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A list of priority habitats requiring spatial connectivity and their restoration potential, in the framework of Action 12 of the Nature Action Plan (update)

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1 Habitats and connectivity

1.1 Introduction

This study presents illustrative habitats in need of spatial connectivity, in support of EU-transboundary protected areas management and in line with Green Infrastructure (GI). Based on sound scientific principles a selection of habitats is made based on their relevance for conservation and their need for an improved spatial connectivity. Moreover, it is requested that the examples show how Green Infrastructure can contribute to ecosystem services, in line with MAES (Eionet Art. 17 reporting, Maes *et al.* 2014).

In 'Our life insurance, our natural capital: an EU biodiversity strategy to 2020' the European Commission has set itself ambitious targets. Target 2 of the EU-Biodiversity Strategy is:

By 2020, ecosystems and their services are maintained and enhanced by establishing Green Infrastructure and restoring at least 15 % of degraded ecosystems.

Action 6b of the EU Biodiversity Strategy to 2020 concerns the development of a Green Infrastructure Strategy. The EU-wide strategy on Green infrastructure (GI) was adopted in 2013 and promotes investments to ensure that natural areas remain connected together, to restore the health of ecosystems and allow species to thrive across their entire natural habitat so that nature keeps on delivering its many benefits. GI is defined as:

Green Infrastructure is strategically planned network of high quality natural and semi-natural areas with other environmental features, which is designed and managed to deliver a wide range of ecosystem services and protect biodiversity in both rural and urban settings (European Commission 2013).

The underlying principle of Green Infrastructure is that the same spatial area can frequently perform multiple functions if its ecosystem is in a healthy state, resulting in win-win or 'small loss-big gain' solutions.

Green Infrastructure consists of a wide variety of environmental features which operate on different levels, from small elements such as green walls to healthy and fully functioning ecosystems. If well implemented, it can support conservation targets, as well as a variety of important environmental functions.

Spatial connectivity is one important function of Green Infrastructure. Some studies have been done for specific ecosystem types, such as forests (Estreguil *et al.* 2013). Also studies on (Pan) European networks and studies on landscape connectivity are used to expand the dataset (Bouwma *et al.* 2002; Bloemmen *et al.* 2004; Bouwma *et al.* 2004; Biro *et al.* 2006; Van der Sluis *et al.* 2012b; Bouwma *et al.* 2013).

The report is based on the preliminary study (Van der Sluis *et al.* 2018a) and the methodology was adjusted, the report has been improved, updated and expanded to clarify the methods. The analysis covers now a more complete selection of Annex I habitats.

1.2 Aim of the study

As shown in the above definition, GI can provide multiple benefits and a wide range of ecosystem services. The aim of this study is to provide a list of habitats which are sensitive to connectivity, and which do have potential for restoration. Further some examples are provided for habitat restoration and reconnection of areas through Green Infrastructure, with multiple benefits for the environment. All European priority habitats classified as 'unfavourable-inadequate' (U1) and 'unfavourable-bad' (U2), in some cases combined with 'favourable' (FV), and what their potential for restoration is.

The methods are described in Chapter 2, how the priority habitats were selected and which of the priority habitats were analysed. Next, the criteria are described and how they were used for a ranking of the potential and need for restoration.

Chapter 3 presents the results of the analysis, as well as a ranking of the restoration potential to come to a first prioritization of habitats. A few examples of successful habitat restoration programs are described in more detail and for few species well known for their needs in terms of connectivity in Chapter 4. In Chapter 5, finally there is a short discussion of the results as well as some recommendations for further study.

2 Methods

2.1 Introduction

This study consists of an analysis of the restoration potential of priority habitats, with the aim to improve spatial connectivity. A prioritization of habitats exists, and was developed by experts from ETC mostly. The selection of priority habitats is described in par. 2.2 below.

Several additional criteria have been applied to further prioritize between the large number of habitats of interest. The criteria applied are the 1) landscape configuration 2) biological vulnerability 3) abiotic vulnerability of habitat and 4) the restoration capacity. These criteria are further described in the paragraphs 2.3 below.

2.2 Selection of Priority habitats

In the Biogeographical Process a prioritization of habitats was prepared for most of the biogeographical regions (Table 2.1). For most regions there were some 20 habitats, only for the Continental a much larger number of priority habitats was selected, for various reasons.

Table 2.1: Priority habitats for the different biogeographical regions

Biogeographical region	Number of priority habitats for discussion	Reference
Boreal	18, including: 6 grasslands, 5 mires & bogs, 5 forests, 1 coastal, 1 freshwater	Pre-scoping document for the Boreal region , 2011
Atlantic	20, including: 6 grasslands, 3 mires &bogs, 1 forest, 2 heathlands and scrubs, 4 coastal, 4 freshwater	Pre-scoping document for the Atlantic region, 2012
Alpine	22 including: 6 grasslands, 3 mires &bogs, 7 forests, 6 freshwater	Revised pre-scoping document for the Alpine region, 2012
Mediterranean	23 including: 3 grasslands, 4 forests, 1 heathlands and scrubs, 13 coastal or marine, 2 freshwater	Pre-scoping document for the Mediterranean region, 2013
Continental/ Pannonian/ Steppic/ Black Sea	59 including: 18 grasslands, 7 mires & bogs, 14 forests, 4 heathlands & scrubs, 9 coastal, 6 freshwater, 1 rocky	Pre-scoping document for the Continental/Pannonian/Steppic/ Black sea regions, 2014
Macaronesian	No discussion has taken place yet between ES and PT for this region	Unofficial list, 2018

In the results table the Biogeographical regions have been shortened as follows: Bor, Atl, Alp, Med, Con, Pan, Stp, Bls, and Mac.

In different reports the priority habitats may vary, apparently there have been changes over time. To have an unambiguous list of priority habitats we used the lists as published on EIONET [1], reference lists which were updated on 23.04.2018.

[1] https://www.eionet.europa.eu/etcs/etc-bd/activities/building-the-natura-2000-network#autotoc-item-autotoc-3

Based on the Article 17 reporting on the conservation status of Habitats, the habitats have been classified according to their conservation status in the various Member States and Biogeographical Regions. They are classified as 'favourable' (FV), 'unfavourable-inadequate' (U1) and 'unfavourable-bad' (U2), XX unknown; (See also: https://nature-art17.eionet.europa.eu/article17/).

For the assessment of this report we have selected all habitats that are in an unfavourable-inadequate (U1) or unfavourable – bad (U2) conservation status (although U1 or U2 sometimes would have a favourable status in one or more biogeographical regions). This selection of priority habitats is the starting point for further review, an assessment of the potential for restoration, in particular with a view on improving spatial connectivity.

2.3 Criteria for the assessment of habitats

In 2018 an initial test of suitable criteria was done to estimate the potential for restoration, with a view to restore landscape connectivity through development of Green Infrastructure (Van der Sluis *et al.* 2018a).

Initial criteria selected were:

- landscape configuration vulnerability,
- biological vulnerability of habitats,
- abiotic vulnerability of habitats,
- restoration or regeneration capacity of habitats.

These criteria worked well for the first assessment. In this study the assessment was expanded to all habitats with U1 and U2 status, the classification was refined in some cases, and rigorously applied for the assessment of all habitats. In figure 2.1 the method is depicted. Below the criteria used are described in more detail.

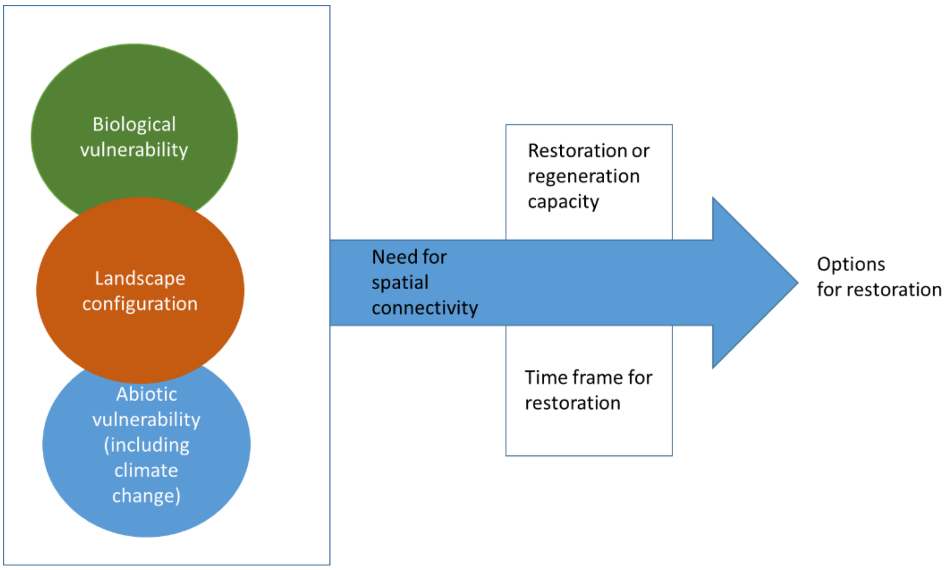
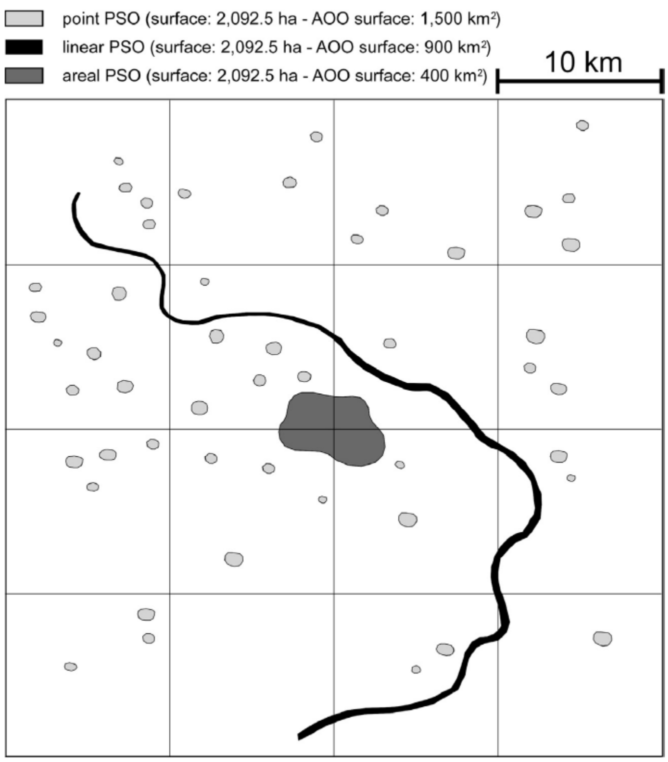


Figure 2.1 The approach taken to assess need for connectivity and options for restoration

2.3.1 Landscape configuration vulnerability/ pattern of habitat types

Our environment is spatially structured, and habitats have some intrinsic, ecologically based and scale-dependent spatial features, which give rise to different types of pattern of spatial occupancy. Depending on the spatial configuration, the habitats might have a different need for connectivity: the vulnerability and/ or the need for connectivity is higher for some habitat types than others. We identify three main patterns of habitat types: areal, linear and point pattern[2] which were considered as crucial features in explaining rareness of habitats (Gigante *et al.* 2016). This pattern of habitat is a tool to discriminate among broad categories of plant community-based habitat types. Figure 2.2 shows the various landscape patterns distinguished.

Habitats with point distribution, often naturally small in size and dispersed, are more susceptible to fragmentation. Linear habitat types and point habitat types are due to their small size more vulnerable too. At the same time several point habitat types are 'naturally fragmented', such as petrifying springs with tufa formation- also many of these habitats although susceptible to fragmentation cannot easily be spatially reconnected due to their very specific requirements.



[2] Areal habitat types: with an extended distribution; e.g. broadleaved temperate forests, natural and semi-natural grassland formations; linear: with a distribution in strips, where length is much greater than width, like riparian and water-dependant formations, coastal plant communities; point: with a naturally scattered spatial distribution, e.g. vegetation of temporary ponds.

Figure 2.2: The configuration of habitat types, like the linear habitat types, will also define suitability for measures to improve spatial connectivity. Three classes have been defined: point, linear, and areal habitats (Gigante et al. 2016)

Linear habitat types may be more suitable for improved spatial connectivity. Linear habitats may be related to coastal areas (cliffs, mudflats, dunes), to rivers (running water, floodplains) or rocky slopes (calcareous rocky slopes), forests depending on water et cetera (Gigante et al., 2016).

We determine in this study the need for connectivity based on the landscape configuration. The assessment is done based on the distribution as presented e.g. in the Art. 17 reporting [3]. The reporting shows distribution maps of the specific habitat type; based on this, as well expert knowledge of the authors, it was decided what type a particular habitat belongs to (linear, point, areal), this has been included in the resulting table. This assessment uses three landscape vulnerability levels that are important for spatial connectivity:

- Score 1 = Point (– naturally fragmented –the need for spatial connectivity is assessed as low although the systems can be very susceptible to fragmentation);
- Score 2 = Area (– medium landscape vulnerability);
- Score 3 = Linear (– highest landscape vulnerability).

2.3.2 Biological vulnerability of habitats

The need for connectivity of habitats is based on the specific species depending on the habitat. Some isolated habitats like moors and heathers may have (mostly) species with a very limited dispersal range (Van der Sluis 2000), whereas species e.g. from riverine habitats often have a much larger range (Foppen *et al.* 1999; Van der Sluis *et al.* 2007).

One study assessing the species-habitat interaction in relation to mobility of species within European ecological networks involved the quantitative modelling of species of Natura 2000 habitats for (mostly) the Atlantic and Continental Biogeographical region (Vos 2013). The model DIMO was used to model representative species from heathers, moors and dune associations, forests, and natural grasslands. An example for Rowan *Sorbus aucuparia* is presented in Figure 2.3. DIMO is a plant dispersal model that shows how plant species may move across regions when growing conditions change, for example, due to climate change. It can be used for analysis of spatial connectivity and for land use planning. DIMO simulates plant dispersal in time, given (abiotic) suitability and species-specific characteristics. As a result it gives the potential plant species distribution e.g. due to habitat changes. The maximum dispersal distance was calculated in the European landscape, from the South of France northwards for some 50 species.

