A methodology for assessing the vulnerability to climate change of habitats in the Natura 2000 network

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1. Introduction

The aim of this project is to propose a methodology for assessing the vulnerability of European habitats within the Natura 2000 network to climate change. The European Union (EU) Habitats Directive (Annex I) lists 231 natural habitat types, including 71 priority habitats (habitats in danger of disappearance and whose natural range mainly falls within EU territory).

Understanding the vulnerability of habitats and species to climate change is vital in the development of adaptation strategies for biodiversity. Since resources for nature conservation (including the protection of habitats and species from climate change) are limited, it is necessary to identify and prioritise those that are most vulnerable as a focus for adaptation action. Vulnerability assessments can inform decisions on these priorities.

The vulnerability assessment process includes assessments of climate change impacts and of the ability of species and habitats to successfully respond to these impacts. The magnitude of the climate change likely to be experienced (exposure) and the degree to which the species or habitat might be affected (sensitivity) are compared to give a measure of impact. The ability of impacted species or habitats to successfully respond to climate change (adaptive capacity) is then assessed to establish a robust indication of vulnerability.

Research into the exposure and sensitivity of EU species to climate change is reasonably abundant in the scientific literature, particularly for species in northern and western Europe (EC, 2009 *Task 1 report*). These studies utilised a variety of approaches to understand climate change impacts on species, including analyses of observed data and modelled projections, and knowledge-based expert assessments. Few projects have moved beyond the assessment of exposure and sensitivity to a structured approach that considers adaptive capacity and, thereby, vulnerability.

Thuiller *et al.* (2005) used climate envelope models for more than 1,350 plant species to assess the amount of climate space lost (sensitivity) under a range of climate change (exposure) and dispersal (adaptive capacity) scenarios. The amount of climate space lost was then compared to IUCN threat categories (IUCN, 2001) to assign threat category labels. The work of Thuiller *et al.* implicitly blends the assessments of exposure, impact and adaptive capacity in its methods.

Harrison *et al.* (2001) assessed the vulnerabilities of species and habitats in Great Britain and Ireland to climate change. This work used detailed knowledge of the ecology and current status of species and habitats to qualitatively identify those most vulnerable.

The European Commission (EC) project *Biodiversity and climate change in relation to the Natura 2000 network* (EC, 2009 *Task 2a report*) was the first to establish a semi-quantitative methodology for assessing the vulnerability of species to climate change. A measure of vulnerability was obtained by comparing assessments of climate change impacts with those for adaptive capacity. The project had initially hoped to include assessments of habitat vulnerability, but this was not possible due to constraints on data availability.

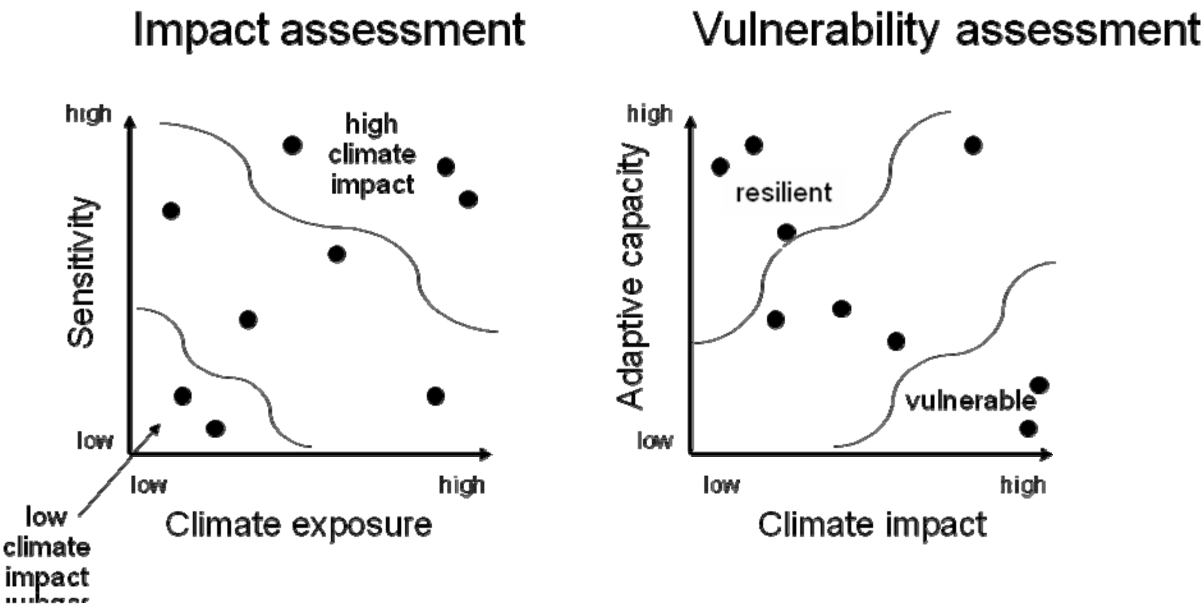
Research into the exposure and sensitivity of EU habitats to climate change and their adaptive capacity is sparse. Building on the EC project, the European Topic Centre on Air and Climate Change undertook the study *A methodology for assessing the vulnerability to climate change of habitats in the Natura 2000 network* for the European Environment Agency (EEA). The project used data provided by the European Topic Centre on Biological Diversity to test the applicability of the methodology developed for the EC project in assessing habitat vulnerability. Eight (forest) habitats were chosen for the study on the basis of data being available to inform the assessment process.

