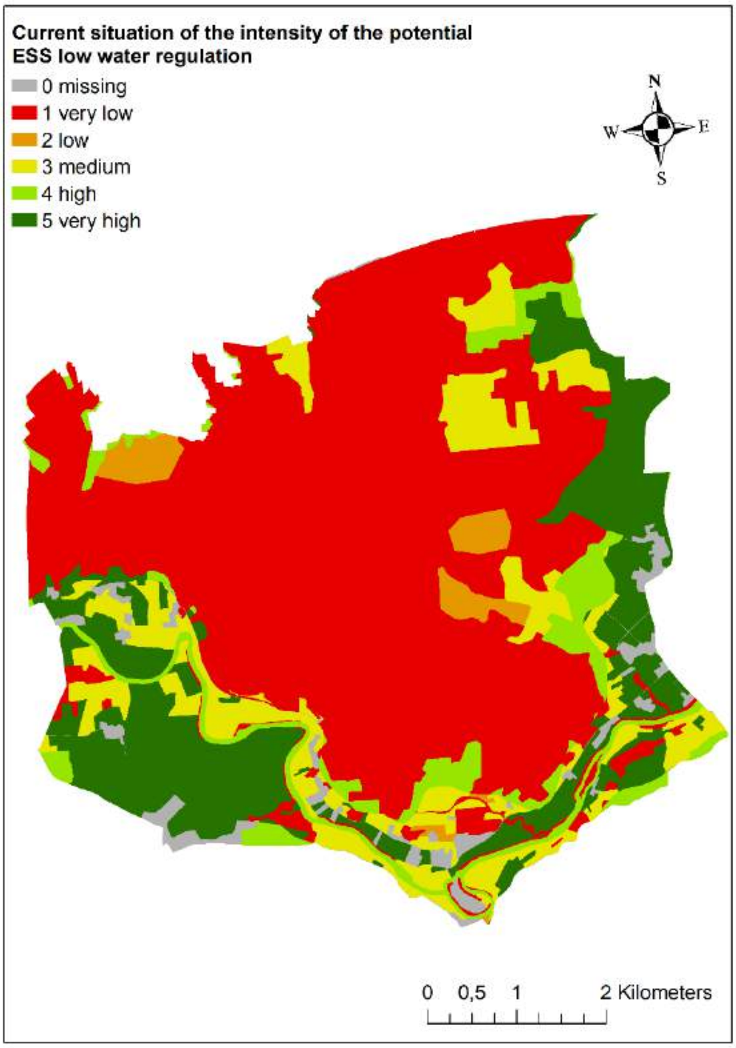


Figure 69: Intensity of the potential regulating ESS low water regulation in the current situation. The values of the intensity of the potential ESS are marked in different colours.

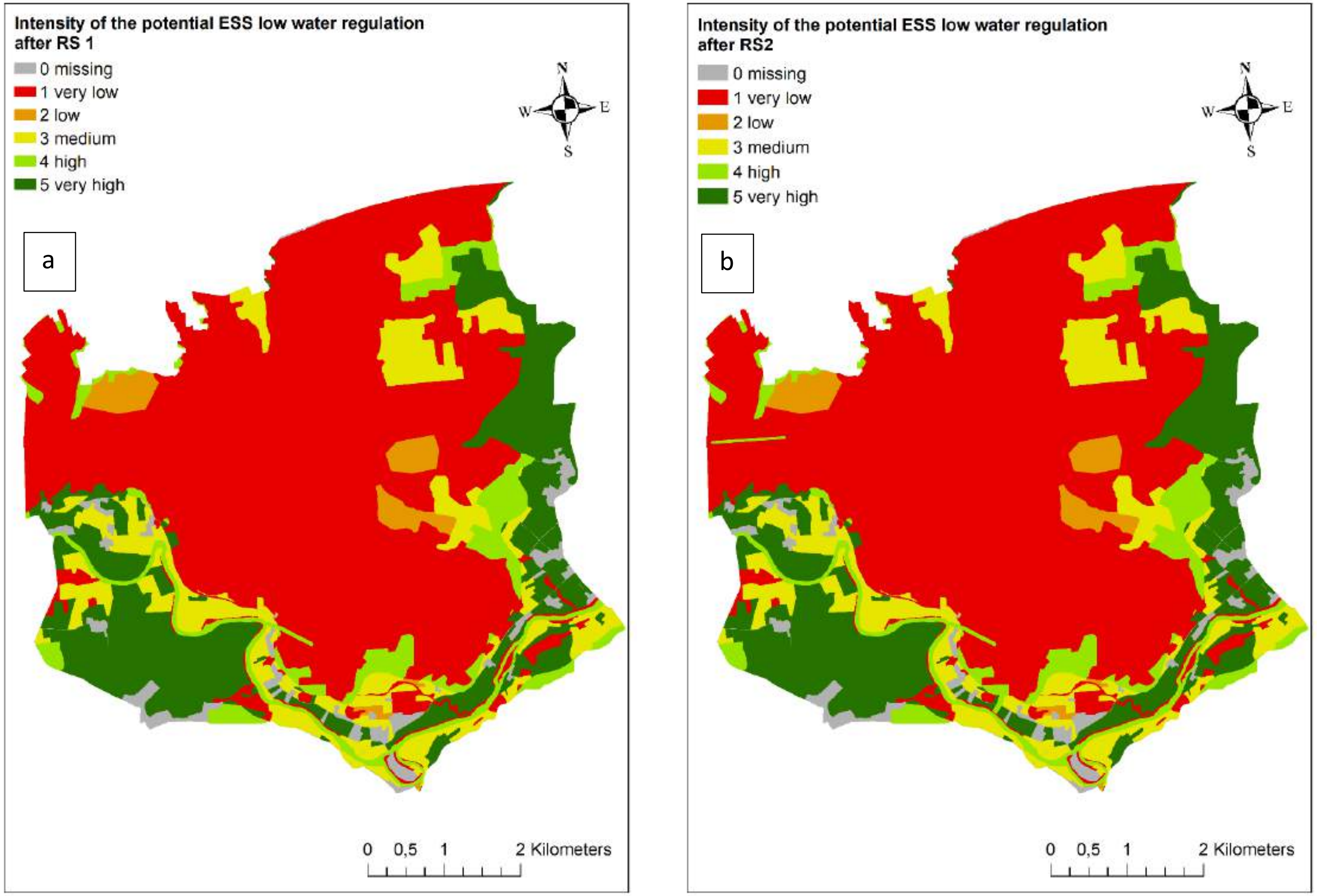


Figure 70: Intensity of the potential regulating ESS low water regulation a) after restoration scenario RS1 and b) after restoration scenario RS2. The values of the intensity of the potential ESS are marked in different colours.

In the current situation, the forest area has a high potential to ensure the ESS flood retention (figure 71). Except for grassland, all other land cover/land use types have very low or no potential to provide this ESS. The measures improve the provision of potential ESS flood retention to a very high level within the flood corridors (figures 72a and b).

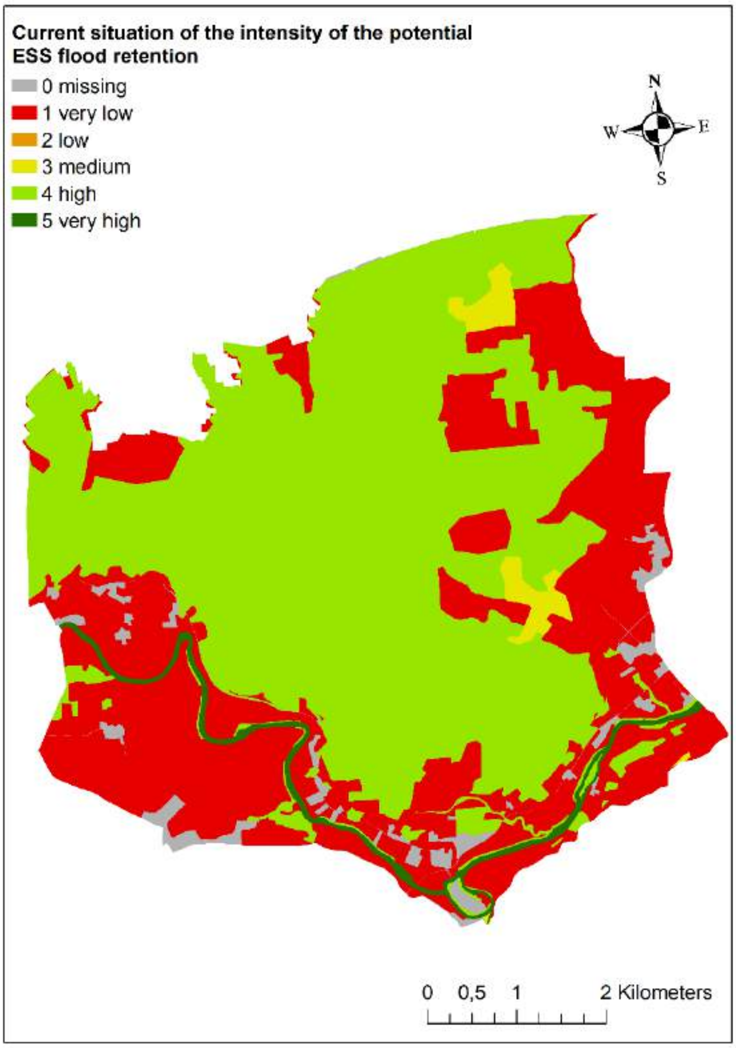
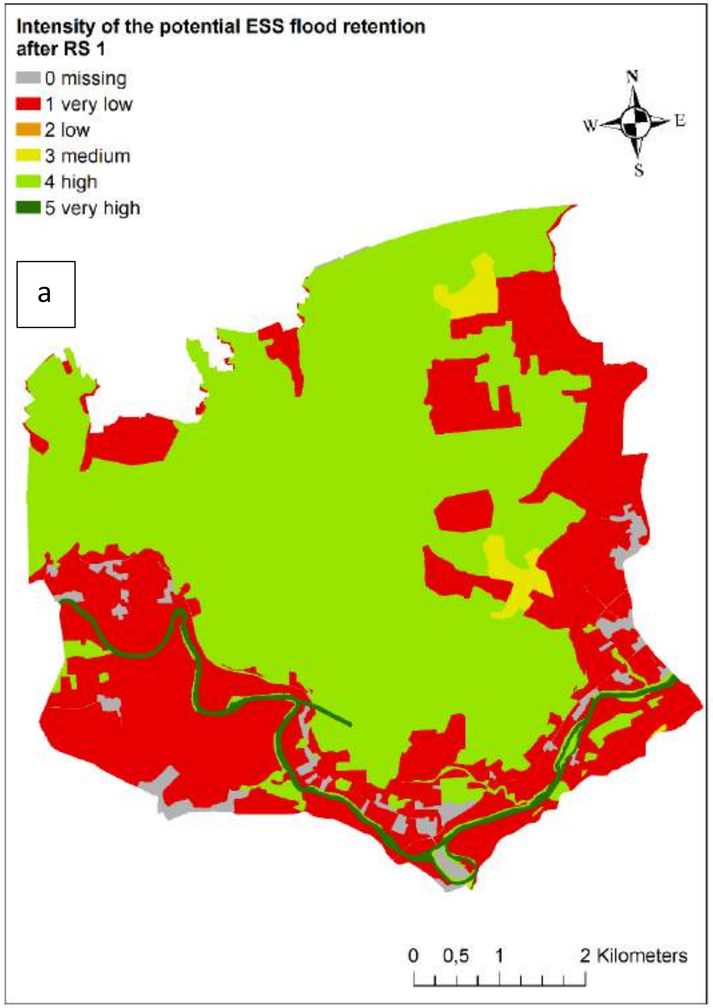


Figure 71: Intensity of the potential regulating ESS flood retention in the current situation. The values of the intensity of the potential ESS are marked in different colours.



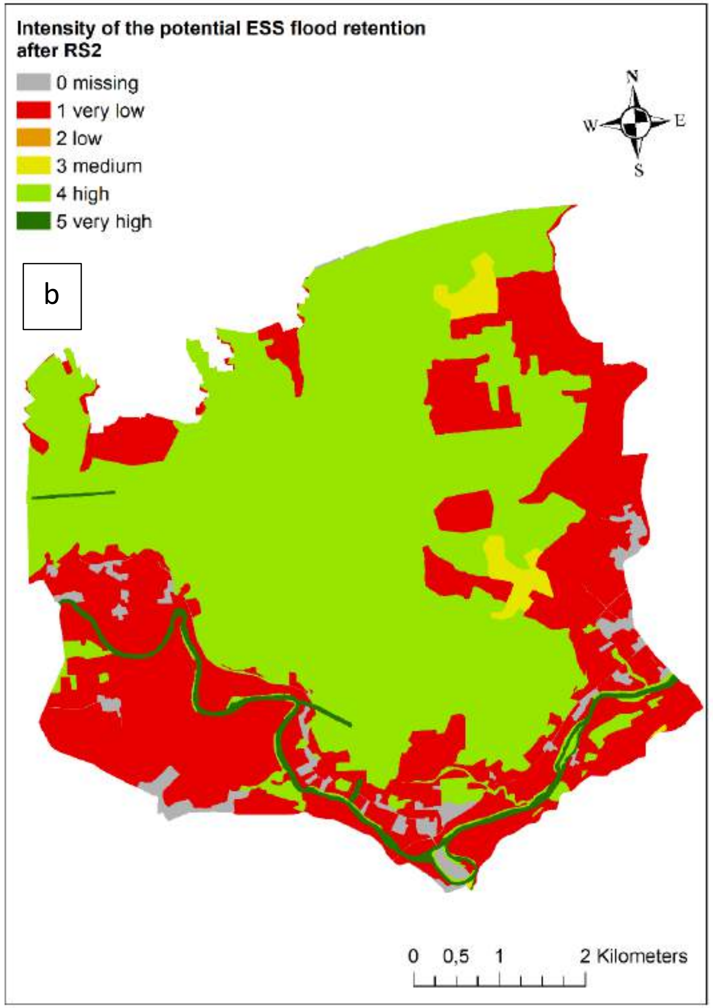


Figure 72: Intensity of the potential regulating ESS flood retention a) after restoration scenario RS1 and b) after restoration scenario RS2. The values of the intensity of the potential ESS are marked in different colours.

The large contiguous forest area provides a very high potential of the ESS *noise regulation* that is very low or non-existent outside the forest (figure 73). The implementation of the flood corridors leads to a loss of this potential in the affected areas (figures 74a and b).

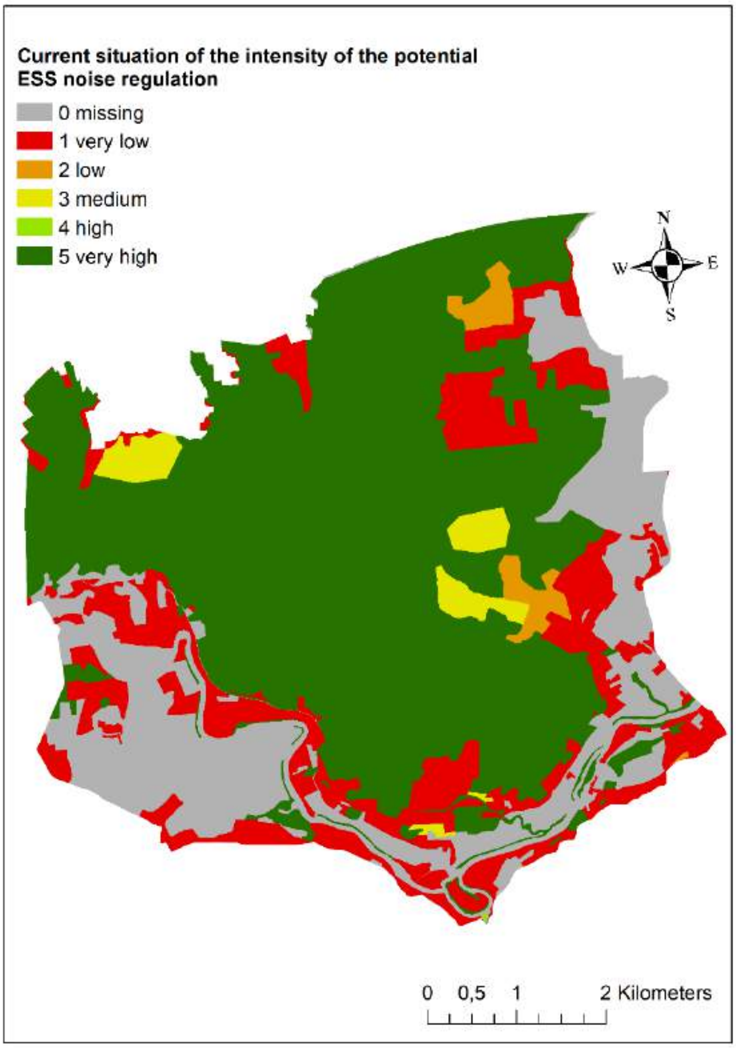


Figure 73: Intensity of the potential regulating ESS noise regulation in the current situation. The values of the intensity of the potential ESS are marked in different colours.

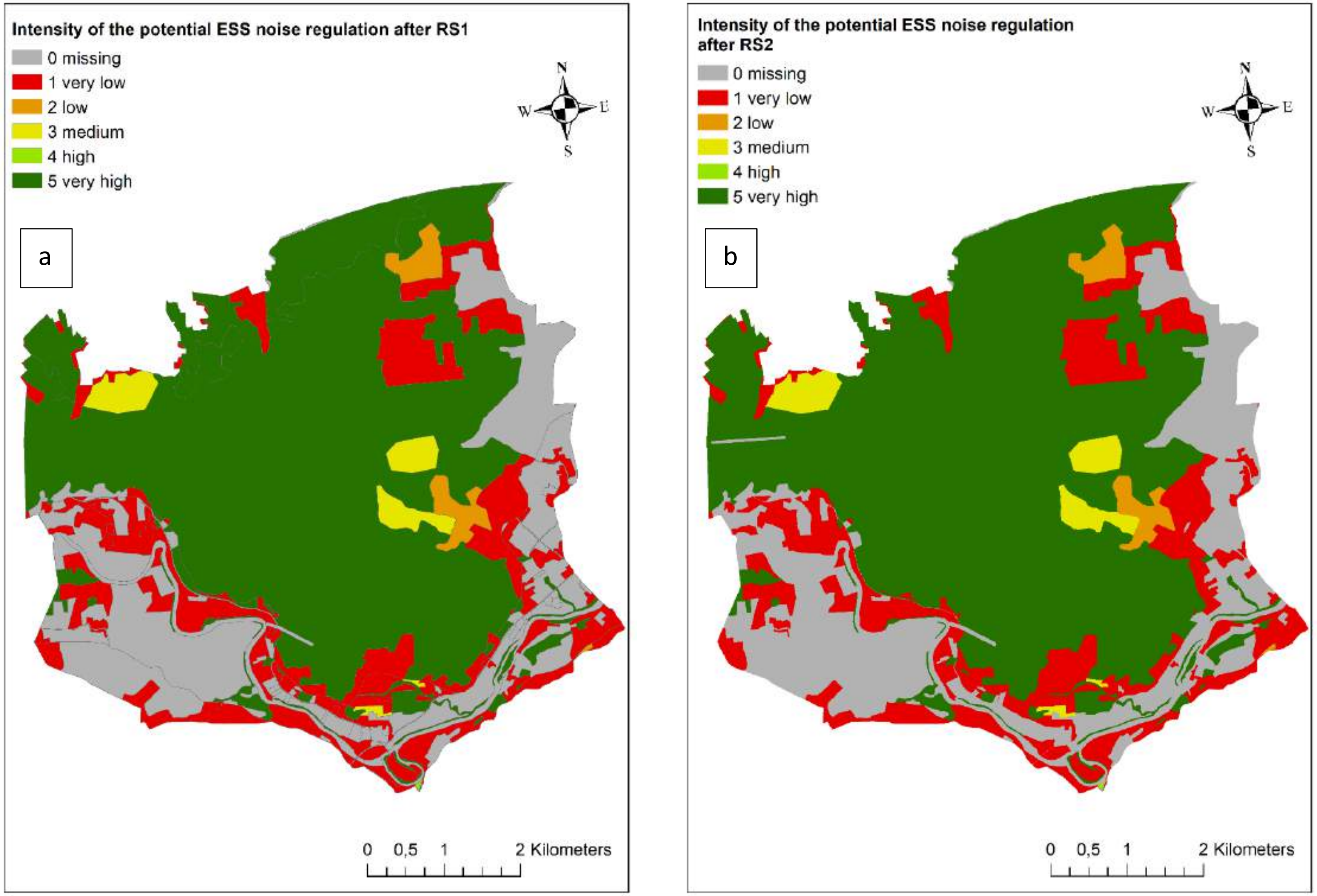


Figure 74: Intensity of the potential regulating ESS noise regulation a) after restoration scenario RS1 and b) after restoration scenario RS2. The values of the intensity of the potential ESS are marked in different colours.

The potential ESS *nutrient retention* varies between very low and very high levels (figure 75). Only urban areas have no potential to provide this ESS. The planned flood corridor of the restoration scenario RS1 improve the intensity of the potential ESS nutrient retention in grassland areas (figure 76a). In RS2 two of the three flood corridors increases the provision of the potential ESS nutrient retention within the grassland and arable land areas affected by the measures (figure 76b).

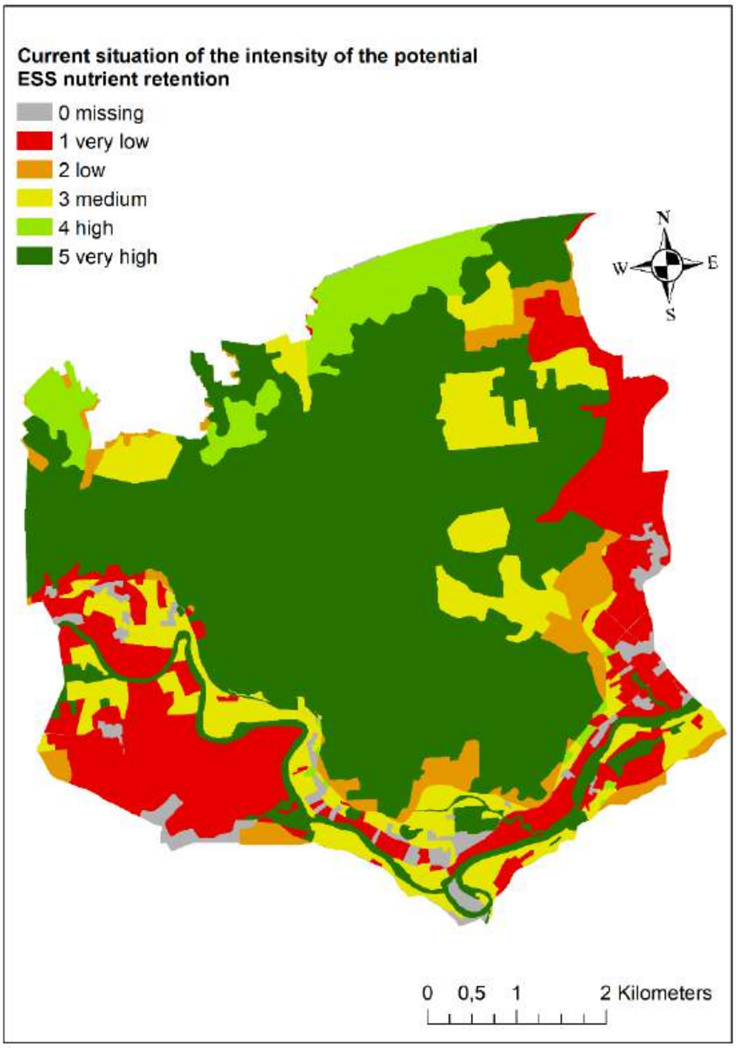


Figure 75: Intensity of the potential regulating ESS nutrient retention in the current situation. The values of the intensity of the potential ESS are marked in different colours.

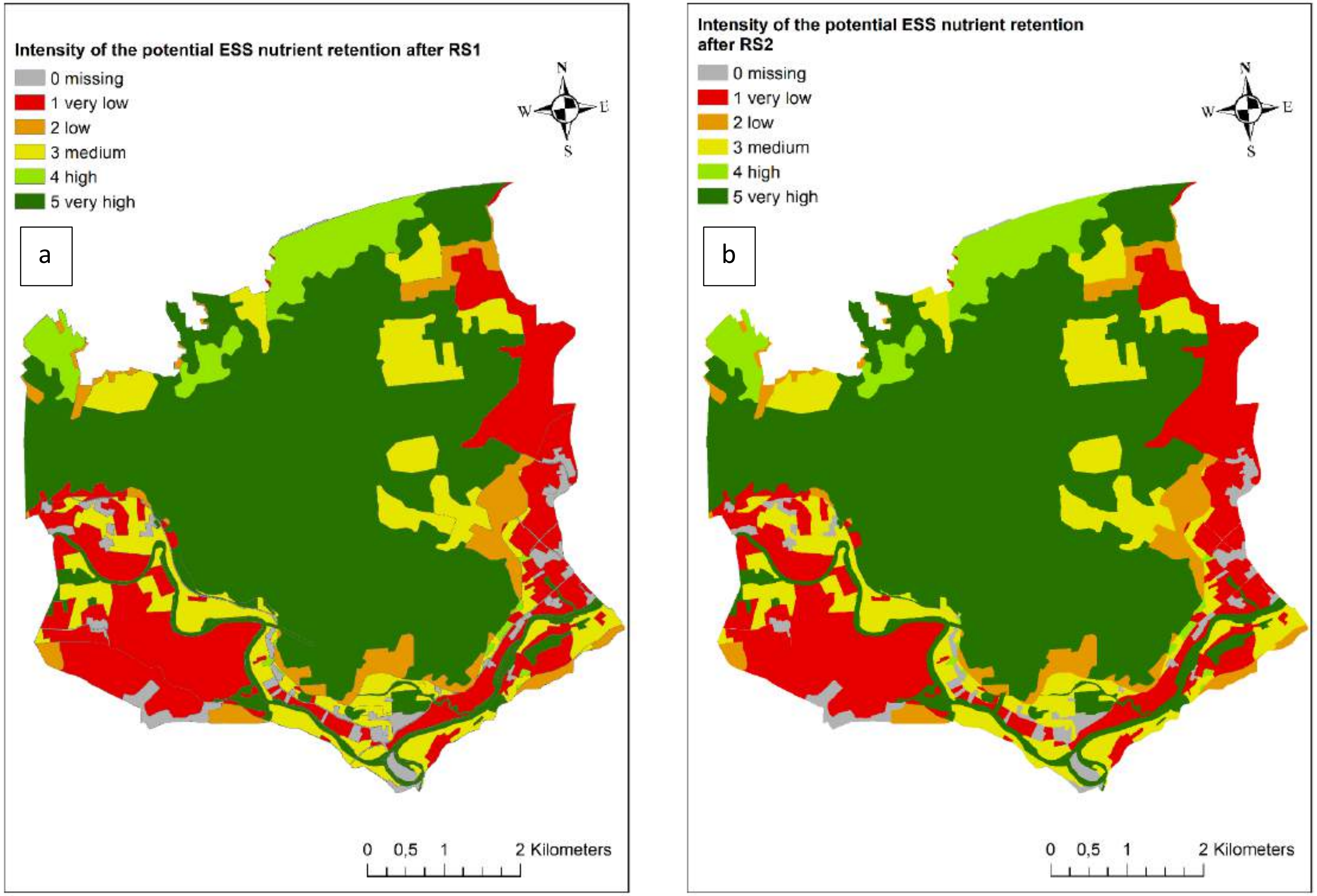


Figure 76: Intensity of the potential regulating ESS nutirent retention a) after restoration scenario RS1 and b) after restoration scenario RS2. The values of the intensity of the potential ESS are marked in different colours.

Most of the pre-selected pilot area Krka has a very high potential to provide habitats for floodplain typical species (figure 77). However, there are also some areas with no potential to provide the ESS provision of habitats. The new flood corridor in restoration scenario RS1 and the same one in RS2 increases the intensity of the potential ESS provision of habitats (figure 78).

