Impacts of climate change and selected renewable energy infrastructures on EU biodiversity and the Natura 2000 network

Task 3a - Applying the vulnerability assessment framework: impacts of climate change on the Natura 2000 network

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Executive summary

The Natura 2000 network is the centrepiece of the biodiversity and conservation policy of the European Union. The network is one of the main vehicles for achieving the 2010 target for biodiversity conservation: to halt the loss of biodiversity by 2010. Climate change, however, may have significant negative impacts on the Natura 2000 network. In order to design and develop appropriate adaptation measures, the vulnerability to climate change of those species identified as of Community interest in the Birds and Habitats Directive needs to be examined in relation to their spatial occurrence.

This report presents the results of Task 3a of the project “Biodiversity and climate change in relation to the Natura 2000 network”. As a first step, climate change projections for the European Union are presented under different scenarios and for different time horizons. These projections are then overlaid with spatial data for the Natura 2000 network to demonstrate where large numbers of Natura 2000 sites or large areas within the network are affected by the largest projected increase in temperature by the end of this century. The project then uses the results of Task 2a (vulnerability assessments of species of Community interest) and relates them to the spatial occurrence of these species in Natura 2000 sites. Statistical analyses have been carried out for Member States and for biogeographic regions.

Almost 80 percent of all Natura 2000 sites will face temperatures 2-3˚C higher towards the end of the century under the A2 scenario. This increase would affect more than 75% of the area covered by Natura 2000 sites. Under the B1 scenario these percentages are considerably lower. However, even under the less severe B1 scenario 67% of all sites, corresponding to about 65% of Natura 2000 coverage, may experience a temperature increase of 1-2˚C. A small number of Natura 2000 sites are projected to experience a rapid temperature increase of 3-4˚C before 2065 under the A2 scenario.

Further analyses were based on vulnerability scores developed in Task 2a for species of Community interest. Such scores were produced for a total of 212 (~ 24.4%) out of 869 species listed in the Birds and Habitats Directives, thereof 149 bird species, 12 amphibian species, 12 reptile species, 13 butterfly species and 26 plant species. For the remaining 657 (869 minus 212) species of Community Interest no suitable modelling data was available for their inclusion in the vulnerability assessment conducted in Task 2a (which underpins the present Task 3a analysis). See the Task 2a Report, Section 2 “Overview of methodology and data sets” for further information.

Eight of the 24 reptile and amphibian species were assessed as highly vulnerable and are reported to occur in the Alpine, Mediterranean and Continental biogeographic regions; five of them are also reported in the Atlantic region. Their occurrence is distributed across Natura 2000 sites of various countries. Two amphibian species are considered particularly vulnerable since they are reported as occurring only in a very few Natura 2000 sites in Italy and Romania. None of the reptile species assessed as highly vulnerable are reported to occur in only a very few Natura 2000 sites.

For butterflies, the distribution of highly vulnerable species across biogeographic regions resembles that of other taxa, except that some species are also reported in Natura 2000 sites of the Pannonian biogeographic region in Hungary, Romania, Slovakia and Slovenia. One species is considered to be particularly vulnerable as it is reported to be present in only 10 Natura 2000 sites in Sweden.

The vulnerability assessments for plants do not show a large number of highly vulnerable species. Two plant species are considered of particular vulnerability because they are assessed as more than moderately vulnerable while they are reported to occur in only a

small number of Natura 2000 sites. However, one of these species is reported from separate sites in nine different countries. The other species is reported to occur in the Pannonian biogeographic region in Hungary, Romania and Slovakia.

Large numbers of bird species assessed as highly vulnerable are reported to occur in the Mediterranean biogeographic region and, within this region, in Italy, Greece and Spain. Large numbers of highly vulnerable bird species are also reported from the Alpine and Continental biogeographic regions. Several bird species have been assessed as, at least, highly vulnerable and are reported to occur only in a very small number of Natura 2000 sites; this makes them particularly vulnerable.

Member States can use the results of this study in different ways. The design and implementation of adaptation measures may require focus on regions that host a large number of species assessed as highly vulnerable. Highly vulnerable species that are reported to occur only in a very few Natura 2000 sites could receive special attention; cooperation with neighbouring countries hosting these species would make it possible to address their conservation in a more holistic way. Member States may also want to follow up on the occurrence of particularly vulnerable species outside Natura 2000 sites and consider the distribution of these species in the design of landscape scale conservation measures.

The study points to the need to assess the vulnerability of a larger number of species of Community interest in order to obtain a more complete picture of the robustness of the Natura 2000 network.

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Introduction

The Fourth Assessment Report of the IPCC reported a range of impacts from climatic changes in Europe (Alcamo *et al.* 2007). Based on empirical evidence and best practice models, it concluded that climate related hazards and water stress across Europe will mostly increase, regional differences of Europe's natural resources and assets will get magnified, and natural ecosystems and biodiversity will be substantially affected, with many species expected to have difficulties in adapting (Alcamo *et al.* 2007). Europe has warmed more than the global average [i.e. about 1.0°C compared with pre-industrial times for land and oceans (global mean = 0.8°C) and about 1.2°C for land alone (global mean = 1.0°C) (EEA *et al.* 2008)]. Warming trends in Europe have been most intense in the south-west, in the north-east and in mountainous areas (EEA *et al.* 2008). The glaciers of the European Alps, for example, have lost two thirds of their volume since 1850 (Haeberli *et al.* 2007).

In 2002 the European Union adopted the target of halting the loss of biodiversity by 2010 (known as the 2010 target). The Natura 2000 network is the centrepiece of biodiversity and conservation policy in the European Union and the major tool to achieve the 2010 target (EC 2003). Member States are legally bound to designate Special Areas of Conservation under the Habitats Directive (Council of the European Communities 1992) and Special Protection Areas under the Birds Directive (Council of the European Communities 1979). One of the specific aims of the network is to protect species of Community interest. The network currently consists of more than 26,000 sites and covers an area of around 850,000 km^2 (terrestrial and marine area), corresponding to about 20% of the territory of the European Union and 17% of its terrestrial area (European Commission 2009b). Table 1 shows the area and percentage coverage of Natura 2000 sites by Member State of the European Union.

Table 1: Area of Member States covered by Natura 2000 sites (Source: EC 2008)

Member state	National terrestrial area (km^2)	Natura 2000 terrestrial area (km^2)	% Natura 2000 terrestrial area	Natura 2000 marine area (km^2)
Austria	83859	11533	13.8%	/
Belgium	30528	3883	12.7%	337
Bulgaria	110910	37656	34.0%	973
Cyprus	5736	1005	17.5%	51
Czech Republic	78866	10453	13.3%	/
Denmark	43093	3857	9.0%	12819
Estonia	45226	7988	17.7%	6574
Finland	338145	48637	14.4%	6889
France	549192	68420	12.5%	14945
Germany	357031	48473	13.6%	23224
Greece	131940	27621	20.9%	6382
Hungary	93030	19564	21.0%	/
Ireland	70280	7800	11.1%	6481
Italy	301333	57368	19.0%	4469
Latvia	64589	7116	11.0%	559
Lithuania	65301	9085	13.9%	895
Luxembourg	2597	462	17.8%	-
Malta	316	41	13.0%	9
Netherlands	41526	5785	13.9%	5435
Poland	312685	51629	16.5%	7239
Portugal	91990	18717	20.3%	1465
Romania	238391	48850	20.5%	1574
Slovakia	48845	14128	28.9%	/
Slovenia	20273	7201	35.5%	2
Spain	504782	134644	26.7%	7912
Sweden	414864	60151	14.5%	5035
United Kingdom	244820	17364	7.1%	16712
Total	4290148	729431	17.0%	129981

In May 2006, the European Commission adopted a Communication on "Halting the loss of Biodiversity by 2010 – and Beyond: Sustaining ecosystem services for human well-being". The Communication underlined the importance of biodiversity conservation and included a detailed EU Biodiversity Action Plan (BAP, COM 2006/216) to achieve its objectives. In 2008 the Biodiversity Action Plan underwent a mid-term assessment, the report[1] of which provides essential reflections on the achievements of biodiversity and nature policy in the EU (see Task Report 2b & 3b, Section 3 for further information).

While the Member States have made significant progress in designating Natura 2000 sites, the process has not yet been concluded. By December 2008, sites declared under the Birds Directive were still incomplete in 19 Member States and sites declared under the Habitats Directive were incomplete in 22 of the 27 Member States of the European Union (European Commission 2009a).

It is clear that, for a number of reasons, the 2010 target will not be met (EEA 2009). The role played by climate change in this failure is not yet understood since the impacts of climate change on species and habitats have only recently started to become visible. However, it is obvious that future climate change impacts will not spare the Natura 2000 network.

Species and habitats react differently to climatic changes. While some European species may benefit, others will suffer considerably (Harrison *et al.* 2006). Climate change will affect species distribution ranges, reproductive cycles, growing seasons and interactions with their biophysical environment (Reid 2006). If they can, species will adapt their distribution ranges to the changing conditions. However, whether this is possible depends on their mobility and on species-specific dependencies on environmental conditions (including other species). The vulnerability of species will decide their fate under changing climatic conditions. In addition, the mobility of species can be constrained by man-made barriers (BRANCH partnership 2007). By knowing where the most vulnerable species occur, policy measures can be developed to support these species. This will be of major importance in maintaining the significance of the Natura 2000 network for the long-term protection of species of Community interest.

This report presents the results of Task 3a of the project “Biodiversity and climate change in relation to the Natura 2000 network”. It builds on Tasks 1 and 2a of the same project by looking at the vulnerability of species of Community interest under climate change in the context of their representation in Natura 2000 sites across the European Union.

[1] http://ec.europa.eu/environment/nature/biodiversity/comm2006/bap_2008.htm

Aim and specific objectives

Aim

Task 3a of this project has two aims:

- To relate temperature projections for different time horizons and under different scenarios to the European Union's Natura 2000 network.
- To analyse the spatial distribution of species of Community interest that are vulnerable to climate change across the European Union's Natura 2000 network.

Specific objectives

This report presents the results of linking the outcomes of Task 2a of this project with climate change scenarios and spatial data on the Natura 2000 network. The specific objectives are:

- To demonstrate where in the European Union temperature changes are expected to be highest for the timescales 2011 – 2030, 2046 – 2065 and 2080 – 2099.
- To demonstrate the location and percentage of Natura 2000 sites that will be affected by the expected temperature changes.
- To show the vulnerability of assessed species of Community interest and their occurrence across taxa, Member States and biogeographic regions.
- To highlight those assessed species of Community interest that only occur in a few Natura 2000 sites and are considered of high vulnerability to future climate change.

Source data and methods

The study required a combination of different datasets and application of different methods. Table 2 presents the datasets that were used and their sources. The subsequent sections describe the datasets and the methods applied to process, combine and analyse them.

Table 2: Datasets and sources used in Task 3a

Dataset	Description	Source
1	Climate projections from scenario and model combinations	Data Distribution Centre of the Intergovernmental Panel on Climate Change (http://www.ipcc-data.org/).
2	Spatial data for the Natura 2000 network	European Topic Centre on Biological Diversity (restricted access)
3	Spatial dataset on the biogeographic regions of the EU	European Environment Agency (http://dataservice.eea.europa.eu/atlas/viewdata/viewpub.asp?id=3641)
4	Natura 2000 databases containing information about all the sites electronically registered to date	European Topic Centre on Biological Diversity (restricted access)
5	Vulnerability assessments for species of Community interest	Task 2a of this project

Climate projections from scenario and model combinations (dataset 1)

In modelling future climate, different assumptions about future human energy consumption and development paths can be made. The Intergovernmental Panel on Climate Change (IPCC) responded to the resulting wide range of possible futures by developing a set of so-called "scenarios", each of which is based on a different "storyline". Figure 1 presents the storylines of the four main scenario families in a comparative way (source: Nakicenovic and Swart 2000).

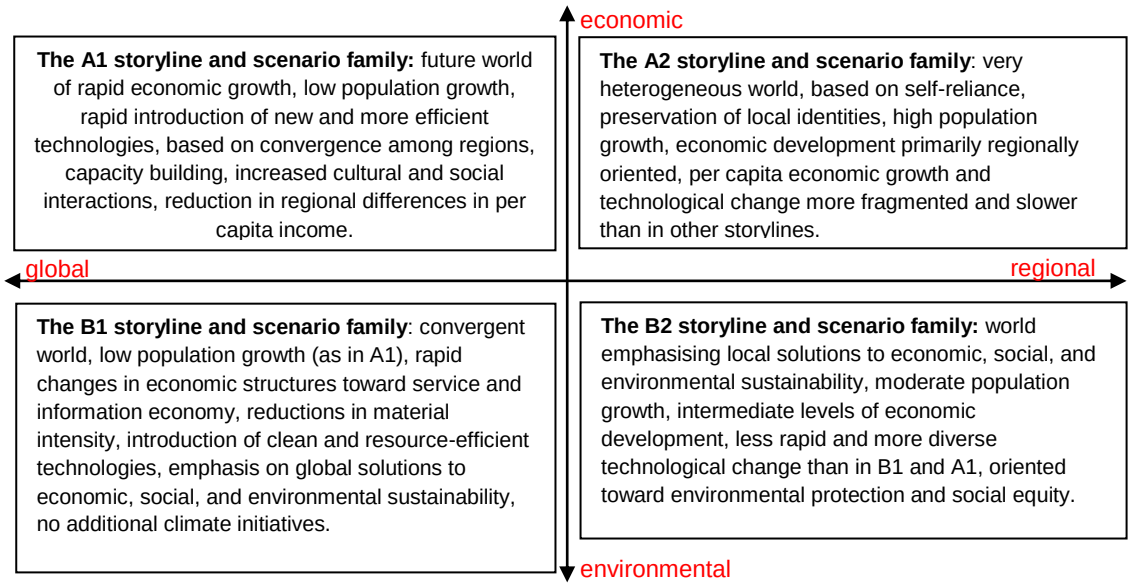


Figure 1: The IPCC storylines and scenario families (after Nakicenovic and Swart 2000)

For the purpose of this project, the scenario families A2 and B1 were selected. This scenario selection was based on: a) the wide range of possible future climates they project; and b) the availability of the scenario data from the IPCC's Fourth Assessment Report in combination with an appropriate Global Climate Model (see explanation below).
Table 3 compares the main characteristics of the scenarios A2 and B1 according to Nakicenovic and Swart (2000) in order to highlight their major differences.

Table 3: Main characteristics of the scenarios A2 and B1 (after Nakicenovic and Swart 2000)

Characteristic	A2	B1
Population growth	High	Low
GDP growth	Medium	High
Energy use	High	Low
Land-use changes	Medium/high	High
Resource availability	Low	Low
Pace and direction of technological change favoring	Slow and regional	Medium, towards efficiency and dematerialization

For climate change projections, scenario assumptions are applied to General Circulation Models (GCM). Numerous studies of climate change impacts on European biodiversity have shown that the Hadley Centre Climate Model 3 (HadCM3) is appropriate for use at the European level (Schroter *et al.* 2005; Araujo and Rahbek 2006; Rounsevell *et al.* 2006; Berry *et al.* 2007). Based on this and the availability of the respective data from the IPCC Data Distribution Centre (IPCC DDC) the HadCM3 model was selected for the purpose of this study.

The IPCC DDC provides climate, socio-economic and environmental data from the past as well as in scenarios projected into the future. Dataset 1, referring to the data for the scenarios A2 and B1 both calculated with the HadCM3 model for the three time slices 2011-2030, 2046-2065 and 2080-2099, was downloaded from the IPCC DDC for the atmospheric prognostic variable air temperature. Advantages of using this data are that it is the most recent combined climate scenario and model data that is freely available and that the data on average temperature did not need extensive processing. A disadvantage of the data is its resolution of only 3.75 by 2.5 degree grid cells. Data sources of other projects on climate change and biodiversity across the European Union were reviewed to find out whether there are other

recent, freely available, and easily processable datasets of higher resolution. However, the reviewed projects have used earlier scenario and model data and processed this data in more complex ways (e.g. Thuiller *et al.* 2005; Berry *et al.* 2007). The more recent data provided by the IPCC DDC was therefore preferred. Apart from air temperature no data for other prognostic variables was downloaded from the IPCC DDC. The reasoning for this is further discussed in the section “Caveats”.

To close, it appears and must be kept in mind that the climate models and predictions underlying the IPCC 4th Assessment Report are today believed to under-estimate the impacts of climate change because several aspects including positive climate feedbacks and the melting of important ice-sheets were not considered in the calculations and analyses.

Spatial data for the Natura 2000 network (dataset 2)

Dataset 2 was provided by the European Topic Centre on Biological Diversity and presents the most up-to-date spatial dataset for the Natura 2000 network. It contains data on 24,764 of the more than 26,000 Natura 2000 sites distributed across the 27 Member States of the European Union. Each site has a unique site code. However, since some of these sites are spread over different locations and therefore consist of more than one polygon, several sites have more than one entry with the same site code and the spatial dataset includes more than 100,000 polygons in total. Map 1 shows the distribution of Natura 2000 sites across the biogeographic regions of the European Union. Table 4 shows the number of Natura 2000 sites per Member State.

Dataset 2 was linked to datasets 3, 4 and 5, as described in the section “Linking the datasets”.

Table 4: Number of Natura 2000 sites per Member State

Country	No. of sites	Country	No. of sites	Country	No. of sites
Austria	217	Germany	5097	Netherlands	212
Belgium	462	Greece	371	Poland	480
Bulgaria	332	Hungary	509	Portugal	136
Cyprus	38	Ireland	533	Romania	381
Czech Republic	896	Italy	2563	Slovakia	420
Denmark	344	Latvia	336	Slovenia	286
Estonia	524	Lithuania	340	Spain	1723
Finland	1859	Luxembourg	60	Sweden	4062
France	1705	Malta	33	United Kingdom	845

Spatial dataset on the biogeographic regions of the EU (dataset 3)

Dataset 3 (biogeographic regions) is available from the European Environment Agency and was used for analyses at the sub-European Union level. This aligns well with Task 1, since biogeographic regions are used there to structure the literature review. Biogeographic regions are also used within the Birds and Habitats Directives (Roekaerts 2002).

Map 1 shows the biogeographic regions of the European Union combined with dataset 2 (the spatial distribution of Natura 2000 sites). Table 5 shows the percentage coverage of Natura 2000 sites by Member State and biogeographic region.

Whereas several biogeographic regions cover a number of Member States, others cover only a few Member States. The Black Sea biogeographic region is the smallest by area (less than 10,000 km^2), three quarters of which falls within Bulgaria and the remaining part in Romania. The next smallest biogeographic region is the Macaronesian with an area of just over 10,000

km^2 in Spain and Portugal. A total of 18 Member States include parts of the Continental biogeographic region which is the largest in size with a total coverage of more than 1.25 million km^2.

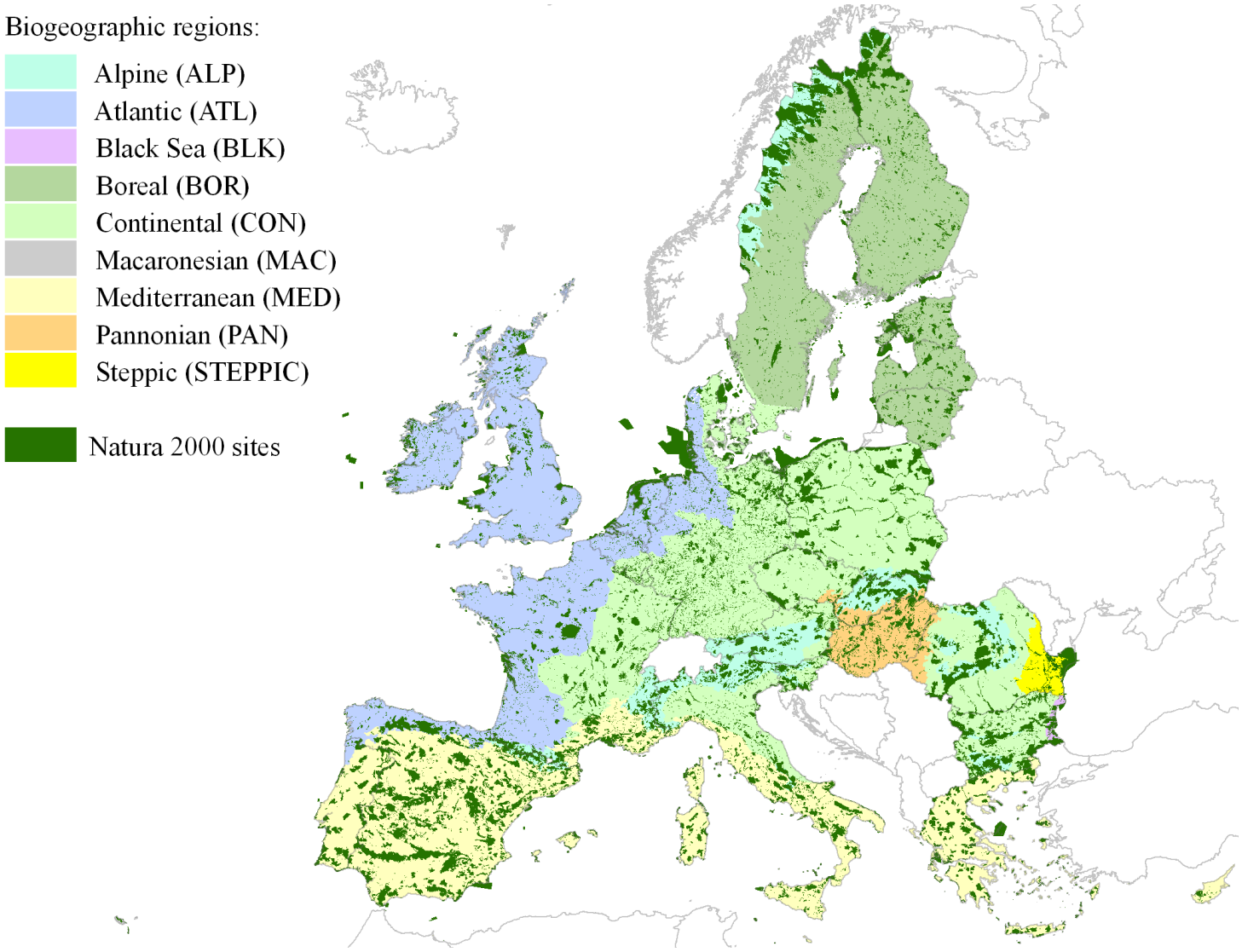
Table 6 summarises the number of countries representing each of the biogeographic regions and their total area (in km^2).

Table 5: Percentage coverage of biogeographic region by Member State

Country	Alpine	Atlantic	Black Sea	Boreal	Continental	Macaronesian	Mediterranean	Pannonian	Steppic
Austria	62.69%	/	/	/	37.21%	/	/	0.10%	/
Belgium	/	61.27%	/	/	38.73%	/	/	/	/
Bulgaria	15.46%	/	6.69%	/	77.67%	/	0.05%	/	0.13%
Cyprus	/	/	/	/	/	/	10/	/	/
Czech Republic	0.02%	/	/	/	95.67%	/	/	4.31%	/
Denmark	/	32.62%	/	/	67.38%	/	/	/	/
Estonia	/	/	/	10/	/	/	/	/	/
Finland	4.84%	/	/	95.16%	/	/	/	/	/
France	5.58%	48.96%	/	/	33.53%	/	11.92%	/	/
Germany	1.13%	19.60%	/	/	79.27%	/	/	/	/
Greece	0.09%	/	/	/	0.09%	/	99.81%	/	/
Hungary	0.01%	/	/	/	0.06%	/	/	99.93%	/
Ireland	/	10/	/	/	/	/	/	/	/
Italy	16.95%	/	/	/	29.13%	/	53.92%	/	/
Latvia	/	/	/	10/	/	/	/	/	/
Lithuania	/	/	/	99.95%	0.05%	/	/	/	/
Luxembourg	/	/	/	/	10/	/	/	/	/
Malta	/	/	/	/	/	/	10/	/	/
Netherlands	/	10/	/	/	/	/	/	/	/
Poland	3.22%	/	/	0.01%	96.78%	/	/	/	/
Portugal	/	5.15%	/	/	/	3.51%	91.34%	/	/
Romania	21.08%	/	0.98%	/	56.52%	/	/	5.82%	15.60%
Slovakia	70.69%	/	/	/	0.04%	/	/	29.26%	/
Slovenia	38.02%	/	/	/	61.96%	/	/	0.03%	/
Spain	1.91%	11.02%	/	/	/	1.48%	85.59%	/	/
Sweden	19.18%	/	/	77.29%	3.53%	/	/	/	/
United Kingdom	/	10/	/	/	/	/	/	/	/

Table 6: Number of Member States in each biogeographic region and total area of biogeographic regions

Biogeographic region	No. of Member States in the region	Total area of the region (km^2)
Alpine	15	370,116
Atlantic	9	782,613
Black Sea	2	9,746
Boreal	6	841,681
Continental	18	1,256,900
Macaronesian	2	10,693
Mediterranean	8	886,472
Pannonian	6	124,583
Steppic	2	37,176



Map 1: Biogeographic regions of the European Union and distribution of Natura 2000 sites

By combining datasets 2 and 3 the number of Natura 2000 sites can be calculated by Member State and biogeographic region (see Table 7). The largest number of Natura 2000 sites is found in the Continental region (more than 7900 sites). The smallest number of Natura 2000 sites is in the Black Sea biogeographic region (53 sites).