2. Overview of methodology

The methodology presented here for assessing the vulnerability of Natura 2000 habitats is based on that developed for the EC project *Biodiversity and climate change in relation to the Natura 2000 network* (EC, 2009 *Task 2a report*). The methodology comprises a two-part process (Figure 1). Firstly, information on the degree of **exposure** to climate change likely to be experienced by a habitat was plotted against its **sensitivity** to that exposure to give a measure of **impact** (i.e. with no adaptation). Secondly, **impact** was plotted against the **adaptive capacity** of that habitat to give a measure of **vulnerability**. Adaptive capacity was only assessed for those habitats likely to be subject to significant impacts. The definitions of exposure, sensitivity, impact, adaptive capacity and vulnerability accord with guidance provided in IPCC's Fourth Assessment Report (IPCC, 2007):

- Exposure - the nature and degree to which a system is exposed to climatic variations.
- Sensitivity - the degree to which a system is affected, either adversely or beneficially, by climate change.
- Impact - all impacts that may occur given a projected change in climate, without considering adaptation; impact is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed and its sensitivity.
- Adaptive capacity - the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences.
- Vulnerability - the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes; vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity (resilience is the amount of change a system can undergo without changing state).

Figure 1: Impact and vulnerability assessment framework



3. Impact assessment framework

Two variables - exposure to climate change and sensitivity to climate change - were the basic elements used in the assessment of climate change impacts on habitats. When considered together, these provided a semi-qualitative measure of impact.

Exposure

As a measure of exposure, temperature projections for the 2050s and 2080s from the Hadley Centre's coupled ocean-atmosphere General Circulation Model (HadCM3) were used for the SRES A1, A2, B1 and B2 greenhouse gas emissions scenarios (IPCC, 2000). For the purposes of detailed analysis, two SRES scenarios (A1 and B1) were chosen as being representative of the possible range of futures:

- The A1 scenario family is an example of future 'high' scenarios with, for example, a global temperature increase of up to 3.6^{o}C by the 2080s. It portrays a world of very rapid economic growth, global population that peaks in mid-century and declines thereafter, and the rapid introduction of new and more efficient technologies.
- The B1 scenario is a lower emissions future, with a global temperature increase of up to 1.8^{o}C by the 2080s. It describes a world where rapid changes in economic structures toward a service and information economy, with reductions in material intensity, and the introduction of clean and resource-efficient technologies. Global population is also projected to peak in mid-century and decline thereafter.

Sensitivity

Data on the sensitivity of habitats to climate change were not readily available. Therefore, characteristic species of a habitat were used as proxies for that habitat. Plant species were chosen as, by virtue of their sedentary nature, they are likely to most accurately reflect the responses of a habitat to climate change. If one or more of these species are vulnerable to climate change, it is reasonable to expect that the habitat as a whole might be vulnerable.

Data from the EU Habitat Interpretation Manual (EC, 2007) were used to identify characteristic species. The manual describes the characteristic species for each EU habitat. For example, Table 1 lists the plant species that characterise the habitat 'Subalpine and montane *Pinus uncinata* forests'.

Table 1: Characteristic plant species of the habitat 'Subalpine and montane *Pinus uncinata* forests' (source: EU Habitat Interpretation Manual; EC, 2007)

Arctostaphylos alpina, A. uva-ursi, Astrantia minor, Calluna vulgaris, Coronilla vaginalis, Cotoneaster integerrimus, Crepis alpestris, Daphne striata, Deschampsia flexuosa, Dryas octopetala,Erica herbacea, Homogyna alpina, Huperzia selago, Juniperus hemisphaerica, J. nana, Lycopodiumannotinum, Pinus uncinata, Polygala chamaebuxus, Rhamnus saxatilis, Rhododendron ferrugineum,Rhododendron hirsutum, Thesium rostratum, Vaccinium myrtillus, V. uliginosum

Bioclimatic envelope model outputs for plant species were used in the assessment process (Thuiller, 2004; Thuiller *et al.*, 2005). The chosen models identify the climate space available to species in the 2050s and 2080s and project changes to their potential distribution. Model outputs show only where suitable climatic conditions for a particular species could exist under a range of climate change scenarios from the HadCM3 General Circulation Model (A1, A2, B1 and B2 emission scenarios). The ability of a species to take advantage of potential suitable climate space will depend on a range of factors, including the availability of suitable habitat and the dispersal ability of the species in question (Berry *et al.*, 2007).