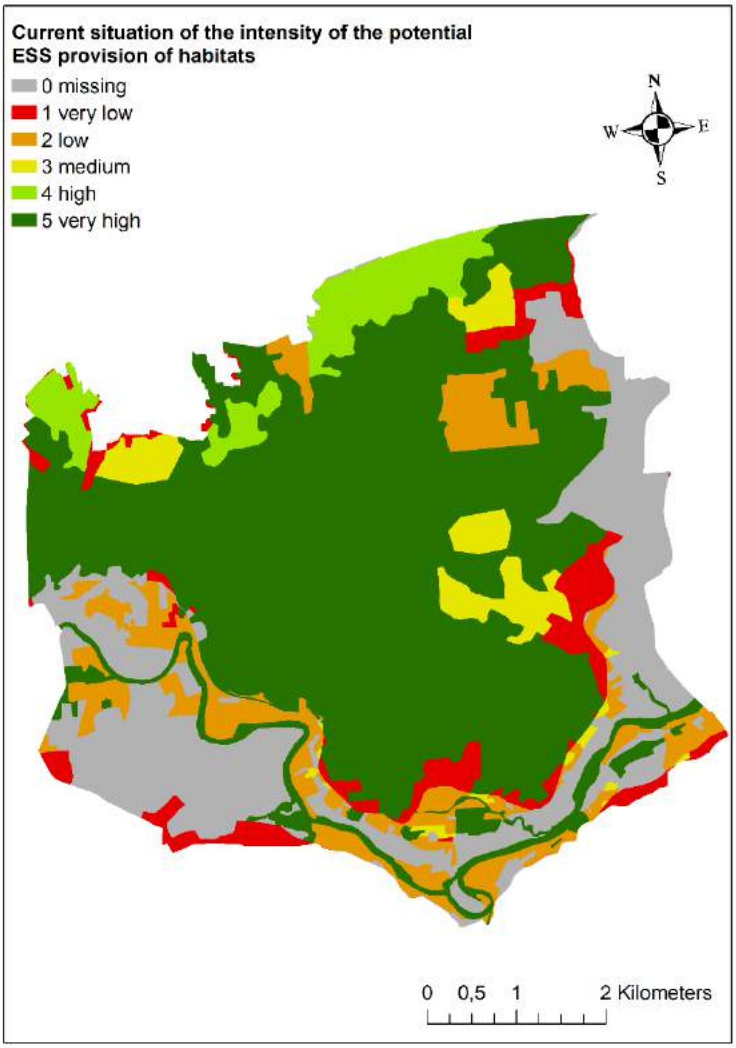
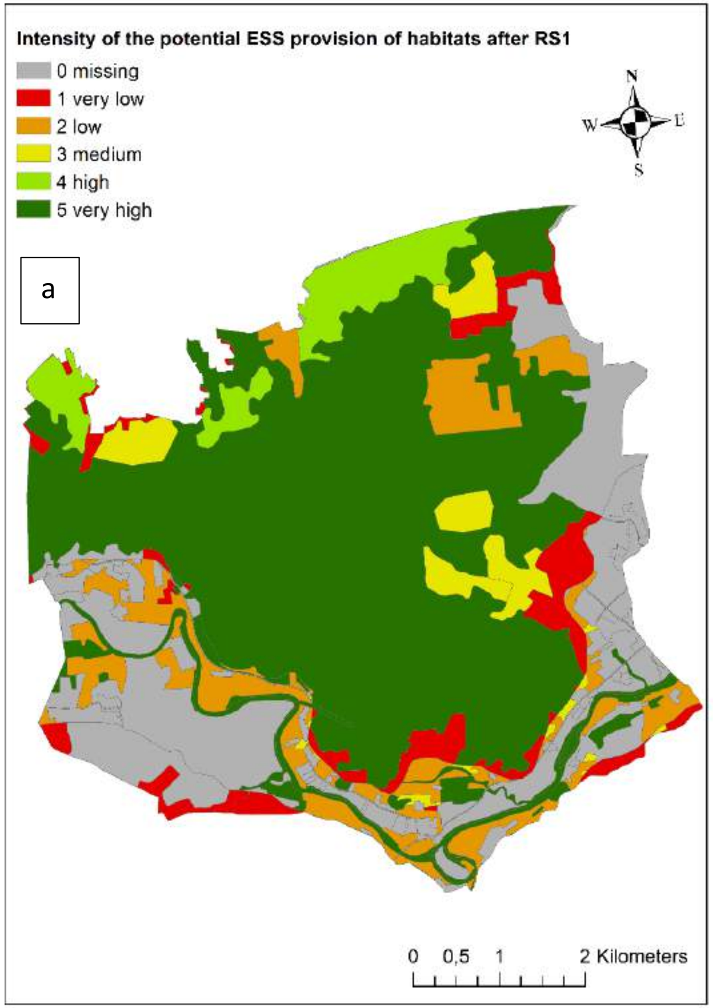


Figure 77: Intensity of the potential regulating ESS provision of habitats in the current situation. The values of the intensity of the potential ESS are marked in different colours.



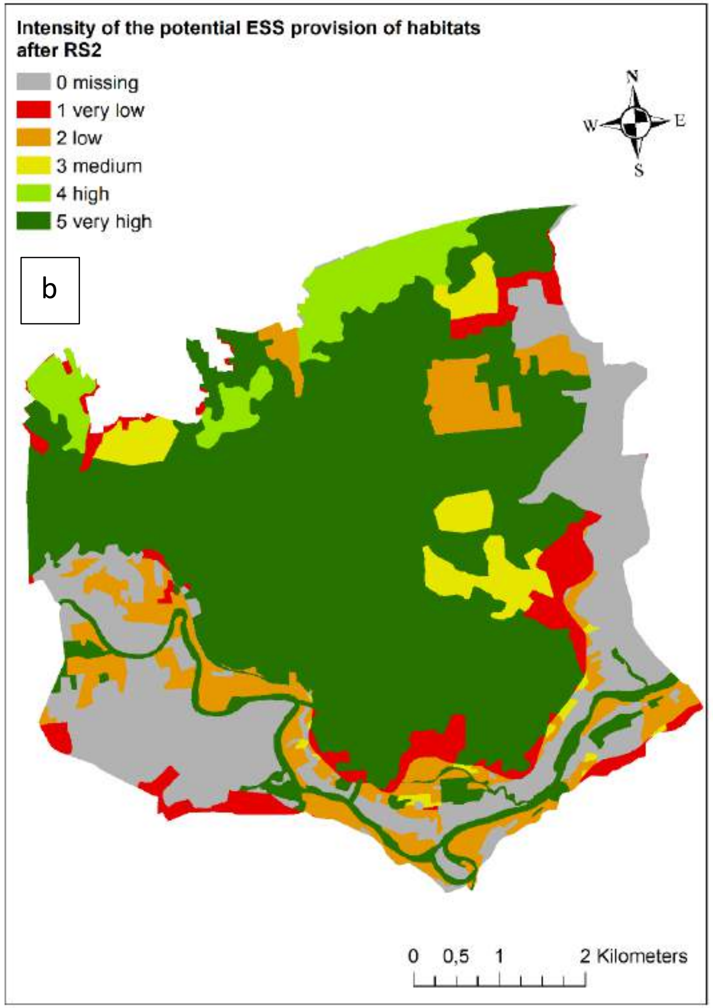


Figure 78: Intensity of the potential regulating ESS provision of habitats a) after restoration scenario RS1 and b) after restoration scenario RS2. The values of the intensity of the potential ESS are marked in different colours.

Joint consideration of all potential provisioning ESS and all potential regulating ESS

The intensity of all provided potential provisioning ESS is mainly low (figure 79). Only grassland areas provide all potential ESS at a medium level. The intensity of all provided provisioning ESS decreases with creating flood corridors from low to very low (figures 80a and b).

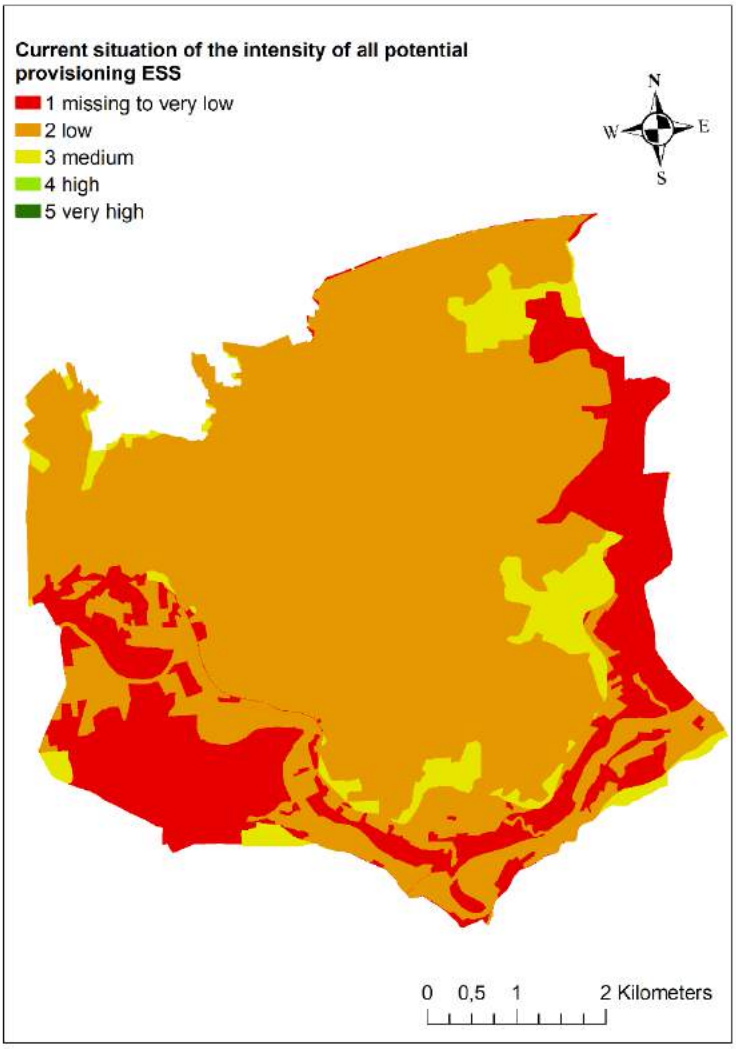


Figure 79: Intensity of all potential provisioning ESS in the current situation. The values of the intensity of the potential ESS are marked in different colours.

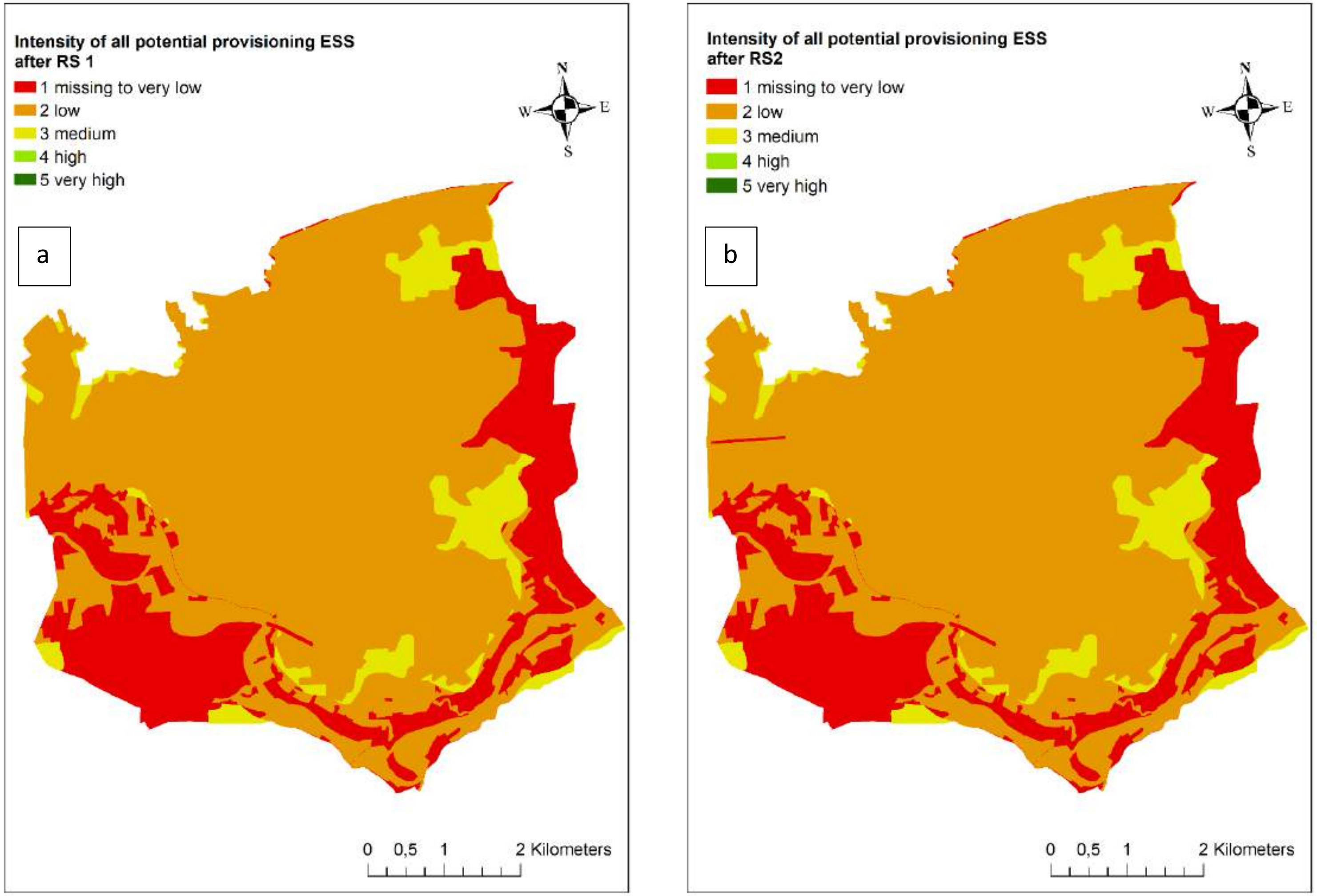


Figure 80: Intensity of all potential provisioning ESS a) after restoration scenario RS1 and b) after restoration scenario RS2. The values of the intensity of the potential ESS are marked in different colours.

The provision of all potential regulating ESS together is differently distinct in intensity in the pilot area (figure 81). The Krakovski Forest has the highest potential to simultaneously provide many regulating potential ESS at a high level. The intensity of all provided potential regulating ESS jointly considered increases within the newly built flood corridor in restoration scenario RS1 and RS2 (figure 82).

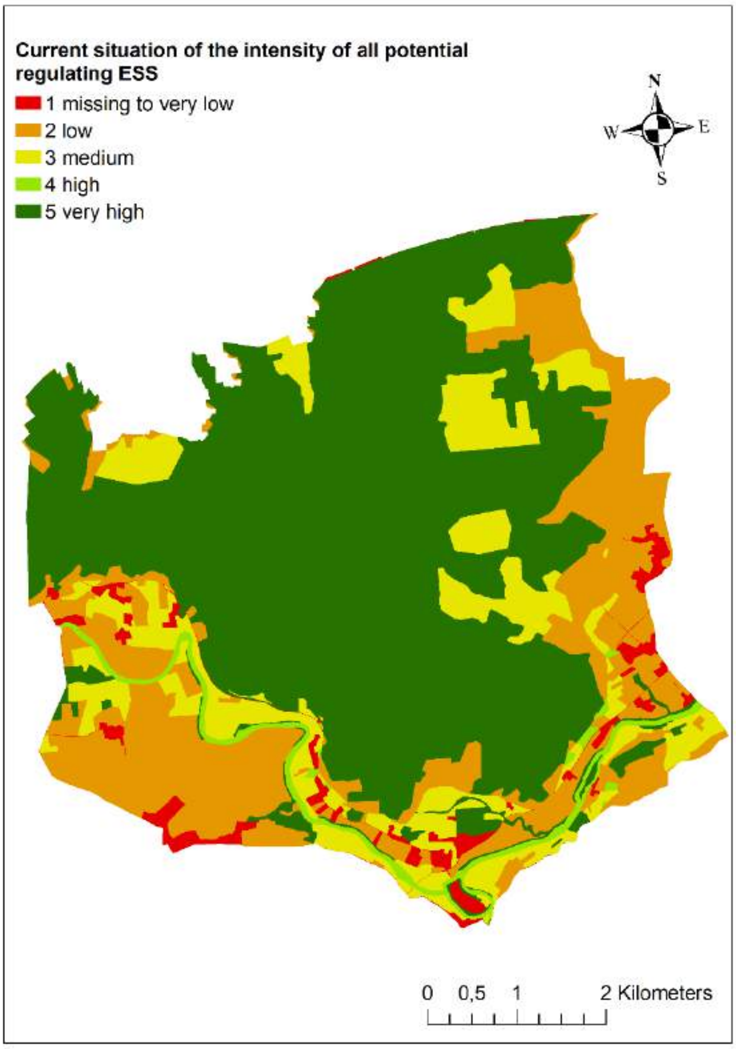


Figure 81: Intensity of all potential regulating ESS in the current situation. The values of the intensity of the potential ESS are marked in different colours.

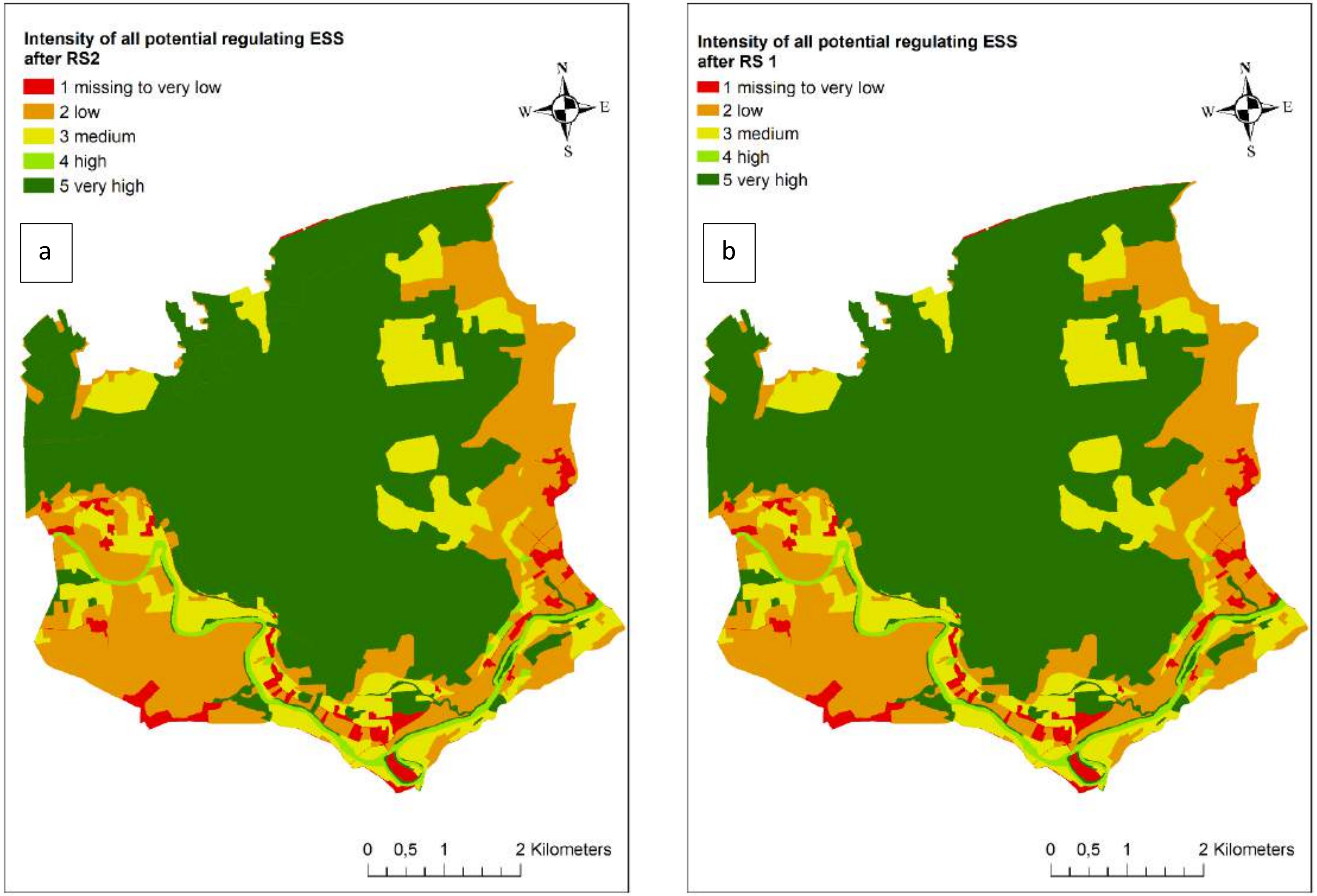


Figure 82: Intensity of all potential regulating ESS a) after restoration scenario RS1 and b) after restoration scenario RS2. The values of the intensity of the potential ESS are marked in different colours.

5.3.4 Middle Tisza

Along both sides of the Middle Tisza river there are large riparian forests between the river and the dike. On the eastern side of the pilot area, there are managed grasslands as well as urban areas consisting of private weekend houses with gardens. The western side is dominated by arable land behind the dike. In addition, there are oxbow lakes separated from the Tisza River and very few agricultural areas.

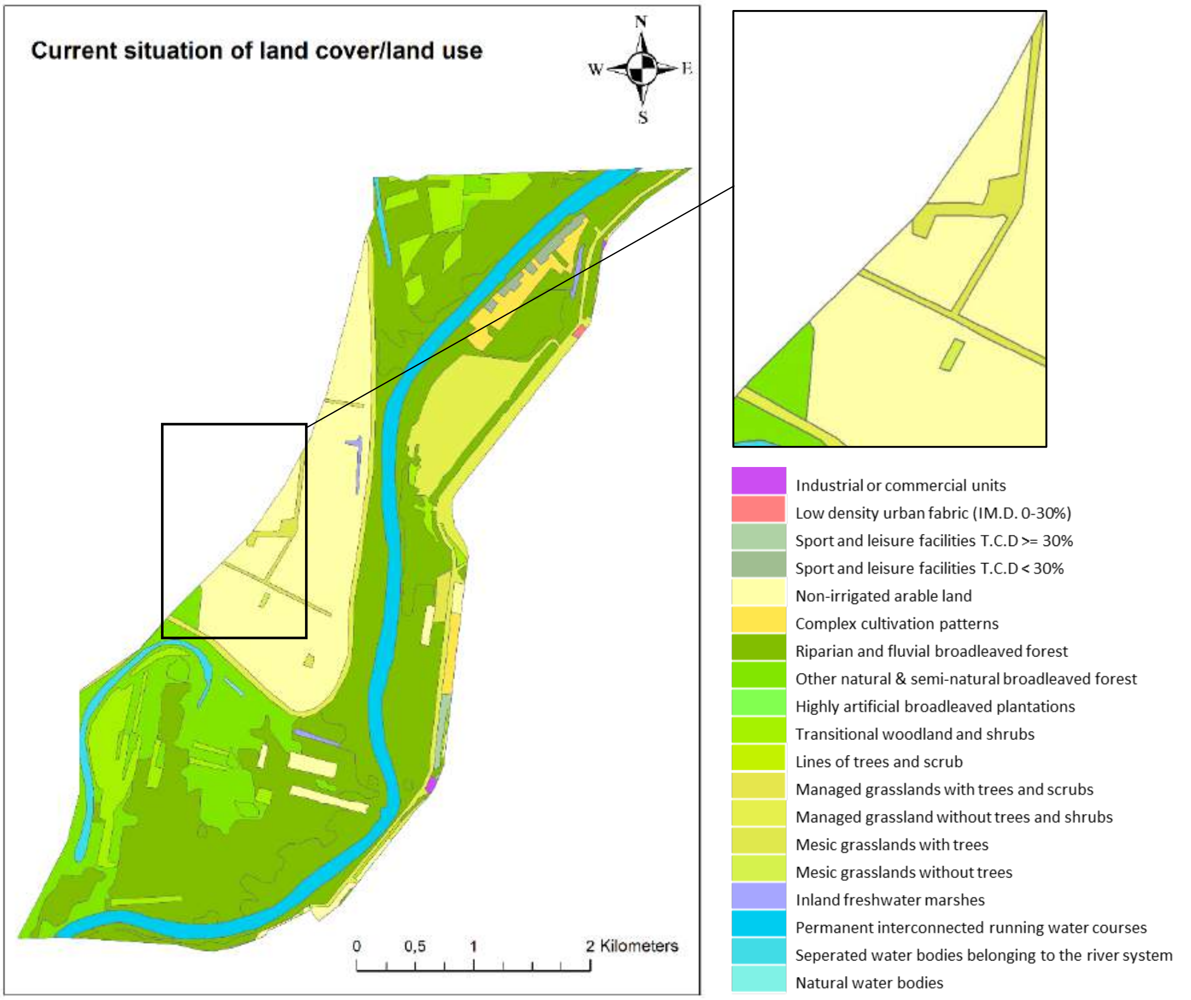


Figure 83: Land cover/land use of the current situation of the pre-selected pilot area Middle Tisza. The black outline covers the area where the measures are planned, this is shown enlarged in the map section on the right.

Dike relocation is planned for both RS1 and RS2 restoration scenarios. In addition, a new fish spawning habitat and several reforestation areas are planned in RS2 (figure 84a and b). Besides, the RS2 restoration scenario plans for the reconnection of the oxbow lake in the southern part during floods. At the time of the assessments, no other land uses were planned within the reclaimed flood retention area.

Figure 84: Land cover/land use of the current situation of the pre-selected pilot area Middle Tisza. The black outlines cover the area where most measures are planned, this is shown enlarged in the map section between both restoration scenario maps.

Potential of the provisioning ESS

The intensity of the ESS *agricultural product* is very high in areas outside the dike and some smaller areas inside the dike (figure 85). On the right side of the Tisza River there are also two larger areas with high intensity of the provision of the ESS *agricultural product*.

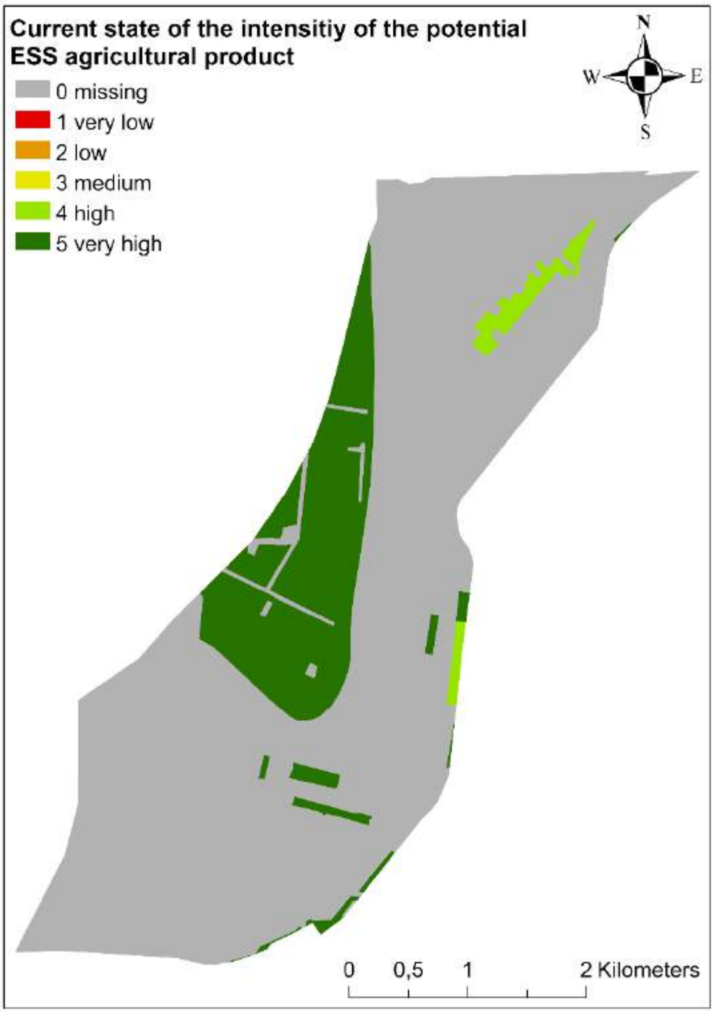


Figure 85: Intensity of the potential provisioning ESS agricultural product in the current situation. The values of the intensity of the potential ESS are marked in different colours.

There will be no changes in the intensity of the provision of the ESS *agricultural product* in restoration scenario RS1 (figure 86a). However, in the RS2 restoration scenario, some arable land will be converted to forest and water areas, so there will be a reduction in the supply of ESS *agricultural product* here (figure 86b).

