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EDITORIAL

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Launched to accelerate biodiversity conservation

Nature Conservation – a new dimension in Open Access publishing bridging science and application

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Abstract

This Editorial presents the focus, scope and policies of the inaugural issue of Nature Conservation, a new open access, peer-reviewed journal bridging natural sciences, social sciences and hands-on applications in conservation management. The journal covers all aspects of nature conservation and aims particularly at facilitating better interaction between scientists and practitioners. The journal will impose no restrictions on manuscript size or the use of colour. We will use an XML-based editorial workflow and several cutting-edge innovations in publishing and information dissemination. These include semantic mark-up of, and enhancements to published text, data, and extensive cross-linking within the journal and to external sources. We believe the journal will make an important contribution to better linking science and practice, offers rapid, peer-reviewed and flexible publication for authors and unrestricted access to content.

Keywords

Nature Conservation, biodiversity, conservation science, conservation policy, conservation management, semantic markup, semantic enhancements, data publishing

Introduction

Nature conservation is an essential element in the cultural development of humans. Our approaches to protect nature are continuously changing with major implications for conservation science and hands-on, practical applications (Haila 2012). Humans have been extraordinarily successful in part because of our ability to manipulate ecological systems and the services they provide (Chapin et al. 2001). Yet, rapid population growth and growth in consumption, especially since the Industrial Revolution, have led to the substantial exploitation of Earth's natural resources (Orr 2006). As a consequence, we are losing species and are causing detrimental changes to natural ecosystems at an unprecedented rate (Groombridge 1992, Kuussaari et al. 2009, Butchart et al. 2010). We are undermining the capacity of ecosystems to support human life (Daily 1997, MEA 2005, Garibaldi et al. 2011). There is good evidence that the loss of ecosystems and the services they provide have already contributed to the demise of some societies (Tainter 1988, Ehrlich and Ehrlich 2004, Diamond 2005). Threats to nature conservation occur at local to global scales, including trade globalization, climate change and land-use change. These processes are non-linear across scales and approaches to manage them often do not address the most relevant spatial or temporal scales and therefore are often inefficient or fail completely (Henle et al. 2010). Moreover, management actions are mostly driven by short-term economic or political interests that may only benefit certain sectors of society, rather than addressing broader-scale and longer-term nature conservation issues to the benefit of current and future generations.

Despite tremendous growth and progress in research on biodiversity (including nature conservation) (Fig. 1), increasing political commitments, such as the establishment of the Intergovernmental Panel for Biodiversity and Ecosystem Services (IP-

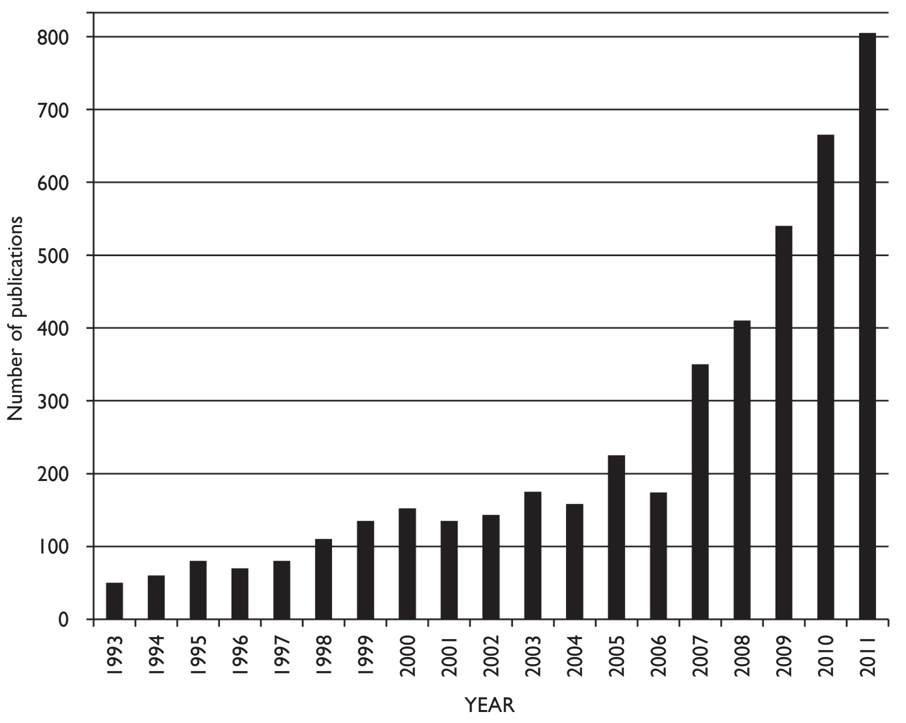

Figure 1. Increase in the number of publications in the field of biodiversity and nature conservation, created from the Web of Science using the string: Title = „biodiversity" OR „nature conservation" OR Topic ="biodiversity" OR „nature conservation".

BES) (Görg et al. 2010), and practical achievements, such as the major extension of the networks of protected areas across the world (World Database on Protected Areas http://www.wdpa.org/, Evans 2012), we are far from achieving our targets in nature conservation (Walpole et al. 2009). Moreover, conservation targets are continuously shifting over time (Haila 2012). For example, there is currently a strong tendency to focus on ecosystem services in national and international strategies for biodiversity conservation, sometimes together with the belief that only such a focus can create a sufficiently high profile for conservation to bring it on par with other societal interests (e.g. development). Yet, others argue that this may be a dangerous approach because the modification and transformation of natural ecosystems for an improved delivery of specific ecosystem services can be a major contributor to the decline of natural ecosystems and their associated biota [see, for example, Skroch and López-Hoffman (2009) and Adams and Redford (2009) for opposing opinions].

While there is a current trend to use nature as service provider as a way of promoting conservation more broadly, other motivations can drive the development of conservation ethics and movements, including the emotional attachment of humans to nature (Leopold 1949, Haila 2012). And if we are successful, we often create new problems. For example, some species have returned to ranges from which they have been extirpated, for example, top-level carnivores that often create considerable conflicts among humans with different interests and ethics (White et al. 2009, Klenke et al. in press).

As a consequence, balancing anthropocentric and ecocentric views regarding nature conservation remains a major challenge for current research, policy and applied biodiversity conservation. A range of priority scientific questions (e.g. Sutherland et al. 2012) and unresolved policy and management issues have already been identified for the coming decades at the national (e.g. DEFRA 2011), European (EU 2020 Biodiversity Strategy ttp://ec.europa.eu/environment/nature/biodiversity/policy/), and global levels (Aichi targets of the CBD http://www.cbd.int/sp/targets/).

To be effective, research on natural resource management and conservation must be communicated to practitioners involved in hands-on conservation efforts and to policy makers. However, the results of scientific research are often not readily applied in management. Many applied conservation schemes do not reflect current research knowledge (e.g. Lynne et al. 2010). The "knowledge-implementation-gap" (Knight et al. 2008) is increasingly becoming obvious. As a consequence, the 10th Party of the Convention on Biological Diversity, in Nagoya October 2010, identified a strengthened link between science and policy as an explicit target (http://www.cbd.int/sp/targets/). This requires new alliances between science, economics, policy makers, and natural resource managers (Briggs and Knight 2011).

A major goal of the interdisciplinary journal **Nature Conservation** is to support synergistic interactions among scientists, policy-makers and managers. This is a practical task. The knowledge base of conservation biologists is already extensive, and the numbers of experienced practitioners are increasing around the world. The task is to bring different specialists together and create a forum that supports knowledgeable practices, and to learn from the experience – successes and failures – of all parties. The journal specifically aims at strengthening the link between science, policy and management by publishing timely, innovative papers with clear practical relevance.

The papers selected for the first volume of **Nature Conservation** largely reflect this vision. The paper by Evans (2012) provides background information on the development of the largest network of protected areas in the world, the European Union's Natura 2000, and the process for assessing successes and gaps in the network. This may facilitate similar developments elsewhere in the world. The contribution by Haila (2012) highlights the continuously changing approaches to nature conservation and their dependence on societal and political backgrounds (called 'Zeitgeist'). Based on these relationships, Haila recommends how to address current and future problems in nature conservation. The paper by Votsi et al. (2012) assesses the relationship between road networks and biodiversity in Natura 2000 areas in Greece, which contributes to our knowledge of the effectiveness of protected areas in this country and beyond. The final paper, Van Sway et al. (2012), translates current knowledge on the conservation biology of butterflies into recommendations for the conservation and management of butterfly species listed in the Annexes of the European Habitats Directive.