Eight forest habitats were selected to demonstrate the applicability of the methodology in the assessment of impact and then vulnerability. The selection of exemplar habitats was determined by the availability of data for characteristic species from the bioclimatic envelope models (data are not available for all characteristic plant species occurring within Natura 2000 habitats). Based on data being available for a representative number of characteristic species, the following habitats were chosen:

- Western Taiga
- Bog woodland
- Pannonic woods with *Quercus petraea* and *Carpinus betulus*
- Euro-Siberian steppic woods with *Quercus spp.*
- Ilyrian *Fagus sylvatica* forests (*Aremonio-Fagion*)
- Acidophilous *Picea* forests of the montane to alpine levels (*Vaccinio-Piceetea*)
- Alpine *Larix decidua* and/or *Pinus cembra* forests
- Subalpine and montane *Pinus uncinata* forests.

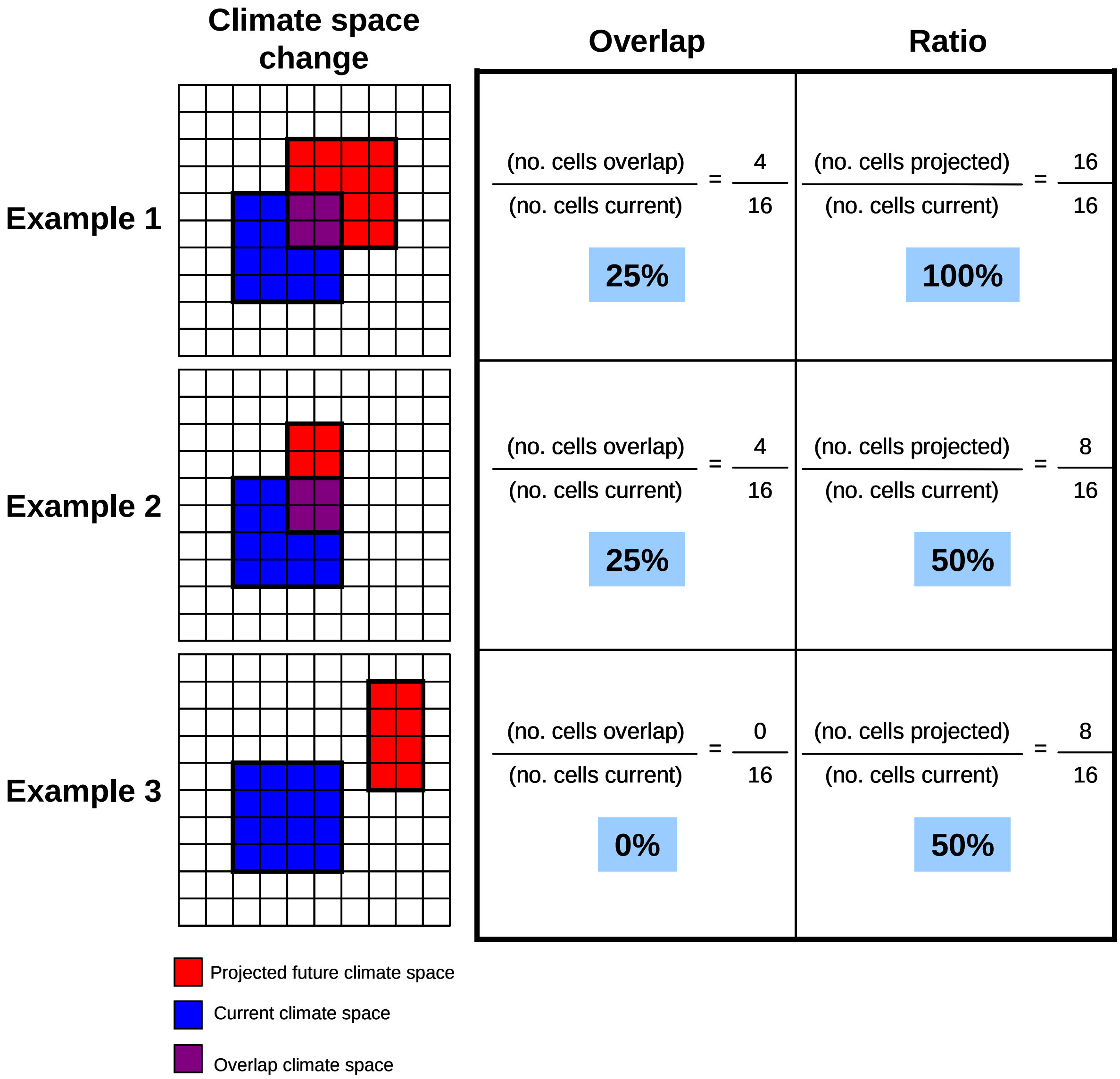
Measures of sensitivity were based on changes in potential suitable climate space. This is described by two metrics:

1. 'Overlap' is calculated as the number of grid cells within the intersection between the projected and simulated recent ranges divided by the number of squares in the simulated recent range (Figure). This metric is expressed as a percentage where 100% overlap indicates that all current climate space is covered by the projected future climate space. An overlap of 0% indicates that none of the current climate space is contained within the projected future climate space of that species.

2. 'Ratio' is calculated as the number of grid cells in the projected future range divided by the number in the simulated recent range. While this metric is difficult to depict graphically, it describes the relative change in total suitable climatic space. This metric is also expressed as a percentage where values less than 100% indicate a decrease in total suitable climatic space. Values greater than 100% suggest an expansion of total suitable climatic space.

Both climate sensitivity metrics are important. A projected reduction in suitable climate space (i.e. a low ratio) suggests that a reduction in range is likely (at least to some extent). A projected low overlap between current and future modelled climate space suggests that the species will need to move to new areas of suitable climate to maintain the total area of their range. Although some species can move in response to climate change, many may be limited by dispersal and colonisation constraints (e.g. limited dispersal abilities, physical barriers to movement, low levels of breeding productivity, or lack of suitable habitat). Suitable habitat may develop in some areas, whereas other areas may be incompatible due to geological or hydrological conditions, or prevailing land uses. Moreover, the community composition of many habitats is unlikely to remain intact or be replicated, but will change because their constituent species will be impacted to varying degrees by climate change.

Figure 2: Overlap and ratio calculations for exemplar changes in climate space



Impact categories

Sensitivity values based on overlap and ratio metrics were used to define impact categories for overlap and ratio (Table 2). The aggregated overlap and ratio metrics obtained for the proxy species representative of each exemplar habitat were assessed against these threshold values to assign an impact category to that habitat.

Table 2: Impact categories based on sensitivity values for overlap and ratio (e.g. for a ratio value of <30% (a small ratio), the impact category is 'very high')

	Overlap and ratio sensitivity values defining the impact category				
	<30%	**30-50%**	**50-70%**	**70-100%**	**>100%**
Overlap **Impact category**	Very high	High	Moderate	Low	NA*
Ratio **Impact category**	Very high (< in climate space)	High (< in climate space)	Moderate (< in climate space)	Low (< in climate space)	> in climate space

*It is not possible to obtain an overlap of greater than 100%

As an example, Table 3 shows the aggregated overlap and ratio metrics (sensitivity) for the proxy species of the habitat 'Subalpine and montane *Pinus uncinata* forests' under four SRES scenarios (exposure) for the 2050s and 2080s.The A1 SRES/2080 scenario shows the greatest reduction in overlap (rated 'high'), suggesting that projected future climate space will share only a small portion of current climate space. The A1 scenario often produces the most significant changes in climate and is expected to have the most dramatic impacts on potential suitable climate space (although this is not always the case). In contrast, under all other scenarios, the overlap impact category is 'moderate' or 'low'. The ratio impact category does not vary (rated 'low - decline'), suggesting that that suitable climate space for this habitat is likely to shrink in the future.