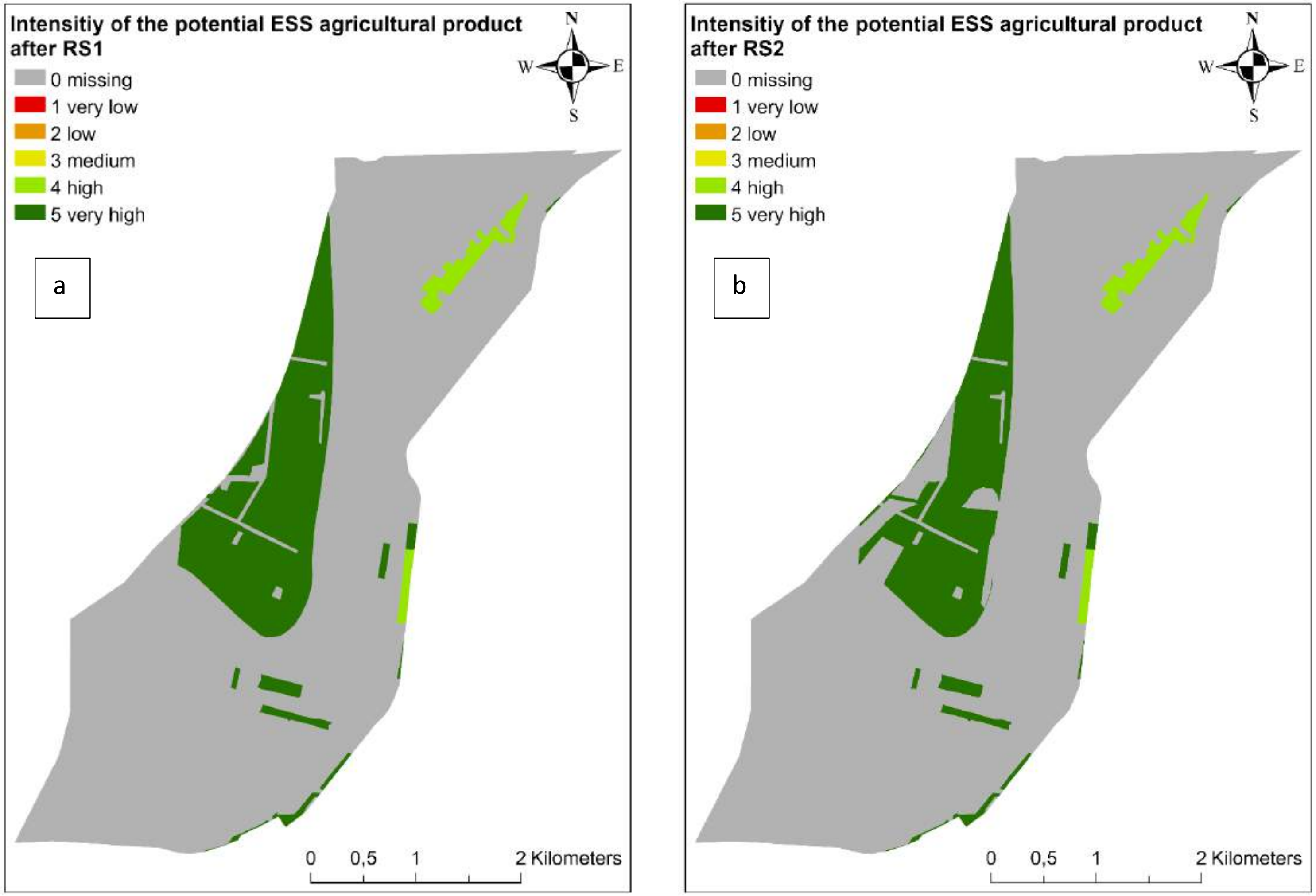


Figure 86: Intensity of the potential provisioning ESS agricultural product a) after restoration scenario RS1 and b) after restoration scenario RS2. The values of the intensity of the potential ESS are marked in different colours.

There is a high capacity for the ESS *wood* in the current state. The intensity of the provision of the ESS *wood* is mainly very high and high, but there are also some regions with a low or very low intensity outside the dike and in the eastern part of the area (figure 87).

Figure 87: Intensity of the potential provisioning ESS wood in the current situation. The values of the intensity of the potential ESS are marked in different colours.

The ESS *wood* will be increased in both restoration scenarios RS1 and RS2 due to reforestations inside the dike (figures 88a and b). However, not all added forest areas will have a very high potential to provide the ESS *wood* in RS2, some will only have a medium potential (figure 88b). In addition, however, in restoration scenario RS2, the intensity of providing the ESS *wood* in the new channel to reconnect the oxbow will slightly decrease, from very high intensity to high intensity.

Figure 88: Intensity of the potential provisioning ESS wood a) after restoration scenario RS1 and b) after restoration scenario RS2. The values of the intensity of the potential ESS are marked in different colours.

In the current state (figure 89), the potential for providing the ESS *animal product* is mainly at a low level in the pilot area (figure 89). There are only a few areas with grassland, mostly grassland with trees. Larger areas with a very high intensity of ESS *animal product* are just outside the areas of restoration measures, so they will hardly be affected by the restoration scenarios (figures 90a and b). Both restoration scenarios RS1 and RS2 have no significant impact on the provision of the ESS *animal product* (figure 90b).

Figure 89: Intensity of the potential provisioning ESS animal product in the current situation. The values of the intensity of the potential ESS are marked in different colours.

Figure 90: Intensity of the potential provisioning ESS animal product a) after restoration scenario RS1 and b) after restoration scenario RS2. The values of the intensity of the potential ESS are marked in different colours.

The intensity to supply the ESS *game meat* is mainly very high due to large forest areas, except in the area behind the dike. Here, the intensity is generally very low (figure 91).

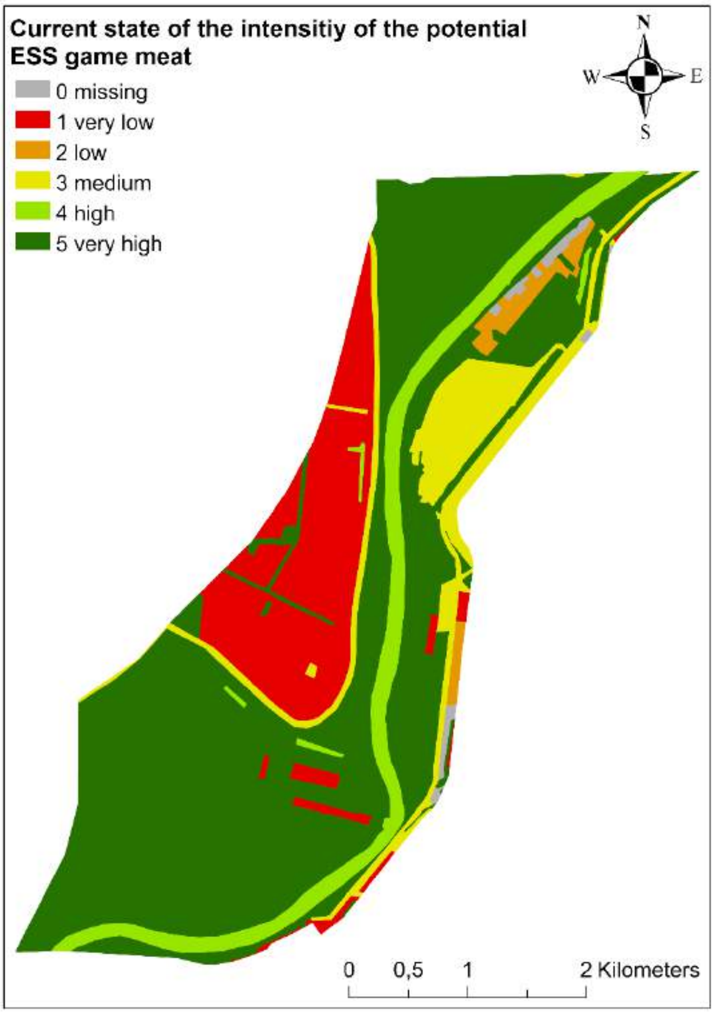


Figure 11: Intensity of the potential provisioning ESS game meat in the current situation. The values of the intensity of the potential ESS are marked in different colours.

The supply of ESS *game meat* will increase depending on the size and type of newly afforested areas in the reforestation scenarios (Figure 91a and b). As there are more new forested areas after the implementation of RS2, the supply of ESS *game meat* will also increase more here. These areas will increase their intensity of the provision of the ESS *game meat* from very low to high or very high depending on the forest type.

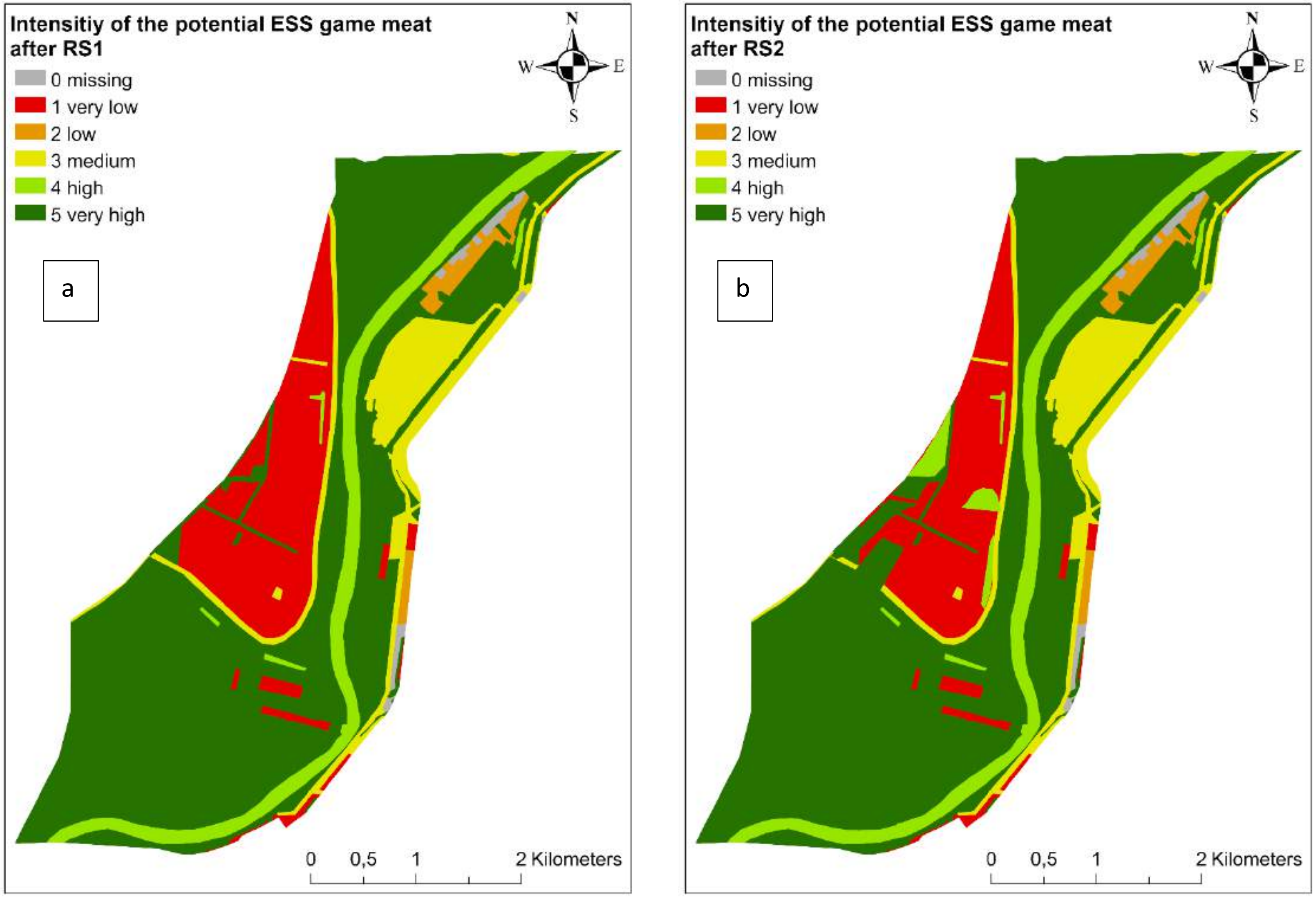


Figure 92: Intensity of the potential provisioning ESS game meat a) after restoration scenario RS1 and b) after restoration scenario RS2. The values of the intensity of the potential ESS are marked in different colours.

In the current state, the potential of providing ESS *honey* is high in most parts of the pilot area (figure 93). However, behind the dike there are only a few stretches with a very high intensity of ESS honey, the main part does not provide ESS *honey*.

Figure 93: Intensity of the potential provisioning ESS honey in the current situation. The values of the intensity of the potential ESS are marked in different colours.

The new reforestation areas will lead to an increase in the supply of the ESS *honey* to a high level in the restoration scenario RS1 (figure 94a). In contrast, the intensity of the provision of the ESS *honey* in the additional reforestation areas of RS2 will only slightly increase from missing to low due to the planned land use type 'highly artificial broadleaved plantations' (figure 94b).

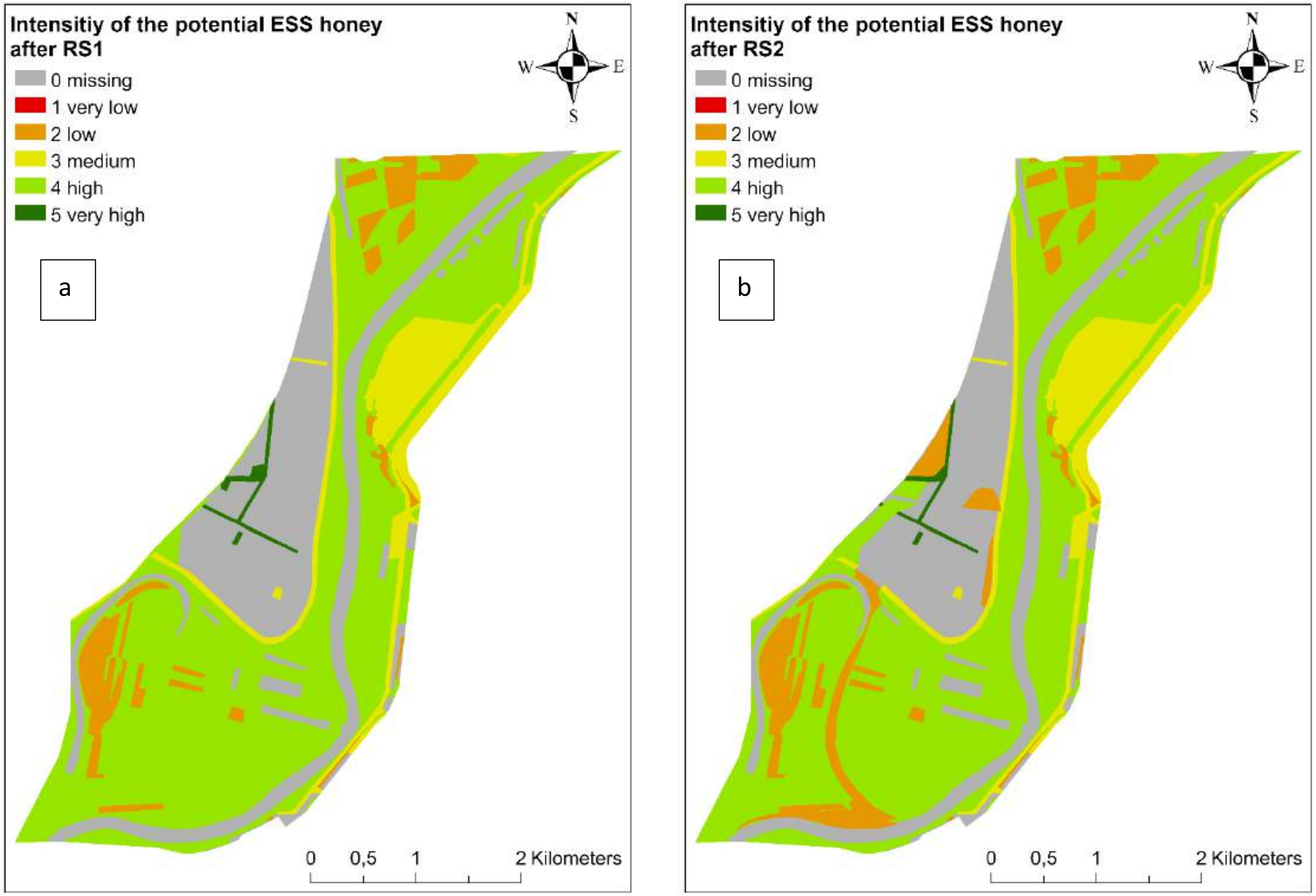


Figure 94: Intensity of the potential provisioning ESS honey a) after restoration scenario RS1 and b) after restoration scenario RS2. The values of the intensity of the potential ESS are marked in different colours.

The capacity of the pilot area to provide ESS *water* varies from low to very high in the current state (figure 95). The highest value is reached in the oxbow lakes.

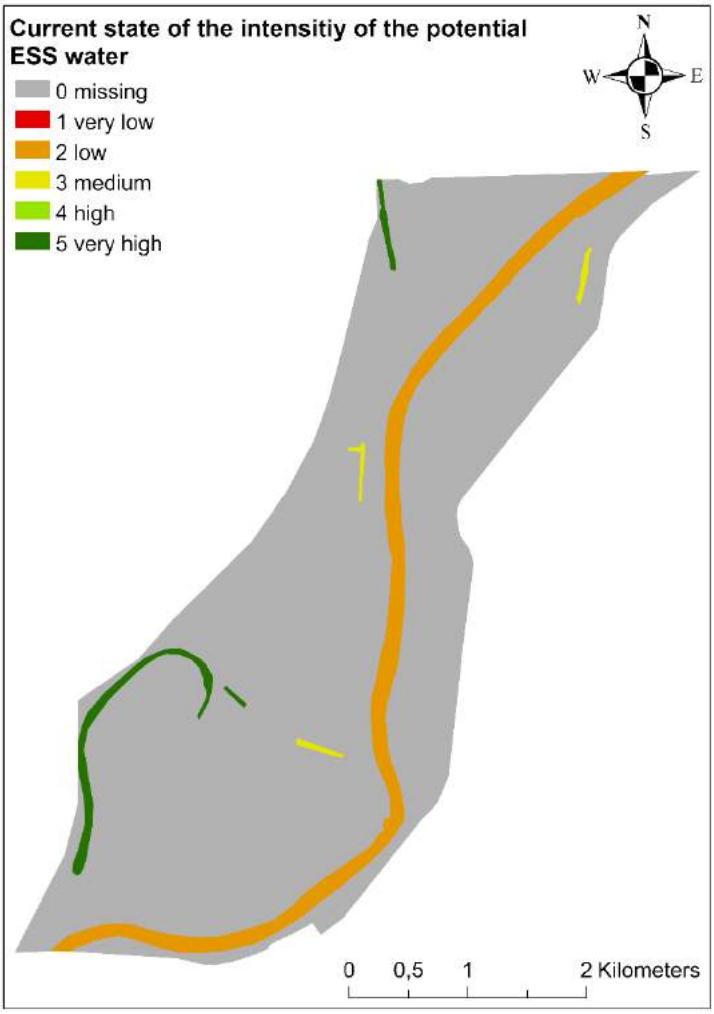


Figure 95: Intensity of the potential provisioning ESS water in the current situation. The values of the intensity of the potential ESS are marked in different colours.

The intensity of providing the ESS *water* will not be influenced by the measures of restoration scenario RS1, but by the newly planned lake of restoration scenario RS2 (figures 96a and b). The intensity of the lake to provide the ESS *water* will be very high.

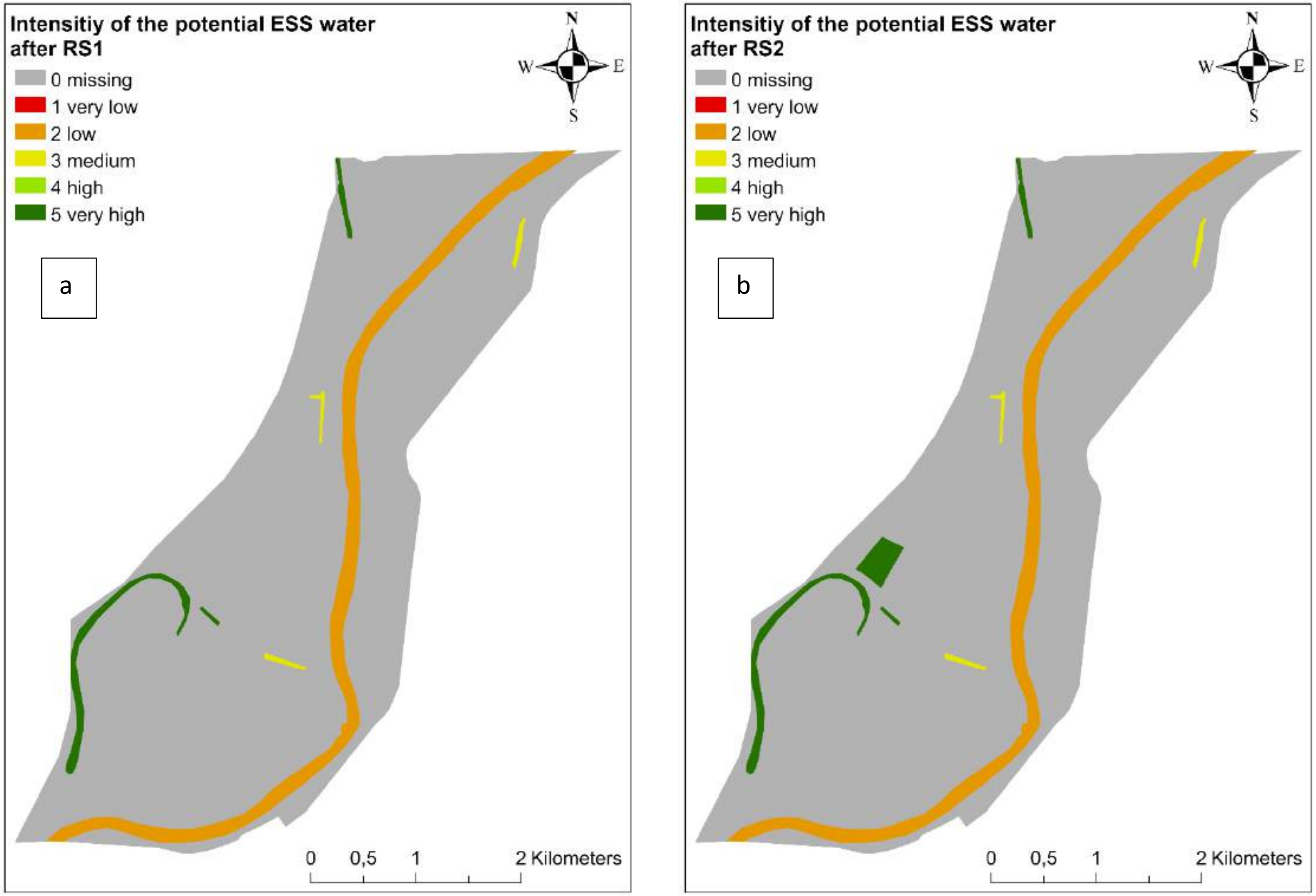


Figure 96: Intensity of the potential provisioning ESS water a) after restoration scenario RS1 and b) after restoration scenario RS2. The values of the intensity of the potential ESS are marked in different colours.

Potential of the regulating ESS

The potential to provide the ESS *air purification* has a very high intensity in the forest areas in the current state (figure 97). However, outside the dike the land cover/land use types generally do not have the potential to provide the ESS *air purification*, only some small stretches have very low or low provisioning intensity.

Figure 97: Intensity of the potential regulating ESS air purification in the current situation. The values of the intensity of the potential ESS are marked in different colours.

The potential to provide the ESS *air purification* is increased by the new reforestation areas behind the dike in both restoration scenarios RS1 and RS2 (figure 98a and b). Behind the dike, the effectiveness of RS2 is higher than of RS1 due to the larger reforestation areas in restoration scenario RS2 (figure 98b). But, the forest composition determines the intensity of the provided ESS *air purification*. Natural forests such as ‘riparian and fluvial broadleaved forests’ have a very high intensity, whereas ‘highly artificial broadleaved plantations’ have only a medium intensity. However, there is also a decrease in the intensity of the ESS *air purification* outside the dike due to the planned reconnection channel in RS2.

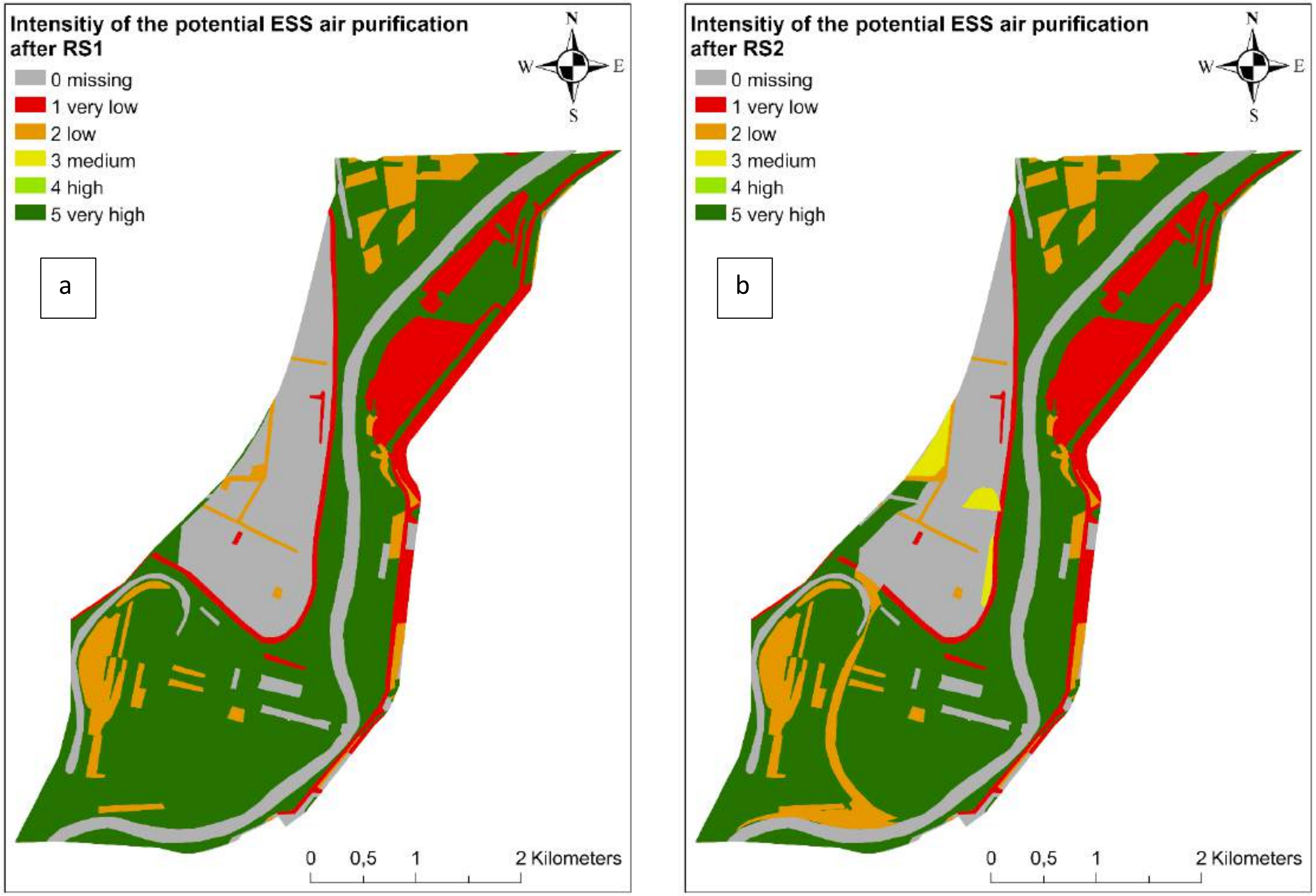


Figure 98: Intensity of the potential provisioning ESS air purification a) after restoration scenario RS1 and b) after restoration scenario RS2. The values of the intensity of the potential ESS are marked in different colours.

The ability to provide the ESS *local climate regulation* within the pilot area is high to very high in the forest areas and water bodies in the current state (figure 99). In contrast, grasslands provide only a medium provision of the ESS *local climate regulation,* and on agricultural land, commonly behind the dike, it is very low.

Figure 99: Intensity of the potential regulating ESS local climate regulation in the current situation. The values of the intensity of the potential ESS are marked in different colours.

With dike relocation and reforestation, the provision of ESS *local climate regulation* will increase in the newly forested areas in restoration scenarios RS1 and RS2 (Figure 100a and b). In restoration scenario RS2, the newly created water area will also increase the intensity of the provided ESS *local climate regulation*, while the new channel from the Middle Tisza to the new lake will provide a lower intensity of this ESS than in the current situation, at least at times when there is no water in the channel. Thus, the intensity will slightly decrease from a very high level to a high level.

