The EU Habitats Directive and the German Natura 2000 Network of Protected Areas as Tool for Implementing the Conservation of Relict Species

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Abstract This study analyses whether the Natura 2000 network of Sites of Community Importance (SCIs) is able to protect relict species in the taxonomic groups of higher plants, molluscs, dragonflies and damselflies as well as butterflies (only Rhopalocera) in Germany. Altogether, a total of 157 species from all groups are identified as relict species in Germany. Fourteen of these are included in Annexes II, IV or V of the Habitats Directive.

Most glacial relicts are well covered by an indirect protection regime of the European Union (EU) Habitats Directive as they occur in 46 of Annex I habitat types, and their occurrences are to a large extent covered by Natura 2000 sites (SCIs). For a few relict species and certain relict plant communities a gap remains in the EU protection regime, which can be filled by a national protection regime, for example, in nature reserves. The best way to protect local relict species is to include them in special management plans for their conservation.

1 Introduction

The protection of relict species is a prominent goal in nature conservation (Soulé 1986; Ås et al. 1992). These are taxa with only small recent occurrences and which now show only isolated distribution remaining from a once wider distribution.

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There may be very different reasons for their decline in the past. The species may be a relict of former stages of historical vegetation and landscape development resulting from past climate changes (glacial and post-glacial periods). Very often, the anthropogenic effects of cultural landscape development interfere or overlap with this, resulting in additional reduction of the distribution area, the density or fragmentation of patches or the population itself.

The scope of this paper is to focus mainly on the first category of relict species (which have developed mainly as a result of natural changes in abiotic conditions), as anthropogenic fragmentation and isolation has accelerated in recent decades and is at least partly documented in Red Data Books.

Most present-day relict species were widely distributed during the last glacial period, when their ecological requirements were well fulfilled; relict species with this type of distribution pattern are called climatic relicts or glacial relicts (e.g. Cox and Moore 2006).Today, these species are not well adapted to the prevailing climate conditions and are thus often very rare and localized, with the result that their occurrences are generally well documented. A prominent example of such glacial relict species is the dwarf birch (*Betula nana*) in bogs and fens in Germany. After the last glacial period, conditions were good for *B. nana* because cold-steppe vegetation covered the entire Central European landscape. Temperature increase resulted in more and more suboptimal conditions for *B. nana*, because other herbs and trees were more competitive and better adapted to the new conditions. *B. nana* was able to survive only in regions with low temperatures and low nutrient input where competition was reduced. Most glacial relicts, both plants and animals, follow this general pattern (Varga 1977). Often these species show arctic-alpine or boreo-alpine distribution patterns and are nowadays widely distributed in Northern Europe and/or remain isolated in cold areas such as the highest mountain regions or peatlands.

Thermophilic relicts represent a second type of relict species. These are the relicts from once warmer times during the Atlantic period, when thermophilic species were well adapted to warm and dry conditions. During this time, these species were widely distributed, but they later became isolated and restricted to favourable habitats due to colder temperatures and an increase of rainfall. A good example of a thermophilic relict is the Heath Bush-cricket *Gampsocleis glabra* in heathland in Northern Germany. In warm and dry years, Mediterranean species were able to expand to the North. When climate changes resulted in lower temperatures, these species were able to survive only in exposed habitats where higher temperatures are usually reached more quickly. This is often the case in stony and dry biotopes like dunes or rocks on Southern slopes. Areas with thermophilic relicts may often be found in the rain shadow of mountain ranges.

The goal of nature conservation is to conserve all these different types of relict species in their natural habitats as a witness of the natural conditions and developments in the past. Often it is quite clear that these species are not able to expand their ranges because current conditions are bad for them. In these often small populations with no contact to neighbour populations, evolution means that speciation and adaptation occur. This makes such populations very interesting objects of evolutionary research.

We have a responsibility to protect these species and their isolated populations. It is an important policy target to conserve a species' entire gene pool (BMU 2007; BFN 2008; Gruttke et al. 2004). The German government pointed out in its national strategy for biological diversity (BMU 2007) that the entire gene pool of species and populations has to be conserved, e.g. populations with local adaptations to regional microclimatic conditions. Fragmented populations often show significant changes in their character states, so if populations are separated for a long period from each other (several 1,000 years) with an interruption of gene flow, gene drift can mean that these populations change character states. The concept of Evolutionary Significant Units (ESUs) takes into consideration that such populations are on their way to an evolutionary unit of their own, leading to a different taxonomic status (Moritz 1994). For Germany, Gruttke et al. (2004) give a summary of current knowledge on this modern field of conservation biology, where glacial relicts are an important topic.