Table 3: Impact assessment for the habitat 'Subalpine and Montane *Pinus uncinata* forests

Time horizon	SRES Scenario	Overlap	Overlap impact category	Ratio	Ratio impact category
2050	A1	69.3%	Moderate	88.2%	Low - decline
2050	A2	71.6%	Low	89.7%	Low - decline
2050	B1	70.7%	Low	89.4%	Low - decline
2050	B2	70.5%	Low	88.8%	Low - decline
2080	A1	45.1%	High	76.3%	Low - decline
2080	A2	55.6%	Moderate	81.5%	Low - decline
2080	B1	61.4%	Moderate	83.8%	Low - decline
2080	B2	59.8%	Moderate	89.4%	Low - decline

4. Vulnerability assessment framework

Adaptive capacity traits

In order to assess the vulnerability of species or habitats to climate change, impact assessment outputs were plotted against a metric for adaptive capacity. As information on the ability of species and habitats to adapt to climate change is not widely available, proxy measures for identifying and scoring key ecological parameters which influence adaptive capacity are required. The EC project *Biodiversity and climate change in relation to the Natura 2000 network* (EC, 2009 *Task 2a report*) used parameters relating to the distribution, population size and trend, and dispersal ability of species that constrained their adaptive capacity, including:

- Small population and/or range in Europe
- Low survival and/or productivity rates
- Long generation times
- Declining population in Europe
- Low genetic diversity
- Specialised and uncommon habitat requirements
- Narrow niche
- Critical association with another vulnerable species.

However, there were insufficient data to carry out adaptive capacity assessments for all species (and their respective habitats) in this study. Instead, data available from the EU Article 17 database (EIONET, 2010) - which provides an EU-wide assessment of the conservation status of habitats and species at Natura 2000 sites - were used to 'illustrate' the process. The outcomes of the Article 17 assessments are presented in one of four categories: 'favourable', 'unfavourable inadequate', 'unfavourable bad' or 'unknown'. Adaptive capacity constraints ('low', 'medium', 'high') were aligned with each of these categories - whilst recognising that the conservation status of a habitat is very often determined by other sources of stress and harm that have nothing to do with the capacity of that habitat to adapt to climate change. Habitats assessed as 'unknown' were considered alongside those in the 'unfavourable bad' category to account for uncertainty and ensure that vulnerability was not under-estimated. Table 4 shows the condition assessment categories, related adaptive capacity constraints and constraint descriptions used here.

Table 4: Adaptive capacity constraints based on Article 17 data

Article 17 assessment category	Adaptive capacity constraint	Description
Unfavourable bad Unknown*	High	High level of constraint on adaptive capacity (i.e. habitat is limited in the extent to which it can adapt to changing climatic conditions)
Unfavourable inadequate	Medium	Medium level of constraint on adaptive capacity (i.e. habitat is partially limited in the extent to which it can adapt to changing climatic conditions)
Favourable	Low	Low level of constraint on adaptive capacity (i.e. habitat is able to adapt fairly easily to changing climatic conditions)

* Habitats categorised as 'unknown' were placed in this category to account for uncertainty and ensure that vulnerability was not under-estimated

The adaptive capacity constraints for each of the exemplar habitats in the study were assessed using the described methodology (Table 5).

Table 5: Adaptive capacity constraints for the eight exemplar habitats

Habitat	Article 17 assessment category	Adaptive capacity constraint
Western Taiga	Unfavourable bad	High
Acidophilous *Picea* forests of the montane to alpine levels (*Vaccinio-Piceetea*)	Unfavourable inadequate	Medium
Alpine *Larix decidua* and/or *Pinus cembra* forests	Unfavourable inadequate	Medium
Subalpine and montane *Pinus uncinata* forests	–Unknown (unfavourable bad)	(High)
Bog woodland	Unfavourable inadequate	Medium
Pannonic woods with *Quercus petraea* and *Carpinus betulus*	Favourable	Low
Euro-Siberian steppic woods with *Quercus spp*.	Favourable	Low
Illyrian *Fagus sylvatica* forests (*Aremonio-Fagion*)	Favourable	Low

Vulnerability categories

The vulnerability categories used in the assessment process were defined by combining the climate impact category with the adaptive capacity constraint for each habitat (Table 6). The categories are similar to those used in the EC project *Biodiversity and climate change in relation to the Natura 2000 network* (EC, 2009 *Task 2a report*). Worst case impact scores (overlap in climate space or ratio of climate space) were used to capture uncertainties and data limitations. Projected increases in climate space are positive climate impact factors and, therefore, were not considered further in the vulnerability assessment.

Table 6: Vulnerability categories used in the assessment process

	Climate impact category			
Adaptive capacity constraint	**Low**	**Moderate**	**High**	**Very high**
High	High	Very high	Critical	Extremely critical
Medium	Moderate	High	Very high	Critical
Low	Low	Moderate	High	Very high