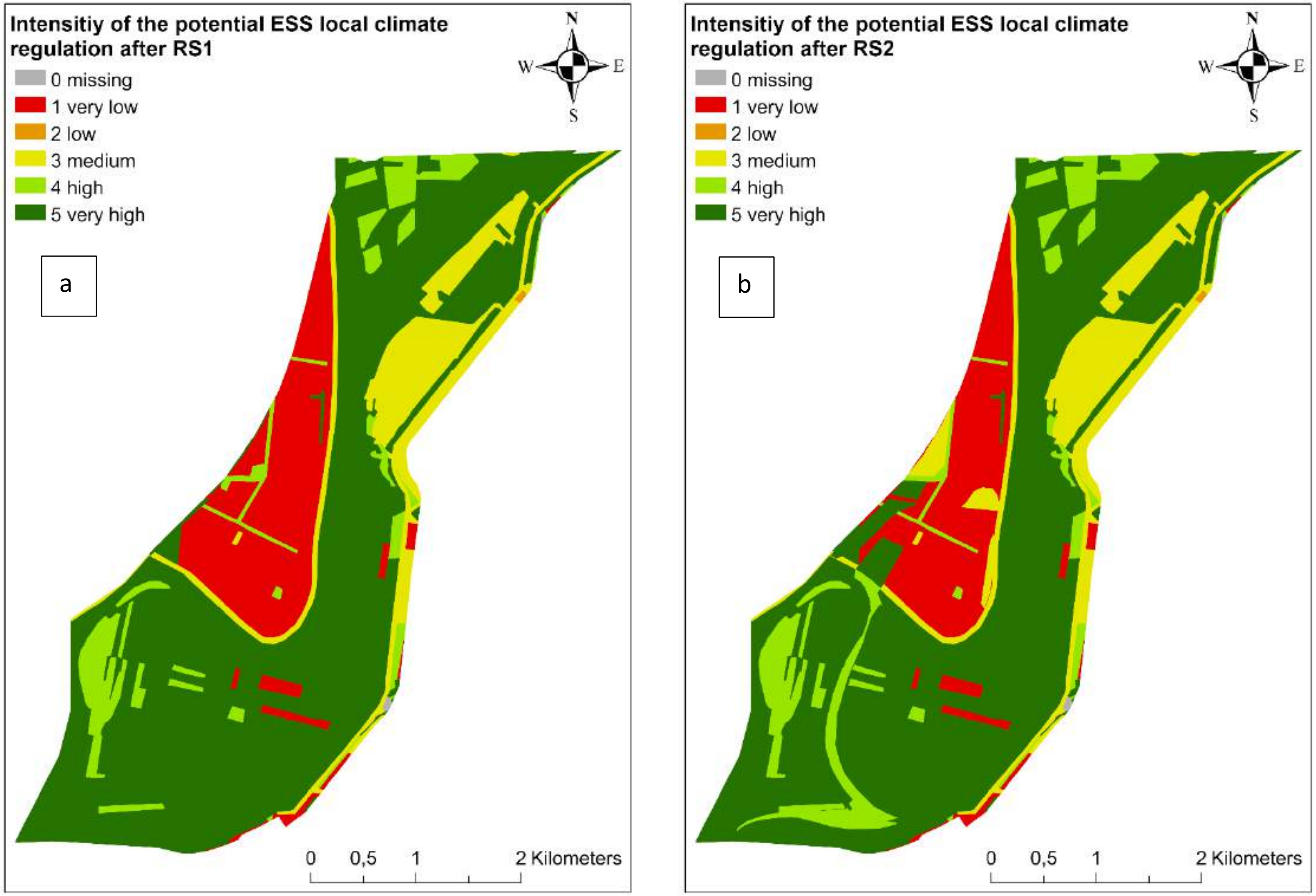


Figure 100: Intensity of the potential provisioning ESS local climate regulation a) after restoration scenario RS1 and b) after restoration scenario RS2. The values of the intensity of the potential ESS are marked in different colours.

The intensity of the ESS *low water regulation* is, in contrast to all other regulating ESS, at the highest level (value of 5) in agriculturally used areas (figure 101). Besides the agricultural areas, the Middle Tisza has a high potential to provide this ESS. Forest areas only have very low potential to provide the ESS *low water regulation* and grassland areas have medium potential.

Figure 101: Intensity of the potential regulating ESS low water regulation in the current situation. The values of the intensity of the potential ESS are marked in different colours.

The afforestation areas will decrease the intensity of the provided ESS *low water regulation* from very high to very low in both restoration scenarios RS1 and RS2 (figure 102a and b). The new grassland area from restoration scenario RS2 will decrease the intensity from very high to medium. Also, the new lake, planned in restoration scenario RS2, will decrease the intensity from very high to low. But the new channel will slightly increase the provided ESS *low water regulation* from very low intensity to low intensity.

Figure 102: Intensity of the potential provisioning ESS low water regulation a) after restoration scenario RS1 and b) after restoration scenario RS2. The values of the intensity of the potential ESS are marked in different colours.

The capacity of riparian and broadleaved forest areas to provide the ESS *flood retention* is high and that of water bodies is very high (figure 103). Agricultural land and grassland areas have only a very low intensity of the ESS *flood retention*. The 'complex cultivation patterns', such as those found outside the dike, have a medium intensity of the provided ESS *flood retention*.

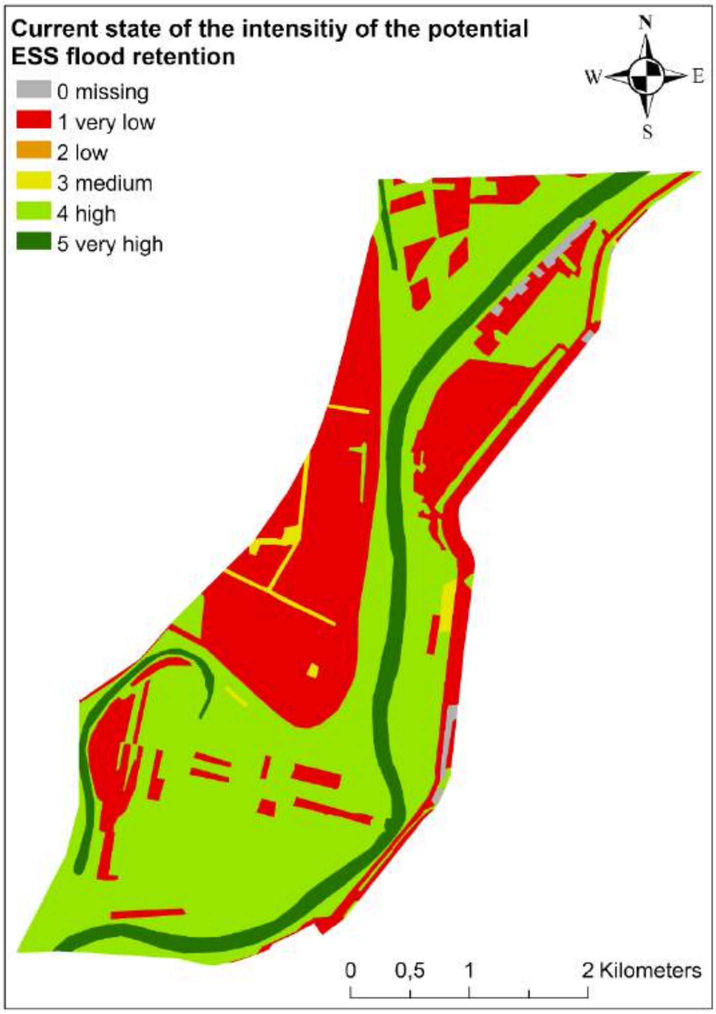
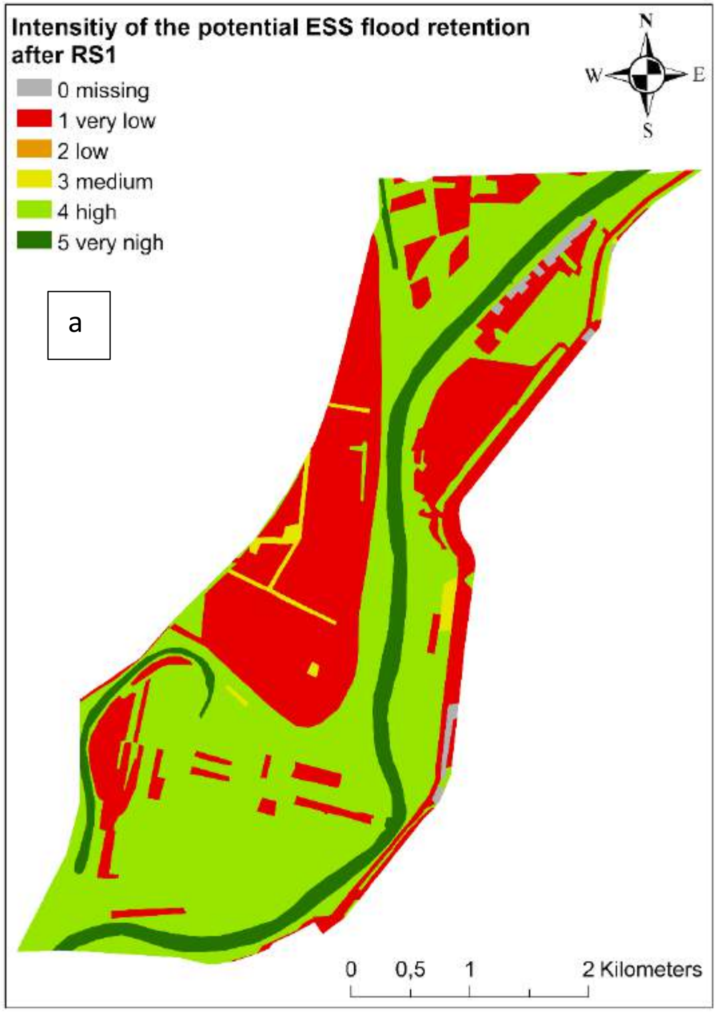


Figure 103: Intensity of the potential regulating ESS flood retention in the current situation. The values of the intensity of the potential ESS are marked in different colours.

The intensity of the ESS *flood retention* will increase with the afforestation areas of both restoration scenarios RS1 and RS and the newly created aquatic habitat and grassland areas in RS2 (figure 104a and b). However, with the reconnection of the floodplain through the proposed channel, the intensity of the ESS *flood retention* in the channel area will almost be lost. Thereafter, the intensity there will be at a very low level due to the land cover change.



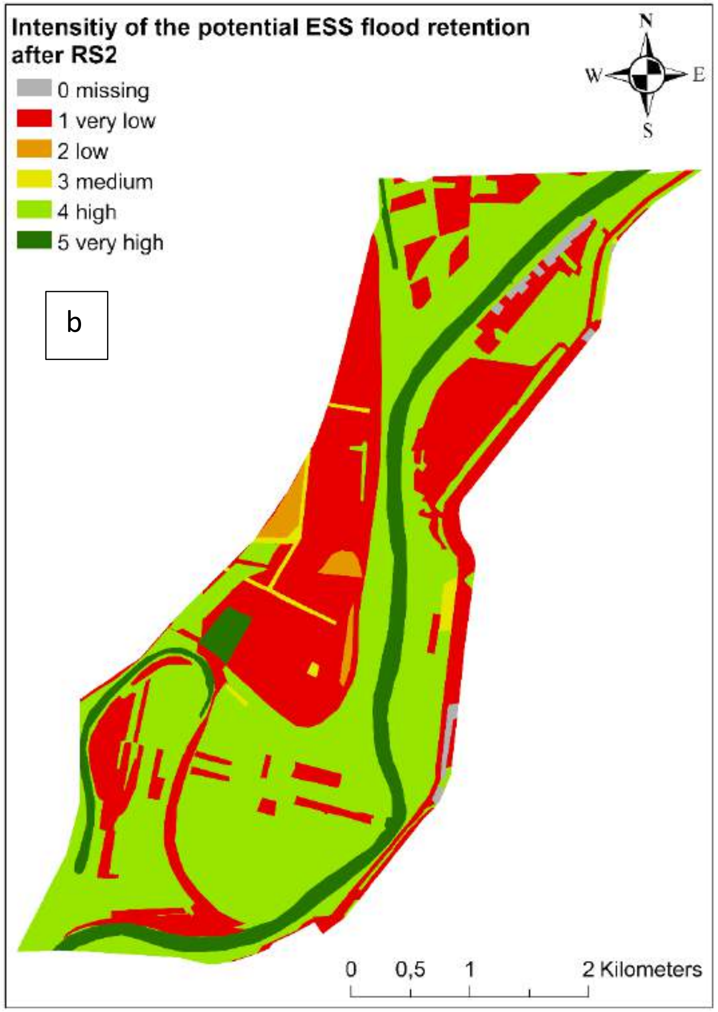


Figure 104: Intensity of the potential provisioning ESS flood retention a) after restoration scenario RS1 and b) after restoration scenario RS2. The values of the intensity of the potential ESS are marked in different colours.

The pilot area has a very high potential to provide the ESS *noise regulation* due to the forest areas in the current state (figure 105). Transitional woodland and shrubs only provide a medium intensity of the ESS *noise regulation*. The ESS *noise regulation* is not provided by agricultural areas and water bodies, on the contrary, wide water bodies can increase noise.

Figure 105: Intensity of the potential regulating ESS noise regulation in the current situation. The values of the intensity of the potential ESS are marked in different colours.

The afforestation of the RS1 and RS2 restoration scenarios will increase the capacity to provide ESS *noise regulation* from missing to very high provision (106a and b). However, with the creation of the reconnected channel in the RS2 restoration scenario, the intensity of ESS *noise regulation* in this former forest section will decrease from a very high to a medium level. The new grassland areas of RS2 in the reconnected floodplain will only raise the ESS *noise regulation* to a low level.

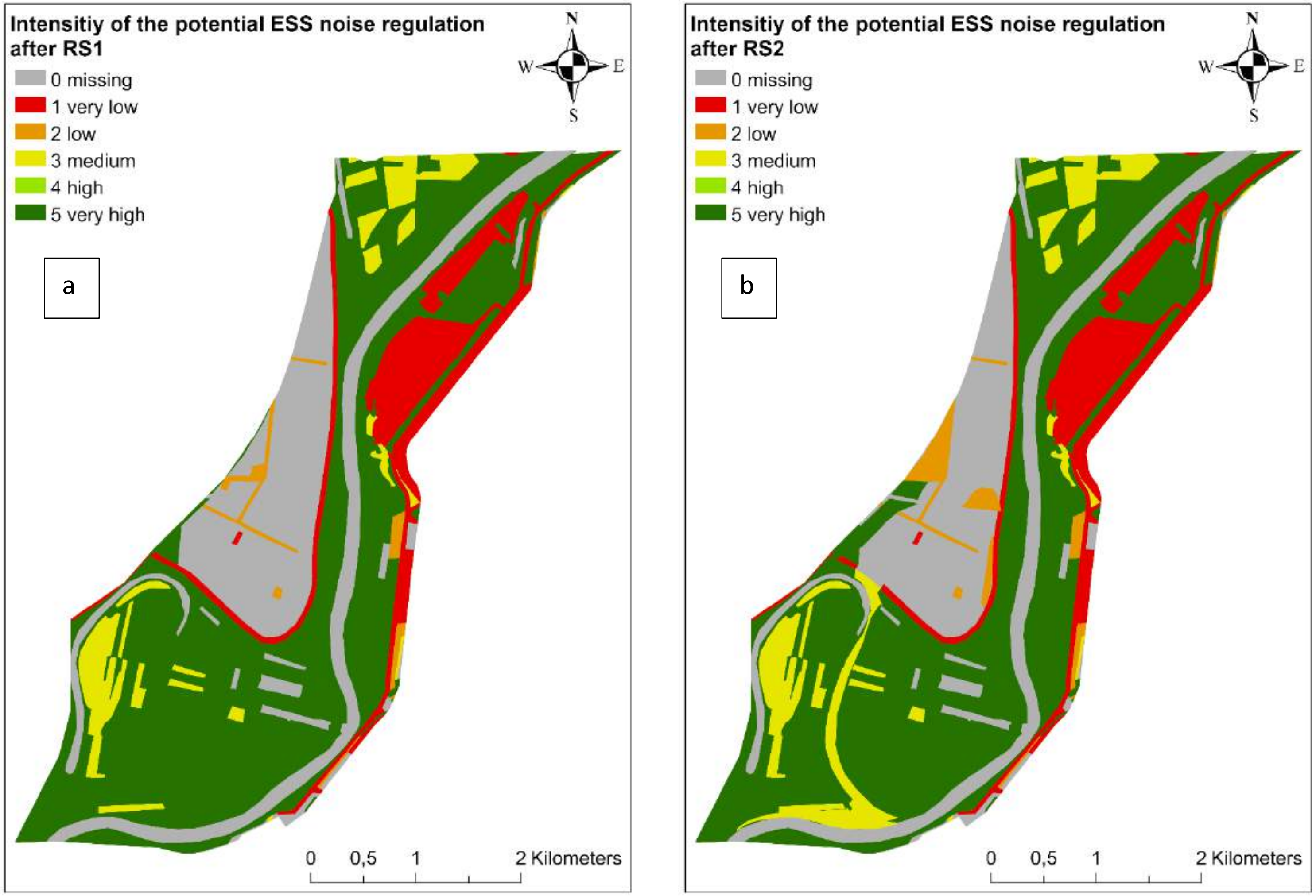


Figure 106: Intensity of the potential provisioning ESS noise regulation a) after restoration scenario RS1 and b) after restoration scenario RS2. The values of the intensity of the potential ESS are marked in different colours.

The intensity of the ESS *nutrient retention* in the floodplain is mainly very high, especially in the near-natural forest areas, but there are also some bigger parts of medium or high intensity in the pilot areas (figure 107). Outside the dike the situation is completely different, the intensity here is generally at a very low level.

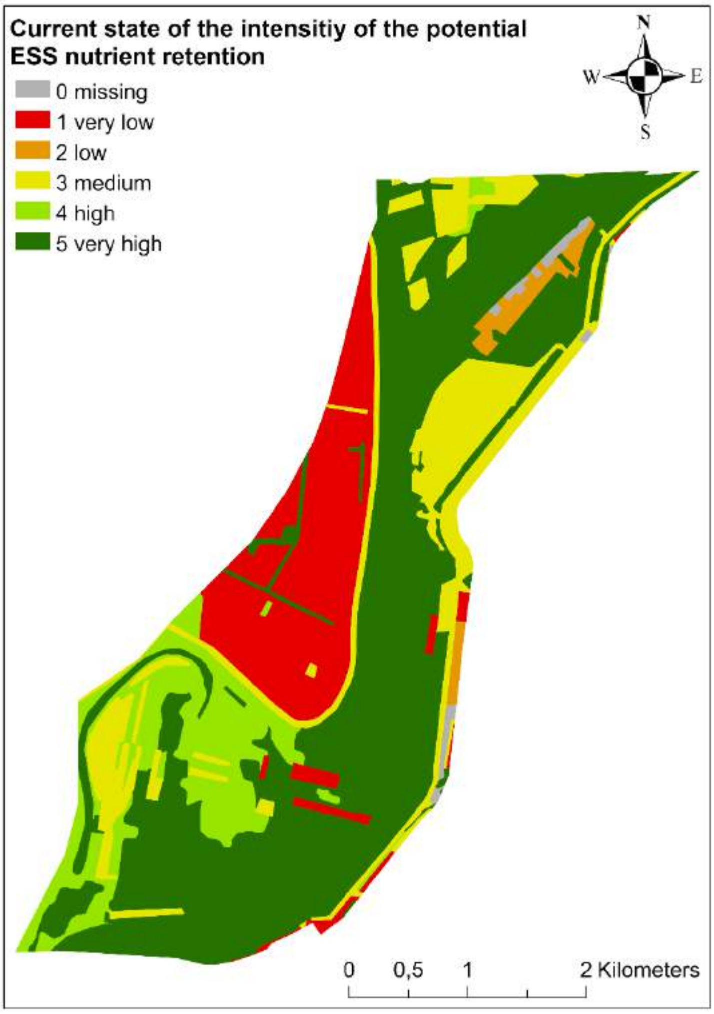
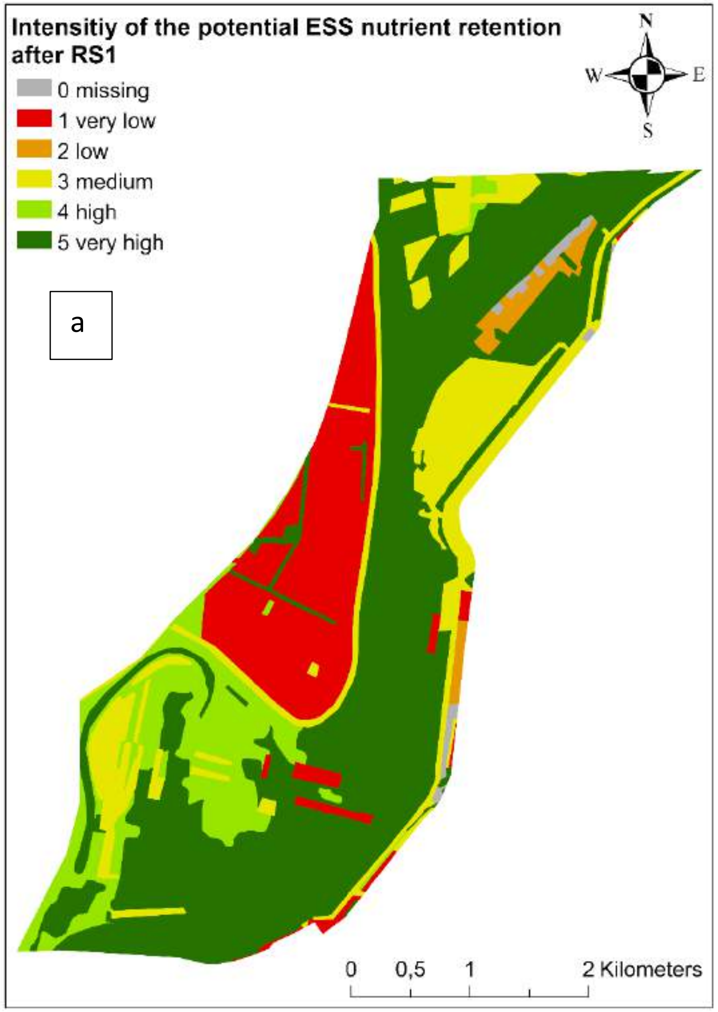


Figure 107: Intensity of the potential regulating ESS nutrient retention in the current situation. The values of the intensity of the potential ESS are marked in different colours.

The ability to provide the ESS *nutrient retention* will be enhanced by the reconnection of the former floodplain if a land use change such as afforestation of arable land or conversion to a water body occurs simultaneously (figure 108 a and b). In contrast, a land use change from cropland to grassland will have a smaller effect, the intensity will increase from very low to a low level. The new flood channel will reduce the previous ability to provide the ESS *nutrient retention* at a very high intensity to a medium intensity.



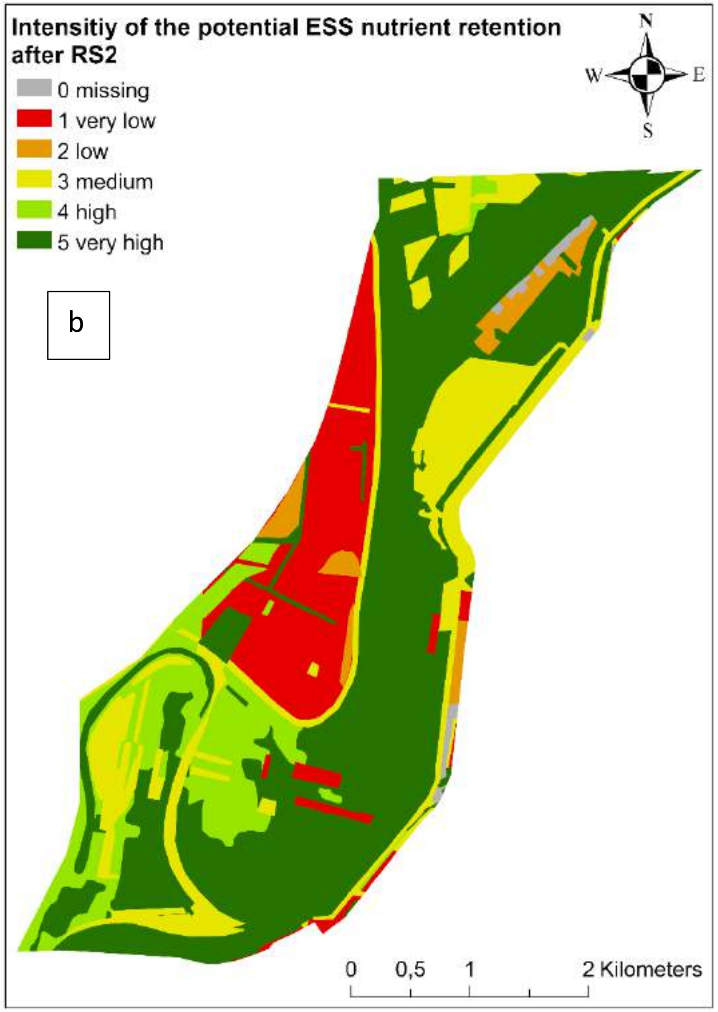


Figure 108: Intensity of the potential provisioning ESS nutrient retention a) after restoration scenario RS1 and b) after restoration scenario RS2. The values of the intensity of the potential ESS are marked in different colours.

In the current state, the intensity of the provided ESS *provision of habitats* fluctuates between missing and very high (figure 109). The 'riparian and fluvial broadleaved forests' have a very high intensity, whereas arable land does not provides any habitats typical for floodplains.

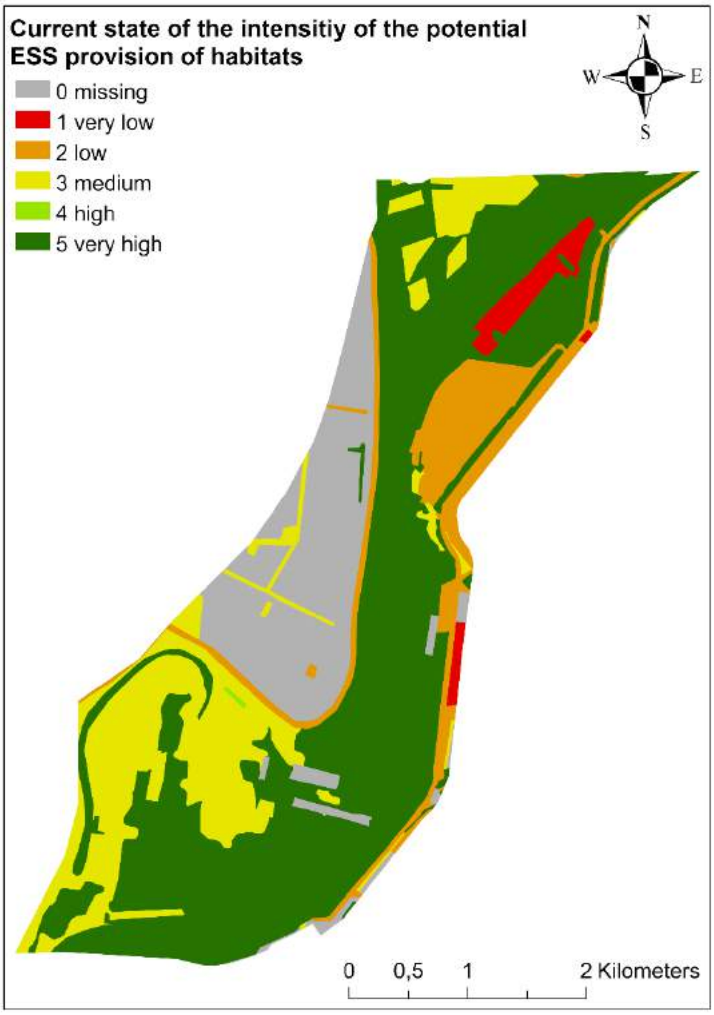


Figure 109: Intensity of the potential regulating ESS provision of habitats in the current situation. The values of the intensity of the potential ESS are marked in different colours.

Due to the restoration scenarios RS1 and RS2, the ability to provide the ESS *provision of habitats* will increase with the new reforestation areas inside the reconnected floodplain from missing to medium intensity (figure 110a and b). The new aquatic water body in RS2 will increase the ability to provide the ESS *provision of habitats to* a very high intensity. In contrary, the intensity to provide the ESS *provision of habitats* will decrease with the building of the new flood channel.