Nature conservation often means nature management. This involves the question of how relict species can be best protected. Since 1992, there has been an established, important and modern concept in nature conservation: The implementation of the EC Habitats Directive. The main goal of this Directive is to establish a network of Sites of Community Importance (SCI) for species listed in Annex II of the Directive. In Germany there are three biogeographic regions: Atlantic, Continental and Alpine (for further details see Balzer et al. 2008).One hundred and thirty-three plant and animal species as well as 91 habitat types are listed in Annexes II and I of the Habitats Directive, respectively. In Germany, a total of 4,622 SCI have been integrated into the EU network of protected areas "Natura 2000" for these species and habitat types. SCIs in Germany cover a terrestrial area of 3,313,083 ha equalling 9.3% of the territory. No scientific analysis has been performed to date to determine whether relict species are represented in the Natura 2000 network of protected sites in Germany. The current work gives an overview of whether, how and to what extent relict species are conserved by the EC Habitats Directive.

2 Method

A data analysis was carried out to determine whether the EU Habitats Directive provides sufficient protection for relict species in taxa of higher plants, molluscs, dragonflies and damselflies, and butterflies (Rhopalocera only) in Germany. For this purpose a database, containing for the most part glacial relict species, was set up based on studies by CLECOM (2002), De Lattin (1967), Holdhaus (1954), Kudrna (2002), Thorn (1960), Reisch (2001), Welk (2001) and Buchholz and Welk (2005). This database was modified for plants: i.e. *Gentiana clusii* was not accepted as a glacial relict species (populations in the Black Forest) as proposed by Thorn (1960) and Reisch (2001), because the species is not autochthonous there (Oberdorfer 1990). On the other hand, the database does not claim to be exhaustive for all potential glacial relicts with occurrences in Germany. Species on the edge of

their distribution area and endemics (other than relicts) in Germany were not included in the data analysis. Assessment was carried out on two levels:

1. Direct species protection was checked, i.e. whether the species is covered by Annex II (site protection within Natura 2000), Annex IV (strict species protection) or Annex V (limited protection of used or managed plants) of the Habitats Directive.
2. Protection of the habitat of the relict species was checked, i.e. whether the species is indirectly protected by the Natura 2000 sites: This can be assumed if the habitat of the species corresponds to a protected Annex I habitat type. We also assessed whether the occurrences of these glacial relicts are really covered by existing SCI and do not by chance lie outside the Natura 2000 network.

3 Results and Discussion

3.1 Glacial Relicts in Higher Plants and Their Protection by the Habitats Directive

In total, 100 plant species were identified as glacial relics in Germany (excluding *Rubus fruticosus* agg.). Most of the glacial relicts in higher plants belong to the alpine, pre-alpine or arctic-alpine distribution types (Table 1). Species that occur in Germany only in the Alps as part of their main distribution area but have relict populations outside of Germany only were not considered (six species, e.g. *Sibbaldia procumbens* in the Vosges or *Moehringia muscosa* in the Bohemian Forest). Six species are already extinct or presumed extinct in Germany, and another two species are extinct or presumed extinct in the isolated parts of their former natural distribution area outside the Alps (and the Alpine foreland), where relict populations remained until the last century (e.g. *Selaginella helvetica* formerly in the Thuringian Forest). A few other species are extinct in one or more discrete

Table 1 Distribution of the glacial relicts of higher plants in Germany according to www.floraweb.de

Area type	Number of species	Examples in Germany
Arctic-alpine	19	*Carex vaginata, Epilobium alsinifolium, Saxifraga stellaris*
Arctic (5), arctic-North (3), North (3), North-continental (1), North-prealpine (1)	13	*Carex paupercula, Pedicularis sceptrum-carolinum, Rubus chamaemorus*
Central Europe (2), central Europe-endemic (1)	3	*Pulsatilla alpina* ssp. *alba*, *Salix bicolor, Saxifraga oppositifolia* ssp. *amphibia*
Alpine	40	*Adenostyles alliariae, Carex sempervirens, Kernera saxatilis*
Prealpine	25	*Anthriscus nitidus, Homogyne alpina, Soldanella montana*
Total	100	–

Table 2 Relict plant species in Germany listed in the Habitats Directive

Species	Habitats Directive	Conservation status (National Report Art. 17, Hab. Dir.; Nationaler Bericht 2007) Biogeographic region		
	Annex	Atlantic	Continental	Alpine
Marsh saxifrage *Saxifraga hirculus*	II, IV	Extinct in Germany		
Yellow gentian *Gentiana lutea*	V	–	Favourable	Favourable
Alpine clubmoss *Diphasiastrum alpinum*	V	–	Unfavourable - inadequate	Favourable
Myosotis rehsteineri	II, IV	–	Unfavourable - bad	–

parts of their former natural distribution area (e.g. *Gnaphalium norvegicum* in the Erzgebirge), but they still have recent relict populations in other parts of their distribution area in Germany. The 92 species that currently exist in relict populations in Germany were analysed in detail.