Table 7: Number of Natura 2000 sites by Member State and biogeographic region

Country	Alpine	Atlantic	Black Sea	Boreal	Continental	Macaronesian	Mediterranean	Pannonian	Steppic
Austria	136	/	/	/	81	/	/	/	/
Belgium	/	126	/	/	336	/	/	/	/
Bulgaria	29	/	41	/	262	/	/	/	/
Cyprus	/	/	/	/	/	/	38	/	/
Czech Republic	/	/	/	/	773	/	/	123	/
Denmark	/	93	/	/	251	/	/	/	/
Estonia	/	/	/	524	/	/	/	/	/
Finland	20	/	/	1839	/	/	/	/	/
France	159	638	/	578	/	/	330	/	/
Germany	52	775	/	/	4270	/	/	/	/
Greece	/	/	/	/	/	/	371	/	/
Hungary	/	/	/	/	/	/	/	509	/
Ireland	/	533	/	/	/	/	/	/	/
Italy	526	/	/	/	657	/	1380	/	/
Latvia	/	/	/	336	/	/	/	/	/
Lithuania	/	/	/	340	/	/	/	/	/
Malta	/	/	/	/	/	/	33	/	/
Luxembourg	/	/	/	/	60	/	/	/	/
Netherlands	/	212	/	/	/	/	/	/	/
Poland	35	/	/	/	445	/	/	/	/
Portugal	/	10	/	/	/	48	78	/	/
Romania	108	/	12	/	167	/	/	26	68
Slovakia	254	/	/	/	/	/	/	166	/
Slovenia	102	/	/	/	184	/	/	/	/
Spain	66	217	/	/	/	208	1232	/	/
Sweden	132	/	/	3495	435	/	/	/	/
United Kingdom	/	843	/	/	/	/	2	/	/
Total	**1619**	**3447**	**53**	**7112**	**7921**	**256**	**3464**	**824**	**68**

The spatial dataset for biogeographic regions was used in combination with datasets 2, 4 and 5 in order to generate statistics on the occurrence of species in the biogeographic regions (see also the section “Linking the datasets”).

Natura 2000 databases (dataset 4)

Dataset 4 was provided by the European Topic Centre on Biological Diversity. It consists of two separate databases, one of all Natura 2000 sites designated under the Birds Directive, and one of all those designated under the Habitats Directive. For each Natura 2000 site, there is information on which species and habitats occur at the site. These databases together hold information about more than 26,000 Natura 2000 sites now designated in the European Union and almost 870 species considered of Community interest. All those species assessed in Task 2a were in the Natura 2000 databases and therefore considered in Task 3a.

For the purpose of the project, the two databases had to be merged into one database of all Natura 2000 sites. However, a large number of sites are designated under both Directives. Therefore, when merging the datasets, site duplicates had to be identified and deleted. The resulting dataset made it possible to calculate how many Natura 2000 sites each of the assessed species occurred in. Some species occur in only one site (e.g. *Falco rusticolus*), while others occur in several thousand (4511 in the case of *Lanius collurio*). Annex II provides lists of all assessed species including the number of sites where they occur.

Dataset 4 provides the link between dataset 2, and 5 since it holds information on species names that can be linked with assessment results of dataset 5 as well as site codes for where the species occur and that can be linked to the spatial data of dataset 2. This is further explained in the separate section “Linking the datasets”.

Vulnerability assessment results for species of Community Interest (dataset 5)

Dataset 5 consists of the assessment results produced by Task 2a. Overall, 212 species were assessed, representing almost 25% of all species of Community interest according to the Birds and Habitats Directives. Table 8 shows the taxa coverage in Task 2a. All species assessed in Task 2a were considered in Task 3a.

Table 8: Taxa coverage in Task 2a and Task 3a

Taxon	No. of species of Community Interest	No. of species assessed in Tasks 2a & 3a	% of species assessed in Tasks 2a & 3a
Amphibians	25	12	48.0 %
Reptiles	24	12	50.0 %
Butterflies	38	13	34.2 %
Plants	588	26	4.4 %
Birds	194	149	76.8 %
Total	**869**	**212**	**24.4 %**

For all the taxa combined, the Natura 2000 sites of Italy host the largest number of species assessed in the present study (152), followed by Greece (146) and Spain (142) (see Figure 2). The lowest number of assessed species occurs in Natura 2000 sites in Ireland (31 bird species and one butterfly species).

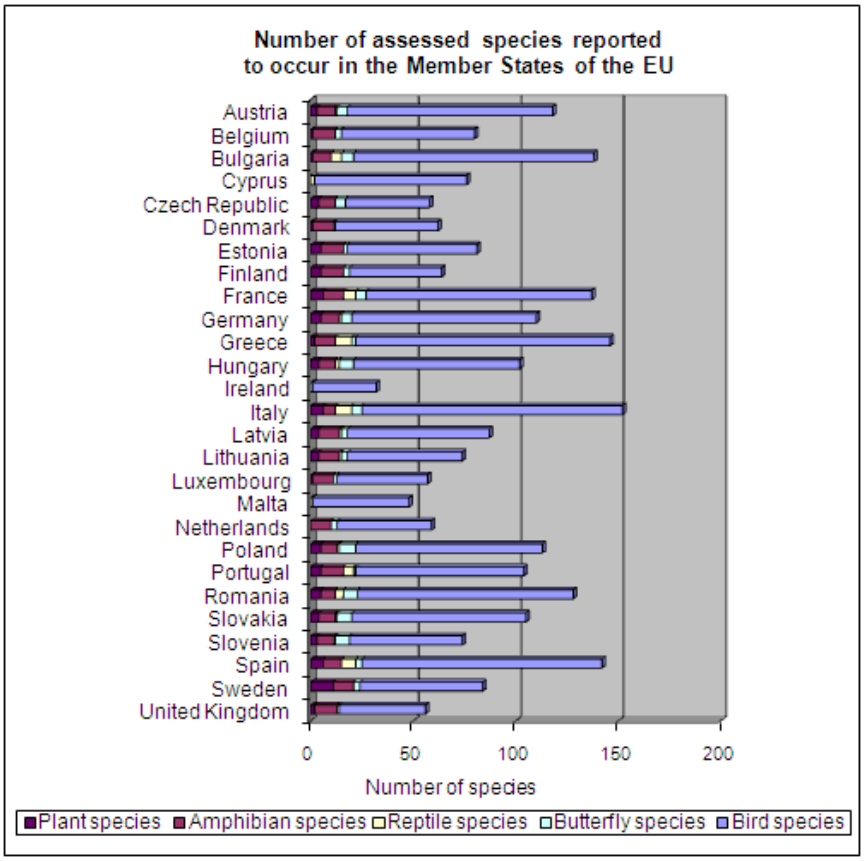


Figure 2: Number of assessed species reported to occur in the Member States of the EU

The vulnerability assessments conducted in Task 2a were based on results from previous studies of species distribution shifts and changes in their climate space under climate change (see Task 2a report). These studies were not all conducted according to the same method and therefore not all of the results are directly comparable. The assessments of amphibians and reptiles delivered four vulnerability scores per species for the time horizon to 2050, by applying the four main IPCC scenarios. Butterflies were assessed to 2050 and to 2080 by applying the A1F1, A2 and B1 scenario, resulting in six vulnerability scores per species. Each plant species was assessed to 2050 and to 2080 by applying the four main IPCC scenarios: A1F1, A2, B1 and B2, resulting in eight vulnerability scores per species. For each bird species, one vulnerability score was calculated for the time slice 2070 to 2099 by applying the B2 scenario.

From these different combinations of scenarios and time horizons, a smaller number has been selected for combination with other data in Task 3a. This selection aimed at maximising consistency between Task 2a and Task 3a, as well as within Task 3a, and also comparability of results across taxa, as far as possible. Table 9 summarises the assessments conducted in Task 2a and the selection of results used for further analyses in Task 3a.

Table 9: Selection of data from Task 2a used in Task 3a

Taxon	Assessed in Task 2a		Selected for analysis in Task 3a	
	Time horizon	Scenarios	Time horizon	Scenarios
Amphibians	2050	A1F1, A2 B1, B2	2050	A2
Reptiles	2050	A1F1, A2 B1, B2	2050	A2 and B1
Butterflies	2050	A1F1, A2 B1	2050	A2 and B1
	2080	A1F1, A2 B1	2080	A2 and B1
Plants	2050	A1F1, A2 B1, B2	2050	A2
	2080	A1F1, A2 B1, B2	2080	A2 and B1
Birds	2070-2099	B2	2070-2099	B2

No separate statistics were calculated for the vulnerability assessments of amphibians and plants under the B1 scenario to 2050, as these were almost identical to the A2 assessment outcomes to 2050. The small existing differences are explained in the text in the corresponding sections.

In the following, assessment results from Task 2a are briefly presented by taxon in the same order as listed in Table 9 and for the time horizons and scenarios selected for analysis in Task 3a and shown in the same table. It is this data that is presented in a spatial context in the results section of the report.

Amphibian species

In the case of amphibians the vulnerability of 12 species was assessed, covering 48% of all amphibian species of Community interest. The distribution of species among vulnerability categories is shown in Figure 3.

The distribution of species across vulnerability categories is not shown for the B1 scenario since the difference is minimal when compared to the distribution under the A2 scenario. Only one species, *Salamandrina terdigitata*, is assessed differently under A2 and B1. It was assessed as of very high vulnerability by 2050 under the A2 scenario but of only high vulnerability under the B1 scenario.

Figure 3 shows that 50% of the assessed amphibian species were considered of high vulnerability under A2 by 2050, and *Salamandrina terdigitata* of very high vulnerability. Two of the assessed amphibian species, *Bombina variegata* and *Pelobates fuscus insubricus*, are expected to benefit from climate change under the A2 scenario.

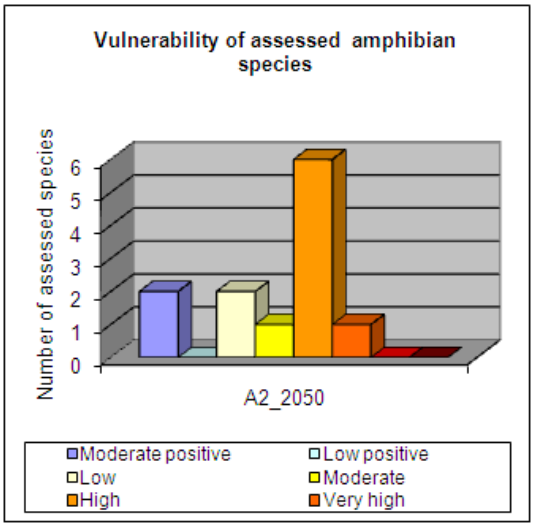


Figure 3: Vulnerability of assessed amphibian species

Reptile species

In the case of reptile species, the vulnerability of 12 species was assessed, covering 50% of all reptile species of Community interest. The distribution of species among vulnerability categories is shown in Figure 4. For the assessed reptile species, more species are classified as vulnerable under the B1 scenario than under the A2 scenario.

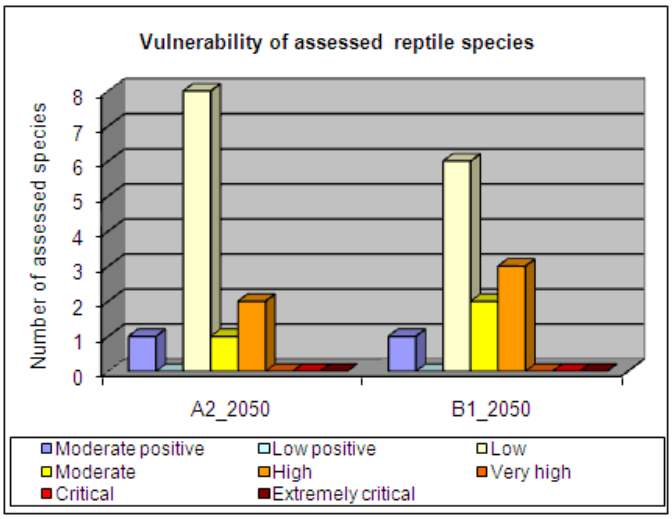


Figure 4: Vulnerability of assessed reptile species

Butterfly species

Of 38 butterfly species of Community interest, 13 were assessed in Task 2a under different scenarios and for different time horizons, equalling about 34% of all butterfly species of Community interest.

Figure 5 shows the distribution of assessed butterfly species across vulnerability categories under different scenarios and for different time horizons. *Colias myrmidone* was assessed as being critically vulnerable to climate change under A2 for both 2050 and 2080.

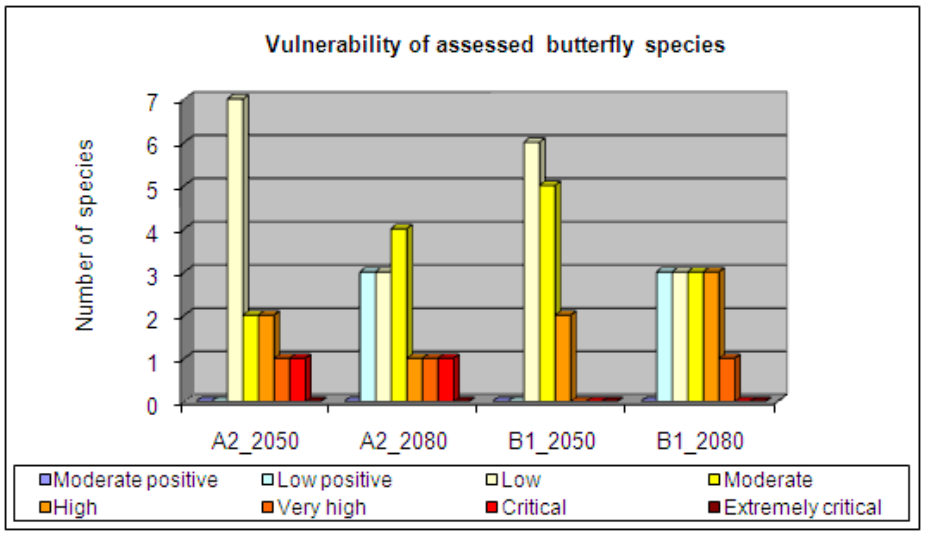


Figure 5: Vulnerability of assessed butterfly species

According to the assessed vulnerability scores for butterfly species, several species have the potential to benefit from climate change; for example *Melania arge*: The species vulnerability score changes from a high level of vulnerability under the A2 scenario in 2050 to a slightly positive reaction under A2 in 2080.

Plant species

Out of the 588 plant species of Community interest, the vulnerability of 26 was assessed in Task 2a of this project. Figure 6 shows the distribution of assessed species among vulnerability categories under different scenarios and for different time horizons.

Assessment results under the B1 scenario for the 2050 time horizon was almost identical to those under the A2 scenario, and are therefore not shown separately in Figure 6. Existing differences between the outcomes under the two scenarios relate to only two species: *Asplenium adulterinum*, for which vulnerability under the B1 scenario was low positive rather than low under A2; and *Papaver radicatum*, for which vulnerability was low under B1 rather than high under A2.

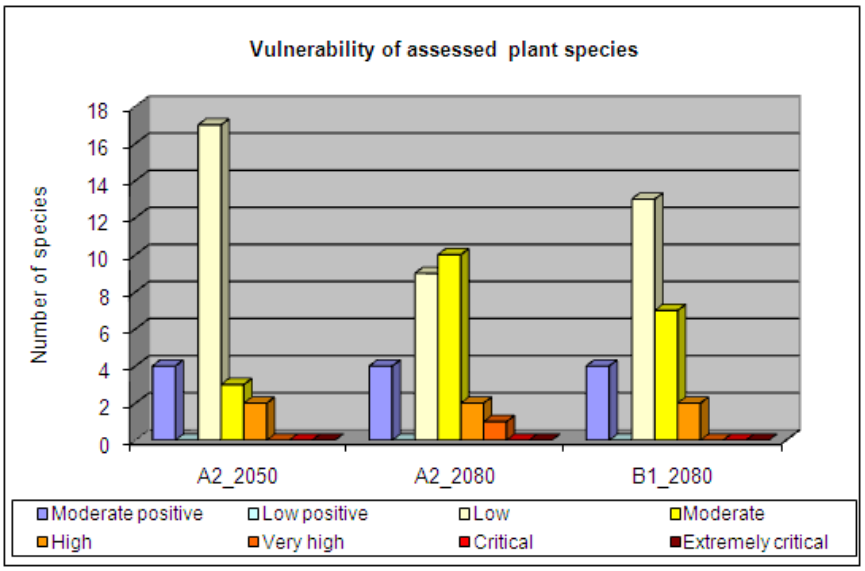


Figure 6: Vulnerability of assessed plant species

Differences between the two scenarios are more pronounced for the assessment to 2080. Here, more plant species were assessed as moderately vulnerable under the A2 scenario than under the B1 scenario. The species assessed as of very high vulnerability under the A2 scenario is *Pulsatilla pratensis.* It is also assessed as highly vulnerable under the B1_2080 scenario. When comparing assessment outcomes under A2 but for the different time horizons 2050 and 2080 it can be seen that a larger number of species is assessed to be of moderate vulnerability in the period to 2080 compared to 2050.

Bird species

Task 2a assessed 149 out of 193 bird species of Community interest, thereby covering almost 77% of these species.

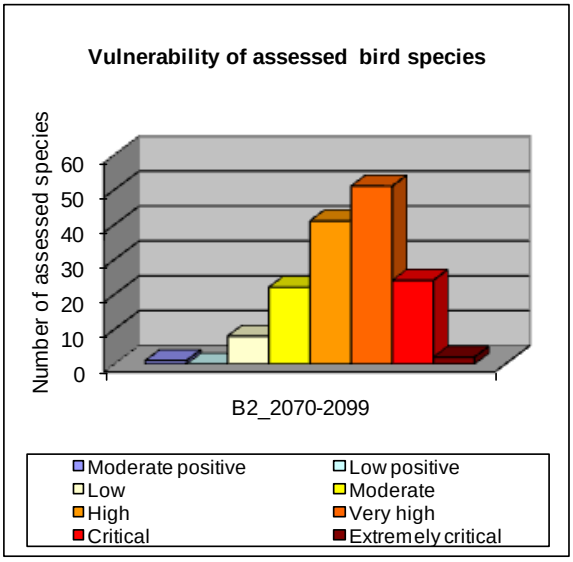


Figure 7: Vulnerability of assessed bird species

Figure 7 shows the distribution of assessed species across the vulnerability categories. Only one of the 149 species was assessed as reacting positively to climate change (*Alcedo atthis*).

Eight species of birds were assessed as being of low vulnerability, 22 species as moderately vulnerable, 41 species as highly vulnerable, 51 species as very highly vulnerable, 24 species as critically vulnerable and 2 species as extremely critically vulnerable (see Figure 7).

Linking the datasets

Before dataset 5 could be combined with datasets 2, 3 and 4, the Latin species names in the databases had to be checked for consistency across all datasets. This was necessary since the datasets used different names for some species. For example, the same butterfly species is named *Agriades glandon aquilo* in dataset 4 but *Plebejus glandon* in dataset 5. These had to be identified and made consistent to ensure accurate calculations of the number of sites where species occur. Annex II of this report provides information on the number of Natura 2000 sites each of the assessed species occurs in.

By connecting the species for which vulnerability scores were produced in Task 2a with the species records in the merged Natura 2000 database, the assessed species could be allocated to the Natura 2000 sites where they occur. The site codes of the resulting merged database were then linked to the site codes in the spatial dataset so that species vulnerability could be considered in relation to its spatial occurrence and statistical calculations could be made.

For calculating the number of Natura 2000 sites per biogeographic region, the centre point of each site was taken and the site then allocated to the biogeographic region in which the centre point lay. The majority of sites whose polygons cross the boundaries of biogeographic regions extend only slightly over these boundaries. Thus, the allocation of such sites to more than one biogeographic region would not have added much value to the statistical outputs.

Analyses were made for:

- The distribution of assessed species across the Member States by taxon.
- The distribution of assessed species across biogeographic regions by taxon.
- The number of assessed species that were considered of at least high vulnerability by taxon and by biogeographic region.
- The number of Natura 2000 sites and biogeographic regions in which each assessed species occurs.

Species that were assessed as at least highly vulnerable while only occurring in 20 or less Natura 2000 sites are analysed in more detail and results are discussed in a separate section. Complete tables of assessed species and their vulnerability scores divided by country and by biogeographic region are attached as Annex II.

Results

Temperature projections for the European Union

The IPCC DDC provided monthly average temperatures for the three time slices 2011-2030, 2046-2065 and 2080-2089 and for the two scenarios A2 and B1. In order to demonstrate the differences between the two scenarios, monthly average temperatures were transformed into seasonal average temperatures by building four groups of three monthly average values each: December, January, February = Winter; March, April and May = Spring; June, July and August = Summer; September, October and November = Autumn.

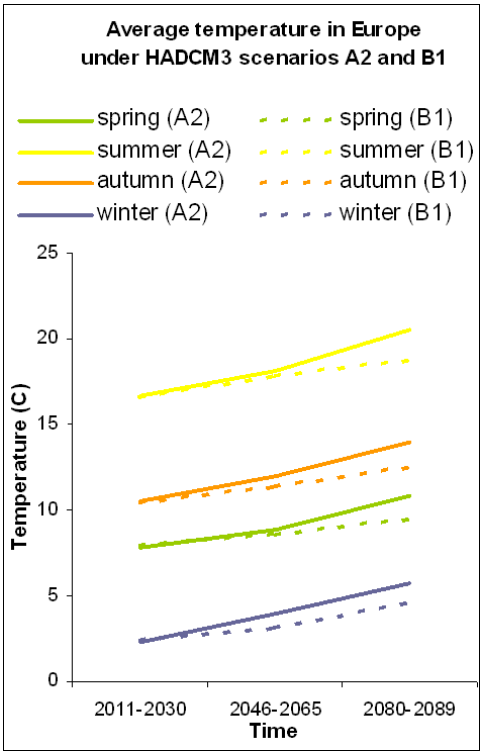
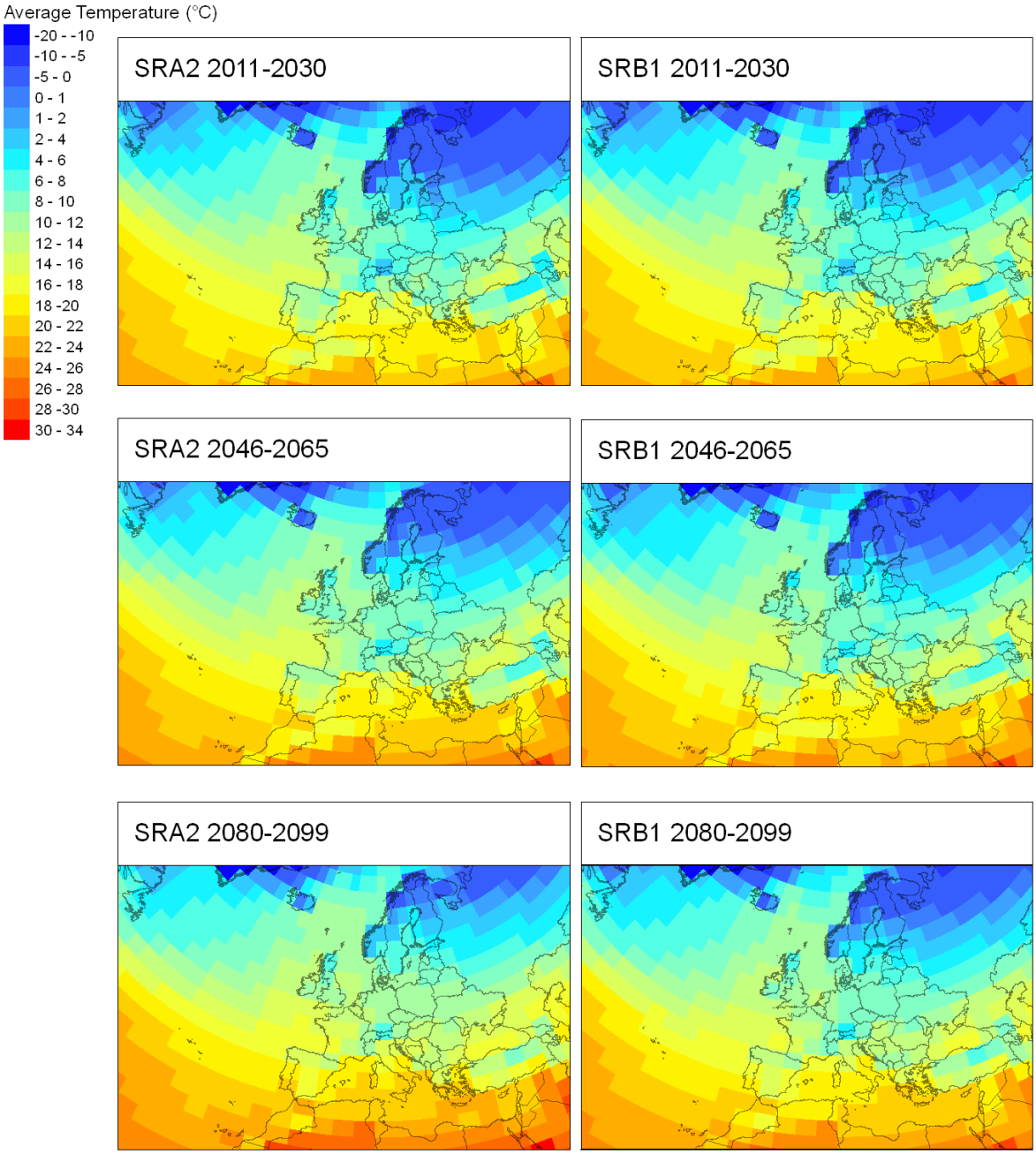


Figure 8: Average spring, summer, autumn and winter temperature in Europe under HADCM3 scenarios A2 and B1 and for the time slices 2011-2030, 2046-2065 and 2080-2089

Figure 8 shows that expected average temperatures are higher under the A2 scenario than under the B1 scenario. This difference becomes more pronounced on a longer time scale. In fact, for the time slice 2011-2030, the difference between the two scenarios is very small, especially when comparing the spring and summer average temperatures under the two scenarios. However, there is a difference of several degrees Celsius in the average temperature in all four seasons under the two scenarios within the last time slice.