Challenges of innovative publishing

The publication and dissemination of scientific information have reached conceptually new dimensions in the past decade. Although a large part of the scholarly literature is still published in the traditional manner (i.e. printed books and journals), publishers are increasingly moving towards entirely digital or a combined (conventional and digital) model for the publication of scientific data. Digital publishing is evolving rapidly in the area of 'Open Access', a model that is increasingly taking over from the 'restricted access' forms of publishing. There are many reasons for publishers to change their publication models, but this process is mainly driven by strong demands from the scientific community to publish in a format that allows quick discovery, integration, re-use and dissemination of the research data without any financial, legal, or technical barriers other than those inseparable from gaining access to the internet itself (see for instance the Panton principles).

Pensoft is among the leading proponents of Open Access publishing of data relating to biodiversity. For this purpose, the company has developed a number of innovative products to support aggregation, interlinking, converting and the dissemination of published information, such as the publication platform TRIADA, Pensoft Mark-up Tool, Pensoft Wiki Converter, and Pensoft Taxon Profile. Several others are currently under development (Penev et al. 2010, Erwin et al. 2011). These technological innovations make it possible to link scientific information published in Pensoft's journals to various related sources and automatically distribute it through community networks, wiki environments, and indexing and aggregation services. The maximal 'Itemization' of the content of scientific papers into various independently informative components, such as taxon treatments, locality records, habitat descriptions and others, ensures better integration, interlinking and dissemination of the research data. This has been one of the core elements in the company's vision for technical development of the publication platform. In addition, recently Pensoft has invested considerable resources into developing a sustainable model for publication, dissemination and long-term preservation of data relating to biodiversity.

Nature Conservation is a new-generation journal and can be seen as a platform comprising both innovative algorithms and a routine medium for the publication of data related to biodiversity. As with most of Pensoft's journals, **Nature Conservation** is based on cutting-edge Web 2.0 technologies, own content management software and XML-based editorial workflows. By providing a rapid and straightforward publication process, data publication options, and several tools for data sharing and integration, the journal is on the frontline of the present-day technological revolution in scholarly publishing and communication. In addition to "conventional" publication practices, the journal implements functionalities aimed at capturing, storing, integrating and disseminating information related to basic and applied conservation ecology and nature conservation. **Nature Conservation** adopts a *multiple-choice data publishing model* that enables the publication of data of different types and complexity as follows: (1) supplementary files published along with the perspective papers; (2) data files, submitted to data repositories as independent files and linked to the journal article for which they provide evidence; (3) data published through data repositories and aggregators, but indexed within larger databases (e.g., Genbank and the Global Biodiversity Information Facility, GBIF); and (4) data published in the form of marked-up, structured and machine-readable texts. Datasets can also be published as independent papers in the form of peer-reviewed scholarly publications called "data papers" (Chavan and Penev 2011, Penev et al. 2009).

Focus and scope

The journal's major characteristics include:

- Open access to the published scientific content and a barrier-free environment for the dissemination of results
- A rapid and straightforward publication process
- Publication of articles in four different formats: (1) full-colour, high-resolution print version; (2) PDF for reference to the printed version and easy archiving; (3) HTML for easy reading, browsing and applying semantic enhancements to the text; and (4) XML to provide a machine-readable file for archiving and data mining
- Semantic mark-up of and semantic enhancements to published texts using the TaxPub XML schema, an extension of the DTD (Document Type Definitions) of the National Library of Medicine (USA) (Catapano 2010, Penev et al. 2010, 2011) ensuring the enrichment of content via links to external sources and interlinking within the article body

- Automated cross-linking through the Pensoft Taxon Profile with major indexing and aggregation platforms, such as the Global Biodiversity Information Facility (GBIF), Encyclopedia of Life (EOL), the International Plant Name Index (IPNI), ZooBank, the National Center for Biodiversity Information (NCBI), Genbank and Barcode of Life, the Biodiversity Heritage Library (BHL), Pub-Med, PubMedCentral, Mendeley, and many others
- Publishing occurrence data and taxon checklists/inventories using the Darwin Core standard. This is supported by a specialized tool of GBIF, the Integrated Publishing Toolkit (IPT)
- Infrastructure for the publication and indexing of data papers
- Data communication strategy and workflow through an already established system of press releases and posts to social networks
- No restriction in volume or usage of colour

One of the key features of **Nature Conservation** is a strong emphasis on the dissemination of published results. The journal's contents will be harvested automatically by the Directory of the Open Access Journals (DOAJ), Citebank of the Biodiversity Heritage Library, BASE - Bielefeld Academic Search Engine, Vifabio.de, Scirus, Scientific Commons and other indexing platforms. From the very start, **Nature Conservation** will be submitted for indexing and coverage by ISI Web of Science, Scopus and PubMedCentral.

The journal will consider publishing the following types of manuscripts:

- Original research articles
- Comprehensive reviews, historical analyses, ecological modelling and scenarios
- Monographs and collections of papers with no limit in size, published as 'special issues'
- Applied conservation papers
- Short communications
- Letters and Forum papers
- Trend scanning papers
- Datasets and Data papers
- Web-based tools
- Book reviews

Nature Conservation strongly encourages papers on ethical, social, economic, legal and policy issues related to the management and use of biodiversity and ecosystems. Authors or editors publishing large review papers, conference proceedings, Festschrift volumes, etc. will benefit from having ISBN numbers assigned to their work, providing in this way additional dissemination and promotion of the published data through the book industry network.

We are convinced that **Nature Conservation** will establish a new model of publishing and dissemination in basic and applied conservation ecology and nature conservation in general at various spatial, temporal and evolutionary scales, from populations to ecosystems and from microorganisms and fungi to higher plants and animals, taking advantage of exciting possibilities in the application of the semantic Web. The new technologies implemented in the journal will permit ecologists, conservationists and any other reader anywhere to harvest, within seconds, the most essential information (e.g., descriptions, images, maps, keys, gene sequences and references) on a taxon, locality, or even a specimen. **Nature Conservation** is committed to enhance the access to ecological data and to speed up the free dissemination of knowledge about life on Earth.

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REVIEW ARTICLE

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Launched to accelerate biodiversity conservation

Building the European Union's Natura 2000 network

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Abstract

In the second half of the 20th Century there was a growing awareness of environmental problems, including the loss of species and habitats, resulting in many national and international initiatives, including the creation of organisations, such as the IUCN, treaties and conventions, such as Ramsar and the Berne Convention, and the establishment of networks of protected areas. Natura 2000 is a network of sites in the European Union for selected species and habitats listed in the 1979 Birds Directive and the 1992 Habitats Directive. Under the Habitats Directive a series of seminars and other meetings have been held with agreed criteria to ensure a coherent network. Despite both scientific and political difficulties the network is now nearing completion.

Keywords

Natura 2000, Birds Directive, Habitats Directive, Biogeographical seminars

Introduction

During the second half of the 20th century there was an increasing awareness of environmental problems with publications such as Silent Spring by Rachel Carson (Carson 1962), Limits to Growth (Meadows et al. 1972) and well publicised international conferences, such as the 1972 United Nations Conference on the Human Environment in Stockholm and the CBD in Rio de Janeiro in 1992. At the same time several international organisations were formed, such as the Wildfowl & Wetlands Trust (1946); IUCN (1948); WWF (1961) and Friends of the Earth (1969). In particular, there was widespread recognition that many species were in danger of extinction with the IUCN Redlist established in 1963 (Walter and Gillett 1998) and that many habitat types were disappearing. This resulted in a marked increase in the creation of protected areas, such as nature reserves and national parks, in the second half of the 20th century (Dudley 2008). As a result of global concern for the loss of wetlands with a resulting decline in numbers of waterfowl, the Ramsar Convention was signed in 1971, creating the first international network of protected areas. Within Europe the Council of Europe adopted the concept of a European network of Biogenetic reserves to conserve natural or near-natural habitats in 1973, although the programme did not start until 1976. Currently there are 344 Biogenetic reserves in 22 countries but no sites have been added since 1998 (information from EUNIS http://eunis.eea.europa.eu/designations/80:IN01?fromWhere=original).

Following the 2nd European Ministerial Conference on the Environment in 1976 Switzerland published a study recommending a European convention on nature conservation which led to the Berne convention on the Conservation of European Wildlife and Natural Habitats which was opened for signatures in September 1979 (Ribault 2004). The convention included annexes of plant and animal species requiring protection but did not refer to networks of protected areas.