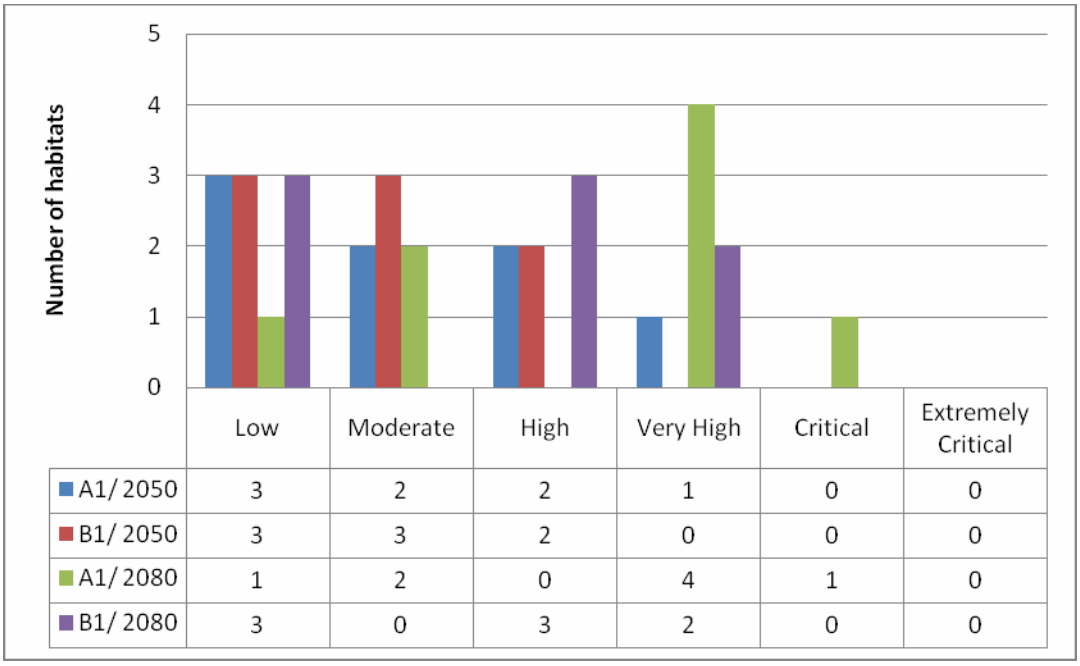
5. Results

The vulnerability of eight Natura 2000 habitats was assessed under two 'high' and 'low' emissions scenarios (SRES A1 and B1) for two time horizons (2050s and 2080s). Full details of the assessment results are given in Annex 1; these are summarised in Table 7 and Figure 3 (below).

Table 7: Summary of vulnerability scores for the eight habitats assessed under the A1 and B1 SRES scenarios for the 2050s and 2080s

	2050s		2080s	
Habitat type	**A1**	**B1**	**A1**	**B1**
Western Taiga	High	High	Very high	Very high
Bog woodland	High	Moderate	Very high	High
Pannonic woods with *Quercus petraea* and *Carpinus betulus*	Low	Low	Moderate	Low
Euro-Siberian steppic woods with *Quercus spp.*	Low	Low	Low	Low
Illyrian *Fagus sylvatica* forests (*Aremonio-Fagion*)	Low	Low	Moderate	Low
Acidophilous *Picea* forests of the montane to alpine levels (*Vaccinio-Piceetea*)	Moderate	Moderate	Very high	High
Alpine *Larix decidua* and/or *Pinus cembra* forests	Moderate	Moderate	Very high	High
Subalpine and montane *Pinus uncinata* forests	Very high	High	Critical	Very high

Figure 3: Vulnerability scores ranked according to SRES scenario and time horizon



Seven of the eight habitats showed an increase in vulnerability from the 2050s to the 2080s under the A1 scenario. The exception was 'Euro-Siberian steppic woods with *Quercus spp.*', which seemed to be largely unaffected by climate change, with vulnerability remaining 'low' under both scenarios. Under the B1 scenario, an additional two habitats ('Pannonic woods with *Quercus petraea* and *Carpinus betulus*' and 'Illyrian *Fagus sylvatica* forests (*Aremonio-*

Fagion)') also appear to be largely unaffected and retain a 'low' level of vulnerability. This suggests that these habitats could be more resilient to climate change overall.

A comparison of the vulnerability scores for the two emissions scenarios in the 2050s with those for the 2080s highlighted some interesting trends. In the 2050, only two habitats are likely to be more vulnerable under the higher A1 scenario ('Bog woodland', and 'Subalpine and montane *Pinus uncinata* forests'), while in the 2080, six habitats are likely to be more vulnerable. This is broadly in line with what would be expected: vulnerability is likely be higher under the A1 scenario due to the magnitude of the projected climate change. The apparent increase in vulnerability between the two time horizons could be attributed to the increasing difference in the magnitude of exposure.