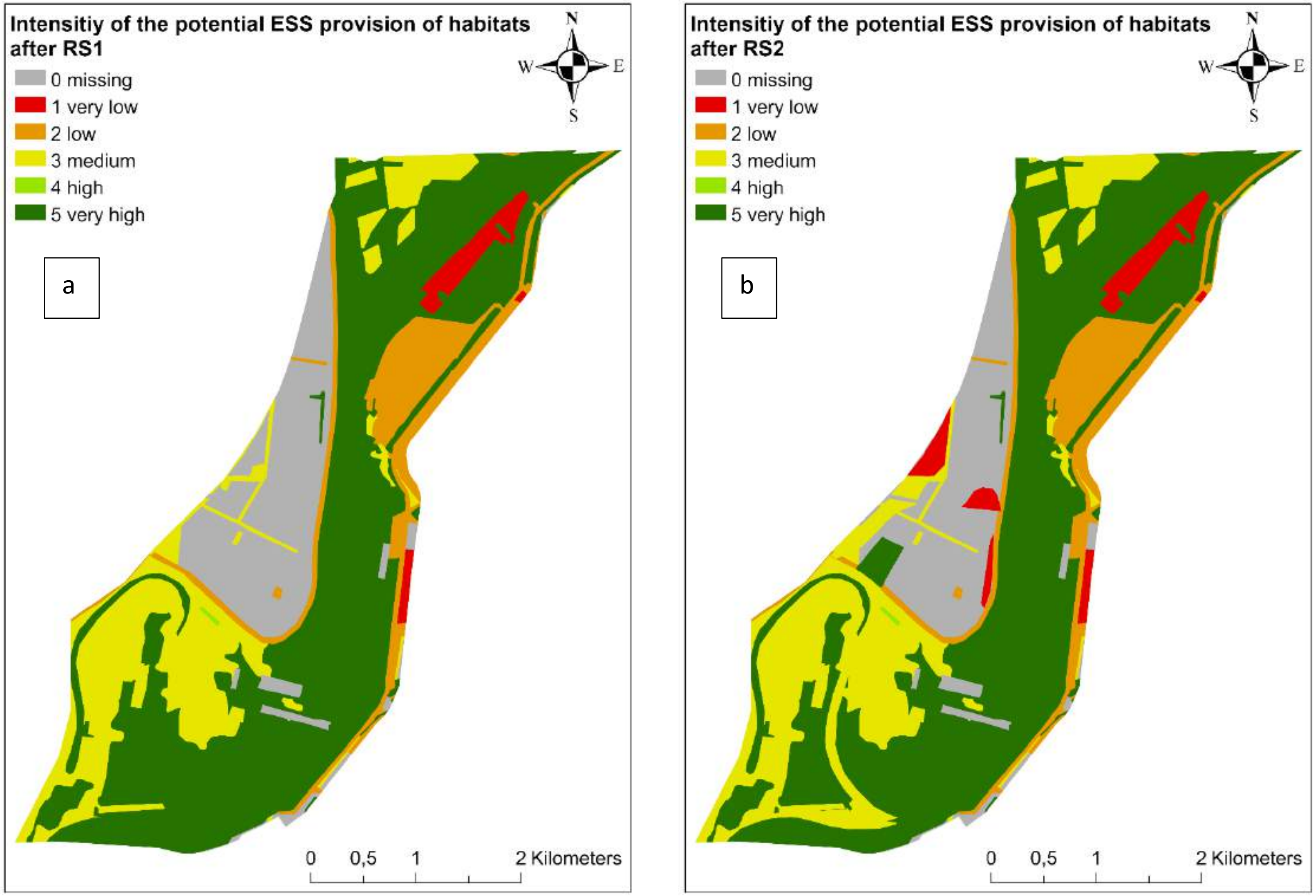


Figure 110: Intensity of the potential provisioning ESS provision of habitats a) after restoration scenario RS1 and b) after restoration scenario RS2. The values of the intensity of the potential ESS are marked in different colours.

The intensity to provide all potential provisioning ESS is generally at a medium level within the diked floodplain area but fluctuates between very low to medium (figure 110). The Tisza River itself supplies provisioning ESS only on a very low intensity as well as most areas outside the dike.

Figure 111: Intensity of all potential provisioning ESS in the current situation. The values of the intensity of the potential ESS are marked in different colours.

The abiltity to provide all potential ESS together will tend to increase in restoration scenario RS2, this due to the new grassland areas and new water body (figure 112a and b) in the reconnected floodplain area. The restoration measure “creation of a channel” has no impact on the intensity of all jointly considered provisioning ESS (figure 112b).

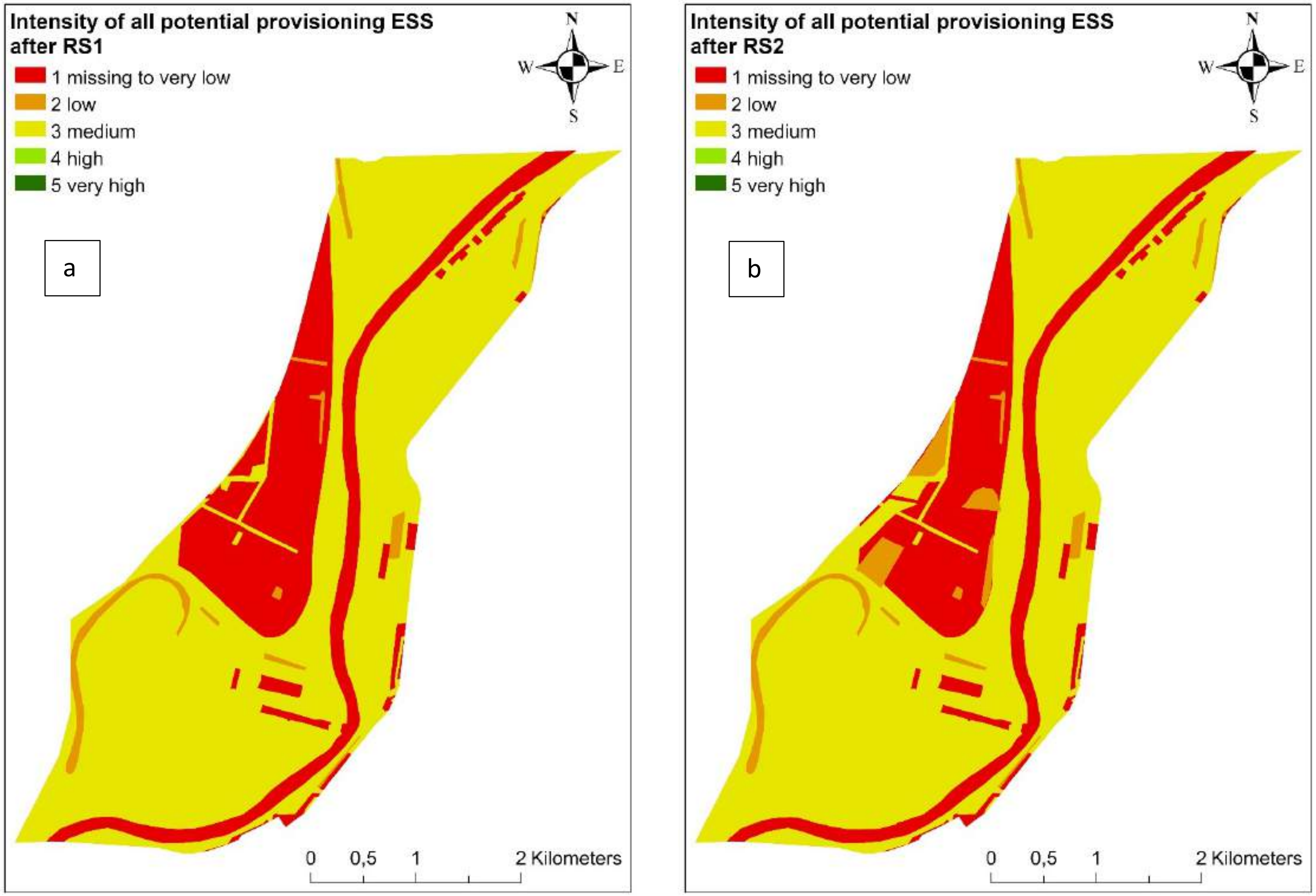


Figure 112: Intensity of all potential provisioning ESS a) after restoration scenario RS1 and b) after restoration scenario RS2. The values of the intensity of the potential ESS are marked in different colours.

In the current situation (figure 113), the intensity of all jointly considered potential regulating ESS varies between low to very high in the floodplain area. Outside the dike, the intensity is mainly at a low level except for the areas of 'complex cultivation patterns'. The intensity to provide all jointly regulating ESS is here at a medium level.

Figure 113: Intensity of all potential regulating ESS in the current scenario. The values of the intensity of the potential ESS are marked in different colours.

The intensity to provide all potential regulating ESS will increase in restoration scenario RS1 due to the reforestation areas (figure 114a) in the reconnected floodplain. In restoration scenario RS2 the ability to provide all regulating ESS will increase more in the reconnected floodplain due to more afforestation areas, new grassland areas and the newly created water body, but the new reconnection channel will decrease the intensity of all jointly considered regulating ESS (figure 114b).

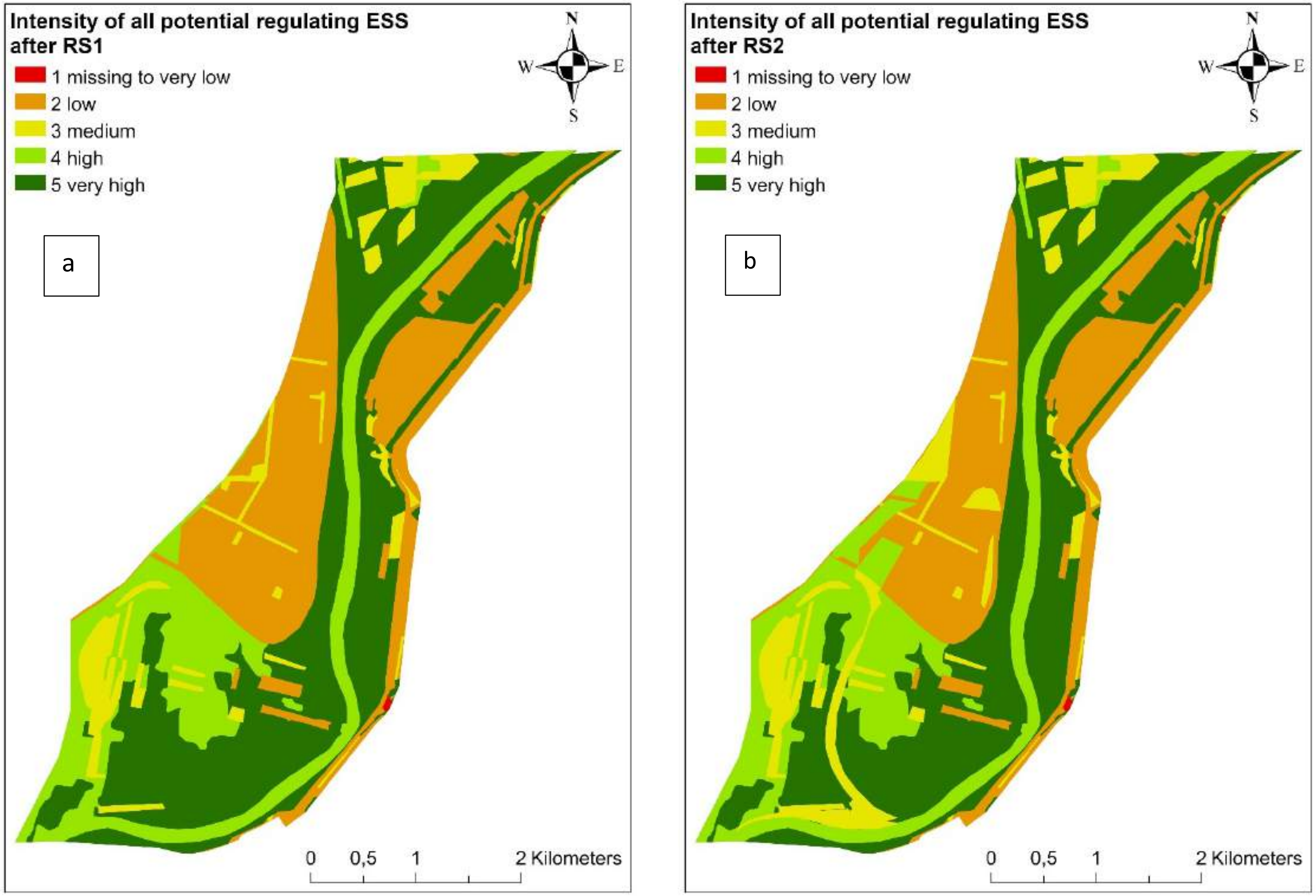


Figure 114: Intensity of all potential regulating ESS a) after restoration scenario RS1 and b) after restoration scenario RS2. The values of the intensity of the potential ESS are marked in different colours.

5.3.5 Morava

The two rivers Thaya and Morava flow through the pilot area. The measures investigated in the Danube Floodplain Project relate exclusively to the Morava river, mainly on the Slovakian side. Several restoration measures have already been carried out on the Thaya river, the border river between Austria and the Czech Republic. The pilot area is characterized by large riparian forests with many lateral river branches and oxbows (figure 115). In the west, arable land borders the riparian forests, settlements are the outer limit.

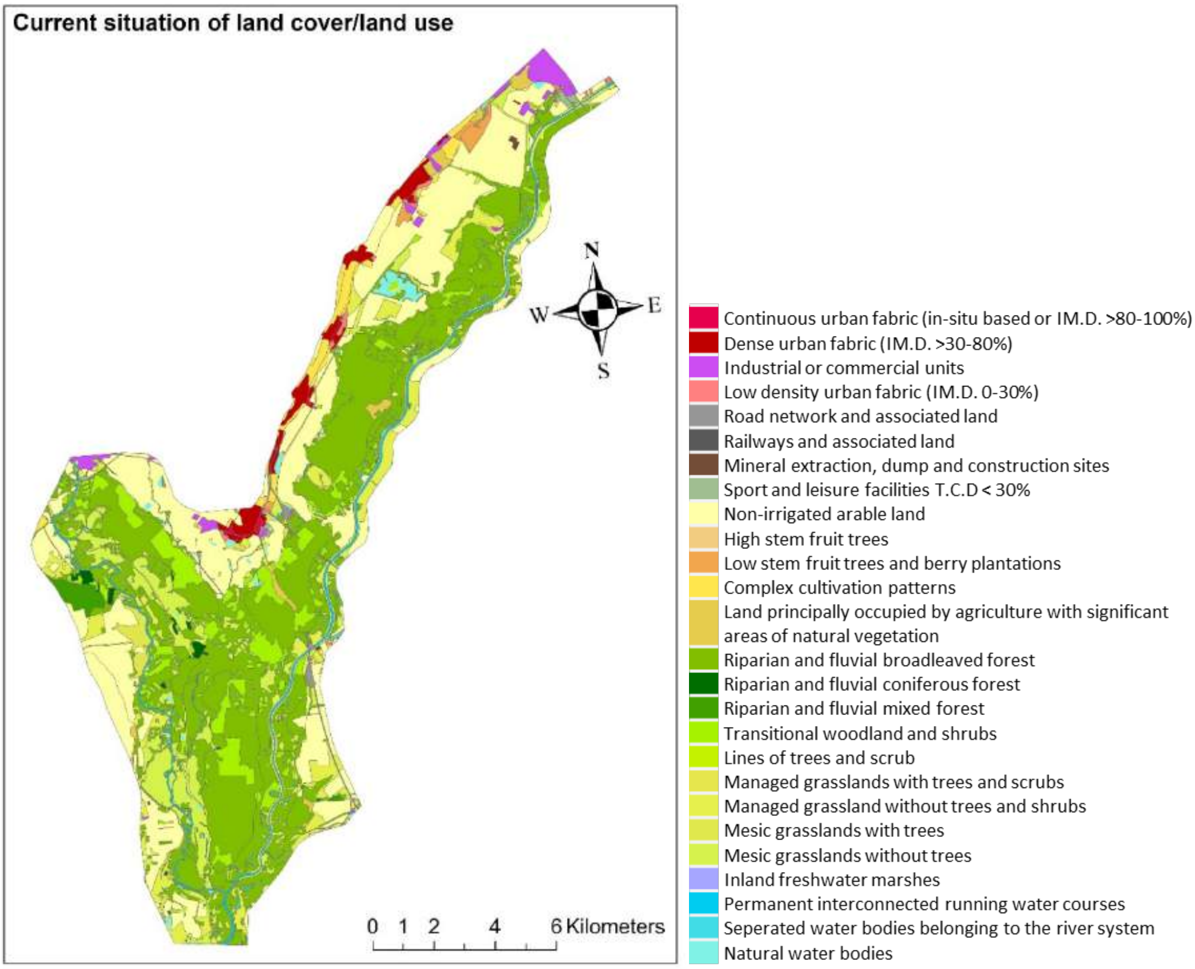


Figure 115: Land cover/land use of the current situation of the pre-selected pilot area Morava.

The implementation of the planned measures will also lead to changes in land cover/land use, especially in the areas which will be reconnected to the active floodplain through dike relocation or reconnection of lateral branches or oxbows (figure 116). The future land cover/land use type here will be a 'riparian and fluvial broadleaved forest.'

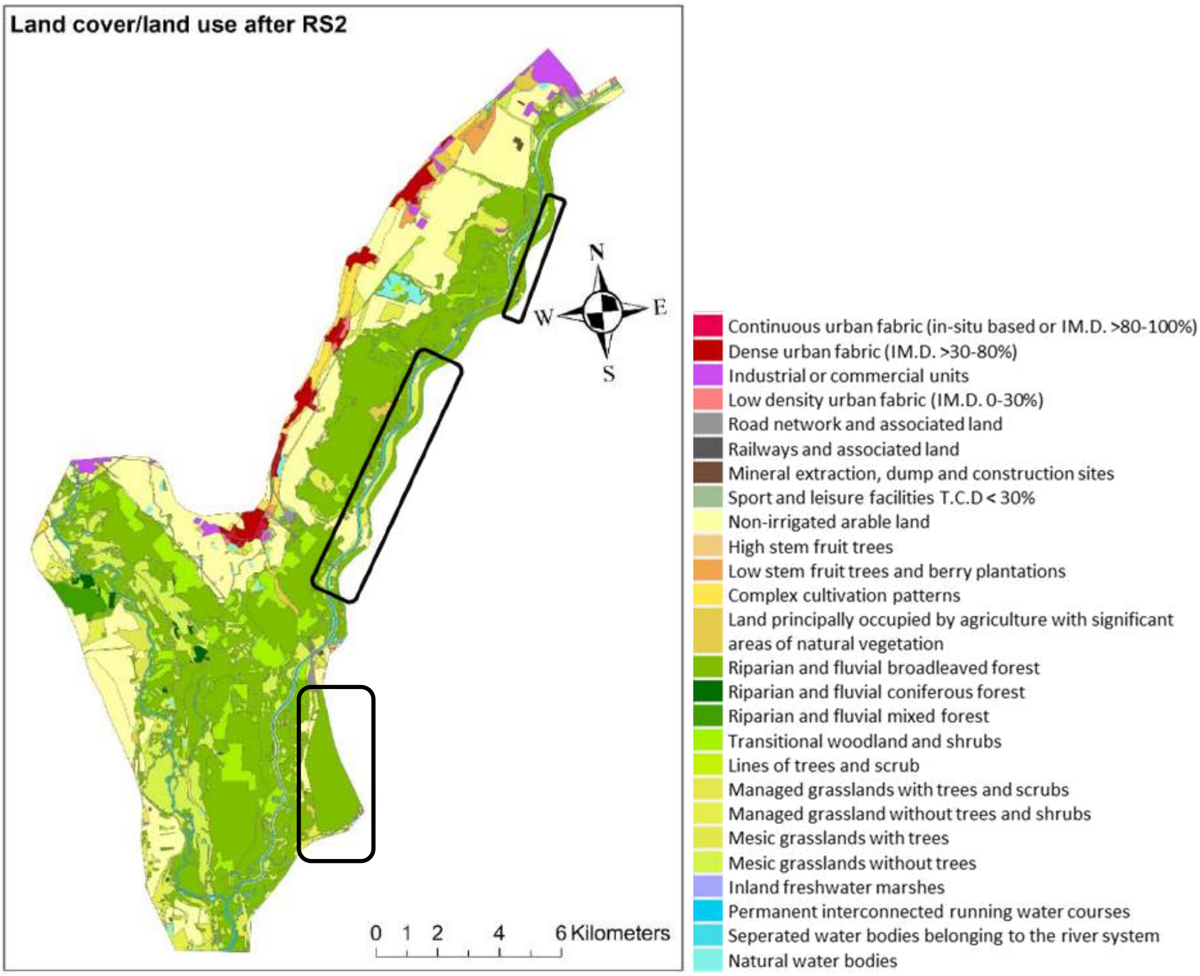


Figure 116: Land cover/land use after restoration scenario RS2 of the pre-selected pilot area Morava.

Potential of the provisioning ESS

In the current state, the ESS *agricultural product* is provided almost exclusively in the fringes of the pilot area mainly at a very high intensity, but also medium and high levels (figure 117). The inner area, on the other hand, is almost exclusively covered with forest, so the potential to provide the ESS *agricultural product* is almost completely missing here.

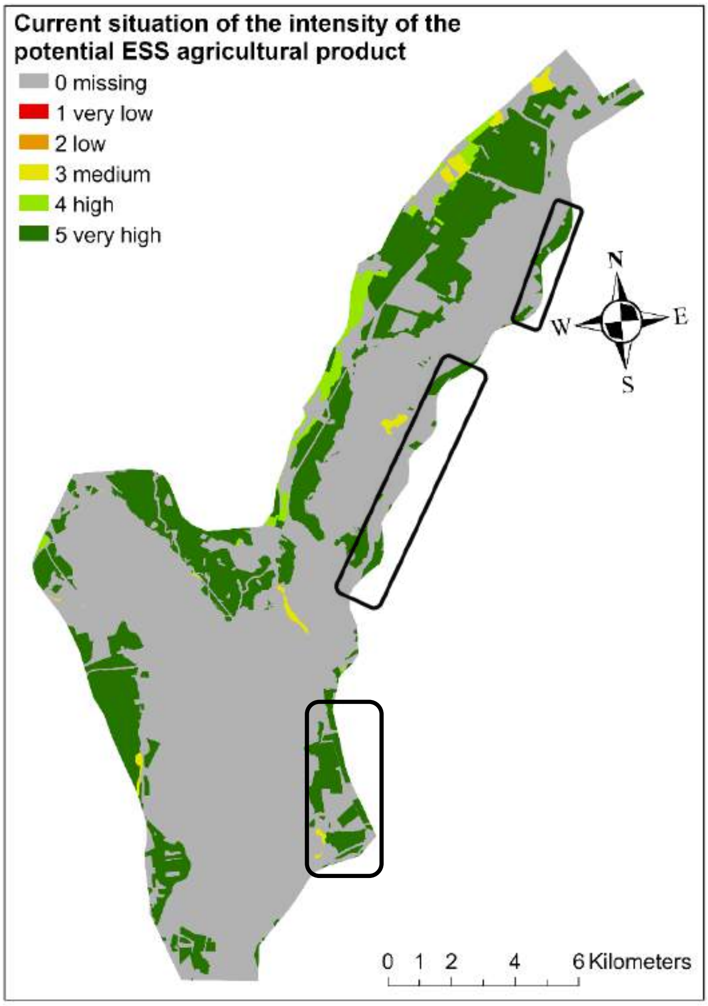


Figure 117: Intensity of the potential provisioning ESS agricultural product in the current situation. The values of the intensity of the potential ESS are marked in different colours.

With the implementation of the dike relocation in restoration scenario RS2, the ESS *agricultural product* will completely disappear in these areas (figure 118)

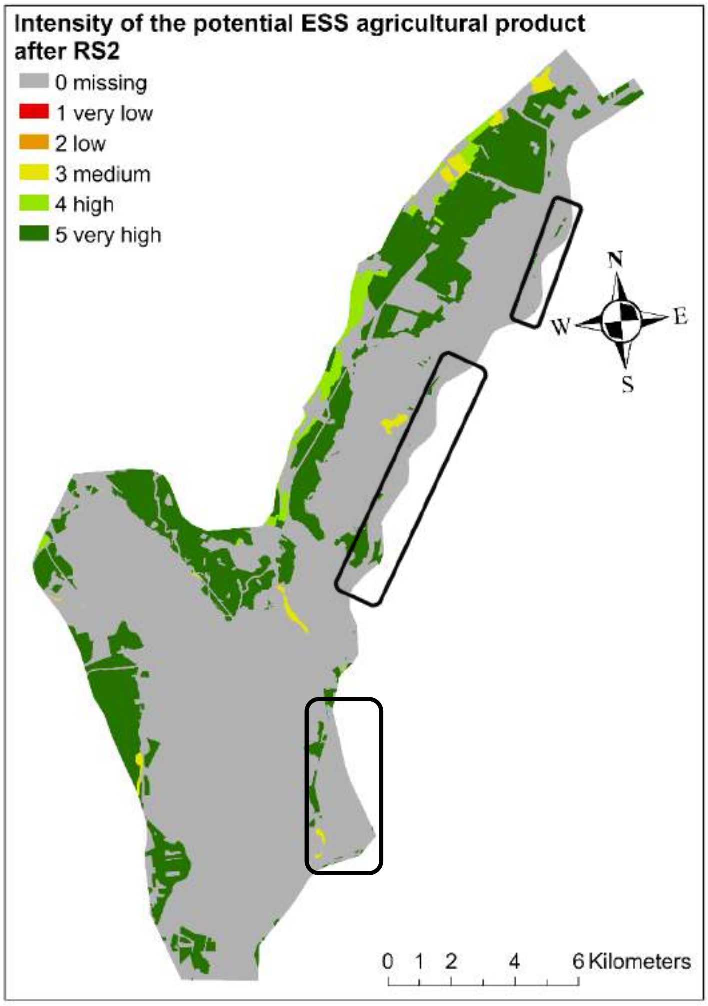


Figure 118: Intensity of the potential provisioning ESS agricultural product after restoration scenario RS2. The values of the intensity of the potential ESS are marked in different colours.

As it is mainly the inner area of the pilot area that is covered with forest, the provision of the ESS *wood* is most pronounced here (figure 119). Within the forest, there are areas of 'transitional woodland and shrub' with high intensity in addition to the riparian forests with very high provision intensity of the ESS *wood*. In contrast, areas with only single trees, rows of trees and shrubs have only a low potential to provide this ESS.

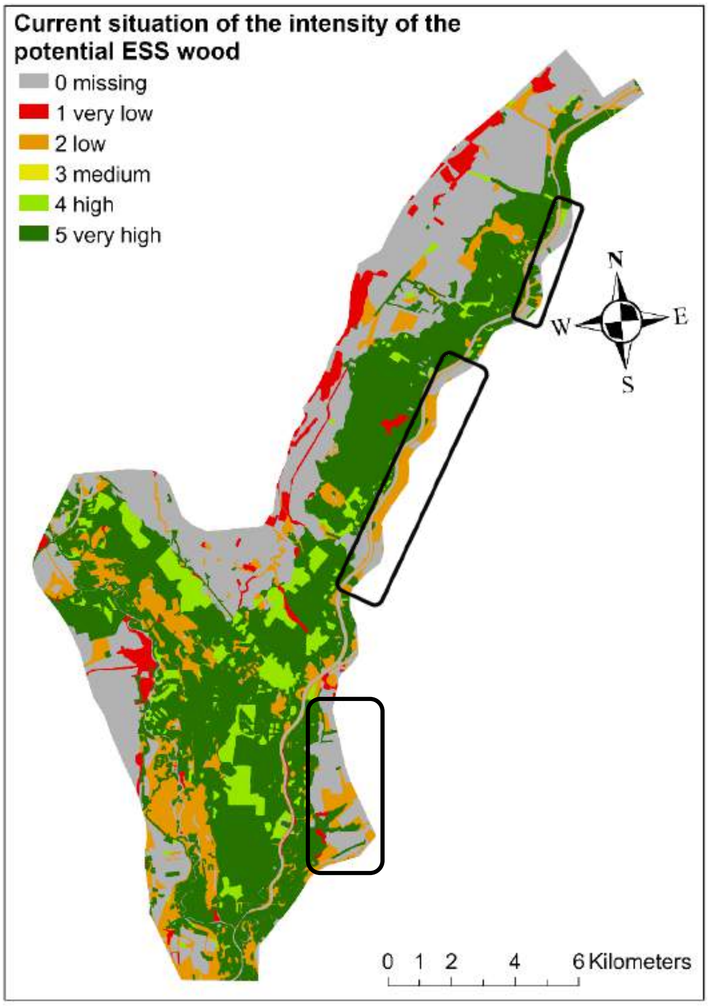


Figure 119: Intensity of the potential provisioning ESS wood in the current situation. The values of the intensity of the potential ESS are marked in different colours.