[3] https://bd.eionet.europa.eu/article17/reports2012/habitat/summary/

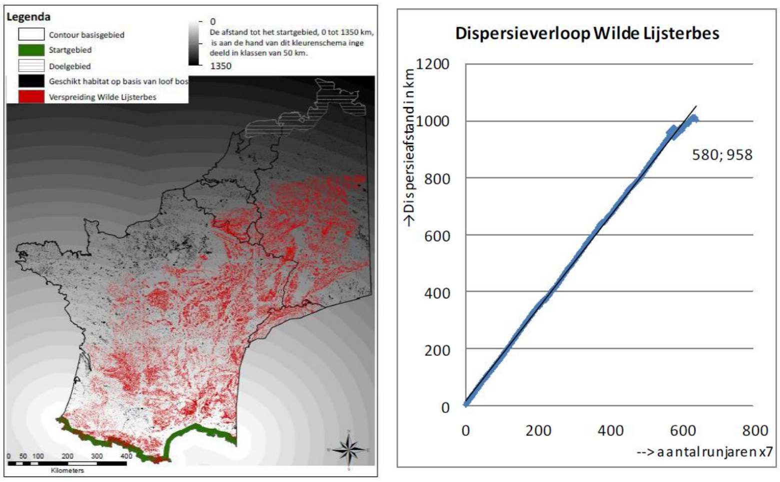


Figure 2.3 Dispersal map and graph for Rowan (Sorbus aucuparia), a fictive example for forest habitats, based on Dimo modelling (Vos 2013). The graph shows the modelling result, dependent on animal dispersal, with a potential dispersal of 958 km. Source: Vos (2013)

The description of habitats in the interpretation manual of the European Union describes also in some cases species which are dependent on a specific habitat type (DG-Env 2013). The possible options encountered for the selection of priority habitats are as follows:

1. no animals, plants,
2. insects and plants,
3. mammals,
4. birds,
5. plants, fish, insects,
6. invertebrates and vertebrates.

In the evaluation of habitats the need for connectivity **has been assessed based on specific fauna species mentioned in the interpretation manual**.

The following scores were assigned:

- Score 1 = no animals species mentioned only plants,
- Score 2= insects and plants mentioned,
- Score 3 = vertebrates (mammals, birds, fish) and plants mentioned.

2.3.3 Abiotic vulnerability of habitats

Besides the landscape configuration and biological vulnerability, also the abiotic vulnerability of habitats plays a role when prioritizing habitats with regard to the need for connectivity. The abiotic requirements of specific habitats will define the sensitivity for fragmentation and hence the need for connectivity. Important abiotic conditions are the vulnerability for desiccation, and climate change impacting on habitats.

Vulnerability for changes in hydrology

In particular the relation with groundwater might determine the vulnerability for fragmentation. A typology could be:

1. independent from ground water;

2. habitats dependant on groundwater;
3. habitats dependant on local seepage and perched water table.

For each habitat type an estimate could be made of the type of habitat, which group it belongs. We regard the last two classes as vulnerable for changes in hydrology.

The estimate of vulnerability with regard to groundwater therefore is **based on expert knowledge mostly,** in some cases **complemented with information from Art. 17 reporting regarding management measures related to hydrology.** Also, the fact sheets for habitats provide specific information on threats for the habitat type (see e.g. [4]). This assessment uses four vulnerability levels:

1. low vulnerability,
2. moderate vulnerability,
3. high vulnerability,
4. unknown.

Vulnerability to climate change

It has been argued that climate change requires a habitat network in order to allow for the movement of species following climate change (Heller and Zavaleta 2009; Verboom *et al.* 2010). Therefore an assessment was done of the vulnerability of habitats to climate change, based on the methodology for the EC Guidance for Climate Change (EU 2012). This assessment uses four vulnerability levels:

1. low vulnerability,
2. moderate vulnerability,
3. high vulnerability,
4. unknown.

This vulnerability to climate change has been incorporated in the current assessment, using this number in the results table.

2.3.4 Restoration or regeneration capacity of habitat

For some habitat types improvement of spatial connectivity is almost impossible due to specific abiotic conditions which are required or the long recovery time. Other habitat types might be more suitable for eco-engineering or other measures to restore or expand habitat.

The restoration capacity, expressing the ability of ecosystems, habitats or plant communities, to be restored to ecological integrity, can be expressed with grades ranging from 'none', through 'poor' and 'limited' to 'good'. This has sometimes been used, like in Bulgaria, (Biserkov ed.)[5] and Germany (Riecken 2006). In the marine environment, where there are limited options for active intervention, regeneration ability is the more commonly used terminology.

For the Netherlands a study was done listing measures for habitat restoration as well as the effectiveness of measures (Smits *et al.* 2000; Bijlsma *et al.* 2012). This however is not available for the

[4] https://eunis.eea.europa.eu/habitats-code-browser.jsp

[5] http://e-ecodb.bas.bg/rdb/en/vol3

remainder of Europe, and will therefore not cover all priority habitats; also, depending on the location effectiveness of restoration measures are likely to differ.

The indication of the restoration capacity of habitat types **has been prepared based on expert judgement as well as indications provided by the management measures, as described in the Article 17 reporting. T**he fact sheets for habitats provide sometimes specific information on restoration measures (see e.g. [6]). The classes are based on the classes mentioned in the description of the red list of habitat types (European Union, 2016).

The classes used in the table are:

- Impossible,
- very difficult,
- difficult,
- conditionally possible.

The estimates are, as mentioned, based on expert judgement, and may differ from place to place, based on the environmental conditions, biogeographical zone and specific time for recovery of habitat.

2.3.5 Time frame for restoration

The regeneration ability is assessed in time frames. For example, the Red List for European Habitats categorised restoration possibilities as 'impossible', 'hardly possible' (restoration period more than 150 years), 'difficult' (15-150 years) and 'conditionally possible' (under 15 years under favourable conditions, although certain typical species might need longer) (von Nordheim et al. 1996, in Rodwell *et al.* 2013).

This estimate partly aligns with the restoration capacity above, which might have been taken as a basis for the assessment. This was however corrected or adjusted where it was felt that the time frame was not correct, e.g. in the case of a Pine forest, which may be easy to restore, the development of the habitat type is likely to exceed. 50 years.

The classes used in the table are:

- Short,
- Intermediate,
- Long,
- Very long,
- - (impossible).

2.4 Mapping Ecosystem Services

An analytical framework for mapping and assessing the condition of ecosystems in relation to the services these ecosystems provide, has been developed by DG Environment, based on key indicators with the feedback of some Member States. The major results were published in the MAES Reports

[6] https://eunis.eea.europa.eu/habitats-code-browser.jsp

(Maes J *et al.* 2016; Estreguil *et al.* 2018; Maes *et al.* 2018). The CICES classification of Ecosystem Services was used (Version 5.1, EEA).

Ecosystem services do not occur independently, they often occur in bundles. Ecosystem services may be prevalent in some Biogeographical Regions, and less so in other; graphs are included in Annex I which demonstrate this link. Also certain habitats tend to have a particular correlation with services, which is also shown in Annex 1 (Ziv *et al.* 2018). This is obvious for e.g. grasslands that may be correlated with grazing. In Annex 1 an overview of these correlations is given; this has been guiding in the selection of Ecosystem services from the extensive list from CICES.

In this report the ecosystem services are described for some habitat types in Chapter 4. The selected ecosystem services are presented in Table 2.2.

Table 2.2: Selected ecosystem services and their relevant indicators/proxies

ES Section	Group Ecosystem Services	Indicator/Proxy
Provisioning	Cultivated crops (CC) Reared Animals (LSU) Wild animals and their output (WI) Materials from timber (MT) Plant-based resources (PR)	Percentage of crop production Livestock Yield, catch per effort Presence of forest and agroforest land Enhanced Vegetation Index (EVI)
Regulating and Maintenance	Erosion protection (EP) Climate regulation (CR) Flood Protection (FP) Pollination and seed dispersal (PS) Maintenance of Nursery Populations and Habitats (NS)	Soil Erosion Prevention (SEP) Below and Above-ground carbon storage Area of wetlands, coastal protection Pollination potential Shannon Diversity Index (SHDI)
Cultural	Outdoor Recreation (RC) Residential (RE) Inspiration (IN)	Recreation potential (natural habitat) Area build-up Extent of protected area

Some studies have been undertaken for specific ecosystem types, such as forests (Estreguil *et al.* 2013). Also studies on (Pan) European networks and studies on landscape connectivity are used to expand the dataset (Bouwma *et al.* 2002; Bloemmen *et al.* 2004; Bouwma *et al.* 2004; Biro *et al.* 2006; Van der Sluis *et al.* 2012b; Bouwma *et al.* 2013).

3 Results

3.1 Habitat assessment

3.1.1 Assessment for the parameters

We developed four distinct criteria to assess the need for connectivity, being landscape configuration, biological vulnerability, abiotic vulnerability: climate change and changes in hydrology. Further we assessed also the restoration capacity. Of the 104 selected priority habitats 68 were reviewed based on their unfavourable conservation status (U1 and U2).

Below the results are presented and discussed first for each criterion, next we prioritized vulnerability on the basis of a combined assessment of the four criteria. The criteria and rating is presented in table 3.1 below.

All scores for the habitats are added, which result in a total score for need for habitat connectivity. The maximum score can be 12, lowest score 2.

Table 3.1: Criteria to assess vulnerability, and rating for each criterion

Criterion	Class	Rating
Landscape configuration	point	1
	areal	2
	linear	3
Biological vulnerability	plants	1
	plants and invertebrates	2
	plants and mammals	3
	plants and birds	3
	plants, fish, insects	3
	plants, invertebrates vertebrates	3
Abiotic vulnerability	low vulnerability	1
- **Climate**	moderate vulnerability	2
	high vulnerability	3
	unknown	0
Abiotic vulnerability	low vulnerability	1
- **Hydrology**	moderate vulnerability	2
	high vulnerability	3
	unknown	0

Landscape configuration

The majority of the reviewed habitats (32 out of 68) have a landscape configuration categorized as ‘areal type’, as described in par. 2.3.1. Some 25 have a point configuration and eight of the reviewed habitat types have a linear configuration. Based on the MAES classification habitat types with a linear configuration are mostly Woodland/Forest (4), to a lesser extent (2) grasslands that occur along rivers or coastlines and sparsely vegetated areas and heathland Shrub (see Table 3.5).

Biological vulnerability

Most of the priority habitats are not specifically mentioned in conjunction with fauna species: in most cases only plant species are mentioned, and more general groups like 'invertebrate species'. Table 3.2 shows that for most habitats only plant species are indicated in the Habitats Manual description, most habitats (56 out of 68) seem -in that respect- not very vulnerable. For five habitats also invertebrates are indicated on top of plants, no mammals are observed, for five habitats birds in combination of plants, two habitat types for other species, including fish and vertebrates. Therefore, although this criterion is logical from an ecological point of view, the habitat manual description of associated species provides limited insights into biological vulnerability of the habitats. Following the MAES ecosystem types, most vulnerable are the woodland/Forest habitats, as well as grasslands.

Abiotic vulnerability

Table 3.2 shows that the abiotic vulnerability for climate change is high for six, moderate for 25 and low for 26 habitat types.

Abiotic vulnerability due to changes in hydrology are estimated as low for 41, moderate for 13 habitat types, high for 13 habitat types, unknown for one. With regard to the MAES classification habitat types with a high abiotic vulnerability are mostly wetlands and woodland/Forest, to a lesser extent grasslands and rivers/lakes that occur along rivers or coastlines (see Table 3.5).

Table 3.2: Selection of the Priority habitats for biogeographical regions with unfavourable conservation status, with an indication of the vulnerability (number of habitats)

	Point	**area**	**linear**	**mixed**		**Total**
Landscape configuration vulnerability	25	32	8	3		68
	no animals	**insects**	**mammals**	**birds**	**Multiple**	
Biological vulnerability	56	5	0	5	2	68
	Low	**moderate**	**high**	**unknown**		
Abiotic vulnerability (climate change)	26	25	6	11		68
Abiotic vulnerability (changes in hydrology)	41	13	13	1		68

Restoration capacity of Habitat

Restoration capacity is 'impossible' for two, and 'very difficult' for five habitats. For 30 habitat types it is 'difficult' with regard to restoration opportunities, whereas most, 31 are 'conditionally possible', which might mean a restoration period under 15 years under favourable conditions.

3.1.2 Overall assessment

Table 3.3 shows the results based on a ranking exercise using the four criteria. For each of the criteria a numerical score is given (described in the previous paragraphs). The need for connectivity is a simple summation of the ranking criteria for all factors, which means that the lowest calculated value would be 2, highest would be 12. Therefore, we assume a high need for connectivity with a score of 8.5 or more, a moderate need for connectivity is a score between 6-8, and a score below of 3-5.5 means a lesser need for connectivity. This, however, can be judged an arbitrary choice, and is depending on the scores and distribution over habitats. Based on this score, the distribution would be as follows:

Table 3.3: Total score for the need for connectivity, based on landscape configuration and biotic and abiotic vulnerability of the habitat type

Score	Need for connectivity	# types
3-5.5	less important	29
6-8	Moderate	32
8.5-11	High	7

Based on the ranking only one habitat type ranks high on all four criteria, being *1630- Boreal Baltic coastal meadows*. The habitat scores high due to its linear landscape configuration, its' biological vulnerability based on associated bird species, its sensitivity for climate change and dependence on groundwater.

Second ranking is the habitat type *9010* - Western Taiga, although the landscape vulnerability is slightly lower.

Also 7120- Degraded raised bogs still capable of natural regeneration, score high with 10 points.

The other four habitats score slightly lower with 8.5 or 9.

Another 32 habitat types score *moderate need for connectivity*.

We used the MAES classification for further analysis of the results. The four habitat types with a linear configuration are grasslands that occur along rivers or coastlines (Table 3.5). Some two habitat types belonging to sparsely vegetated area and one is belonging to the wetland group.

3.1.3 Habitats most in need for connectivity

The habitats ranking highest in the score (table 3.5) are presented in table 3.4. They are well distributed over most biogeographical regions, some are restricted to one or two regions (1630 - Boreal Baltic coastal meadows, 7120 - Degraded raised bogs still capable of natural regeneration, 9360 - Macaronesian laurel forests, 7310 - Aapa mires), 9010 - Western Taiga and 91E0 - Alluvial forests have a wider range (Eionet reporting Art. 17, DG-Env 2013).

The final table ranking the habitats is presented in Table 3.5.

Table 3.4: Habitats most in need for connectivity

Habitat type	Priority BGR	Conserv. Status	Need for connec-tivity	Potential for restoration	Time frame	Maes classification	Need for connec-tivity
1630 Boreal Baltic coastal meadows	Bor, Con	U2	11	difficult	Intermed iate	grassland	high
9010 Western Taiga	Alp, Bor, Con	U1/U2	10	difficult	long	woodlandForest	high

7120 Degraded raised bogs still capable of natural regeneration	Bor, Con	U2	10	difficult	long	wetlands	high
9360 Macaronesian laurel forests	Mac	U1	9	difficult	long	woodlandForest	high
7310 Aapa mires	Alp, Bor	U1/FV	9	cond. Possible	long	wetlands	high
91E0 Alluvial forests with Alnus glutinosa and Fraxinus excelsior	Med, Alp, Bls, Bor, Con, Pan	U2/U1	9	High	Intermed iate	woodlandForest	high
3170 Mediterranean temporary ponds	Med, Alp, Con, Mac	U1/XX/FV	8	cond. Possible	short	riversLakes	moderate

3.1.4 Potential for restoration and time frame

For all habitats an estimate was made of the restoration capacity (see 2.3.5). This can be used as indication for the restoration potential; Also habitats with high restoration potential can be selected based on table 3.5.