Within the European Union (in this paper EU refers both to the European Union and its predecessors) environmental issues were initially focused on the control of pollution although the 1973 first action plan on the environment identified migratory birds as a possible focus for EU action (EC 1973). After pressure from members of the European parliament following lobbying from the public and Non-governmental organizations (NGOs) for measures by the EU to protect birds, especially migratory species, a proposal for a directive on the conservation of wild birds was published by the European Commission in 1976 (EC 1977) and the Directive on the Conservation of Wild Birds was adopted in 1979 (EC 1979). Before the 1987 Single Act the EU had no formal competence for environmental issues but it was agreed unanimously by the then nine Member States that the conservation of birds was a transfrontier responsibility requiring coordinated action (Jordan 2005). The directive requires the member states to designate sites, known as Special Protection Areas (SPAs), for a list of species considered rare and/or threatened listed in Annex I of the Directive (currently 192 species) together with sites which are important for migratory species.

The EU ratified the Berne Convention in 1982 and, following pressure from NGOs and some Member States (MS), the European Commission published a proposed directive to implement the convention in 1988 (EC 1988). Following the 1987 Single European Act the EU now had a clear legal basis for taking action (Jordan 2005). After heated discussion (e.g. see Sharp 1998) a Directive on the Conservation of Natural Habitats and of Wild Fauna and Flora was adopted on 21 May 1992, more commonly known as the Habitats Directive (EC 1992). This directive includes measures for the strict protection of selected species (listed in Annex IV) and requires the designation of protected sites for selected habitats and species listed in Annexes I & II known initially as Sites of Community Importance (SCIs) and once designated as Special Areas of Conservation (SACs). These sites, together with the SPAs designated under the Birds

Directive, form the Natura 2000 network. With more than 26 000 sites and covering about 17.5% of the EU land territory, Natura 2000 is the largest network of protected areas in the world (Sundseth and Creed 2008).

Although there now exists a substantial literature on the two directives and the Natura 2000 network, little has been published on the development of the network and in particular the series of biogeographical seminars held to examine the Member State proposals for SCIs.

Establishing the network – a brief history

Special Protection Areas are selected and designated by the Member States with no agreed EU criteria for site selection although many countries use criteria based on the Ramsar 1% of flyway population. Once sites have been designated, site details are forwarded to the European Commission using an agreed format, which since the mid 1990s has been in the form of a database. This 'Standard Data Form' (SDF) includes general information on the site (name, latitude & longitude, date designated, etc) together with information on the species present (EC 1997a). The same form is also used for SCIs.

Progress in designating sites was slow at first (Fig. 1) and although there was no agreed process to evaluate site proposals, most Member States have been subject to legal proceedings for non implementation of the directive due to the slow rate of site designation (EC 2006). In many cases the European Commission has used the Birdlife 'Important Bird Areas' (Heath et al. 2000) as a comparison.

The Habitats Directive has criteria for site selection given in Annex III and a system whereby Member States propose potential sites to the European Commission for approval and with a timetable for site proposal and subsequent designation. Although the timetable has not been respected, and many of the EU15 were subject to legal proceedings for failure to propose sites in time (Paavola 2004), it is clear from Figure 1 that progress has been much faster than for the Birds Directive sites.

In response to Article 4 of the directive, the Commission, together with the Member States, and supported by the European Topic Centre on Biological Diversity (ETC/BD) and its predecessors has developed the concept of biogeographical seminars to examine the proposals and to identify gaps in the proposed network. The directive makes reference to biogeographical regions, which are based on maps of natural vegetation but adjusted to fit political and administrative boundaries (ETC/BD 2006). These are used as a framework for assessment with discussions held between all countries within a region, or occasionally for a sub region (e.g. the Pyrenees or the Scandinavian mountains, which are both part of a larger but fragmented Alpine region).

At a meeting held in Funchal, Portugal, in November 1994 to discuss the Macaronesian region the concept of a 'Reference List' was developed and it was agreed that seminars should be held even though the proposals were clearly incomplete using the Macaronesian region as a pilot. The Reference List notes, which Annex I habitat types

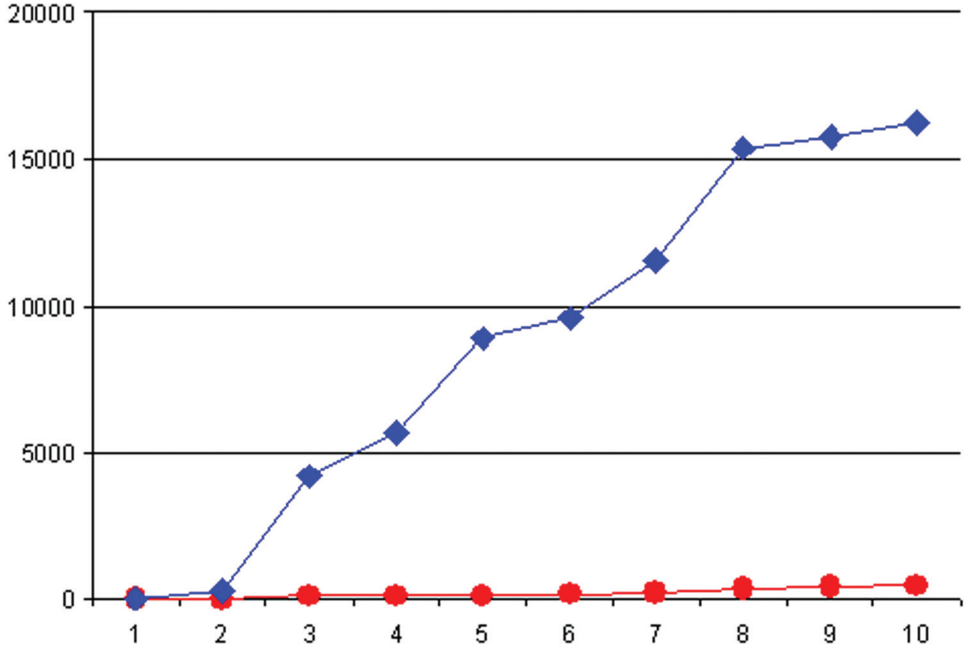

Figure 1. Growth in the number of sites designated in the first ten years of the Birds Directive (1982-1992, red circles) and the Habitats Directive (1994-2004) blue squares). Note that some 10% of SPA and 5% of SCIs have no designation date in the database and that the EU grew from 12 MS in 1992 to 15 MS in 1995 and 25 MS in 2004 (Source ETC/BD).

and Annex II species require sites in a given biogeographical region per country. This is not the same as a classic checklist as a species may be present but only as an occasional visitor such that site designation is not possible.

The 1997 criteria also introduced the so called "20-60% guidelines" but this was clearly to help focus discussion where most useful and was never meant to mean that a given percentage of a population of a species or area of a habitat type must be proposed. However, this has often been misunderstood to mean that at least 60% coverage of the population of a species or area of a habitat was required, especially by NGOs (e.g. WWF 2008).

Further biogeographical seminars were held for Macaronesia in 1996 and 1997 where the methods used later elsewhere (see below) were developed. Meetings held for other regions before 1999 concentrated on agreeing the Reference Lists as very few sites had been proposed by the Member States and, with a few exceptions of mostly endemic species with one or very few known sites, most species and habitat types were not sufficiently represented in the embryo network.

By 1999 most countries had proposed enough sites to allow an analysis of the network species by species and habitat by habitat following the criteria agreed earlier and a series of seminars for the other biogeographical regions started in April 1999 in Vargön, Sweden, for the Boreal region and the Fennoscandian section of the Alpine region. For the EU15 it was necessary to have two or more seminars per region as it was clear at the first meeting that the proposals were not sufficient for all countries (e.g. for the first Atlantic meeting there were no German sites). However, the first seminars identified the habitats and species that clearly required additional sites and allowed a discussion on the interpretation of some of the Annex I habitats (see Evans 2006, 2010).

The meetings were attended by representatives of the Member States, usually from the Ministries of Environment and/or agencies responsible for nature conservation, the European Commission, the ETC/BD and NGOs. A small number of experts identified by the ETC/BD were also invited, ideally these are independent of both the national authorities and the NGOs. This is not always possible in small countries and some invited experts had given advice to national authorities but had not been involved in the final stages of site selection. At first, only NGOs with an interest in nature conservation were involved, with participation coordinated by the European Habitats Forum (http://www.iucn.org/about/union/secretariat/offices/europe/places/brussels/european_habitats_forum/) but from 2002 onwards NGOs representing land owners and users also participated, coordinated by the European Landowners Organisation (http://www.europeanlandowners.org/). The NGOs have played a major role in implementing Natura 2000 (Weber and Christophersen 2002). Observers were also invited to many seminars, especially from countries negotiating to join the EU who are expected to have their lists of SCIs ready on the day of accession.