Direct protection by species annexes of the Habitats Directive is/was given only for four species (Table 2). This includes *Myosotis rehsteineri*, which is a glacial relict species according to Brackel (2001), but is not mentioned by the authors listed in the Methods section above. The species occurs at larger lakes at the Northwestern and Southern edges of the Alps and is classified as endemic in this region. Because the species is listed in Annexes II and IV of the Habitats Directive, we considered it in Table 2. *Saxifraga hirculus* is listed in Annex II; however, it is presumed extinct in its last known German locality in the Murnauer Moos, where Natura 2000 "came too late." No other glacial relict is listed in Annex IV, and only two species (*Gentiana lutea* and *Diphasiastrum alpinum*) are covered by Annex V. Thus, the Habitats Directive affords very little direct species protection of relict species.

Table 3 shows the extent of indirect protection afforded by Annex I habitat types.

Only three glacial relicts (*Carex brunnescens*, *Epilobium alsinifolium* and *E. nutans*) grow outside Annex I habitat types and could not be attributed to one or more habitat types. These species are definitely not protected by the Habitats Directive.

As expected, the main occurrence of glacial relicts is concentrated on a few Annex I habitat types, which serve as refuges. These are hydrophilous tall herb fringe communities (Habitat type 6430), especially in their montane to subalpine subtypes of the class Betulo-Adenostyletea, which host 26 glacial relicts (28.3%); alpine and subalpine calcareous grasslands (habitat type 6170) which host 15 species (16.3%); calcareous rocky slopes with their chasmophytic vegetation (habitat type 8210) with 13 species (14.1%); and the calcareous and calcshist screes of the montane to alpine level (habitat type 8120) which host nine species (9.8%). On siliceous substrates, the situation is similar, with the siliceous alpine and boreal grasslands (habitat type 6150) hosting 20 glacial relicts (21.7%) and the species-rich *Nardus* grasslands in mountain areas (habitat type 6230) hosting 16 glacial relicts (17.4%). All these habitat types have in common the fact that during glacial

Table 3 Coverage of relict species by Annex I habitat types (data base 92 glacial relict species)

Formation/group of habitat types	Number of species per habitat group	Annex I habitatcode	Habitat type	Number of species per habitat type	in %
Freshwater habitats	6	3220	Alpine rivers and the herbaceous vegetation along their banks	5	5.4
Heath and scrub formations	12	4060	Alpine and boreal heaths	5	5.4
		4070	Bushes with *Pinus mugo* and *Rhododendron hirsutum* (Mugo-Rhododendretum hirsuti)	8	8.7
Grassland and tall herb communities	65	6150	Siliceous alpine and boreal grasslands	20	21.7
		6170	Alpine and subalpine calcareous grasslands	15	16.3
		6210	Semi-natural dry grasslands and scrubland facies on calcareous substrates (Festuco-Brometalia)	6	6.5
		*6230	Species-rich *Nardus* grasslands, on silicious substrates in mountain areas (and submountain areas in Continental Europe)	16	17.4
		6410	Molinia meadows on calcareous, peaty or clayey-silt-laden soils (Molinion caeruleae)	3	3.3
		6430	Hydrophilous tall herb fringe communities of plains and of the montane to alpine levels	26	28.3
		6520	Mountain hay meadows	7	7.6
Bogs, transition mires and fens	16	*7110	Active raised bogs	5	5.4
		7120	Degraded raised bogs still capable of natural regeneration	3	3.3
		7140	Transition mires and quaking bogs	7	7.6
		7150	Depressions on peat substrates of the Rhynchosporion	1	1.1
		*7220	Petrifying springs with tufa formation (Cratoneurion)	4	4.3
		7230	Alkaline fens	6	6.5

(*continued*)

Table 3 (continued)

Formation/group of habitat types	Number of species per habitat group	Annex I habitatcode	Habitat type	Number of species per habitat type	in %
Rock and scree habitats	24	8110	Siliceous scree of the mountains to snow levels (Androsacetalia alpinae and Galeopsietalia ladani)	2	2.2
		8120	Calcareous and calcshist screes of the montane to alpine levels (Thlaspietea rotundifolii)	9	9.8
		8150	Medio-European upland siliceous screes	1	1.1
		*8160	Medio-European calcareous scree of hill and montane levels	1	1.1
		8210	Calcareous rocky slopes with chasmophytic vegetation	13	14.1
		8220	Siliceous rocky slopes with chasmophytic vegetation	6	6.5
		8230	Siliceous rock with pioneer vegetation of the Sedo-Scleranthion or of the Sedo albi-Veronicion dillenii	2	2.2
Forests	9	9140	Medio-European subalpine beech woods with *Acer* and *Rumex arifolius*	5	5.4
		*91D0	Bog woodland	2	2.2
		*91E0	Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (Alno-Padion, Alnion incanae, Salicion albae)	1	1.1
		9410	Acidophilous Picea forests of the montane to alpine levels (Vaccinio-Piceetea)	5	5.4