The provisioning ESS wood will be strongly fostered with the change from partly agricultural land to natural riparian forest areas in the reconnected floodplain areas (figure120) in restoration scenario RS2. Here, the intensity of the provision of ESS wood will be very high after the implementation of the measure.

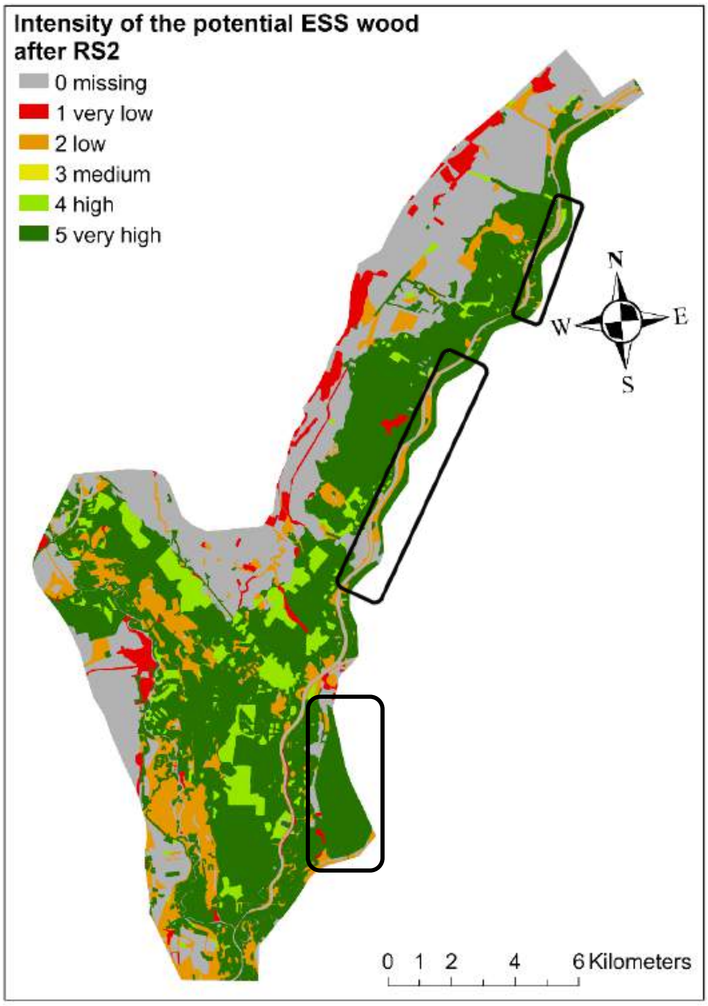


Figure 120: Intensity of the potential provisioning ESS wood after restoration scenario RS2. The values of the intensity of the potential ESS are marked in different colours.

The intensity of the ESS *animal product* is predominantly missing to very low in the current state (figure 121). There are only a few areas with a medium and very high intensity to provide the ESS *animal product*.

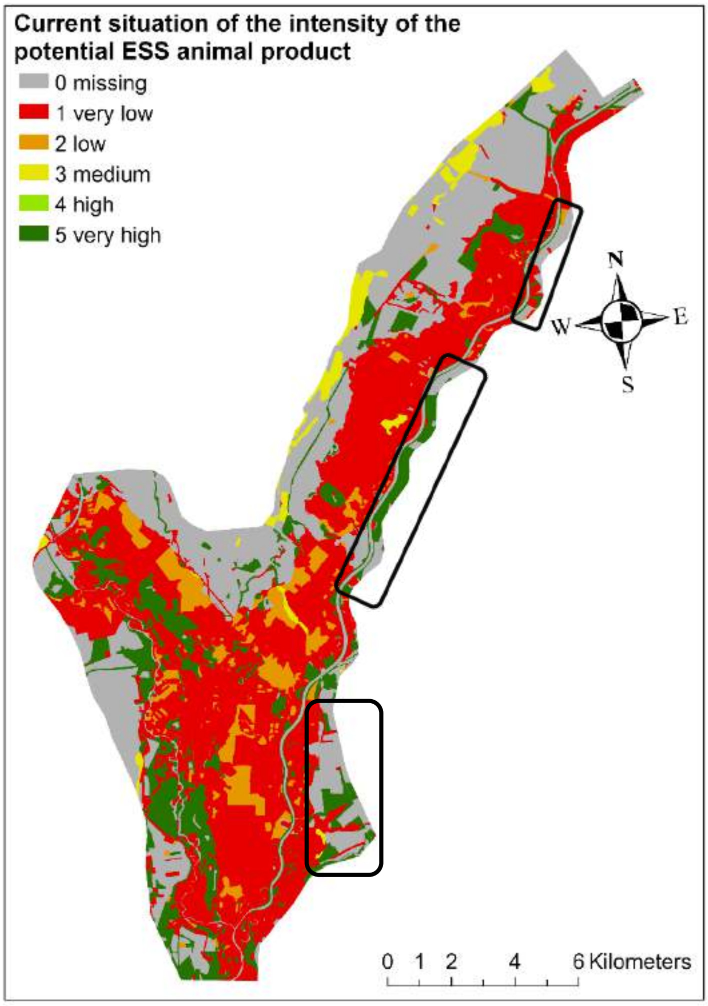


Figure 121: Intensity of the potential provisioning ESS animal product in the current situation. The values of the intensity of the potential ESS are marked in different colours.

In restoration scenario RS2, the changes in the intensity of the ESS *animal product* varies between the single dike relocation areas (figure 122). In the northernmost dike relocation area, the intensity of the ESS *animal product* increases in part from missing to very low. In contrast, the intensity of the provided ESS animal product will decrease in the middle dike relocation area from very high to very low. In the southern implementation area, the former varying intensity of the provision of the ESS *animal product* changes to a uniform low intensity.

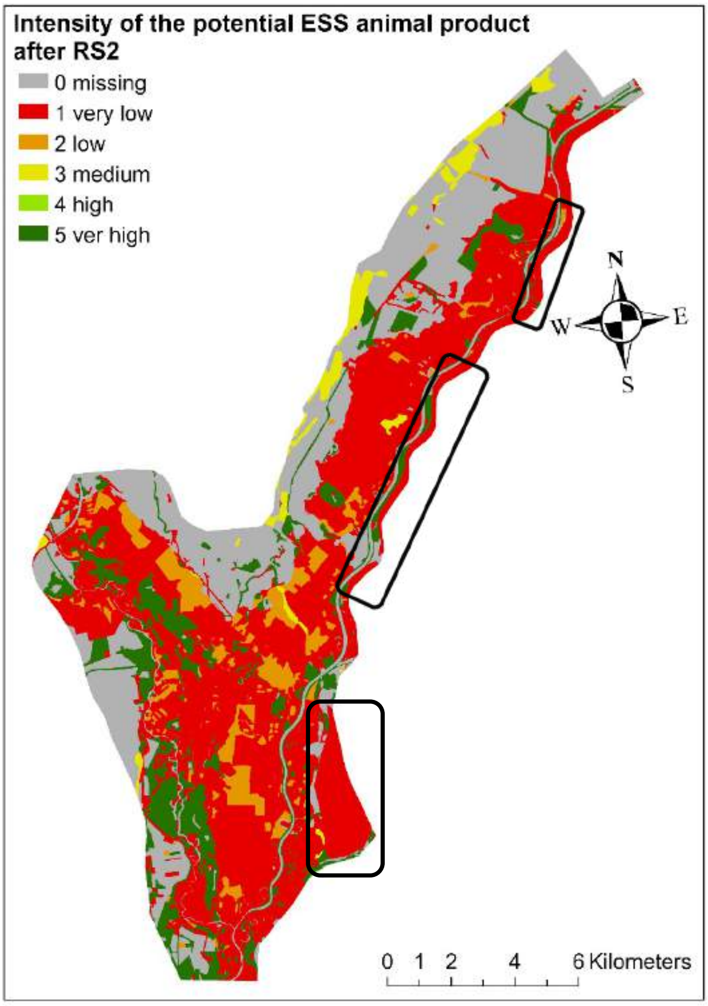


Figure 122: Intensity of the potential provisioning ESS animal product after restoration scenario RS2. The values of the intensity of the potential ESS are marked in different colours.

The pilot area has a very high intensity for providing the ESS *game meat* in the forest areas (Figure 123). In the fringe areas of the pilot areas, where the land is used for agriculture, this intensity is significantly lower. Water areas have a medium intensity to provide the ESS *game meat*.

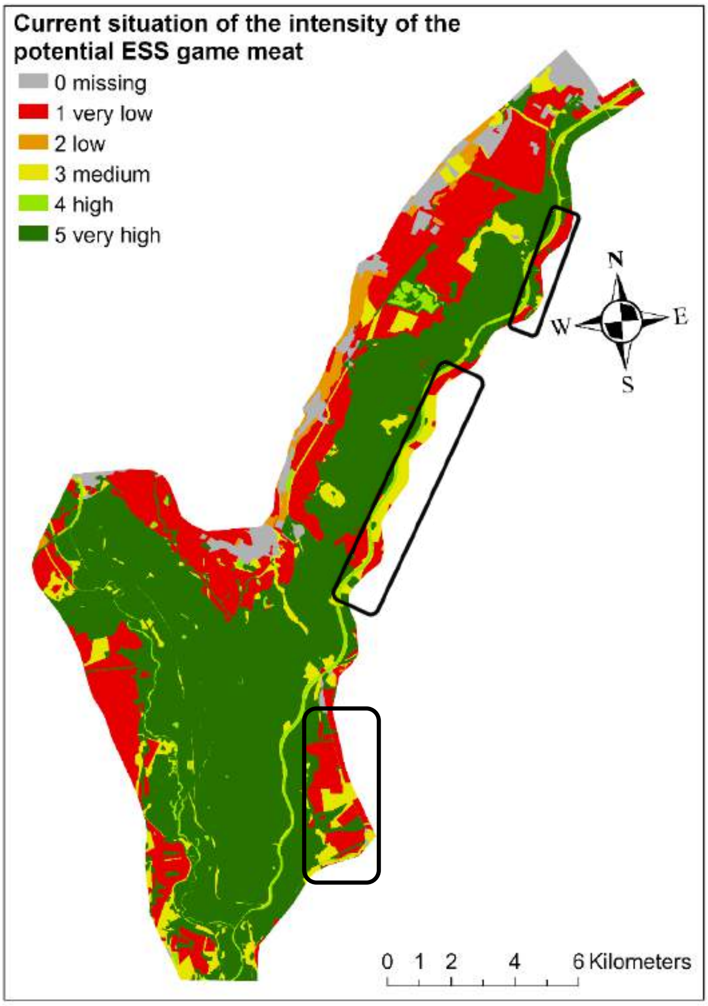


Figure 123: Intensity of the potential provisioning ESS game meat in the current situation. The values of the intensity of the potential ESS are marked in different colours.

The capacity of the ESS *game meat* will increase with the dike relocation of the restoration scenario RS2 (Figure 124). The former intensity of the ESS *game meat* will increase from a very low or medium level to a very high level due to the land cover/land use change in the dike relocation areas.

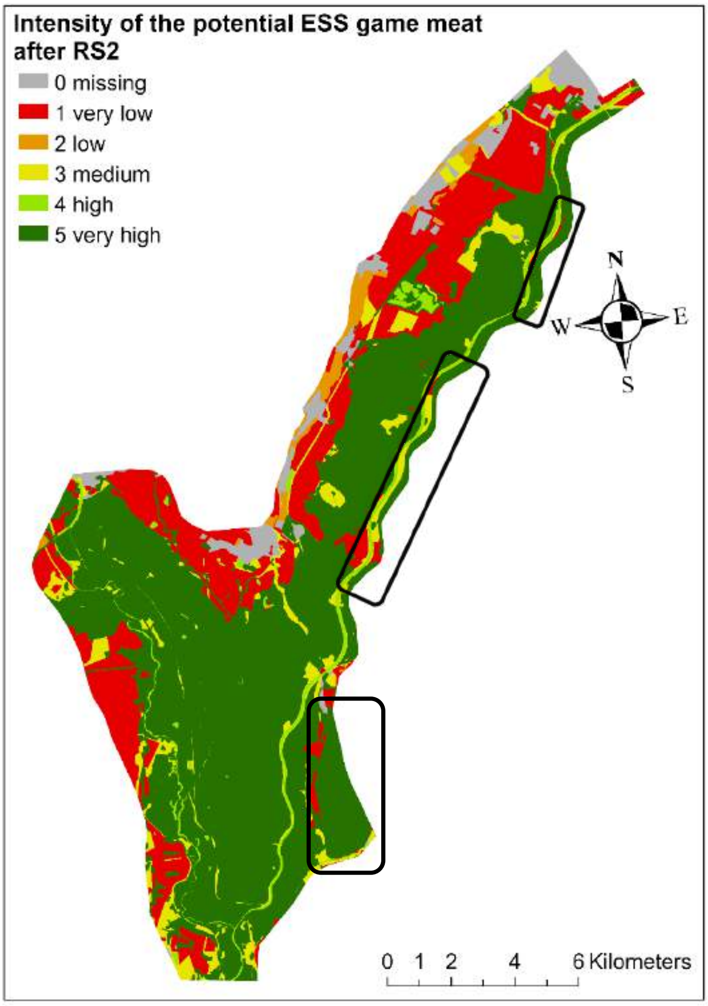


Figure 124: Intensity of the potential provisioning ESS game meat after restoration scenario RS2. The values of the intensity of the potential ESS are marked in different colours.

The intensity to provide the ESS *honey* varies from missing to very high in the current state of the pilot area Morava (figure 125). The highest intensity have natural grassland areas or fruit trees and berries plantations. Natural riparian and fluvial broadleaved forest types or extensive used agricultural areas provide the ESS *honey* at high level, whereas riparian forest with coniferous trees, urban gardens or managed grassland have only a medium intensity. In intensively used arable land and urban areas, the potential to provide the ESS honey is missing.

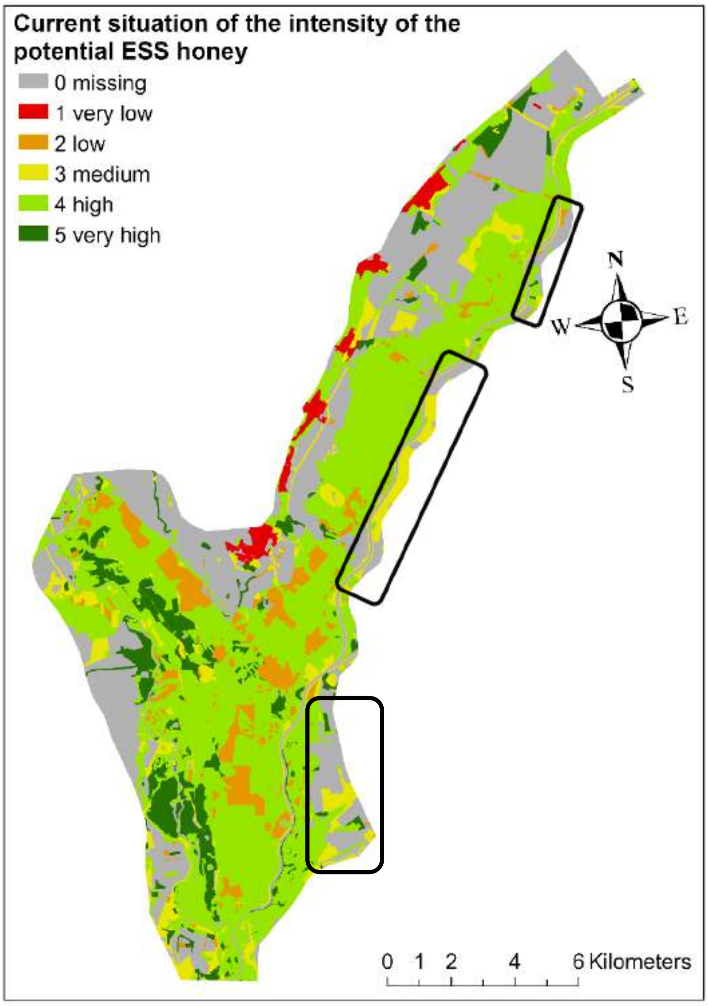


Figure 125: Intensity of the potential provisioning ESS honey in the current situation. The values of the intensity of the potential ESS are marked in different colours.

This ESS also benefits from land cover/land use conversion in the dike relocation areas (figure 126). The intensity of the provision of the ESS *honey* will increase to a high level in restoration scenario RS2.

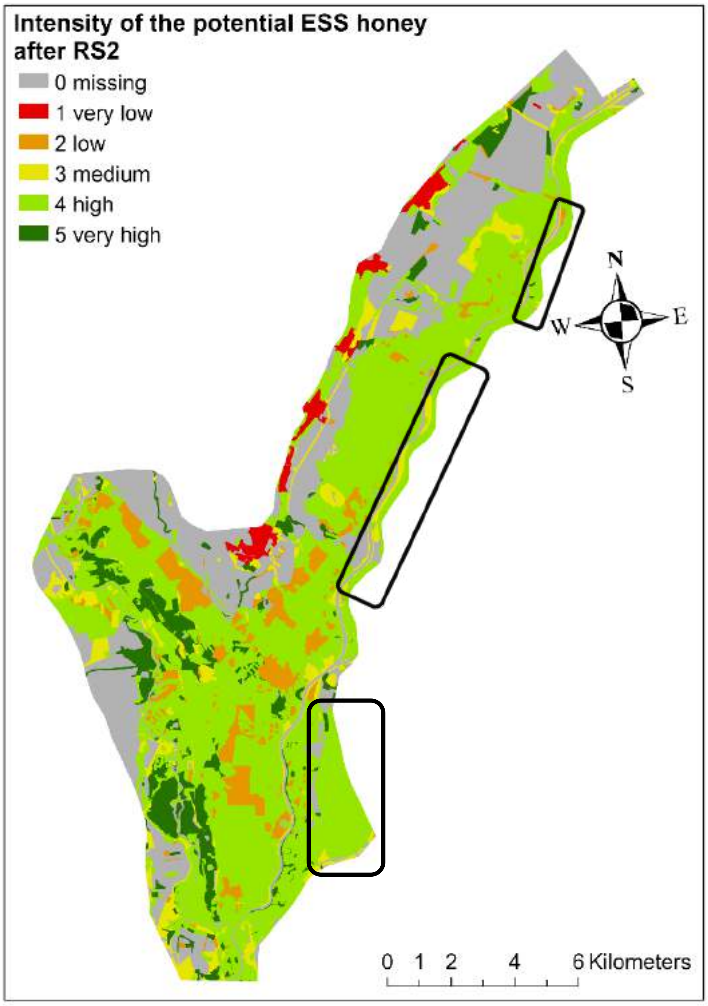


Figure 126: Intensity of the potential provisioning ESS honey after restoration scenario RS2. The values of the intensity of the potential ESS are marked in different colours.

In the current state, the capacity of the ESS *fish* is very high in the pilot area (figure 127). However, fishing is only allowed on the Austrian and Slovakian side of the Tisza, so that only the potential for providing the ESS *fish* is illustrated here and not the intensity of the used ESS.

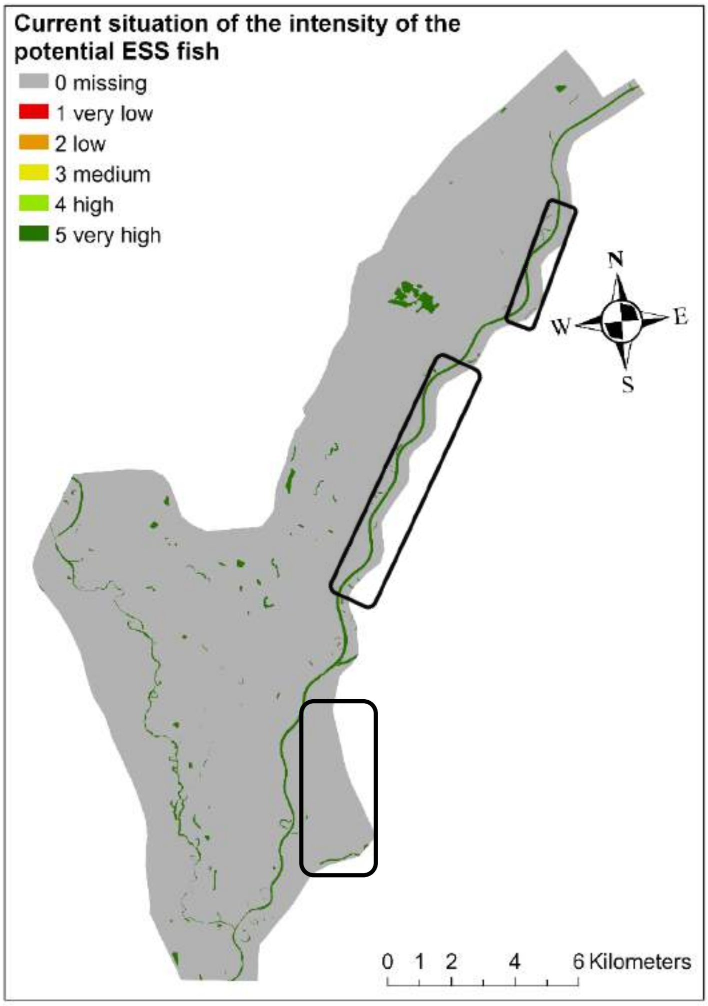


Figure 127: Intensity of the potential provisioning ESS fish in the current situation. The values of the intensity of the potential ESS are marked in different colours.

The planned restoration measures will not influence the intensity of the ESS *fish* in restoration scenario RS2 (figure 128).

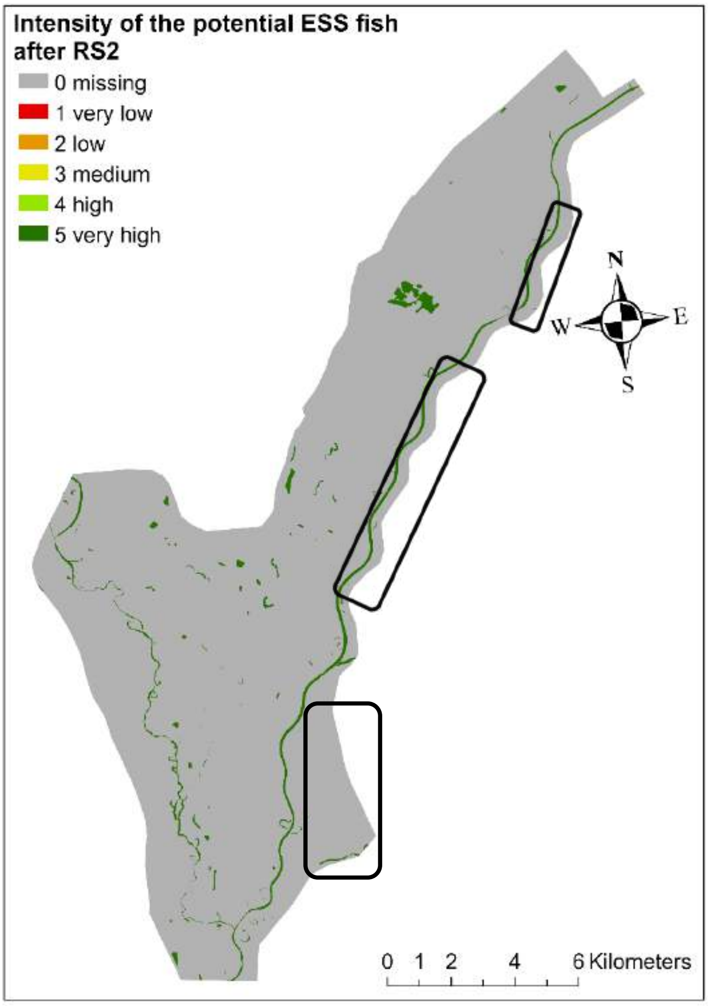


Figure 128: Intensity of the potential provisioning ESS fish after restoration scenario RS2. The values of the intensity of the potential ESS are marked in different colours.

In the current state, the intensity to provide the ESS *water* is either low, medium or very high. The Morava River only provide the ESS *water* at a low level due to the hydro-morphological alterations. In contrast, natural water bodies have the potential to provide ESS *water* to very high intensity. The intensity to provide the ESS *water* of inland marshes is at medium level.

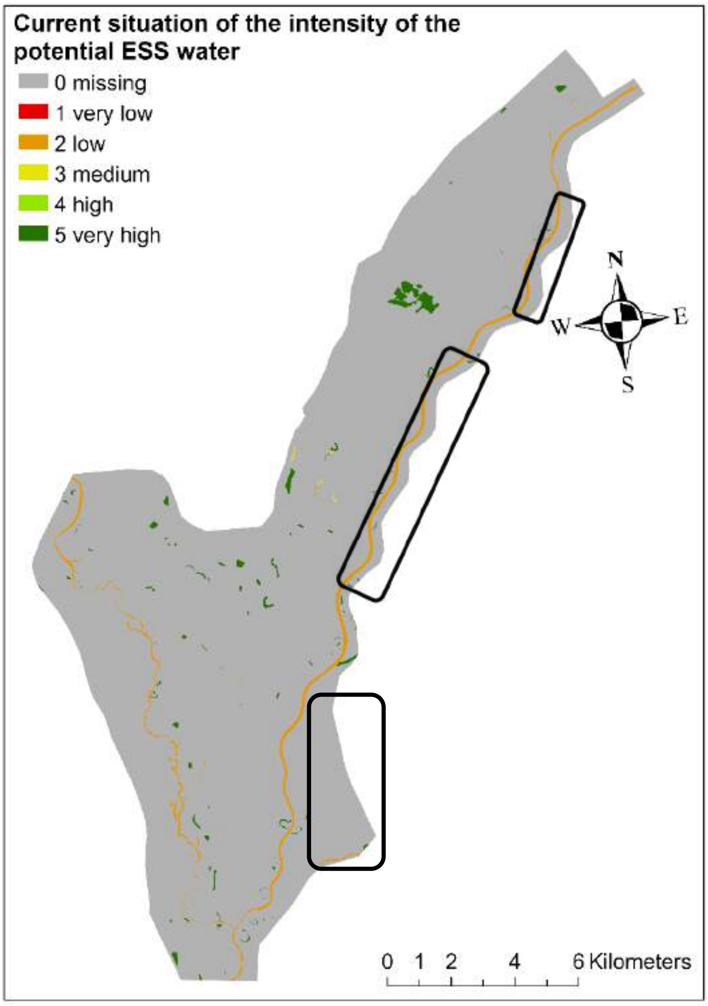


Figure 129: Intensity of the potential provisioning ESS water in the current situation. The values of the intensity of the potential ESS are marked in different colours.

The restoration scenario RS2 will not have any effect on the intensity of the ESS *water* (figure 130).

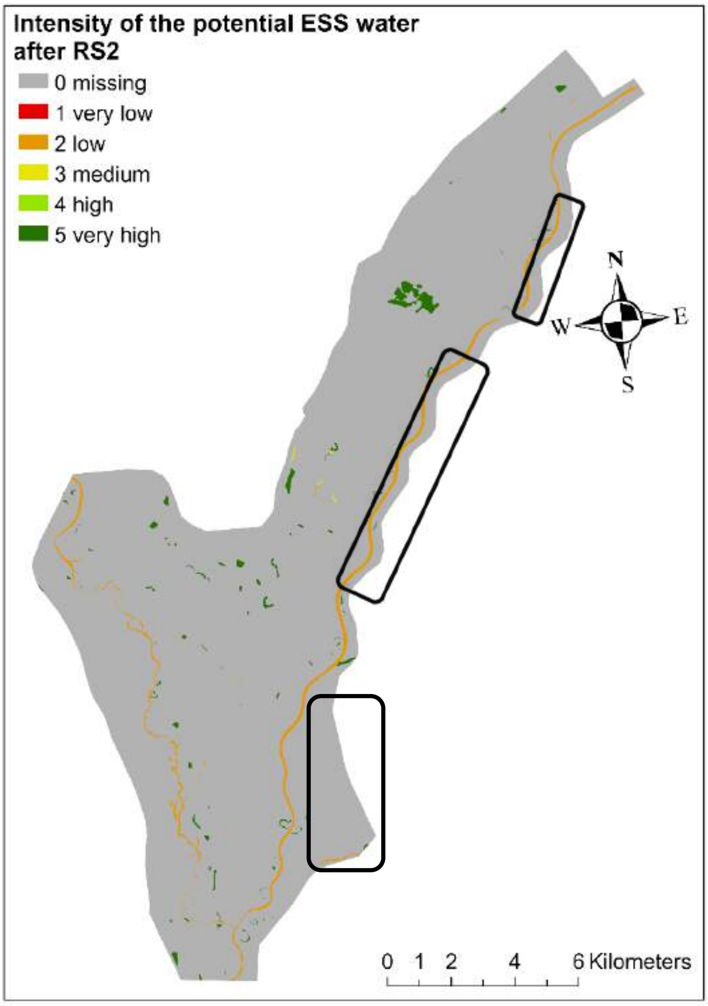


Figure 130: Intensity of the potential provisioning ESS water after restoration scenario RS2. The values of the intensity of the potential ESS are marked in different colours.