The crucial question for the biogeographical seminars was what coverage of a species or habitat type was required in order to meet the obligations of the directive. For very rare species or habitats, for example the Annex II plant *Odontites granatensis,* which is endemic to a small area of the Sierra Nevada in Spain, it is clearly necessary to have all known sites included in the network (although to be sure of long-term survival ex-situ conservation may also be required). But for rare but widespread species and habitats it is not so clear what proportion is required. Following discussions at the Habitats Committee (a committee of Member State representatives established to assist the Commission in implementing the directive) and its Scientific Working Group, the Commission published criteria for the assessment of Member State proposals and for approval of sites as SCIs (EC 1997b). This accepts that a case by case analysis will be necessary but gives the following points to be taken into account during discussion:

- Comparison between the geographical distribution of the sites submitted by the Member States for a given habitat type or species and its known distribution patterns;
- Comparison between the range of habitat or species variation of the whole of the series of proposed SCIs relative to the described ecological and genetic variations of the habitats or species;
- An assessment of the trends of distribution and abundance of the habitats and species related to natural and anthropogenic factors

For each seminar the ETC/BD produced a series of working documents, which included maps of the sites proposed for each habitat or species, summary descriptions of each site and a preliminary analysis for each species or habitat. This preliminary analysis followed the 1997 criteria.

Many sources of information were used for this analysis. For species these included atlases, both national and European, Redbooks and a search of the scientific literature. Much less information was available for habitats, especially at the start of the seminar series. It is clear that it had been intended that the Corine biotopes database (Moss and Wyatt 1994) would be a major source of information but it proved to be of limited use. Many habitats are based on plant communities so the phytosociological literature was very useful, especially for variation in habitat types. However, in many cases it was necessary to use the distribution of key plant species or other features as an indication of probable distribution. For example, distribution maps of *Pinus cembra* and *Larix decidua* give a good indication of the probable distribution of habitat type '9420 Alpine *Larix decidua* and/or *Pinus cembra* forests'. Soil and geological maps also helped. This type of approach was later formalised by the PeenHab project (Mücher et al. 2009).

Many countries published handbooks or other sources of information on the Annex I habitats and Annex II species, such as the French Cahiers d'Habitats series (Bensettiti 2001-2005), although many were published too late to be of use during the seminars. The nature NGOs produced many useful reports, including shadow lists of potential sites (see e.g. Irish Peatland Conservation Council 1999, WWF 2000, WWF Austria & Oikos Inc. 2004). It was particularly difficult to obtain estimates of the area of Annex I habitats present in each Member State and for the populations of some less well known species, such as insects and bryophytes. In such cases discussion was focused on ensuring a good coverage of distribution and variation.

Many habitat types show variation, often linked to environmental factors, such as climate, soil type or altitude. For example '6230 Species-rich *Nardus* grasslands, on siliceous substrates in mountain areas (and submountain areas in Continental Europe)' has distinct lowland and upland forms (Galvánek and Janák 2008) and seminars have ensured both forms are represented in the network. Although the species of Annex II have genetic variability this is rarely known in any detail and it has been assumed that a good geographical distribution of sites will capture any such variation. In some cases differences have been described at subspecies level and these can be taken into account, for example the Annex II butterfly *Euphydryas aurinia,* which has several described subspecies and forms (van Helsdingen et al. 1996).

Habitats known to require management, often based on extensive agriculture (Halada et al. 2011), such as hay meadows, have often been the subject of particular attention, especially when there is a known decline in the recent past.

The last seminars for the EU15 were in 2003 for the Mediterranean and Boreal regions by which time all 15 Member States had made substantial proposals (see Fig. 2) but still had gaps for certain habitats and species. Further progress has been assessed through bilateral meetings between the Member States and the European Commission, assisted by the ETC/BD. These meetings are still continuing although

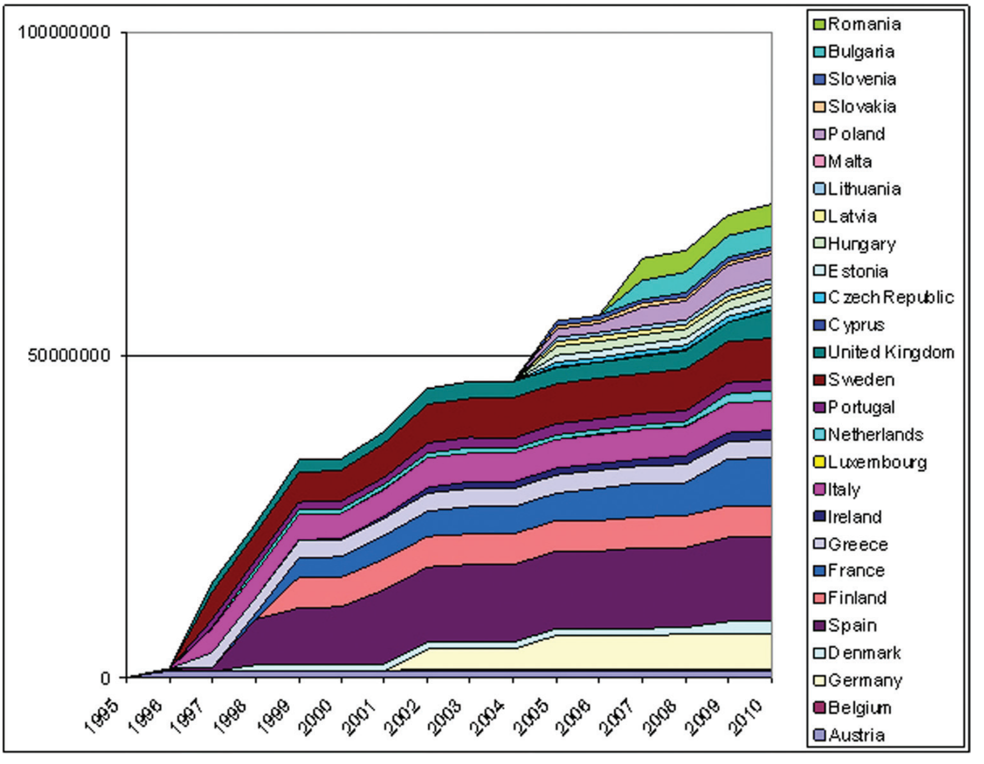

Figure 2. Growth of area (ha) proposed as SCI per MS from 1995 to present (Source ETC/BD).

mostly to discuss changes made to existing sites rather than the proposal of new sites; changes include modifications to site boundaries and the addition or deletion of habitats or species to a given site following re-surveys.

There have been independent assessments of the network but only for some groups of species or habitats and often just in single countries. For example Verovnik et al. (2010) examined the network in Slovenia from the perspective of butterflies while Jantke et al. (2010) examined the effectiveness of Natura 2000 for the conservation of wetland species.

Site Designation

Following discussion species by species and habitat by habitat during the seminars and subsequent bilateral meetings the sites themselves were examined following the 1997 criteria to exclude sites that do not qualify as SCIs and lists of accepted sites are published in the Official Journal of the European Communities for each biogeographical region. The first 'List of SCIs' was adopted in 2001 (Macaronesia) and lists have now been adopted for all regions. Relatively few proposed sites have been rejected, usually as they host no Annex I habitats or Annex II species.

Once sites have been included on a 'Community List' the Member States have six years in which to formally designate the sites as SACs.

EU Enlargement

When the Birds Directive was adopted in 1979, the EU had nine MS but has since grown to 27. At each enlargement the candidate countries have had the opportunity to add habitats and species to the annexes of both directives, and for species of the Habitats Directive to have exemptions (for example several countries have an exemption from Annex IV for *Castor fiber*). Table 1 summarises the changes since the Habitats Directive was adopted. When Austria, Finland and Sweden joined in 1995, only Austria had agreed a full list of amendments and only one habitat type and one species had been proposed by Finland and Sweden for the annexes of the Habitats Directive. A complete list of additional habitats and species for Finland and Sweden was published in 1997 (EC 1997c). Further additions were made in 2004 when 10 countries joined the EU with the latest changes in 2007 when Bulgaria and Romania joined. These amendments followed some four years of negotiations with the ETC/BD giving scientific advice to the European Commission. Further changes will probably be needed for any future EU enlargement.

A second round of seminars started in May 2005 for the EU+10 and as these countries mostly had substantial proposals only one seminar per region has been held. This was due to an agreement that Natura 2000 sites should be identified by the date of accession to avoid damage by EU funded projects, such as transport links. In Poland, the initial proposals were clearly inadequate due to political reasons (see Grodzinska-Jurczak and Cent 2010) and a bilateral meeting including all stakeholders was

Table 1. Changes in the number of habitats and taxa listed in the annexes of the Birds & Habitats Directives due to EU enlargement. The taxa are mostly species but also include subspecies and genera e.g. *Dianthus arenarius* subsp. *bohemicus, Alosa* spp.

