European Strategy for the conservation of invertebrates

John R. Haslett

Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention)

Nature and environment, No. 145

Council of Europe Publishing

The work leading to the elaboration of the European Invertebrate Strategy was possible thanks to a financial contribution by the Swiss Agency for the Environment, Forest and Landscape.

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Cover design: Graphic Design Workshop, Council of Europe
Cover images: See photo credits p. 3.

Council of Europe Publishing
F-67075 Strasbourg Cedex
http://book.coe.int

ISBN 978-92-871-6359-2

Printed in Belgium

Acknowledgements

The work was undertaken in consultation with a small discussion group of experts that consisted of Yves Gonseth, Anastasios Legakis, Martin C.D. Speight, Deborah Procter, Marian Ramos, Zoltan Varga, Henrik Enhoff, Marc Meyer. The Secretariat was provided by Eladio Fernández-Galiano and Carolina Lasén Díaz. I thank them all for their constructive comments, support and in some instances additional input to particular portions of the text. In addition, I thank Richard Harrington and Alan Stubbs for providing critical comment on the initial discussion document for the Strategy. Richard was also most helpful in sourcing and providing some of the photographs. I am most grateful to the Delegates of Contracting States and the other participants at the official Meeting of the Group of Experts on the Conservation of Invertebrates for many discussions and suggestions. Michael Samways and George McGavin provided the final scientific filter and gave important comments and advice during editing. I also thank my botanical collegues in Plantlife and Planta Europa for many important discussions and ideas, particularly Jane Smart (now with IUCN), Hugh Synge and Liz Radford. I thank Thomas Moertelmaier, Patrick Gros (both in Austria) and Robert Paxton (Queen´s University Belfast) for sourcing and providing further photographs. Individual photograph credits are given under the photograph legends in the text and below for the cover.

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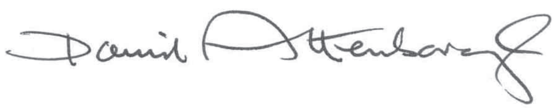
Foreword

Terrestrial invertebrates do not have glamour. They do not even have a readily recognisable collective name. Most, for most of the time, are invisible to us. All are relatively tiny. Yet these creatures are essential to the survival of many plants and all other animals, including ourselves.

And terrestrial invertebrates are under threat. As our expertise in extermination grows even greater, as we continue to force more and more of the natural world to meet our immediate purposes, and now as the climate changes with increasing speed as a consequence of our actions, so the survival of terrestrial invertebrates in all their richness and variety is increasingly threatened.

Here is guidance on how we might help rather than harm. It is clear and authoritative. If we follow it we can halt – perhaps even repair – some of the damage we have done.

We ignore it at our peril.



Sir David Attenborough CH. FRS

Invertebrates, high in Europe´s conservation agenda

– A message from the Council of Europe –

Even though they form most of the biological diversity of our planet and its biomass, invertebrates have, for a long time, been neglected in conservation because of the high number of species, the relative lack of specialist scientists and a limited public image. Conservation treaties have also often ignored these animals.

The Bern Convention was the first international treaty to include a substantial list of invertebrates targeted for strict protection. Since 1987 it has included more than 100 species, mostly insects, but also crustacea and molluscs. Now the Convention's lists also include sponges, cnidarians, echinoderms and one spider *(Macrothele calpeiana)*. Many of those species are highly endangered. The 45 European and African states that are Parties to the Convention, as well as the European Community, also a Party in its own right, have needed and wished for a long time to have a political and strategic instrument to permit the further development of conservation work on invertebrates, at the national and European levels. The "European Strategy for the Conservation of Invertebrates" was finally adopted by the Standing Committee to the Bern Convention in November 2006, together with a recommendation that encouraged the different governments and the European Union to draw up and implement national strategies and enhance invertebrate conservation.

This strategy brings together the problems and requirements of invertebrate conservation across Europe, without marine species. It is the work of Professor John R Haslett, commissioned by the Council of Europe, in collaboration with a small discussion group of experts, also selected by the Council of Europe. The text was further supplemented and revised according to comments from the full Group of Experts for the Conservation of Invertebrates of the Bern Convention at their meeting in Strasbourg in June 2006. The work was then subjected to peer review by eminent scientists in the fields of invertebrate zoology and conservation biology.

The Council of Europe has great hopes that the Strategy will promote interest in the variety of invertebrate species and promote conservation action to protect their populations and natural habitats.

Eladio Fernández-Galiano
Head of the Biological Diversity Unit
Council of Europe
June 2007

Conservation biology and the European Invertebrate Strategy

Guest essay by Robert M. May

It is very pleasing to see the Council of Europe addressing the manifold threats to the diversity of invertebrate animals through their European Invertebrate Strategy.

Although all efforts at conservation of biological diversity are to be welcomed, it is an unfortunate, if understandable, fact that a vastly disproportionate amount of effort is focussed on vertebrates in general, and birds and mammals in particular. Such differential attention derives from understandable emotional factors – the furries and featheries seem “closer to us”, and evoke an empathetic response that invertebrates rarely match – rather than any balanced appreciation of the evolutionary history they represent or the ecosystem services they deliver.

We can quantify such disparities in attention given to different groups in various ways. The total number of distinct species of vertebrates which have been named and recorded is around 45-50 thousand, with bird and mammal species especially well-known. The roughly 300 thousand species of plants known to science probably represent around 90% or more of the true total alive on earth today. But the roughly one million species of named and recorded insects are variously estimated to represent somewhere between one half (an implausibly high estimate) or one thirtieth (implausibly low in my opinion) of those to be found on earth today[1]. Not the least of the problems here are lack of coordinated databases for most insect and other invertebrate species, and the consequent difficulties with synonyms – the same species being known under two or more different names, from different collections[2] (one estimate is that as many as 40% of named beetle species – the most numerous single group – are known from only one site, and sometimes only one specimen).

Such disparities in species numbers do not accord with the distribution of scientific effort. Bringing together such evidence as was available on “the taxonomy of taxonomists”, some 10 years ago Kevin Gaston and I concluded that the world’s taxonomic workforce was roughly evenly partitioned among vertebrates, plants, and invertebrates[3]. Given that known plant species are roughly 10 times more numerous than vertebrate species, and invertebrate species at least 10 times more numerous again, this suggests a most peculiar mismatch of taxonomic effort to the job to be done.

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[1] May, R. M. (1999). The dimensions of life on Earth, In *Nature and Human Society*. National Academy of Sciences Press, Washington D.C., pp. 30-45

[2] Solow, A. R., Mound, L. A. & Gaston, K. J. (1995). Estimating the rate of synonymy. *Systematic Biology*, **44**, 93-96.

[3] Gaston, K.J.& May, R.M. (1993). Taxonomy of taxonomists. *Nature*, **356,** 281-282 . (1992) [Reprinted in Italian: *Sapere*, No 59, 14-16].

Things get even worse if we analyse the research literature on conservation biology. A study of papers in the two leading conservation research journals from 1987 to 2001 showed roughly 70% dealing with vertebrates, 20% with plants, and 10% with invertebrates (of which half were butterflies or moths, enjoying the status of a kind of honorary bird)[4]. And when we turn to conservation oriented NGOs (Non-Governmental Organisations), we find an even greater preponderance of attention given not just to vertebrate species, but to the less than one third that are birds or mammals.

These facts are essentially vagaries of intellectual fashion. They do not reflect any balanced appraisal of where the planet's genetic diversity resides, nor of how the variety of present species represents the evolutionary history of life on earth; invertebrates undoubtedly preserve more "independent evolutionary history" than do vertebrates[5]. Nor are wild vertebrates of greater practical consequence, in terms of ecosystem services or other measures, than invertebrates. Indeed, it can be argued that the arthropod, helminth and other fauna in the soil are crucial to the maintenance of the biosphere, in ways that few, if any, vertebrate species can claim.

Just as we know less about invertebrate biodiversity than about vertebrates, so too our knowledge of the conservation status of invertebrates is very poor. Looking at the IUCN Red Data Books for 2004[6], we find that, using specific and sensible criteria, they estimate 20% of recorded mammal species are threatened with extinction, and likewise 12% of birds, 4% of reptiles, 31% of amphibians, 3% of fish, and 31% of the 980 known species of gymnosperms (conifer and cycad plants). However, when these figures are re-expressed in terms of the number of species whose status has actually been evaluated (as distinct from dividing the number known to be threatened by the total number known – however slightly – to science), the corresponding numbers are similar for mammals, birds, amphibians and gymnosperms (20, 12, 31, 34% respectively), but very different for reptiles (61% versus 4% for reptiles, 26% versus 3% for fish). The corresponding figures for the majority of plant species, dicots and monocots, are respectively 4 and 1% of those known, versus 74 and 68% of those evaluated. But most telling are the two numbers for the most numerous group, insects: 0.06% of all known species are threatened, versus 73% of those actually evaluated. The same pattern holds true for other invertebrate groups. When, around 10 years ago, I was last familiar with the numbers of animal species recorded as having become extinct over the past few centuries, more than half were vertebrates, even though they represented only around 4% of recorded species of animals. But this, of course, was a measure of attention not extinction. Of the 73 insect species thus certified extinct, essentially all came from islands (more than half were Hawaiian *Drosophila* fruit flies), and of the nine continental species, 8 came from North America and one from Germany. Not one was a mainland tropical insect.

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[4] Clark, J.A. & R.M. May (2002). Taxonomic bias in conservation research. *Science*, **297**, 191-192

[5] Nee, S. & May, R. M. (1997). Extinction and the loss of evolutionary history. *Science*, **278**, 692-694.

[6] *IUCN Red Data Book 2004.* www.redlist.org/info/tables/html

Given how little we know about the true total numbers of distinct animal species alive on earth today, and even less about the extinction threats that individual species face, it is clearly impossible to give a sensible estimate of the actual number likely to become extinct over the next few centuries. Perhaps surprisingly, we can nevertheless say some relatively precise things about current and likely future rates of extinction in relation to the average rates seen over the roughly 550 million year sweep of the fossil record[7]. For bird and mammal species (a total of approximately 14,000), there has been an average of about one certified extinction per year over the past century. This is a very conservative estimate of the true extinction rate, because many species receive relatively little attention even in this unusually well-studied group. Such a rate, if continued, translates into an average “species’ life expectancy” of the order of 10,000 years. By contrast, the average life expectancy – from origination to extinction – of a species in the fossil record lies in the general range 1 to 10 million years, albeit with great variation both within and among groups.

So, if birds and mammals are typical – and there is no good reason to assume they are not – extinction rates in the twentieth century were higher, by a factor of 100 to 1,000, than the fossil record’s average background rates. And four different lines of argument suggest a further tenfold speeding up over the coming century[7]. Such an acceleration in extinction rates is of the magnitude which characterised the Big Five mass extinction events in the fossil record. These Big Five are used to mark changes from one geological epoch to the next. Although there is much need for further work to refine estimates of this kind, it does seem likely that we are standing on the breaking tip of a Sixth great wave of mass extinctions.

The crucial difference between the impending Sixth Wave of mass extinction and the previous Big Five is that the earlier ones stemmed from external environmental events. The Sixth, set to unfold over the next several centuries – seemingly long to us, but a blink of the eye in geological terms – derives directly from human impacts: habitat destruction, overexploitation, alien introductions, and usually combinations of two, or even all three[8]. And climate change will increasingly make things worse, not least by changing species’ ranges[9].

The recent UN-sponsored Millennium Ecosystem Assessment[10], published in 2005, spells out in grim detail the impacts that such impoverishment of invertebrate species’ diversity is likely to have on ecosystem services. Some of these explicitly catalogued services may seem “merely” cultural: spiritual and religious values; aesthetic values; recreation and ecotourism. Most have

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[7] May, R. M., Lawton, J. H. & Stork, N. E.(1995). Assessing extinction rates, In *Extinction Rates* (eds. J.H. Lawton & R.M. May) pp.1-24, Oxford University Press.

[8] Diamond, J.M. (1989) The present, past and future of human-caused extinctions, *Phil. Trans. R Soc. B* **325**, 469-477.

[9] Lovejoy, T. E. & Hannah, L. (eds) (2005). *Climate Change and Biodiversity.* Yale University Press, 2005).

[10] *Millennium Ecosystem Assessment,* Ecosystems and Human Well-being: Synthesis. Island Press, Washington D.C., 2005.

implications for the material well-being of human populations, “regulation services” pertaining to air quality, water, erosion, disease, pests, pollination; “provisioning services” relating to food – crops, livestock, fisheries – fibre, genetic resources, and much else.

In Europe, invertebrates are as important for providing all of these types of ecosystem services as anywhere else on our planet. There is often a preconceived idea that in this part of the world there is little cause for concern – invertebrate biodiversity and ecosystem services can be easily maintained because levels of documentation, research effort and financial resources are higher in Europe than in most of the rest of the world. In fact such complacency is unfounded, and my observations in this essay are just as valid for Europe as for the tropics, or the polar regions, or anywhere else in between.

For all these reasons, ranging from ethical to down-to-earth practicalities, the European Invertebrate Strategy could not be more timely (well, actually it could have been more timely by being started sooner!). It is greatly to be welcomed.

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The Strategy

Vision, goal and objectives of the strategy

Vision

A world in which invertebrate animals are valued and conserved, in parallel with all other groups of organisms, now and in the future.

Goal

To halt the loss of invertebrate animal diversity in Europe.

Objectives

O1 raise awareness and alter human attitudes and behaviour towards the importance of conserving invertebrate animals;

O2 promote integrated management of landscape mosaics at the relevant scales to be sustainable for invertebrates;

O3 strengthen European to national/sub-national invertebrate conservation policy and action;

O4 identify and prioritise key actions to be implemented at different political and geographical levels;

O5 promote accessibility and efficient flow and exchange of information on invertebrates within and between the scientific and public domains;

O6 promote inclusion of a fully representative variety of invertebrate species in conservation and environmental management decisions, including integration of invertebrate conservation into existing and future conservation strategies involving other groups of organisms

O7 build scientific and technical capacity for the conservation of invertebrates and identify areas of urgent further research.

1. Introduction

Why it is important to conserve insects, spiders, snails and other small creatures

> So important are insects and other land-dwelling arthropods that if all were to disappear, humanity probably could not last more than a few months. Most of the amphibians, reptiles, birds, and mammals would crash to extinction the same time. Next would go the bulk of the flowering plants and with them the physical structure of most forests and other terrestrial habitats of the world.
>
> (E.O. Wilson, 1992).

Whether or not one agrees with the time scale, or with the exact order of events, the message in the above quote from one of the world´s most renowned biologists is as poignant as it is true.

There are vast numbers of species of invertebrate animals, so many that they make up the greater part of the world´s entire biodiversity. Insects alone are estimated to be about 65% of all species of organisms on the planet, including plants and micro-organisms (e.g. Speight *et al*, 1999). Not only are invertebrates more numerically diverse than other groups of organisms, they also dominate nearly every kind of habitat that the world has to offer. Perhaps most importantly, invertebrates perform a very wide range of essential functional roles in the world´s ecosystems. From the tropics to arctic and alpine, from terrestrial to aquatic, there are massive numbers of invertebrate herbivores, predators, decomposers, parasites, pollinators, seed dispersers and more. Equally, invertebrate animals are themselves the food necessary to support organisms at other levels in the food web. Thus the invertebrates are the motor that drives ecosystem function at all scales of definition, from microsystem to worldwide. Beyond these biological roles, invertebrates are now beginning to be recognised as providers of ecosystem *services* that have measurable economic values, such as pollination, dung degradation, pest control or nutrition for other wildlife (Losey & Vaughan, 2006).