Double entries of glacial relicts occurring in more than one habitat types of Annex I are possible.
*indicates priority habitat type

and post-glacial times they had a wider distribution between the two main European ice shields in the North and in the Alps. This distribution then slowly diminished and became fragmented during the post-glacial warming-up. This development was aggravated and accelerated by anthropogenic influence which resulted in further

fragmentation and extinction in some of the refuges in the lower mountain ranges (e.g. Dörr 2000[1]). As the formations of mountain grasslands, tall herbs, rocky habitats and screes and, to a lesser degree, bogs are rich in glacial relicts and at the same time well represented in Annex I of the Habitats Directive, most of the species theoretically enjoy good indirect protection by the EU nature Directives. As this protection regime is valid only within accepted SCIs of the Natura 2000 network, it was necessary to verify coverage of the occurrences of glacial relicts in SCIs in order to assess the real protection regime. As not every occurrence could be checked individually, the results were classed in four different groups:

(a) Occurrences (almost) completely within SCIs: 43 plant species
(b) Sufficiently represented in SCIs, with a minor proportion of the occurrences outside: 47 species
(c) Unclear, precise verification not possible: 1 species (*Salix myrtilloides*)
(d) Not covered by SCIs: 1 species (*Minuartia stricta*).

Category (b) includes at least seven species, which are probably not or not sufficiently covered in every part of their fragmented occurences, but the species are not in danger of extinction in Germany (e.g. *Hieracium bupleuroides* in the Franconian Alb). Furthermore, three species occur within Natura 2000 without, however, belonging to an Annex I habitat type, so they might not benefit from the EU protection regime.

Not only plant species but also whole plant communities (syntaxa) can be glacial relicts. These communities also need special conservation attention, not only because they are likely to host a number of glacial relicts in their fauna which has not yet been well studied. Rock-crevice communities of *Asplenietea trichomanis* are especially rich in relict species or paleo-endemics, as has been shown for *Kernera saxatilis*, *Draba aoizoides* and *Saxifraga paniculata* in the Swabian Alb by Wilmanns and Rupp (1966) and Wilmanns (1993). Spring formations of the class Montia-Cardaminetea, vegetation of snow-beds (Salicetea herbacea) and fens of the Scheuchzerio-Caricetea nigrae also have relict associations with the higher mountain ranges in central and Southern Germany. Examples of this are the Bryo-Philonotidetum seriatae (acid subalpine springs rich in mosses and *Saxifraga* species) on the Feldberg above 1,300 m altitude (Black Forest) with the nearest occurrences to the Alps, as well as the Bartsio-Caricetum fusca and possibly the Caricetum frigidae. A typical example of snow bed communities is the Nardo-Gnaphalietum supini on the Feldberg. Good examples of glacial relict communities are the Nardus grasslands of the higher mountains such as Leontodonto-Nardetum in the Black Forest, a vicariant association of the Violo-Nardetum (with *Pulsatilla alba* and *Viola lutea*) in the Vosges, the Lycopodio-Nardetum in the Bavarian and Bohemian forest and, finally, the Pulsatillo-Nardetum on the Brocken in the Harz mountains. Today, the subalpine tall herb communities of the Betulo-Adenostyletea have a nordic-alpine distribution with relicts in the lower mountain ranges, such as the Alnetum viridis, the

[1] This article includes some species as glacial relicts which were not listed as glacial relict species by Thorn (1960) and/or Reisch (2000) and were not considered in our study.

Adenostylo-Cicerbitetum and the Salicetum appendiculatae in the Black Forest, and the tall grass vegetation of the Sorbo-Calamagrostietum arundinaceae in both the Black Forest and the Vosges. These relict populations are of outstanding scientific and conservation interest, as their primary stands host species which were the ancestors of many grassland species of our cultivated meadows. The associations of the fluvial gravel deposits of the Salicion eleagni such as the Salici-Myricarietum and the Salicetum eleagni with *Hippophae rhamnoides* ssp. *fluviatile* can also be regarded as relict vegetation, formerly widespread in the fluvioglacial plains of the ice ages. Some pine forests of the Erico-Pinion alliance, such as the Coronillo-Pinetum sylvestris, as a post-glacial relict of the warm period in the Swiss Jurassic (Richard 1972) and the Swabian Alb (Müller 1980) are examples of relict forests.

Of the relict syntaxa listed, most plant associations are covered by Annex I of the Habitats Directive, with two major exceptions: the acidic spring vegetation (Montio-Cardaminetea) and the Erico-Pinion relict pine forests. These merit special protection under national legislation in Germany, as long as they are not covered by the Habitats Directive.

3.2 Molluscs

A total of 342 species of non-marine molluscs were recorded from Germany in the CLECOM list (Falkner et al. 2001; CLECOM 2002) (the subterranean freshwater molluscs are not included here), of which 70 are freshwater and 236 terrestrial species. Twenty freshwater species are considered relicts (glacial or post-glacial isolated). The terrestrial molluscs are represented by 18 relicts.

The relict species include mountain molluscs as well as specialist species at low altitudes, for example in mires, fens and calcareous grasslands. Most relict populations suffer severely from bad environmental conditions. This situation has worsened in recent years because of an intensification of anthropogenic land use.