Table 3.5: Ranking of the 30 habitat types based on the four criteria. Need for connectivity column can be read as High need for connectivity= score > 8.5, moderate need for connectivity score between 6-8, low need for connectivity < 6

Habitat type	Priority BGR	Conserv. Status	Landscape configuration vulnerability	Biological vulnerability	Abiotic vulnerability (climate)	Abiotic vulnerability (hydrology)	Potential for restoration	Need for connectivity Score	Potential for restoration	Time frame	Maes classification
1340 - Inland salt meadows	Med, Alp, Atl, Con, Pan	U2	point	1	moderate	high	difficult	7	difficult	Intermediate	grassland
1510 - Mediterranean salt steppes (Limonietalia)	Med	XX	areal	1	unknown	moderate	difficult	5	difficult	long	grassland
1520 - Iberian gypsum vegetation (Gypsophiletalia)	Med	U1/XX	areal	1	unknown	low	cond. Possible	4	cond. Possible	short	heathlandShrub
1530 - Pannonic salt steppes and salt marshes	Con, Bls, Pan, Stp	U2	areal	1	unknown	moderate	difficult	5	difficult	long	grassland
1630 - Boreal Baltic coastal meadows	Bor, Con	U2	linear	4	high	moderate	difficult	11	difficult	Intermediate	grassland
2130 - Fixed coastal dunes with herbaceous vegetation ("grey dunes")	Med, Bls, Bor, Atl, Con, Mac	U2	linear	1	moderate	low	cond. Possible	7	cond. Possible	short	grassland
2140 - Decalcified fixed dunes with Empetrum nigrum	Bor, Con	U1	point	1	low	moderate	difficult	5	difficult	long	heathlandShrub
2150 - Atlantic decalcified fixed dunes	Med, Con	U1/U2	point	1	low	low	difficult	4	difficult	Intermediate	heathlandShrub
2250 - Coastal dunes with Juniperus spp.	Med, Atl, Bor, Con, Mac, Bls	U1/U2	linear	1	moderate	low	cond. Possible	7	cond. Possible	short	heathlandShrub
2270 - Wooded dunes with Pinus pinea and/or Pinus pinaster	Med, Con	U1	linear	1	low	low	difficult	6	difficult	long	woodlandForest
2340 - Pannonic inland dunes	Con	U2	point	1	unknown	low	difficult	3	difficult	long	sparselyVegetated

Habitat type	Priority BGR	Conserv. Status	Landscape configuration vulnerability	Biological vulnerability	Abiotic vulnerability (climate)	Abiotic vulnerability (hydrology)	Potential for restoration	Need for connectivity Score	Potential for restoration	Time frame	Maes classification
3170 - Mediterranean temporary ponds	Med, Alp, Con, Mac	U1/XX/FV	point	1	high	high	cond. Possible	8	cond. Possible	short	riversLakes
3180 - Turloughs	Med, Alp, Bor, Con	U1/U2	point	2	moderate	high	cond. Possible	8	cond. Possible	short	riversLakes
31A0 - Transylvanian hot-spring lotus beds	Pan	XX	point	5	unknown	moderate	cond. Possible	7	cond. Possible	short	riversLakes
4020 - Wet heaths	Med, Alp, Con	U1/U2/XX	point	1	moderate	high	difficult	7	difficult	Intermediate	heathlandShrub
4050 - Endemic macaronesian heaths	Mac	FV	areal	1	low	low	difficult	5	difficult	long	heathlandShrub
4070 - Pinus mugo	Alp, Con	FV/U1	areal	1	moderate	low	cond. Possible	6	cond. Possible	long	heathlandShrub
40A0 - Subcontinental peri-Pannonic scrub	Alp, Bls, Con, Pan	U1/U2	point	1	low	low	cond. Possible	4	cond. Possible	Intermediate	heathlandShrub
40C0 - Ponto-Sarmatic deciduous thickets	Con, Stp	U1	point	1	unknown	low	difficult	3	difficult	long	heathlandShrub
5140 - Cistus palhinhae formations on maritime wet heaths	Med	U1	point	1	moderate	moderate	difficult	6	difficult	long	heathlandShrub
5220 - Arborescent matorral with Zyziphus	Med	U2	point	1	moderate	low	cond. Possible	5	cond. Possible	Intermediate	heathlandShrub
5230 - Arborescent matorral with Laurus nobilis	Med, Con	U1	point	1	low	low	cond. Possible	4	possible	long	heathlandShrub
6110 - Rupicolous calcareous or basophilic grasslands of the Alysso-Sedion albi	Med, Alp, Bls, Bor, Con, Pan	U1/U2	point	1	low	low	cond. Possible	4	cond. Possible	short	sparselyVegetated
6120 - Xeric and calcareous grasslands	Med, Bls, Bor,	U2	areal	1	moderate	low	cond. Possible	6	cond. Possible	short	grassland

Habitat type	Priority BGR	Conserv. Status	Landscape configuration vulnerability	Biological vulnerability	Abiotic vulnerability (climate)	Abiotic vulnerability (hydrology)	Potential for restoration	Need for connectivity Score	Potential for restoration	Time frame	Maes classification
	Con, Pan, Stp										
6220 - Pseudo steppe	Med, Alp, Bls, Con	U1/U2	areal	1	low	low	cond. Possible	5	cond. Possible	short	grassland
6230 - Species-rich Nardus grasslands, on silicious substrates in mountain areas	Med, Alp, Bor, Con, Pan	U2	point	4	moderate	low	difficult	7	difficult	long	grassland
6240 - Sub-Pannonic steppic grasslands	Alp, Bls, Con, Pan	U1/U2	point	1	low	low	cond. Possible	4	possible	short	grassland
6250 - Pannonic loess steppic grasslands	Con, Pan	U1	areal	1	low	moderate	cond. Possible	6	cond. Possible	Intermediate	grassland
6260 - Pannonic sand steppes	Con, Pan	U1/U2	areal	2	low	low	cond. Possible	6	cond. Possible	Intermediate	grassland
6270 - Fennoscandian lowland species-rich dry to mesic grasslands	Alp, Bor	U2	areal	1	moderate	low	difficult	6	difficult	long	grassland
6280 - Nordic alvar and precambrian calcareous flatrocks	Bor, Con	U2/FV	areal	1	moderate	high	very difficult	8	very difficult	long	grassland
62B0 - Serpentinophilous grasslands of Cyprus	Med	FV	areal	1	low	low	difficult	5	difficult	long	grassland
62C0 - Ponto-Sarmatic steppes	Bls, Con, Stp	U1	areal	1	unknown	low	very difficult	4	very difficult	long	grassland
6530 - Fennoscandian wooded meadows	Bor, Con	U2	point	1	low	unknown	difficult	3	difficult	Intermediate	grassland
7110 - Active raised bogs	Med, Alp, Bor, Con, Mac, Pan	U1/U2	point/areal	2	moderate	high	cond. Possible	8.5	cond. Possible	long	wetlands
7120 - Degraded raised bogs still	Bor, Con	U2	point	4	high	high	difficult	10	difficult	long	wetlands

Habitat type	Priority BGR	Conserv. Status	Landscape configuration vulnerability	Biological vulnerability	Abiotic vulnerability (climate)	Abiotic vulnerability (hydrology)	Potential for restoration	Need for connectivity Score	Potential for restoration	Time frame	Maes classification
capable of natural regeneration											
7210 - Calcareous fens with Cladium mariscus and species of the Caricion davallianae	Med, Alp, Con, Pan, Stp	U1/U2/FV	point	1	moderate	high	very difficult	7	very difficult	long	wetlands
7220 - Petrifying springs with tufa formation	Med, Alp, Bls, Con, Mac, Pan	U1/U2	point	1	low	high	very difficult	6	very difficult	long	wetlands
7240 - Alpine pioneer formations of Caricion bicoloris-atrofuscae	Med, Alp	U2	point/linear	2	moderate	moderate	cond. Possible	7.5	cond. Possible	short	wetlands
7310 - Aapa mires	Alp, Bor	U1/FV	areal	2	moderate	high	cond. Possible	9	cond. Possible	long	wetlands
7320 - Palsa mires	Alp, Bor	U2	point	1	high	moderate	difficult	7	difficult	long	wetlands
8160 - Calcareous scree	Atl, Alp, Con, Pan	U1/U2/FV	linear	1	moderate	low	cond. Possible	7	possible	short	sparselyVegetated
8240 - Limestone pavements	Med, Alp, Bor, Con	U1/FV	areal	1	unknown	low	impossible	4	impossible	-	sparselyVegetated
9010 - Western Taiga	Alp, Bor, Con	U1/U2	areal	6	high	moderate	difficult	10	difficult	long	woodlandForest
9020 - Fennoscandian hemiboreal natural old broad-leaved deciduous forests	Bor, Con	U1/U2	areal	1	low	low	difficult	5	difficult	long	woodlandForest
9030 - Natural forests of primary succession stages of landupheaval coast	Bor	U1	linear	1	low	low	cond. Possible	6	cond. Possible	Intermediate	woodlandForest
9080 - Fennoscandian	Alp, Bor, Con	U2	linear	1	low	moderate	difficult	7	difficult	long	woodlandForest

Habitat type	Priority BGR	Conserv. Status	Landscape configuration vulnerability	Biological vulnerability	Abiotic vulnerability (climate)	Abiotic vulnerability (hydrology)	Potential for restoration	Need for connectivity Score	Potential for restoration	Time frame	Maes classification
deciduous swamp woods											
9180 - Tilio-Acerion forests of slopes, screes and ravines	Med, Alp, Bls, Bor, Con, Pan	U2/U1	areal	1	low	moderate	difficult	6	difficult	long	woodlandForest
91AA - Eastern white oak woods	Med, Alp, Bls, Con, Stp	U2	areal	1	unknown	low	cond. Possible	4	cond. Possible	Intermediate	woodlandForest
91D0 - Bog woodland	Alp, Bor, Con, Mac	U1/U2	point	1	moderate	high	difficult	7	difficult	long	woodlandForest
91E0 - Alluvial forests with Alnus glutinosa and Fraxinus excelsior	Med, Alp, Bls, Bor, Con, Pan	U2/U1	linear	1	moderate	high	cond. Possible	9	High	Intermediate	woodlandForest
91G0 - Pannonic woods with Quercus petraea and Carpinus betulus	Alp, Bls, Con, Pan	U1	areal	1	low	low	cond. Possible	5	cond. Possible	long	woodlandForest
91H0 - Pannonian woods with Quercus pubescens	Med, Alp, Bls, Con, Pan	U2/U1	areal	1	moderate	low	cond. Possible	6	cond. Possible	Intermediate	woodlandForest
91I0 - Euro-Siberian steppic woods with Quercus spp.	Alp, Bls, Con, Pan, Stp	FV/U1/U2	areal	1	low	low	cond. Possible	5	cond. Possible	long	woodlandForest
91N0 - Pannonic inland sand dune thicket	Pan	U2	areal	1	low	low	cond. Possible	5	possible	short	woodlandForest
91S0 - Western Pontic beech forests	Bls, Con	U1	areal	1	unknown	low	cond. Possible	4	cond. Possible	long	woodlandForest
91X0 -Dobrogean beech forests	Stp	U1	areal	1	unknown	low	impossible	4	impossible	-	woodlandForest
9210 - Appenine beech	Med, Alp, Con	FV/U1	areal	1	low	low	difficult	5	difficult	very long	woodlandForest
9220 - Appenine beech w abies	Med, Alp, Con	FV	areal	1	low	low	difficult	5	difficult	very long	woodlandForest
9360 - Macaronesian laurel forests (Laurus, Ocotea)	Mac	U1	point	4	high	moderate	difficult	9	difficult	long	woodlandForest

Habitat type	Priority BGR	Conserv. Status	Landscape configuration vulnerability	Biological vulnerability	Abiotic vulnerability (climate)	Abiotic vulnerability (hydrology)	Potential for restoration	Need for connectivity Score	Potential for restoration	Time frame	Maes classification
9370 - Palm groves of Phoenix	Med, Mac	FV/U1	point	1	low	high	cond. Possible	6	cond. Possible	Intermediate	woodlandForest
9390 - Scrub and low forest vegetation with Quercus alnifolia	Med	FV	areal	1	moderate	low	cond. Possible	6	cond. Possible	Intermediate	woodlandForest
9510 - Appenine abies	Med, Alp	U1	areal	1	moderate	low	difficult	6	difficult	very long	woodlandForest
9530 - Medit pine	Med, Alp, Con	U1	areal	4	low	low	difficult	7	difficult	long	woodlandForest
9560 - Endemic Juniper	Med, Alp, Con, Mac	U1/U2	point/areal	1	moderate	low	very difficult	5.5	very difficult	very long	woodlandForest
9570 - Tetraclinis articulata forests	Med	U1	areal	1	moderate	low	cond. Possible	6	cond. Possible	Intermediate	heathlandShrub
9580 - Medit Taxus baccata	Med, Alp, Atl	U1/U2	point	1	low	low	difficult	4	difficult	long	woodlandForest
9590 - Cedrus brevifolia forests	Med	FV	areal	1	moderate	low	difficult	6	difficult	long	woodlandForest

3.2 Ecosystem Services associated with restoration measures

Based on measures for defragmentation, and development of Green Infrastructure, the provision of Ecosystem Services may change. Selected ecosystem services for this assessment are related to Provisioning services, Regulating and Maintenance services, and Cultural services.

Although this selection might be challenged to be subjective, the selected services are relevant in the wider European context and commonly used in other studies, and selected services may change as a result of landscape changes or measures for GI (Vallés-Planells *et al.* 2014; Bürgi *et al.* 2015). To estimate how the service provision changes as a result of measures to improve connectivity through GI, a semi-quantitative approach is followed based on the analysis of land cover change (Table 3.6) (Van der Sluis *et al.* 2018b).

The results are related to the examples described in Chapter 4 below.