	1992	1995	1997	2004	2007
a) Birds Directive					
Annex I Birds	175	+7 182	-1 181 †	+13 194 ‡	194
b) Habitats Directive					
Annex I Habitats	169	+9 178	+20 198	+20 218	+13 231
Annex II taxa	633	+6 639	+68 707	+168 875	+22 897

† *Phalacrocorax carbosinensis* was removed from Annex I

‡ *Alectoris graeca* replaced *A. graeca saxatilis* & *A. graeca whitaken* previously listed

held in 2010 following further site proposals. Following the accession of Bulgaria and Romania a seminar was held in 2008 for all four biogeographical regions present. A regularly updated list, with dates, of all seminars and bilateral meetings is available on the ETC/BD website (http://bd.eionet.europa.eu/activities/Natura_2000/pdfs/History_of_the_biogeographical_process_2010.pdf).

Marine Natura 2000

When the first seminars were held it was not clear if the Habitats Directive applied offshore and therefore the marine habitats and species were only assessed in territorial waters (usually 12 nautical miles) during the seminar for the adjacent biogeographical region. Following a court case in England in 1999 and a subsequent judgement by the European Court of Justice in 2005 it was agreed that the two directives apply to all waters where Member States exercise sovereignty or jurisdictional rights. For most Member States this means that the directives apply to their Exclusive Economic Zones, which can extend 200 nautical miles from their coasts (Evans et al. 2011). The Member States asked for guidance on applying the Directives offshore and in March 2003 the Commission established a marine working group, which published guidelines in 2007 (EC 2007). As it was clear that previous assessments needed to be revisited a 'Marine Reserve' was introduced for habitat types and species thought to occur offshore and Member States given more time to identify and propose sites. By 2009 enough SCIs had been proposed to hold a series of marine seminars with a first meeting in Galway, Ireland, in March 2009. As the biogeographical regions are based on terrestrial vegetation they do not form natural regions at sea and so marine regions based on the marine conventions have been used for seminars and also for reporting under Article 17 of the Habitats Directive. Although some countries have proposed significant areas, in general the marine component of the Natura 2000 network is far from complete (Evans et al. 2011).

Site selection

When the Habitats Directive was being negotiated many Member States, especially in NW Europe expected that their existing networks of protected areas would be sufficient for Natura 2000 and these existing sites (nature reserves, national parks etc.) did form the starting point for site selection in most countries. However, as shown by Figure 3, all countries have had to find additional sites for Natura 2000 and this figure understates the additional sites as in some countries designation under national legislation is often involved in site protection. For example, in the United Kingdom most Natura 2000 sites are protected to a large degree due to being also designated as Sites of

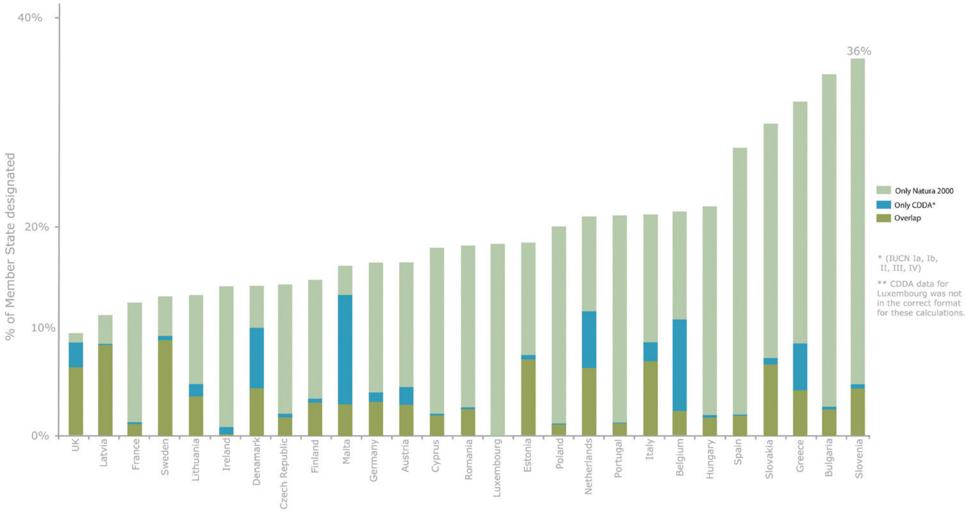

Figure 3. Natura 2000 and protected areas designated under national legislation (IUCN management categories I to IV, Dudley 2008) (Source ETC/BD).
Note. The data from Luxembourg could not be used as it consisted of points, but not the required polygons of the protected area. Only 50% of nationally designated sites in Spain have an IUCN management category reported

Special Scientific Interest (SSSI) and sites identified as being necessary for Natura 2000 are usually also designated as SSSI – of 32 new SSSI in Scotland designated in 1996, 31 were designated in order to be part of Natura 2000 (information from Scottish Natural Heritage sitelink http://gateway.snh.gov.uk/sitelink/index.jsp). In Scotland many of the sites added to the national network were for rivers as these had previously been under represented.

The proportion of each country included into Natura 2000 varies from 7% (United Kingdom) to 36% (Slovenia). Part of this variation is due to ecological differences with relatively few areas of nature conservation interest in urbanised and intensively farmed areas, such as southern England or northern France, but also due to national policies. For example, although the United Kingdom has a low proportion of its territory as SPA or SCI, it does have a well developed system of planning control, which means buffer zones around the key areas of interest are less necessary.

National policy also influences the size of sites, with some countries opting for few, large sites and others for many small sites as shown for Spain and Germany in Figure 4. Large sites may be easier to administer and in some countries management may be directed at a group of sites rather than at individual sites, as in France.

Although software tools such as Marxan (http://www.uq.edu.au/marxan/; Ball et al. 2009) or Zonation (http://www.helsinki.fi/bioscience/consplan/software/Zonation/index.html; Moilanen and Arponen 2011) exist to help design optimal networks of protected areas, it appears that they have not been used for Natura 2000. In many countries funding from the EU LIFE programme helped with site selection, as with the BioItaly project (Blasi 1996).

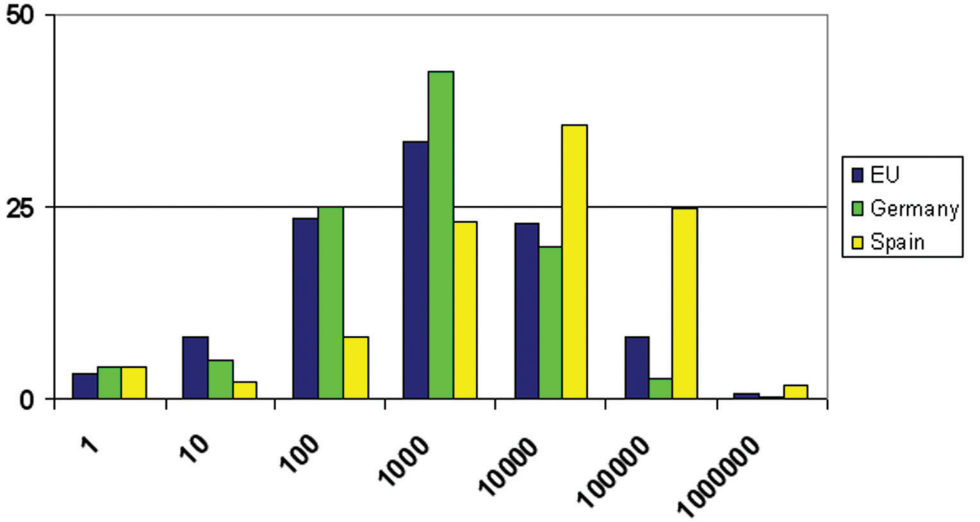

Figure 4. Percentage of sites in each size class (ha) of SCIs in Germany, Spain and the EU, marine sites have been excluded. (Source ETC/BD).

Conclusion

Although there have been considerable difficulties, both scientific and political (Paavola 2004, Keulartz and Leistra 2008), the network is close to complete on land but not at sea and, given the current rate of proposing new marine sites, it seems unlikely that the EU Biodiversity Strategy to 2020 target that "Member States and the Commission will ensure that the phase to establish Natura 2000, including in the marine environment, is largely complete by 2012" (EC 2011a) will be reached. The benefits of the Birds Directive have been demonstrated by Donald et al. (2007) who showed population increases of endangered species in response to conservation measures but to date there is no comparable published study on the Habitats Directive.

The lists of species and habitats has often been criticised and suggestions made for changes (e.g. Evans 2006, Bergmeier et al. 2010) and some countries have had lists of additional interests to help with site selection, such as Italy (Blasi 1996) and Greece (Dafis et al. 1996). However, site designation can help conserve species not listed on the annexes as shown for birds in Latvia (Opermanis et al. 2008) and for gypsophilous plants in Spain (Martínez-Hernández 2011). Indeed the incidental protection of many non listed species was one of the reasons to list habitats rather than just species as for the annexes of the Berne Convention.