Invertebrates also provide a richness of medical and technical services and resources. From medicinal leeches to wound-cleaning insect larvae, from forensic entomology to models for robotics or molecular structures in materials science, the positive commercial potential of invertebrate animals is only beginning to be exploited. Also, there are the delights of such things as eating snails with garlic, or wearing a necklace of pearls from fresh-water pearl mussels (*Margaritifera* spp.). But such commercial exploitation of species creates its own sets of problems, just as with plants, vertebrates and other organisms, and requires tight control to ensure sustainable use.

All this means that despite, or rather because of the great abundance of invertebrate animals, it is essential they be conserved.

Present threats and risks to European invertebrates

Levels of knowledge of the invertebrate fauna and its conservation status vary considerably between States, but large numbers of invertebrate species are under severe threat of extinction in Europe, or are already extinct. The main factors responsible and/or creating high potential future risk may be summarised as:

– habitat destruction and fragmentation,
– land use changes in agriculture, forestry and the construction and transport industries,
– loss of complex habitat mosaic structure across different spatial scales,
– drainage of wetlands,
– water course regulation,
– direct impacts of economic activities, including direct harvesting,
– impacts of invasive species,
– negative human attitudes to most invertebrate animals,
– light pollution (for nocturnal and underground species),
– climate change (may contribute to, or otherwise affect each of the above).

All of these threats are the same as, or directly involve, threats to plants, birds and other organisms, but the specific needs for invertebrate conservation management have been largely neglected. Europe´s invertebrate fauna continues to decline and the scale of the problem is great (e.g. Thomas & Morris, 1995).

Invertebrate conservation and climate change

Climate change is a reality. Increasing concentrations of carbon dioxide and other substances in the atmosphere is causing substantial and rapid changes to the global climate.

The potential impacts of such change on biodiversity are great, and underly all aspects of modern conservation biology. Indeed, climate change and its general implications for biodiversity conservation in Europe form the essential backdrop for the development and successful implementation of all European conservation strategies (see Usher, 2007 for a discussion of many of the central issues).

For invertebrates, climate change may impact in a wide variety of ways. There will be changes in the available ´climate space` – the areas containing the physical climatic conditions suitable for the survival of the different species and communities. There will also be changes to the biotic aspects of invertebrate habitats, particularly the vegetation. This may involve spatial shifts and/or changes in the composition of the plant communities as responses to changes in the plants´ own climate space. It may also involve physiological changes within the plants caused by increases in the amount of carbon dioxide available for photosynthesis, which, in turn, affect plant quality as invertebrate food.

Generally, it may be expected that under a warming climate in Europe, there will be a trend for species to move regionally northwards and/or locally upwards (e.g. see Thomas *et al*, 2006). However, the mobility of invertebrates is extremely variable among species in both space and time, so that although it is already clear that many invertebrates are rapidly changing their range, man-made habitat fragmentation and isolation mean that many species are no longer able to move with the climate. Thus the less vagile species will be at greater risk of extinction. Climate change and habitat fragmentation may indeed combine and have synergistic adverse effects on invertebrate biodiversity (Warren *et al*, 2001; Travis, 2003). Most worryingly, it is clear that many of the presently designated Protected Areas across Europe are not likely to be in the right place under future climate change scenarios. The solution must be sought at a landscape scale to ensure that there are as many corridors and stepping stones as possible to allow species to migrate or adapt. Regionally or locally significant sites may be paramount as part of such a European Strategy. But even here there are challenges to be overcome, because the efficiency of corridor-type habitat links for the facilitation of directional movement of most invertebrates remains unknown (e.g. Haslett & Traugott, 2000). Thus careful planning and execution of new actions is essential now for securing biodiversity for the future.

The situation is exacerbated by the further complication that in situations of change, it is not so much the mathematical average of the change that is important, but more the variance of that average – the likelihood of an extreme situation. Invertebrate populations may be wiped out by exposure to an extremely cold winter, hot summer, abnormally long period of drought or of flood much more than geographical averages. Here, many species have little or no opportunity to move away from the adverse conditions.

The effects of climate change on invertebrate/plant interactions are of particular significance, by separating them in space or time. Differences in vagility and phenological changes to the seasonal cycles of the species mean that there will be, for example, segregation of plants from pollinators, and loss of phytophagous species and related guilds of invertebrates. These and other important separations and desynchronisations have far-reaching implications throughout entire food chains, detrimentally affecting the functioning of whole ecosystems.

In the light of all of the above, three general statements may be made regarding the effects of climate change on invertebrate biodiversity. First, negative responses, such as local extinction, are generally faster than positive responses, such as colonization of new areas. Second, many of today´s communities of organisms will not exist under future climates. Third, specific biological and geographical traits of the different species will make some species particularly sensitive to changes in climate. These include those that are at the edge of their range, geographically localised, of low genetic diversity, slow reproducers, poor dispersers or highly specialised in their ecological requirements.

It is not the role of the present Strategy to investigate the many possible consequences of all these issues. However, recognition that the Strategy will have to be applied under conditions where conservation priorities may change extremely quickly is paramount to its success. This requires considerable flexibility and increased effort in monitoring invertebrate populations and communities.

The Kyoto Protocol is only one of a number of international legal instruments that has focussed recent attention on climatic change from human influences, and the subject is now high on the political agenda. The repercussions go well beyond invertebrate conservation.

Invertebrate interactions with plants and other organisms

Invertebrates interact with each other and with all other types of organisms at all levels across the food web. The variety and frequency of these interactions is immense, and provides the grounds for regarding invertebrates as the motor that drives ecosystem function (under this analogy, plants provide the fuel for the motor through photosynthesis). Invertebrates may be herbivores, detritivores, predators or prey, they compete with other organisms for food and other resources, they may be parasitic, or vectors of disease organisms or may be part of positive symbiotic partnerships. But perhaps most significantly, invertebrates have developed many close interactions with the plant kingdom.

Many invertebrates are herbivores and can have a strong influence on the vegetation, such as these sawfly larvae. (Hymenoptera: Symphyta). (Photo © John R. Haslett)

Interactions with plants

After the invertebrates, the plant kingdom is the second biggest overall contributer to known global (and European) species diversity. The two groups have existed and developed together through a very long period of evolutionary time. A complex variety of relationships and interdependencies has developed that make invertebrates and plants functionally inseparable. Invertebrate animals eat and live on every conceivable part of a plant, living or dead, while the plants rely heavily on the invertebrates for their pollination and other aspects of their reproduction, and for recycling nutrients in the soil (Wilson, 1992). Invertebrates are also central to soil formation (see Box 1).

Box 1 Invertebrates and soil

Soil is an extremely complex and variable mixture of broken-down rocks and minerals, organic matter, water and air. The proportion of organic material, the sizes of the particles, the porosity and the degree of mixing of the different ingredients are important in defining different layers or `horizons´ that describe the soil´s vertical structure, from plant and animal debris at the top to mineral substrate at the bottom.

Plants and many other organisms take their nourishment from the soil or live on or within it (see also Box 5, underground habitats) and we humans depend heavily on its fertility and cultivation. But it is often overlooked that invertebrate animals are instrument in soil formation: Without invertebrates the ground under our feet would be very different, as would the vegetation we see around us.

Invertebrates play important roles in the formation and structuring of soil in two main ways. Many species are detritivores – animals that decompose and recycle dead plant and animal material, converting it into soil humus. They are aided in this task by other groups of organisms such as microbes and fungi (see also Box 10 on saproxylic invertebrates). The second, equally important but perhaps less obvious function of invertebrates in the soil is that of ´ecosystem engineering` – physically changing the soil structure and mixing it by excavating, burrowing, transporting and digesting. Burrows and other excavations allow air into the soil and also change the hydrological dynamics, thus altering the physical conditions, availability of resources and accessibility of the habitat for other organisms. Transportation and digestion of materials brings nutrients to new places and often changes the consistency and content of the soil particle mixture. Annelid earthworms are one of the best known examples of invertebrates that do all these things, often transporting plant litter from near the surface, digesting it and depositing the remains deeper underground or pushing the material back up as ´worm casts`. Ants (Formicidae) modify soil structure by bringing lower soil particles to the surface, obvious as ´ant-hills` or unseen in their below-ground nests. Dung beetles (*Geotrupes*) excavate holes up to 30 cm deep to bury pieces of animal faeces as food for their larvae. And there are thousands of other invertebrate species that have equivalent functions, exerting their effects over spatial scales from a few centimetres to entire landscapes and forming an important part of long-term soil evolutionary biology (Samways, 2005).

Many invertebrates also have complicated life cycles, with adult and larval stages. These different stages often have very different demands for plant (and other) resources, so that the same species may occupy different niches at different times and may live in completely different habitats and require the presence of different plants or vegetation types. All are necessary for the survival of the species.

A hoverfly (Syrphidae: *Scaeva pyrastri*) visiting a flower to obtain pollen and nectar. The plant relies on such visits for its pollination. (Photo © John R. Haslett)

The spectrum of close associations between invertebrates and plants creates a `chicken-and-egg´ situation that is particularly relevant to the conservation of both, with each type of organism community relying heavily upon the continued well-being of the other. Pollination services provided by invertebrates in return for flower food resources are of particular relevance. This means that by definition, invertebrate and plant conservation strategies must also be closely inter-related in their design and implementation. Also, as noted above, many of the major threats to invertebrates are the same, or similar, to those of plants. Thus a co-ordinated approach to invertebrate and plant conservation strategies is essential for the well-being of both.

The species-habitat dilemma

In the early days of conservation biology, emphasis was placed primarily upon protecting particular species that were recognised to be somehow ´rare`, mainly flowers, birds and furry animals. Protecting nature was equated with protecting beautiful and aesthetically appealing species. Then it was recognised that species are becoming extinct because their habitats are being destroyed. Now, the dilemma as to whether to use limited and usually inadequate human and financial resources to pursue the conservation of particular species or whether to invest in the management and protection of habitats that are of notable biological value remains a critical issue in practical conservation strategy. However, it is clear that in the end, both directions are essential for the protection of biological diversity (Haslett, 2004). Indeed, it may be most useful to regard species and habitat protection as extremes of a continuous spectrum of valid conservation strategies, relevant to most organisms, but depending upon particular circumstances. (Note: Throughout this Strategy, ´habitat` of a species, or population of a species, is taken to mean the sum of the abiotic and biotic factors essential to the life and reproduction of the species within its natural geographical range (full definition in Resolution 1, 1989 of the Standing Committee on the provisions relating to the conservation of habitats, Council of Europe).

The importance of integrating species and habitat conservation is now beginning to be fully appreciated at the European level through the acknowledgement of both the Habitats Directive of the EU and in the approaches adopted by the Council of Europe. Such integration is just as essential for invertebrates as for other groups of organisms and this is appropriately reflected in the European Strategy for invertebrate conservation.

Rationale for a European Strategy on the conservation of invertebrates

European ecosystems depend heavily upon the high diversity of invertebrate animals for their function and health. (Ecosystem ´health` is a vague term, but refers to an ecosystem that persists, maintains vigour, organisation and resilience, (see Hudson *et al*, 2006). Human well-being is thus directly affected. The many and varied relationships between invertebrates and other organisms, particularly plants, are of central significance. Yet this pivotal position of the invertebrates remains, even now, largely ignored in Europe.

Maintenance of invertebrate biodiversity in Europe lags far behind the conservation of other groups of organisms (e.g. plants, birds, mammals), for which clear European strategies have now been developed and are being implemented at various legal and technical levels. Whilst present public perception of most invertebrates is clearly negative, this can not postpone decisive and balanced action for invertebrate conservation policy and practice.

Loss of invertebrate biodiversity could already have been considerably reduced if the functional importance of these animals had been highlighted and their conservation integrated within existing plant and bird protection initiatives rather than assuming that strategies of ´umbrella protection` would suffice for all organisms. Wider appreciation of the ubiquitous functional roles of invertebrates and an awareness of the importance of different spatial scales are paramount.

At the genetic level, invertebrates harbour a vast resource of diversity that remains largely unknown, just as with all other organisms. While a ´species` is often a recognisable entity that allows an easy perception of diversity, genetic variability is usually not visible without the use of sophisticated molecular techniques. To ensure conservation of such an important but unclear aspect of diversity is difficult, but it may be assumed that genetic variability be maintained by conserving species over as wide a geographical range as possible in as many habitats as possible, with particular emphasis on meta-populations, populations at the edge of the species range and situations that promote hybridisation between regionally endemic (including naturally migratory) species (see Samways, 2005, Usher, 2007).

Although the necessity of a pan-European approach to invertebrate conservation has long been recognised in scientific circles and by some European institutions including the Council of Europe, efforts towards conservation have been largely superficial and uncoordinated.

In the public view there appears to be no real need to conserve most invertebrate species. The general attitude towards these animals remains largely negative – invertebrates tend to be closely associated with pest species that bite, sting, spread disease and/or cause illness or eat our crops and food products (e.g. Loxdale, 2004). On top of this, the aesthetic appeal of most invertebrates is at best not appreciated, and often distinctly lacking (Samways, 2005).

Of course there are exceptions to this negative way of thinking about invertebrates. For example, adult butterflies and dragonflies are widely accepted as beautiful animals that help to make nature enjoyable and are therefore worthy of protection. These and similarly regarded invertebrates have achieved the higher status of ´honorary birds` by being so accepted in public and political conservation circles.

The risks associated with inaction - of allowing invertebrate biodiversity to continue to decrease – are immense. Without co-ordinated new effort within and between States and in different sectors, not only will we lose a significant part of our natural heritage, but we are in danger of losing many of the important services that ecosystems provide for our normal well-being. Also, we risk the loss of resources directly provided by invertebrate animals that have not yet been fully appreciated and exploited, such as food and medicinal resources, as clearly highlighted at the European level as long ago as 1986, in the Council of Europe´s Charter on Invertebrates (Pavan, 1986).

In summary, invertebrates need to be conserved at European and global levels because they:

- are key components of, and perform essential functions in just about every ecosystem;
- contribute much more to biodiversity than any other group of organisms on our planet;
- dominate in nearly every conceivable habitat, but are at the same time extremely vulnerable;
- are the basic food resource, directly or indirectly, for other organisms higher in the food web;
- provide a valuable and still underestimated resource for commercial use in medicine, technology, food and other services;

– have aesthetic value that remains often unappreciated and contributes significantly to the beauty and enjoyment of nature.

Scope of the Strategy

The Strategy covers the majority of terrestrial and fresh-water invertebrate groups, but issues of conserving biodiversity among very small organisms such as protozoans, many nematode worms and some of the other lower and less well documented groups of animals are not considered because their requirements and threats are very different, or, more commonly, completely unknown.

Geographic limitations

Organism distributions and ecosystem functions do not abide by political boundaries. Nevertheless, such boundaries continue to change, causing Europe to considerably widen its extent. This requires that a European Strategy be flexible enough to take account of presently planned and future alterations to the geographical definition of Europe and its constituent States. Thus the Strategy is mainly intended to address invertebrate conservation problems in Council of Europe states, and it also applies to African states that are Parties to the Bern Convention.