Table 3.6: Quantitative assessment of change in landscape service provision in study areas: + increase, ++ : strong increase, - decrease, -- strong decrease, ◦ negligible

Example study / Service Provision	Boreal Baltic Meadows (H1630)	Aapa mires (H7310)	Temporary Mediterranean ponds (H3170)	Alluvial forests (H91E0)
Cultivated crops (CC)	◦	◦	◦	◦
Reared Animals (LSU)	++	◦	◦	+
Wild animals and their output (WI)	+	+	◦	++
Materials from timber (MT)	◦	◦	◦	++
Plant-based resources (PR)	++	+	◦	++
Erosion protection (EP)	++	++	+	++
Climate regulation (CR)	+	++	◦	++
Flood Protection (FP)	++	++	++	++
Pollination and seed dispersal (PS)	++	+	+	+
Maintenance of Nursery Populations and Habitats (NS)	++	++	++	++
Outdoor Recreation (RC)	+	+	++	++
Residential (RE)	+	◦	◦	+
Inspiration (IN)	++	+	++	++

4 Descriptions of some habitats and species

Below, information related to the ecology, the conservation status, the main threats, measures for GI and possible services are described for a selection of habitats assessed in this report.

The same information have been collected for few species well known for their needs in terms of connectivity. For the description of the Stag beetle and Large copper use was made of material prepared by W. van Wingerden and C. van Swaay (van der Sluis et al. 2004), which was updated and expanded for this purpose.

4.1.1 (1630) Boreal Baltic coastal meadows*

Ecology and distribution

The ‘Boreal Baltic coastal meadows’ are characterized by low growing plant communities. They occur in the geolittoral zone and are sometimes interspersed with salt patches. Characteristically the vegetation occurs in distinct zones, with saline vegetation closest to the sea. The salinity is low since tide hardly exists, but they can be affected by land upheaval.

The habitat is widespread along the Baltic coast of Estonia, Finland and Sweden, rare in Latvia and absent from Lithuania. Estonia reported the largest habitat area. Of the approximately 190 km^2 of this habitat in the Boreal region, about 78 % is included in Natura 2000 sites.

Land use in this zone consisted historically mostly of grazing and mowing, which resulted in a gradual expansion of the habitat, keeping the vegetation low and open and rich in vascular plants. The flora is very rich, e.g. in Estonia a total of 390 plants species have been found on coastal meadows, which is 26% of all Estonian species. More than 20 protected species grow on coastal meadows, including many orchids: *Dactylorhiza ruthei*, Frog orchid, Fen orchid, Baltic orchid, Blood-red dactylorhiza, Early marsh orchid, Musk orchid, Marsh helleborine, Early-purple orchid, Common spotted orchid, Military orchid, Fly orchid and Fragrant orchid. Other decorative species in coastal meadows are: *Gladiolus imbricatus, Armeria maritima, Tetragonolobus maritimus*, large pink *Dianthus superbus* and Red kidney vetch (2011).

Important bird species depending on this habitat type and adjoining lagoons (Habitat 1150) is Birds Directive Annex I species Eurasian bittern (*Botaurus stellaris*), and several Annex II species, including black-tailed godwit (*Limosa limosa*), Common redshank (*Tringa totanus*), Mute swan (*Cygnus olor*), Eurasian coot (*Fulica atra*), Northern lapwing (*Vanellus vanellus*) and Common snipe (*Gallinago gallinago*). Also the Dunlin (*Calidris alpinas schinzii*), Ruff (*Philomacus pugnax*) and other meadow wader species breed, and grassland passerine community is present. A large number of waders of different species, as well as migrating geese and other waterfowl are present during passing migration (Rūsiņa *et al.* 2017). In moister areas, large sedge tussocks are preserved, which are important for birds. This also indicates that the scale of the area and variety of habitats defines the completeness of bird assemblages (Rūsiņa *et al.* 2017).

Coastal meadows are valuable habitats for a large diversity of invertebrate species, in particular nectar feeding species and grassland species associated with animal excrement. One of the few endemic insects found in Estonia, *Aeschna osiliensis*, is specifically associated with coastal meadows and other coastal habitats. Seaweed mounds and salinas are home to an unconventional community of predatory beetles. Shallow water bodies that appear in coastal meadows provide habitat for the rare large white-faced darter (*Leucorrhinia pectoralis*). In coastal meadows there are various dragonflies and species of *homoptera*, *auchenorrhyncha* and *heteroptera*. Areas with a long standing grazing tradition feature sods generated by ant species of *Lasius* and *Myrmica*.

Conservation status

The conservation status of this habitat type is unfavourable-bad, based on the assessment in all Member States except Estonia which reported unfavourable-inadequate. The range is favourable in all countries, but other parameters are poor or bad for most of the region. In Sweden the bad situation is stable.

Problem

Inappropriate land use, particularly the abandonment of agricultural management (grazing and mowing) represents the major pressure to this habitat type. Abandonment of traditional management results in encroachment, which causes a decline in bird populations: grasslands smaller than 10 ha, will hold no waders and the passerine community may be incomplete. Pressures with less intensity are recreation, sport and water pollution. Finland informed that dredging/ removal of limnic sediments and dumping and depositing of dredged deposits is a threat.

Proposed measures for GI

Appropriate management is the main proposed measure for maintenance of grasslands. Other proposed measures include establishment of protected areas and improvement of legislation. The 'Natureship project (2009–2013)', financed by the EU Central Baltic Interreg IV A Programme 2007–2013 and national funding providers. The project has two focus areas: ”Water protection and coastal planning” and ”Biodiversity and cultural landscapes”. The project activities target coastal areas in Finland, Sweden and Estonia. A total of eleven organisations have been involved in project implementation. Lead partner is the Centre for Economic Development, Transport and the Environment in Southwest Finland, with other partners from Finland such as Metsähallitus, the University of Turku, municipalities, from Estonia Environmental Board of Estonia and University of Tartu, and from Sweden the County of Gotland and Norrtälje Nature Conservation Foundation.

The goal of the project is to increase cooperation in habitat management and water protection in the Central Baltic operating area. The most important objectives of the Natureship project are promoting interdisciplinary coastal planning following the principles of sustainable development. The aim of integrated coastal planning is to find solutions that will benefit all users of the area over the long term, taking natural values into account. It aims at finding best cost-efficient methods for water protection and biodiversity and rating ecosystem services.

The project has promoted conservation cooperation between these areas and the exchange of experiences on habitat and species management. Ecosystem service thinking plays a role in the planning and implementation of management measures. The project aims at finding win-win solutions that benefit all: nature, water protection, local farmers and entrepreneurs, as well as inhabitants. Special emphasis is placed on Natura 2000 areas.

To proceed in reaching the objective of multiple-use planning, an optimal network of harvested reed beds and coastal meadows is being designed in the project for areas where reed beds are growing heavily.

Photo 4.1: Coastal meadows, Lihula Vala N2000 site, Estonia

Photo: © Theo van der Sluis

Assessment of Ecosystem Services

Ecosystem services related to the proposed measures, as described above, are discussed in par. 2.4 and presented in Table 3.6.

The Boreal Baltic coastal meadows are maintained through livestock herds which as part of agro-ecosystems have different outputs, reared animals and their resources, hay and possible other wildlife. ES include the supply of nutrition and other renewable natural resources as well as occurrence of natural ecosystem processes, maintenance of water resources and circulation of nutrients. The meadow ecosystem can protect the coast against erosion, floods, and do some climate regulation, but the meadows also maintain pollinator populations and livestock will facilitate seed dispersal. Ecosystem services also include recreational use of nature and the experiences obtained there, as well as residential services, and inspirational services.

4.1.2 (7310) Aapa mires (including mires or raised bogs, e.g. 7120, 7140)*

Ecology and distribution

The aapa mires are only found in the southern, middle and northern Boreal region and the adjacent part of the Alpine region. It is a broad wetland, with open areas in its centre, the edges consist of forested pine bogs and fens. Aapa mires are mineratrophic: they receive their nutrients from the surrounding area, so the centre is relatively low-lying. An aapa mire can also obtain nutrients from the underlying soil, from groundwater or run-off from surrounding areas. In springtime the snowmelt will contribute to water collecting in the mire. At the edge of the aapa mire there is usually a gradient from wetland into wet peaty mineral soils into upland forests. The mire consists of linear structures called 'flarks', and 'strings', wet non vegetated and mossy strips alternating. Special bogs are the palsa mires (with frozen centre) and hanging bogs.

The mire complexes are characterised by a minerotrophic fen vegetation in the central parts of the complexes. The peat in aapa mires is most typically formed of brown moss (*Bryales* sp.), species like

Warnstorfia procera and residues of sedgelike plants. Most of peatmoss (Sphagnum spp.) species suffer from excess moisture and they consist mostly of the surface layer of the peat column. Many vascular plants, among others twigs and dwarf arctic birch (*Betula nana*) succeed best in strings. Among others bogbean (*Menyanthes trifoliata*) and many sedges (*Carex spp*.) thrive in flark. Highest species richness is found in fen areas, with accumulation of nutrients. Here in particular orchid species are found such as *Dactylorhiza cruenta, D. traunsteineri* and *Malaxis monophyllos*.

The aapa mires are important nesting, resting and foraging areas for birds. The number of species of nesting birds increases from south to north, contrary to other environments. A large number of invertebrate species ensures the supply of food and, due to its limited accessibility it is well protected for the breeding of species. Important bird species depend on this habitat type. In mire lakes black-throated divers (*Gavia arctica*), Smews (*Mergus albellus*) and many other duck species are found. The number of waders is very high; the most typical species are wood sandpiper (*Tringa glareola*), broad-billed sandpiper (*Limicola falcinellus*) and ruff (*Philomachus pugnax*). Forest fragments host in particular many passeriformes, and Western capercaille (*Tetrao urogallus*).

Some particular butterfly species for aapa mires are: *Pyrgus centaureae, Erebia disa*; Moths: *Syngrapha diasema, Apamea maillardi, Nola karelica, Hypoxyxtis pluviaria*.

Conservation status

Aapa mires are assessed as "unfavourable inadequate" for the Boreal region with ‘structure & function’ and ‘future prospects’ considered poor in both Finland and Sweden, with ‘area’ also considered poor in Finland. The overall conservation status of this habitat type in the Alpine biogeographical region is favourable. There has been no change in conservation status since 2001–2006.

Problem

Most important pressures and threats mentioned in the article 17 reporting for aapa mires are forestry activities and changes in hydrology.

People used to collect bog grass to feed the cattle. Traditional forms of management like mowing have ended, e.g. in Central Lapland in Finland during the 1950’s. Present forms of land use are mostly tourism (hiking), picking berries and hunting.

Proposed measures for GI

Aapa Mires are particular sensitive for changes in hydrology due to their relationship with groundwater (Tahvanainen 2011; Jaros *et al.* 2019). The most important conservation measure reported in the Art. 17 reporting is the establishment of protected sites, with its adjoining legal protection of habitats and species and opportunities for succession. This requires generally a landscape approach, large areas to allow for such processes. Another important measure is the restoration or improvement of the hydrological regime. Lastly, measures can be taken for species protection.

There have been many LIFE projects over the past decades to restore the hydrological conditions in mires.

Peat stores six times as much C as compared to forests (Ojanen et al). However, the impact of restoration depends on several factors, and prioritization is needed:

- Habitat type: poor vs rich
- Degradation status
- Tree stand: how much C in trees?

An ongoing project (until 2023) is the Finnish project: Hydrology LIFE (LIFE16NAT/FI/000583). This project is run by Metsähallitus, Parks & Wildlife Finland. Finland has a long history with peatland restoration over the past decades. The majority of peatlands in Finland are severely degraded by drainage of forest areas, also areas within N2000 sites. Measures which have been taken are the blocking of ditches and removal of trees on 5200 hectares in and around 95 Natura 2000 sites, to recover the wet and open habitats. The measures also restore the storage capacity for water, nutrients and carbon. Dredging, channelization and drainage have reduced the ability of streams and ponds to sustain its natural communities and the circulation of water. Some 34 km of degraded streams have been restored and the water table has been raised in 17 ponds to recover their natural hydrological functioning, and to regain valuable species.

The open water areas and mosaics of water and vegetation decreased in many lakes due to succession and nutrient accumulation from the surrounding areas. The open water areas are restored to increase the mosaic structure of habitats e.g. by dredging and raising the water table in four important bird lakes.

The NATNET LIFE+ project focuses on Green Infrastructure (http://en.natnet.fi/). The objective of the project is to increase the ecological connections between the Natura 2000 area and other existing protection areas in Southwest Lapland. The ecological connections are established by voluntary permanent protection agreements on privately owned land. Habitats are protected through The Forest Biodiversity Programme of Finland (METSO-programme). Through the METSO-program habitats associated to aapa mires such 91D0 * Bog woodland, (parts of 7110 * Active raised bogs, 7120 Degraded raised bogs still capable of natural regeneration7140 Transition mires and quaking bogs, 7230 Alkaline fens can be restored.

NATNET concentrates on making inventories of potential habitats for more connected Natura 2000 network through the METSO program, restoring forests and mires, and offering counselling related to natural values for forest owners. The project offers for forest owners in south-western Lapland a chance to make a nature management plan, which takes into account the natural values of the forest and nature, and is free of charge. In order to make the nature management plan, it is essential to find habitats and estates that increase the ecological connectivity between the Natura 2000 sites. During the planning process valuable habitats and potential objects for restoring are surveyed. Habitat for restoring could be for example low productivity wooded mires (bog woodland). Forest owner will have an estimation of financial compensation on the basis of the nature management plan. The nature management plan is suitable for a forest owner, who wants to take into account the landscape, the recreation and natural values of forest besides the economic values.

Key parts of the project are the permanent protection agreements. They are made in collaboration with forest owners to safeguard the forest habitats that are important for the biodiversity and increased connectivity of the Natura 2000 network. On the basis of the protection agreement landowners will get a (full) tax-free financial compensation to cover the loss of income resulting from refraining of logging. The preservation contract does not change the ownership of the land.

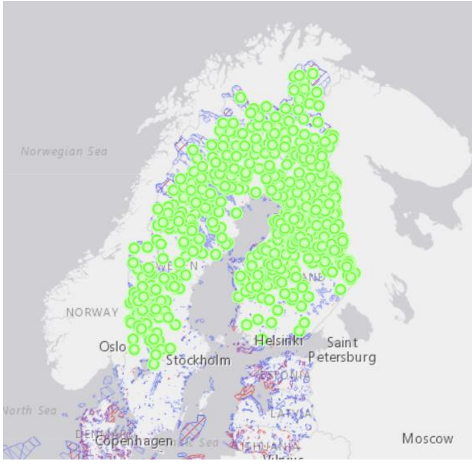


Photo 4.2: Aapa Mire in Estonia

Photo: © Kalev Sepp

Assessment of Ecosystem Services

Ecosystem services related to the proposed measures, as described above, are discussed in par. 2.4.