Table 4 Relict molluscs species in Germany listed in the Habitats Directive

Species	Habitats Directive	Conservation status (National Report Art. 17, Hab. Dir.; Nationaler Bericht 2007)		
		Biogeographic region		
	Annex	Atlantic	Continental	Alpine
Snail, *Theodoxus transversalis*	II, IV	–	Unknown	–
Little Whirlpool Ramshorn Snail, *Anisus vorticulus*	II, IV	Unfavourable - bad	Unfavourable - bad	–
Freshwater Pearl Mussel, *Margaritifera margaritifera*	II, V	Unfavourable - bad	Unfavourable - bad	–
Geyerѕ whorl snail, *Vertigo geyeri*	II	–	Unfavourable - bad	Unfavourable - inadequate
Round-mouthed whorl snail, *Vertigo genesii*	II	Not evaluated 2007 because thought to be extinct; found again in 2008		

In Annexes II, IV and V of the EU Habitats Directive, 5 of these 18 relicts were represented (*Theodoxus transversalis*, *Anisus vorticulus*, *Margaritifera margaritifera*, *Vertigo geyeri*, *V. genesii*), all of which are represented in the German Natura 2000 network (Table 4). The remaining 13 mollusc relicts mainly live in the following habitat types of Annex I of the Habitats Directive:

- 3110 oligotrophic waters containing very few minerals of sandy plains (Littorelletalia uniflorae)
- 3130 oligotrophic to mesotrophic standing waters with vegetation of the Littorelletea uniflorae and/or of the Isoeto-Nanojuncetea
- 3140 hard oligo-mesotrophic waters with benthic vegetation of *Chara* spp.
- 3150 natural euthrophic lakes with Magnopotamion or Hydrocharition-type vegetation
- 3260 water courses of plain to montane levels with Ranunculion fluitantis and Callitricho-Batrachion vegetation
- 6210 semi-natural dry grasslands and scrubland facies on calcareous substrates (Festuco Brometalia)
- *6240 sub-Pannonic steppe grassland
- 7140 transition mires and quaking bogs
- 7230 alkaline fens
- 8210 calcareous and calcshist screes of the montane to alpine levels (Thlaspietea rotundifolii)
- 9110 Luzulo-Fagetum beech forests
- 9130 Asperulo-Fagetum beech forests
- *9180 Tilio-Acerion forests of slopes, screes and ravines
- *91E0 alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (Alno-Padion, Alnion incanae, Salicion alvae)
- 9410 acidophilous Picea forests of the montane to alpine levels (Vaccinio-Piceetea)

This assortment of habitat types and the German Natura 2000 network protects most of the 38 relict species. Only six species which prefer the potamic region of large streams, and *Vertigo lilljeborgii*, a glacial relict of acid sedge beds, are only partly included in the network. Not only the relict species but also other associated species – such as their specialized predators – should be protected. For example, some local populations of the Pyrenean shell crusher beetle *Carabus pyrenaeus* are so highly adapted to their prey, the relict mollusc *Arianta xatarti*, that these populations already show differences in mandible form compared to populations in the Western Pyrenees (Assmann et al. 2000).

3.3 Dragonflies and Damselflies

Eighty-one dragonflies and damselflies are known to occur in Germany, and two of them are listed as extinct. Only 7 of the 81 species were recognized in this study as relict species (cf. Sternberg 1998). *Coenagrion hylas* is extinct in

Table 5 Relict dragonflies and damselflies species in Germany listed in the Habitats Directive

Species	Habitats Directive	Conservation Status (National Report Art. 17, Hab. Dir.; Nationaler Bericht 2007) Biogeographic region		
	Annex	Atlantic	Continental	Alpine
Damselfly, *Coenagrion hylas*	II	Extinct in Germany		
Siberian Winter Damselfly, *Sympecma paedisca*	IV	Unfavourable - bad	Unfavourable - inadequate	Unknown

Germany (one of the two extinct species in Germany), and five of the remaining six species are specialists of dystrophic habitats. Two species are listed in the Annexes of the Habitats Directive (Table 5). Most of the breeding habitats of these five species (*Nehalennia speciosa*, *Aeshna caerulea*, *A. subarctica*, *Somatochlora alpestris*, *S. arctica*) belong to the following habitat types of the Habitats Directive:

- 7110 active raised bogs
- 7120 degraded raised bogs still capable of natural regeneration
- 7140 transition mires and quaking bogs
- 3160 natural dystrophic lakes and ponds.