The Strategy is limited to the consideration of terrestrial and freshwater invertebrate species. Invertebrates are also of extremely high significance in marine systems but the ecological requirements of marine species and the threats to their extinction in Europe differ considerably from those inhabiting other types of environment. Thus marine invertebrates are not included here.

The European and global perspective

Europe differs from other regions of the world in the pivotal role played by the European Union (EU). Uniquely, underlying policy on the environment is developed at EU rather than national level. Thus the present Invertebrate Strategy fits within the frameworks of existing European conservation policy, including those of the European Union and the Council of Europe. Importantly, all of these are within the global Convention on Biological Diversity (CBD), and the different sections of the present Strategy reflect this. The Strategy is also intended to aid in achieving the goal to halt the loss of biodiversity in Europe by the year 2010.

Many of the basic demands and requirements of the European Invertebrate Conservation Strategy are very similar to those identified and now in place for practical plant conservation in Europe. Given the close functional associations between plants and invertebrates throughout European ecosystems, the Strategy for invertebrates is designed to be complementary to and to support the European Plant Conservation Strategy and other relevant Strategies. Thus many of the objectives and other aspects of the different initiatives are similar. This serves to promote scientific coordination between the strategies and should also ease practical implementation. However, it must be stressed that the demands of invertebrate conservation are unique, and often differ significantly from those of plant protection, or protection of birds and other large animals.

Who is the Strategy for?

The Strategy is targeted specifically at governments of all Council of Europe Member States and other Bern Convention Parties, but also at all decision-makers, land managers, scientists and teachers that have potential influence on invertebrate conservation. It is a comprehensive document addressed to nature conservation agencies and all other sectoral agencies with responsibility for activities relevant to invertebrate conservation and management. It is recognised that some aspects of implementation will be delivered through existing plant, animal and other agencies that have long-standing expertise in particular areas (e.g. Planta Europa/Plantlife; Birdlife).

The Strategy is also meant to guide the future work of the Bern Convention in the field of invertebrate conservation and strongly supports closer and sustained co-ordination and co-operation with relevant European and international organisations.

The Strategy further seeks to engage stakeholders involved in the movement, use and control of potentially invasive alien species (industry and trade, transporters, retailers, resource managers, the public etc.) and to build on the expertise and commitment of competent non-governmental organisations and research institutes. Many of the proposed key actions call for joint or complementary initiatives by private and public stakeholders.

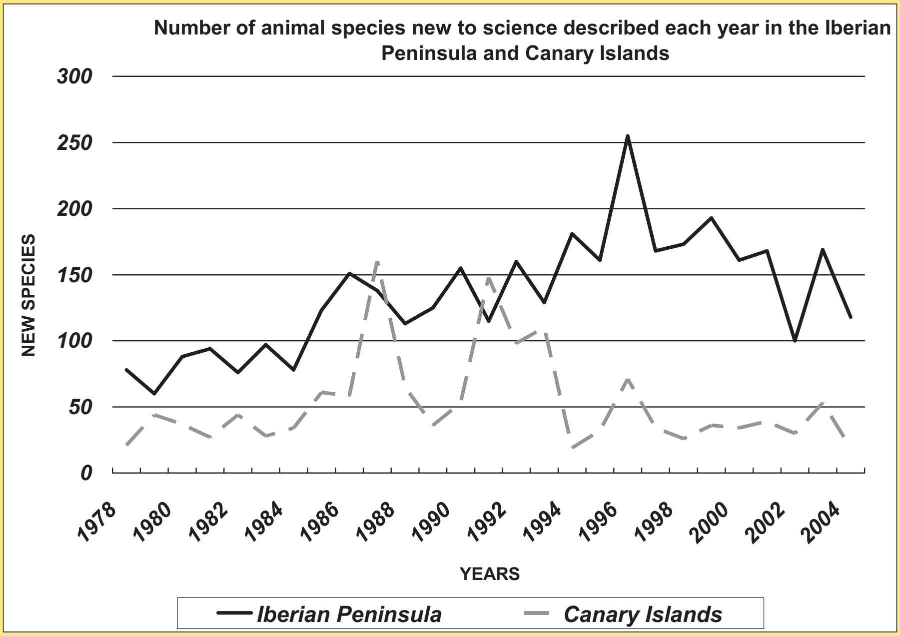
2. Inventorying, mapping and understanding invertebrate diversity

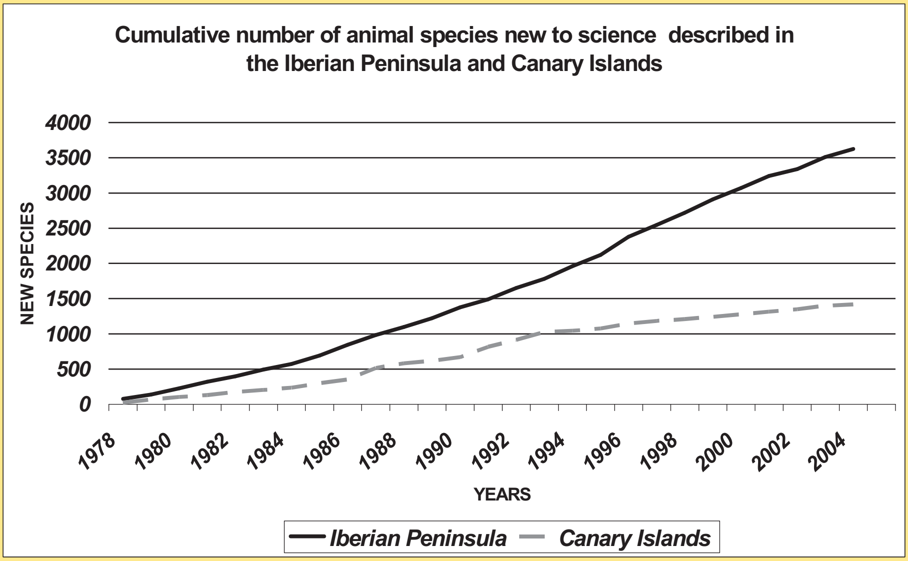
If the decline of invertebrate diversity is to be halted, a clear understanding of the European fauna is needed. In an ideal world, this would include full listing and assessment of all invertebrate species, their abundances, and monitoring change in their distributions and status. Realistically, this will only be possible for a selected sub-set of the fauna under the present (urgent) time scales. There are simply too many species to deal with. In most European countries, we don`t even know how many species of the different groups of invertebrates exist! (See Box 2 for the example of Spain). The lack of information is relevant to rare and threatened species but is equally applicable to common and widespread invertebrates. To improve the levels of understanding of either it will be essential to continue to employ both species and habitat oriented approaches. Thus it is important not only to map the occurrence of species, but also to include the complementary approach of inventorising those species present within particular areas and to monitor changes within each of these types of approach over time. A sound taxonomic basis is prerequisite to all of this. Such information provides the scientific basis for red-listing of species. Continued use, promotion and expansion of red lists of invertebrates remain an essential ingredient of invertebrate conservation effort. It is essential that such effort should prioritise new groups of invertebrates for inclusion on future red lists, also accounting for the genetic variability of the species, when human and financial resources permit.

Box 2 – Numbers of newly discovered animal species in Spain/Iberian Peninsula

Biodiversity in Europe increases southwards (and eastwards) and is especially rich both in the total number of species and in endemics in the three Mediterranean peninsulas. The inventory of the invertebrates inhabiting the Mediterranean Basin (and other) European countries is still far from complete. As an example, in the Iberian Peninsula (continental Spain and Portugal and the Balearic Islands) between 100 and 250 animal species new to science (mostly invertebrates) are presently being described each year (upper graph) and the trend of increase continues at a rather constant rate (lower graph). It is estimated that presently, around 60 000 animal species inhabit the Ibero-Balearic region (Ramos & Templado, 2002). The Canary Islands also have a rich fauna of invertebrates, including many endemics and here also new species continue to be described each year. The functional significance of both new and previously documented species in the entire region remains largely unknown. The Iberian/Spain situation may be considered representative of many countries in Europe.

Box 2 (cont'd)





Data collected by the Fauna Ibérica project (M.A. Ramos & J. Fernández, unpublished)

Recovering threatened species and maintaining red lists

The major focus of species conservation effort remains the documentation of rare species threatened with extinction: those restricted in range or numbers. Nearly all European countries now have national lists of at least some threatened invertebrates, but these remain largely confined to some of the more popular groups and are often badly in need of revision. (Even so, these ´flagship species` can be an efficient tool for promoting the importance of invertebrate conservation, though presently not used to its full potential). Definition and application of criteria to estimate levels of threat to invertebrates remains problematical. Particularly, there are problems in applying the IUCN criteria (IUCN, 2001) to many groups of the invertebrates. The main reason is a significant lack of relevant information to allow the criteria to be applied (´Data Deficient`). Some attempts have been made to apply modified versions of the IUCN criteria to whole groups of invertebrates (e.g. European butterflies: van Sway & Warren, 1999). Although such work makes major advances by demonstrating that the problems may be to some extent overcome, there is still the inherent problem of forcing quantitative analysis upon mainly qualitative/ subjective information.

The Apollo butterfly (*Parnassius apollo*), a flagship invertebrate, prominent on European Red Lists. (Photo © Richard Harrington)

At the European level, small numbers of invertebrate species are listed in the Appendices of the Bern Convention of the Council of Europe (the Bern Convention Invertebrates, BCI´s) and in the Annexes of the Habitats Directive of the EU. These two lists are broadly similar, and a data sheet has been compiled for each species, allowing them to be usefully employed as tools for invertebrate conservation (van Helsdingen *et al*, 1996). However, the lists remain unrepresentative of invertebrate biodiversity in Europe in terms of both the selection and number of species included.

Key actions

2.1 Compile National red lists of threatened species of the relevant main groups of invertebrates, including those rich in sub-species or of high genetic diversity.

2.2 Advance progress in creating European red lists of invertebrates by:

2.2.1 promoting a European synthesis of existing red lists and the (regular) updating and further elaboration of national and sub-national lists of threatened invertebrates;

2.2.2 encouraging standardisation of the application of the relevant criteria;

2.2.3 gaining information of European status of threatened species within each state in order to determine international responsibilities to take action under National Biodiversity Strategies and Action Plans (NBSAP);

2.2.4 prioritising invertebrate groups (taxonomic, functional, service-providing or other) for action on red listing and collate information available (data sheets);

2.2.5 updating information and including further species in the Bern Convention Invertebrates.

2.3 Increase awareness of protected area managers that they are responsible for many populations of rare and declining invertebrate species.

Threats to widespread and abundant species

It is now recognised that the focus on our rarest species reveals only part of the biodiversity decline. While the rescue of known rare and threatened invertebrate species is urgent, an equally or perhaps more serious long term problem is the reduction in abundance and range of many of the more numerous and widespread species. This is as much an expression of overall biodiversity loss as the increasing numbers of threatened species. Populations of any species or community of species, common or rare, often have economic value as providers of ecological services (Luck *et a*l 2003, Losey & Vaughan, 2006) and need to be conserved to maintain those services. Threat to widespread and abundant species is often closely tied to habitat loss, and is likely to be most acute among those species that are associated with specialised habitats or plant species that require traditional management, or that are being destroyed by widespread factors (e.g. drainage of wetlands). Such losses will be unlikely to be detected in red data books, but may appear in changes in distributions of the species if monitored.

Key actions

2.4 Use existing mechanisms to promote the importance of conservation effort for widespread and abundant species.

2.5 Establish a pan-European monitoring programme on some widespread (but specialist) invertebrate species. These species should be associated with specific habitat types (wetlands, dead wood, agriculture abandonment, etc).

2.6 Collate existing information and undertake focussed new research on the provision of services by invertebrates and the economic values of those services.

3. Preventing habitat destruction and ensuring appropriate management

Habitat destruction is undoubtedly the greatest threat to invertebrate animals in Europe and indeed worldwide. Direct loss of habitat, habitat fragmentation and changes in land use and/or management are all detrimental to invertebrate survival and are all well known problems in conservation biology generally.

The idea of heterogeneity over a wide range of spatial (and temporal) scales is the essence of the habitat concept in its modern form (see Box 3). Different organisms perceive and exploit their environment at different scales and it is essential that this be taken into account in conservation management.

Box 3 – Habitat mosaics

Habitats are not single, simple homogeneous areas; they are heterogeneous, dynamic mosaics of patches, nested across a wide range of spatial scales. A mosaic of different habitat patches at the scale of looking out of an aeroplane window – an eagle´s eye view of a woodland, a meadow, a lake – is very different to the habitat mosaic relevant to a beetle that spends its life within a few square metres, but which experiences equally heterogeneous patches of terrain at that scale. Thus mosaics of microhabitats – tiny patches that we, as humans, would normally overlook – are of paramount importance to invertebrate conservation. Within habitat mosaics of any scale, the content of the different patches is clearly important, but this may not always be obvious. For example, an apparently homogenous patch of vegetation may contain areas of different ages or different height structure of the plants, or of different amounts of dead plant matter on the ground. All of these can have relevance to invertebrates` perception of habitat heterogeneity. Even less obvious is that the borders between the patches – whether they are straight or complicated, hard or soft, are of ecological significance to invertebrates (e.g. Haslett, 1994). Indeed a wide variety of mosaic patch parameters are important to conservation, including not only the content and the border complexity, but also their shape, size, contrast, connectivity, orientation, frequency and more (Wiens, 1995). All are relevant to how the different plants and animals exist and interact within the mosaics.

Theoretical aspects of modern landscape ecology and conservation biology have begun to take account of all this complexity, and recent technical advances in geographical information systems (GIS) and remote sensing techniques make the practicalities of understanding and managing habitat mosaic dynamics much easier. Despite this, conservation management of habitats remains mostly large scale and over-simplified. This is inappropriate for the conservation of the majority of invertebrates, terrestrial and aquatic.

For invertebrates, there is a particularly important role of spatial scale in their conservation, because large numbers of species have a small body size, but are also extremely mobile (flying insects, for example). This means that they are required to use a wide range of scales in their daily existence. For example, a bee or a fly may crawl around on a single flower or leaf, or move between plants, or fly kilometres between habitats in a single day. Freshwater habitats present their own suite of problems, both for invertebrates that are entirely aquatic and for those that spend only part of their life cycle in water (see Box 4).

Many invertebrates inhabit freshwaters throughout or during only part of their life, creating complex links between aquatic and terrestrial habitats. (Photo © Thomas Moertelmaier)

Box 4 – Freshwater habitats

Water is essential for all life on our planet, at levels from sub-cellular metabolism to ecological habitat. Human pressures and influences on freshwater habitats, which are already intense, will continue to increase (see Wescoat & White, 2003, for a global socio-economic and environmental perspective). Without immediate action, there will be serious impoverishment of aquatic biological diversity across Europe. Three main types of freshwater systems may be distinguished that are relevant to invertebrate faunas:

(1) the surface hydrographic network (streams, rivers, ponds, lakes, etc);

(2) underground aquifers (water in eroded cavities and caves, wet interstitial spaces between alluvial particles – the ground water, and see Box 5);

(3) the interface between surface and underground (springs and alluvial beds under flowing and still waters).

Box 4 (cont'd)

All may be interlinked and are flow systems, so that change at one place may also affect the system somewhere else.