Potential of the regulating ESS

The forested areas in the Morava pilot areas provide a very high intensity of ESS *air purification* in the current situation (figure 131). However, there are also many areas (urban, agricultural, managed grassland) without the provision of the ESS *air purification* or only at very low or low levels, especially in the planned dike relocation areas.

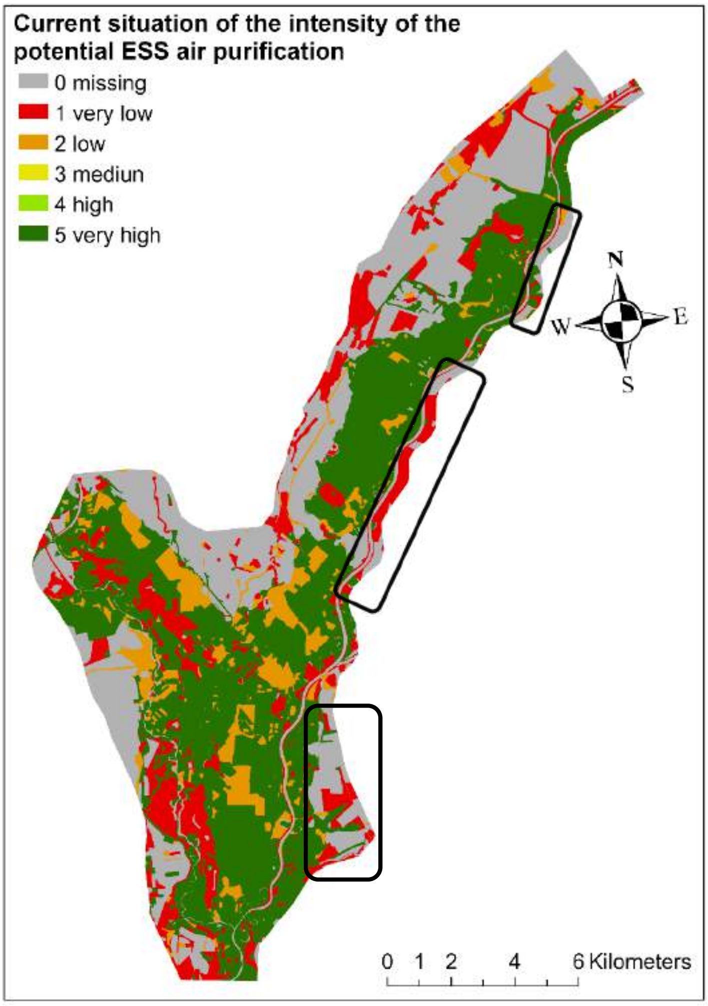


Figure 1311: Intensity of the potential regulating ESS air purification in the current situation. The values of the intensity of the potential ESS are marked in different colours.

The intensity of the ESS *air purification* will increase with the implementation of the dice relocations and the conversion of the land cover/land use from agricultural land into forest (figure 132). The intensity value will increase to a very high level, except for a few small areas.

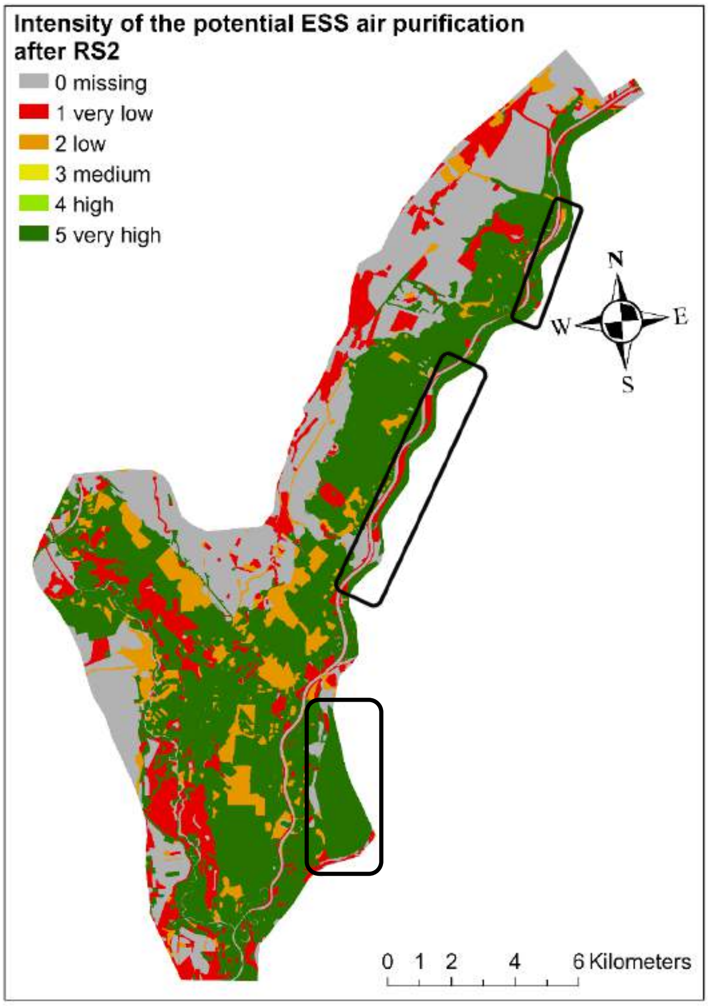


Figure 132: Intensity of the potential provisioning ESS air purification after restoration scenario RS2. The values of the intensity of the potential ESS are marked in different colours.

Inside the pilot area, the potential to provide the ESS *local climate regulation* is very inhomogeneous due to the different land cover/land use types. The forested areas and also the water areas have a very high capacity to provide the ESS *local climate regulation* (figure 133), whereas the intensity of the ESS *local climate regulation* is very low in the urban areas. In the planned action areas, the intensity of the ESS *local climate regulation* is also very low for most parts, except for the medium planning area, which provides the ESS *local climate regulation* at a medium level.

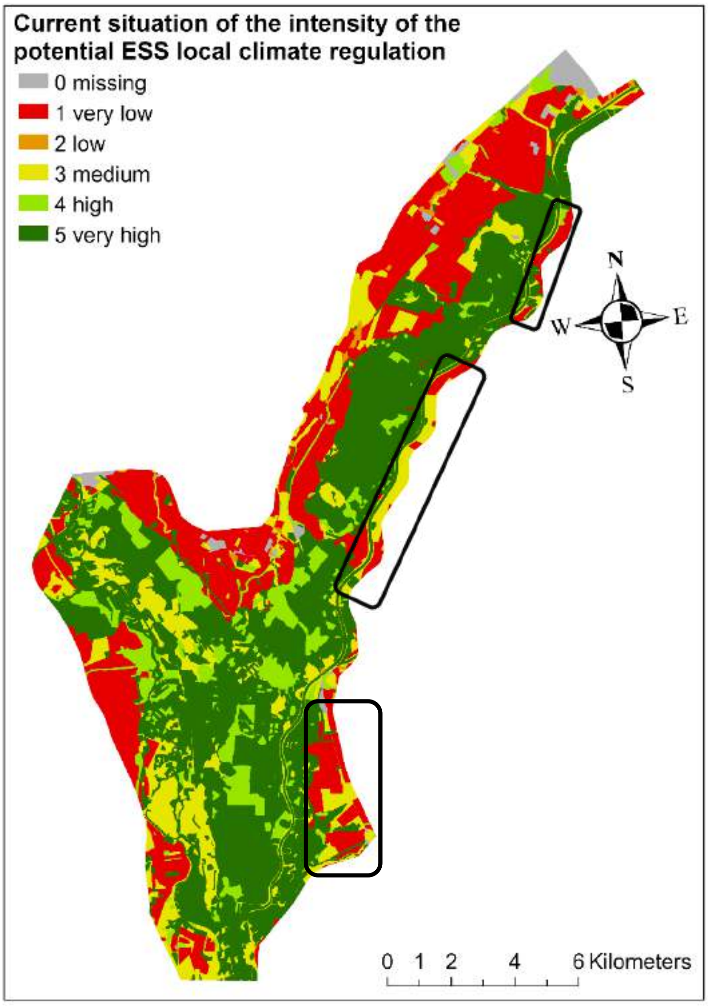


Figure 133: Intensity of the potential regulating ESS local climate regulation in the current situation. The values of the intensity of the potential ESS are marked in different colours.

In restoration scenario RS2, the intensity of the provided ESS local climate regulation will increase in general to a very high intensity due to the dike relocation and the conversion of the land cover/land use (figure 134).

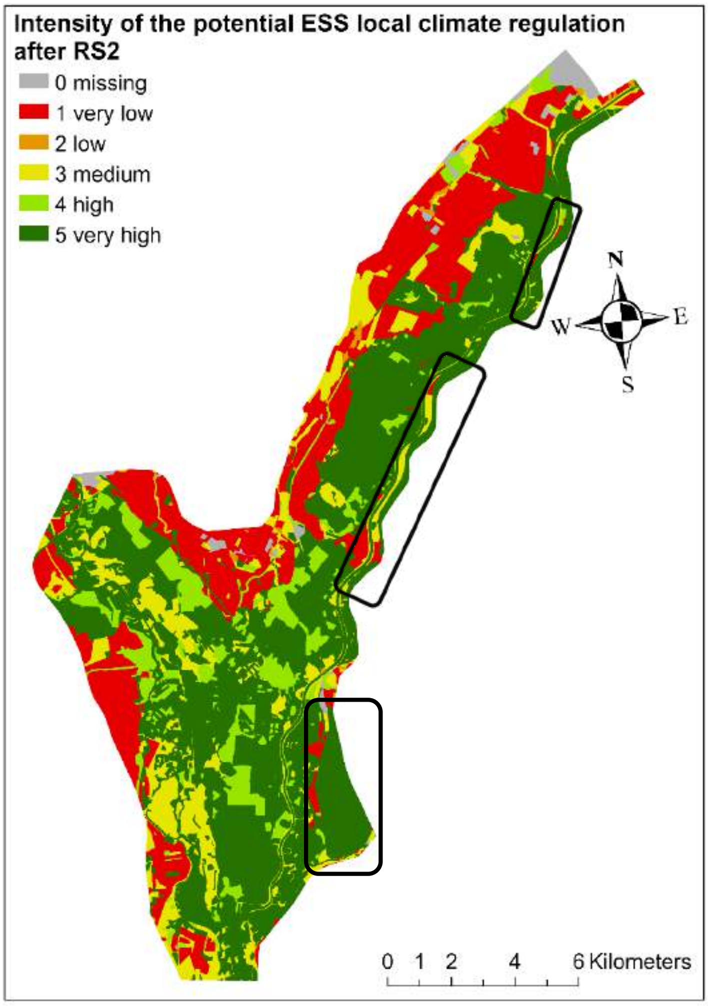


Figure 134: Intensity of the potential provisioning ESS local climate regulation after restoration scenario RS2. The values of the intensity of the potential ESS are marked in different colours.

In contrast to all other regulating ecosystem services, the provision of the ESS *low water regulation* is highest in agricultural areas and is provided at very low or low intensity in forest areas or “transitional woodland and shrubs” areas (figure 135). The intensity of the ESS *low water regulation* in the restoration areas varies between a medium and very high level.

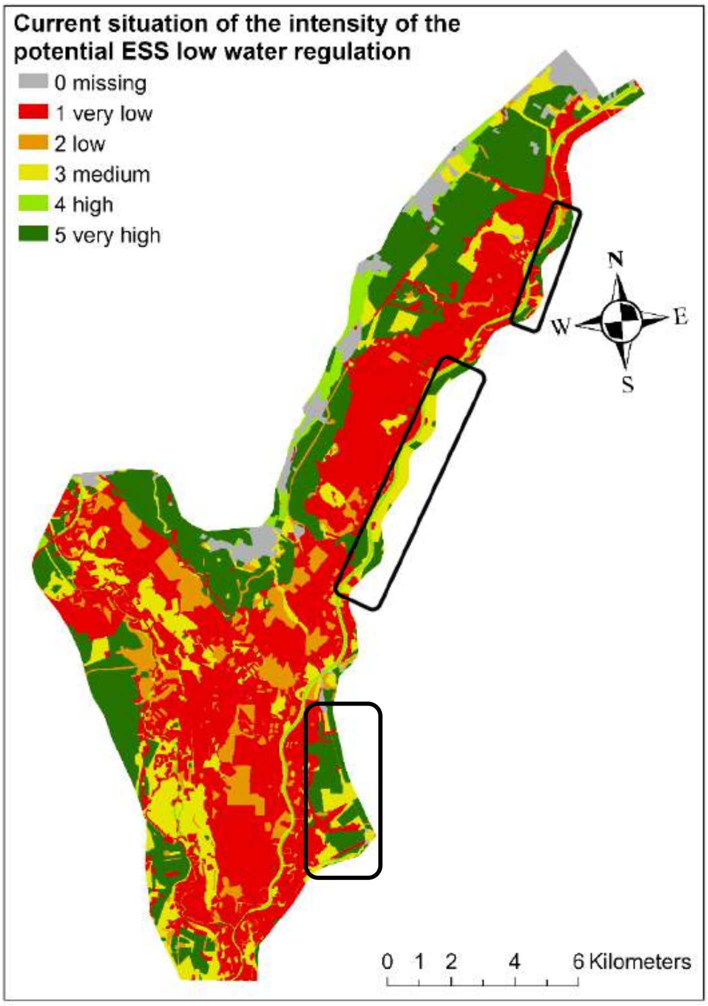


Figure 135: Intensity of the potential regulating ESS low water regulation in the current situation. The values of the intensity of the potential ESS are marked in different colours.

The intensity for providing ESS *low water regulation* will decrease to a very low level within the dike relocated areas after implementation of the restoration measures of restoration scenario RS2 (figure 136).

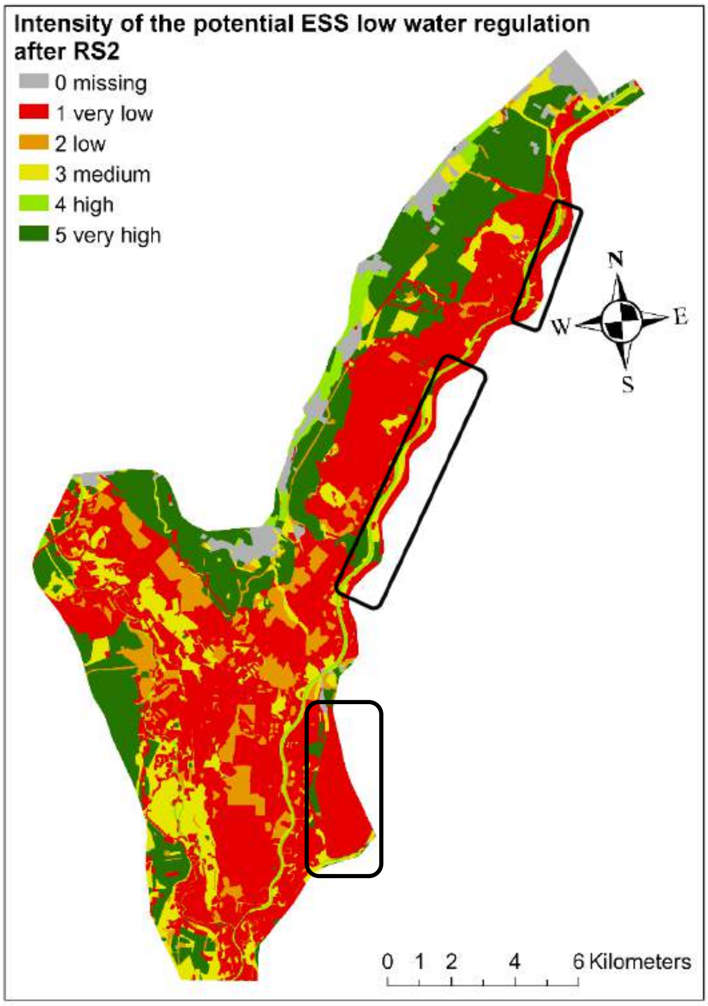


Figure 136: Intensity of the potential provisioning ESS low water regulation after restoration scenario RS2. The values of the intensity of the potential ESS are marked in different colours.

The capacity of the pilot area to ensure ESS *flood retention* is in the current situation high in forest areas, but otherwise very low, in particular in the three areas of the planned measures (figure 137).

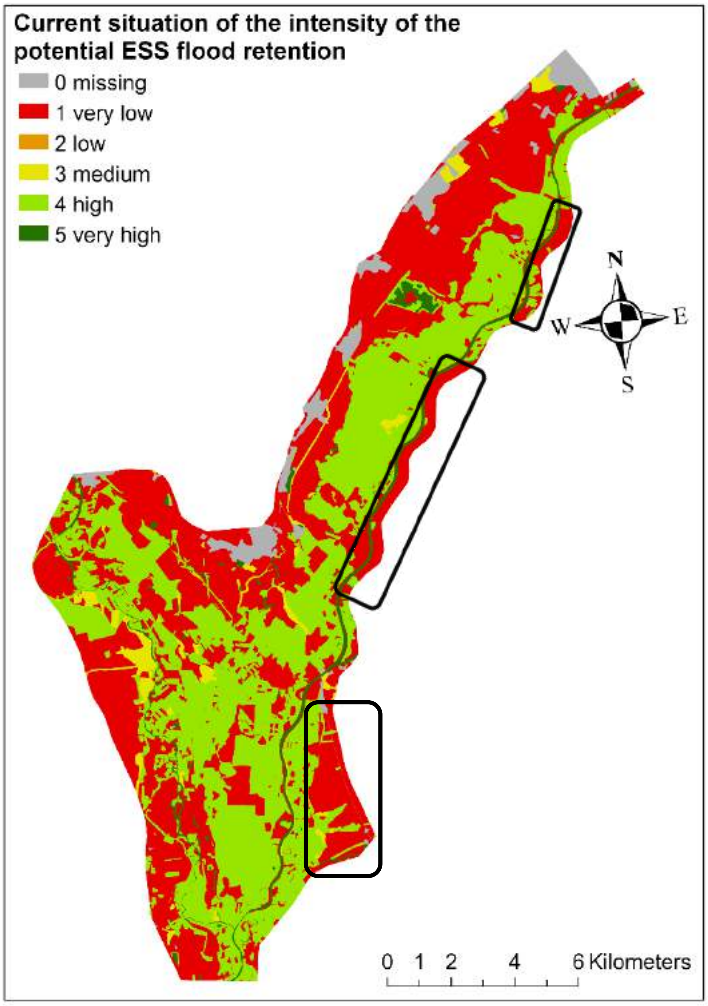


Figure 1372: Intensity of the potential regulating ESS flood retention in the current situation. The values of the intensity of the potential ESS are marked in different colours.

After the implementation of the dike relocation and conversion of the land cover/land use of restoration scenario RS2, the intensity to provide the ESS flood retention will increase to a high level (figure 138).

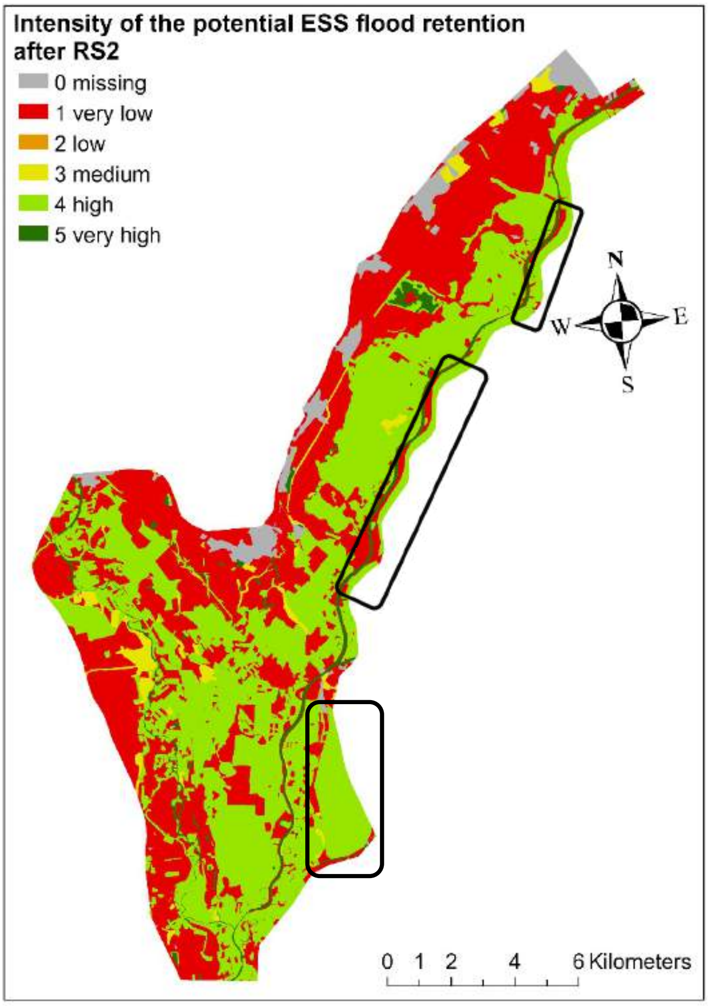


Figure 138: Intensity of the potential provisioning ESS flood retention after restoration scenario RS2. The values of the intensity of the potential ESS are marked in different colours.

The urban areas at the fringes of the pilot area are very well protected from the noise from the railway line and roads due to the high proportion of forest (figure 139). The forest provides a very high intensity of the ESS *noise regulation*, while water bodies and agricultural land provide this ESS only at a very low level.

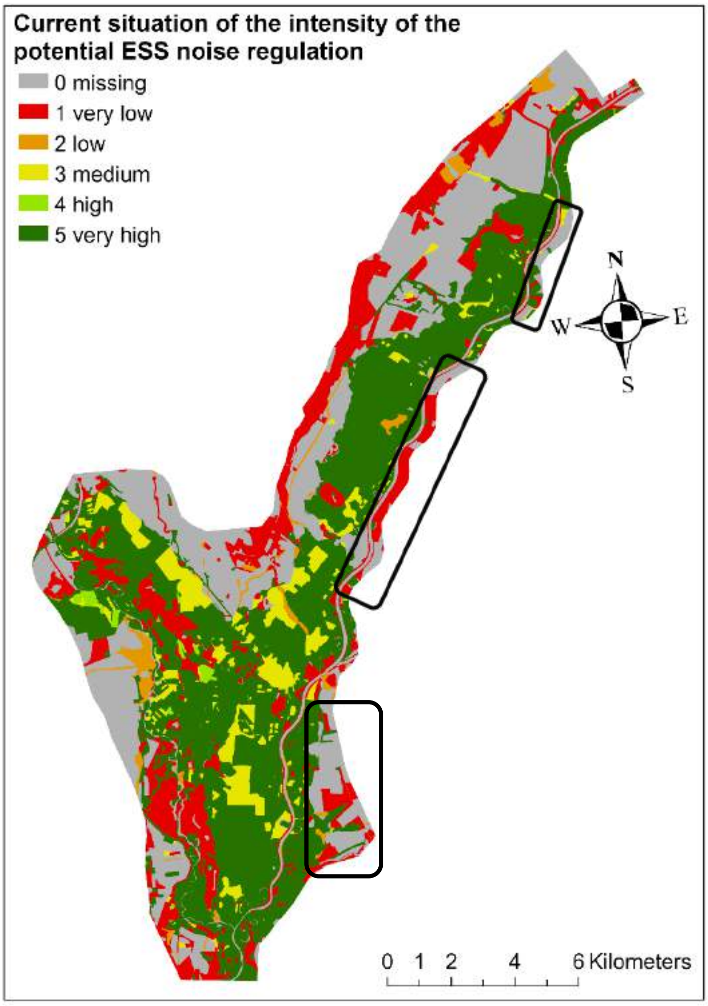


Figure 139: Intensity of the potential regulating ESS noise regulation in the current situation. The values of the intensity of the potential ESS are marked in different colours.

The intensity to provide the ESS *noise regulation* will increase from missing and very low to very high due to the dike relocation and afforestation within the new dike (figure 140).

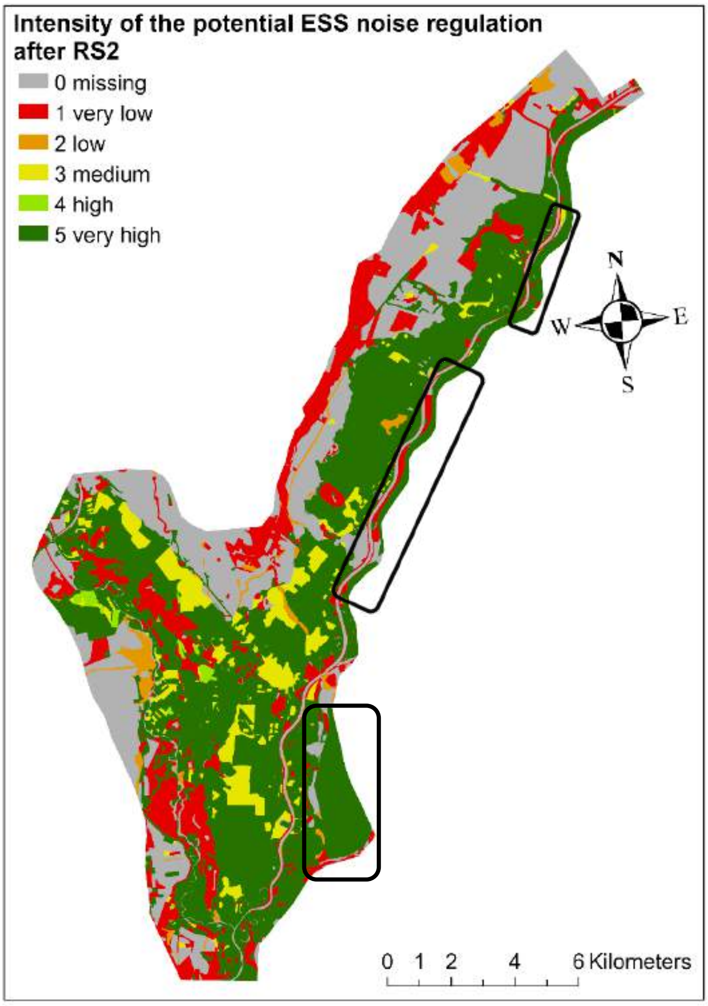


Figure 140: Intensity of the potential provisioning ESS noise regulation after restoration scenario RS2. The values of the intensity of the potential ESS are marked in different colours.

Like most regulating ESS, the intensity of the ESS *nutrient retention* is very high in natural forest types, medium in managed grassland, very low in cropland and missing in urban zones (figure 141). The intensity of ESS *nutrient retention* thus varies from very low to medium depending on the land cover/land use type in the diked areas.