Map 2 shows projected annual average temperature in Europe under the scenarios A2 and B1 for the three time slices 2011-2030, 2046-2065 and 2080-2099.

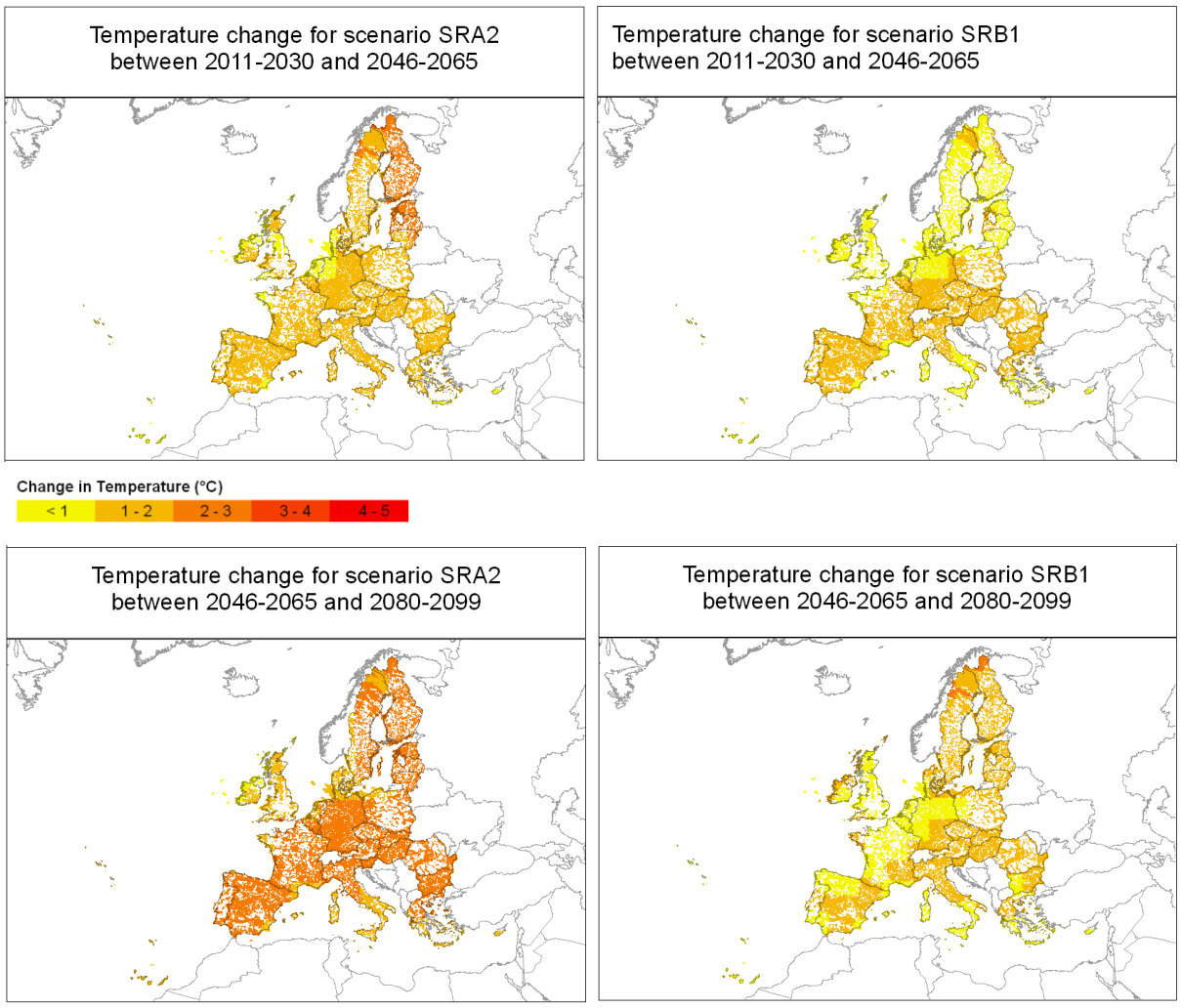
Map 2 reflects the trends indicated by Figure 8 on a yearly average. Differences between the two scenarios are most obvious for the third time slice: projected average temperature is higher e.g. in the Mediterranean and Scandinavia under the A2 scenario. Across the European Union and under both scenarios average temperature tends to increase rather than decrease towards the end of the century: Some of the areas coloured dark blue in the first time slice are coloured lighter blue in the third.



Map 2: Average temperature projections for the European Union under the A2 and B1 scenario using the HadCM3 model (data source: IPCC Data Distribution Centre)

Temperature changes across the Natura 2000 network

A comparison of the projections for the different time slices in Map 2 shows that different parts of the European Union will be differently affected by changes in annual average temperature in the future. Map 3 shows these projected temperature changes by comparing the annual average temperatures of the first and the second time slice and the second and the third time slice under the A2 and B1 scenarios. Natura 2000 sites are coloured according to the change in annual average temperature between the two time slices (see map legend, e.g. <1˚C expected temperature change = yellow coloured sites).



Map 3: Projected temperature change by Natura 2000 site between the time slices 2011-2030 and 2046-2065 (top row) and between the time slices 2046-2065 and 2080-2099 (bottom row) under the A2 and B1 scenarios

Overall, temperature changes projected under the A2 scenario are larger than those projected under the B1 scenario. Under the A2 scenario, temperature changes to 2065 are largest in the northern-most latitudes, Estonia and Latvia. From then until 2099 temperature changes are projected to be larger in most parts of the European Union and only lower in Great Britain, Denmark and the southern part of Italy. Projections under the B1 scenario result in a less severe temperature increase in Scandinavia to 2065, but from then until 2099 changes of 2-3°C in some northern parts of Sweden and Finland. Parts of Western Europe are less severely affected from rising temperatures under the B1 scenario than they are under the A2 scenario.

In order to capture the number of Natura 2000 sites affected by the projected changes in temperature, as well as the area they cover, the following two maps (Map 4 and Map 5) present the number of Natura 2000 sites per grid cell (upper two maps) and area of Natura 2000 sites per grid cell (lower two maps). Both sets of map use the same temperature changes shown in Map 3. The importance of the difference between the number of sites and area of sites becomes clear when looking at the grid cell with the highest number of Natura 2000 sites (1303), which cover 12,935 km^2, and comparing it, for example, with the grid cell covering most of the boundary between France and Spain; this contains less than a third of Natura 2000 sites (365) while covering more than twice the area (almost 26,000 km^2).

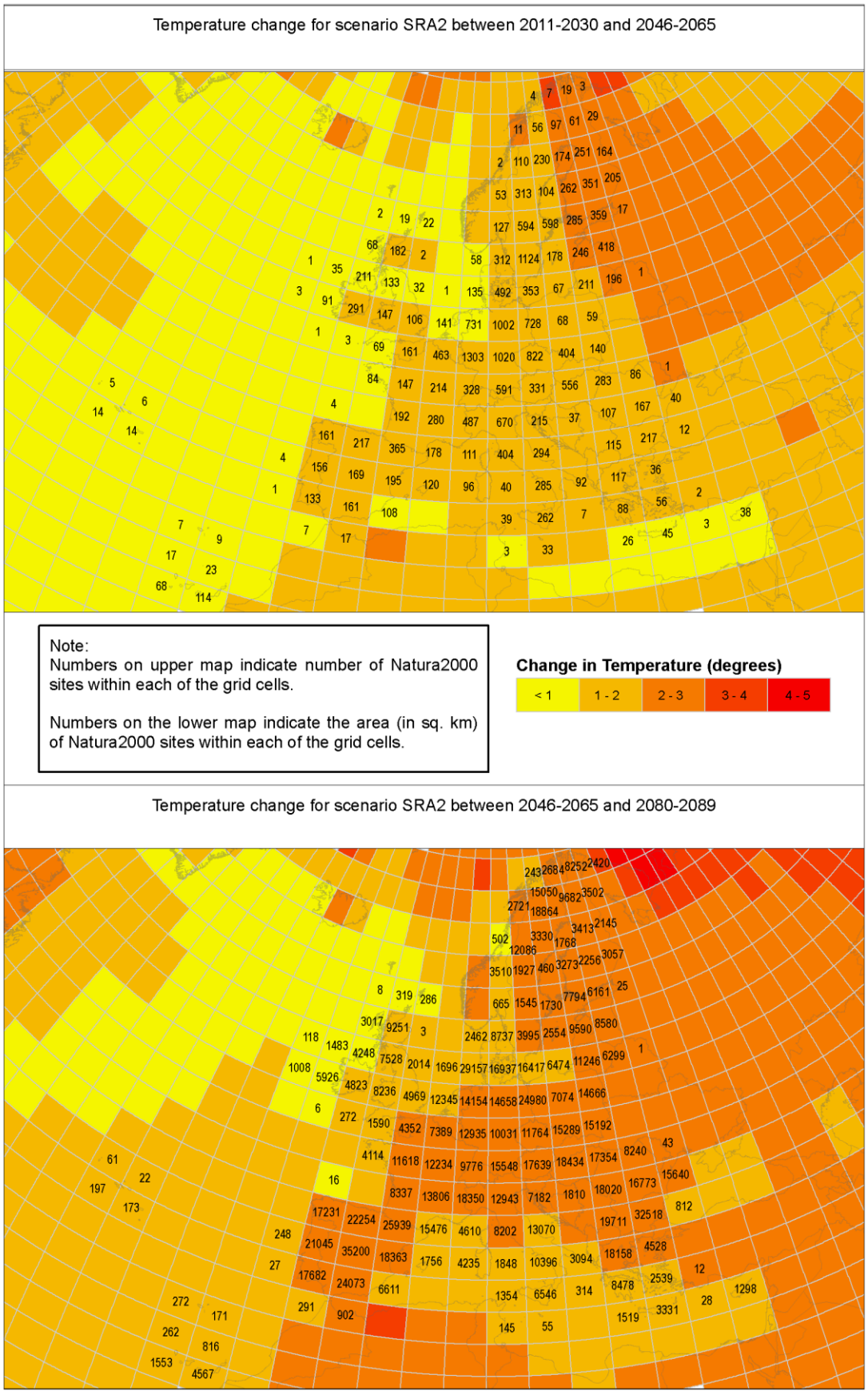
Table 10 shows the percentage of Natura 2000 sites (and the percentage of the total area of Natura 2000 sites) subject to the projected temperature changes under the A2 and B1 scenarios.

Table 10: Percentage of Natura 2000 sites subject to projected temperature changes
(slice 1: 2011-2030, slice 2: 2046-2065, slice 3: 2080-2099)

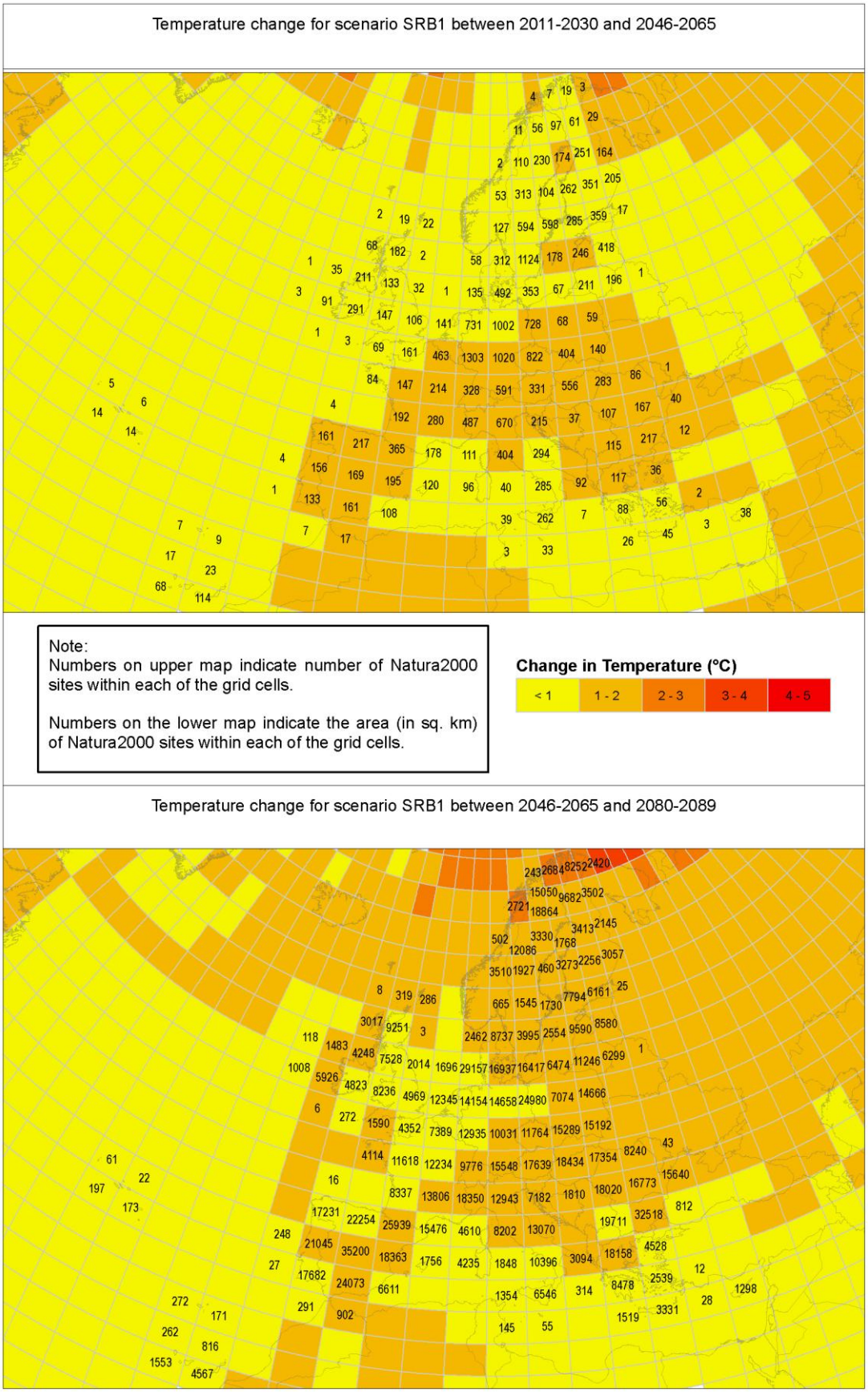
	A2				B1			
	Between slice 1 and slice 2		Between slice 2 and slice 3		Between slice 1 and slice 2		Between slice 2 and slice 3	
Temperature change	% Sites affected	% Area affected	% Sites affected	% Area affected	% Sites affected	% Area affected	% Sites affected	% Area affected
< 1	8.98%	10.77%	1.75%	1.61%	50.07%	39.70%	32.85%	33.57%
+1-2˚C	79.00%	79.86%	19.11%	22.57%	49.93%	60.30%	67.00%	64.90%
+2-3˚C	12.00%	9.12%	79.14%	75.83%	/	/	0.15%	1.53%
+3-4˚C	0.03%	0.25%	/	/	/	/	/	/

According to Table 10, almost 80 percent of all Natura 2000 sites will face temperatures 2-3˚C higher towards the end of the century under the A2 scenario. This increase would affect more than 75% of all area covered by Natura 2000 sites. Under the B1 scenario these percentages are considerably lower. However, even under the less severe B1 scenario 67% of all sites, corresponding to about 65% of Natura 2000 coverage, may experience a temperature increase of 1-2˚C. Only about 9% of all sites are expected to see a temperature increase of less than 1˚C by 2065 under the A2 scenario. Under the B1 scenario this percentage is five times higher and the area affected by a temperature rise of less than 1˚C covers almost 40% of the total area of the Natura 2000 network. A small number of Natura 2000 sites are projected to experience a rapid temperature increase of 3-4˚C before 2065 under the A2 scenario. The upper image in Map 4 shows the grid cell in which this increase is expected (7 sites).

It is of course not only temperature change that impacts on the Natura 2000 network. Depending on the location of sites, other climate change impacts may play an equal or even larger role than temperature changes. For example, sea surface temperatures have increased around the European Union's terrestrial area; sea levels have changed along some coastlines; annual precipitation has gone up especially in Scandinavia and the Baltic countries; and precipitation has gone down in most parts of the southern European Union (EEA *et al.* 2008). For more information on the difficulty of including more climate change impacts in the present study see the section "Caveats".



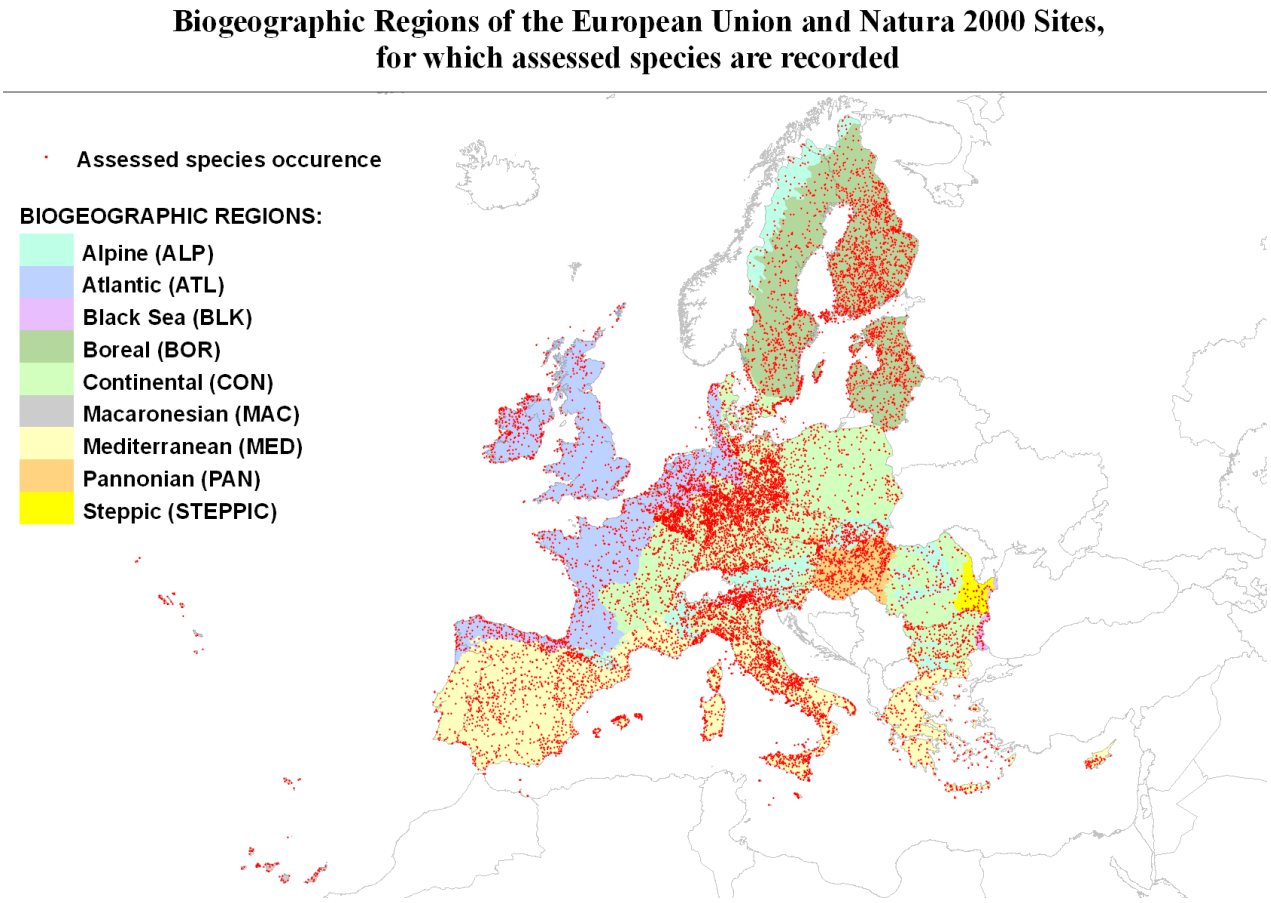
Map 4: Number and area of Natura 2000 sites affected by projected temperature change per grid cell under the A2 scenario (NB: the lower time slice is to 2080-2099, not 2080-2089)



Map 5: Number and area of Natura 2000 sites affected by projected temperature change per grid cell under the B1 scenario (NB: the lower time slice is to 2080-2099, not 2080-2089)

The distribution of vulnerable species across the Natura 2000 network

The spatial dataset of Natura 2000 sites includes polygons for 24,764 sites. By linking the species assessed in Task 2a to this spatial dataset, the Natura 2000 sites in which the species are reported to occur were identified. The 212 assessed species are reported to occur in 14,372 (or 58%) of the 24,764 sites. Map 6 shows the location of the 14,372 Natura 2000 sites in which the assessed species occur.



Map 6: Biogeographic regions of the European Union and Natura 2000 sites for which assessed species are recorded

Table 11 shows the distribution of assessed species across biogeographic regions. The largest number of assessed species is reported to occur in the Mediterranean biogeographic region (175 species), followed by the Continental region (161 species) and the Alpine region (155 species). Many of the 212 assessed species are reported to occur in more than 1 biogeographic region.

In the following, results of the combination of species' vulnerability scores with spatial Natura 2000 data are presented. This is done by first looking at the combined results for plants, amphibians, reptiles and butterflies. It is possible to present these results jointly since vulnerability assessment results exist for all these taxa under the A2 scenario to 2050. Subsequently, results are presented for all these taxa separately. This is followed by the results for birds. It was not possible to combine the results for birds with those of other taxa since the birds' vulnerability scores were calculated under the B2 scenario and to 2070-2099 (see Table 9).

Table 11: Number of assessed species per taxon and biogeographic region

Biogeographic region	Number of assessed species					
	Amphibians	Reptiles	Butterflies	Plants	Birds	Total
Alpine	10	6	12	10	117	**155**
Atlantic	6	4	5	6	100	**121**
Black Sea	2	5	3	-	107	**117**
Boreal	2	1	3	11	76	**93**
Continental	9	7	10	10	125	**161**
Macaronesian	-	1	-	2	33	**36**
Mediterranean	6	12	6	9	142	**175**
Pannonian	4	2	8	4	90	**108**
Steppic	2	4	2	1	94	**103**

Overview: plant, amphibian, reptile, and butterfly species

Figure 9 shows how the assessed plant, amphibian, reptile and butterfly species for each vulnerability category are distributed across the Member States of the European Union. The largest number of assessed amphibian, reptile, butterfly and plant species is reported to occur in Italy (25 species), followed by Romania (21 species), Spain and France (19 species each). Species of several countries are clearly underrepresented, such as Cyprus, Ireland and Malta. Only four of the assessed species occur in the United Kingdom and Denmark.