The animal communities of the surface water habitats are influenced by a complex variety of variables within the water column that may include water current, volume, light intensity and oxygen content. The maximum animal species richness in surface waters occurs in meso-oligotrophic boundary water layers that are well oxygenated and rather cool. Invertebrates are dominant in terms of biomass and species. They have a major role in ensuring vertebrate nutrition and water purification through the filtration, degradation and re-cycling of organic matter.

The animal communities of underground aquifers rely on dissolved oxygen and organic matter in the water and are also composed principally of invertebrates. In deep zones, there is often a high incidence of endemism due to the species' low dispersion potential and to the lack of direct connectivity between many aquifers.

Invertebrate communities of upwellings and springs in central Europe include more than 1500 species, of which nearly a third is specifically associated with these habitats (Zoolhöfer, 1997). Alluvial sediments harbour various invertebrate communities according to the particle size and depth of the alluvium. The higher horizon communities are characterised by the presence of surface water species as well as a unique fauna that cannot survive in deeper sediments or in free flowing water. With increasing depth, surface water species are replaced by the typical fauna of underground aquifers.

The main threats from human activities to the invertebrates of fresh water systems may be broadly classified in three groups:

1) Changes to the physical structure and dynamics of the hydrographic network.

This occurs by human modifications of water systems for drainage, flood protection, erosion control, agricultural, industrial and domestic use of water resources (and related resources such as peat, gravel), hydro-electric power production and others. The resulting disturbances mean that the water network has been greatly altered throughout Europe. Water volume and associated changes to water levels, flow rates discharge reduction or even temporary drying of surface waters, and depletion of below ground aquifers. All of these may have strongly adverse effects on the invertebrate faunas and on the entire ecosystems involved.

2) Physical and chemical changes to the water column

Physical disturbances in surface aquatic systems may considerably increase water turbidity and reduce the depth of the photic zone. Fine particle deposition can plug micro-cavities within the sediment and cause suffocation of the biotic communities. Industrial water discharge may alter ambient water temperature. Boats cause turbulence and unnatural wave action. All of these may adversely affect the invertebrate faunas of the water bodies and/or their edges.

Box 4 (cont'd)

Chemical pollution arises from industry, agriculture, energy production, transport, human waste and other sources. The chemicals invade the surface hydrographic networks and/or the subterranean aquifers. Even if some of these substances are progressively degraded by micro-organisms living in the water, others accumulate and contaminate the habitats of the existing invertebrate communities. Fertilizers in surface waters stimulate algal and phytoplankton growth, which often causes a lowering of water oxygen levels (eutrophication) and associated loss of invertebrate biodiversity. Various groups of invertebrates are well established as sensitive indicators of water quality (e.g. particular species of Ephemeroptera, Plecoptera, Odonata, Trichoptera) and their value in this way must be emphasised, but their presence does not necessarily reflect the ecological quality of the habitat for invertebrate diversity in general.

3) Biological changes

Changes to freshwater invertebrate communities may occur from the invasion, introduction or manipulation of populations of particular organisms. Invasive species pose a major threat to freshwater invertebrates. Extension of navigable waterways and construction of canals linking some large European river basins, together with increased mobility of humans and goods, have led to the appearance of organisms from very diverse origins in fresh-water systems. For example, 30 invasive invertebrate species (3 annelids, 17 crustaceans, 9 molluscs, 1 fly (Diptera) have been recorded in Swiss lakes and rivers (Wittenberg, 2005). Further threats to freshwater invertebrates arise from stocking particular animal populations for commercial aquaculture or for sport angling purposes. This may affect the invertebrate fauna directly through predation, competition for resources or through other species interactions, or indirectly through the parasites and associated disease control measures required to maintain the stocked species.

The freshwater ecosystems across Europe are the main target of the EU Water Framework Directive, which addresses rivers and their catchments, lakes, wetlands, transitional waters, and groundwater ecosystems. The Water Framework Directive deals with both the sustainable use of water resources and conservation and enhancement of freshwater ecosystem biodiversity. However, the approach of the Water Framework Directive is rather different compared to other Conventions addressing biodiversity conservation, such as the Habitats Directive and the Birds Directive and the different Directives may lead to contrasting monitoring systems, restoration targets and measures, all of which may directly affect invertebrate conservation. (Also, see Naiman, 2006 for a more global perspective).

Umbrella or ´blanket` management and spatial scale

One of the main problems with present habitat conservation *per se* is the temptation to adopt a 'blanket` or ´umbrella` protection approach in which a particular habitat, or a group of habitats within an area, is managed at large, 'human' scales (often focussing on the needs of a few birds or larger mammals) in the expectation that this will automatically protect everything under the umbrella. However, the large scale is inappropriate for the majority of the invertebrate species present and for the functioning of the system (e.g. Haslett, 1997). Successful management also requires maintenance of intact mosaics of microhabitat elements. Large, heavy machinery may be convenient in human-scale land management, but it often destroys micro-topography and other aspects of the micro-habitat mosaic. Establishing systems of ´micro-reserves`, with appropriate management, as has been successfully undertaken for some plants (Laguna *et al*, 2004), would be of considerable benefit to small scale conservation requirements for invertebrates.

Important areas for invertebrate protection

In recent years there has been a move to define and formally establish areas of habitat, of variable size, that are recognised to be of priority importance for specific groups of organisms at the European level, irrespective of any formal protection status. Programmes for identifying and managing Important Bird Areas, Important Plant Areas and Prime Butterfly Areas across Europe exist and flourish. All such initiatives aim to conserve their own particular aspects of biodiversity, and are beginning to achieve this aim. All also benefit from significant public interest in the groups of organisms concerned, which lends considerable backing and provides a strong lobby in political circles. The only general, but species oriented partial attempt to list European biotopes important for invertebrates was undertaken by Koomen & van Helsdingen (1993).

Invertebrates are an important cross-cutting issue in this set of initiatives. They are important in the identification and management of important areas of *all* types of organism because of their dominance in both ecosystem function and their contribution to species diversity.

Thus it is essential to determine the extent to which plant areas, bird areas and now also butterfly areas (Van Swaay & Warren, 2003) overlap with the geographical areas and management needs of invertebrate habitats/sites in general. There are also many situations in which areas important for invertebrates may be unique, such as dead wood, exposed riverine sediments, or soft rock cliff coasts (see Box 5). Equally, it is essential to identify ´hotspots` of invertebrate biodiversity in Europe (see Box 6).

This integrative approach to invertebrate habitat conservation will require international manpower and financial backing, but would greatly save on the ´doubling up` of uncoordinated conservation effort between organism groups. It will require that workers ´on the ground` as well as policy makers recognise such overlapping interests and act upon the implications for practical management.

Box 5 – Examples of overlooked habitats important for invertebrate biodiversity conservation

There are various situations in which the presence and/or importance of the invertebrate fauna and its conservation are not immediately apparent, often because they are not clearly associated with plants, birds or other larger animals, so that the need for specific conservation effort for invertebrates is not recognised. Examples requiring particular attention include:

Underground habitats

Underground habitats comprise any cavity of any size (e.g. cave, lava tunnel, fissure and drain network, or interstitial microspaces in the alluvium) that offers potential living conditions for underground terrestrial or aquatic species (Juberthie, 1995). Characteristics of such habitats are, among others, absence of light and photoperiod, stable, moderate temperature range and, when not aquatic, high relative humidity. The recognition of different spatial scales in the definition is particularly relevant to invertebrates, in that underground is not limited only to caves that are penetrable by humans, but also includes a micro-world of spaces within rock including the superficial underground environment which is in contact with the lower soil horizons. Thus underground habitats in their entirety form nested mosaics of patches exhibiting varying degrees of connectedness across a wide spectrum of spatial scales, just as in above-ground landscapes. The invertebrates that occur in these habitats live and evolve mostly without, or at most with very limited relations to plants. The long-term stability of habitat conditions has led to high levels of endemism, over a wide spectrum of evolutionary time scales. Various crustacea dominate in most aquatic situations, while insects usually predominate in terrestrial habitats. There are also molluscs, spiders, harvestmen, myriapods and many others. All may be truly troglodytic, or may have infiltrated from the soil or sediment layers.

The main threats to underground invertebrates are the threats to their habitats, and include physical destruction, excessive visitation and/or tourism in caves with associated lighting, trampling, vandalism and pollution problems. At least equally important, but less obvious are threats from chemical pollution, water abstraction and alterations to water courses and quarrying activities.

The importance of, and the threats to the invertebrate fauna of European underground habitats has been highlighted by Juberthie (1995) and is formally recognized in Recommendation No. 36 (1992) of the Standing Committee of the Bern Convention, which states that Contracting parties should \`identify underground invertebrate species requiring special conservation measures and draw up lists of such species for protection´. This task remains to be completed.

Labile habitats

There are many instances where natural physical forces and conditions cause considerable disturbance, movement or other change to the substrate. Examples include soft rock coastal or inland cliffs and slopes. scree slopes, permanent

Box 5 (cont'd)

avalanche tracks and river and stream beds, as well as their edges and sediment deposits.

In common with short-term ephemeral habitats, these areas are usually dominated by early successional (pioneer) communities of plants and animals, often with considerable amounts of bare substrate. These habitat mosaics contribute greatly to invertebrate diversity. Appropriate management to conserve mosaics of early successional habitat patches across different spatial scales, with links to other patches of similar habitat is a crucial aspect in maintaining invertebrate biodiversity.

Box 6 – Invertebrate hotspots

Biodiversity is spatially unevenly distributed, and biodiversity ´hotspots` have been defined and interpreted in a variety of different ways in attempts to identify priority areas for conservation. The mechanisms by which such patterns have occurred remain controversial, but this is not greatly relevant to understanding conservation priorities. Areas with high numbers of endemic species or total numbers of species, or of threatened species have each been used alone or in various combinations to attempt to identify areas of greatest conservation importance. Unfortunately invertebrate animals have been left out of the equation on most occasions (e.g. Myers *et al*, 2000). This omission has severe consequences for the general conclusions drawn from plants, birds and mammals, because invertebrate hotspots do not necessarily coincide with those of other organisms, but yet invertebrates constitute the greater part of biodiversity, whatever way it is measured. Identification of hotspots for invertebrates in Europe and close examination of how these relate to hotspots for other organisms must be given top priority. There is presently a lack of quantitative studies in this direction globally, but particularly in Europe. Only with such information can the necessary strategy of complementarity of approaches to defining and protecting hotspots be achieved as (correctly) envisaged by Samways (2005). This particularly under a situation of climate change, which has the potential to alter considerably the present patterns and future conservation requirements. Also, even today, many known invertebrate hotspots lie outside presently protected areas – conservation strategies will need to be even more spatially flexible in the future. Some types of areas may be highlighted that are particularly worthy of attention as invertebrate hotspots at the European level:

Mediterranean ecosystems

For invertebrates, particularly arthropods, the Mediterranean area is the richest in Europe in terms of numbers of species. About three quarters of the total European insect fauna is concentrated within the Mediterranean Basin (Balletto & Casale, 1991) and the discovery of species new to science continues (see Box 2). This species richness follows the general latitudinal pattern of increasing diversity from north to south.

Endemism is also high in Mediterranean ecosystems, – up to about 30% of species in some situations. However, Mediterranean-type ecosystems have been strongly affected by humans, and human presence has been rapidly increasing, particularly during the last 5000 years. Many areas, particularly islands are strongly under pressure from tourism, and invertebrate faunas of highly frequented areas such as sand dunes have to compete with human activities. Small wetlands harbouring many endemic species are also under threat as water is being polluted, removed for drinking and irrigation or simply left to flow to the sea when the vegetation is cut to create human habitations.

Even with present major pressures from human activities, the essential functional roles of invertebrates in these ecosystems has not been appreciated or taken into account in land planning and management.

Oceanic islands

Islands are well known to harbour specific and characteristic invertebrate faunas arising from evolutionary patterns created by varying degrees of isolation in space

Box 6 (cont'd)

and time. Island faunas appear to be more sensitive to environmental change and more prone to extinctions than continental ones (e.g. Howarth & Ramsay, 1991). Invertebrates on European islands and especially those of the Mediterranean show a very high degree of endemism. For many groups of insects, endemism on Mediterranean islands may reach 15-20%. At the same time, the increasing pressure of humans is threatening insular faunas at levels often much higher than on the mainland, as a result of the concentrating effect of limited space.

Mountain regions

Mountains are characterised by their extreme spatial heterogeneity, offering complex, nested mosaics of habitat conditions over a wide range of scales (Haslett 1997). These harbour an immense diversity of invertebrates, even though there is a general trend of decreasing numbers of species with increasing altitude. The invertebrate faunas of the highest parts of European mountains often exhibit high levels of endemism – up to 20% for some invertebrate groups in certain areas. This is due, at least in part, to the isolation of populations, in many ways similarities to island situations. Under a changing climate, there will be a tendency for species to migrate upwards, so that mountains provide a refuge for many species, but exhibit high extinction risk for species at high altitudes where their `climate space` is reduced or runs out (see Introduction).

Mountains such as the Alps are important centres of invertebrate biodiversity. (Photo © Thomas Moertelmaier)

Protected areas – policy and networks

Every country in Europe has a system of protected areas, supported by agreed international frameworks such as the Ramsar Convention and the EU Habitats Directive (see Appendix I). Yet the geographical distribution and biological representation are uneven. IUCN categorises protected areas by management category, with six categories defined with increasing levels of intervention. Within Europe, IUCN has also identified a strong marketing approach and clear audits of management efficiency as two important ingredients for improving conservation in protected areas.

Networks and corridors for protected areas

Conservation areas need to form a vast interconnected network across Europe, rather than be thought of in isolation. This requires adequate government policies on protected areas. The initiatives of Natura 2000, The Emerald Network, World Heritage Sites, Biosphere Reserves, Ramsar Sites, the CBD, and designations of protected areas that are not legally binding are doing much to define the size and extent of the network, which should exhibit a high degree of connectivity through measures such as linking corridors and 'stepping stones' between core areas. Habitat restoration may be necessary in key areas to achieve this, and it will help facilitate the spread of invertebrates and other organisms in response to climate change. However, for invertebrates, there is concern that the spatial and temporal scales appropriate to the animals impose restrictions to corridor efficiency as the promotion of directional movement of individuals may be much less than expected.

In Europe the connectivity approach has emerged in the concept of the Pan-European Ecological Network (PEEN), part of the Pan-European Biodiversity and Landscape Diversity Strategy (PEBLDS). Ministers from 54 countries in the UN-ECE region endorsed the proposal to establish PEEN by 2015. Realisation of the Natura 2000 network and the Emerald Network has contributed greatly in the establishment of PEEN, as well as other regional treaties and initiatives.

Key actions

3.1 Promote enhancement of existing important area schemes by taking greater notice of invertebrates and their functional roles in different habitats and ecosystems.

3.2 Promote identification of important invertebrate sites and hotspots in Europe.

3.3 Promote the establishment of small scale protected area schemes, including micro-reserves, to aid conservation of the many rare and threatened invertebrates and invertebrate habitats that are confined to extremely small areas.

3.4 Improve understanding and improve the efficiency of ecological corridors for invertebrates across Europe`s protected areas.

3.5 Evaluate and build upon the existing framework of Prime Butterfly Areas in Europe to maximise their relevance to the protection of other invertebrate groups.