Although many of the populations and habitats of the relict species are protected by the network of Natura 2000, their conservation status is not good. The main reason is the unfavourable conservation status of their habitat types. In the Atlantic and the Continental biogeographic regions, all four habitat types are considered to have an unfavourable conservation status. Only in the Alpine biogeographic region is the conservation status mostly favourable. The essential threats to these low-nutrient habitats are the intake of nutrients and the exposure level of air pollutants (even by air), the lowering of ground water levels and recultivation of bogs. As a result, the typical poor nutrient water ecosystems and the water chemistry have to be safeguarded, and buffer zones should be created to minimize the inflow of nutrients from surrounding surfaces. The damselfly *Sympecma paedisca* is endangered in Europe and strongly protected by the EU Habitats Directive Annex IV. It is a relict with a Continental distribution. Beneath moorland habitats such as dystrophic waters more nutrient-rich standing waters were also colonized. Although there are no sites especially protected by the Habitats Directive for this species, many of the populations are found in protected areas in Germany. The conservation status of the species in the Atlantic and Continental region is unfavourable - bad and unfavourable - inadequate, respecitvely, and is unknown in the Alpine region. The number of populations of *S. paedisca* in Germany is decreasing severely, at least in Lower Saxony and Baden-Württemberg. Besides habitat degradation, climate change could also be one of the reasons for the decline (Ellwanger and Mauersberger 2003).

3.4 Butterflies

Currently, 188 butterfly species are established in Germany (Lepidoptera: Rhopalocera). Twelve species from two different groups of relict species were identified as relicts. Butterflies such as *Lycaena helle* represent species that are well adapted to cold-stenothermic conditions. Examples for species in Europe that are adapted to cold conditions, and thus defined as glacial relicts, can be found in the work of Varga (1977) and Weidemann (1995). Other species such as *Chazara briseis* are thermophilic relicts from warmer times.

Only one of these relict species in Germany is listed in Annex II of the Habitats Directive (Table 6). This means that relict species in Lepidoptera (Rhopalocera) are underrepresented in Annex II, because SCIs have only been established for one species in the network of Natura 2000 sites. For the other 11 species, it is not obligatory to integrate their populations in the network. In Annex IV another two species are listed (Table 6). These are protected by law, but no special sites (SCIs) need to be set up. Most of the relict species settle in habitat types listed in Annex I of the Habitats Directive, and SCIs should also be selected for those habitat types. Thus, there is a good chance of saving the locations of Germany's butterfly species with the protection of the Annex I habitat types.

All thermophilic relict species live primarily in the following habitat types of Annex I of the Habitats Directive:

- 5110 stable thermoxerophilic formations with *Buxus sempervirens* on rock slopes (Berberidion p.p.)
- 5130 *Juniperus communis* formations on heaths or calcareous grasslands
- *6110 rupicolous calcareous or basophilic grasslands of the Alysso–Sedion albi
- *6120 xeric sand calcareous grasslands
- 6210 semi-natural dry grasslands and scrubland facies on calcareous substrates (Festuco-Brometalia)
- *6240 sub-pannonic steppe grasslands
- 8210 calcareous rocky slopes with chasmophytic vegetation
- 8220 siliceous rocky slopes with chasmophytic vegetation
- 8230 siliceous rock with pioneer vegetation of the Sedo-Scleranthion or of the Sedo albi-Veronicion dillenii.

Table 6 Relict butterfly species in Germany listed in the Habitats Directive

Species	Habitats Directive	Conservation Status (National Report Art. 17, Hab. Dir.; Nationaler Bericht 2007)		
		Biogeographic region		
	Annex	Atlantic	Continental	Alpine
Scarce Heath, *Coenonympha hero*	IV	Unfavourable - bad	Unfavourable - bad	–
Violet Copper, *Lycaena helle*	II, IV	–	Unfavourable - inadequate	Unfavourable - bad
Apollo, *Parnassius Apollo*	IV	–	Unfavourable - bad	Favourable

No thermophilic relict species is listed in Annex II, and only one (*Parnassius apollo*) is listed in Annex IV. But all four thermophilic relict species in Germany can be found in the habitat types described below and also in 2310 (dry sand heaths with *Calluna* and *Genista*), 2320 (dry sand heaths with *Calluna* and *Empetrum nigrum*), 2330 (inland dunes with open *Corynephorus* and *Agrostis* grasslands) and 4030 (European dry heaths).

Eight cold-stenothermic relict species occur in Germany. One of these is listed in Annex II and IV (*Lycaena helle*) and one only in Annex IV (*Coenonympha hero*).

The cold-stenothermic relict species live primarily in the following habitat types of Annex I of the Habitats Directive:

- 4010 Northern Atlantic wet heaths with *Erica tetralix*
- 4060 alpine and boreal heaths
- *6230 species-rich *Nardus* grasslands, on silicious substrates in mountain areas (and submountain areas in Continental Europe)
- 6410 *Molinia* meadows on calcareous, peaty or clayey-silt-laden soils (Molinion caeruleae)
- 6430 hydrophilous tall herb fringe communities of plains and of the montane to alpine levels; important for feeding habitats)
- *7110 active raised bogs
- 7120 degraded raised bogs still capable of natural regeneration
- 7140 transition mires and quaking bogs
- 7150 depressions on peat substrates of the Rhynchosporion
- 7230 alkaline fens
- *91D0 bog woodland.