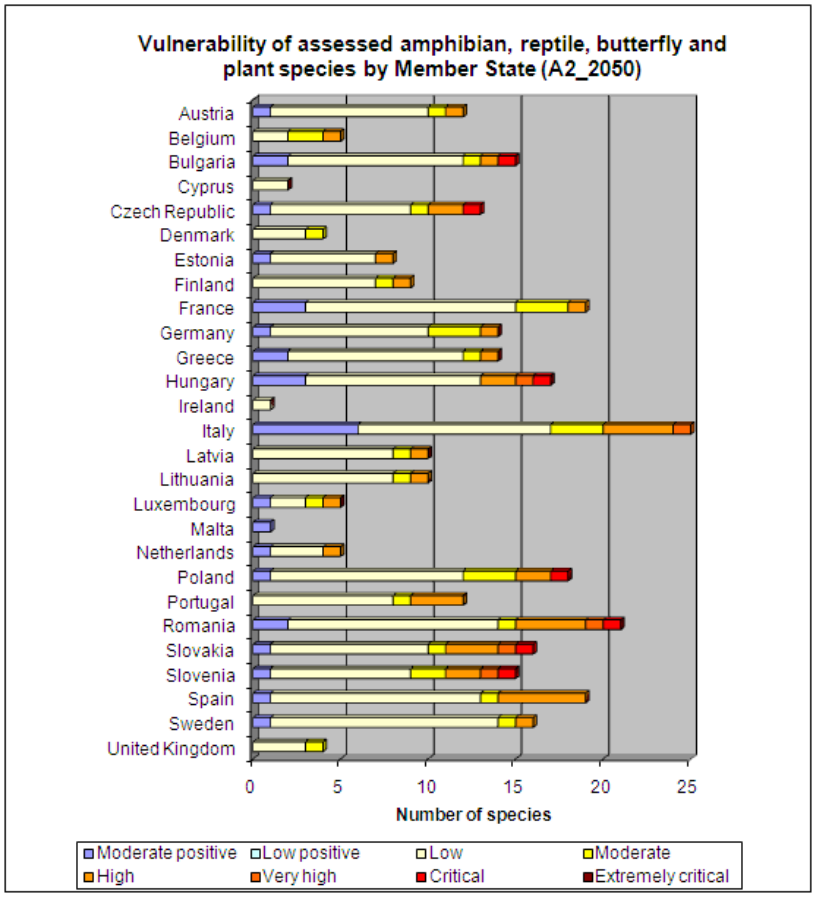


Figure 9: Occurrence of assessed amphibian, reptile, butterfly and plant species in Member States under the A2 scenario to 2050

Figure 9 shows that Natura 2000 sites in some Member States do not host any plant, amphibian, reptile or butterfly species assessed as more than moderately vulnerable in Task 2a, namely Cyprus, Denmark, Ireland, Malta and the United Kingdom. Of those countries for which more than moderately vulnerable species are reported, Romania hosts the largest number (6 species), followed by Italy, Slovakia and Spain with 5 species. Table 12 shows the total number of assessed amphibian, reptile, butterfly and plant species by Member State and the percentage of those that are considered of more than moderate vulnerability. It shows that, by percentage, Slovakia is leading the table with more than 30% of its assessed amphibian, reptile, butterfly and plant species considered at least highly vulnerable, closely followed by Romania with more than 28% of species considered at least highly vulnerable.

Table 12: Percentage of assessed amphibian, reptile, butterfly and plant species considered of high, very high, critical or extremely critical vulnerability by Member State

EU Member State	Number of assessed amphibian, reptile, butterfly and plant species reported from each country	% considered of high, very high, critical or extremely critical vulnerability
Austria	12	8.3%
Belgium	5	20.0%
Bulgaria	15	13.3%
Cyprus	2	0.0%
Czech Republic	13	23.1%
Denmark	4	0.0%
Estonia	8	12.5%
Finland	9	11.1%
France	19	5.3%
Germany	14	7.1%
Greece	14	7.1%
Hungary	17	23.5%
Ireland	1	0.0%
Italy	25	20.0%
Latvia	10	10.0%
Lithuania	10	10.0%
Luxembourg	5	20.0%
Malta	1	0.0%
Netherlands	5	20.0%
Poland	18	16.7%
Portugal	12	25.0%
Romania	21	28.6%
Slovakia	16	31.3%
Slovenia	15	26.7%
Spain	19	26.3%
Sweden	16	6.3%
United Kingdom	4	0.0%

Another joint analysis was carried out for the occurrence of assessed amphibian, reptile, butterfly and plant species across the biogeographic regions of the European Union (see Figure 10). This figure shows that Natura 2000 sites in the Alpine, Continental and Mediterranean biogeographic regions host the largest number of species considered of more than moderate vulnerability. They are also the biogeographic regions in which the largest numbers of assessed species are reported to occur (see Table 11). Whether the former is a consequence of the latter cannot be confirmed from the data available. Table 13 shows the percentage of assessed amphibian, reptile, butterfly and plant species considered of more than moderate vulnerability by biogeographic region.

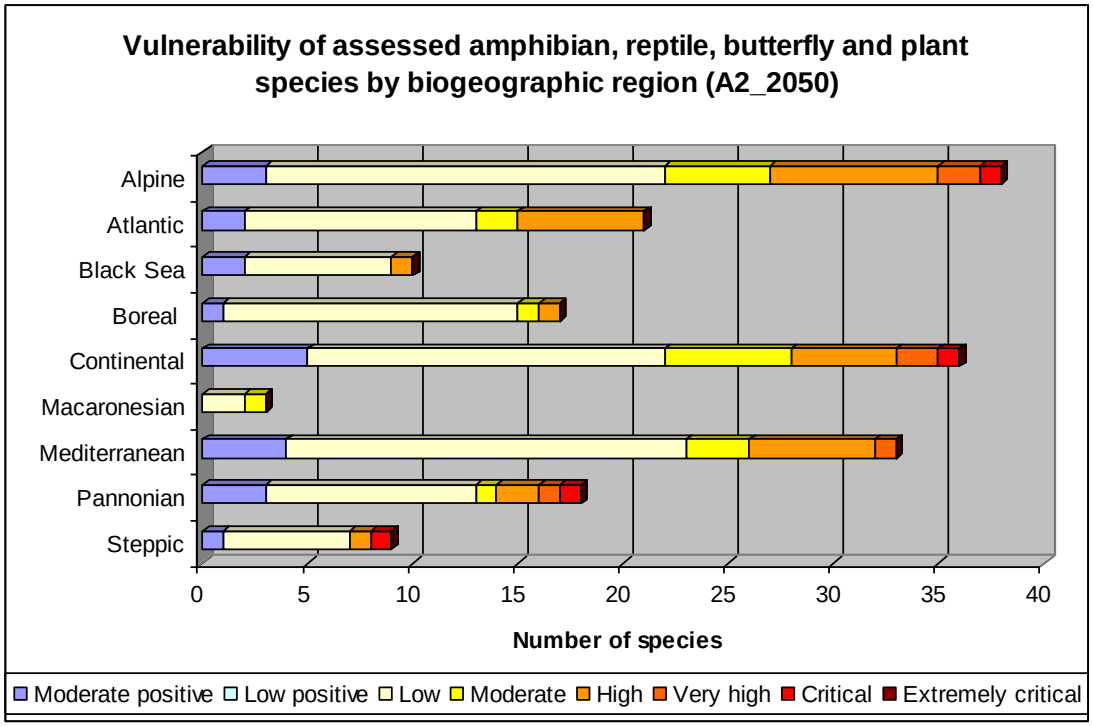


Figure 10: Occurrence of assessed amphibian, reptile, butterfly, and plant species in biogeographic regions under the A2 scenario to 2050

Table 13: Percentage of assessed amphibian, reptile, butterfly and plant species considered of high, very high, critical or extremely critical vulnerability by biogeographic region

Biogeographic region	Number of assessed amphibian, reptile, butterfly, and plant species reported in each biogeographic region	% considered of high, very high, critical or extremely critical vulnerability
Alpine	38	29.0%
Atlantic	21	28.6%
Black Sea	10	10.0%
Boreal	17	5.9%
Continental	36	22.2%
Macaronesian	3	0.0%
Mediterranean	33	21.2%
Pannonian	18	22.2%
Steppic	9	22.2%

Amphibian species

The largest number of assessed amphibian species occurs in the Natura 2000 sites of Italy. None of the assessed species occur in Natura 2000 sites in Cyprus, Ireland and Malta.

Three of the six Italian species are of high or even very high vulnerability (*Salamandrina terdigitata*). All three species reported from the Natura 2000 sites of Spain are considered of high vulnerability. Other countries with species assessed of high vulnerability are the Czech Republic, Poland, Portugal, Romania, Slovakia and Slovenia. Figure 11 shows the occurrence of assessed amphibian species in the Member States of the European Union.

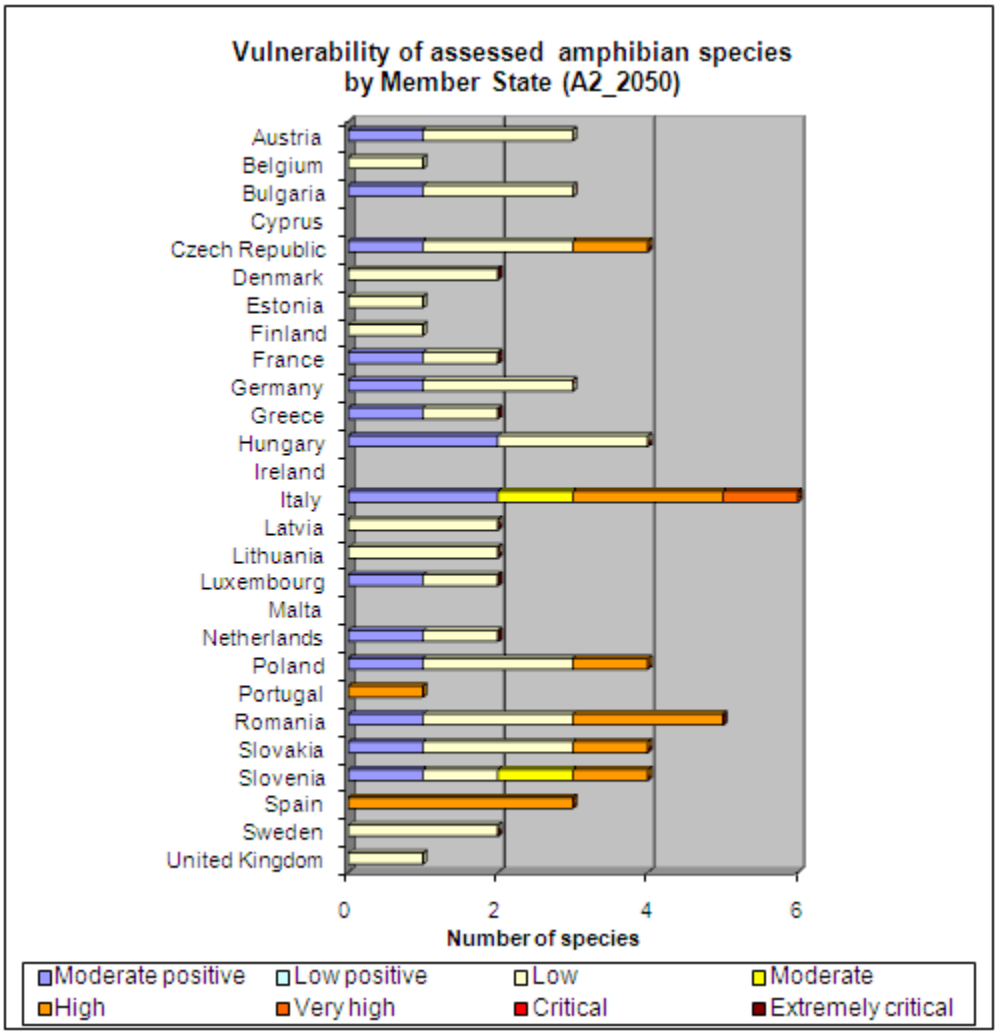


Figure 11: Occurrence of assessed amphibian species of different vulnerability categories in Member States

When doing the same analysis by biogeographic region (see Figure 12), the results show that the smallest number of assessed amphibian species occur in the Black Sea, Boreal and Steppic biogeographic regions (2 species each), and those reported from these regions are of low vulnerability or even expected to benefit from climate change. The amphibian species considered of high or very high vulnerability occur in Natura 2000 sites of the Alpine, Atlantic, Continental and Mediterranean biogeographic regions. Five of the 10 species assessed for the Alpine biogeographic region belong to these two categories.

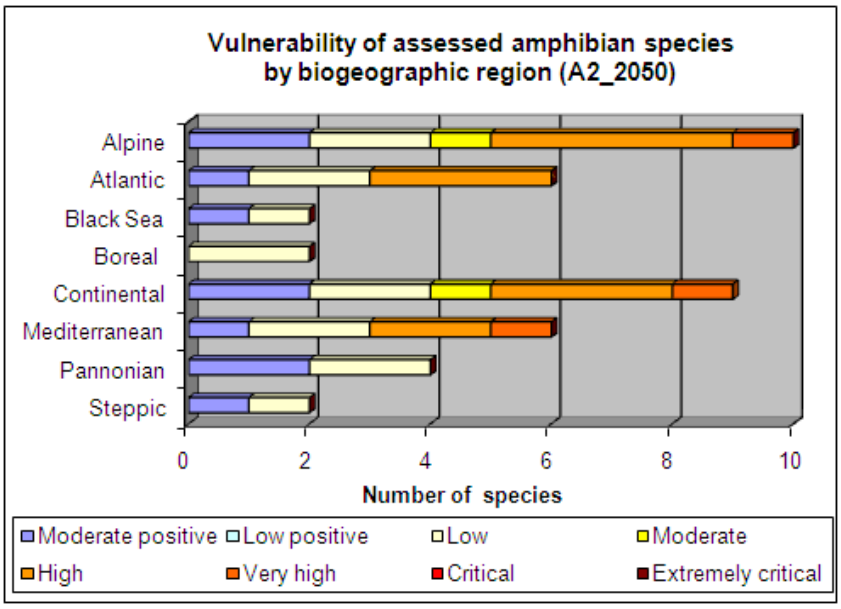


Figure 12: Occurrence of assessed amphibian species of different vulnerability categories in biogeographic regions

Reptile species

The largest number of assessed reptile species is reported to occur in the Natura 2000 sites of Greece and Italy. None of the assessed species are reported to occur in the Natura 2000 sites of Belgium, the Czech Republic, Denmark, Estonia, Finland, Ireland, Luxembourg, the Netherlands, Sweden or the United Kingdom.

Figure 13 shows the occurrence of assessed reptile species of different vulnerability categories in Member States of the European Union (the countries from which no species are reported to occur are not shown in the figure). The figure shows that the B1 scenario assessment for reptiles resulted in higher vulnerabilities of species than the A2 scenario. Whereas under the A2 scenario species assessed as highly vulnerable (*Lacerta monticola* and *Lacerta schreiberi*) are only reported from Portugal and Spain, there are seven countries reporting the occurrence of highly vulnerable species under the B1 scenario. However, this increase in countries reporting the occurrence of a species assessed as highly vulnerable under the B1 scenario is because of one species that is assessed differently under A2 and B1: *Vipera ursinii.* This species occurs in all the countries showing one species assessed as highly vulnerable under the B1 scenario to 2050.

Figure 14 shows the occurrence of assessed reptile species of different vulnerability categories in the biogeographic regions and again for the two scenarios to 2050. All of the 12 assessed reptile species are reported to occur in the Natura 2000 sites of the Mediterranean biogeographic region, while only one occurs in the Boreal and Macaronesian regions. The two reptile species that are considered of high vulnerability under the A2 scenario, *Lacerta monticola* and *Lacerta schreiberi*, occur in the Atlantic and Mediterranean biogeographic regions, and one of them also occurs in the Alpine region. *Vipera ursinii,* the species assessed of high vulnerability under the B1 scenario, occurs in the Steppic, Pannonian, Continental, Atlantic and Alpine biogeographic regions.

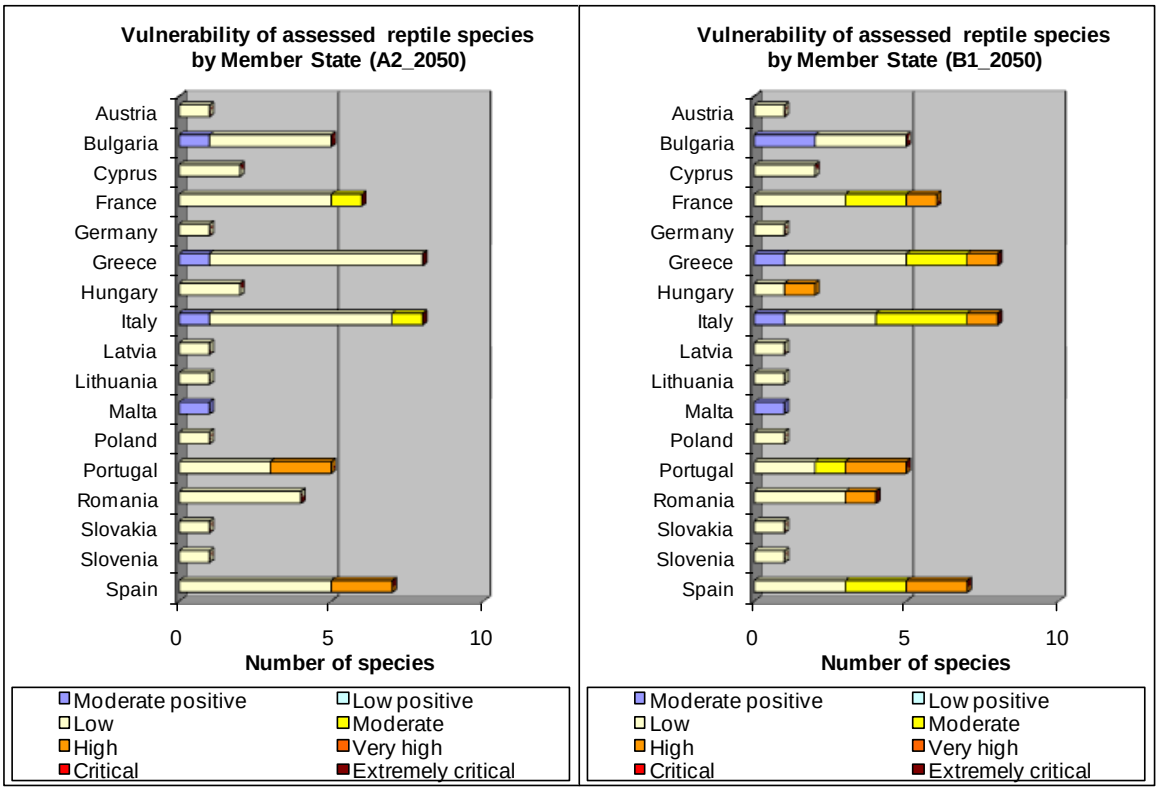


Figure 13 Occurrence of assessed reptile species of different vulnerability categories in Member States for the scenarios A2 and B1 to 2050

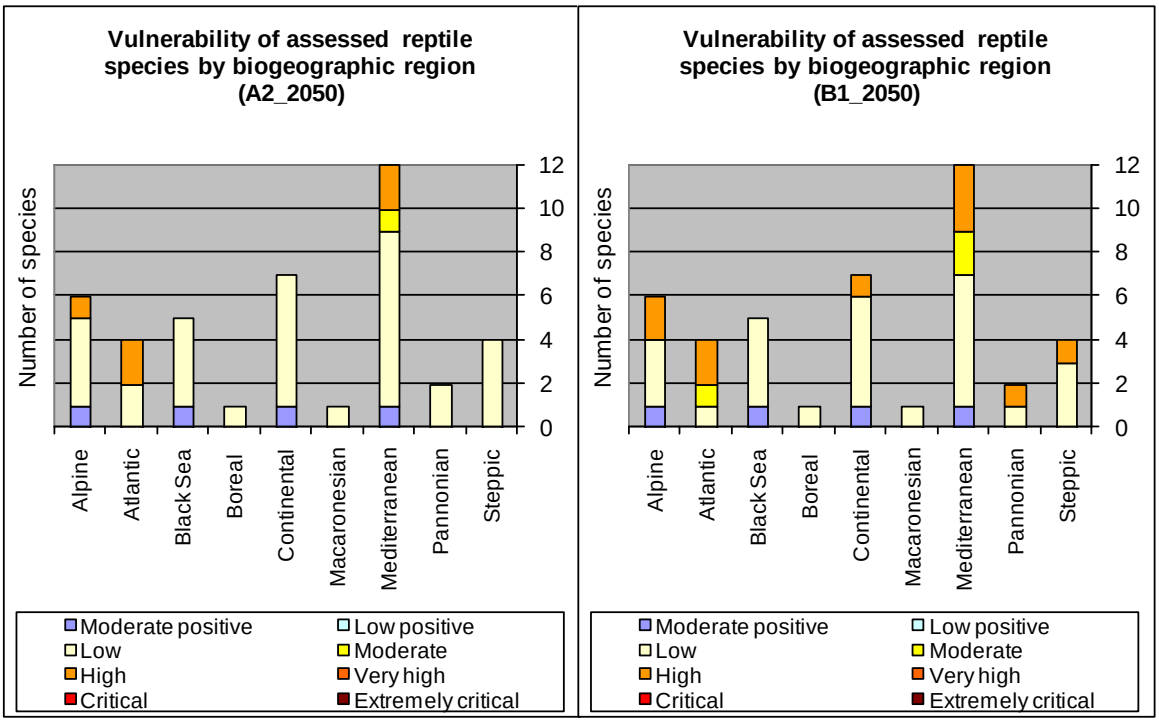


Figure 14: Occurrence of assessed reptile species of different vulnerability categories in biogeographic regions for the scenarios A2 and B1 to 2050

Butterfly species

Eight of the 13 assessed butterfly species occur in Natura 2000 sites of Poland and seven in those of Hungary, Romania, Slovakia and Slovenia. The critically vulnerable *Colias myrmidone* occurs in Natura 2000 sites of these countries, but is also reported from Bulgaria and the Czech Republic. None of the assessed species occur in Cyprus or Malta and only one species of low vulnerability occurs in Natura 2000 sites of Denmark, Ireland, Portugal and the UK. Figure 15 shows the occurrence of assessed butterfly species of different vulnerability categories in the Member States of the European Union.

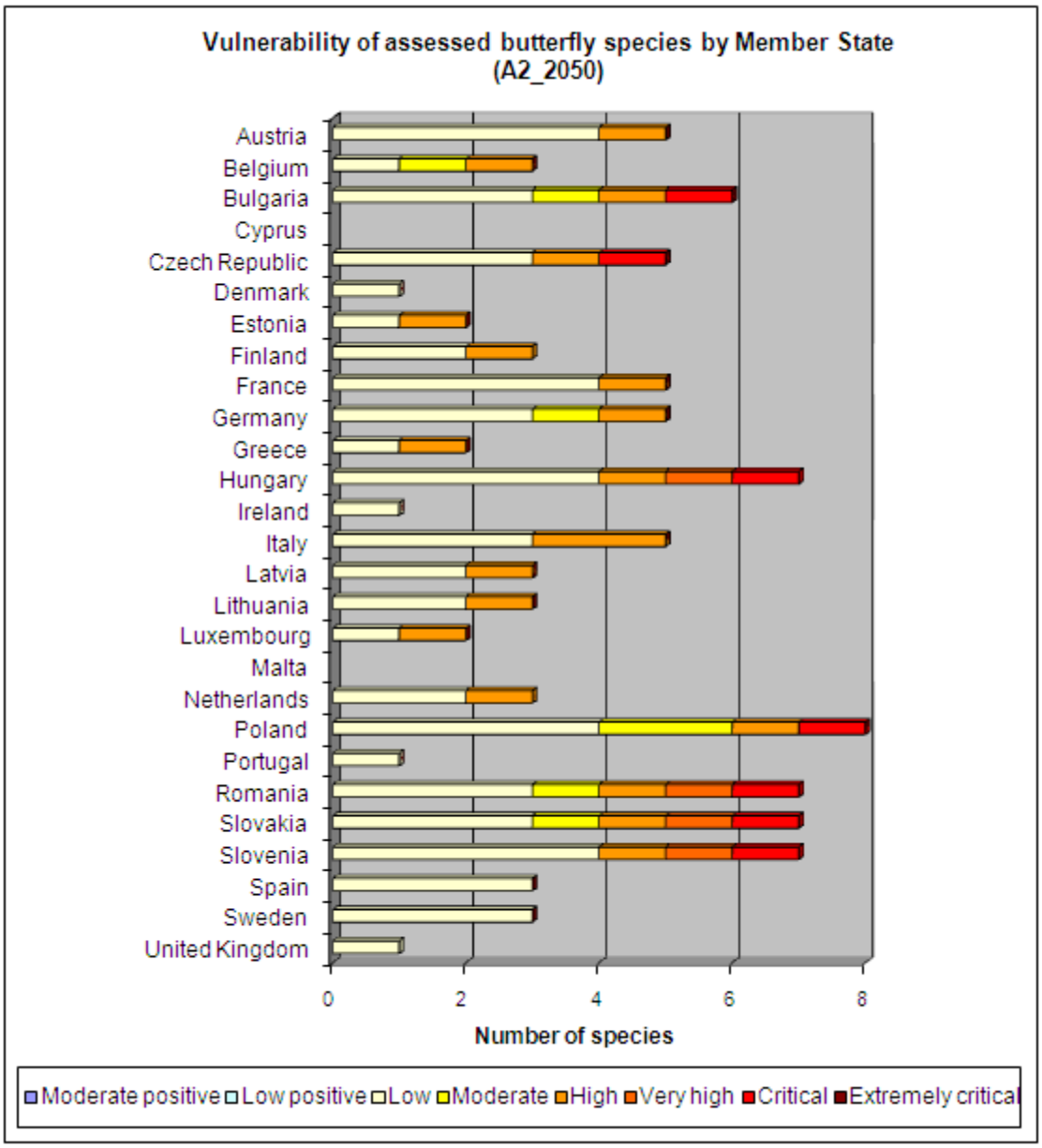


Figure 15: Occurrence of assessed butterfly species of different vulnerability categories in Member States

Figure 16 shows the occurrence of assessed butterfly species of different vulnerability categories in the biogeographic regions. Of the 13 assessed butterfly species, 12 occur in Natura 2000 sites of the Alpine biogeographic region, 10 in the Continental region and 8 in the Pannonian region. The three biogeographic regions also host the largest number of species assessed as of high vulnerability, very high vulnerability or critical vulnerability. None of the assessed butterfly species are reported to occur in Natura 2000 sites of the Macaronesian

biogeographic region. The critically vulnerable species *Colias myrmidone* is reported to occur in four different biogeographic regions, indicating that it is a widely distributed species, a characteristic that could be beneficial in the face of climate change.