6. Discussion

This study builds on the vulnerability assessment methodology developed for the EC project *Biodiversity and climate change in relation to the Natura 2000 network* (EC, 2009 Task 2a report). Task 2a (*An assessment framework for climate change vulnerability: methodology and results*) established a semi-quantitative methodology for assessing the vulnerability of species to climate change. In this study, the methodology was developed and evaluated to establish its suitability as a tool for assessing the vulnerability of habitats. The assessment framework uses metrics for climate change impact and adaptation potential to determine vulnerability. Whilst the metrics used in the impact assessment process were applicable to both species and habitats, the trait-based adaptation metrics used in species' vulnerability assessments could not be applied to habitats. Proxy data for adaptation potential were, therefore, necessary. These were considered alongside impact assessment outputs to give a measure of habitat vulnerability - on a six point scale, ranging from 'low' to 'extremely critical'. The results presented here demonstrate the application of the 'modified' assessment methodology to eight exemplar Natura 2000 habitats. Whilst the application of the approach was far from comprehensive, the initial results suggest that, if the assessment methodology was to be applied to all Natura 2000 habitats and the results subjected to rigorous interpretation (e.g. Why are alpine habitats and habitats with specialised requirements, such as 'Bog woodland', facing higher vulnerability than pannonian or continental habitats?), the outputs could be used to determine priorities for conservation/adaptation action throughout the Natura 2000 network.

The wider application of the vulnerability assessment methodology will depend on the availability of required input data. The scope of this study was limited by a lack of available data. The eight exemplar habitats were selected because the sensitivity data required for the impact assessments was available from niche modelling studies of characteristic species. Further modelling of characteristic species or other reliable sensitivity data is required in order to extend the approach to other Natura 2000 habitats. Data on the adaptive capacity or constraints on the adaptive capacity of habitats, required for the vulnerability assessments, are not available. Proxy data were obtained from the EU Article 17 database (EIONET, 2010). The database provides condition assessments for most Natura 2000 habitats, which was considered to be an acceptable 'illustrative' proxy for the purpose of this study. However, more robust data on adaptive capacity, and the relationships between adaptation constraints and adaptation responses, is clearly required to inform the vulnerability assessment process. This could include detailed exploration of habitat traits or of the combined traits of representative species.

With the required improvements in data availability and reliability, the resulting vulnerability assessments will provide valuable indicative sign-posts as to where conservation effort should be focused. It must be emphasised, however, that the outputs should not be considered as 'conclusive' evidence of habitat vulnerability. Uncertainties and limitations inevitably surround the exposure and sensitivity data used in the impact assessments. There are inherent uncertainties in the climate models used to determine exposure, as the underlying climate variables can only provide an approximation of the changes likely to be experienced. It is also unclear how sensitivity of individual species will affect entire habitats. Each will respond differently to climate stimuli in terms of dispersal, population size etc, and there could be interactions which influence impact that cannot be identified in the assessment.

In conclusion, the methodological framework allows the vulnerability of Natura 2000 habitats to be assessed with relative ease. However, its wider use requires significant increases in available data on the sensitivity of representative species and the adaptive capacity of habitats. Its outputs, whilst scientifically robust, should not be considered as conclusive, but indicative of where conservation action should be focussed.

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Annexes

Annex 1: Full details of impact and vulnerability assessment results

Annex 1: Full details of impact and vulnerability assessment results

Assessment type	Impact assessment							Vulnerability assessment	
Degree of	Exposure		Sensitivity					Adaptive capacity	Vulnerability
Habitat type	Time horizon	Exposure	Overlap	Category	Ratio	Category	Worst impact category	Adaptive capacity constraint category	Vulnerability category
Western Taiga	2050	A1	73.60%	Low	83.70%	Low	Low	High	**High**
Western Taiga	2050	B1	75.00%	Low	84.50%	Low	Low	High	**High**
Bog woodland	2050	A1	69.50%	Moderate	80.50%	Low	Moderate	Medium	**High**
Bog woodland	2050	B1	70.90%	Low	81.40%	Low	Low	Medium	**Moderate**
Pannonic woods with *Quercus petraea* and *Carpinus betulus*	2050	A1	87.00%	Low	130.10%	Moderate increase	Low	Low	**Low**
Pannonic woods with *Quercus petraea* and *Carpinus betulus*	2050	B1	84.80%	Low	121.70%	Low increase	Low	Low	**Low**
Euro-Siberian steppic woods with *Quercus spp.*	2050	A1	90.40%	Low	143.60%	Moderate increase	Low	Low	**Low**
Euro-Siberian steppic woods with *Quercus spp.*	2050	B1	90.20%	Low	133.30%	Moderate increase	Low	Low	**Low**
Illyrian *Fagus sylvatica* forests (*Aremonio-Fagion*)	2050	A1	81.70%	Low	117.30%	Low increase	low	Low	**Low**
Illyrian *Fagus sylvatica* forests (*Aremonio-Fagion*)	2050	B1	82.40%	Low	116.00%	Low increase	Low	Low	**Low**