Site designation is just a first step in conserving the habitats and species as most require appropriate site management, and there are obligations to protect sites from loss and damage and to monitor the habitats and species listed on the annexes. Although site management plans are not obligatory, they are recommended (EC 2011b) and in some countries, such as France, are required by national law. Two recent publications concerning Greece and Romania (Apostolopoulou and Pantis 2009, Iojă et al. 2010) suggest that the necessary administration is not in place in some countries.

The Commission, together with the Member States, NGOs and the ETC/BD, is planning a series of seminars, organised by biogeographical regions, to discuss management of Natura 2000 sites. The first meeting will be for the Boreal region and is scheduled for 2012; it is expected to focus on a small number of habitat groups and associated species.

As well as the site network, work towards Natura 2000 has also had other benefits, not least increased scientific study of the habitats and species listed on the annexes including habitat mapping, in some cases of entire countries as in the Czech Republic and Spain (Rivas-Martínez and Peans 2003, Härtel et al. 2009). Future challenges include ensuring the network allows for adaptation to environmental change, including climatic change (Harrison et al. 2006, Vos et al. 2008).

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RESEARCH ARTICLE

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Genealogy of nature conservation: a political perspective

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Abstract
Modern nature conservation is a product of post-Enlightenment modernity; I explore the heterogeneity of its conceptual and ideological background. The 19th century legacy comprises concern over human-caused extinctions; protests against excessive hunting and cruelty toward animals; utilitarian care for natural resources; and romantic sensibility concerning the value of nature for human health and spirituality. The 20th century added into conservation thinking increasing consciousness about human biospheric dependence; efforts to identify appropriate conservation targets; and most recently concern over the loss of biodiversity. The politics of nature conservation has taken shape within the framework of politics of nature, that is, choices vis-á-vis nature that have been made either as deliberate decisions on resource use or as side-effects of subsistence practices of various types. Because of tensions and conflicts with alternative ways of using nature, formulating realistic conservation policies has been a complicated task. Problems and uncertainties emerge: pursuing material aspirations of the current world society will necessarily bring about damage to ecological systems of the Earth. The way forward is to identify feasible alternatives in the midst of the tensions and ambiguities that arise, and to open up space for carrying through conservation initiatives.

Keywords
conservation thought, conservation policy, conservation governance, utilitarian conservation, romanticism, genealogy, framing, normativity, normative order, action space

Introduction

The political in nature conservation

Conservation of nature became established as a duty of national governments in the course of the 20th century. Every country went through particular idiosyncratic stages, but the process was essentially international, driven since the first half of the 19th century by a strengthening public opinion and, eventually, citizen movements. Good national histories are available, variably sensitive to the international background scene; I'll mainly restrict the discussion below to Britain (Evans 1992; Adams 1996) and the US (Hays 1969; Keiter 2003; Andrews 2006), backed with my own Finnish experience.

As a research speciality, nature conservation was stabilized quite recently, basically with the origin of the new biological sub-discipline of conservation biology in the 1980s: *The Society for Conservation Biology* and its journal *Conservation Biology* were established in 1986. The self-image of the research field was summarized in the 20th anniversary issue of the journal, published in June 2006 (Meine et al. 2006). It is woven around a narrative of a growing concern about deterioration of nature under human encroachment which triggered concerned biologists to establish a new "crisis discipline," in Michael Soulé's often quoted phrase (Soulé 1985).

However, this brief narrative scratches only the surface. The current ethos of nature conservation is a product of post-Enlightenment modernity. An early springboard for what later grew into the current conservation ethos was strengthening doubt against Enlightenment trust in historical progress which was backed by a religious conviction that the design of the Earth was inherently favourable for human well-being. Clarence Glacken (1967, 549) assessed the scepticism about progress as follows: "When the protective cover of design is removed, lesser ideas escape and assert themselves like children rebelling from their parents. The idea of progress has similarly concealed supposedly minor failures in the millennial march of civilization. Remove it, and these failures stand on their own feet."

The path from early post-Enlightenment scepticism to modern nature conservation has been long and winding. My aim in this essay is to trace stages through which nature conservation has become a broadly accepted but also contentious field of public policy. The main argument of the essay comprises two parts. The first part presents an outline of the genealogy of conservation thought: how nature has got normative weight in modern societies and what kind of specific knowledge has supported this development. I summarize my perspective on genealogy in the next section, and describe the genealogy in the subsequent section. The second part, in the last two sections of the paper, presents key aspects of the political challenges brought about by nature conservation. I use 'framing' and 'reframing' as a methodological perspective to specify goals and background assumptions of various stages of conservation thought. Several essays in Hajer and Wagenaar (2003) describe the methodological approach.

I use the term *politics of nature* to describe the general background of choices that are made vis-á-vis nature, either deliberately or as side-effects of activities that build up human subsistence. This perspective is largely congruous with the term 'politics of nature' as used by Bruno Latour (2004). First decisions pertinent to politics of nature were made at the dawn of human cultures, such as, for instance, choosing favourable sites for houses and villages, marking their surroundings with human symbolism and paraphernalia, and claiming space for hunting, gathering and cultivating. Later on the scope of politics of nature has expanded in parallel with the growth and diversification of human economic activity. Politics of nature gives shape to the political and societal conditions under which nature conservation either gets, or does not get political leverage.

Politics of nature cuts both ways: humans modifying nature mould themselves, by their very actions. Various elements and processes of nature are active participants in this interplay. Awareness of such interdependence is ancient and has formed one of the springboards of modern nature conservation. Understanding of what nature is has, of course, been modified over the centuries, but politics of nature is primarily about concrete decisions on resource use, modification of the surroundings, and so on, in increasingly complicated economic, social and political contexts. Modern nature conservation is one alternative among many others in making decisions concerning nature. The whole scene is thoroughly permeated by uncertainties, doubts and vested interests.

However, I have to add one important caveat: The perspective in what follows is seriously biased toward the industrialized world. While the developing countries have a critical position on the current scene of politics of nature and nature conservation, I mainly have to leave them out, for lack of space and expertise. One of the reasons is the huge variation there is in both natural and political conditions across the developing world. Brief generalizations would be caricatures of no analytic value; for the theme, see Western et al. (1994), and Adams and Mulligan (2003).

As human historical experience of use of nature can be made meaningful within mutually contradictory interpretative frames, ambivalence is an unavoidable companion in politics of nature. My view is that such ambivalence can play a productive role in conservation thought. Nature conservation is about choices in relation to nature, and the inherent ambiguity of criteria forces us to assess what is important in any particular situation. Identifying critical ambiguities opens up space for constantly rethinking the framing of conservation policy. Every apparently simple decision has complex trade-offs and unanticipated consequences. Puristic fundamentalism paves the way for disasters.

On genealogy

People have, of course, always known that their sustenance depends on something that is outside of their powers, that is, nature. Accordingly, the view that humans are not entitled to deal with the rest of nature any way they wish is ancient. Nature sets rules on proper human behaviour, and people have tried to figure out what those rules are.

This reasonable position is less conclusive than it may seem, however. In material terms, the success of humanity in the intercourse with nature has been stupendous. Is the success due to following rules set by nature or, in contrast, to creating new rules?

Nature gives no answers. The human historical experience seems to support the latter alternative, but time and again, the human enterprise has suffered set-backs, often as unanticipated consequences of human actions that show up with time. Plato's lament of the disappearance of forests from the mountain sides of Attica is a famous early example.

The fact is that it is difficult to come up with unambiguous criteria as to whether a particular human-induced modification of nature is ultimately benign or destructive. We humans are denizens of the biosphere of the Earth. We have to live out of nature. Whatever we do brings about changes in the rest of nature. Decisions on what to do, choices between alternatives are always necessary.

Thus, the story of nature conservation is largely a story of how nature has won a place in the normative order of modern societies. Genealogy aims at analyzing the historical constitution of normative orders; a paradigmatic model is Friedrich Nietzsche's *The Genealogy of Morals*. Accordingly, a genealogical perspective toward any particular idea sheds light on how the idea came to be, and what kind of background made it seem like deserving serious attention and, perhaps, acceptance. Philosopher Ian Hacking (2002) uses an alternative expression, 'historical ontology.' It brings into focus beliefs people have had in the past about what reality is like. A pertinent question is what kind of observations and experience was accepted as evidence supporting particular beliefs. This question obviously concerns scientific assumptions and theories as well as more mundane popular beliefs (Chandler et al. 1995).