3.6 Promote restoration and management programmes for fresh water and wetland habitats to benefit the invertebrate faunas, paying particular attention to counter-acting the effects of (1) physical destruction of and alterations to the habitats, such as channelling waterways and drainage, (2) changes to water flow and discharge rates (3) pollution, including heat pollution.

3.7 Promote best practices for the sustainable use of all water resources, including underground aquifers, while taking the interests of the invertebrate fauna into account.

4. Indicators and monitoring

The task of identifying areas of Europe that are important for the protection of invertebrates - whether they be large, small, or very small – and how to define the criteria employed to make such decisions, are central to invertebrate conservation effort. There are too many invertebrate species to attempt to make most area appraisals taxonomically universal, so indicator groups (surrogates) must be sought, tested and engaged. These groups should provide representation of the general invertebrate biodiversity value of any particular area, reflecting the composite picture. Information obtained about the indicator species can then be used for making informed conservation decisions (Samways, 2005). However, this poses some problems. By definition, employing the indicator/surrogate approach automatically involves the idea of ´umbrella` or ´blanket` management for conservation discussed in Section 3 above.

It is all too tempting to ´decide` that a particular taxonomic group or an accepted rare or endangered group of species should be used as overall indicators, and to advertise them as such. But there is a range of biological, practical and socio-political factors that make selection of indicator groups more complicated. Although public acceptance, rarity and even ease of recognition (identification) are all very important, full representation of the spectrum of ecological functional roles is essential. A single surrogate group is insufficient to reflect the situation for many other groups of organisms unless a wide range of ecological roles and functions is incorporated (as, for example, in the case of hoverflies (Diptera: Syrphidae), see Box 7) and rare or endemic species may be overlooked.

There is also the question of choosing the right selection of species for different habitats. National Biodiversity Strategies and Action Plans (NBSAPs) priority habitats require lists of not too rare invertebrates to be able to monitor whether maintenance/enhancement/restoration has been successful. If the species used are too rare few sites will have them, and/or numbers will be too small to interpret trends.

For invertebrates, the indicator approach is unavoidable, but the inherent difficulties must be recognised and allowed for in any practical application. In the end, there is no single solution to the problem, and indicators must be selected from those available according to the area considered and the specific conservation aims.

Box 7 – Syrph-the-Net: A prime example of an indicator group and its usage

The Syrph-the-Net (StN) database of European hoverflies (Diptera: Syrphidae) provides digitised information on the distributions, biologies and habitat associations of the majority of European species (about 600 from an estimated

Box 7 (cont'd)

European total of around 800 species), and has been updated annually since 1997 (e.g. Speight *et al*, 2005). Syrphids happen to be a particularly acceptable group of insects as indicators of the biodiversity value of any particular area, being both attractive and with an unusually extensive range of larval and adult biologies and habitats, accessible to determination and with a significant volume of information available about the species. An innovative attribute of Syrph-the-Net is that it acts as a predictive model against which to judge the intactness of the fauna for the habitats and geographic area under consideration. The database may be employed at different spatial scales, from single site to region (Speight & Castella, 2001). Thus the concept allows assessment of both faunal status and status of habitat. As such it functions as an "expert system" (Speight, 2005) permitting evaluation of present site quality and providing a basis for future monitoring, whether assessing site management success or monitoring environmental quality generally.

Assimilated information on other groups of invertebrates is as yet rarely comprehensive enough to support such a digitised database, though the situation is gradually improving at European scales (Falkner *et al*, (2001) on gastropod molluscs) and more locally (Gittings and Bond, (in press) on noctuid Lepidoptera).

Further development of this type of methodology, using other carefully selected indicator groups, would provide a sound basis for the general incorporation of invertebrates in processes of identification and management of areas of biodiversity value.

Key actions

4.1 Identify and establish a palette of ´indicator groups` of invertebrates that reflect the biodiversity and the full range of ecological functions of the existing faunas of different habitat types. To do this will require clear definition of criteria for selection such that indicator groups will usefully supplement existing ´rare` species indicators already in use.

4.2 Test the efficacy of different indicator groups for different habitat types and situations.

4.3 Promote the use of invertebrate indicator groups and ensure that they are correctly engaged in biodiversity and habitat conservation issues throughout Europe.

4.4 Undertake focussed research to establish the degree of correlation between invertebrate protection using invertebrate indicator groups and established important area schemes for other organisms.

Monitoring

Once indicator groups have been established for any given situation, monitoring is essential to recognise and understand changes in invertebrate diversity over time. In order to promote and facilitate collaboration in monitoring and use of indicators for reporting on Europe's biodiversity, the

European Biodiversity Monitoring and Indicator Framework (EBMI-F) has been developed within the framework of PEBLDS implementation.

Changes in the threat status of a species can only be efficiently assessed by monitoring changes in its numbers and in distribution. This is lacking at the international level for most invertebrate groups, and although a few European countries have good monitoring schemes, most do not.

Key actions

4.5 Ensure that the invertebrate species on international red lists and in international treaties such as those in the Appendices of the Bern Convention and the EU Habitats Directive are the subjects of efficient, co-ordinated and standardised monitoring across Europe.

4.6 Set up standardised monitoring schemes for selected widespread and abundant species across Europe (see Section 2 of this Strategy).

4.7 Review availability of electronic databases of species distributions in general at national and international scales, and establish a means of integrating the information.

5. Invasive alien species

Invasive Alien Species (IAS) are those species that have been introduced outside their normal current or past range, and whose introduction and spread cause harm to human health, the economy, and/or the environment. (This, and other definitions of terms relating to IAS in the present document, are as given in the relevant Guiding Principles of the CBD). IAS may have been introduced accidentally or intentionally, (but do not include species responding naturally to climate change) and they may be plants, animals, fungi, bacteria, blue-green algae, or viruses. They pose strong threats to invertebrate and plant biodiversity, and to the habitats of all organisms.

Our knowledge of how invasive species may affect invertebrate diversity and conservation in Europe, or indeed globally, is minimal. Invasive plants may alter the physical structure of the habitat and/or the variety and availability of food or other resources. Possible time-lags between invasion and impacts make the problem long term for invertebrates. The pressures may arise in the future from both new invasions and the emergence of previously latent species.

There is even less information on how invasive vertebrates may impact upon invertebrate diversity. The effects may be direct, such as by eating invertebrates, or indirect by altering the habitat.

Rates of introduction of invertebrate species to and within Europe through human actions are thought to be high, though not all species necessarily establish populations. There is little documented information on the effects of invasive invertebrates on other invertebrate species. One issue of concern is the risk attached to classical biological control of pests or weeds, in which particular invertebrate species or invertebrate pathogens (fungi, bacteria, viruses) are purposefully introduced to an area. Here there is some evidence that non-target invertebrate species may also be attacked. Thus there is a trade-off between the economic benefits of the pest control against the risks associated with the introduced control agent.

One promising avenue of future research in this direction is exemplified by the harlequin ladybird beetle *Harmonia axyridis*. This species is native to central and eastern Asia, but has been introduced to Europe and other parts of the world for biological control of aphids and other plant pests. It arrived in Britain from continental Europe in 2004, and the situation is being used to monitor the spread and ecological impact of this invasive alien species (Majerus & Roy, 2005).

Potential effects of invasions by Genetically Modified Organisms (GMOs) remain highly contentious for all organisms. For this reason the present Strategy does not include discussion of GMOs and their specific relevance to invertebrate conservation.

The Harlequin ladybird beetle (*Harmonia axyridis*), an invasive alien species in Europe. (Photo © Ian Woiwod)

Further discussion and examples of all of the above issues involving invasive species, in specific relation to insects worldwide, is provided by Samways (2005).

The Global Invasive Species Programme (GISP) suggests measures are needed to predict, prevent and control problem species. IUCN has stated a prime guiding principle: that the prevention of introduction of the invasive species is the cheapest, most preferred option and should be given highest priority. At the European level, through the Bern Convention the Council of Europe has developed a European Strategy on Invasive Species that is within the framework of the CBD (Genovesi and Shine, 2004).

Key actions

5.1 Provide active support for the implementation of the European Strategy on Invasive Alien Species on all issues directly concerning invertebrates. This will involve identifying how invertebrates are affected by invasive species of any type and how invertebrates themselves contribute to the problem.

5.2 Compile a register of invasive species that have already significantly negatively affected invertebrate biodiversity and conservation.

5.3 Undertake risk analyses in situations of new threats to invertebrates from invasive species.

5.4 Promote the screening of organisms intended for biological control introductions for their effects on non-target invertebrates.

6. Reversing the effects of intensive agriculture and forestry, and of industry and urbanisation

Agriculture

Agriculture has a massive effect on invertebrates and their habitats. Farming accounts for 60% of the land surface of the European Union and of Central and Eastern Europe (Planta Europa, 2002), though the proportion is much less in Scandinavia and northern Russia, where forestry predominates. Modern farming practices are harmful to invertebrate diversity, destroying many habitats. In particular, the trend towards large scale intensive farming has destroyed many small habitat ´islands´, both terrestrial and aquatic. The effects of intensive use of pesticides, fertilizers and herbicides damage farmlands and affect neighbouring land and water systems (see Box 8). Farm subsidies have often proved detrimental to many aspects of nature conservation in Europe, and an important hidden effect of subsidising crops is to increase water demands and change water courses.

The apricot blossoms may look pretty, but use of pesticides and lack of more natural vegetation make this landscape in Greece unsuitable for most invertebrates. (Photo © Robert Paxton)

Box 8 – Pesticides and invertebrates

Chemicals have a long history of widespread use against invertebrate pests, particularly insects, mites, parasites and against the plants or fungi upon which many invertebrates depend. Environmental and conservation problems arise because the substances used are normally toxic to a wide range of organisms (including the natural enemies of the pests) and they persist over time, often accumulating in food webs and spreading from land into water systems. Also, the chemicals may directly affect the structure and chemical characteristics of the soil. This persistence of the toxic impact is critical to invertebrates and to the entire food web. Further, chemical application is often inexact, or careless, despite many technological advances in spraying and other application techniques.

The effects of pesticides and other chemical agents may be direct, acting as toxins to non-target species and causing death or, more subtly, reducing their overall fitness. This may in turn cause indirect effects by upsetting species interactions (e.g. predator/prey, interspecific competition), leading to instabilities within invertebrate communities and upsetting the balance of ecosystems. All this even though modern Integrated Pest Management (IPM) aims to control pest populations underneath thresholds, rather than totally exterminating the target species.

Systemic pesticides such as avermectins are widely used to control parasites of cattle and other livestock. This presents its own suite of problems as the vetinary substances are toxic to dung faunas and the effects can be rather long lasting, particularly if the drugs are administered in slow-releasing bolus form. Resulting reduced rates of dung decomposition represent a significant loss of ecological service provision, with adverse economic consequences including decreased dung burial, increased fouling of forage vegetation, and reduced mobilisation of nitrogen reserves (Losey & Vaughan, 2006). Systemic herbicides create a different but parallel set of problems for phytophagous invertebrates.

Thus the problems for invertebrate conservation associated with the use of pesticides and other chemicals for controlling particular target species are complex. The effects of the chemicals may be adversely synergistic with many other factors, from fertilizer input to habitat fragmentation or the presence of invasive alien species (Samways, 2005). This entire suite of issues is interlinked with economic and environmental parameters that spread throughout the food web.

Given that projected increases in pesticide usage may be 270% compared with present levels by the year 2050 (Tilman *et al*, 2001), it is of utmost importance that their effects on non-target invertebrate biodiversity be understood and controlled. Genetically modified crop plants also act to prevent pest outbreaks, but their effects on invertebrates in this way, and in comparison to chemical pesticides, remain unknown.

Some farmland is of intrinsic conservation value as its flora, fauna and landscape depends on the continuation of low intensity, often traditional farming practices (e.g. mountain agro-ecosystems). Abandonment of this kind of extensive farming is perhaps one of the greatest causes of loss of previously common invertebrate animals and plants in Europe. Often the landscape undergoes successional change towards woodland because of the lack of traditional management. At the other extreme, intensification of farming practices exterminates biodiversity and turns such areas into ´green desert`. Designation and management of set-aside land could do much to aid invertebrate conservation in such circumstances. Set-aside is only useful if there is continuity of habitat availability (see Box 9 on Swiss policy) and the field edges concept is one of the better options. Also, set-aside must not be sprayed with herbicide, or subjected to drift from pesticide application.

Agricultural policy

The Common Agricultural Policy (CAP) of the European Union is of decisive importance within the EU and increasingly in the accession States. EU policy also has a great effect on non-EU States through its effect on farm prices and through its assistance programmes.

The view that farming and nature conservation can be compatible is not being communicated efficiently. It is essential for conservation of biodiversity in general, and particularly invertebrate conservation, that biological and landscape biodiversity interests be integrated with polices for sustainable agriculture in Europe (see Bacon, 2001; Council of Europe, 2002). It is also of paramount importance that money is made available, for example through re-direction of previous farm subsidies within the EU; for conservation purposes in agro-ecosystems that benefit the maintenance of invertebrate biodiversity. Financial support for set-aside land must be one of the top priorities and the time periods of this support must be realistic for continuous, long term conservation. Continued agricultural reforms that integrate environmental concerns are to be commended (see Box 9 for the example of Swiss agricultural policy).

Box 9 - Swiss Agricultural policy

In Switzerland the authorities responsible for the protection of agriculture and the environment introduced an `ecological compensation´ policy in 1993 as a tool to aid conservation of wild flora and fauna on agricultural land.

The scheme is compatible with international agreements ratified by Switzerland, and to receive financial contributions, Swiss farmers must assign 7% of their usable agricultural land to the *surfaces de compensation écologique* (SCE). Fifteen types of SCE have been defined. These are either natural environments exploited in an extensive manner (for example meadows and pastures, hedges, fallow ground) or elements characteristic of the local rural landscape (for example dry stone walls, orchards of high-stem fruit trees).

The aim is to preserve and increase the diversity of the wild flora and fauna within agricultural land. To do this it was considered necessary to have 10% (about 65 000 ha) of the usable agricultural land in Switzerland designated as SCE. This would

Box 9 (cont')

safeguard and allow restoration of natural environments and conserve typical elements of the traditional agricultural landscape.

Although the 10% land area objective was achieved in 2001, the SCE registered land rarely provided the desired biological diversity and the sites were found not to provide the expected faunistic and floristic flow of organisms between other natural environments. As a result, a new legislative instrument, the federal ordinance for ecological quality (OQE) was installed in 2001.

The OQE supports biological quality and the networking of the SCE by offering each of the Cantons the possibility to adapt the minimal requirements endorsed by the Swiss Confederation to the realities of the field situation. Thus financial compensation is provided only with a proven level of biological diversity.

The ´biological quality` section of the OQE grants compensation for SCE areas which fulfil requirements such as presence of particular plant species or structural elements favourable to a specialized fauna (birds and insects in particular). The Swiss Confederation has fixed the minimal requirements to which the SCE must respond by preparing lists of plant species and structural criteria within each SCE type. These have been subsequently adapted to the local needs of the Cantons.

The `network´ section of the OQE encourages projects in which the site and the SCE types are chosen according to precise biological objectives. Animal and plant target species are selected and the sites allocated to the SCE so that the target organisms can live, feed, reproduce or spend the winter there. Financial compensation will be given only if all the conditions necessary for the selected species are implemented together. The participation of the farmers in either the biological quality or the networking sections is voluntary but the land must fulfil the requirements for a minimum of 6 years.