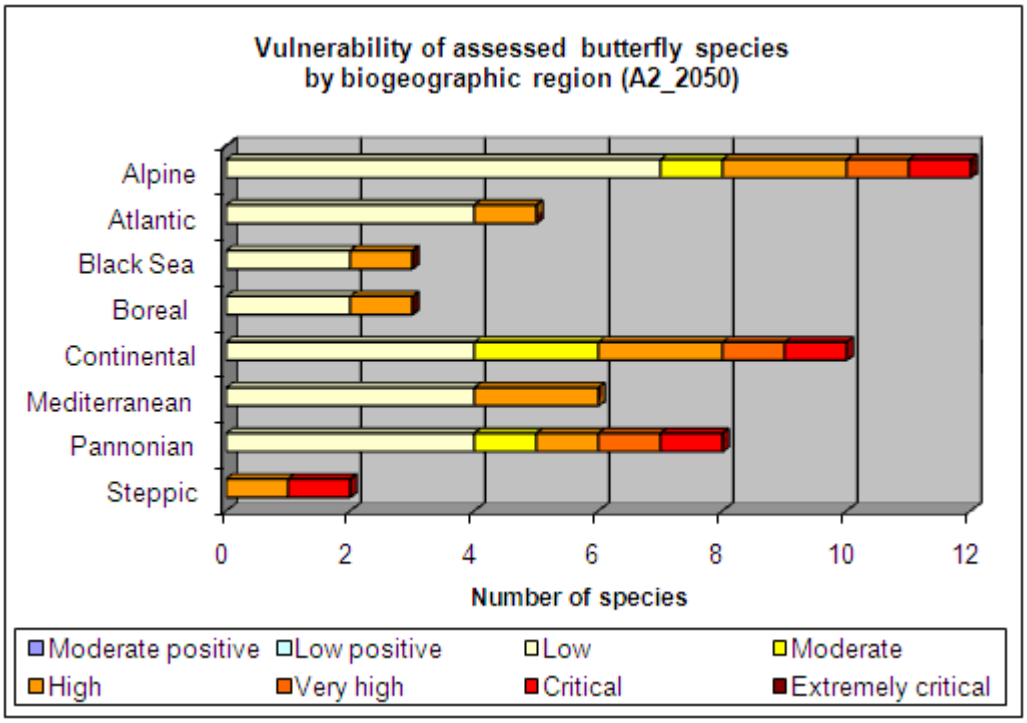


Figure 16: Occurrence of assessed butterfly species of different vulnerability categories in biogeographic regions

Plant species

Few of the assessed plant species are expected to face serious difficulties under climatic changes according to their vulnerability assessments (see also Annex II for assessment results per species).

Figure 17 shows the occurrence of the assessed plant species of different vulnerability categories in the Member States of the European Union under the A2 scenario to 2050 and to 2080. The largest number of assessed plant species is from Natura 2000 sites in Sweden (11 species), followed by Spain, Italy and France with 6 species each. None of the assessed species occur in Natura 2000 sites in Cyprus, Ireland, Malta or the Netherlands.

Species assessed as more than moderately vulnerable in the period to 2050 occur only in Hungary, Romania, Slovakia and Sweden. The assessment results to 2080 show that species assessed as more than moderately vulnerable are reported to occur in eight more countries. The vulnerability category of several species changed from low to moderate or high between 2050 and 2080 under the A2 scenario. Of those species occurring in Sweden, for example, 5 of the 11 assessed species shift from low vulnerability to moderate and high vulnerability between 2050 and 2080. Only one species is assessed as of very high vulnerability by 2080. This is *Pulsatilla pratensis* and it occurs in Natura 2000 sites in Slovakia, Romania and Hungary. For several countries, including Spain, Portugal and Italy, the number of species reported from the country per vulnerability category is identical between 2050 and 2080 under the A2 scenario.

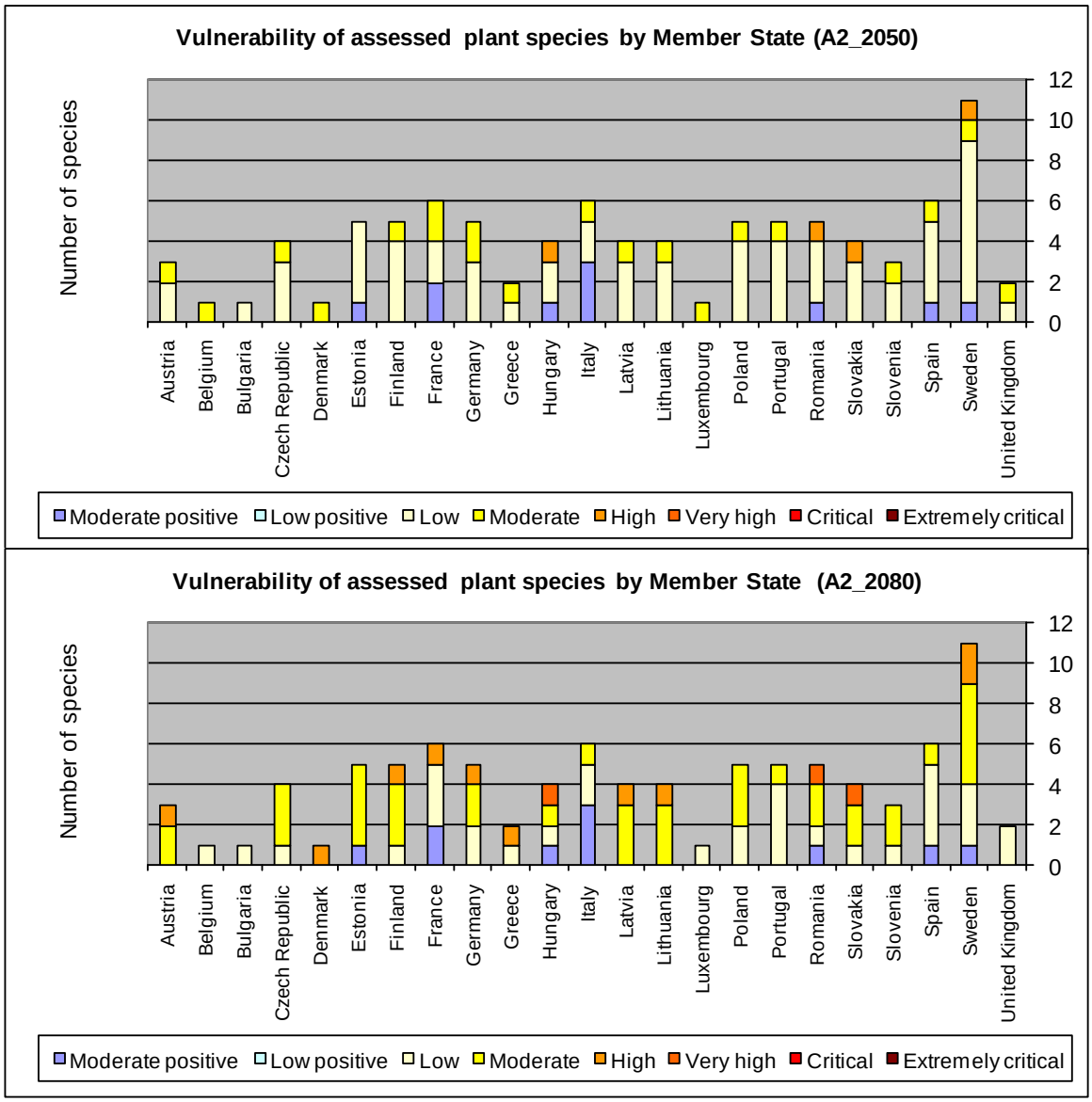


Figure 17: Occurrence of assessed plant species of different vulnerability categories in Member States under the A2 scenario to 2050 (top) and 2080 (bottom)

Figure 18 shows the occurrence of assessed plant species of different vulnerability categories in the biogeographic regions under the A2 scenario to 2050 and 2080. The largest number of assessed plant species is from Natura 2000 sites of the Boreal biogeographic region (11 species). None of the assessed species occur in Natura 2000 sites in the Black Sea biogeographic region.

As was the case in Figure 17, it is obvious from Figure 18 that many of the assessed species change from lower to higher vulnerability categories from 2050 to 2080. *Pulsatilla pratensis*, which is assessed as of very high vulnerability by 2080 under the A2 scenario, occurs in the Pannonian biogeographic region.

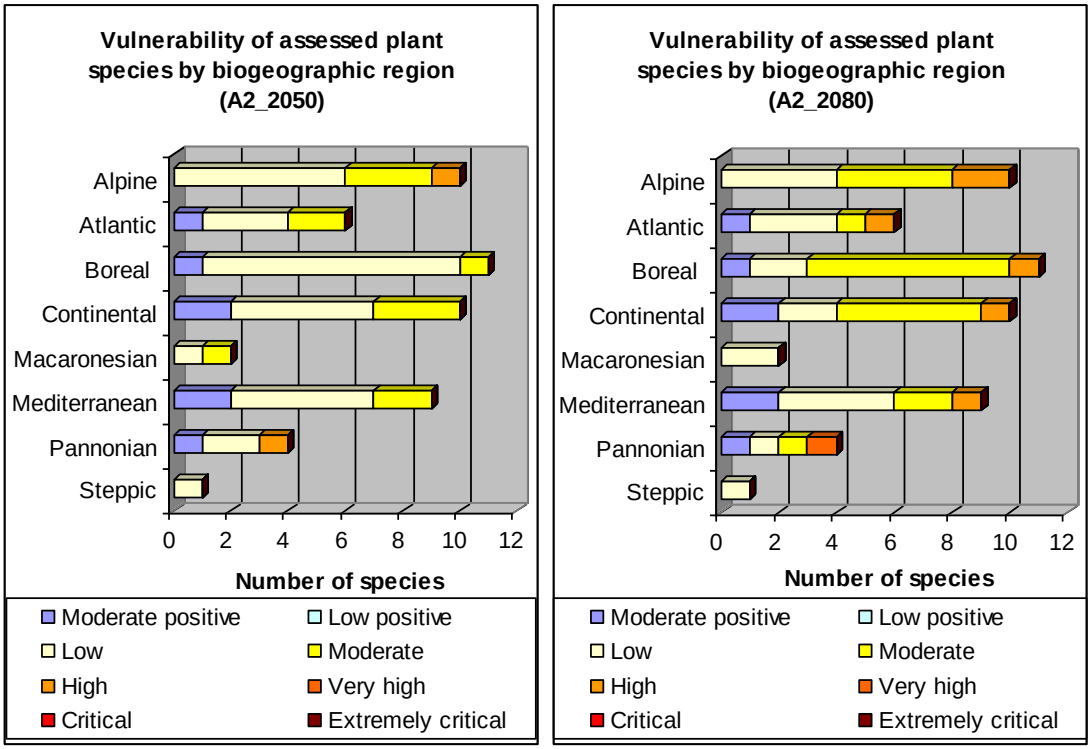


Figure 18: Occurrence of assessed plant species of different vulnerability categories in biogeographic regions under the A2 scenario to 2050 (left) and 2080 (right)

Bird species

Figure 19 shows the occurrence of assessed bird species of different vulnerability categories in the EU's Member States. The species appearing as moderately positive in this figure is *Alcedo atthis,* which occurs in Natura 2000 sites of all Member States except the United Kingdom. Of the 149 assessed species, 127 are reported to occur in Italy. The two bird species that were assessed as extremely critical are *Anser erythropus* and *Aquila clanga. Anser erythropus* is reported to occur in a total of 84 Natura 2000 sites and *Aquila clanga* in 137 Natura 2000 sites. Both species occur in several different countries.

Overall, Figure 19 indicates that a large proportion of all assessed bird species are considered to be more than moderately vulnerable. Table 14 summarises the percentage of bird species considered of more than moderate vulnerability across Member States. The table shows that more than 78% of the 117 assessed bird species that occur in the Natura 2000 sites of Spain fall into one of the top four vulnerability categories. The same applies to almost 78% of the 127 assessed bird species occurring in the Natura 2000 sites of Italy.

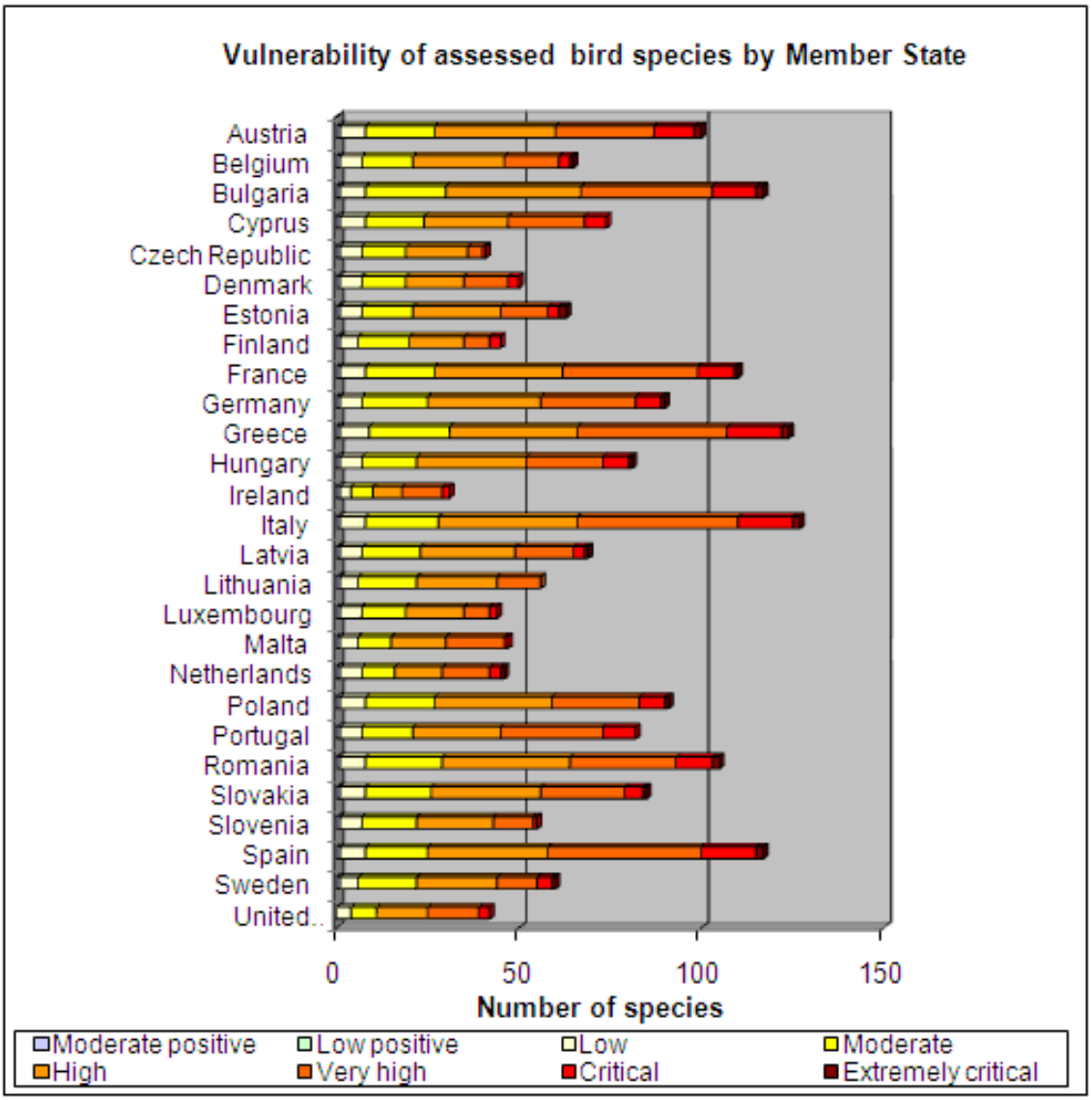


Figure 19: Occurrence of assessed bird of different vulnerability categories in Member States

Table 14: Percentage of assessed bird species considered of high, very high, critical or extremely critical vulnerability by Member State

Member State	Number of assessed bird species reported from each country	% considered of high, very high, critical or extremely critical vulnerability
Austria	100	73.00%
Belgium	65	67.69%
Bulgaria	117	74.36%
Cyprus	74	67.57%
Czech Republic	41	53.66%
Denmark	50	62.00%
Estonia	63	66.67%
Finland	45	55.56%
France	110	75.45%
Germany	90	72.22%
Greece	124	75.00%
Hungary	81	72.84%
Ireland	31	67.74%
Italy	127	77.95%
Latvia	69	66.67%
Lithuania	56	60.71%
Luxembourg	44	56.82%
Malta	47	68.09%
Netherlands	46	65.22%
Poland	91	70.33%
Portugal	82	74.39%
Romania	105	72.38%
Slovakia	85	69.41%
Slovenia	55	60.00%
Spain	117	78.63%
Sweden	60	63.33%
United Kingdom	42	73.81%

In Figure 20, the occurrence of assessed bird species of different vulnerability categories in biogeographic regions is shown. *Alcedo atthis*, the species that is expected to react moderately positively to climate change, occurs in Natura 2000 sites from all biogeographic regions except the Macaronesian. Figure 20 shows that the largest number of assessed species is from the Mediterranean biogeographic region (142 species), while the lowest number is from the much smaller Macaronesian region (33 species). However, when looking at the percentage of assessed species classified under the four highest vulnerability categories by biogeographic region (see Table 15), more than 72% of the assessed bird species occurring in Macaronesian Natura 2000 sites fall into the top four vulnerability categories. In the Mediterranean biogeographic region about 78% of species fall into these top four categories.

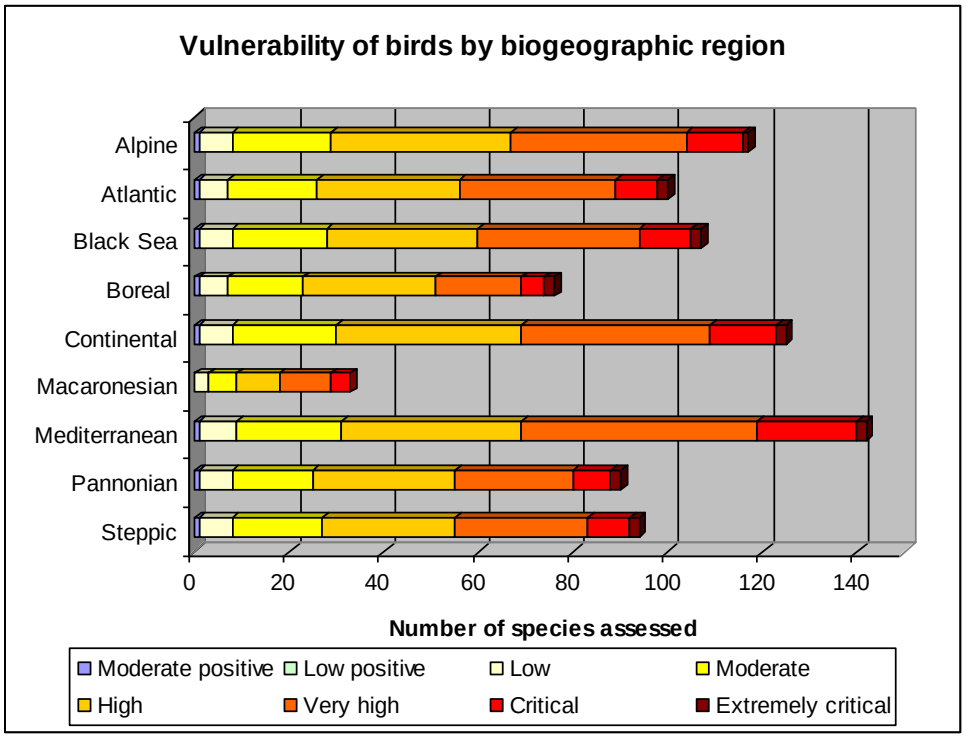


Figure 20: Occurrence of assessed bird species of different vulnerability categories in biogeographic regions

Table 15: Percentage of assessed bird species considered of high, very high, critical or extremely critical vulnerability by biogeographic region

Biogeographic region	Number of assessed bird species reported in each biogeographic region	% considered of high, very high, critical or extremely critical vulnerability
Alpine	117	75.21
Atlantic	100	74.00
Black Sea	107	73.83
Boreal	76	69.74
Continental	125	76.00
Macaronesian	33	72.73
Mediterranean	142	78.17
Pannonian	90	72.22
Steppic	94	71.28

Particularly Vulnerable Species

Overall, 135 of 212 assessed species were ranked as *more than moderately vulnerable* (i.e. High, Very High, Critical, and Extremely Critical) under at least one scenario and time horizon. These 135 species are made up of 3 plant species, 3 reptile species, 7 amphibian species, 4 butterfly species and 118 bird species. However, many of these species are reported to occur in several hundred or more Natura 2000 sites. The following table (Table 16) gives some examples from several taxa. The complete table of species and the number of sites in which they occur is attached as Annex II.

Table 16: Examples for species of at least High vulnerability and the number of Natura 2000 sites they occur in

Taxon	Species	Vulnerability	No. of Natura 2000 sites recorded
Amphibians	*Salamandrina terdigitata*	Very High	207
Amphibians	*Discoglossus galganoi*	High	251
Reptiles	*Lacerta monticola*	High	89
Reptiles	*Lacerta schrieberi*	High	214
Butterflies	*Lycaena dispar*	High	976
Birds	*Egretta alba*	Very high	987
Birds	*Ardea purpurea*	Very high	1076
Birds	*Ciconia nigra*	High	1815

Of the species that are *more than moderately vulnerable*, those that are represented in only a few Natura 2000 sites may be more at threat from climate change. Therefore we have **categorised species that are both more than moderately vulnerable and that occur in 20 or less Natura 2000 sites, as "Particularly Vulnerable"**. Eleven species to which this applies are listed in Table 17. It needs to be noted that some of the species listed here have not been ranked as at least highly vulnerable under all scenarios of time horizons for which they were assessed. However, as soon as the criteria "at least highly vulnerable" and "not occurring in more than 20 Natura 2000 sites" applied to at least one of the scenario and time horizon assessment results, the species was included in the list.

Table 17: Eleven species ranked as "Particularly Vulnerable", defined as those species whose vulnerability was ranked as High, Very High, Critical or Extremely Critical, and who in addition are reported to occur in 20 or fewer Natura 2000 sites.

Taxon	Name	Vulnerability	Scenario_time	No. of Natura 2000 sites recorded
Plants	*Botrychium simplex*	Moderate	A2_2050	17
Plants	*Botrychium simplex*	High	A2_2080	17
Plants	*Botrychium simplex*	Moderate	B1_2080	17
Plants	*Papaver radicatum*	High	A2_2050	5
Plants	*Papaver radicatum*	High	A2_2080	5
Plants	*Papaver radicatum*	High	B1_2080	5
Plants	*Pulsatilla pratensis*	High	A2_2050	12
Plants	*Pulsatilla pratensis*	Very high	A2_2080	12
Plants	*Pulsatilla pratensis*	High	B1_2080	12
Amphibians	*Salamandra atra*	High	A2_2050	3
Amphibians	*Triturus vulgaris*	High	A2_2050	14
Butterflies	*Plebejus glandon*	Low	A2_2050	10
Butterflies	*Plebejus glandon*	Low	B1_2050	10
Butterflies	*Plebejus glandon*	High	B1_2080	10
Butterflies	*Plebejus glandon*	Low	A2_2080	10
Birds	*Falco rusticolus*	Very High	B2_2070-2099	1
Birds	*Sitta krueperi*	Critical	B2_2070-2099	3
Birds	*Emberiza cineracea*	Very High	B2_2070-2099	5
Birds	*Loxia scotica*	Critical	B2_2070-2099	5
Birds	*Nyctea scandiaca*	Critical	B2_2070-2099	9

None of the 12 assessed reptile species met the defined criteria for particularly vulnerable species.