The locations of most of the cold-stenothermic relict species are protected through this assortment of habitat types and with the German Natura 2000 network.

3.4.1 The Violet Copper (*Lycaena helle*) in Germany

The distribution area of the Violet Copper ranges from Scandinavia to Russia. It is also distributed over Central Europe and the Alps, and reaches East into Siberia (Region Amur) (Weidemann 1995). The species belongs to the Northern-boreal distribution type and is classified as a cold-stenothermic relict species in Germany.

The distribution map shows a high level of fragmentation in Germany (Fig. 1): In the German low mountain ranges, the species is present only in peninsulas in the Westerwald, Eifel, Rothaargebirge and in an isolated area in the Northern German lowlands near the river Oder in Eastern Germany. The best areas are in the prealpine lowlands of the Alps, where this species shows the highest abundances in Germany and the largest coherent area without interruptions. Nearly all localities in Germany are found in the Continental biogeographic region, with the exception of one population in the German Alpine biogeographic region (near Garmisch-Partenkirchen). The conservation status in the German Continental biogeographic region was assessed as unfavourable - inadequate in the German National Report (Art. 17 Habitats Directive)

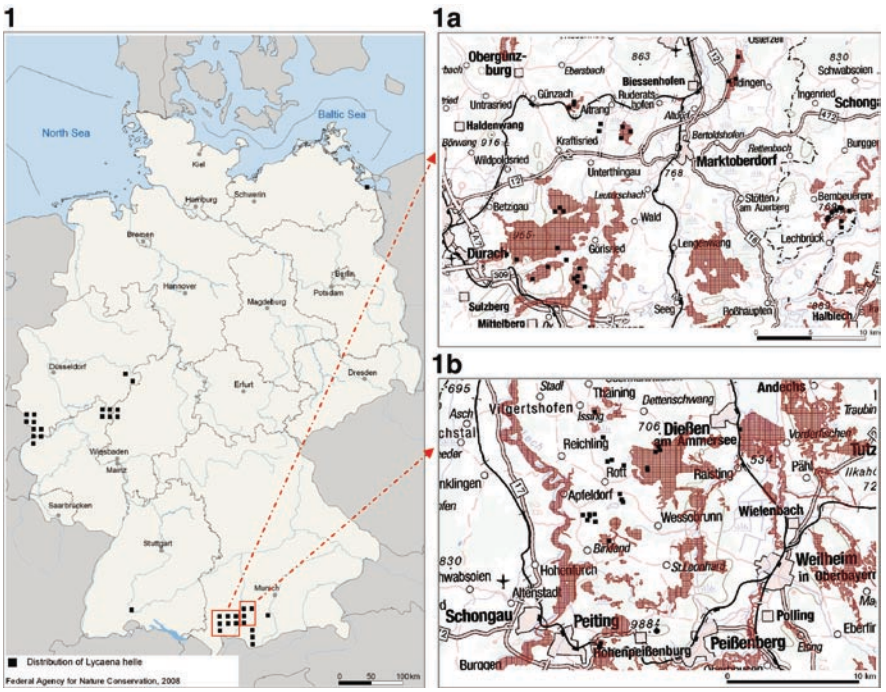

Fig. 1 Distribution of *Lycaena helle* (Source: German National Report according to Art. 17 Hab. Dir.) (**a, b**) Occurrences of *Lycaena helle* (1992–2003, black quadrat) and the Sites of Community Importance (Data as of Dec. 2006, red areas) in Bavaria

in 2007 and in the Alpine biogeographic region as bad (red). Figure 1 shows the current distribution area in Germany.

Imagos of *Lycaena helle* can be found during only a short period from May to June and only in cool climates and wetlands with Calthion (also Cirsietum rivularis and Chaerophyllo-Ranunculetum aconitifolii), where *Polygonum bistorta* occurs. Habitat types with these associations are not well represented in Annex I of the Habitats Directive.

The Violet Copper was submitted to Annexes II and IV during the enlargement of the European Union (EU) to the East in 2004 (Biewald and Nunner 2006). All member states with occurrences of such newly listed species in the Habitats Directive are responsible for their protection. However, the old member states were not urged to install SCIs for the species added to Annex II, but they do fall under the protection of already existing Natura 2000 sites. In Germany, no area has been especially nominated to date for Natura 2000 for *Lycaena helle*, so this species occurs only in a few SCIs where other protected species of Annex II also occur. Only four of the six federal states in Germany where *Lycaena helle* is found have so far completed their duty to update the Standard Data Forms indicating the presence of the species within their sites. Germany has to ensure protection of *Lycaena helle* as it is listed in Annexes II and IV of the Habitats Directive, so a Natura 2000

network will need to be implemented for the protection of this species in the next few years. Figure 1a, b shows the problem that only few habitats of *Lycaena helle* are protected so far in Germany. The best areas should be integrated in the list of SCIs as soon as possible.