Assessment type	Impact assessment							Vulnerability assessment	
Degree of	Exposure		Sensitivity					Adaptive capacity	Vulnerability
Habitat type	Time horizon	Exposure	Overlap	Category	Ratio	Category	Worst impact category	Adaptive capacity constraint category	Vulnerability category
Acidophilous *Picea* forests of the montane to alpine levels (*Vaccinio-Piceetea*)	2050	A1	70.10%	Low	86.30%	Low	Low	Medium	**Moderate**
Acidophilous *Picea* forests of the montane to alpine levels (*Vaccinio-Piceetea*)	2050	B1	73.00%	Low	88.80%	Low	Low	Medium	**Moderate**
Alpine *Larix decidua* and/or *Pinus cembra* forests	2050	A1	70.20%	Low	87.00%	Low	Low	Medium	**Moderate**
Alpine *Larix decidua* and/or *Pinus cembra* forests	2050	B1	70.70%	Low	87.30%	Low	low	Medium	**Moderate**
Subalpine and montane *Pinus uncinata* forests	2050	A1	69.30%	Moderate	88.20%	Low	Moderate	High	**Very high**
Subalpine and montane *Pinus uncinata*	2050	B1	70.70%	Low	89.40%	Low	Low	High	**High**
Western Taiga	2080	A1	51.90%	Moderate	64.40%	Moderate	Moderate	High	**Very high**
Western Taiga	2080	B1	66.20%	Moderate	75.30%	Low	Moderate	High	**Very high**
Bog woodland	2080	A1	44.60%	High	59.40%	Moderate	High	Medium	**Very high**
Bog woodland	2080	B1	60.70%	Moderate	71.40%	Low	Moderate	Medium	**High**

Assessment type	Impact assessment							Vulnerability assessment	
Degree of	Exposure		Sensitivity					Adaptive capacity	Vulnerability
Habitat type	Time horizon	Exposure	Overlap	Category	Ratio	Category	Worst impact category	Adaptive capacity constraint category	Vulnerability category
Pannonic woods with ***Quercus petraea*** and ***Carpinus betulus***	2080	A1	68.20%	Moderate	152.60%	High increase	Moderate	Low	**Moderate**
Pannonic woods with ***Quercus petraea*** and ***Carpinus betulus***	2080	B1	77.30%	Low	131.50%	Moderate increase	Low	Low	**Low**
Euro-Siberian steppic woods with ***Quercus spp.***	2080	A1	81.90%	Low	193.80%	Very high increase	Low	Low	**Low**
Euro-Siberian steppic woods with ***Quercus spp.***	2080	B1	88.00%	Low	155.40%	High increase	Low	Low	**Low**
Illyrian ***Fagus sylvatica*** forests (***Aremonio-Fagion***)	2080	A1	61.80%	Moderate	135.80%	Moderate increase	Moderate	Low	**Moderate**
Illyrian ***Fagus sylvatica*** forests (***Aremonio-Fagion***)	2080	B1	72.60%	Low	118.80%	Low increase	Low	Low	**Low**
Acidophilous ***Picea*** forests of the montane to alpine levels (***Vaccinio-Piceetea***)	2080	A1	48.90%	High	73.60%	Low	High	Medium	**Very high**

Assessment type	**Impact assessment**							**Vulnerability assessment**	
Degree of	**Exposure**		**Sensitivity**					**Adaptive capacity**	**Vulnerability**
Habitat type	**Time horizon**	**Exposure**	**Overlap**	**Category**	**Ratio**	**Category**	**Worst impact category**	**Adaptive capacity constraint category**	**Vulnerability category**
Acidophilous *Picea* forests of the montane to alpine levels (*Vaccinio-Piceetea*)	2080	B1	65.30%	Moderate	84.60%	Low	Moderate	Medium	**High**
Alpine *Larix decidua* and/or *Pinus cembra* forests	2080	A1	45.80%	High	74.80%	Low	High	Medium	**Very hgh**
***Alpine Larix decidua* and/or *Pinus cembra* forests**	2080	B1	61.60%	Moderate	81.10%	Low	Moderate	Medium	**High**
Subalpine and montane *Pinus uncinata* forests	2080	A1	45.10%	High	76.30%	Low	High	High	**Critical**
Subalpine and montane *Pinus uncinata* forests	2080	B1	61.40%	Moderate	83.80%	Low	Moderate	High	**Very high**