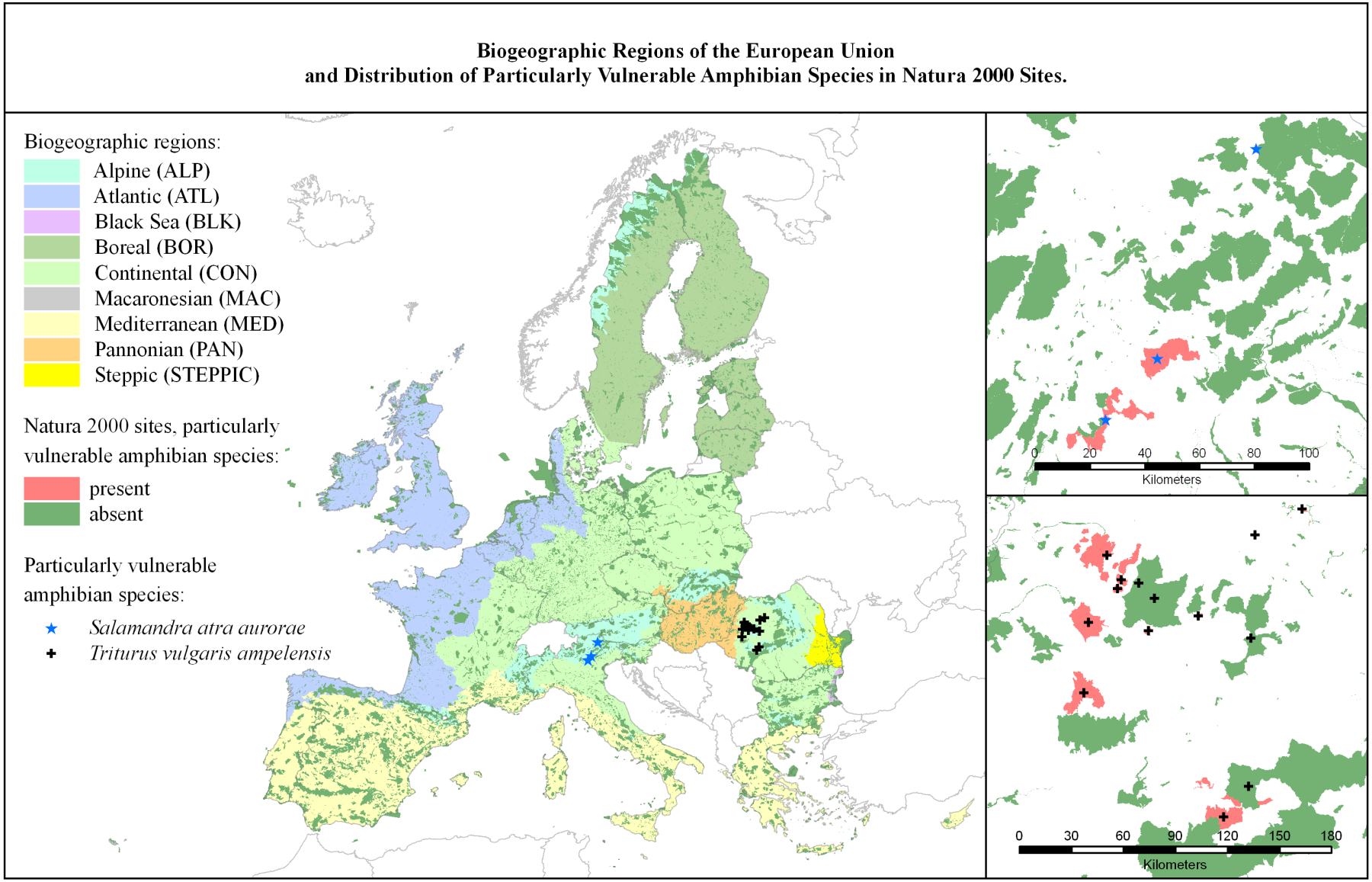
Two of the 12 amphibian species were assessed as of High vulnerability by 2050 under the A2 scenario and are reported to occur in less than 20 Natura 2000 sites. *Salamandra atra* is an Italian species and *Triturus vulgaris* occurs in Romania. The spatial distribution of the two species across the Natura 2000 network is shown in Map 7.

One of the 13 assessed butterfly species, *Plebeius glandon* (synonymous with *Agriades glandon aquilo* in the EC database), was ranked as Highly vulnerable, under the B1 scenario by 2080, and is reported to occur in only 10 Natura 2000 sites in Sweden. The spatial distribution of the species across the Natura 2000 network is shown in Map 8.

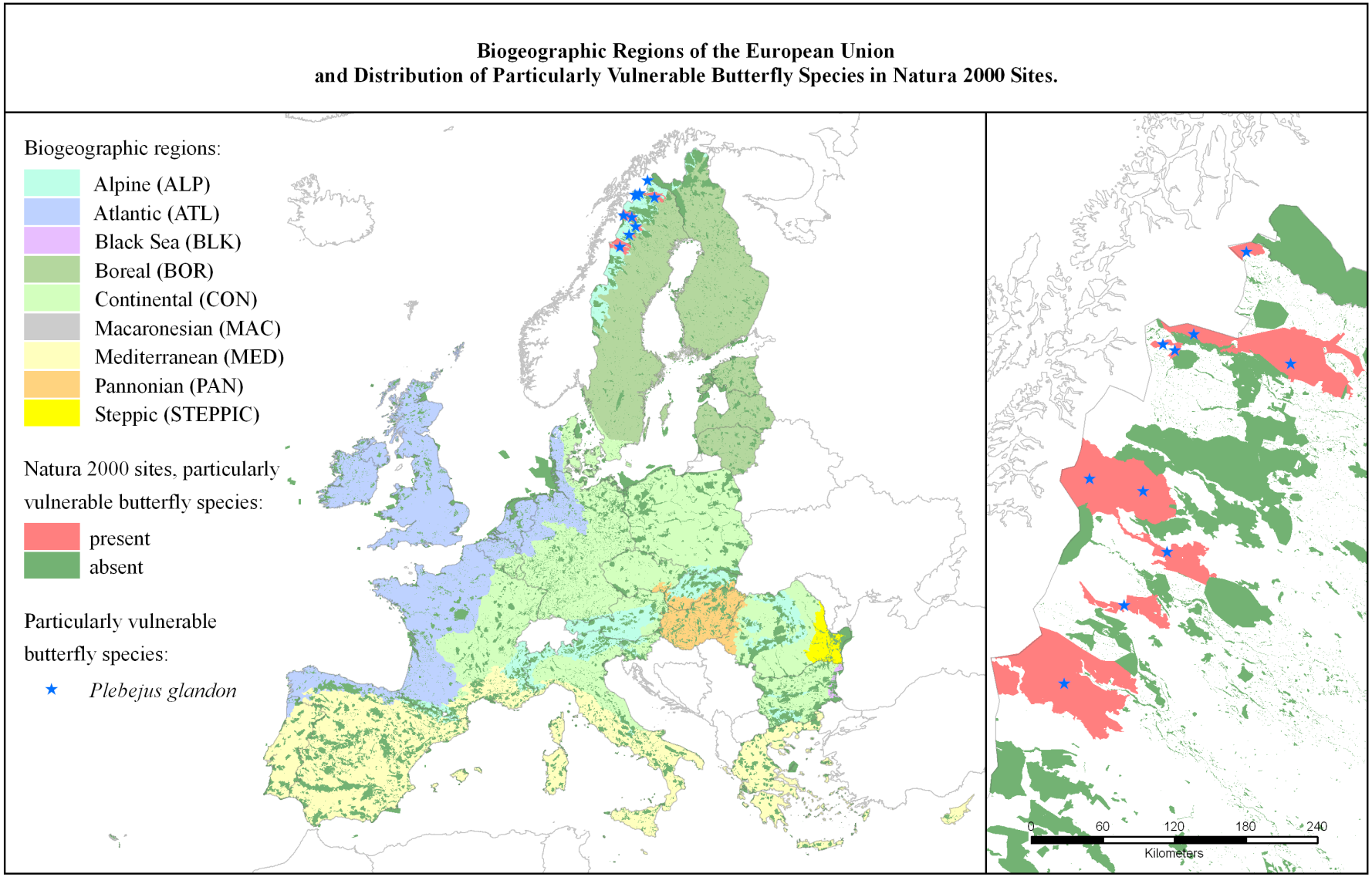
Among the plant species assessed in Task 2a there are three species to which the criteria apply. *Botrychium simplex* was assessed as Highly vulnerable only under the A2 scenario by 2080. It is recorded in a total of 17 Natura 2000 sites. However, these 17 sites are located in nine different countries. It is therefore possible, that the species is widely distributed. The 12 Natura 2000 sites where *Pulsatilla pratensis* occurs are all located in the Pannonian biogeographic region and distributed across Hungary (seven sites), Romania (two sites) and Slovakia (three sites). Map 9 shows the spatial distribution of the three plant species across the Natura 2000 network.

Many bird species were assessed as of High, Very High, Critical and Extremely Critical vulnerability and occur in less than 100 Natura 2000 sites. However, only five of them occur in 20 or less sites. *Falco rusticolus* occurs in only one Natura 2000 site in Poland, *Sitta krueperi* is reported from 3 and *Emberiza cineracea* from 5 sites in Greece. *Loxia scotica* is reported to occur in 5 Natura 2000 sites in Scotland and *Nyctea scandiaca* in 9 sites in the United Kingdom. The spatial distribution of these species across the Natura 2000 network is shown in Map 10.

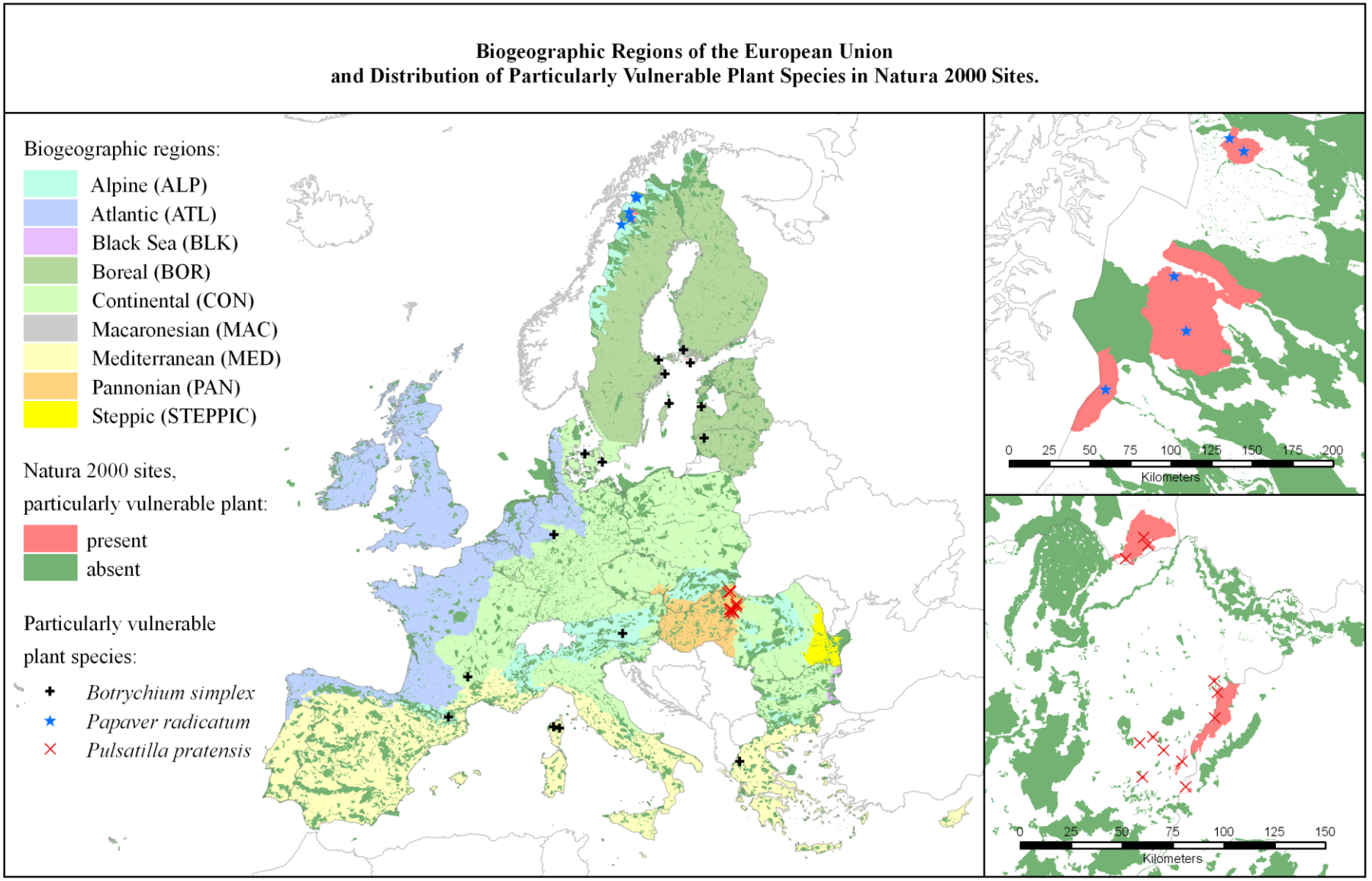
Most of the species for which the two criteria apply occur in Natura 2000 sites of only one country or one biogeographic region or in Natura 2000 sites which are located fairly close to each other. The only exception to this is the plant species *Botrychium simplex*.



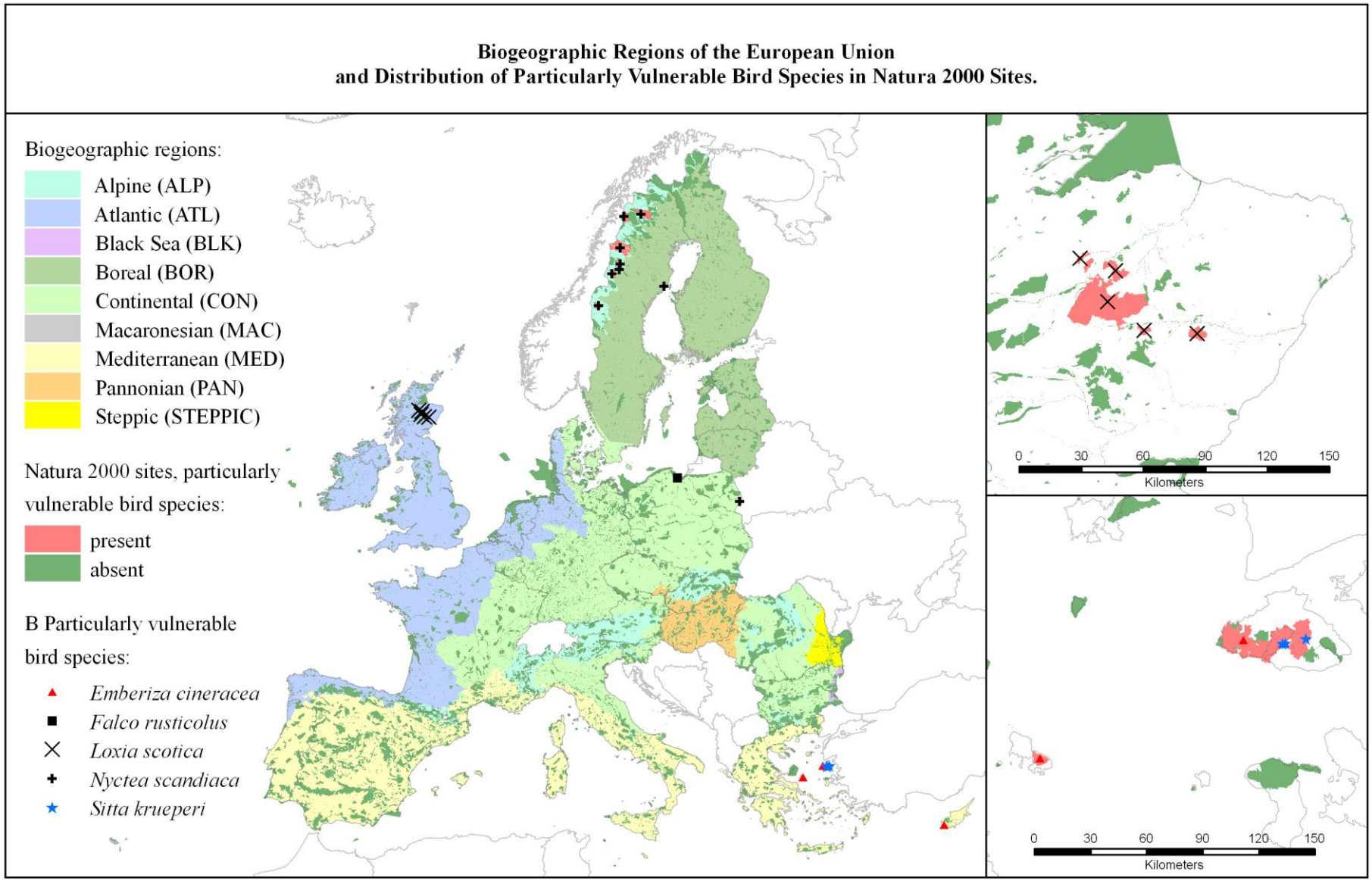
Map 7: Distribution of particularly vulnerable amphibian species in Natura 2000 sites of the European Union



Map 8: Distribution of particularly vulnerable butterfly species in Natura 2000 sites of the European Union



Map 9: Distribution of particularly vulnerable plant species in Natura 2000 sites of the European Union



Map 10: Distribution of particularly vulnerable bird species in Natura 2000 sites of the European Union

Discussion

The temperature projections presented here give an estimate of where in the European Union Natura 2000 sites may be faced with the most severe temperature changes under the two selected scenarios. They indicate the percentage of Natura 2000 sites that will be most seriously affected. Under the A2 scenario, there are few regions in the European Union that are projected to experience an increase of less than 1˚C by the end of the century. Even under the B1 scenario an increase of less than 1˚C is projected for only one third of the area covered by Natura 2000 sites. These projections imply that the major part of the network, between 66 and 98% of the sites, will face a temperature increase of 2˚C or more by the end of the century, compared to the first of the time slices (2011-2030). A 2˚C increase in average temperature compared to pre-industrial levels has been adopted as the warming limit and guiding principle for mitigation efforts by more than 100 countries, including the European Union (Council of the European Union 2005; Meinshausen *et al.* 2009).

Table 18 summarises the number of assessed species recorded from each of the biogeographic regions, the number of Member States with territory in those regions and the area the biogeographic regions cover.

Table 18: Biogeographic regions, their size, and the numbers of the 212 assessed species present in the respective regions

Biogeographic region	No. of Member States representing the region	Total area of the region (km^2)	Total of assessed species recorded
Alpine	15	370,116	155
Atlantic	9	782,613	121
Black Sea	2	9,746	117
Boreal	6	841,681	93
Continental	18	1,256,900	161
Macaronesian	2	10,693	36
Mediterranean	8	886,472	175
Pannonian	6	124,583	108
Steppic	2	37,176	103

The smallest number of assessed species was recorded from the Macaronesian biogeographic region with only 1 amphibian and reptile species each, no butterfly species, 2 plants and 33 birds (see Table 11 for a differentiation between the number of species assessed from Macaronesia by taxon). However, when looking at the number of species included in the Task 2a assessment per km^2 of the biogeographic regions, then the Macaronesian ranks second, following the Black Sea region with the largest number of assessed species per km^2 (see Figure 21). In fact, it is the four largest biogeographic regions, the Atlantic, Boreal, Continental and Mediterranean that have the smallest number of assessed species per area unit. For a more balanced representation of species from different biogeographic regions more species from these four regions would need to be included.

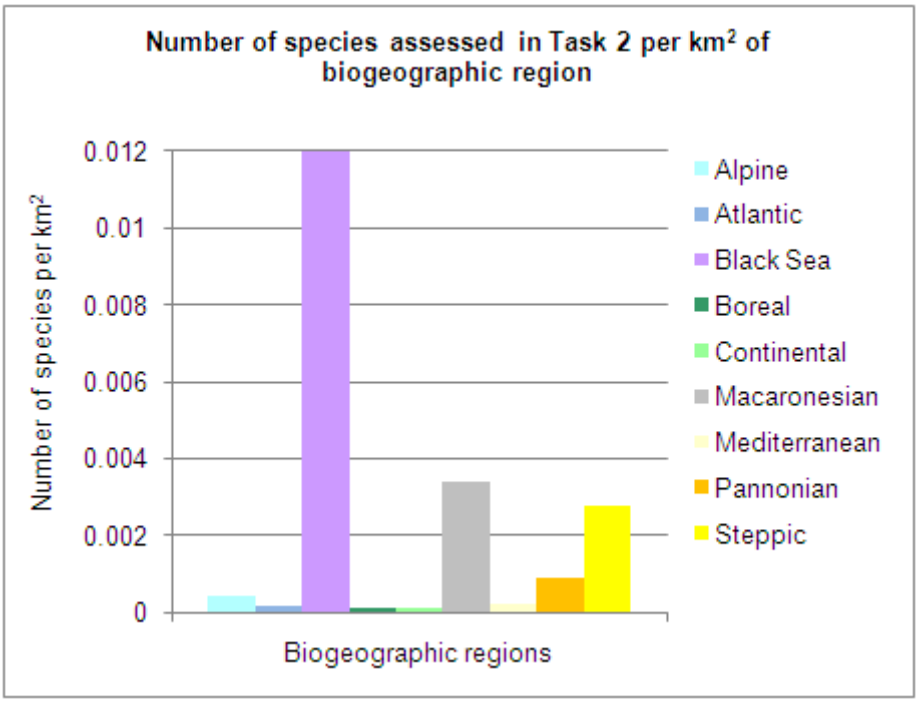


Figure 21: Number of assessed species per km² of biogeographic regions

Of the amphibian, reptile, butterfly and plant species assessed as more than moderately vulnerable under the A2 scenario to 2050, most are reported from sites of the Alpine, Continental and Mediterranean regions. Of those bird species assessed as more than moderately vulnerable under the B2 scenario by 2070-2099 more than 50% are reported to occur in the Natura 2000 sites of the Mediterranean biogeographic region (Annex II to this report lists all assessed species together with their assessment results and the number of Natura 2000 sites where they occur). The occurrence of many of the species assessed as more than moderately vulnerable in the Mediterranean and Alpine biogeographic regions is in line with other studies on climate change impacts in the European Union. Thuiller *et al.* (2005) and Bakkenes *et al.* (2006) both project a decrease of plant species in the Mediterranean. Araujo *et al* (2006) project decreasing suitable habitat for amphibian and reptile species of the Iberian peninsula. The BRANCH partnership (2007) considers the Mediterranean as particularly vulnerable to losing existing species. Guisan and Theurillat (2000) found that alpine plant species with small elevation ranges are considered to be at high risk of local extinctions and Lenoir *et al.* (2008) provide evidence for already occurring altitudinal distribution shifts in different mountain areas of west Europe. Alpine vegetation is likely to contract considerably as a consequence of climatic changes (Olofsson *et al.* 2008). Changes in distribution ranges of plant species may be followed by changing distribution ranges of other taxa, or vice versa (e.g. Biesmeijer *et al.* 2006). Schroter *et al.* (2005) projected for the Mediterranean and mountain regions declining water availability and increasing risks of fires by 2080. These climate change impacts, which can both be related to increasing temperatures, could play an important role in decreasing species numbers in these regions. Italy and Spain, both largely located in the Mediterranean biogeographic region, host large numbers of species assessed as more than moderately vulnerable. The same the same is true of the bird assessments for Greece, another Member State largely located in the Mediterranean region. In the case of plants and butterflies, Eastern European countries host large numbers of those species considered of more than moderate vulnerability.

According to the BRANCH partnership (2007), the Boreal biogeographic region may experience a steady rise in species numbers by the 2080s because of immigrating species. However, this does not imply that those species currently occurring in the Boreal

biogeographic region will remain unaffected by climatic changes. Almost 70% of bird species from the Boreal biogeographic region fall into the top four vulnerability categories.

Amphibian species, because they are strongly associated with wetland habitats and depend on water availability, react to climate change more than other taxa (Araujo *et al.* 2006; Commission of the European Communities 2009). Seven out of 12 assessed amphibian species were considered to be of more than moderate vulnerability by 2050.

On a more general level, Thomas *et al.* (2004), reviewing regional studies up to the publication date, concludes that between 7% (under maximum expected climate change with dispersal) and 48% (under maximum expected climate change without dispersal) of European bird species and between 6% (under minimum expected climate change and with dispersal) and 29% (under maximum expected climate change without dispersal) of European plant species may go extinct by 2050. However, the study does not consider the value of protected areas as potential refuges for species. What should be aimed at though is a good representation of those species assessed as of more than moderate vulnerability across the Natura 2000 sites within their distribution range.

Particularly vulnerable species were defined in this study as those that are more than moderately vulnerable and occurring in less than 20 Natura 2000 sites. Sites hosting such species are in Greece, Hungary, Italy, Poland, Romania, Slovakia, Sweden and the United Kingdom. Some of the species only occur in a small area of a single country while others are more widely distributed (compare Maps 8 - 11). Instead of using the number of Natura 2000 sites as a criterion for a species to be considered particularly vulnerable, a minimum distribution area indicated by the area coverage of Natura 2000 sites where the species occur could have been used as a threshold. However, it is possible that the assessed species also occur around the Natura 2000 sites where they are listed and thus the area where they occur may be larger than the area of the Natura 2000 sites. As a proxy for representativeness of species in the Natura 2000 network it was therefore decided to look at the number of sites where they occur. For those species considered particularly vulnerable the outcomes of the study should be used to check whether the records for the occurrence of species across the Natura 2000 network are complete. If the representation of the species considered of more than moderate vulnerability across the Natura 2000 network is in fact as small as the dataset provided by the European Topic Centre on Biological Diversity suggests, then these species urgently need adaptation plans.