The OQE has proved to be a successful instrument. The flexibility given to those who ensure its application, (i.e. the Cantons and those concerned with the realisation of the networking projects) creates a close working relation among all parties and adaptation to the biological realities of field situations. The flexibility of the criteria of the network section also makes it possible to combine effort with other landscape or natural resource protection projects.

The payment of contributions on the basis of the proven ecological quality of agricultural land is a targeted and effective investment of public finances and is to be encouraged. Farmers` participation in the OQE is a service of public interest supported by the farming industry. Education and public awareness may be efficiently communicated to improve the image of agriculture among a human population that is increasingly concerned with environmental health. In short, the successful implementation of the Swiss scheme means that a functioning mosaic of habitat patches is created within agricultural land that supports wild populations and communities of invertebrates and other organisms.

For further information see http://www.blw.admin.ch/themen/00005/00044/index.html?lang=de (in French and German).

Key actions

6.1 Actively support initiatives directed at farmers, foresters and gardeners to use less pesticides and herbicides and add invertebrates to the botanical arguments to reduce use of herbicides.

6.2 Promote integrated pest management and organic farming methods to reduce use of pesticides by farmers and gardeners.

6.3 Provide data on the decline of invertebrate species in farmland.

6.4 Actively support the conservation networks working for agricultural change.

6.5 Support the work of relevant agencies (e.g. farming and wildlife advisory groups) to help them reduce the damage to invertebrate communities on agricultural land.

6.6 Engage the public and organisations to promote environmentally friendly farming, including the continuous support of set-aside conservation land.

6.7 Take appropriate action to improve the temporal stability of national and European policy regarding the designation and management of set-aside land.

Forestry

More than 40% of Europe is forested (Planta Europa, 2002) but the proportion of forested land varies greatly from one country to another – from about 1% closed forest in Iceland to 60% in Finland. However, just about all European forest is secondary vegetation that has been subject to human interference for thousands of years. Only a few tiny fragments of primordial forest still exist in Europe. These fragments are of the greatest value for invertebrates, especially for the saproxylic species (see Box 10).

Now, the extent of forest in Europe is increasing as marginal land is abandoned and reverts to scrub and woodland. Moreover, there is now a great trend to plant trees (often non-native or otherwise inappropriate species) rather than let trees regenerate naturally in the landscape.

Forest management differs greatly across Europe. In the Atlantic seaboard countries with little remaining forest, afforestation on moorlands, heathlands, raised bogs and other valuable habitats has been a major threat to biodiversity. In Scandinavia and France, most natural and semi-natural woodlands have been converted to more intensive production forests. In the Mediterranean region, forest fires and grazing continue to devastate forests. In Central and Eastern Europe, forests have suffered particularly from air pollution, as well as from conversion to monocultures, although there are also long-standing traditions of ecologically beneficial forest management.

Spruce (*Picea abies*) forest monocultures greatly reduce invertebrate biodiversity and promote pest outbreaks. (Photo © Patrick Gros)

Much of the present forest land is intensively managed, often for non-native and/or coniferous species in plantations, and the crop of trees that results, usually of a single species all of the same age, is of little biodiversity value. Forest hygiene practices such as removing dead wood removes the habitat for the whole spectrum of saproxylic invertebrates, many of which are rare and which maintain the essential ecosystem function of recycling (Speight, 1989, and see Box 10). Similarly, forests that are managed without maintaining understories of shrubs and ground vegetation or those that lack patches of open habitats (e.g. a clearing arising from the fall of a single tree, or open areas created by the extensive grazing activities of large herbivores) also removes the heterogeneity of the habitat mosaic necessary for the survival of many invertebrate species, particularly those that have complex life cycles and occupy a number of different ´partial niches`. Maintaining the dynamic, open-mosaic nature of forests is essential for invertebrate conservation, particularly saproxylic species, and must be a central aim of woodland conservation policy and practice (Alexander, 2005).

A highly structured near-natural mixed woodland provides the mosaic of habitats necessary for high invertebrate biodiversity. (Photo © Patrick Gros)

In drier forest areas of southern Europe wildfires are a normal aspect of forest ecology, directly affecting the distribution and abundance of many plant and animal species, particularly invertebrates. Now forest fires are becoming more frequent as a result of human activities. Also, under a changing climate, there are likely to be changes to wildfire regimes that increase the amplitude and duration of extreme fire weather. Presently, little or no account of this is taken in forest conservation legislation.

Sustainable forest management (which is very different to sustainable wood production) is the better alternative. Many countries are now beginning to take measures to create more natural forests and the protection of large semi-natural forest areas as National Parks is a positive sign.

Presently, intergovernmental commitments and processes on forests, such as the Ministerial Conference on the Protection of Forests in Europe and its associated Pan-European Work Programme take little or no account of the requirements of invertebrate conservation.

Box 10 – Saproxylic invertebrates

Saproxylic organisms are those that are dependent, at some part of their life cycle, upon the dead or dying wood of moribund or dead trees (standing or fallen) or upon wood-inhabiting fungi, or upon the presence of other saproxylics (Speight, 1989). These organisms play an important role in recycling dead, woody tissue through the ecosystem, much of this activity occurring in dead wood still attached to living trees, before it falls to the forest floor. Unfortunately, forests with old trees are not always of intrinsic botanical interest and their importance to maintenance of saproxylic biodiversity is not reflected in habitat definitions. Since attention was drawn to the plight of European saproxylic invertebrates by Speight (1989), their significance has been recognised as indicators of forest quality and as a functional group important in forest dynamics. Many species are now under threat at the European level and a few, such as the beetles *Osmoderma eremita* and *Limoniscus violaceus*, have gained prominence through inclusion in the lists of the Bern Convention and Habitats Directive. However, there are thousands of saproxylic invertebrate species in Europe, few of which can survive in commercially managed forests. Protocols have now been published that aid in maintenance of old trees (Read, 1999) and exemplify methods for increasing the availability of dead-wood micro-habitats (Cavalli and Mason, 2003).The effects on management of forests maintained primarily for commercial exploitation has so far been largely restricted to achieving an increase in the quantities of cut timber left on the forest floor. This is helpful in northern parts of Europe (Martikainen, 2000), but further south, particularly in the Mediterranean zone, the situation is more complicated. There are indications that most saproxylics in these regions are associated more with ancient, living trees than with fallen, dead wood (Speight and Good, 2003). Also, there is the need to minimise risk of forest fires and dead wood on the forest floor becomes an unacceptable hazard. Here the rich fauna of saproxylic invertebrates remains extremely threatened and cannot survive without the specific protection of ancient, living trees.

Recommendations from recent symposia on European saproxylic organisms (Hardersen *et al*, 2003; Blondel, 2005) identify specific objectives for their protection. These include the need to protect old trees wherever they occur, the establishment of extra protected forests explicitly for conservation of saproxylic organisms, particularly where `hot-spots´ of saproxylic diversity are known to exist, the establishing of European red lists of a wide range of saproxylic invertebrate taxa, the compilation of databases of information on the red-listed species and the increase of awareness of Europe's resource of saproxylic invertebrates among forest managers and in the wider community. As yet, almost no attempt has been made to make information about saproxylics available to the non-specialist - they still remain largely hidden from the public.

Saproxylic invertebrates require dead wood, often at a specific stage of degradation, for their survival. (Photo © Thomas Moertelmaier)

Key actions

6.8 Promote management to maintain a dynamic, heterogeneous mosaic structure of European forests, that also includes open areas, for maintaining the diversity of invertebrates and other organisms, including:

- 6.8.1 increasing the diversity of species and age structure of native species of trees in forests;
- 6.8.2 maintaining a complex vertical structure of forests by keeping native shrub and ground level vegetation;
- 6.8.3 leaving fallen and standing dead wood in place;
- 6.8.4 revising mowing regimes of woodland tracks and borders to ensure that invertebrates can complete their life cycles;

6.8.5 avoiding application of chemicals in forests, both as biocides or fertilizers.

6.9 Encourage forest managers to adopt more multiple use policies in all forestry operations, remembering that invertebrate requirements do not always co-incide with those of other organisms.

6.10 promote the maintenance of flood plain woodlands and other wet forest types that may be at risk from drainage.

6.11 Co-operate with other organisations to promote sustainable forest practices.

6.12 Encourage forest managers to ensure that new afforestation does not occur on non-wooded land of high value for invertebrates and that native tree species are not replaced by other species.

6.13 Adapt policies in Mediterranean forests to the fact that fires will occur.

6.14 Take initiatives to direct attention to the importance of saproxylic invertebrates in the forestry agenda by highlighting the Council of Europe´s report (Speight, 1989).

6.15 Promote awareness among forest managers as to the importance of micro-habitats for forest invertebrates, particularly saproxylic species.

Town and country planning, industry, transport

Land-use planning is particularly important in Europe because of the great pressures on the land for agriculture, industry, transport, energy, recreational activities and other uses. Some countries have strong traditions of planning, resulting in a firm delineation between town and country, whereas others have a relaxed approach, often with devastating visual and ecological effect. Even where countries have effective land-use planning systems in place, implementation can be difficult and is often jeopardized by strong political and other pressures.

In towns and cities, the planning framework can encourage an invertebrate-rich environment by emphasizing the need for human settlements to be part of the balance of nature. Urban gardens and parks can be important habitats and refuges for invertebrates. In rural situations planning can provide for or destroy the bulk of invertebrate conservation. The demands of recreational activities and tourism often conflict with conservation interests. Paradoxically, it is usually the healthy functioning of the ecosystem that is the basis of the aesthetical appeal in the first place, and this service is dependent upon the invertebrates, in both terrestrial and aquatic environments throughout all seasons of the year. Mountain regions provide one of the more important examples. These areas consist of particularly complex habitat mosaics that are important for invertebrates and are extremely vulnerable to human influences over a wide range of scales. Ski-runs, lifts and the associated mass tourism now adversely affect just about all the mountain regions of Europe, including Mediterranean mountains. Invertebrate diversity is strongly reduced by such activities (e.g. Illich & Haslett, 1994; Haslett, 1997).

Skiing causes severe “trampling effects”, only visible when the snow has gone, that are detrimental to the fragile mountain vegetation and its associated invertebrate fauna. (Photo © John R. Halsett)

The need for sustainable development with relation to invertebrates is paramount in this and many other situations involving recreation and tourism, and must be fulfilled to meet the requirements of the CBD.

Industry has two main impacts on invertebrate diversity and abundance: damage from pollution, (which may also induce melanism in some species) and direct physical damage to the biological landscape by using space for buildings or for mining and other extractive industries, or by over-use of water resources.

Invertebrates may be directly poisoned by industrial pollutants and by human or agricultural effluents or, more commonly in terrestrial environments, affected by the ill-health of the vegetation. The European Commission's annual 2000 report on Europe's trees concluded that only a third of Europe's trees are healthy. It found an improvement in western and central countries but a deterioration in the Mediterranean region, where defoliation of nearly all tree species has increased considerably. Pollution is the cause. There are clear implications for invertebrates that rely on the trees for food or living space. Similar arguments hold for invertebrates associated with any other types of plants subjected to stress from the environment. In aquatic situations industry has the added effect that many factories take up vast quantities of water, and may increase the temperature of used water resources.

For nocturnal invertebrates, particularly night-flying insects, there is a new and important threat from the increasing levels of lighting in towns and also in the countryside. This is becoming particularly significant in cases of advertising or commercial light shows that take place in otherwise near natural areas.

Equally, artificial lighting in underground habitats is a major threat to the invertebrate communities of these habitats.

Increasing energy requirements and associated alternative energy sources further add to land planning problems that may affect invertebrate conservation interests. For example, wind farms, a known risk for birds (Langston & Pullan, 2004), are a potential but presently unresearched physical hazard for the many wind-borne invertebrates (Badmin, 2005). Equally, production of plant-based fuels requires that large areas be given over to monocultures of the relevant plants (e.g. rapeseed or maize) thus exacerbating the existing problems related to agro-ecosystems.

Protected areas and important invertebrate sites sometimes coincide with areas that are also of value to mining and other extractive industries. Modern Europe requires vast amounts of fill for roads and limestone for concrete and cement. Inevitably some of the land being removed previously had rich invertebrate biodiversity. Substrates rich in minerals are naturally attractive to the mining industry but usually support a unique and endemic fauna and flora.

Transport has an increasing negative impact on natural habitats and biodiversity (Bickmore, 2003; de Sadeleer *et al* 2003). Many of the most contentious issues in conservation over the last decades have been over road schemes, which, by avoiding towns and villages, all too often interfere with more natural areas. Increasingly, too, the new high-speed railways are detrimental to landscapes because of their need for new track alignments that are level and straight. Often, the damage done to natural sites, and especially protected areas, is ignored or under-estimated in the planning of transport infrastructure. The needs of invertebrates are generally not considered. Transport routes can also be a physical barrier for many invertebrates, further fragmenting their habitats and landscapes. Also, the extent and significance of the cull of invertebrates that occurs from collisions with windscreens or fronts of cars, trucks and trains remains unquantified. Such direct damage to invertebrate populations is likely to be of particular significance where transport routes traverse areas of particular conservation value for these animals.

Key actions

6.16 promote biodiversity-friendly engineering practices such that habitats, including micro-habitats, are created rather than destroyed.

6.17 Influence town and country planning processes by ensuring that government agencies aid interpretation of legislation and influence wording of ministry guidelines.

6.18 Promote and develop the inclusion of invertebrates in ecological and environmental impact assessments.

6.19 Support and use existing mechanisms for highlighting red-listed species and species listed in international treaties to ensure that key invertebrate sites are safeguarded from damaging planning decisions.

6.20 Draw attention to the problems of light pollution, at night and underground, by undertaking appropriate case studies and engaging astronomers as an ally.

6.21 Halt the threats resulting from the development of ski facilities in European mountains including the Mediterranean countries using government tourism ministries and tour companies to alter public perception.

6.22 Obtain further facts on the threats posed by transport by undertaking case studies involving key invertebrate sites, and use the information obtained as the basis for further lobbying.

6.23 Undertake studies to determine how significant is the cull of flying insects that occurs as a result of collisions with car windscreens and radiator grills etc in areas of known importance to invertebrate conservation.

7. Sustainable use

A variety of invertebrate species are used by humans for a variety of reasons; leeches, snails, predatory mites, silk moths, ladybirds, honey bees, bumble bees, parasitic wasps and many others. Leeches are of great value to plastic surgeons when venous congestion of skin and muscle flaps is a problem. Medical use of leeches also includes treatment of black eyes and osteoarthritis, and hirudin is used in the treatment of inflammations. Snails are part of the human diet in many countries. They are being collected, fed and sold in various forms. Predatory mites, ladybirds, bumblebees, parasitic wasps and others are important in the biological control of arthropods harmful to cultivations. The silk worm is well known from ancient times for the production of silk. Bees produce honey and wax.

Helix pomatia is one of a number of species of snails that taste good, but harvesting wild populations is a major threat to these invertebrates. (Photo © Thomas Moertelmaier)

Most of these species are being reared or collected by individuals or small size enterprises. Many of these activities have been going on for thousands of years in a sustainable way. Indeed, the use of invertebrates is, in many cases, a very good example of sustainable use that brings benefits to small and sometimes isolated human communities.