Figure 1a shows a small region of Bavaria to the East of Durach, where most areas with populations of the Violet Copper can be found in Natura 2000 sites. In other regions in Bavaria, for example in the West near Lake Ammersee, most remaining populations are located outside Natura 2000 sites (Fig. 1b). Because most settled areas in Western Germany are not represented by Annex I habitat types, there are not enough sites represented in the network of SCIs.

Only one relict butterfly species is listed in Annex II of the Habitats Directive in Germany. Another two species are listed in Annex IV. Most populations of all identified 12 relict species of day-flying butterflies in Germany live in Annex I habitats, so protection for these species is possible in their habitats. The habitats of the Violet Copper as a new species in Annex II are not well represented in the Annex I habitat types. The conservation status of the species in the Continental biogeographic region is unfavourable - inadequate, and in the Alpine biogeographic region it is unfavourable - bad. The specific situation of this species will obviously need additional SCI proposals or enlargement of existing SCIs to fulfil the requirements of the Habitats Directive, and this might be the only means of securing a better conservation status in future. Species-specific protection, site protection and/or management plans are urgently needed.

4 Conclusion

4.1 Habitat Conservation

The habitats of the relict species are mostly covered by Annex I habitat types. This means that even if a species itself is not directly protected, there is an indirect habitat protection in the Natura 2000 network of protected areas. Relict species are sensitive to climate change because they are generally strongly adapted to special conditions. Because of an increase in the anthropogenic causes of climate change, there is a high risk of extinction particularly for glacial relict species, as these represent the largest group of relict species in Germany. The best way to protect these local relict species is to include them in special management conservation plans. For many Natura 2000 sites, management plans should be set up and the relict species in Natura 2000 sites should be integrated as typical species where they occur.

Altogether, relict species from the analysed groups can be found in 46 habitat types of the Directive. At least 60–80% of the total area of most of these habitat types has been included in Natura 2000 sites. The most important habitat types hosting these relict species are bogs and species-rich grasslands, mainly of mountain ranges. In addition, screes represent an important glacial refuge for other relict species groups such as spiders. The importance of bogs has been pointed out in this

study for several taxa, but screes were only detected to be important for higher plants among the studied groups. In the latter, the most important habitat types referring to the studied groups were the following:

- 6210 semi-natural dry grasslands and scrubland facies on calcareous substrates (Festuco-Brometalia)
- *7110 active raised bogs
- 7120 degraded raised bogs still capable of natural regeneration
- 7140 transition mires and quaking bogs
- 7230 alkaline fens
- 8210 calcareous rocky slopes with chasmophytic vegetation.

4.2 Species Conservation

One hundred and fifty-seven relict species in the taxonomic groups of higher plants, molluscs, dragonflies, damselflies and butterflies have been analysed in this study. Of these relict species, 143 are not covered by the direct species protection regime or have to be formally integrated into designated sites (not listed in Annexes II and IV of the Habitats Directive). A total of 14 species can be found in Annexes II, IV and V of the Habitats Directive (Table 7). Two of these species are extinct in Germany (*Saxifraga hirculus* and *Coenagrion hylas*), nine species are included in Annex II. The largest group of relict species in Germany directly listed in the Annexes of the Habitats Directive is molluscs (five species). Most relict species have no contact with other populations. Thus, they are isolated without gene flow between the remaining populations, so that they often show criteria that qualifies them as candidates for ESUs; however, more research work is needed on this topic. In accordance with the concept of assessing the responsibility of a region for the worldwide conservation of species (Gruttke et al. 2004), relict species are identified as conservation items of high priority.

Relict species in Germany can mostly be protected by the network of Natura 2000 sites as characteristic or typical species for habitat types of Annex I rather than by direct species protection from Annexes IV and II. Only nine species are listed in Annex II, so SCIs are being established or provided for seven of these nine species, because two species are extinct in the wild in Germany. The refuges of

Table 7 Relict species in four taxonomic groups in Germany

	Number of species in Germany	Relict species	Relict species listed in the annexes of the Habitats Directive
Plants (without mosses and lichens)	ca. 3,500	100	4
Molluscs	342	38	5
Dragonflies and damselflies	81	7	2
Butterflies (Rhopalocera)	188	12	3

most relict species in Germany are at present protected by coverage through the network of Natura 2000 sites conserving the habitats of Annex I, in which the highest number of relict species occur. Because of climate change and their often fragmented and very small survival areas, relict species are subject to a high risk of extinction; so management plans should be provided for their conservation. For a few species, additional sites would be desirable to adequately cover their habitats within Natura 2000. Because the influence of anthropogenic climate change is increasing rapidly, management plans for the protection of relict species should be provided. The urgent need for management plans or species action plans is evident when considering the results of the current conservation status (German National Report, Nationaler Bericht 2007) of relict species listed in the Annexes of the Habitat Directive: two species are extinct and nine of the 14 species are identified as having an unfavourable - inadequate or unfavourable - bad conservation status in Germany (Tables 2–6).

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