Caveats

In order to interpret and use the findings of this project correctly it is necessary to understand certain caveats regarding the methodology used in Tasks 2a and 3a.

Caveats derived from the Task 2a methodology

The vulnerability scores calculated in Task 2a were based on information from literature but there was no raw data available on the current and potential future distribution of species. As a consequence, it was not possible to consider in Task 3a how species' current and potential future distribution ranges overlap with the location of Natura 2000 sites. This means that there is a risk of under- or overestimating the problem caused by climate change.

Figure 22 illustrates a hypothetical example of a species whose future distribution range shifts in space and decreases in size due to climate change. Within the original distribution range (dotted area) there is only one Natura 2000 site while there are three Natura 2000 sites within the future distribution range (light blue). A species whose distribution range is shifting and decreasing due to climate change may therefore end up occurring in more Natura 2000 sites within its future distribution range than in its current distribution range (see Figure 22), assuming there are no obstacles on the mobility of the species. Without information about how the distribution ranges overlap with the location of Natura 2000 sites there is therefore a risk of over- or underestimating the problem climate change may cause for different species.

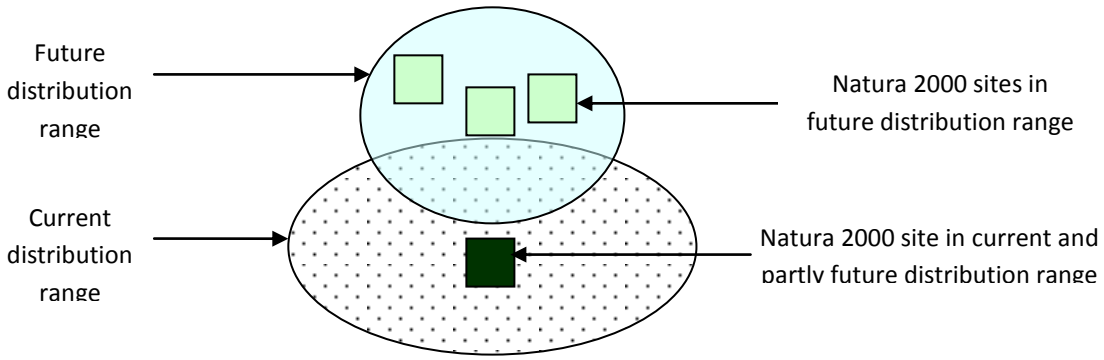


Figure 22: Potential changes in species distribution ranges and location of Natura 2000 sites, example 1

Figure 23 shows another example for the difference the location of Natura 2000 sites within the current and future distribution range of a species can make. On the left side of Figure 23, a species occurs in a Natura 2000 site that is located exactly in the overlapping area of the current and the projected future distribution range. This means that the species, although its distribution range is shifting, remains unaffected at this Natura 2000 site. On the right side, the Natura 2000 site where the species occurs is not located in the overlapping area of the current and the future distribution range. This species will in the future no longer occur in any Natura 2000 site. Therefore, a species with a distribution relating to the location of Natura 2000 sites as shown on the right side is in a much more serious situation than a species with a distribution relating to the location of Natura 2000 sites as shown on the left side. As mentioned earlier, it was not possible to consider these aspects in the present project due to the lack of raw data on the species' current and potential future distribution ranges.

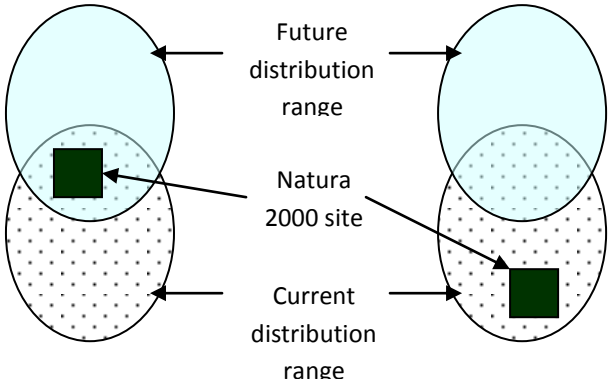


Figure 23: Potential changes in species distribution ranges and location of Natura 2000 sites, example 2

The vulnerability of habitats of Community interest listed in the Habitats Directive (Council of the European Communities 1992) to climate change could not be assessed in the present study. However, first attempts to assess the vulnerability of habitats of Community interest exist. Vos *et al.* (2008) looked at changes in the climate space of species under consideration of dispersal capacity, area required per reproductive unit and barrier sensitivity as factors of importance for the species' vulnerability to climate change. The study was restricted to nine species that were selected in groups of three to represent forests, wetlands and natural grasslands as broader habitat types. The authors conclude that, under the A2 scenario and for the 2020 and 2050 time slices, the suitable habitat of all selected species in northwest Europe will be decreasing and large parts of new suitable habitat will be too isolated to be colonised thereby resulting in a decline in the amount of suitable habitat protected in Natura 2000 sites. Ideally, the use of a combination of species to represent habitats of Community interest would lead to vulnerability scores for habitat types, too. For the habitats of Community interest occurring in Denmark this has already been realised (Normand *et al.* 2007), however, available information on species that are characteristic for the habitat types of Community interest, was insufficient to do such an analysis on the European Union level. A recent report of the Commission of the European Communities (2009) summarises the Member States' reports on the conservation status of species and habitats of Community interest within their boundaries. Among other questions, the Member States were asked to assess on how many habitats climate change has a negative impact. It was found that climate change is expected to impact on 42 habitats of Community interest. The habitats that were reported to be most affected by climate change were wetland habitats, such as bogs, mires and fens, but sand dunes were also negatively affected (Commission of the European Communities 2009). In addition to this, the BRANCH project finds that coastal habitats, such as saltmarsh and mud flats, will continue to shrink as a result of rising sea levels (BRANCH partnership 2007).

Vulnerability assessments of habitats would be of considerable relevance in understanding the overall robustness of the Natura 2000 network under changing climatic conditions. EuMon, an EU funded project aiming at building capacity on monitoring methods for species and habitats of Community interest and monitoring existing activities, as well as its follow up project EBONE (European Biodiversity Observation Network) are promising initiatives towards increased availability the information that is needed to conduct such an assessment (EuMon portal: http://eumon.ckff.si/index1.php, accessed 18.08.2009).

Vulnerability assessments were carried out for a limited range of taxa. A subsequent study could focus on mammals and other taxa that have not been part of the present project. Levinsky *et al.* (2007), for instance, assessed the potential impacts of climate change on the distribution of 120 non-volant, terrestrial mammal species across Europe.

Especially in the case of plants the number of assessed species (26) was not representative for the total number of plant species of Community interest (588).

Caveats on the Task 3a methodology

While only temperature projections for the European Union were shown in the results of Task 3a, Natura 2000 sites will also be affected by other impacts of climate change, such as precipitation changes, rising sea levels, extreme events potentially increasing in frequency and intensity, and other consequences of these impacts, for example plagues and larger fire risks (Alcamo *et al.* 2007; EEA *et al.* 2008). However, for reasons explained in the following paragraph, the outcomes of the vulnerability assessments of Task 2a could not be linked to projections covering other parameters. It was therefore decided to use only temperature projections as one indication of future climatic changes under different scenarios.

The vulnerability scores delivered by Task 2a do not provide insights into the reason for a species to be classified as vulnerable. This means that the combination of vulnerability scores with spatial data in Task 3a cannot be discussed in light of climate change projections, because we do not know whether the species are assessed as vulnerable because of temperature or any other potential climate change impacts.

Moreover, outcomes of climate envelope modelling using different models, scenarios and time horizons (see Table 9) were used in the calculation of the species' vulnerability scores. This means that an analysis of the vulnerability scores in light of projected climate changes in Task 3a would have introduced a degree of circulating into the analysis.

There is no information about the completeness of the Natura 2000 databases that were provided by the European Topic Centre on Biological Diversity (dataset 4). As a consequence, it is possible that assessed species occur in more Natura 2000 sites than the dataset currently records. As mentioned earlier, several Member States are still in the process of designating sites. It can therefore be assumed that the Natura 2000 databases will be updated as information on newly designated sites becomes available. In addition, the information on currently included sites may change, for example when new data is gathered. It would be interesting to repeat the current analyses when more Member States have completed the designation of Natura 2000 sites and the corresponding data has been added to the databases.

Conclusions

This study linked vulnerability assessments for species of Community interest identified under the Birds and Habitats Directive with their spatial occurrence across the Natura 2000 network. Results demonstrate different patterns for the distribution of assessed species among vulnerability categories by biogeographic regions and Member States. In addition, climate change projections for the European Union were overlaid with spatial data on the Natura 2000 network to identify regions and Natura 2000 sites that are projected to face the most severe temperature changes for different time horizons. The results may help to identify particularly vulnerable species and sites for which adaptation actions are needed.

Member States can use the results of this study in different ways. The design and implementation of adaptation measures may need to focus on regions that host a large number of species assessed as highly vulnerable. Those species that are assessed as highly vulnerable and are reported to occur in only a very few Natura 2000 sites are likely to require special attention. Cooperation with neighbouring countries that also host these species might be beneficial in addressing their conservation in a more holistic way. Member States may also want to establish the occurrence of particularly vulnerable species outside designated Natura 2000 sites and consider the distribution of these species in the design of landscape scale conservation activities.

It is possible that countries will find that, as a result of this study, species records are incomplete in the Natura 2000 database and that the identified data gaps can be filled in future reports to the European Topic Centre on Biological Diversity.

Finally, the study clearly points to the need to assess the vulnerability of more species of Community interest in order to achieve a more complete picture of the robustness of the Natura 2000 network and to support the efforts of Member States in halting the loss of biodiversity. To this aim the development and use of a new generation of climate models that fully integrate missing elements such as positive climate feedbacks and ice-sheet melting would be desirable; sadly, any resulting new assessment of climate change impacts on biodiversity may indeed prove to be even more worrisome.

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References

Alcamo, J., Moreno, J. M., Nováky, M., Bindi, M., Corobov, R., Devoy, R. J. N., Giannakopoulos, C., Martin, E., Olesen, J. E., and Shvidenko, A. (2007). Europe. In: Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. (M. L. Parry, O. F. Canziani, J. P. Palutikof, P. J. van der Linden, and C. E. Hansen, Eds.) Cambridge University Press: Cambridge, UK. pp. 541-580.

Araujo, M. B., Thuiller, W., and Pearson, R. G. (2006). Climate warming and the decline of amphibians and reptiles in Europe. *Journal of Biogeography* **33**, 1712-1728.

Araujo, Miguel B. and Rahbek, Carsten (2006). ECOLOGY: How Does Climate Change Affect Biodiversity? *Science* **313**, 1396-1397.

Berry, P. M., Jones, A. P., Nicholls, R. J., Vos, C. C., and (Eds.) (2007). Assessment of the vulnerability of terrestrial and coastal habitats and species in Europe to climate change, Annex 2 of Planning for biodiversity in a changing climate - BRANCH project Final Report. Natural England, UK:

Biesmeijer, J. C., Roberts, S. P. M., Reemer, M., Ohlemuller, R., Edwards, M., Peeters, T., Schaffers, A. P., Potts, S. G., Kleukers, R., Thomas, C. D., Settele, J., and Kunin, W. E. (2006). Parallel Declines in Pollinators and Insect-Pollinated Plants in Britain and the Netherlands. *Science* **313**, 351-354.

BRANCH partnership (2007). Planning for biodiversity in a changing climate - BRANCH project Final Report. Natural England: UK.

Commission of the European Communities (2009). Report from the Commission to the Council and the European Parliament. Composite Report on the Conservation Status of Habitat Types and Species as required under Article 17 of the Habitats Directive. COM(2009) 358 final . Commission of the European Communities: Brussels, Belgium.

Council of the European Communities (1979). Council Directive 49/409/EEC of 2 April 1979 on the conservation of wild birds.

Council of the European Communities (1992). Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora.

Council of the European Union (2005). European Council Brussels, 22 and 23 March 2005. Presidency Conclusions. European Council: Brussels, Belgium.

EC (2003). MEMO on Commission strategy to protect Europe's most important wildlife areas – frequently asked questions about NATURA 2000

http://ec.europa.eu/environment/nature/info/pubs/docs/nat2000/2003_memo_natura.pdf. Accessed 9.4.2009.

EEA (2009). Progress towards the European 2010 biodiversity target. European Environment Agency, EEA: Copenhagen, Denmark. EEA Report No. 4 2009.

EEA, JRC, and WHO (2008). Impacts of Europe's changing climate - 2008 indicator-based assessment. European Environment Agency: Copenhagen.

European Commission (2009a). Natura 2000 barometer http://ec.europa.eu/environment/nature/natura2000/barometer/index_en.htm. Accessed 19.8.2009a.

European Commission (2009b). Nature & Biodiversity http://ec.europa.eu/environment/nature/index_en.htm. Accessed 16.4.2009b.

Guisan, Antoine and Theurillat, Jean Paul (2000). Assessing alpine plant vulnerability to climate change: a modeling perspective. *Integrated Assessment* **1**, 307-320.

Haeberli, W., Hoelzle, M., Paul, F., and Zemp, M. (2007). Integrated monitoring of mountain glaciers as key indicators of global climate change: the European Alps. *Annals of Glaciology* **46**, 150-160.

Harrison, P. A., Berry, P. M., Butt, N., and New, M. (2006). Modelling climate change impacts on species' distributions at the European scale: implications for conservation policy. *Environmental Science & Policy* **9**, 116-128.

Lenoir, J., Gegout, J. C., Marquet, P. A., de Ruffray, P., and Brisse, H. (2008). A significant upward shift in plant species optimum elevation during the 20th century. *Science* **320**, 1768-1771.

Levinsky, I., Skov, F., Svenning, J. C., and Rahbek, C. (2007). Potential impacts of climate change on the distributions and diversity patterns of European mammals. *Biodiversity and Conservation* **16**, 3803-3816.

Meinshausen, M., Meinshausen, N., Hare, W., Raper, S. C. B., Frieler, K., Knutti, R., Frame, D. J., and Allen, M. R. (2009). Greenhouse-gas emission targets for limiting global warming to 2 §C. *Nature* **458**, 1158-1163.

Nakicenovic, N and Swart, R (2000). *Special Report on Emissions Scenarios. A Special Report of Working Group III of the Intergovernmental Panel on Climate Change.* Cambridge University Press: Cambridge, UK and New York. 570 pp. http://www.ipcc.ch/ipccreports/sres/emission/index.htm.

Normand, Signe, Svenning, J. C., and Skov, F. (2007). National and European perspectives on climate change sensitivity of the habitats directive characteristic plant species. *Journal for Nature Conservation* **15**, 41-53.

Olofsson, J., Hickler, T., Sykes, M. T., Araujo, M. B., Baletto, E., Berry, P. M., Bonelli, S., Cabeza, M., Dubuis, A., Guisan, A., Kuehn, I., Kujala, H., Piper, J., Rounsevell, M., Settele, J., and Thuiller, W. (2008). MACIS: Minimisation of and Adaptation to Climate change Impacts on biodiverSity. Deliverable 1.1: Climate change impacts on European biodiversity - observations and future projections. MACIS. Project as part of the 6th Framework Programme of the European Union.:

Reid, H. (2006). Climate Change and Biodiversity in Europe. *Conservation and Society* **4**, 84-101.

Roekaerts, M. (2002). The Biogeographical Regions Map of Europe. Basic principles of its creation and overview of its development. European Topic Centre Nature Protection and Biodiversity, European Environment Agency: Copenhagen, Denmark.

Rounsevell, M. D. A., Reginster, Isabelle, Araujo, M. B., Carter, T. R., Dendoncker, N., Ewert, F., House, J. I., Kankaanpaa, Susanna, Leemans, R., Metzger, M. J., Schmit, C., Smith, P., and Tuck, G. (2006). A coherent set of future land use change scenarios for Europe. *Agriculture, Ecosystems & Environment* **114**, 57-68.

Schroter, Dagmar, Cramer, Wolfgang, Leemans, Rik, Prentice, I. Colin, Araujo, Miguel B., Arnell, Nigel W., Bondeau, Alberte, Bugmann, Harald, Carter, Timothy R., Gracia, Carlos A., de la Vega-Leinert, Anne, Erhard, Markus, Ewert, Frank, Glendining, Margaret, House, Joanna I., Kankaanpaa, Susanna, Klein, Richard J. T., Lavorel, Sandra, Lindner, Marcus, Metzger, Marc J., Meyer, Jeannette, Mitchell, Timothy D., Reginster, Isabelle, Rounsevell, Mark, Sabate, Santi, Sitch, Stephen, Smith, Ben, Smith, Jo, Smith, Pete, Sykes, Martin T., Thonicke, Kirsten, Thuiller, Wilfried, Tuck, Gill, Zaehle, Sonke, and Zierl, Barbel (2005). Ecosystem Service Supply and Vulnerability to Global Change in Europe. *Science* **310**, 1333-1337.

Thomas, C. D., Cameron, A., Green, R. E., Bakkenes, M., Beaumont, L. J., Collingham, Y. C., Erasmus, B. F. N., de Siqueira, M. F., Grainger, A., Hannah, L., Hughes, L., Huntley, B., van Jaarsveld, A. S., Midgley, G. F., Miles, L., Ortega-Huerta, M. A., Peterson, A. T., Phillips, O. L., and Williams, S. E. (2004). Extinction risk from climate change. *Nature* **427**, 145-148.

Thuiller, W., Lavorel, S., Ara£jo, M. B., Sykes, M. T., and Prentice, I. C. (2005). Climate change threats to plant diversity in Europe. *Proceedings of the National Academy of Sciences* **102**, 8245-8250.

Vos, C., Berry, P., Opdam, P., Baveco, H., Nijhof, B., O'Hanley, J., Bell, C., and Kuipers, H. (2008). Adapting landscapes to climate change: examples of climate-proof ecosystem networks and priority adaptation zones. *Journal of Applied Ecology* **45**.

Annexes

Annex I.a: Number of bird species in each vulnerability category by country and biogeographic region

Country	Biogeographic region	No. of assessed species reported	Vulnerability							
			Moderate positive	Low positive	Low	Moderate	High	Very high	Critical	Extremely critical
Austria	ALP	87	1		7	18	32	22	7	
Austria	CON	89	1		6	19	32	21	8	2
Belgium	ATL	62	1		6	13	23	15	3	1
Belgium	CON	40	1		6	8	18	6	1	
Bulgaria	ALP	70	1		6	16	23	18	5	1
Bulgaria	BLK	107	1		7	20	32	34	11	2
Bulgaria	CON	104	1		7	22	33	30	9	2
Cyprus	MED	74	1		7	16	23	21	6	
Czech Republic	CON	36	1		6	9	16	4		
Czech Republic	PAN	19	1		4	7	5	1	1	
Denmark	ATL	43	1		6	10	13	11	2	
Denmark	CON	42	1		6	8	15	9	3	
Estonia	BOR	63	1		6	14	24	13	3	2
Finland	ALP	20				5	10	3	2	
Finland	BOR	45	1		5	14	15	7	3	
France	ALP	58	1		6	13	22	14	2	
France	ATL	90	1		6	15	28	32	7	1
France	CON	84	1		6	16	29	26	5	1
France	MED	103	1		7	18	32	34	10	1
Germany	ALP	16	1		4	3	6	2		
Germany	ATL	60	1		6	16	20	12	4	1
Germany	CON	88	1		6	17	31	26	6	1
Greece	MED	124	1		8	22	35	41	15	2
Hungary	PAN	81	1		6	15	30	21	7	1
Ireland	ATL	31	1		3	6	8	11	2	
Italy	ALP	91	1		6	19	35	24	5	1
Italy	CON	113	1		7	19	35	37	12	2
Italy	MED	115	1		7	18	33	42	12	2

Country	Biogeographic region	No. of assessed species reported	Vulnerability							
			Moderate positive	Low positive	Low	Moderate	High	Very high	Critical	Extremely critical
Latvia	BOR	69	1		6	16	26	16	3	1
Lithuania	BOR	56	1		5	16	22	12		
Luxembourg	CON	44	1		6	12	16	7	2	
Malta	MED	47	1		5	9	15	16	1	
Netherlands	ATL	46	1		6	9	13	13	3	1
Poland	ALP	46	1		6	11	20	8		
Poland	CON	90	1		7	19	32	23	7	1
Portugal	ATL	27	1		4	7	10	5		
Portugal	MAC	8			1	1	2	3	1	
Portugal	MED	81	1		6	14	23	28	9	
Romania	ALP	72	1		6	17	25	18	4	1
Romania	BLK	45	1		4	11	10	14	4	1
Romania	CON	82	1		6	17	29	22	5	2
Romania	PAN	73	1		6	14	26	17	7	2
Romania	STEPPIC	94	1		7	19	28	28	9	2
Slovakia	ALP	50	1		6	12	18	11	2	
Slovakia	PAN	78	1		7	16	27	21	5	1
Slovenia	ALP	35	1		4	8	16	6		
Slovenia	CON	42	1		6	12	14	8	1	
Spain	ALP	34	1		5	5	13	9	1	
Spain	ATL	82	1		6	15	26	29	5	
Spain	MAC	32			3	6	9	10	4	
Spain	MED	114	1		7	17	33	40	14	2
Sweden	ALP	31			2	6	14	6	3	
Sweden	BOR	53	1		5	13	20	10	4	
Sweden	CON	52	1		5	15	17	10	3	1
United Kingdom	ATL	42			4	7	14	14	3	

Annex I.b: Number of amphibian species in each vulnerability category by country and biogeographic region (A2_2050)

Country	Biogeographic region	No. of assessed species reported	Vulnerability							
			Moderate positive	Low positive	Low	Moderate	High	Very high	Critical	Extremely critical
Austria	ALP	3	1	0	2	0	0	0	0	9
Austria	CON	3	1	0	2	0	0	0	0	0
Belgium	ATL	1	0	0	1	0	0	0	0	0
Belgium	CON	1	0	0	1	0	0	0	0	0
Bulgaria	ALP	2	1	0	1	0	0	0	0	0
Bulgaria	BLK	2	1	0	1	0	0	0	0	0
Bulgaria	CON	3	1	0	2	0	0	0	0	0
Czech Republic	CON	4	1	0	2	0	1	0	0	0
Czech Republic	PAN	2	0	0	2	0	0	0	0	0
Denmark	ATL	1	0	0	1	0	0	0	0	0
Denmark	CON	2	0	0	2	0	0	0	0	0
Estonia	BOR	1	0	0	1	0	0	0	0	0
Finland	BOR	1	0	0	1	0	0	0	0	0
France	ALP	2	1	0	1	0	0	0	0	0
France	ATL	2	1	0	1	0	0	0	0	0
France	CON	2	1	0	1	0	0	0	0	0
France	MED	2	1	0	1	0	0	0	0	0
Germany	ALP	2	1	0	1	0	0	0	0	0
Germany	ATL	3	1	0	2	0	0	0	0	0
Germany	CON	3	1	0	2	0	0	0	0	0
Greece	MED	2	1	0	1	0	0	0	0	0
Hungary	PAN	4	2	0	2	0	0	0	0	0
Italy	ALP	5	2	0	0	0	2	1	0	0
Italy	CON	5	2	0	0	1	1	1	0	0
Italy	MED	2	1	0	0	0	0	1	0	0
Latvia	BOR	2	0	0	2	0	0	0	0	0
Lithuania	BOR	2	0	0	2	0	0	0	0	0
Luxembourg	CON	2	1	0	1	0	0	0	0	0

Country	Biogeographic region	No. of assessed species reported	Vulnerability							
			Moderate positive	Low positive	Low	Moderate	High	Very high	Critical	Extremely critical
Netherlands	ATL	2	1	0	1	0	0	0	0	0
Poland	ALP	3	1	0	1	0	1	0	0	0
Poland	CON	4	1	0	2	0	1	0	0	0
Portugal	ATL	1	0	0	0	0	1	0	0	0
Portugal	MED	1	0	0	0	0	1	0	0	0
Romania	ALP	4	1	0	1	0	2	0	0	0
Romania	CON	4	1	0	2	0	1	0	0	0
Romania	PAN	3	1	0	2	0	0	0	0	0
Romania	STEPPIC	2	1	0	1	0	0	0	0	0
Slovakia	ALP	4	1	0	2	0	1	0	0	0
Slovakia	PAN	3	1	0	2	0	0	0	0	0
Slovenia	ALP	2	1	0	0	1	0	0	0	0
Slovenia	CON	4	1	0	1	1	1	0	0	0
Spain	ATL	3	0	0	0	0	3	0	0	0
Spain	MED	2	0	0	0	0	2	0	0	0
Sweden	BOR	1	0	0	1	0	0	0	0	0
Sweden	CON	2	0	0	2	0	0	0	0	0
United Kingdom	ATL	1	0	0	1	0	0	0	0	0

Annex I.c: Number of reptile species in each vulnerability category by country and biogeographic region (A2_2050)