Restoration of mires has particular relevance for climate change mitigation: it slows down the release of Carbon dioxide. In addition, it benefits recreational activities as well as collecting of fruits and other products from nature. It will benefit the restoration of hunting areas. Also, restoration of mires will improve the water quality further downstream, and lower peak discharges after rainfall or snow melt.

Restoration of mires will generally result in increased biodiversity, which will safeguard ecosystem functionality. It will result in improved connectivity in the fragmented landscapes. It will also reduce impacts of extreme conditions: slowing down surface water fluxes, cutting down peak flows and diminishing erosion.

4.1.3 (3170) Temporary Mediterranean ponds*

Ecology and distribution

Mediterranean temporary ponds are seasonal wetland habitats, subjected to extreme and unstable ecological conditions. Temporary Mediterranean shallow ponds are very shallow (a few centimetres deep) which exist only in winter or late spring. Mediterranean temporary ponds provide the microhabitats for crustaceans, macro-invertebrates, amphibians and reptiles. The flora is mainly composed of Mediterranean therophytic and geophytic species of the alliances Isoetion, *Nanocyperion flavescentis*, *Preslion cervinae*, *Agrostion salmanticae*, *Heleochloion* and *Lythrion tribracteati*.

Mediterranean temporary water bodies occur in very small stands, all over the Mediterranean biogeographical region (Figure 4.1). Temporary ponds appear in depressions during the first rain events in the hydrological year. Rainwater accumulates due to the less permeable soil layer underneath the pond, which retains the rain water. The first flooding end up infiltrating and/or evaporating. These ponds are hydraulically connected to the groundwater and from the moment it reaches and surpasses the base elevation of the pond the water retention period becomes longer. Therefore, the hydroperiod of most of these ponds is higher than the one corresponding to simple accumulation of rainwater in soil depressions with low permeability.

The salinity and hydroperiod are probably the most important community structuring factors, in particular for the active and dormant crustacean communities. The aridification as a result of climate change may lead to a loss of species that come late in the succession, while salinisation may lead to the loss of already fragile freshwater species. Although resting egg banks can temporarily buffer against unfavourable conditions, persisting bad conditions may lead to their exhaustion.

Photo 4.3: Kornat island, Croatia

Conservation status

Temporary Mediterranean ponds are assessed as Unfavourable inadequate in three regions, as stable in the Mediterranean and Macaronesia and improving in the Atlantic together with Unfavourable bad (deteriorating) in the Continental region and Unknown in the Alpine region (Apennines).

Problem

Most important pressures and threats mentioned in the article 17 reporting are changes in hydrology and pollution. Over the last two-decades, also changed land use such as modern industrialised agriculture and tourism have caused a steep decline in the condition of this habitat type. Temporary ponds are subjected to strong anthropogenic pressures, such as deep soil turning, accelerated drainage, change of the surface topography or transformation of ponds into permanent reservoirs for irrigation.

Not much featuring in the Art 17 reporting (yet) but increasingly important in the near future will be climate change. Increased temperatures combined with more irregular precipitation will probably result in a shorter hydroperiod, loss of species and fragmentation of habitat and dependent communities. Urgent action is needed in order to assure their long-term protection.

Proposed measures for GI

Most important conservation measure reported in the Art. 17 reporting is the establishment of protected areas/sites and Legal protection of habitats and species. Additional measures might be to set out management rules for maintaining a favourable conservation status of temporary ponds; also the demonstration of ecological restoration techniques and measures could inspire countries and managers to take action. Creating a seeds bank specifically for this habitat, which can be used in restoration actions and as a safekeeping of genetic reference for the flora of the habitat.

We must consider these habitats as ‘communicating’ networks, whereby regular exchange takes place. The habitats are in particular vulnerable because they are small, dynamic and ephemere. It is therefore important is to maintain or improve the connectivity between these habitats. This requires the protection of existing ponds against destruction, restoration of destroyed or overgrown habitats and the creation of new habitats in particular where this would support the network of ponds.

The Project LIFE+ 'Conservation of Temporary Ponds on the Southwest Coast of Portugal' (LIFE12NAT/PT/997), LIFE CHARCOS, coordinated by the 'Nature Protection League (LPN), promotes the conservation of the Mediterranean Temporary Ponds. Among the practical activities that were done, the following might be relevant for replication elsewhere:

- Construction of temporary ponds, planting shrubs on the margins of ponds and creating shelters from stone and wood to promote habitat connectivity for amphibians, mammals, reptiles and other biological groups in the pond complex.
- Eradication of exotic plants, shrub control.
- Rehabilitation of ponds with replacement of the natural relief with slight sinking and replacement of the upper organic horizon to ensure the safeguard of the seeds and cysts of the species of the temporary ponds.
- Removal of drainage ditches.

The Life PRIMed (LIFE17 NAT/GR/000511) promotes restoration of temporary ponds in the Greek Nestos Delta. Restoring the habitat includes the clearing of the vegetation that covers and falls into the temporary ponds. The shrub removal is necessary for the survival of the species Emys orbicularis, *Testudo hermanni* and *Callimorpha quadripunctaria*, present in these habitats. Enlargement of the habitat 3170* area is necessary due to the reduction of the total pond surface area that has occurred during the last 20 years.

New pond sites should be identified based on the proximity to other ponds and accessibility for plants and animals, as well as on the hydrographic system of the area. A GIS-topographic analysis may help to identify suitable areas where the flow of the rainfall converges optimally, allowing natural filling of the ponds during the wet season. A soil survey may assist to identify areas where a waterproof clay substrate feature, which is indispensable for the persistence of ponds. Based on this site identification approach, a maximum 50 cm-excavation is required to excavate the temporary ponds.

An additional habitat restoration measure may be the planting of shrubs on the margins of ponds. Also creation of shelters from stone and wood can be important to create additional habitat and improve connectivity for amphibians, mammals, reptiles and other biological groups in the pond complex. If ponds are too isolated, keystone or target species might be introduced in the pond, in particular for those species which are not mobile. In particular in new sites it might be worthwhile to 'transplant' water with e.g. crustaceans to ensure a fast establishment of temporary pond communities, improve water stability, and spread the risks of loss of species over a larger number of ponds.

Assessment of Ecosystem Services

Ecosystem services related to the proposed measures, as described above, are discussed in par. 2.4.

Conservation, Restoration or creation of Mediterranean temporary ponds will have positive effects with relation to erosion protection and climate regulation. In particular the micro climate around ponds will be positively affected, providing some shade and water in an otherwise dry and harsh habitat. The ponds may to some extent positively affect flood protection due to buffering peak rainstorm events. Of particular importance are the maintenance of nursery populations and habitats, as indicated for amphibians, reptiles, crustaceans etc.

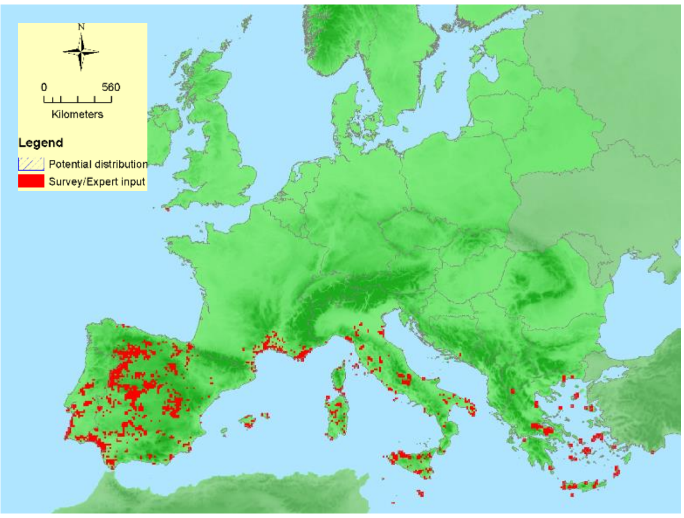


Figure 4.1: Distribution of Mediterranean temporary ponds (Janssen et al. 2016)

4.1.4 (91E0) Alluvial forests*

Ecology and distribution

The habitat Alluvial forests, 91E0, is rather widespread and occurs in 7 biogeographical regions. It is listed as one of the 10 most widespread forest types from the Habitats Directive (Sotirov 2017), with approximately 884.200 ha, which is some 0.5% of the forest area and other wooded land.
This habitat includes several sub-types: ash-alder woods of springs and their rivers (44.31 – Carici-remotae- Fraxinetum); ash-alder woods of fast-flowing rivers (44.32 - Stellario-Alnetum glutinosae); ash-alder woods of slow-flowing rivers (44.33 - Pruno-Fraxinetum, Ulmo-Fraxinetum); montane grey alder galleries (44.21 - Calamagrosti variae-Alnetum incanae Moor 58); sub-montane grey alder galleries (44.22 - Equiseto hyemalis-Alnetum incanae Moor 58); white willow gallery forests (44.13 - Salicion albae). The Spanish types belong to the alliance Osmundo-Alnion (Cantabric atlantic and southeast Iberia peninsula). All types occur on heavy soils (generally rich in alluvial deposits) periodically inundated by the annual rise of the river (or brook) level, but otherwise well-drained and aerated during low-water.

Conservation status

Alluvial forests are assessed as Unfavourable bad in all six regions where it occurs (everywhere, except for the Macaronesian region). However, in these regions, the status of the habitat was mostly 'unfavourable-inadequate' at the country level.

Problem

The article 17 reporting lists as the major threats the changes in water body conditions, forest management and use, and invasive alien species.

The pollution of surface waters (limnic & terrestrial), flooding modifications and water abstraction from groundwater are considered as major threats for alluvial forests (European Commission, 2015). Forest management, like forest clearance and thinning of tree layer, are reported among the main threats, together with anthropogenic reduction of habitat connectivity and succession. Also important are those threats linked to the alteration of natural systems, such as human induced changes in hydrological conditions (canalisation & water deviation, lack of flooding). Due to the reclamation of floodplains for agricultural purposes as well as the canalisation of rivers, the surface of alluvial forests in many parts of Europe has decreased in the last century, although there are regional differences and in particular in Eastern Europe an opposite tendency is observed over last decades, such as in Hungary (Biró *et al.* 2018).

Proposed measures for GI

The main measures to restore alluvial forest is to restore forests in floodplain areas as well as re-establishment of the flooding regime of the floodplains. Several LIFE projects, in particular in the Atlantic region, have been undertaken.

The LIFE SCALLUVIA (LIFE12 NAT/BE/000596) (Belgium) is an example of one of the projects to restore the alluvial forest habitat. The main aim is to develop a sub-area of Kruibeke-Bazel-Rupelmonde (89.97 ha) as a high-quality site, in a good state of conservation, that functions as a flooding and recreational area. The project will help restore a total of 80 ha of alluvial forests and 10 ha of small lakes. Such restoration will have a beneficial impact on: European bitterling, Spined loach, Bluethroat, Common kingfisher, Little bittern and Purple heron.

Also LIFE Feuchtwälder - Conservation and restoration of alluvial forests and bog woodland in Brandenburg (LIFE13 NAT/DE/000091) is an example for this approach. The project`s main aims focus on securing and restoring floodplains that include habitats of bog woodlands and alluvial forests, in three riverine systems in Brandenburg. A total of 130 ha of alluvial forests will be restored. As the moorlands of bog woodlands depend heavily upon the stabilisation and re-establishment of natural hydrologic conditions, the project seeks to re-establish a near-natural water regime within the alluvial areas and forests, as well as the associated waterways.

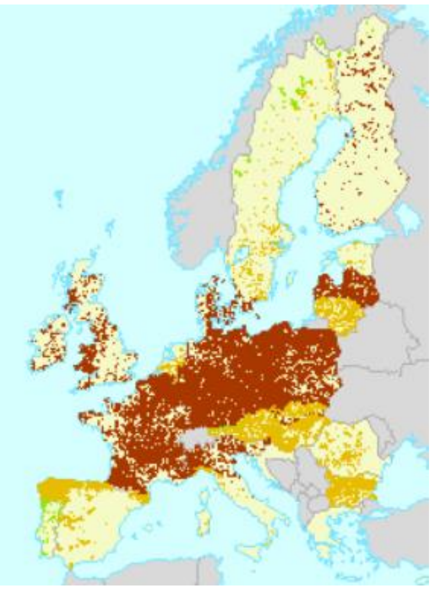


Photo 4.4: Habitat restoration works at Hainburg on the Danube (Austria)

Photo: © Theo van der Sluis

Assessment of Ecosystem Services

Ecosystem services related to the proposed measures, as described above, are discussed in par. 2.4 and presented in Table 3.6.

The alluvial forests can contribute many ecosystem services: in particular services related to wood production and associated habitat functions. It is very important for climate change, as well as possible flood retention. In addition, the habitat also can provide important recreational services.

4.1.5 Eurasian lynx (Lynx lynx)

Ecology and distribution

The Eurasian lynx (*Lynx lynx*) used to occur throughout Europe, but currently the European distribution is associated with a rather scattered pattern of large continuous forest regions. Important core areas are: East Poland, the Carpathians, the Alps and the Jura Mountains. The species occurs in many Biogeographical regions: Boreal, Alpine, Continental, Pannonian, and a small part of the Mediterranean region (Figure 4.2).

The Czech Sumava and German Bavarian Forest hold recently established populations. In some Western European regions the species has been reintroduced very recently. The home-range size within these regions varies according to the season, prey-density, sex and age. Dense populations are mainly found where prey availability of roe deer and chamois is high. Human activity and intensive land use is tolerated as long as there is enough vegetation cover.

Conservation status

The Eurasian lynx is protected under the Bern Convention (appendix III), EU Habitats Directive (appendix II and IV, for some Eastern European countries annex V), CITES (Appendix II) and IUCN Red list (Least Concern status). The species seems stable throughout most of its territory (Adamec et al., 2012). The last article 17 reporting indicated that the species has a favourable conservation status in the Alpine and Boreal region, an unfavourable inadequate status in the continental region whilst it has an unfavourable bad conservation status in the Mediterranean, Pannonian and Black sea region.

Problem

The habitat of the lynx has mostly a patchy distribution; suitable habitat is often destroyed by deforestation and agriculture. As a result, most smaller populations have limited genetic variation or are even inbred. Other problems are related to persecution, low acceptance due to conflict with hunters and shepherds, and vehicle collision.

The landscape is fragmented for the Lynx: potential suitable habitat is badly connected with core areas and peripheral areas are especially badly connected with already occupied areas. The latter is problematic for the species, because relatively small populations of the Eurasian lynx may easily become extinct as a result of environmental stochasticity (random fluctuations), such as prey availability, poaching (nowadays), hunting (in the past) or road kills.