As a normatively grounded perception of human place in the natural world, nature conservation has straightforward implications as to what is right and what is wrong in the economic and social practices of a given society. Hence, it lines up with the normative order of the society. Sociologist Barry Barnes (1988) analyses the nature of normative order in society in a useful way. First of all, a normative order is a collective phenomenon that has taken shape through experience-backed common agreement among members of a society: "The normative order must arise from calculative conformity and the calculative sanctioning of others into conformity." As a product of history, a normative order is analogous to "second nature" as a human-created world which is facing the present generation as a set of external constraints (see Dyke 1988 on convention as second nature).

As Barnes further notes, knowledge has a special role at the basis of normative order. Knowledge shared among members of a particular society supports the acceptance of social facts such as division of labour and differentiation of social classes. Barnes emphasizes the self-referentiality of social knowledge. When a large enough number of people in a given society share a belief, the belief is accepted without further questioning. Barnes (1983) calls this a "boot-strapping" view of social knowledge.

Knowledge of nature is less pliable than knowledge of society. Obviously, "boot-strapping" cannot make nature to fold into whatever shape people want to get it. However, when nature is allocated a role in supporting societal norms, the difference gets diluted: factual knowledge of nature is at a distance from the norms it is supposed to support. This relationship resonates with ambiguities inherent in nature conservation:

normative standards derived from nature become self-referential to the extent that any interpretation of nature can be made concordant with several alternative normative goals.

Improving knowledge of the human dependence on the rest of nature has certainly had a critical role in the stabilization of conservation thought. However, there is a need for more groundwork on identifying the bits of knowledge that have been accepted as relevant, the framing of such bits of knowledge, and the normative implications. The transformation of knowledge into evidence at any point in time in the past as well as in the present is a key term in this riddle. Evidence is Janus-faced: In a straightforward sense, evidence consists "of one thing pointing beyond itself" (Hacking 1975, 34). On the other hand, however, evidence is self-referential and speaks for itself: "evidence also carries the rhetorical sense of vividness, a gesture which refers to the immediate appeal of the fact itself." (Schaffer 1995, 57).

The vividness-dimension of evidence has been influential in nature conservation. Any exposition of the roots of modern conservation thought supports this view. For instance, David Evans (1992) opens his narrative of nature conservation in Britain with a chapter on "The why and the wherefore" and dedicates its first section to "Aesthetics." Evans cites a whole range of conservationists giving testimony to the significance of personal and aesthetic motivations for their activism in the conservation movement. According to such views, nature bears evidence all by herself, through natural harmony and beauty that are available for all humans to experience directly. Ralph Waldo Emerson's essay "Nature" is a classical expression of this view (Emerson 1965[1884]).

It is clear, nevertheless, that increasing knowledge about human place in the world has been a critical factor in the history of nature conservation. Science is a specialized form of knowledge that connects together specific factual claims and interpretative frames. Science has succeeded in this by developing its own specializations, both conceptual and practical, and giving rise to new specialist-professionals. Scientific knowledge-practices as well as the stabilization of criteria of validity within different fields of science have been essential in this development. Ian Hacking (1992) describes the dynamics of stabilization as a 'self-vindicating structure' that is created by the practical work of scientists themselves.

Stabilization of a knowledge base is necessary for any branch of research. The knowledge base of conservation thought is created primarily by ecology and its sister disciplines. The practices ecologists have been involved with are critical as establishing and supporting evidence held decisive. Hacking applied the notion of 'self-vindicating structure' to laboratory sciences, but a similar process has stabilized also ecological field research (Haila 1992, 1998). Specifying the conditions of stabilization is one of the challenges of genealogical analysis: In Chuck Dyke's apt term, stabilization depends on "the progress in investigative practice" (Dyke 1988, 138). As Dyke also emphasizes, the progress of investigative practice is not linearly accumulative. This is certainly important in conservation science tied to normative views which change through a different dynamics than the research itself (Haila 2004), but I have to leave this aspect to a few short remarks in this essay.

An ethical conviction can, of course, be more compelling than the knowledge it is backed with. A passionate concern for everything alive, at the extreme an Albert Schweizer type respect of life, is one manifestation in the sphere of conservation thought. Although the decline of trust in a Divine providence was an early springboard of conservation thought, religious convictions have not vanished. The forcefulness of moral visions underlines the fact that the acceptance of conservation norms moulds human subjectivities.

In the following I chart main layers of the genealogy of modern nature conservation. As is the case with the genealogy of all traditions of any complexity, such layers cannot be ordered into a chronology. Instead, modern conservation thought has grown from several different sources which have partially separable and partially convergent histories. My interest is mainly to explore how conservation thought has slowly become explicitly political, in the sense of aiming at changes in the politics of nature of modern societies. The narrative layers form a background for the last two sections of the paper, focused on conservation governance.

Modern conservation thought: from moral awakening to systematic knowledge claims

Human-caused extinction

Extinction of species is the apotheosis of irreplaceable change in nature that humans are capable of bringing about. William Adams names "the stand against extinction" as the common concern in the 20th century conservation thinking (2004, 17). Originally, the question was whether extinctions have happened in the history of life at all. The historical fact of extinction arose from palaeontology in the 18th century; this triggered religion-driven controversies about the mutability of the natural order, lasting well into the 19th century (Mayr 1982, 347-349). Darwin's theory of evolution finally settled the issue; in *The Origin*, Darwin dedicated a 4-page section to "On Extinction." The fact of extinction had to break through a metaphysically grounded dogmatic view of the world.

Human culpability in species extinction was finally accepted in the late-19th century, by and large (Adams 2004). Decisive evidence seems to have grown from the practical experience of the "community" of big game hunters in European colonies. Adams (2004, 30) makes the point in a forceful wording: "There is no doubt that the driving force for wildlife conservation at the start of the 20th century in both Africa and India were the European hunters." As luminous members of high societies of the affluent world, colonial hunters were in the position to launch international meetings and organizations supporting the cause of nature conservation. One of the results was the establishment of the *Society for the Preservation of the Wild Fauna of the Empire* (1903). The society dropped 'wild' from its name in 1919; it became *Fauna Preservation Society* in 1950 (Adams 2004). British hunters got whole-hearted support from prominent

Americans such as Theodore Roosevelt. Later on, the fact of human-caused extinction was brought into public attention by symbolically important cases such as the passenger pigeon (*Ectopistes migratorius*), the great auk (*Pinguinus impennis*), the quagga (*Equus quagga quagga*), the dodo (*Raphus cucullatus*), and so on. Natural history stories of these and other cases are documented in a great number of works.

However, as always, the view that human modification of nature may drive other species to extinction had precursors. Clarence Glacken (1967, 678) regards Count Buffon as an important figure. Although an Enlightenment man and a firm believer in human progress, Buffon was aware of negative changes that humans may bring about in the surrounding nature.

Romantic sensibility

Although romanticism had its origin within Enlightenment rationalism and, thus, shared the same basic assumptions, it brought new elements into a general understanding of the humanity-nature relationships. The famous phrase that German romanticists discovered the Alps has some truth in it, although they had a long row of precursors, extending back at least to Petrarch and his climb to Mount Ventoux on April 26, 1336. Nature was not only to be exploited; nature was also to be adored.

Perhaps the most important legacy of romanticists is their view that nature has a special role in the spiritual improvement of humanity. Major literary figures supported the romantic vision and gave voice to adoration of nature with a distinctly modern tone. William Wordsworth was an important inspiration in England; his *Guide to the Lakes* (1810) includes one of the earliest suggestions on the need to protect natural areas as "a sort of national property, in which every man has a right and an interest who has an eye to perceive and a heart to enjoy" (cited in Holdgate 1999, 4). Geographer and explorer Alexander von Humboldt had a similar inspirational role in German speaking continental Europe around the same time. Also Humboldt used the attribute 'national' in his vocabulary. In northern Europe, a prominent promulgator of the cause of nature conservation was Finnish born explorer Adolf Erik Nordenskiöld.

Romantic adoration of untouched nature had a great influence in North America, mediated by East Coast transcendentalists. Famous personalities, such as Ralph Waldo Emerson, Henry David Thoreau and John Muir were moulded by this movement (Nash 1967 tells this story). They all had visions, but John Muir was an organizer under whose influence for instance the Sierra Club, one of the most influential conservation organizations in the US, was founded in 1892.