Country	Biogeographic region	No. of assessed species reported	Vulnerability							
			Moderate positive	Low positive	Low	Moderate	High	Very high	Critical	Extremely critical
Austria	CON	1	0	0	1	0	0	0	0	0
Bulgaria	ALP	4	1	0	3	0	0	0	0	0
Bulgaria	BLK	5	1	0	4	0	0	0	0	0
Bulgaria	CON	5	1	0	4	0	0	0	0	0
Cyprus	MED	2	0	0	2	0	0	0	0	0
France	ALP	1	0	0	1	0	0	0	0	0
France	ATL	1	0	0	1	0	0	0	0	0
France	CON	1	0	0	1	0	0	0	0	0
France	MED	6	0	0	5	1	0	0	0	0
Germany	CON	1	0	0	1	0	0	0	0	0
Greece	MED	8	1	0	7	0	0	0	0	0
Hungary	PAN	2	0	0	2	0	0	0	0	0
Italy	ALP	2	0	0	2	0	0	0	0	0
Italy	CON	4	0	0	4	0	0	0	0	0
Italy	MED	8	1	0	6	1	0	0	0	0
Latvia	BOR	1	0	0	1	0	0	0	0	0
Lithuania	BOR	1	0	0	1	0	0	0	0	0
Malta	MED	1	1	0	0	0	0	0	0	0
Poland	CON	1	0	0	1	0	0	0	0	0
Portugal	ATL	3	0	0	2	0	1	0	0	0
Portugal	MAC	1	0	0	1	0	0	0	0	0
Portugal	MED	4	0	0	2	0	2	0	0	0
Romania	BLK	1	0	0	1	0	0	0	0	0
Romania	CON	3	0	0	3	0	0	0	0	0
Romania	PAN	1	0	0	1	0	0	0	0	0
Romania	STEPPIC	4	0	0	4	0	0	0	0	0
Slovakia	PAN	1	0	0	1	0	0	0	0	0
Slovenia	ALP	1	0	0	1	0	0	0	0	0

Country	Biogeographic region	No. of assessed species reported	Vulnerability							
			Moderate positive	Low positive	Low	Moderate	High	Very high	Critical	Extremely critical
Slovenia	CON	1	0	0	1	0	0	0	0	0
Spain	ALP	1	0	0	0	0	1	0	0	0
Spain	ATL	4	0	0	2	0	2	0	0	0
Spain	MAC	1	0	0	1	0	0	0	0	0
Spain	MED	7	0	0	5	0	2	0	0	0

Annex I.d: Number of butterfly species in each vulnerability category by country and biogeographic region

Country	Biogeographic region	No. of assessed species reported	Vulnerability							
			Moderate positive	Low positive	Low	Moderate	High	Very high	Critical	Extremely critical
Austria	ALP	5	0	0	4	0	1	0	0	0
Austria	CON	5	0	0	4	0	1	0	0	0
Belgium	CON	3	0	0	1	1	1	0	0	0
Bulgaria	ALP	4	0	0	2	1	1	0	0	0
Bulgaria	BLK	3	0	0	2	0	1	0	0	0
Bulgaria	CON	5	0	0	2	1	1	0	1	0
Czech Republic	CON	5	0	0	3	0	1	0	1	0
Czech Republic	PAN	1	0	0	0	0	1	0	0	0
Denmark	ATL	1	0	0	1	0	0	0	0	0
Denmark	CON	1	0	0	1	0	0	0	0	0
Estonia	BOR	2	0	0	1	0	1	0	0	0
Finland	ALP	2	0	0	2	0	0	0	0	0
Finland	BOR	1	0	0	0	0	1	0	0	0
France	ALP	5	0	0	4	0	1	0	0	0
France	ATL	4	0	0	3	0	1	0	0	0
France	CON	5	0	0	4	0	1	0	0	0
France	MED	2	0	0	2	0	0	0	0	0
Germany	ALP	3	0	0	3	0	0	0	0	0
Germany	ATL	1	0	0	1	0	0	0	0	0
Germany	CON	5	0	0	3	1	1	0	0	0
Greece	MED	2	0	0	1	0	1	0	0	0
Hungary	PAN	7	0	0	4	0	1	1	1	0
Ireland	ATL	1	0	0	1	0	0	0	0	0
Italy	ALP	5	0	0	3	0	2	0	0	0
Italy	CON	5	0	0	3	0	2	0	0	0
Italy	MED	3	0	0	1	0	2	0	0	0
Latvia	BOR	3	0	0	2	0	1	0	0	0
Lithuania	BOR	3	0	0	2	0	1	0	0	0
Luxembourg	CON	2	0	0	1	0	1	0	0	0

Country	Biogeographic region	No. of assessed species reported	Vulnerability							
			Moderate positive	Low positive	Low	Moderate	High	Very high	Critical	Extremely critical
Netherlands	ATL	3	0	0	2	0	1	0	0	0
Poland	ALP	1	0	0	0	0	1	0	0	0
Poland	CON	8	0	0	4	2	1	0	1	0
Portugal	ATL	1	0	0	1	0	0	0	0	0
Portugal	MED	1	0	0	1	0	0	0	0	0
Romania	ALP	5	0	0	2	0	1	1	1	0
Romania	BLK	1	0	0	0	0	1	0	0	0
Romania	CON	7	0	0	3	1	1	1	1	0
Romania	PAN	2	0	0	1	0	1	0	0	0
Romania	STEPPIC	2	0	0	0	0	1	0	1	0
Slovakia	ALP	6	0	0	2	1	1	1	1	0
Slovakia	PAN	7	0	0	3	1	1	1	1	0
Slovenia	ALP	6	0	0	3	0	1	1	1	0
Slovenia	CON	7	0	0	4	0	1	1	1	0
Spain	ALP	2	0	0	2	0	0	0	0	0
Spain	ATL	2	0	0	2	0	0	0	0	0
Spain	MED	3	0	0	3	0	0	0	0	0
Sweden	ALP	2	0	0	2	0	0	0	0	0
Sweden	BOR	1	0	0	1	0	0	0	0	0
Sweden	CON	1	0	0	1	0	0	0	0	0
United Kingdom	ATL	1	0	0	1	0	0	0	0	0

Annex I.e: Number of plant species in each vulnerability category by country and biogeographic region (A2_2050)

Country	Biogeographic region	No. of assessed species reported	Vulnerability							
			Moderate positive	Low positive	Low	Moderate	High	Very high	Critical	Extremely critical
Austria	ALP	1	0	0	0	1	0	0	0	0
Austria	CON	2	0	0	2	0	0	0	0	0
Belgium	CON	1	0	0	0	1	0	0	0	0
Bulgaria	CON	1	0	0	1	0	0	0	0	0
Czech Republic	CON	4	0	0	3	1	0	0	0	0
Denmark	CON	1	0	0	0	1	0	0	0	0
Estonia	BOR	5	1	0	4	0	0	0	0	0
Finland	ALP	2	0	0	2	0	0	0	0	0
Finland	BOR	5	0	0	4	1	0	0	0	0
France	ALP	2	0	0	0	2	0	0	0	0
France	ATL	4	1	0	2	1	0	0	0	0
France	CON	4	1	0	1	2	0	0	0	0
France	MED	2	1	0	0	1	0	0	0	0
Germany	ATL	2	0	0	1	1	0	0	0	0
Germany	CON	4	0	0	3	1	0	0	0	0
Greece	MED	2	0	0	1	1	0	0	0	0
Hungary	PAN	4	1	0	2	0	1	0	0	0
Italy	ALP	2	0	0	2	0	0	0	0	0
Italy	CON	3	1	0	2	0	0	0	0	0
Italy	MED	3	2	0	0	1	0	0	0	0
Latvia	BOR	4	0	0	3	1	0	0	0	0
Lithuania	BOR	4	0	0	3	1	0	0	0	0
Luxembourg	CON	1	0	0	0	1	0	0	0	0
Poland	CON	5	0	0	4	1	0	0	0	0
Portugal	ATL	1	0	0	0	1	0	0	0	0
Portugal	MAC	2	0	0	1	1	0	0	0	0
Portugal	MED	3	0	0	3	0	0	0	0	0
Romania	ALP	3	0	0	3	0	0	0	0	0

Country	Biogeographic region	No. of assessed species reported	Vulnerability							
			Moderate positive	Low positive	Low	Moderate	High	Very high	Critical	Extremely critical
Romania	CON	4	1	0	3	0	0	0	0	0
Romania	PAN	2	0	0	1	0	1	0	0	0
Romania	STEPPIC	1	0	0	1	0	0	0	0	0
Slovakia	ALP	2	0	0	2	0	0	0	0	0
Slovakia	PAN	3	0	0	2	0	1	0	0	0
Slovenia	ALP	1	0	0	0	1	0	0	0	0
Slovenia	CON	3	0	0	2	1	0	0	0	0
Spain	ATL	2	0	0	1	1	0	0	0	0
Spain	MAC	1	0	0	0	1	0	0	0	0
Spain	MED	5	1	0	3	1	0	0	0	0
Sweden	ALP	4	0	0	3	0	1	0	0	0
Sweden	BOR	8	1	0	6	1	0	0	0	0
Sweden	CON	3	1	0	1	1	0	0	0	0
United Kingdom	ATL	2	0	0	1	1	0	0	0	0

Annex II: Vulnerability assessment results by species and the number of Natura 2000 sites in which they are reported to occur

Taxon	Species	Vulnerability	No. of Natura 2000 sites reported from	Scenario / time horizon
Birds	*Gavia stellata*	Moderate	529	B2_2070-2099
Birds	*Gavia arctica*	Moderate	799	B2_2070-2099
Birds	*Podiceps auritus*	Very high	427	B2_2070-2099
Birds	*Calonectris diomedea*	Very high	295	B2_2070-2099
Birds	*Hydrobates pelagicus*	Very high	174	B2_2070-2099
Birds	*Oceanodroma leucorhoa*	Very high	26	B2_2070-2099
Birds	*Botaurus stellaris*	High	1421	B2_2070-2099
Birds	*Ixobrychus minutus*	Moderate	1292	B2_2070-2099
Birds	*Nycticorax nycticorax*	High	1050	B2_2070-2099
Birds	*Ardeola ralloides*	Very high	636	B2_2070-2099
Birds	*Egretta garzetta*	High	1306	B2_2070-2099
Birds	*Egretta alba*	Very high	987	B2_2070-2099
Birds	*Ardea purpurea*	Very high	1076	B2_2070-2099
Birds	*Ciconia nigra*	High	1815	B2_2070-2099
Birds	*Ciconia ciconia*	Moderate	1771	B2_2070-2099
Birds	*Plegadis falcinellus*	Very high	355	B2_2070-2099
Birds	*Platalea leucorodia*	Very high	578	B2_2070-2099
Birds	*Phoenicopterus ruber*	Critical	234	B2_2070-2099
Birds	*Cygnus bewickii (Cygnus columbianus bewickii)*	Very high	422	B2_2070-2099
Birds	*Cygnus cygnus*	Very high	782	B2_2070-2099
Birds	*Anser erythropus*	Extremely critical	84	B2_2070-2099
Birds	*Branta leucopsis*	Critical	333	B2_2070-2099
Birds	*Marmaronetta angustirostris*	Very high	41	B2_2070-2099
Birds	*Aythya nyroca*	Very high	620	B2_2070-2099
Birds	*Mergus albellus (Mergellus albellus)*	Critical	785	B2_2070-2099
Birds	*Oxyura leucocephala*	Critical	79	B2_2070-2099
Birds	*Pernis apivorus*	Low	3189	B2_2070-2099
Birds	*Milvus migrans*	Moderate	2295	B2_2070-2099

Taxon	Species	Vulnerability	No. of Natura 2000 sites reported from	Scenario / time horizon
Birds	*Milvus milvus*	High	1974	B2_2070-2099
Birds	*Haliaeetus albicilla*	Very high	758	B2_2070-2099
Birds	*Gypaetus barbatus*	Critical	254	B2_2070-2099
Birds	*Neophron percnopterus*	Very high	587	B2_2070-2099
Birds	*Gyps fulvus*	Very high	625	B2_2070-2099
Birds	*Aegypius monachus*	Critical	123	B2_2070-2099
Birds	*Circaetus gallicus*	High	1466	B2_2070-2099
Birds	*Circus aeruginosus*	Low	2917	B2_2070-2099
Birds	*Circus cyaneus*	High	2320	B2_2070-2099
Birds	*Circus macrourus*	Critical	213	B2_2070-2099
Birds	*Circus pygargus*	High	1549	B2_2070-2099
Birds	*Aquila pomarina*	Very high	646	B2_2070-2099
Birds	*Aquila clanga*	Extremely critical	137	B2_2070-2099
Birds	*Aquila chrysaetos*	Very high	1505	B2_2070-2099
Birds	*Hieraaetus pennatus*	Very high	852	B2_2070-2099
Birds	*Hieraaetus fasciatus*	High	457	B2_2070-2099
Birds	*Pandion haliaetus*	High	1580	B2_2070-2099
Birds	*Falco naumanni*	Low	410	B2_2070-2099
Birds	*Falco vespertinus*	Very high	528	B2_2070-2099
Birds	*Falco columbarius*	High	1127	B2_2070-2099
Birds	*Falco eleonorae*	High	268	B2_2070-2099
Birds	*Falco biarmicus*	Very high	307	B2_2070-2099
Birds	*Falco rusticolus*	Very high	1	B2_2070-2099
Birds	*Falco peregrinus*	Low	2465	B2_2070-2099
Birds	*Bonasa bonasia*	High	1566	B2_2070-2099
Birds	*Tetrao urogallus*	High	1365	B2_2070-2099
Birds	*Alectoris graeca*	Very high	43	B2_2070-2099
Birds	*Alectoris barbara*	Critical	68	B2_2070-2099
Birds	*Porzana porzana*	Moderate	1249	B2_2070-2099
Birds	*Porzana parva*	High	545	B2_2070-2099
Birds	*Porzana pusilla*	Critical	141	B2_2070-2099
Birds	*Crex crex*	High	1236	B2_2070-2099
Birds	*Porphyrio porphyrio*	Very high	105	B2_2070-2099

Taxon	Species	Vulnerability	No. of Natura 2000 sites reported from	Scenario / time horizon
Birds	*Fulica cristata*	Very high	22	B2_2070-2099
Birds	*Grus grus*	High	2087	B2_2070-2099
Birds	*Tetrax tetrax*	Very high	211	B2_2070-2099
Birds	*Otis tarda*	Critical	139	B2_2070-2099
Birds	*Himantopus himantopus*	High	799	B2_2070-2099
Birds	*Recurvirostra avosetta*	High	680	B2_2070-2099
Birds	*Burhinus oedicnemus*	High	763	B2_2070-2099
Birds	*Glareola pratincola*	Very high	224	B2_2070-2099
Birds	*Charadrius alexandrinus*	Moderate	388	B2_2070-2099
Birds	*Charadrius morinellus (Eudromias morinellus)*	Very high	248	B2_2070-2099
Birds	*Pluvialis apricaria*	Moderate	1620	B2_2070-2099
Birds	*Philomachus pugnax*	High	1701	B2_2070-2099
Birds	*Gallinago media*	Very high	276	B2_2070-2099
Birds	*Limosa lapponica*	Critical	372	B2_2070-2099
Birds	*Tringa glareola*	Moderate	2036	B2_2070-2099
Birds	*Xenus cinereus (Tringa cinerea)*	Critical	35	B2_2070-2099
Birds	*Phalaropus lobatus*	High	301	B2_2070-2099
Birds	*Larus melanocephalus*	Very high	514	B2_2070-2099
Birds	*Larus minutus*	Moderate	562	B2_2070-2099
Birds	*Larus audouinii*	Critical	241	B2_2070-2099
Birds	*Gelochelidon nilotica*	Very high	241	B2_2070-2099
Birds	*Sterna caspia*	Very high	288	B2_2070-2099
Birds	*Sterna sandvicensis*	High	543	B2_2070-2099
Birds	*Sterna dougallii*	High	56	B2_2070-2099
Birds	*Sterna hirundo*	Low	1740	B2_2070-2099
Birds	*Sterna paradisaea*	Very high	557	B2_2070-2099
Birds	*Sterna albifrons*	Very high	779	B2_2070-2099
Birds	*Chlidonias hybridus*	High	601	B2_2070-2099
Birds	*Chlidonias niger*	Very high	1186	B2_2070-2099
Birds	*Pterocles alchata*	Critical	61	B2_2070-2099
Birds	*Bubo bubo*	High	1588	B2_2070-2099
Birds	*Nyctea scandiaca*	Critical	9	B2_2070-2099

Taxon	Species	Vulnerability	No. of Natura 2000 sites reported from	Scenario / time horizon
Birds	*Glaucidium passerinum*	Moderate	873	B2_2070-2099
Birds	*Strix uralensis*	High	373	B2_2070-2099
Birds	*Asio flammeus*	Very high	1004	B2_2070-2099
Birds	*Aegolius funereus*	Moderate	1161	B2_2070-2099
Birds	*Caprimulgus europaeus*	Moderate	2498	B2_2070-2099
Birds	*Alcedo atthis*	Moderate positive	3225	B2_2070-2099
Birds	*Coracias garrulus*	High	717	B2_2070-2099
Birds	*Picus canus*	High	1539	B2_2070-2099
Birds	*Dryocopus martius*	Low	3608	B2_2070-2099
Birds	*Dendrocopos medius*	High	1365	B2_2070-2099
Birds	*Dendrocopos leucotos*	Very high	416	B2_2070-2099
Birds	*Picoides tridactylus*	High	858	B2_2070-2099
Birds	*Melanocorypha calandra*	Moderate	427	B2_2070-2099
Birds	*Calandrella brachydactyla*	Moderate	715	B2_2070-2099
Birds	*Galerida theklae*	Very high	479	B2_2070-2099
Birds	*Lullula arborea*	Moderate	2400	B2_2070-2099
Birds	*Anthus campestris*	High	1486	B2_2070-2099
Birds	*Luscinia svecica*	High	1005	B2_2070-2099
Birds	*Oenanthe leucura*	Very high	278	B2_2070-2099
Birds	*Acrocephalus melanopogon*	High	297	B2_2070-2099
Birds	*Acrocephalus paludicola*	Very high	140	B2_2070-2099
Birds	*Sylvia sarda*	Very high	129	B2_2070-2099
Birds	*Sylvia undata*	Very high	929	B2_2070-2099
Birds	*Sylvia nisoria*	Moderate	850	B2_2070-2099
Birds	*Ficedula parva*	Moderate	793	B2_2070-2099
Birds	*Ficedula albicollis*	High	663	B2_2070-2099
Birds	*Lanius collurio*	Low	4511	B2_2070-2099
Birds	*Lanius minor*	Moderate	533	B2_2070-2099
Birds	*Pyrrhocorax pyrrhocorax*	Very high	759	B2_2070-2099
Birds	*Emberiza hortulana*	Moderate	1321	B2_2070-2099
Birds	*Phalacrocorax pygmeus*	Critical	258	B2_2070-2099
Birds	*Tadorna ferruginea*	Very high	108	B2_2070-2099
Birds	*Elanus caeruleus*	Very high	107	B2_2070-2099

Taxon	Species	Vulnerability	No. of Natura 2000 sites reported from	Scenario / time horizon
Birds	*Accipiter brevipes*	Very high	190	B2_2070-2099
Birds	*Buteo rufinus*	High	312	B2_2070-2099
Birds	*Aquila heliaca*	Critical	185	B2_2070-2099
Birds	*Aquila heliaca adalberti*	Critical	75	B2_2070-2099
Birds	*Tetrao tetrix tetrix*	High	914	B2_2070-2099
Birds	*Pterocles orientalis*	Critical	134	B2_2070-2099
Birds	*Apus caffer*	High	17	B2_2070-2099
Birds	*Dendrocopos syriacus*	Moderate	432	B2_2070-2099
Birds	*Chersophilus duponti*	Critical	57	B2_2070-2099
Birds	*Lanius nubicus*	High	91	B2_2070-2099
Birds	*Hippolais olivetorum*	Moderate	104	B2_2070-2099
Birds	*Sylvia rueppelli*	Very high	65	B2_2070-2099
Birds	*Ficedula semitorquata*	Very high	99	B2_2070-2099
Birds	*Sitta krueperi*	Critical	3	B2_2070-2099
Birds	*Emberiza cineracea*	Very high	5	B2_2070-2099
Birds	*Emberiza caesia*	Low	103	B2_2070-2099
Birds	*Loxia scotica*	Critical	5	B2_2070-2099
Birds	*Bucanetes githagineus*	Very high	36	B2_2070-2099
Birds	*Surnia ulula*	High	178	B2_2070-2099
Birds	*Strix nebulosa*	Critical	66	B2_2070-2099
Birds	*Puffinus yelkouan*	Very high	58	B2_2070-2099
Birds	*Falco cherrug*	Critical	132	B2_2070-2099
Birds	*Oenanthe pleschanka*	High	31	B2_2070-2099
Amphibians	*Triturus cristatus spp*	Low	2044	A2_2050
Amphibians	*Salamandra atra*	High	3	A2_2050
Amphibians	*Chioglossa lusitannica*	High	98	A2_2050
Amphibians	*Salamandrina terdigitata*	Very High	207	A2_2050
Amphibians	*Proteus anguinus*	Moderate	28	A2_2050
Amphibians	*Bombina bombina*	Low	1087	A2_2050
Amphibians	*Bombina variegata*	Moderate positive	1524	A2_2050
Amphibians	*Discoglossus galganoi*	High	251	A2_2050
Amphibians	*Pelobates fuscus*	Moderate positive	27	A2_2050
Amphibians	*Rana latastei*	High	177	A2_2050

Taxon	Species	Vulnerability	No. of Natura 2000 sites reported from	Scenario / time horizon
Amphibians	*Triturus montandoni*	High	109	A2_2050
Amphibians	*Triturus vulgaris*	High	14	A2_2050
Reptiles	*Testudo hermanni*	Low	574	A2_2050
Reptiles	*Testudo marginata*	Low	83	A2_2050
Reptiles	*Testudo graeca*	Low	268	A2_2050
Reptiles	*Emys orbicularis*	Low	1161	A2_2050
Reptiles	*Mauremys leprosa*	Low	331	A2_2050
Reptiles	*Mauremys caspica*	Low	98	A2_2050
Reptiles	*Caretta caretta*	Low	190	A2_2050
Reptiles	*Phyllodactylus europaeus*	Moderate	87	A2_2050
Reptiles	*Lacerta monticola*	High	89	A2_2050
Reptiles	*Lacerta schrieberi*	High	214	A2_2050
Reptiles	*Elaphe situla*	Moderate positive	203	A2_2050
Reptiles	*Vipera ursinii*	Low	54	A2_2050
Butterflies	*Phengaris teleius*	Low	461	A2_2050
Butterflies	*Lycaena dispar*	High	976	A2_2050
Butterflies	*Phengaris nausithous*	Low	745	A2_2050
Butterflies	*Melanargia arge*	High	97	A2_2050
Butterflies	*Euphydryas aurinia*	Low	1010	A2_2050
Butterflies	*Coenonympha oedippus*	Low	58	A2_2050
Butterflies	*Plebejus glandon*	Low	10	A2_2050
Butterflies	*Erebia medusa polaris*	Low	9	A2_2050
Butterflies	*Hesperia comma catena*	Low	6	A2_2050
Butterflies	*Colias myrmidone*	Critical	46	A2_2050
Butterflies	*Leptidea morsei*	Very High	48	A2_2050
Butterflies	*Lycaena helle*	Moderate	92	A2_2050
Butterflies	*Polyommatus eroides*	Moderate	33	A2_2050
Plants	*Botrychium simplex*	Moderate	17	A2_2050
Plants	*Trichomanes speciosum*	Moderate	150	A2_2050
Plants	*Marsilea quadrifolia*	Low	70	A2_2050
Plants	*Thesium ebracteatum*	Low	48	A2_2050
Plants	*Rumex rupestris*	Low	42	A2_2050
Plants	*Dianthus cintranus*	Low	1	A2_2050

Taxon	Species	Vulnerability	No. of Natura 2000 sites reported from	Scenario / time horizon
Plants	*Herniaria lusitanica*	Low	2	A2_2050
Plants	*Petrocoptis grandiflora*	Low	4	A2_2050
Plants	*Herniaria latifolia*	Moderate positive	4	A2_2050
Plants	*Dianthus rupicola*	Moderate positive	95	A2_2050
Plants	*Spergularia azorica*	Low	21	A2_2050
Plants	*Aquilegia pyrenaica*	Low	1	A2_2050
Plants	*Pulsatilla patens*	Low	90	A2_2050
Plants	*Sisymbrium supinum*	Moderate positive	35	A2_2050
Plants	*Arenaria ciliata*	Low	3	A2_2050
Plants	*Braya linearis*	Low	6	A2_2050
Plants	*Dianthus arenarius*	Low	39	A2_2050
Plants	*Diplazium sibiricum*	Low	34	A2_2050
Plants	*Moehringia lateriflora*	Low	24	A2_2050
Plants	*Papaver radicatum*	High	5	A2_2050
Plants	*Pulsatilla vulgaris*	Low	2	A2_2050
Plants	*Ranunculus lapponicus*	Low	164	A2_2050
Plants	*Paeonia officinalis*	Moderate positive	5	A2_2050
Plants	*Asplenium adulterinum*	Low	41	A2_2050
Plants	*Arabis scopoliana*	Moderate	3	A2_2050
Plants	*Pulsatilla pratensis*	High	12	A2_2050