Proposed measures for GI

To strengthen the European lynx population it is essential to improve the connectivity of the landscape, the peripheral areas where small populations face the threat of extinction. Recent Lynx observations in Northern Belgium, the southern parts of the Netherlands and the Dutch Veluwe indicate the potential for colonisation of small isolated areas. Spontaneous recolonisation of potential habitat (forest) may be facilitated by incorporating corridors with stepping stones into the ecological network for the Lynx.

With the LARCH model[7] the potential habitat and the connectivity of the landscape were evaluated for the Eurasian lynx. The analysis confirmed that the potential habitat has a patchy distribution. The most effective corridors comprise the area between North-eastern and North-western Poland, the area from Western Poland, the corridor south of Berlin, towards the Harz area and the area between South-eastern Belgium and the French-Swiss Vosges and Jura area.

Transboundary migration occurs in almost all countries in central and Eastern Europe (e.g. Hungary, Bulgaria, Romania, Czech Republic, Greece, Baltic states). There are specific proposed measures, as described above, that aim at improving the landscape connectivity:

- Life Lynx (https://www.lifelynx.eu/), a consortium of mostly Slovenian partners, with Croatia and Italy;
- the INTERREG project 3Lynx (https://www.interreg-central.eu/Content.Node/3Lynx.html);
- LIFE Luchs Pfälzerwald - Reintroduction of lynxes (Lynx carpathicus) in the Palatinate Forest Biosphere Reserve (LIFE13 NAT/DE/000755) (https://snu.rlp.de/de/projekte/luchs/).

LIFE Lynx project's primary objective is rescuing the Dinaric-SE Alpine lynx population from extinction and to preserve it in the long term. The Dinaric-SE Alpine lynx population went extinct at the beginning of 20th century due to hunting and persecution, habitat loss and lack of prey species. It was successfully reintroduced in 1973 by translocating animals from the Carpathians and Slovenia. The animals spread, but after a few decades the population started declining, mainly due to genetic deterioration.

Currently, the population is small, isolated, and extremely inbred. It urgently needs reinforcement by introducing additional, healthy animals from another population. The Dinaric-SE Alpine population is now reinforced with lynx from population in the Carpathians. This work is done in close cooperation with stakeholders to ensure broad public acceptance of lynx conservation. Scientific information is incorporated into management plans and other strategic documents. Improved population connectivity for lynx will improve natural gene flow of lynx within this population. Such a metapopulation will help reduce negative impacts of habitat fragmentation and will reverse genetic deterioration across entire Dinaric-SE Alpine population.

The INTERREG 3Lynx project has set itself quite a different aim: to integrate lynx monitoring, conservation and management into a common strategy on transnational level. The project does so, by improving lynx conservation capacities of responsible stakeholders through experience, data and tool sharing and by implementing a harmonised lynx monitoring at population level. The project is also an instrument to achieve active involvement of key stakeholders (hunters and foresters) into lynx conservation issues. These are only a small sample of projects, many more initiatives have been listed in (Christine Estreguil et al., 2018).

The LIFE Pfälzerwald program's main aim is to re-establish a lynx population in the Palatinate Forest, the transboundary biosphere reserve Pfälzerwald/Vosges du Nord. This is achieved through a reintroduction programme involving the release of 20 lynx, (10 coming from Switzerland and 10 from Slovakia). This should result in a reproducing population of lynx in Rheinland Pfalz. The project is also monitoring lynx, it aims to increase public acceptance, cooperation with stakeholders (it is all on public land) and improved spatial connectivity[8].

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[7] LARCH (Landscape Analysis and Rules for Configuration of Habitat) is a landscape ecological model to assess species' habitat and viability of populations.

[8] see: https://snu.rlp.de/de/projekte/luchs/wiederansiedlung/massnahmen-zur-wiederansiedlung/ (in German)

Photo 4.5: Eurasian lynx (*Lynx lynx*)

Photo: © Shutterstock, Ondrej Prosicky

Assessment of Ecosystem Services

Ecosystem services related to the proposed measures, as described above, are discussed in par. 2.4 and presented in the Table 3.6. Ecosystem services related to interventions for the Eurasian lynx are mostly related to forest habitats that are promoted. The European lynx is very much dependent on extensive and continuous forest habitats. This demands the conversion from cropland to forest, that may reduce some of the provisioning services such as crop and livestock. The development of Green Infrastructure for the Lynx will however also benefit a range of mammals such as Red deer, Roe deer, Wolf, Brown bear, Badger, Wild cat and Pine marten. The increased cultural services include outdoor recreation services as well as inspirational services.

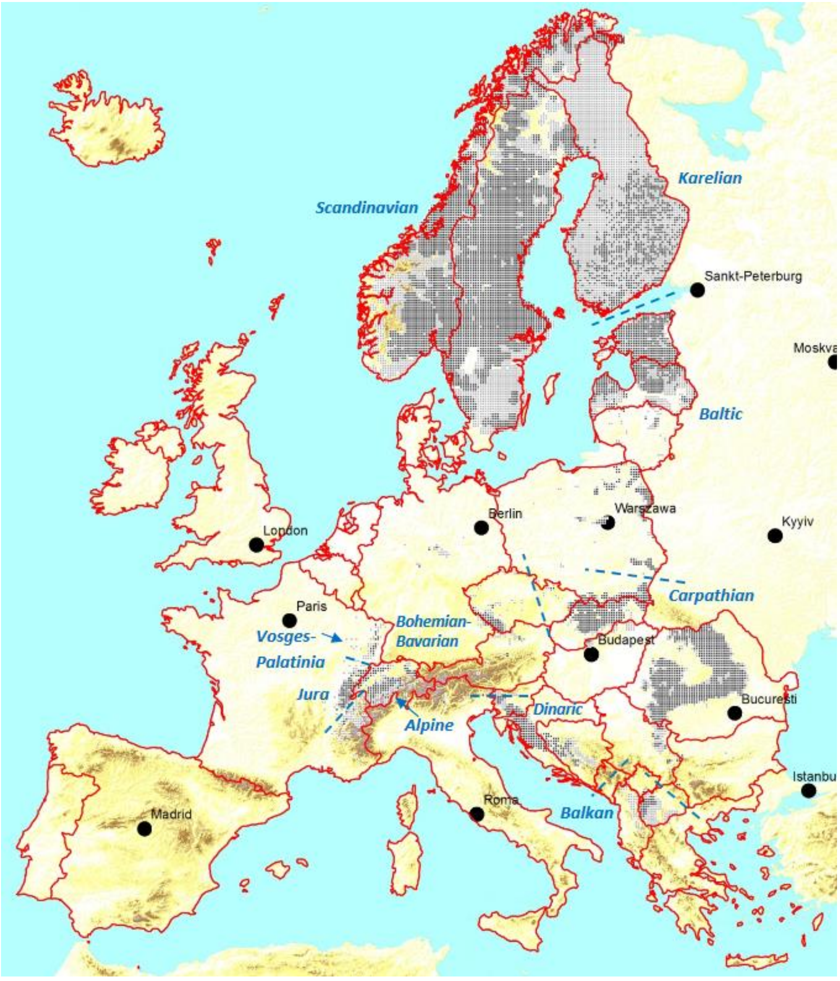

Figure 4.2: Eurasian lynx (*Lynx lynx*) distribution in Europe 2006 - 2011. Dark cells: permanent occurrence, Grey cells: sporadic occurrence. Red borders mark countries for which information was available (Adamec et al., 2012)Stag beetle (Lucanus cervus)

Ecology and distribution

The Stag beetle (*Lucanus cervus*) is one of the largest insect species in Europe. The larval development in dead wood takes five till eight years. Although females are able to fly and need to do so in order to search for stumps for mating and laying eggs, they tend to stay in the neighbourhood of the stump they emerged from. A wide range of woods are used, especially oak, but also ash, elm, sycamore, lime, hornbeam, apple, cherry and even some garden tree varieties. Chances for colonisation of new habitats are therefore limited.

The Stag beetle is common only in Northern and Central Spain and Northern Italy and is rather stable. In France the short-term trend is stable, although the long-term trend is unknown[9]. In South-eastern England its populations are surviving well in several core areas[10].

Distribution patterns have been shrinking since 1900 in the remaining countries, leaving only small isolated populations.

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[9]http://cdr.eionet.europa.eu/Converters/run_conversion?file=/fr/eu/art17/envubhesg/FR_species_reports.xml&conv=354&source=remote#1083ATL

[10] see: https://ptes.org/wp-content/uploads/2018/06/SoBSB_2018.pdf

Photo 4.6: Stag beetle (*Lucanus cervus*)

Photo: © Chris van Swaay, De Vlinderstichting/Dutch Butterfly Conservation

Conservation status

The Stag beetle is listed in appendix III of the Bern convention and in appendix II of the EU Habitats Directive. In many European countries the European Stag beetle also occurs on the national Red-lists, but it does not occur on the IUCN Red-list since the species is not endangered on a global scale. The last article 17 reporting indicated that the species has a favourable conservation status in the Black Sea and Pannonian region whilst it has an unfavourable inadequate status in the other regions where it occurs.

Problem

The main risks for the Stag beetle is its vulnerability -due to its long life cycle which requires large stumps in an undisturbed environment- and the relatively small dispersal range of the females. It appears that the main condition for survival and gradual dispersal forms a rather dense network of undisturbed patches with old large stumps of deciduous trees and sap trees for adult feeding as well.

At the landscape level the beetle is affected by the disappearance and fragmentation of old deciduous forests, leading to smaller and more isolated habitat patches. As a result, the distribution of the beetle is scattered (Figure 4.3). Dispersal distances are reportedly up to 3 km (Rink & Sinsch, 2007).

At the local level, forestry activities also minimize the remaining suitable habitat because they consist of the removal and disturbance of large pieces of dead wood from the forests and the cutting of deciduous trees for forest regeneration purposes. Consequently only small stumps are left behind which are too small for proper larval development of the beetle. In addition the use of herbicides and insecticides threatens the beetle.

The decline and fragmentation of habitat of the Stag beetle also affects other saproxylic (woodboring) insects; Figure 4.4 shows the species richness of endangered species of woodboring invertebrates compiled by an expert group of the IUCN (Cálix et al., 2018).

Some forests are of respectable size, but others are as little as 40 ha. The greater part lies within mountainous parts of the continent. The distribution pattern shown on the map clearly demonstrates that forests being important for saproxylics are either isolated relicts in unforested regions or – although embedded in large woodland regions – isolated from similar forests.

Proposed measures for GI

To create more breeding possibilities for the Stag beetle old and moribund deciduous trees as well as large stumps of these trees are required. At the local level connectivity can be enhanced by the introduction of natural and artificial breeding facilities, such as dead wood pyramids, loggeries and large wooden boxes filled with wood chips and sawdust. The location of these breeding habitats should be based on the core areas already present. The corridors connecting the breeding places should be of the 'nodal type' with nodes every 2 km.

At the landscape level connectivity can be enhanced with the maintenance of ancient woods,

conservation of forest remnants, hedgerows and old deciduous trees. The exchange of individuals between isolated patches of old deciduous woodland can be facilitated with plant schemes for deciduous trees in the vicinity of forest remnants, single trees, open areas and coniferous woodland. These corridors should be constructed away from roads, as Stag beetles are very vulnerable to traffic.

Little evidence is found of larger, transboundary projects aiming at the Stag beetle: the project LIFE for insects - Conservation of selected Natura 2000 insect species in transboundary area (CZ-SK) of Western Carpathian Mts. LIFE16 NAT/CZ/000731 is focused at the regional scale, and partly at meadows for butterflies. The LIFE description notes however: *the most threatened habitats in Central Europe is open-canopy middle forests home to valuable Habitats Directive-listed species such as the stag beetle (Lucanus cervus) or clouded Apollo (Parnassius Mnemosyne) butterfly. With the disappearance of traditional coppicing of woodlands and forest grazing (and changes in forestry practices and legislation), the best way to support this habitat is through the restoration of open-canopy forests.*

In South Sweden a life project aims at restoring saproxylic beetle species (LIFE15 NAT/SE/000772). One of the project aims is to: *Initiate the creation of decaying wood habitats which in the longer term can bridge gaps in space and time for the Annex I habitats (9070, 6530*, 9160, 9020 and 9190) and Annex II species Osmoderma eremita, Cerambyx cerdo, Lucanus cervus and Anthrenochernes stellae within the Natura 2000 sites.*

One of the methods used is 'veteranisation' of trees: a method to create old tree structures in younger trees, carried out using a chainsaw by arborists. The veteranisation methods aim to mimic effects on trees due to naturally occurring disturbances like storm felling, lightning, browsing animals and woodpeckers. It increases the number of available dead-wood-habitats for threatened species, as e. g. hollow trees, trees with partially dead trunks, and sap flows. So far no results have been reported at http://lifebridgingthegap.se/.

Assessment of Ecosystem Services

Ecosystem services related to the proposed measures, as described above, are discussed in par. 2.4 and presented in Table 3.6Table. The Stag beetle is exemplary for the strongly declining group of large wood boring (saproxylic) beetles, such as the black tinder fungus beetle. If ancient woods are maintained then ancient woodland indicator plants will also benefit. These old forests have limited provisioning services, and may in fact require reduced timber harvesting. The regulation services may be high though, in particular climate regulation, pollinator functions and seed dispersal and maintenance of nursery populations and habitats. The habitat finally may facilitate some recreational services, as well as inspirational services (Plieninger et al., 2015).