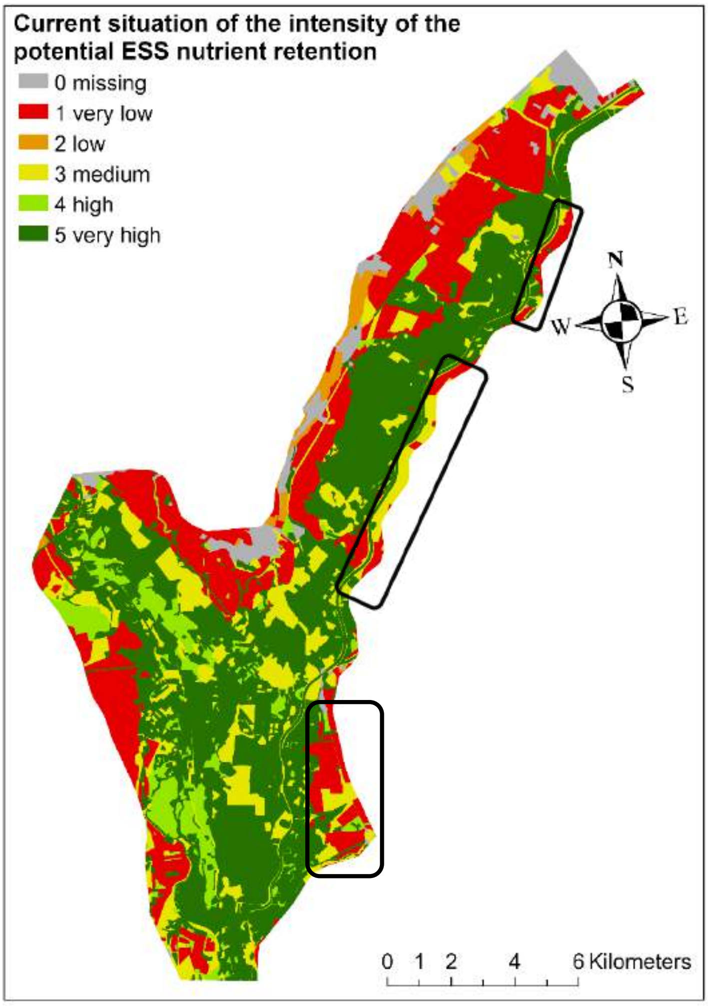


Figure 141: Intensity of the potential regulating ESS nutrient retention in the current situation. The values of the intensity of the potential ESS are marked in different colours.

With the dike relocation and afforestation within the dike, the provision of the ESS *nutrient retention* will generally increase to a very high level (figure 142).

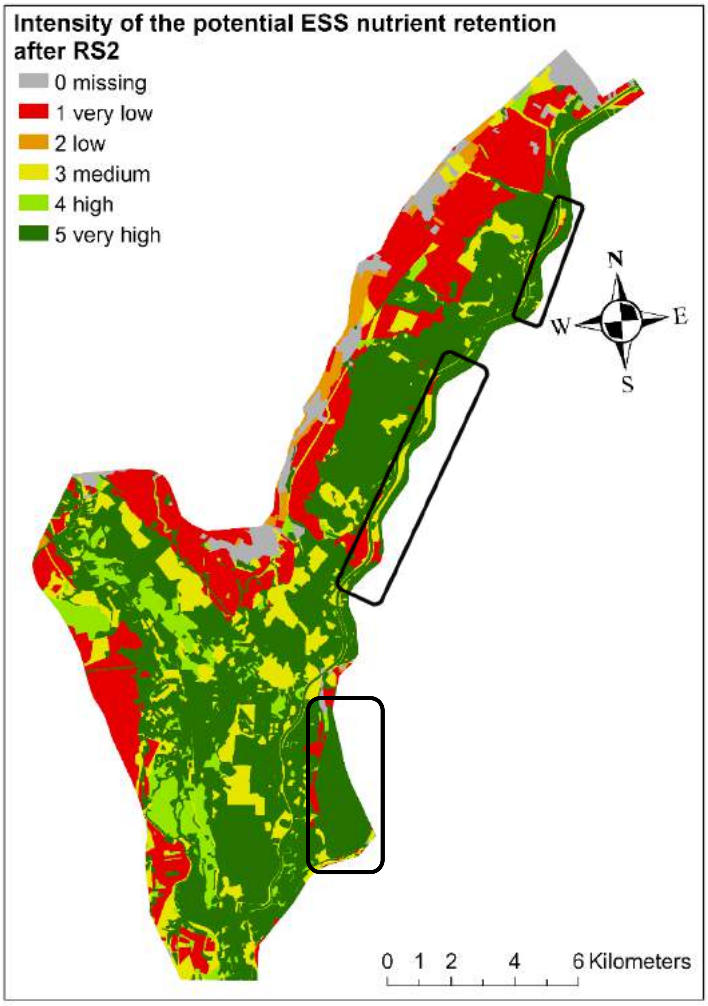


Figure 1423: Intensity of the potential provisioning ESS nutrient retention after restoration scenario RS2. The values of the intensity of the potential ESS are marked in different colours.

The provision of the ESS *provision of habitats* is very diverse in the area in the current situation (figure 143). Natural habitats such as riparian forests and various water body types have a very high capacity to provide this ESS. In contrast, human-influenced land cover/land use types have a medium or no capacity to provide habitats for floodplain-typical species, depending on the degree of pressure. The dikes in the eastern part of the pilot area harm the ESS *provision of habitats*. Therefore, the provision of this ESS is mainly missing or at a low level.

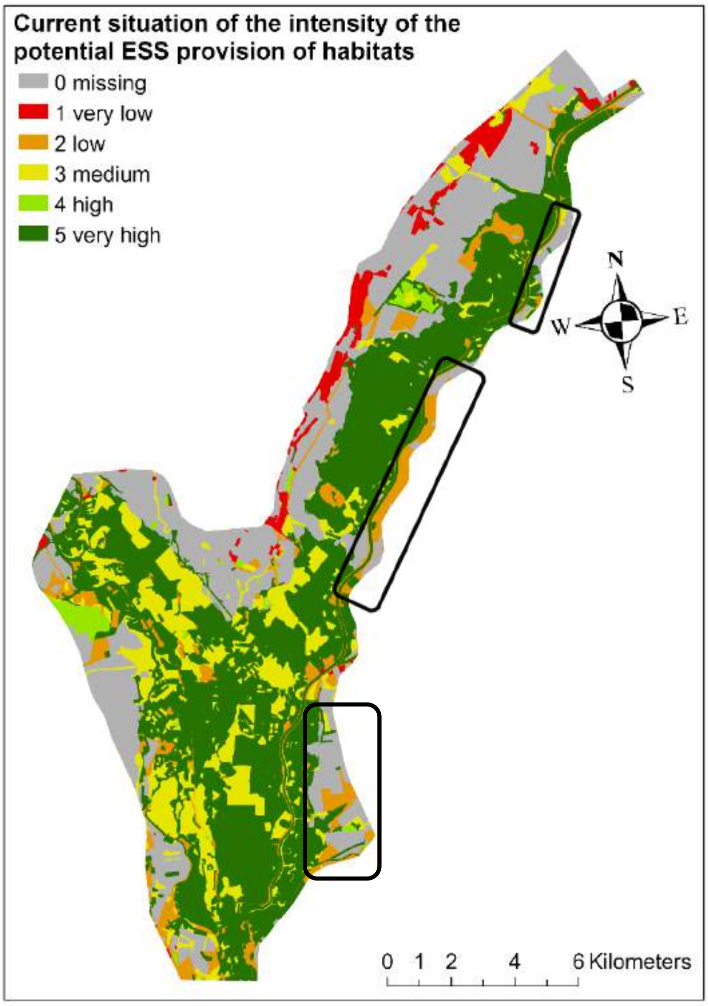


Figure 143: Intensity of the potential regulating ESS provision of habitats in the current situation. The values of the intensity of the potential ESS are marked in different colours.

The intensity of the ESS *provision of habitats* will increase to a very high level after the implementation of the dike relocation and reforestation within the new dikes (figure 144).

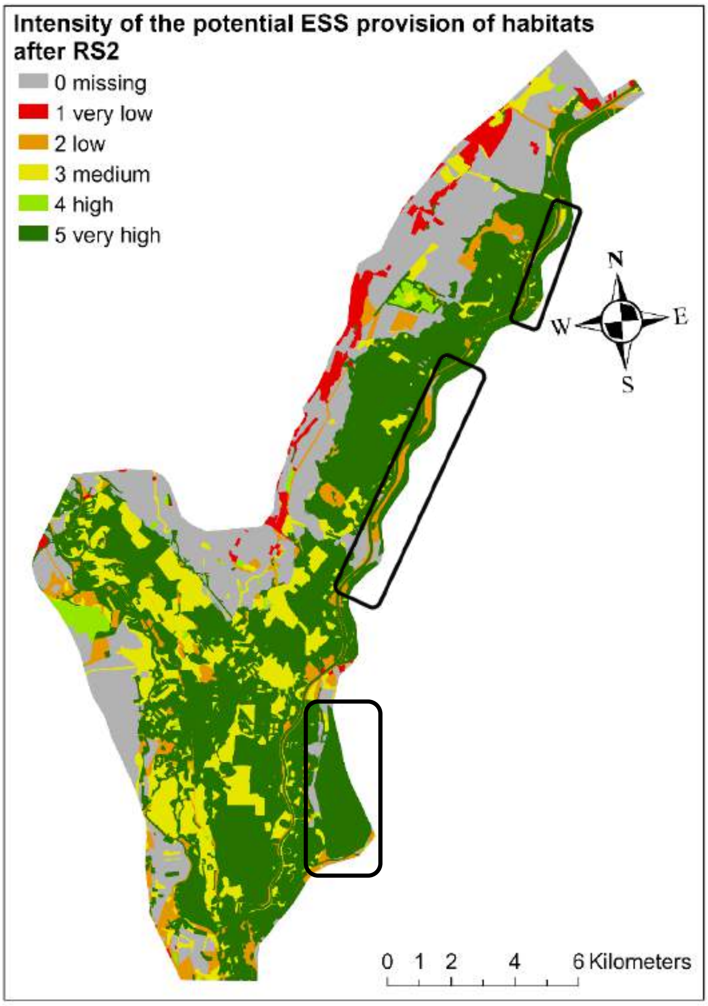


Figure 1444: Intensity of the potential provisioning ESS provision of habitats after restoration scenario RS2. The values of the intensity of the potential ESS are marked in different colours.

The intensity to provide all considered providing ESS is generally at a medium level in the current situation due to forests, but is very low in urban areas as well as on arable land (figure 145). The low intensity of all potentially providing ecosystem services can be attributed to managed grassland areas within the dikes.

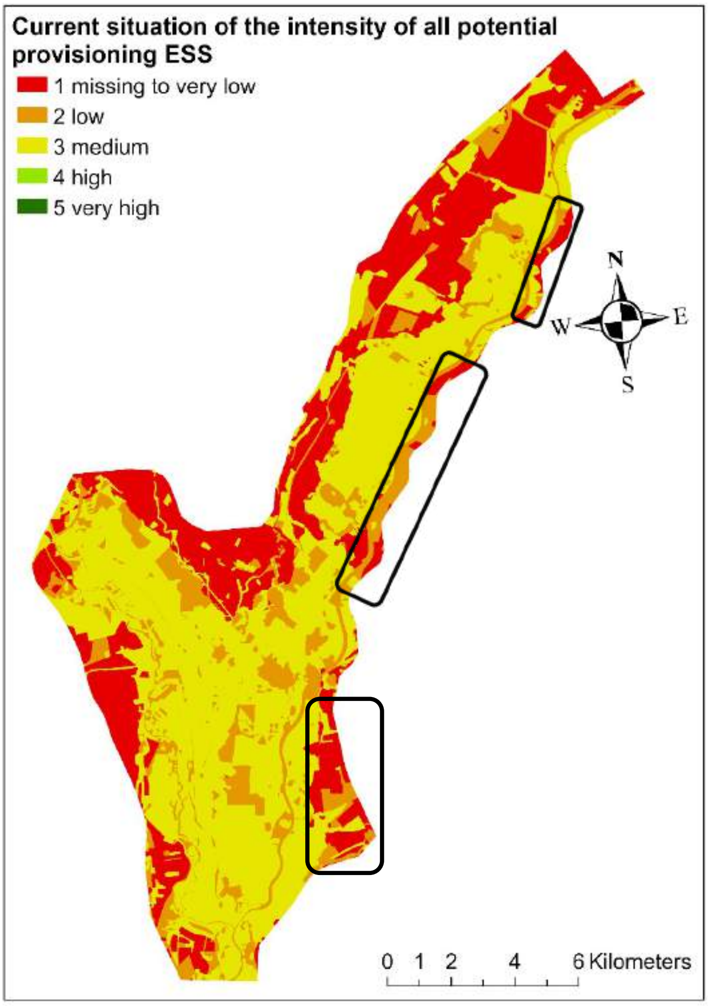


Figure 145: Intensity of all potential provisioning ESS in the current situation. The values of the intensity of the potential ESS are marked in different colours.

After the implementation of the restoration measures in restoration scenario RS2 the intensity to provide all potential provided ESS will increase generally to a medium level (figure 146).

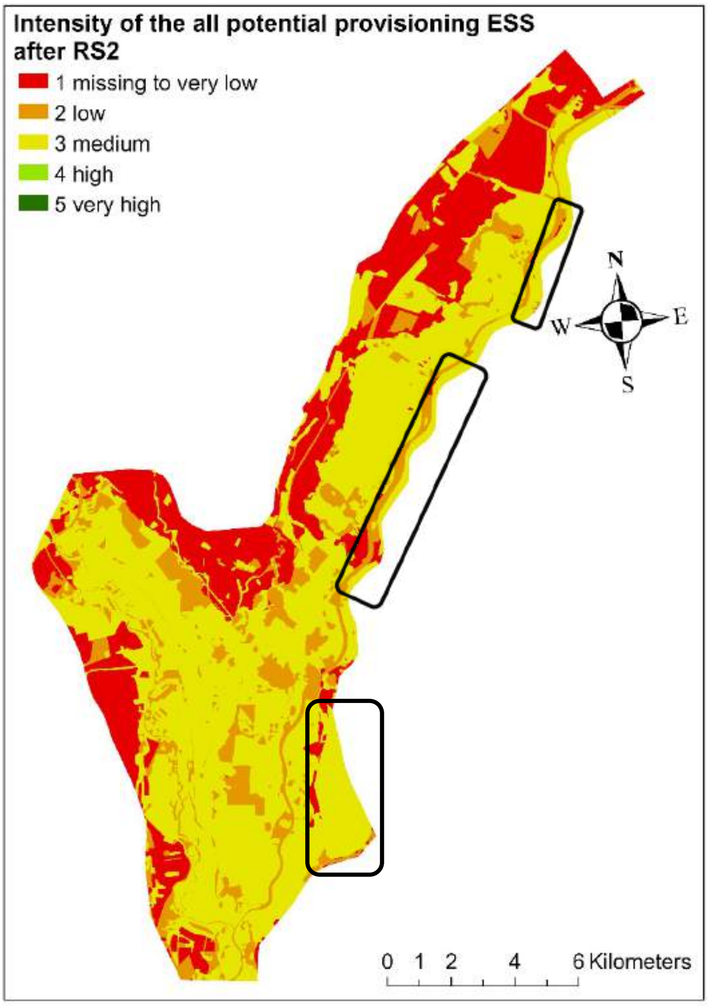


Figure 146: Intensity of all potential provisioning ESS after restoration scenario RS2. The values of the intensity of the potential ESS are marked in different colours.

The potential to provide all regulating ESS varies according to land cover/land use types in the current situation (figure 147). Within the restoration areas along the Morava River, the intensity for providing regulating ESS varies mainly between medium and low, only a few forested areas have a very high intensity. Natural forests provide regulating ESS at a very high level, natural water bodies and mesic grasslands at a high level, managed grasslands at a medium level, arable land and urban areas at a low level or very low level.

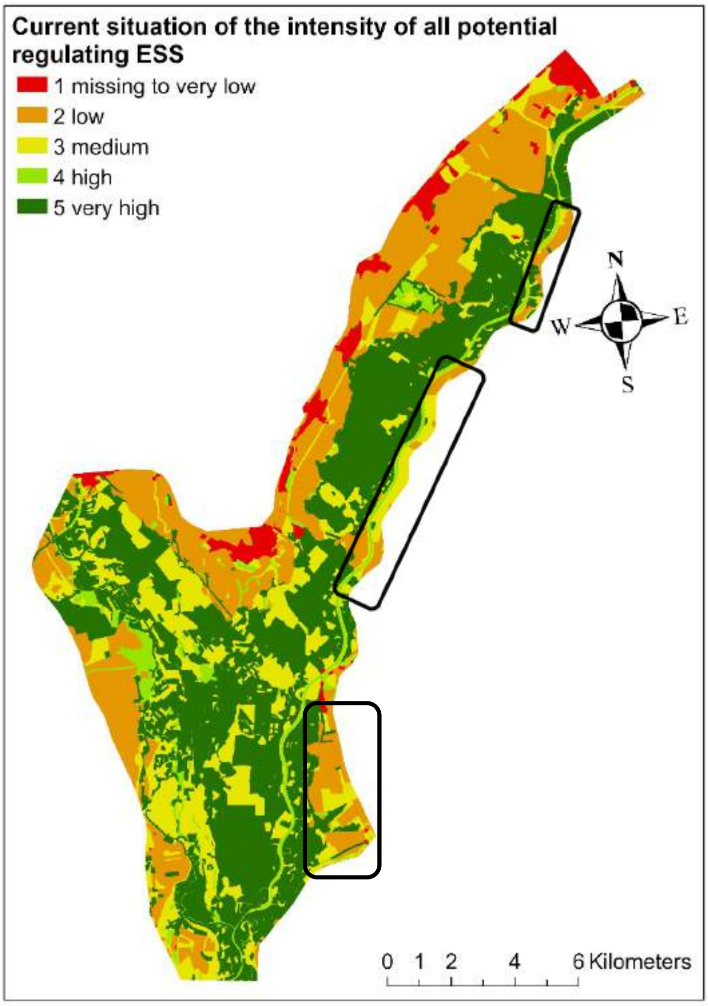


Figure 147: Intensity of all potential regulating ESS in the current scenario. The values of the intensity of the potential ESS are marked in different colours.

After dike relocations and afforestation within the restoration areas, the capacity to provide all regulating ESS will increase to a very high level (figure 148).

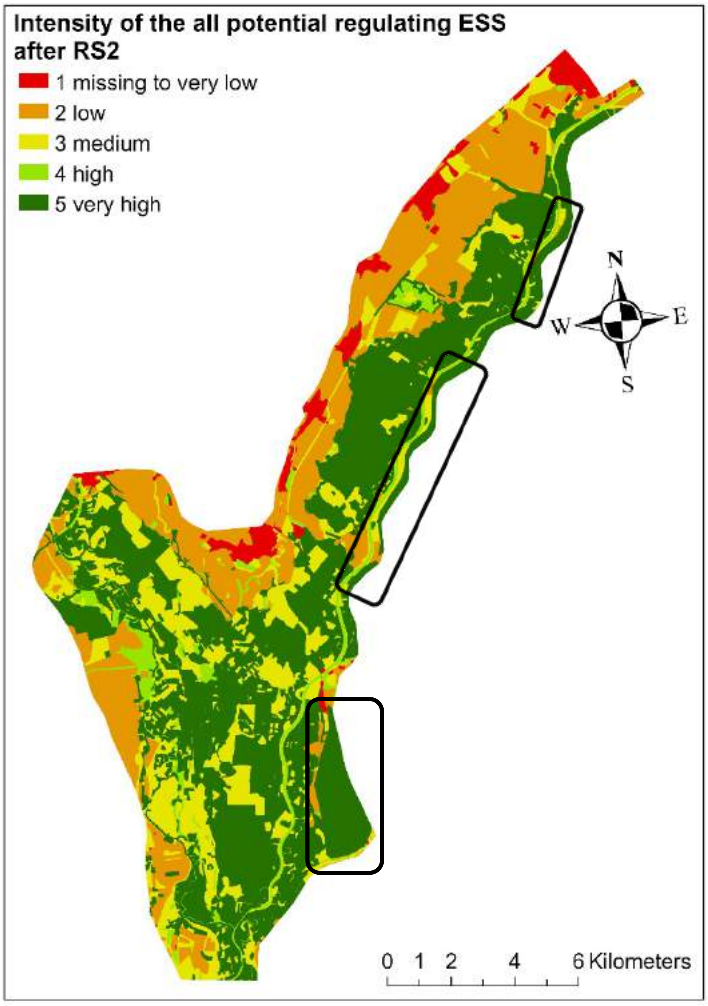


Figure 1485: Intensity of all potential regulating ESS after restoration scenario RS2. The values of the intensity of the potential ESS are marked in different colours.

6 Conclusions

The assessment of ESS based on land cover/land use generally resulted that natural forests provide regulating ESS at a very high level, natural water bodies and mesic grasslands at a high level. In contrast, human-influenced land cover/land use types have medium to no capacity to provide regulating ESS at high intensity, depending on the level of pressure.

The assessment of the intensity of the potentially provided ESS has shown in all five pilot projects that restoration measures such as dike relocation, afforestation or reconnection of floodplain waters almost have a positive effect on the regulating ESS. Rarely can these restoration measures negatively influence regulating ESS, such as ESS *nutrient retention* or ESS *noise regulation*, if riparian forests have to be cleared in the process. This has been shown in the evaluation of restoration scenarios on the Middle Tisza or Krka. Riparian forests in particular have a very high capacity to provide typical riparian ESS such as ESS *flood retention*, ESS *nutrient retention*, ESS *provision of habitats*, ESS *local climate regulation* and ESS *noise regulation*. When assessing the ESS provided, one would expect dike relocations or reconnection of the floodplain to the natural runoff system to have a strong negative impact on the provision of these ESS. However, even here, strong differences in the intensity of provision of the provisioning ESS have been shown. For provisioning ESS to benefit from restorative measures such as dike relocations, land use must be adapted accordingly. Riparian forests or extensive grassland can benefit from regular flooding. As shown by the ESS intensity assessment on the Middle Tisza, the intensity of the ESS wood, ESS animal products, ESS game meat, ESS honey and ESS fish can increase as a result. On the other hand, other agricultural products such as cereals and vegetables are likely to suffer from heavy crop losses due to regular flooding.

Therefore, the economic perspective for the use of the floodplains should also be taken into account, especially in measures to prevent flood risks and to improve the natural situation. It could be shown here that measures such as dyke relocations do not have to completely renounce further use of the floodplains, but that they should be adapted in their use according to the extended flooded area. Often, intensive agricultural use can be converted into extensive use, whereby livestock farming (grazing), commercial hunting or hunting tourism, as well as beekeeping, can benefit from this. If floodplain waters are reconnected to the river or the connected sidearms or oxbows are deepened or widened, fishing or angling tourism can benefit. The use of the forest for timber extraction can also benefit from the connection of the floodplain to the natural flow of the river. In a German project to monitore the "River and Floodplain Restoration on the upper Danube by establishing river continuum and ecological flooding", for example, it was shown that tree species typical of floodplains, such as oak, had their thickness growth severely restricted by disconnecting the floodplain from the river (Weißbrod & Binder 2016).

The approach used here to assess ESS is not suitable for assessing and presenting small-scale restoration measures such as the reconnection of sidearms and oxbow lakes in a very large area such as the pilot area Morava. Nevertheless, it is precisely these measures that would make unconnected water bodies available again as spawning and juvenile habitats for fish. This would increase the potential to provide ESS *fish* at a very high level and not remain at the same level as in the current situation, as has been shown. Also, assessing the ESS *water* in restoration scenario RS2 of the pilot area Morava shows no effect on the intensity of this ESS. This, in turn, is due to the method used here to record and evaluate ecosystem services. The dismantling of weirs and the reconnection of diked floodplains would lead to better water quality and thus to an increase in the provision of *ESS water.*

The maps of the combined ESS of the provisioning and regulating ESS give a first impression of the provision of ESS in an area. It is possible to show areas with a particularly high provision of ESS and to compare different scenarios. Looking at the ESS individually, it refines the picture of changes through scenarios. It is particularly useful to look at the provisioning ESS individually. The overall view gives the impression that the provisioning ESS, especially the *agricultural products*, play a subordinate role in the pilot areas. However, this does not apply for the pilot area Bistret. Agriculture is one of the most important source of income for the region. Due to the method of estimating the level of provision of regulating ESS of different land cover/land use classes, some of the regulatory services could be overestimated. Additional parameters would need to be considered, such as whether oxbow lakes are connected on one or both sides. This has an impact on the sedimentation intensity of these water bodies and thus on the ESS *provision of habitats* as well as on the ESS *local climate regulation*. The presence of weirs or dams is not taken into account either but also has a negative impact on some of the regulating ESS. In the future, the consideration of such parameters would be important and desirable. Furthermore, due to time and personal reasons, no suitable method could be found to visualize the cultural ESS as well. However, the workshops with the various stakeholders provided a good overview of which ESS are used to what extent. Nevertheless, when considering all results in total, it is still possible to obtain a good overview of the respective supply of ESS and their use.

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Annexe

Table 7: The estimated intensity of the potential ESS of each land cover/land use type MAES code 3 of pre-selected pilot area Begečka Jama by project-related and not related experts.

land cover/ land use type	MAES 3	The intensity of the potential provisioning ESS					The intensity of the potential regulating ESS						
		wood	animal product	honey	water	fish	air puri-fication	local climate regulation	low water regulation	flood retention	noise regulation	nutrient retention	provision of habitats
Urban fabric	111	0	0	0	0	0	0	0	0	0	0	0	0
Industrial, commercial and military units	112	0	0	3	0	0	1	2	3	0	1	0	1
Natural and semi-natural broadleaved forest	311	5	1	3	0	0	5	5	1	4	5	5	5
Transitional woodland and shrub	341	4	2	2	0	0	2	4	2	1	3	3	3
Managed grassland	410	1	5	3	0	0	2	4	2	3	2	3	2
Natural grassland without trees and shrubs	421	1	5	5	0	0	2	4	2	3	2	5	3
Beaches and dunes	621	0	0	0	0	0	0	1	5	3	0	1	1
Interconnected running watercourses	911	0	0	0	5	5	0	5	4	5	0	5	5
Separated water bodies belonging to the river system	912	0	0	0	3	3	0	5	2	5	0	5	5
Highly modified natural water courses and canals	913	0	0	0	2	3	0	5	2	5	0	5	4
Natural water bodies	921	0	0	0	5	5	0	5	5	5	0	5	4

Table 8: The estimated intensity of the potential ESS of each land cover/land use type MAES code 4 of pre-selected pilot area Bistret by project-related and not related experts. If two values for the intensity of the ecosystem service provided are entered in a cell, the first value is the intensity in the non-flooded areas and the second value indicates the intensity in the areas that are flooded during a biennial flood (HQ_2).

land cover/ land use type	MAES 4	The intensity of the potential provisioning ESS								The intensity of the potential regulating ESS						
		agricultural product	wood	animal product	game meat	honey	water	fish	water	air purification	local climate regulation	low water regulation	flood retention	noise regulation	nutrient retention	provision of habitats
Industrial or commercial units	1113	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Low density urban fabric	1121	0	0	0	0	2	0	0	1	4	0	0	1	0	1	0
Road network and associated land	1211	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non-irrigated arable land	2111	5/4	0	3/4	1/2	3/4	0	0	0/1	1/2	5/4	1/2	0	1/2	0/1	5/4
Irrigated arable land and rice fields	2131	3/2	0	0	0/1	3/4	0	0	0/1	1/2	5/4	1/2	0	1/2	0/1	3/2
Complex cultivation patterns	2321	4/3	1	3/4	3/4	4/5	0	0	1/2	3/4	4/3	1/2	1	2/3	1/2	4/3
Riparian and fluvial broadleaved forest	3111	0	5	1	5	1	0	0	5	5	1	4	5	5	5	0
Other natural & semi-natural broadleaved forest	3131	0	5	1	5	1	0	0	5	5	1	4	5	4/5	3/4	0
Highly artificial broadleaved plantations	3151	0	5	1	5	1	0	0	4	4/5	1	3	3	3/4	1	0
Transitional woodland and scrub	3411	0	4	1	5	2	0	0	2	4	2	1	3	3	3	0
Dry grasslands without trees and scrubs	4221	0	2	5	0	3	0	0	1	3	3	1	1	2	3	0
Mesic grasslands without trees and scrubs	4222	0	1	5	0	3	0	0	1	3	2	1	1	4	3	0
Sparsely vegetated areas	6111	0	0	0	0	0	0	0	0	0	5	1	0	2	3	0
River banks	6213	0	0	0	0	0	3	0	0	4	5	3	0	3	5	0
Inland freshwater marshes	7111	0	0	0	5	0	3	5	1	5	1	4	0	5	5	0
Permanent interconnected running water courses	9111	0	0	0	5	0	5	5	0	5	4	5	0	5	5	0
Highly modified natural water courses and canals	9113	0	0	0	3	0	5	3	0	4	1	4	0	3	1	0
Permanent separated water bodies belonging to the river system	9121	0	0	0	5	0	5	5	0	5	2	5	0	5	5	0
Natural water bodies	9211	0	0	0	5	0	5	5	0	5	5	5	0	5	4	0
Intensively managed fish ponds	9214	0	0	0	5	0	3	5	0	5	5	5	0	5	1	0