There are, however, cases where the collection of animals from the wild for food, decoration or other purposes causes serious decline of their natural populations. Over-collection of snails, particularly from islands, may result in the collapse of populations. *Helix godetiana* from the Cyclades islands in Greece is an example of a species that is now considered to be endangered because of intense collecting for export. Trade also poses a major threat to other rare European invertebrates, from certain butterflies to fresh-water pearl mussels. The Convention on International Trade in Endangered Species (CITES) aims to regulate such activities.

Colonies of fresh-water pearl mussels (*Margaritifera margaritifera*) may include animals over 100 years old, but all may be decimated within a few hours when collected for their pearls. (Photo © Robert A. Patzner)

Sustainable use of invertebrates must rely on an accurate knowledge, for each species concerned, of the carrying capacity of the habitat, of the minimum viable population and the minimum dynamic area, an assessment of the genetic structure of the population and the possible threat of genetic erosion. Equally, populations may not be permitted to grow to levels that make them invasive and interfere with natural systems (for example honey bees, *Apis mellifera*).

Sustainable use of biodiversity is one of the three major objectives of the CBD, but has received less attention in Europe than in many other regions where people are more dependent upon wild species for their livelihoods. The conservation needs of such species are recognised within the Bern Convention by the lists of Appendix III, which covers species that may be harvested.

Key action

7.1 Develop national programmes to monitor and where necessary regulate the collection and trade in wild-collected invertebrate animals with the objective of achieving sustainability of the populations concerned and the ecosystems of which they are a part.

8. Scientific capacity building

There are still large gaps in our knowledge of the taxonomy of European invertebrates, their biology, their habitat requirements, distributions and their population dynamics. Long-term surveillance is the key to future success, but the present lack of information causes an array of important practical problems in creating and executing a conservation Strategy for particular invertebrate species, or for invertebrate habitats.

Scientific capacity to address these difficulties is uneven in invertebrate zoology across Europe. The former communist countries often had large biological infrastructures and supported traditional zoology, but these departments are now deeply weakened by lack of resources and funds. Throughout Europe, few universities now have zoology departments, which have been replaced by institutes focussed on biotechnology or molecular biology. This is strongly detrimental to biodiversity conservation as the expertise to identify and classify animals (and plants) is disappearing at precisely the time that governments are becoming aware of the vital importance of biodiversity protection, which all acknowledge cannot be delivered without that expertise. Despite an acute awareness of the problem within relevant scientific circles, little is done. It is imperative that education programmes be supported to train invertebrate conservation biologists at all levels, from academic to land management to field workers. And in the absence of a strong framework for invertebrate taxonomy, taxonomic approaches from one country to another are diverging (although the Fauna Europea initiative does provide a little help, see http://www.faunaeur.org/), making the essential continent-wide synthesis more rather than less difficult (see Box 11).

Recently, a strong case has been made for ensuring that conservation decisions are ´evidence based`. In other words, that conservation management decisions should be made on the basis of scientific evidence, rather than on feelings or previous experience of experts (Sutherland *et al*, 2004). This idea promotes the exchange of known information between workers, and exposes the difficulties of computer database incompatibilities!

Box 11 – Invertebrate taxonomy in conservation

The problems of identifying invertebrate species are very familiar to all workers in the field. Without a high level of specialist knowledge it is often impossible to know which species are present in an area or how common or rare they are. Species new to science continue to be described frequently (see Box 1). Even apparently ´well known` groups such as butterflies suffer from the problem of requiring expert opinion for the correct identification of certain ´problem` groups of species. This difficulty is significantly more widespread and intense in many invertebrate animal orders and families than for other organisms. Unfortunately, such experts are

Box 11 (cont'd)

themselves now a very `rare species´ and the threats to taxonomist extinction are severe and increasing. It is of utmost importance to invertebrate conservation in Europe that sufficient numbers of competent taxonomic experts continue to be trained and provided with places of employment at high scientific levels. The work of these experts underpins the entire invertebrate conservation effort. Knowledge of which species are present is prerequisite to their protection!

The biggest problem is in countries that lack a workforce of hobby invertebrate zoologists and/or where most professionals accept employment below or unrelated to their high degree of expertise. Some western and northern European countries have more such people than anywhere else in the world but there is still a problem with co-ordination.

Present governmental policy throughout Europe does not regard invertebrate species identification as a valid enterprise in modern biodiversity conservation. There is little or no support for the future career of an invertebrate expert who can identify species efficiently in the field or in the laboratory. This situation must be reversed.

Not enough young people are being trained as invertebrate taxonomists – an essential job in biodiversity conservation. (Photo © Robert Paxton)

Invertebrate conservation requires people with a wide range of skills. Above all, it needs practitioners – people who are employed to achieve invertebrate conservation, rather than only advise or assist in it.

There are relatively few institutions created specifically for invertebrate conservation. However, many conservation agencies include staff zoologists and/or zoological teams, who are charged with providing an invertebrate input into conservation activity. This has the advantage of integrating invertebrate conservation with other functions but the disadvantage that invertebrates rarely, if ever, receive the attention they need.

Invertebrate conservation lacks the high profile and better political awareness of more prominent organisms and/or parts of the environmental agenda so is without realistic levels of funding. Lack of funding has been particularly acute in developing international cooperation for invertebrate conservation.

Invertebrate conservation will only succeed if new and enlarged sources of funding are found. These will have to come in two ways. First, from increased funding by existing donors and supporters, such as the funding provided by government to its conservation agencies. Political will, fuelled by public attitudes, is the main driving force here. Second, funding will also have to come from new and innovative mechanisms, such as trust funds, charitable events, sale of produce etc. To do this successfully a high public profile is desirable. Awareness about the needs of invertebrate conservation is the crucial driving force.

However, all arguments for more science to underpin invertebrate conservation should make the point that most of the key actions needed for invertebrate conservation do not depend on more science being undertaken. And the precautionary principle can also be invoked.

Key actions

8.1 Make efforts to initiate a revival of invertebrate taxonomy to make the subject more attractive again, to both students and funding agencies.

8.2 Undertake field work and other research necessary to improve the conservation status of invertebrates in Europe by:

- 8.2.1 Improving efficiency of field surveys;
- 8.2.2 Undertaking inventories of Natura 2000 and Emerald Network sites;
- 8.2.3 Selecting permanent sites for long term monitoring;
- 8.2.4 Obtaining and collating autecological, behavioural and other biological information on known rare or threatened species;
- 8.2.5 Obtaining and collating new taxonomical information;
- 8.2.6 Strengthening the capacity to identify invertebrates, including the development of new methods that facilitate and speed identification of species;
- 8.2.7 Promoting easy access to taxonomic information held in scientific collections and data-bases.

8.3 Select an organisation for invertebrate conservation in each country as a cost-effective mechanism to deliver government-funded conservation work and/or as a campaigning force.

8.4 Increase expertise and involvement of official conservation agencies in each country to make sure invertebrates receive the attention they deserve. This should include proper training for decision-makers within ´all purpose` agencies.

8.5 Support the creation and implementation at the relevant levels of ´Codes of Conduct` for researchers in invertebrates to avoid conflicts with conservation policy.

8.6 Determine the level of invertebrate conservation expertise across the region, as a sort of capacity audit.

8.7 Implement a standardised approach to invertebrate taxonomy across Europe.

8.8 Call upon European and other international funding bodies to look upon the needs of invertebrate conservation more favourably.

9. Education and public awareness

Given the fundamental importance of invertebrates, the need for invertebrate conservation is little appreciated. One of the greatest challenges of conserving invertebrate diversity is to overcome the public perception that most invertebrates are not attractive enough and do not have the ´charisma` to warrant their conservation. Invertebrates are there for us to enjoy – they have aesthetic appeal, and they also provide many essential ecological services to us and to most other organisms. Thus a targeted programme of awareness and education is necessary to highlight the importance and plight of invertebrates and in turn to try to change human attitudes and behaviour.

The world is under our feet – if we care to look! The grasshopper on the left is a model of *Aeropus sibiricus.* (Photo © Grossglockner High Alpine Road Company)

While all major international treaties, as well as national and regional conservation strategies, nowadays rightly stress the general importance of environmental education in order to foster and promote environmentally responsible citizenship, more attention needs to be given to the specific importance of invertebrates and the issues that affect them.

Awareness essentially brings the issues relating to invertebrate diversity to the attention of key groups who have the power to influence outcomes. Education is a set of processes that can inform, motivate and empower people to support invertebrate conservation by making lifestyle changes and also through promoting change in the way that institutions, businesses and governments operate. However, awareness alone is not enough. It will only lead to conservation if interest is translated into action. Educational programmes are therefore necessary to influence the formal curricula of schools and universities, and also the work of national parks and other protected areas, museums and other such institutions.

Environmental education is a relatively new discipline, but it is growing in importance as people realise the seriousness of biodiversity loss. The imperative of education, of children and adults, is stressed in all major international conservation strategies, including the Bern Convention (Article 3.3), the CBD and Agenda 21 of the United Nations.

Ideally, a communication, education and public awareness strategy should be developed for many of the key actions in the European Invertebrate Conservation Strategy, as awareness raising is a cross cutting issue. However, it is clear that more funding will be needed to increase the capacity of institutions to implement this important work. Computer technology and the Internet now play a crucial role in all such issues of education and awareness. As the younger generations become increasingly reliant on using such media, it is equally necessary to employ the technology to best advantage in addressing questions of the environment and conservation. Presently, the information on invertebrates and their conservation that is available on the internet is spread across many different and often obscure specialist sites. There is a real need for an easily found, comprehensive source of information on invertebrates in Europe to work as an educational tool.

Key actions

9.1 Pursue and encourage public acceptance of the importance of invertebrate animals to the well-being of the world and ourselves by:

- 9.1.1 Drawing public attention to the functional importance of invertebrate species, and that even these are also at long term risk of becoming threatened;
- 9.1.2 Providing guidelines to influence school curricula;
- 9.1.3 Making invertebrates more interesting in the media and the internet by accentuating their functional roles and their importance to our own quality of life.

9.2 Identify appropriate internet websites for providing comprehensive information about invertebrates, in which key regional and global institutions contribute and then promote invertebrate conservation, emphasising topics prioritised by the present Strategy.

9.3 Support education and awareness programmes in zoological institutions on invertebrate conservation issues (e.g. the programmes of natural history museums).

9.4 Provide advice and education programmes and encourage direct liaison with land managers to help reduce damage to invertebrates (e.g. by minimising the use of pesticides and using integrated control methods and adopting appropriate mowing regimes).

9.5 Support initiatives to encourage the public to understand the environmental cost of ´urbanisation` of the countryside.

10. Co-operation and implementation

In an increasingly interdependent world and in a region where more and more nations are conceding their sovereignty to agreeing action in a multilateral framework, whether it be the European Union, the Council of Europe or the CBD process, international cooperation is of central and growing importance.

Zoology has always been an international science, but co-operation on animal conservation, especially of invertebrate animals and their habitats is relatively new. Yet at both governmental and non-governmental levels, international cooperation has become ever more complex, in part due to the complexity of the various policy initiatives and in part due to a splintering of organizations into smaller components. A process of integration is needed to harmonize disparate policy instruments that have similar goals and to bring together as partners organisations that have common goals.

Trans-boundary co-operations are critical for the successful conservation of invertebrates at the European scale. It is also a requirement of the Bern Convention that Parties co-operate on conservation matters (Bern Convention Articles 1.1 and 11).

Key actions

10.1 Support and enhance the use of existing mechanisms for international co-operation (COE, EU, ECNC, CBD, IUCN, WWF and others) and continue harmonising legislation for the conservation of invertebrates in Europe.

10.2 Increase awareness and enhance the use of ecosystems and habitats as entities for invertebrate conservation at all scales of political boundary, between and within states.

10.3 Promote dialogue between countries, sectors and key institutions that may be locally linked to harmonise strategic plans and develop common approaches to shared problems and pathways for invertebrate conservation.

10.4 Develop and implement local trans-boundary and shared water course initiatives relevant to invertebrates.

The role of the Council of Europe

The Council of Europe, through the Bern Convention, is very well placed to promote national and European co-operation on invertebrate conservation issues. It provides a regional framework for implementation of the CBD in Europe and brings together European states, NGOs and others specialised in biodiversity conservation. It has recently given particular attention to biotic invasions and has adopted a wide range of policy and technical recommendations. Possible roles of the Council of Europe´s Group of Experts on the Conservation of Invertebrates are suggested in Box 11.

Key actions

It is suggested that the Council of Europe:

10.5 Continue with Bern Convention engagement with invertebrate conservation issues by facilitating national implementation of this Strategy and strengthening co-operation with relevant regional and global institutions.

10.6 Continue and support the work of the Convention's Group of Experts on the Conservation of Invertebrates.

10.7 Work with key regional and global institutions (e.g. CBD, European Commission, European Environment Agency, IUCN, Planta Europa, Birdlife International and other appropriate partners) to promote the further development of effective invertebrate conservation measures for Europe and the Mediterranean Region.

10.8 Encourage and support cross-boundary initiatives in invertebrate conservation.

Box 12 – Possible Activities of the Bern Convention Group of Experts on Invertebrates

– Monitor the implementation of this Strategy and report to the Standing Committee on the possible need for further actions in the future.

– Monitor and review management effectiveness for invertebrate conservation within designated Protected Areas and also external to these in the general environment.

– Contribute to the development of technical guidance to halt the loss of European invertebrate biodiversity, working with relevant sectors and organisations.

– Organise seminars on specific invertebrate conservation issues, including training seminars, taking account of the need for capacity-building.

– Provide technical advice on methodology for invertebrate conservation, paying particular attention to important areas for invertebrate conservation and the use of indicator groups and the criteria employed for the selection of both.

– Help to facilitate exchange of information at national to European levels.

– Continue the co-operation with and support the work of the relevant sections of the IUCN and other such institutions.

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Executive summary

Invertebrate animals make up the greater part of the world´s entire biodiversity and dominate just about every habitat. Importantly, invertebrates perform a very wide range of essential *functional* roles in the world´s ecosystems. There are invertebrate herbivores, predators, decomposers, parasites, pollinators, seed dispersers and more. Equally, invertebrate animals are themselves the food necessary to support organisms at other levels in the food web. Beyond these biological roles, invertebrates are providers of ecosystem *services* that have measurable economic values - such as food, medical and technical resources or more indirectly, pollination, dung degradation, pest control and much more. Invertebrates also have aesthetic value that remains often unappreciated and contributes significantly to the beauty and enjoyment of nature. All this means that despite, or rather *because of* the great abundance of invertebrate animals, it is essential they be conserved and their services used sustainably.

Large numbers of invertebrate species are under severe threat of extinction in Europe, or are already extinct. The main factors responsible and/or creating high potential risk are: Habitat destruction and fragmentation; land use changes in agriculture, forestry and the construction and transport industries; loss of complex habitat mosaic structure; drainage of wetlands; water course regulation; direct impacts of economic activities, including direct harvesting; impacts of invasive species; negative human attitudes to most invertebrate animals; light pollution (for nocturnal and underground species); climate change (may contribute to, or otherwise affect each of the above). All of these threats are the same as, or directly involve, threats to plants, birds and other organisms, but the specific needs for invertebrate conservation management have been largely neglected.