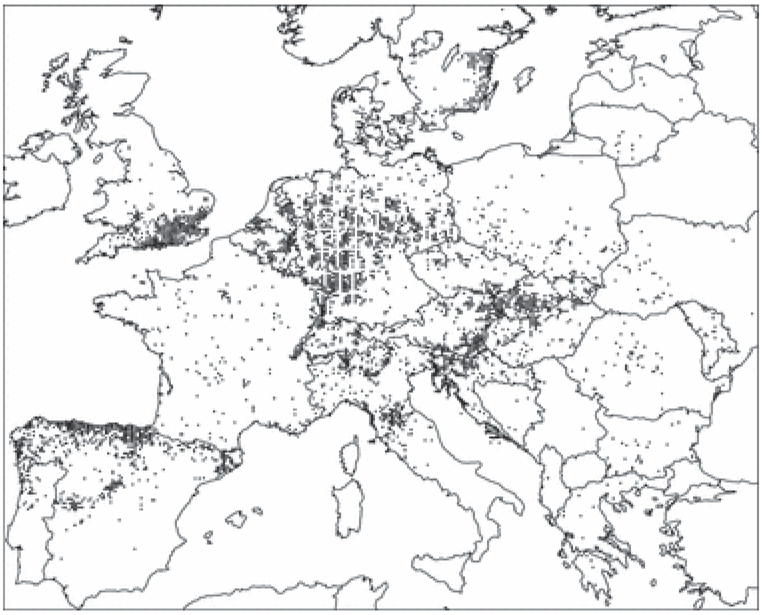


Figure 4.3: Observations of Stag beetle in Europe (Harvey, Gange, Hawes, & Rink, 2011)

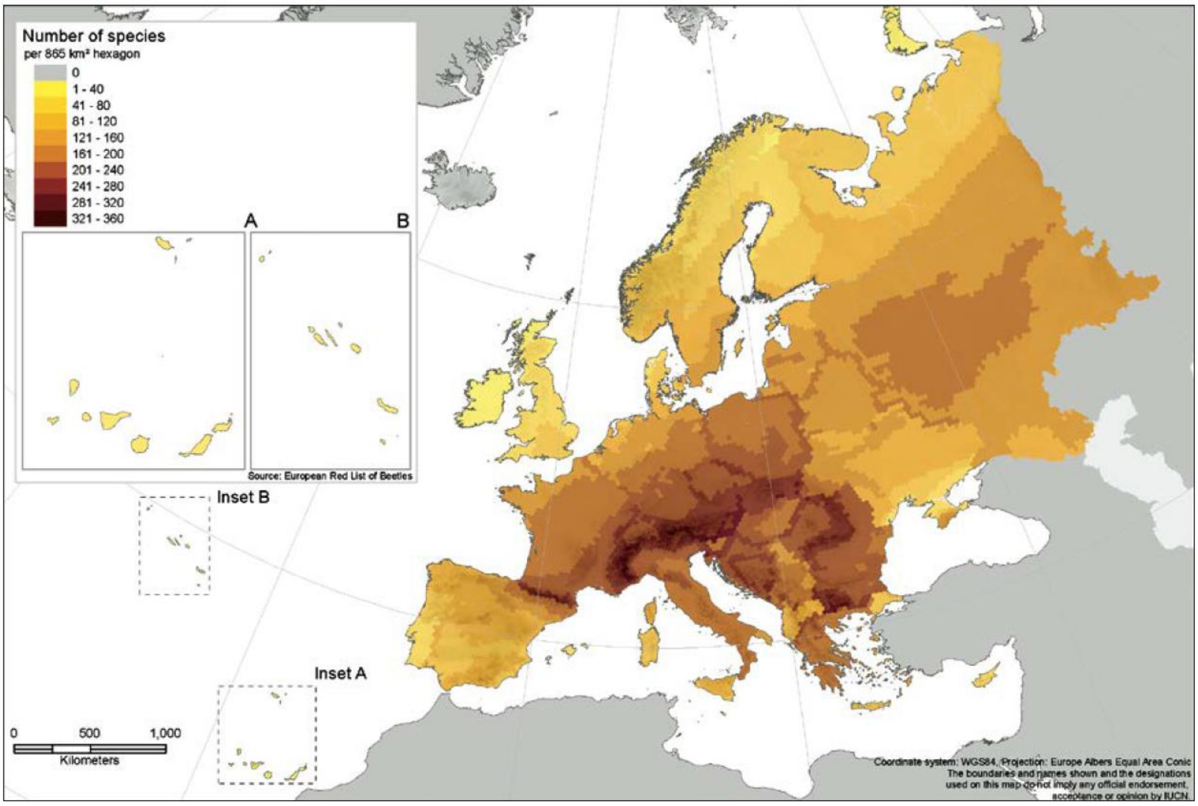


Figure 4.4: Species richness of European saproxylic beetles (Cálix et al., 2018)

4.1.6 European sturgeon/Beluga (Huso Huso)

Ecology and distribution

The Beluga or European sturgeon (*Huso huso*) is endemic to the Ponto-Caspian Sea region that includes the Caspian Sea (the largest inland body of water in the world) as well as the Sea of Azov and the Black Sea. The current native wild distribution within the EU is restricted to the Black Sea (in the Danube only), but it does occur in the Caspian Sea and Volga as well. As it is a long-lived species (has a long life expectancy), individuals can still be caught in areas where their spawning sites have been cut off. The beluga have reached 100 years of age and more than 1,000 kg weight. The last wild population in the Black Sea basin migrates up the Danube river. All other Black Sea stocks are almost extirpated due to overfishing and impoundment of spawning rivers.

Photo 4.7: European sturgeon (*Huso huso*)

Photo: © Measures Project

Conservation status

The European sturgeon is critically endangered, following the IUCN criteria and included in the EU Habitats Directive Annex V, the Bern Convention Annex II & III. Based on catch data, and number of recorded spawning individuals it is estimated that the species have seen a wild native population decline of over 90% in the past three generations (a minimum of 60 years) and overfishing for meat and caviar may cause global extinction of the remaining natural wild populations. Stocks of sturgeons are dramatically decreasing, particularly in Eurasia; the world sturgeon catch was nearly 28,000 tons in 1982 and less than 2,000 tons by 1999 (Billard & Lecointre, 2000). The last article 17 reporting indicated that the species has an unfavourable bad conservation status in the regions where it occurs.

Problem

The decline of Sturgeon resulted from overfishing and environmental degradation such as: accumulation of pollutants in sediments, damming of rivers, and restricting water flows, which become unfavourable to migration and reproduction.

Proposed measures for GI

In the immediate future, survival can only depend on stocking and effective fisheries management and combating illegal fishing. Range states are also encouraged to provide protection to the species spawning and feeding grounds. Protective measures include fishing regulation, habitat restoration, juvenile stocking, and the CITES listing of all sturgeon products including caviar.

In future sturgeon farming may resolve some pressure on the wild populations (due to illegal fishing), presently farming yields more than 2,000 t per year (equivalent to wild sturgeon landings) and about 15 t of caviar. This artificial production may contribute to a reduction of fishing pressure and lead to the rehabilitation of wild stocks.

One of the approaches is the MEASURES project developed under the INTERREG Danube Transnational program: Managing and restoring aquatic EcologicAl corridors for migratory fiSh species in the danUbe RivEr baSin[11]. MEASURES aims to create ecological corridors by identifying key habitats and initiating protection measures along the Danube and its main tributaries. The sturgeons and other migratory fish species act as flagship species in support of these goals. A combination of measurements is required to restore the landscape connectivity for the European sturgeon. These measurements comprise the bypassing of obstructions such as dams, weirs and culverts, the restoration of spawning areas by restoration of the morphology of rivers and streams, and in some cases young fish have been reintroduced in tributaries of big rivers.

The corridor required for migration and dispersal is of the 'linear type'. A coordinated approach is required though, the connectivity may be a major problem, for Sturgeon to reach its spawning areas a chain of measures is required.

Assessment of Ecosystem Services

Ecosystem services related to the proposed measures, as described above, are discussed in par. 2.4 and presented in the Table 3.6. The sturgeon populations can be restored through reversal of engineering works, removal of dams etc. This has some potential for provisioning services, in particular for fisheries. More important are the regulating services like erosion protection, flood protection and maintenance of nursery populations and habitats. The habitat finally may facilitate some recreational services (fishing), as well as large inspirational services.

4.1.7 Large copper (Lycaena dispar)

Ecology and distribution

The Large copper (*Lycaena dispar*) usually occurs in natural marsh vegetation along water courses, rivers and marshes, but may also be found in unimproved, semi-natural grasslands. The male defends his territory, whilst the female wanders over large wetlands looking for a male or –after mating- for a plant to deposit eggs. The females are quite mobile and can colonise relatively quickly suitable habitats up to a distance of ten km. This means that the butterfly functions very well in mosaics of habitat patches. The Large copper has declined significantly in Western Europe, whereas Eastern European populations are mostly stable. At the northern limit of its range in Estonia and more recently in Finland, the butterfly is expanding, probably caused by global warming in the last decades.

Photo 4.8: Large copper (*Lycaena dispar*)

Photo: © Chris van Swaay, De Vlinderstichting/Dutch Butterfly Conservation

[11] http://www.interreg-danube.eu/approved-projects/measures

Conservation status

The Large copper is listed on appendix II of the Bern Convention and on appendix II and IV of the EU Habitats Directive. The butterfly is listed as 'at Lower Risk, Nearly threatened species' on the IUCN Red-list. The last article 17 reporting indicated that the species has a favourable conservation status in the Alpine, Black Sea and Continental region and an unfavourable inadequate status in the other regions.

Problem

The biggest threat to the Large copper is the fragmentation of its habitat, which are the large marshes and natural, humid grasslands. Intensification of agriculture in North-western Europe has resulted in drainage and reduction in size of these habitats. In Eastern Germany and Poland, large viable populations still exist, but unfavourable changes in agricultural practice could take place following the accession of these countries to the European Union.

The accession of the new member states to the European Union causes agricultural intensification in these countries. This leads to the fragmentation of the wetlands in Central Poland.

By means of a LARCH analysis potential habitat of the Large copper was identified and compared with the actual distribution pattern of the species (Figure 4.5). In many areas (1, 2, 3) large core populations exist whereas in other regions populations are smaller, but still well connected (4, 5). In areas such as North-western Germany (6) however the wetlands are too small, scattered and isolated. Although the ecology differs slightly for this species, the model also predicts reasonably well the potential distribution of the Large copper in the Netherland. In reality this subspecies is restricted to the Dutch regions of North-west Overijssel and Southern Friesland.

Proposed measures for GI

To increase the connectivity for the Large copper two types of corridors are required.

Firstly corridors connecting different networks and secondly corridors which link smaller local populations within a particular network. The landscape matrix is very important for the development of such network corridors, but also linear corridors with attached nodes are needed to link the smaller local populations. This is illustrated in Figure 4.4.

In the North-western part of Germany wetlands are small and isolated. This means that the Large copper population occurring in the Netherlands is isolated from populations in Eastern Germany. Only a large scale creation of wetlands could be a solution to this problem.

It is important that existing wetlands with *Lycaena dispar* populations are maintained and the area is connected to the Biebrza valley and Kaliningrad.

Assessment of Ecosystem Services

The Large copper is an umbrella species for many other wetland insects. But also other species of large wetlands, such as the Otter and many birds will profit from action taken to favour this butterfly.
The habitat for the large copper is much related to large wetlands and meadow systems, which should be restored. This has limited potential for provisioning services, some wild animals, but much more important are plant –based resources, the reed which is used for various purposes, roofing, and for

biomass, pellets etc (Van der Sluis et al., 2013). These wetlands have also important regulating services, in particular climate regulation, flood protection and maintenance of nursery populations and habitats (in particular fish species). The areas also form important recreation areas for hikers, canoers, fisherman or hunters. Also inspirational services are associated with large wetland areas (Table 3.6).

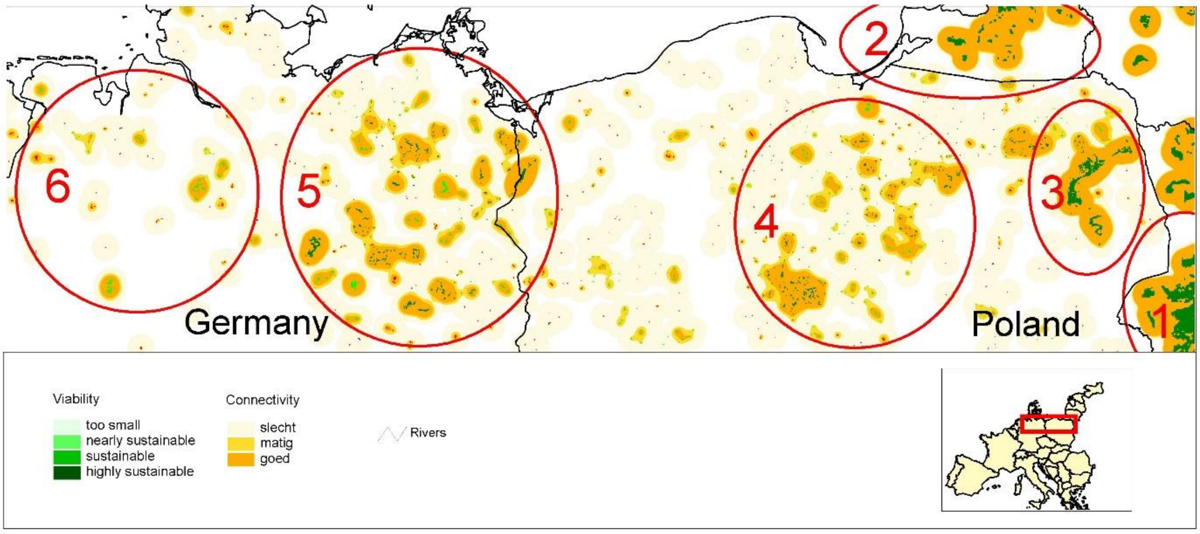


Figure 4.5: Ecological core areas for the Large Copper

5 Discussion, further study

The assessment presented in this study is primarily based on a limited set of criteria that provide different indications for the need for spatial connectivity. As most of the scientific research has focussed on the need for connectivity for single species – limited scientific research is available for the need of connectivity from a habitat perspective. As a result the methodology developed is based on an expert judgement due to the lack of research on this issue.

For one of the criteria – biological vulnerability, we prioritized habitats also on the basis of species mentioned in the Interpretation Manual (DG-Env 2013), for which the habitat is considered representative. However as very few habitats have species listed in the Manual, this criteria is not well developed. This might lead to some overestimation of the habitats for which species are indicated compared to those habitats for which no information is available. It would be recommended to establish better the link between habitats and species, based on an assessment of potential dispersal as shown in figure 2.3. Various models could be used like DIMO (Vos 2013) or LARCH (Van der Sluis *et al.* 2007; Franz *et al.* 2011; Van der Sluis *et al.* 2012a).

In addition it is possible that some of the criteria used for the assessment might not be fully independent from each other – although they do indicate vulnerability from various perspectives (landscape, biotic and abiotic vulnerability). For instance many linear habitats are located along water systems due to their abiotic requirements – as a result they score both high based on their landscape configuration as well as abiotic conditions.

The example descriptions could form the basis for an appealing brochure on transboundary cooperation projects in support of GI. This would require improvement of figures, maps and graphic design.

References

Anonymous (2011) Guidelines for Coastal Meadow Management. Guidance for Estonian Environmental Board land conservation specialists and land managers.

Bijlsma, R., Sevink, J. and de Waal, R. (2012) 'PAS herstelstrategieën Deel III: Landschapsecologische inbedding van de herstelstrategieën', Droog zandlandschap. pas. natura2000. nl/pages/herstelstrategieen-deel_iii. aspx.

Biro, E., Bouwma, I. and Grobelnik, V. (2006) Indicative map of the Pan-European Ecological Network in South-Eastern Europe: European Center for Nature Conservation ECNC.