Maintenance of invertebrate biodiversity in Europe lags far behind the conservation of plants, birds and mammals, for which clear European Strategies have now been developed and are being implemented at various legal and technical levels. Recognising that the risks associated with inaction - of allowing invertebrate biodiversity to continue to decrease – are immense, the Council of Europe commissioned the present Strategy to fill the gap. Messages of support for the Strategy are provided in a message from the Secretariat of the Council of Europe, in a Foreword by Sir David Attenborough and in a Guest Essay by Prof. Robert M. May, Lord May of Oxford.

The Strategy covers the invertebrate faunas of terrestrial and aquatic environments, excluding marine systems. It is targeted specifically at governments of all Council of Europe Member States and other Bern Convention Parties, but also at all decision-makers, land managers, scientists and teachers that have potential influence on invertebrate conservation.

The Strategy begins by defining a Vision, a Goal, and a number of Objectives (see Box). The remainder of the document is then divided into sections reflecting topics central to the conservation of invertebrates in Europe. Each topic is introduced, briefly discussed and relevant Key Actions are listed. Where appropriate, further, more detailed information, or specific examples, are provided in supplementary information `Boxes´.

Vision, goal and objectives of the strategy

Vision

A world in which invertebrate animals are valued and conserved, in parallel with all other groups of organisms, now and in the future.

Goal

To halt the loss of invertebrate animal diversity in Europe.

Objectives

O1 raise awareness and alter human attitudes and behaviour towards the importance of conserving invertebrate animals;

O2 promote integrated management of landscape mosaics at the relevant scales to be sustainable for invertebrates;

O3 strengthen European to national/sub-national invertebrate conservation policy and action;

O4 identify and prioritise key actions to be implemented at different political and geographical levels;

O5 promote accessibility and efficient flow and exchange of information on invertebrates within and between the scientific and public domains;

O6 promote inclusion of a fully representative variety of invertebrate species in conservation and environmental management decisions, including integration of invertebrate conservation into existing and future conservation strategies involving other groups of organisms

O7 build scientific and technical capacity for the conservation of invertebrates and identify areas of urgent further research.

Inventorying, mapping and understanding invertebrate diversity

If the decline of invertebrate diversity is to be halted, a clear understanding of the European fauna is needed. In most European countries, we don`t even know how many species of the different groups of invertebrates exist! The lack of information is relevant to rare and threatened species but is equally applicable to common and widespread invertebrates. Continued use, promotion and expansion of red lists of rare or threatened invertebrates remain an essential ingredient of invertebrate conservation effort. However, an equally or perhaps more serious long term problem is the reduction in abundance and range of many of the more numerous and widespread species. Here threats are often closely tied to habitat loss.

Key actions include compilation of National red lists, creating European red lists, promoting the importance of conserving widespread and common species and undertaking research on services provided by invertebrates, including their economic values.

Preventing habitat destruction and ensuring appropriate management

Habitat destruction is undoubtedly the greatest threat to invertebrate animals in Europe and indeed worldwide. Direct loss of habitat, habitat fragmentation, changes in land use and/or management are all detrimental to invertebrate survival. Every country in Europe has a system of protected areas and effort is being made to inter-connect these into a network using ecological corridors. Realisation of the Natura 2000 network and the Emerald Network has contributed greatly in the establishment of Pan European Ecological Network. However, different organisms perceive and exploit their environment at different scales and it is essential that this be taken into account in conservation management. For invertebrates, there is concern that the spatial and temporal scales appropriate to the animals impose restrictions to corridor efficiency.

Key actions include identification of important sites and ´hotspots` for invertebrates in Europe, establishment of small-scale protected area schemes, improving understanding and efficiency of ecological corridors for invertebrates and restoration and management programmes for freshwater and wetland habitats to benefit invertebrate faunas.

Indicators and monitoring

There are too many invertebrate species to be aware of the conservation needs of each one, so indicator groups (surrogates) must be sought, tested and engaged. These groups should provide representation of the general invertebrate biodiversity value of any particular area, reflecting the composite picture. Indicators must be selected from those available according to the area considered and the specific conservation aims. Once indicators have been engaged, changes in the threat status can only be efficiently assessed by monitoring changes in numbers and in distributions. This is lacking at the international level for most invertebrate groups.

Key actions include identification, testing and establishment of a palette of indicator groups of invertebrates and correlating with protection schemes established for other types of organisms, ensuring that monitoring schemes are undertaken for European red listed invertebrates and for selected widespread and abundant species throughout Europe.

Invasive alien species

Invasive Alien Species (IAS) are those species that have been introduced outside their normal current or past range, and whose introduction and spread cause harm to human health, the economy, and/or the environment. They pose strong threats to invertebrate and plant biodiversity, and to the habitats of all organisms, but our knowledge of how invasive species may affect invertebrate diversity and conservation in Europe is minimal. Invasives may be any sort of organism, including invertebrates themselves, and their effects may be direct, such as by eating invertebrates, or indirect, for example by altering the habitat.

Key actions include providing active support for the European Strategy on Invasive Alien Species, compiling a register of invasive species that have already affected invertebrate biodiversity, undertaking risk analyses in situations of new threats to invertebrates and promotion of screening of organisms intended for biological control for their effects on non-target invertebrates.

Reversing the effects of intensive agriculture and forestry, and of industry and urbanisation.

Agriculture has a massive effect on invertebrates and their habitats. In particular, the trend towards large scale intensive farming has destroyed many small habitat ´islands´, both terrestrial and aquatic. The effects of intensive use of pesticides, fertilizers and herbicides damage farmlands and affect neighbouring land and water systems. The Common Agricultural Policy (CAP) of the European Union is of decisive importance within the EU and increasingly in the accession states. It is essential for conservation of biodiversity in general, and particularly invertebrate conservation, that biological and landscape biodiversity interests be integrated with policies for sustainable agriculture in Europe.

Similarly, much of the present forest land in Europe is intensively managed, often for non-native and/or coniferous species in plantations, and the crop of trees that results, usually of a single species all of the same age, is of little biodiversity value. Maintaining the complex and dynamic, open-mosaic nature of forests is essential for invertebrate conservation and must be a central aim of woodland conservation policy and practice.

Land-use planning is particularly important in Europe because of the great pressures on the land for agriculture, industry, transport, energy, recreational activities and other uses. In towns and cities, the planning framework can encourage an invertebrate-rich environment by emphasizing the need for human settlements to be part of the balance of nature. In rural situations planning can provide for or destroy the bulk of invertebrate conservation. The demands of recreational activities and tourism often conflict with conservation interests. For nocturnal invertebrates, particularly night-flying insects, there is a recent and important threat from the increasing levels of lighting in towns and also in the countryside.

Transport has an increasing negative impact on natural habitats and biodiversity. Many of the most contentious issues in conservation over the last decades have been over road or rail schemes, which, by avoiding towns and villages, all too often interfere with more natural areas.

Key actions are many, covering the issues of agriculture, forestry, town and country planning, industry and transport outlined above.

Sustainable use

A variety of invertebrate species are used directly by humans for a variety of reasons: leeches, snails, predatory mites, silk moths, ladybirds, honey bees, bumble bees, parasitic wasps and many others. These resources must be managed and used sustainably.

Key action is to develop national programmes to monitor and regulate collection and trade in wild-collected invertebrates.

Scientific capacity building

There are still large gaps in our knowledge of the taxonomy of European invertebrates, their biology, their habitat requirements, distributions and their population dynamics. Invertebrate conservation requires people with a wide range of skills. Above all, it needs practitioners. Presently there is a serious shortage of people with such training.

Key actions include making efforts to initiate a revival in invertebrate taxonomy, undertaking field work and other research to improve the conservation status of invertebrates in Europe and calling upon funding bodies to look upon the needs of invertebrate conservation more favourably.

Education and public awareness

One of the greatest challenges of conserving invertebrate diversity is to overcome the public perception that most invertebrates are not attractive enough and do not have the ´charisma` to warrant their conservation. Invertebrates are there for us to enjoy – they have aesthetic appeal, and they also provide many essential services to us and to most other organisms. Thus a targeted programme of awareness and education is necessary to highlight the importance and plight of invertebrates and in turn to try to change human attitudes and behaviour.

Key actions include encouraging public acceptance of the importance of invertebrate animals (using various means), supporting education and awareness programmes on invertebrate conservation issues and providing advice and education programmes for land managers.

Cooperation and implementation

In Europe, a region where more and more nations are conceding their sovereignty to agreeing action in a multilateral framework, international cooperation is of central and growing importance. A process of integration is needed, including trans-boundary co-operations, to harmonize disparate conservation policy instruments that have similar goals. The Council of Europe, through the Bern Convention, is very well placed to promote national and European co-operation on invertebrate conservation issues. Possible roles of the Council of Europe´s Group of Experts on the Conservation of Invertebrates are suggested.

Key actions include supporting and enhancing existing mechanisms of international cooperation for the conservation of invertebrates, promoting dialogue between countries, sectors and institutions to develop common approaches to shared problems and developing and implementing local trans-boundary and shared water course initiatives relevant to invertebrates.

Appendix 1

Policy and legislative frameworks for invertebrate conservation

Global

The Convention on Biological Diversity (CBD) 1992

It includes diversity within species, between species and of ecosystems. The objectives of the CBD include the conservation of biodiversity, the sustainable use of its components and the sharing of benefits arising the use of genetic resources.
http://www.cbd.int

The Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES) 1973

It aims to regulate commercial trade in species in danger of extinction. Species covered are listed in three appendices, each of which has a different level of trade restriction.
http://www.cites.org/

The World Heritage Convention 1972

It allows sites of outstanding cultural and/or natural value to be designated as World Heritage Sites and promotes international co-operation for safeguarding these areas.
http://www.unesco.org/

The Convention on Wetlands of International Importance (Ramsar Convention) 1971

An intergovernmental treaty which provides the framework for national action and international co-operation for the conservation and wise use of wetlands and their resources. Under the Convention, wetlands of international importance are designated as Ramsar sites and the sustainable use of wetlands is promoted. The Ramsar convention provides a tool to help the protection of wetland habitats and their fauna and flora.
http://www.ramsar.org/

Unesco Man and the Biosphere programme (MAB) 1970s

Biosphere reserves are designated as representative international examples of habitats and ecosystems where practical management and research can be undertaken, with a focus on information exchange between all stakeholders.
http://www.unesco.org//mab

The Convention on the Conservation of Migratory Species of Wild Animals (CMS or 'Bonn Convention') 1979

It aims to conserve terrestrial, marine and avian migratory species throughout their range. Migratory species threatened with extinction are listed on Appendix I of the Convention, which Parties must strictly protect. Migratory species that need or would significantly benefit from international co-operation are listed in Appendix II, and range States are encouraged to conclude global or regional agreements about them.
http://www.cms.int/index.html

European

The Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention) 1979

It requires member states of the Council of Europe to ensure the conservation of wild fauna and flora species and their habitats. Special attention is given to endangered and vulnerable species listed in Appendices. Invertebrate species are currently badly under-represented in these Appendices.
http://www.coe.int/t/dg4/cultureheritage/conventions/Bern/default_en.asp

The Emerald Network

It designates Areas of Special Conservation Interest (ASCIs). These are sites in Council of Europe countries that contain species and/or habitats of European importance. ASCIs are designated as a result of the Bern Convention Resolution I (1989) and Recommendations 14, 15 and 16. The Emerald Network in Council of Europe countries assists preparation to comply with the EU Habitats Directive (see below).
http://www.coe.int/t/dg4/cultureheritage/regional/EcoNetworks/EmeraldNetwork_en.asp

The EU Habitats Directive (Directive 92/43/EEC on the conservation of natural habitats of wild fauna and flora)

A legislative instrument with a present main focus of the requirement of member states of the EU to set up a coherent ecological network of Special Areas of Conservation (SACs) that will, with the Special Protection Areas (SPAs) designated under the Birds Directive, become the NATURA 2000 network. SAC selection is based on the presence of species and habitats of European importance that are listed in the Directive´s annexes. Annex I lists the habitat types and Annex II lists the animal and plant species that qualify sites for SAC designation. The list of invertebrate species included is closely similar to that of the Bern Convention, and is similarly not representative. SACs are required to be adequately protected and managed to maintain and improve their nature conservation value. The Directive also makes provision for the protection of listed species outside of the designated SACs.

http://ec.europa.eu/environment/nature/nature_conservation/eu_nature_legislation/habitats_directive/index_en.htm

The Pan-European Biodiversity and Landscape Diversity Strategy (PEBLDS) 1995

It provides a framework for strengthening and building upon existing initiatives and programmes, drawn up as a Pan-European response to the CBD. A Pan-European Ecological Network (PEEN) has been established under PEBLDS and consists of core conservation areas, ecological corridors, buffer zones and restoration areas.
http://www.coe.int /t/dg4/cultureheritage/Policies/Biodiversity/default_en.asp

The European Community Biodiversity Strategy 2001

It provides the framework for developing EU policies and instruments to comply with the CBD. The Strategy aims to anticipate, prevent and attack the causes of reduction or loss of biodiversity at their source, and eight policy areas have objectives on how this can be achieved. EC Biodiversity Action Plans (BAPs) have been developed for four sectoral policies: Conservation of Natural Resources, Agriculture, Fisheries and Development and Economic Co-operation.
http://biodiversity-chm.eea.eu.int

The EU Water Framework Directive (Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for the Community action in the field of water policy).

It protects all waters – rivers, lakes, coastal waters, and groundwaters, setting ambitious objectives to ensure that all waters meet “good status” by 2015. The Directive sets up a system of management within river basins that recognises that water systems do not stop at political borders. Cross border co-operation between countries and all involved parties is also required. It aims to ensure reduction and control of pollution from all sources such as agriculture, industrial activity, and urban areas.
http://ec.europa.eu/environment/water/water-framework/

National initiatives

National Biodiversity Strategies and Action Plans (NBSAPs)

Have been, or are currently being developed by each Party to the CBD and provide a framework for action to deliver national commitments to conserving and promoting sustainable use of biodiversity.

See national government environment department websites.

Appendix 2

List of acronyms

ASCI	Area of Special Conservation Interest (within the the Emerald Network)
BCI	Bern Convention Invertebrates (species listed in the Bern Convention Appendices)
CAP	Common Agricultural Policy (of the EU)
CBD	Convention on Biological Diversity
CITES	Convention on International Trade in Endangered Species
CoE	Council of Europe
EBMI-F	European Biodiversity Monitoring and Indicator Framework (within PEBLDS)
EPCS	European Plant Conservation Strategy
EU	European Union
GIS	Geographical Information System
GISP	Global Invasive Species Programme
GMO	Genetically Modified Organism
IAS	Invasive Alien Species
IPM	Integrated Pest Management
IUCN	International Union for Conservation of Natural Resources (The World Conservation Union)
NBSAP	National Biodiversity Strategies and Action Plans
OQE	Ordonnance sur la qualité écologique. (Swiss federal ordinance for ecological quality)
PEBLDS	Pan European Biological and Landscape Diversity Strategy
PEEN	Pan-European Ecological Network
SCE	Surfaces de Compensation Ecologique (official term within Swiss Agricultural Policy)
StN	Syrph the Net (Electronic database of European hoverflies (Diptera: Syrphidae))
UN-ECE	United Nations Economic Commission for Europe
WWF	World Wide Fund for Nature

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