Biró, M., Bölöni, J. and Molnár, Z. (2018) 'Use of long-term data to evaluate loss and endangerment status of Natura 2000 habitats and effects of protected areas', Conservation Biology, 32(3), 660-671, available: http://dx.doi.org/10.1111/cobi.13038.

Bloemmen, M., Van der Sluis, T. and Bouwma, I. (2004) 'Pan-European ecological networks and European target species'.

Bouwma, I., Foppen, R. and Opstal, S.v. (2004) 'Ecological corridors on a European scale: a typology and identification of target species'.

Bouwma, I., Jongman, R. and Butovsky, R.O. (2002) Indicative map of the Pan-European Ecological Network for Central and Eastern Europe - technical background document, Tilburg, The Netherlands/Budapest Hungary: ECNC.

Bouwma, I., Van der Sluis, T. and Soukop, T. (2013) Fragmentation: Review of the landscape fragmentation methodology. , Task 262_5_2, Copenhagen: European Environment Agency technical report.

Bürgi, M., Silbernagel, J., Wu, J. and Kienast, F. (2015) 'Linking ecosystem services with landscape history', Landscape Ecology, 30(1), 11-20, available: http://dx.doi.org/10.1007/s10980-014-0102-3.

Cálix, M., Alexander, K., Nieto, A., Dodelin, B., Soldati, F., Telnov, D., Vazquez-Albalate, X., Aleksandrowicz, O., Audisio, P.Istrate, P. (2018). European red list of saproxylic beetles. IUCN, Brussels.

DG-Env, E. (2013) Interpretation manual of European Union Habitats - EU 28, Paris.

Estreguil, C., Caudullo, G. and San-Miguel-Ayanz, J. (2013) 'Connectivity of Natura 2000 Forest Sites', EUR 26087EN. Luxemburg: Publications Office of the European Union. JRC, 83104, 2-5.

Estreguil, C., Dige, G., Kleeschulte, S., Carrao, H., Raynal, J. and Teller, A. (2018) Informing strategic green infrastructure and restoration planning through mapping and assessment methods based on spatial and technical data, Copenhagen: EEA, ETC-ULS.

EU (2012) Draft Guidelines on Climate Change and Natura 2000.

European Commission, D.E. (2013) Building a Green Infrastructure for Europe.

Foppen, R., Geilen, N. and Van der Sluis, T. (1999) 'Towards a coherent habitat network for the Rhine'.

Franz, K.W., Romanowski, J. and Saavedra, D. (2011) 'Effects of prospective landscape changes on species viability in Segre River valley, NE Spain', Landscape and Urban Planning, 100(3), 242-250.

Gigante, D., Foggi, B., Venanzoni, R., Viciani, D. and Buffa, G. (2016) 'Habitats on the grid: The spatial dimension does matter for red-listing', Journal for Nature Conservation, 32, 1-9, available: http://dx.doi.org/https://doi.org/10.1016/j.jnc.2016.03.007.

Harvey, d. j., Gange, a. c., Hawes, c. j., & Rink, m. (2011). Bionomics and distribution of the stag beetle, Lucanus cervus (L.) across Europe*. Insect Conservation and Diversity, 4(1), 23-38. doi:10.1111/j.1752-4598.2010.00107.x

Heller, N.E. and Zavaleta, E.S. (2009) 'Biodiversity management in the face of climate change: a review of 22 years of recommendations', Biological Conservation, 142(1), 14-32.

Janssen, J.A.M., Rodwell, J.S., García Criado, M., Gubbay, S., Haynes, T., Nieto, A., N. Sanders, F., Landucci, J., Loidi, A., Ssymank, T., Tahvanainen, M., Valderrabano, A., Acosta, M., Aronsson, G., Arts, F., Attorre, E., Bergmeier, R.-J. Bijlsma, F. Bioret, C., Biţă-Nicolae, I. Biurrun, M. Calix, J., Capelo, A., Čarni, M., Chytrý, J., Dengler, P., Dimopoulos, F., Essl, H., Gardfjell, D., Gigante, G., Giusso del Galdo, M. Hájek, F. Jansen, J. Jansen, J. Kapfer, A. Mickolajczak, J.A. Molina, Z. Molnár, D. Paternoster, A. Piernik, B. Poulin, B. Renaux, J.H.J. Schaminée, K. Šumberová, H. Toivonen, T. Tonteri, I. Tsiripidis, Tzonev, R. and Valachovič, M. (2016) European Red List of Habitats. Part 2, Terrestrial and freshwater habitats, Luxembourg: DG-Environment.

Jaros, A., Rossi, P.M., Ronkanen, A.K. and Klove, B. (2019) 'Parameterisation of an integrated groundwater-surface water model for hydrological analysis of boreal aapa mire wetlands', Journal of Hydrology, 575, 175-191, available: http://dx.doi.org/10.1016/j.jhydrol.2019.04.094.

Maes J, Zulian G, Thijssen M, Castell C, Baró F, Ferreira AM, Melo J, Garrett CP, David N, Alzetta C, D;, G., Cortinovis C, Zwierzchowska I, Louro Alves F, Souto Cruz C, Blasi C, Alós Ortí MM, Attorre F, Azzella MM, Capotorti G, Copiz R, Fusaro L, Manes F, Marando F, Marchetti, M., Mollo B, Salvatori E, Zavattero L, Zingari PC, Giarratano MC, Bianchi E, Duprè E, Barton D, Stange E, Perez-Soba M, van Eupen M, Verweij P, de Vries A, Kruse H, Polce C, Cugny-Seguin M, Erhard M, Nicolau R, Fonseca A, Fritz M and Teller A (2016) Mapping and Assessment of Ecosystems and their Services. Urban Ecosystems. , Luxembourg: Publications Office of the European Union.

Maes, J., Teller, A., Erhard, M., Grizzetti, B., Barredo, J., Paracchini, M., Condé, S., Somma, F., Orgiazzi, A. and Jones, A. (2018) 'Mapping and Assessment of Ecosystems and their Services: An analytical framework for ecosystem condition', Publications office of the European Union, Luxembourg.

Maes, J., Teller, A., Erhard, M., Murphy, P., Paracchini, M., Barredo, J., Grizzetti, B., Cardoso, A., Somma, F. and Petersen, J. (2014) 'Mapping and assessment of ecosystems and their services—indicators for ecosystem assessments under Action 5 of the EU Biodiversity Strategy to 2020', European Commission. ISBN, 978-92.

Riecken, U. (2006) Rote Liste der gefährdeten Biotoptypen Deutschlands: Zweite fortgeschriebene Fassung 2006, Bundesamt für Naturschutz.

Rodwell, J., Janssen, J.A.M., Gubbay, S. and Schaminée, J.H.J. (2013) Red List Assessment of European Habitat Types: A Feasibility Study, Alterra Wageningen UR.

Rūsiņa, S., Auniņš, A. and Spuņģis, V. (2017) '1630* Boreal baltic coastal meadows ' in.

Smits, N., Adams, A., Bal, D. and Beije, H. (2000) 'Herstelstrategieën stikstofgevoelige habitats', Ecologische onderbouwing van de Programmatische Aanpak Stikstof (PAS). Deel I: Algemene inleiding herstelstrategieën: beleid, kennis en maatregelen. Alterra Wageningen UR & Programmadirectie Natura.

Sotirov, M.E. (2017) Natura 2000 and forests: Assessing the state of implementation and effectiveness, 7.

Tahvanainen, T. (2011) 'Abrupt ombrotrophication of a boreal aapa mire triggered by hydrological disturbance in the catchment', Journal of Ecology, 99(2), 404-415, available: http://dx.doi.org/10.1111/j.1365-2745.2010.01778.x.

Vallés-Planells, M., Galiana, F. and Van Eetvelde, V. (2014) 'A Classification of Landscape Services to Support Local Landscape Planning', Ecology and Society, 19(1), available: http://dx.doi.org/10.5751/es-06251-190144.

Van der Sluis, T. (2000) 'Natuur over de grens; functionele relaties tussen natuur in Nederland en natuurgebieden in grensregio's'.

Van der Sluis, T., Bouwma, I. and Condé, S. (2018a) Report on a prioritised list of habitats and emblematic species in the framework of Action 12 of the Nature Action Plan, Paris, France: ETC/BD.

Van der Sluis, T., Eupen, M., Apeldoorn, R. and Schotman, A. (2012a) Luxembourg and the Birds Directive. Analysis of necessity and identification of new SPAs, 2340: Alterra, Wageningen.

Van der Sluis, T., Jongman, R., Bouwma, I. and Wascher, D. (2012b) 'Ein europäischer Biotopverbund - Herausforderungen an den europäischen Kooperations- und Gestaltungswillen', Natur und Landschaft, 87(9), 415.

Van der Sluis, T., Pedroli, B., Frederiksen, P., Kristensen, S.B.P., Busck, A.G., Pavlis, V. and Cosor, G.L. (2018b) 'The impact of European landscape transitions on the provision of landscape services: an explorative study using six cases of rural land change', Landscape Ecology, 34(2), 307-323, available: http://dx.doi.org/10.1007/s10980-018-0765-2.

Van der Sluis, T., Romanowski, J., Bouwma, I.M. and Matuszkiewicz, J. (2007) 'Comparison of scenarios for the Vistula river, Poland' in Landscape Ecological Applications in Man-Influenced Areas. Linking Man and Nature Systems, Dordrecht: Springer, 417-433.

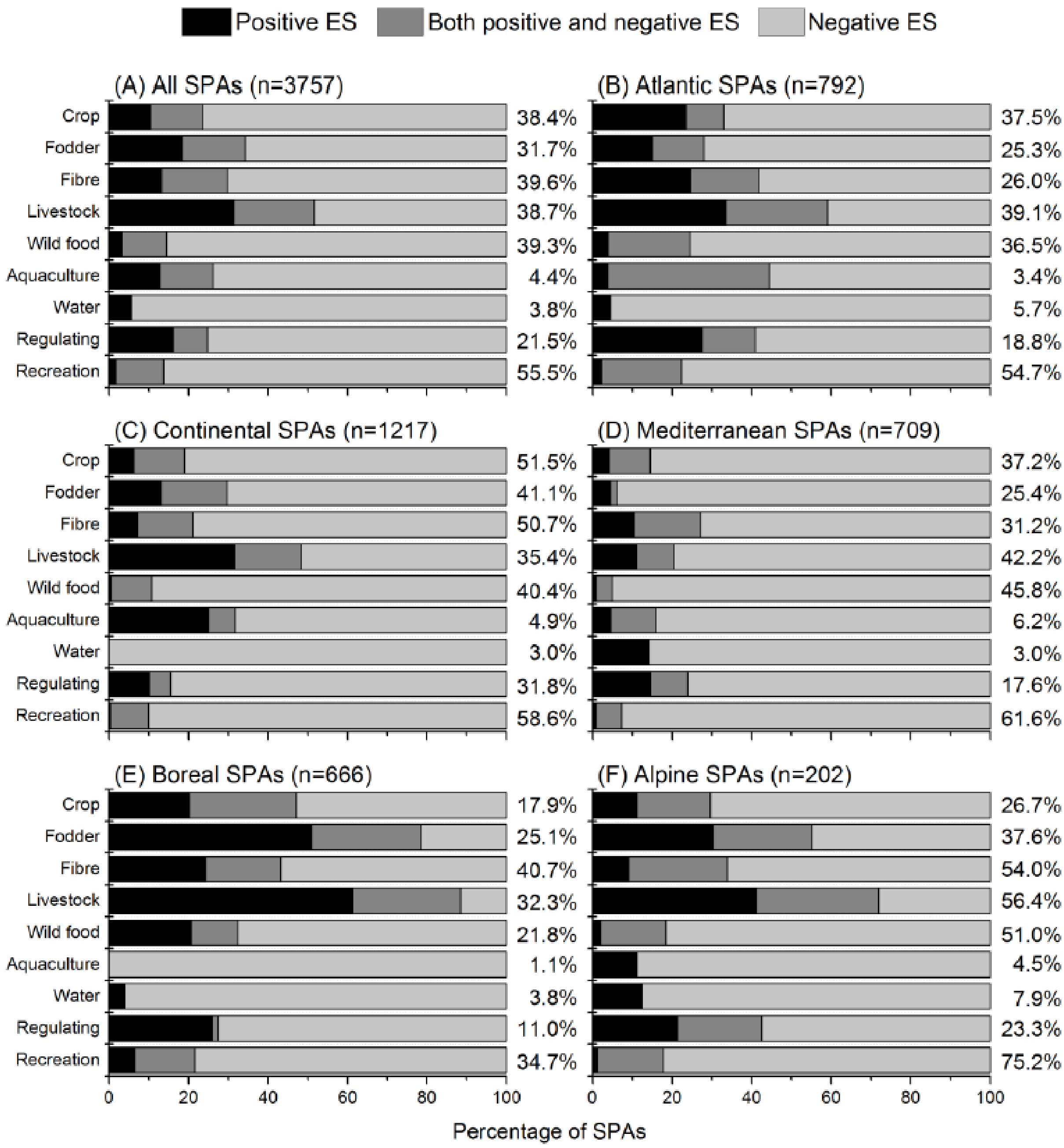
Verboom, J., Schippers, P., Cormont, A., Sterk, M., Vos, C.C. and Opdam, P.F. (2010) 'Population dynamics under increasing environmental variability: implications of climate change for ecological network design criteria', Landscape Ecology, 25(8), 1289-1298.

Vos, M. (2013) Kunnen de Europese plantensoorten de klimaatsverandering bijbenen? Onderzoeksstage naar de migratiemogelijkheden van de Europese plantensoorten via het Europees Ecologisch Netwerk, 's Hertogenbosch, The Netherlands: Hogeschool HAS.

Ziv, G., Hassall, C., Bartkowski, B., Cord, A.F., Kaim, A., Kalamandeen, M., Landaverde-González, P., Melo, J.L.B., Seppelt, R., Shannon, C., Václavík, T., Zoderer, B.M. and Beckmann, M. (2018) 'A bird's eye view over ecosystem services in Natura 2000 sites across Europe', Ecosystem Services, 30, 287-298, available: http://dx.doi.org/https://doi.org/10.1016/j.ecoser.2017.08.011.

Annex 1 Prevalence of habitat types containing each ecosystem service

Correlation of Ecosystem Services ES with Special Protection Areas SPAs in specific Biogeographical Regions (Ziv *et al.* 2018)



Ecosystem service are categorised as positive (darkest colour), both (middle colour), and negative (lightest colour). Colours indicate broad habitat classes: blue = marine/aquatic, turquoise = grass/heath, brown = agricultural, green = forest, purple = other (Ziv *et al.* 2018).