Connotations of the term 'national' are ambivalent in that they include both nationalism and public good. In political terms, the former is exclusive as supporting the consolidation of a particular Nation whereas the latter is inclusive, as advancing the moral education of all citizens. In the views of romantic visionaries such as John Muir the latter aspect was dominant through a Pantheistic belief in the healing powers of nature, available similarly to all humans. But also a more exclusive convergence of nature and nationalism took shape in semi-institutional forms. Particularly in northern Europe, nature was constructed as an important part of the symbolic cultural self-image of the gradually consolidating nation states. It seems there are differences across nations in this regard: younger states, with less of a unified cultural heritage, were more inclined to adopt "original nature" as their emblem than older and more firmly established ones. Germany and France differ in this regard, as do the Nordic countries among one another. Norway (independent since 1905) and Finland (independent since 1917) cherish strong national images of nature: fjords and mountains in the former, forests and lakes in the latter. The old Nordic powers Sweden and Denmark lack unifying "national natures" in a similar sense. What they have as national ideal natures, such as the Danish heath and the Swedish archipelago, bear marks of middle-class identity-construction and class distinction.

Utilitarian conservation

Enlightenment rationalists trusted human capacity to bring about favourable changes in the surrounding nature. Historically, such optimism was supported by the systematic harnessing of natural resources of the developing nation states to support domestic economies. Successful draining of wetlands and management of waterways gave ample support for such optimism. Paradigmatic examples include the Dutch Golden Age (Schama 1988) and the program of "inner colonization" of wetlands along the rivers in northern Germany, launched by Frederick the Great in the 1740s, and the taming of the Rhine a little later (Blackbourn 2006). Inner colonization got boost from the state-centered economic doctrine of Cameralism.

Active human modification of natural elements of the environment was broadly accepted among romanticists as well. Rationalistic functionality and romantic spiritual improvement join hands in the moulding of urban gardens and parks (Rykwert 1980). The colonial experience was Janus -faced in an analogous fashion. On the one hand, as historian Alfred Crosby (1986) has shown, successful colonization on a large scale produced "Neo-Europas" in those parts of the other continents where natural conditions resembled those from which the colonists came. Crosby dubbed the ensuing environmental modifications "ecological imperialism." But the colonial experience produced another reaction, too. In local contexts, colonists were left on their own in environments that were alien to them, and started to familiarize themselves with the conditions in which they eked their living. This experience produced "moral ecologies" that included an incipient need to respect the ecological conditions the European colonists were subjected to. Evidence for such a change comes from different parts of the colonized world: New England (Judd 1997), New Zealand (Wynn 2004), and tropical islands as well as the Cape district in southern Africa (Grove 1997). George Perkins Marsh who published his masterful exposition of humans as geological agents on the Earth, *Man and Nature*, in 1864 was a product of the New England conservationist tradition (Judd 2004).

Critical questions were asked concerning the feasibility of progress also within the European heartlands. Glacken (1967, 485) takes up John Evelyn's *Silva* (1664) and Colbert's *French Forest Ordinance* (1669) as emblematic works that "mark … the beginning of a more reserved attitude towards the modification of nature by man in the history of Western thought."

In other words, despite successes, human-initiated modifications of nature brought into the open a new type of ambivalence: Where does the human ability to improve nature come from, and What are its limits? Although dreams of industrial progress reigned supreme in the 19th century, overt optimism was accompanied by doubt and criticism. Malthus, of course, is a well-known critic of optimism about human progress in the early decades of the 19th century; somewhat anachronistically, he might be regarded as a utilitarian conservationist.

Conservation ideology adopted in the US in the era of Progressivism at the turn to the 20th century was an outgrowth of utilitarian conservation (Hays 1969, Andrews 2006). The approach implied a search for correct rules for human use of nature's resources. Practical traditions in agriculture, range management, forestry and fisheries have produced background knowledge for modern ecology (Haila 2011). The debate in the US produced a conflict between two competing attitudes, 'preservation' and 'conservation', the former drawing upon visionary views of human coexistence with nature (as supported by John Muir), the latter upon wise use of natural resources (as supported by Gifford Pinchot, the first head of the US forest service and a close advisor to Theodore Roosevelt, as well as by Roosevelt himself, to the dismay of Muir). Scientific concepts were adopted to support the conservationist view. The notion of "sustainable yield" was formalized in fisheries and forestry; the term originated in the context of German forestry science in the late 18th century. Later during the 20th century the norm of sustainability was uncoupled from yield and reframed in terms of viable ecosystems.

"Nature is our friend"

The mixing together of utilitarian and romantic views of nature found positive resonance in public opinion in the course of the 19th century. Public protests grew against excessive hunting and cruelty toward animals among the public at large, marking the birth of new attitudes and subjectivities vis-à-vis nature. There is lots of literature on this process. The high social respect enjoyed by naturalism in Victorian Britain is well-known. Evans (1992, 34) names *The Temple Coffee House Botanic Club* (established in 1689) as an early precursor. The club specialized in the use of plants in medicines. The success of Gilbert White's *Natural History of Selborne* (1788) gives testimony for the popularity of naturalism in England, but the phenomenon was wide-spread also elsewhere in Europe (Drouin and Bensaude-Vincent 1996).

Birds gained a special position in this movement: protests against the collection of feathers for use in female fashion, for instance, grew up both in the English speaking world and in continental Europe. Indignation about excessive hunting of birds during migration and at winter quarters gave further fuel to the spread of associations and public protests. Also the usefulness of songbirds in pest control was noted. In Finland, quite typically, a well-known historian and popular author Zacharias Topelius participated in the founding of a bird protection society called *Majföreningen* in 1870 ("May Association" in English; Swedish was at that time the main language of the learned echelons of the Finnish society; Vuorisalo et al. 1999).

The shift was a reflection of changing social identities, class positions and prevailing mores. My hunch is that the new moral sensibility developed in parallel with how the rising urban middle-class self-organized itself in the 19th century (Dyke 1999). As Chuck Dyke points out, the urban middle-class developed a passionate interest in cultural heritage and pre-modern architecture as epitomized, for instance, in the figure of John Ruskin. But no doubt, the shift in public opinion got support from the organizational efforts toward nature conservation initiated by colonial hunters.

Changes in public mores brought about changes in legislation. Bounties were scrapped, and lists of protected species were included in conservation laws. Conservationists made pleas for turning the logic around so that the laws would only include what they called "black lists", i.e., species that lack protection. Eventually such a change took place, but this had to wait until well into the 20th century.

Human biospheric dependence

In current thinking, the need to protect nature cannot be disentangled from a perception that the existence of human societies depends on the 'life-support system' of the Earth, to use Eugen P. Odum's (1989) phrase. This convergence is relatively recent, however. The idea of human biospheric dependence grew out of 19th century science, specifically the view of the Earth as a unified energetic and biogeochemical system. The biosphere is driven by energy carried by solar radiation and assimilated into biological processes by photosynthesis (see Smil 2002, Lenton and Watson 2010 for recent overviews). In terms of materials, the Earth is basically a closed system; hence, for life to have thrived on the Earth for almost four billion years, the materials necessary for metabolic processes have to be constantly recycled. Russian geochemist V.I. Vernadsky was a pioneer of biogeochemistry as well as a promoter of the term 'biosphere'; but as always, there were precursors (Smil 2002; on biogeochemistry: Wilkinson 2006; Lenton and Watson 2010).

Ecosystems ecology represented by, for instance, brothers Howard and Eugen Odum, grew eventually out of the soil prepared by Vernadsky. Biophysicist Alfred Lotka was a critical mediator. Lotka's overview *Elements of Physical Biology* (1924) provided a synthesis of the dynamics of ecological populations and ecological communities (the term 'ecosystem' was adopted in the 1930s). A remarkable feature in Lotka's work is his insightful analysis of the nature of human dependence on what he called "the world engine," formed as the sum total of local ecological energy transformers.

Brothers Odum, particularly Howard T. Odum, made heroic efforts to use energy as a unifying term in ecology and humanity-nature interactions. This effort turned out as a failure, as energetic interactions in ecology are qualitatively specified to a much higher degree than the Odum models implied (Fox 1988; Dyke 1997, Smil 2008). However, their groping produced important background material for ecological economics on the one hand, and biospheric systems science on the other hand.

To summarize, although the biospheric perspective originated in the late 19th century at a considerable distance from contemporaneous conservation issues such as concern over species extinctions and protests against excessive hunting, it brought eventually new and important arguments into the support of the conservation cause.

Identifying conservation targets

Nature conservation requires specification as to what has to be preserved and for what particular purpose. Views concerning proper conservation targets grew from several sources and stabilized only gradually. Originally, the targets were broad-scaled natural landscapes considered symbolically and spiritually invaluable such as the English Lake District praised by Wordsworth. Landscape values were a dominant argument in German protests against dam-building in the 19th century, and this ethos carried along well into the 20th century. In the 1930s, conservationist Arno Naumann described activists like himself as "guardians of aesthetic landscape values" (Blackbourn 2006, 224). A similar ethos on the primacy of large-scale conservation targets spread to North America with the romantic movement.

It is probable that the first measures toward nature protection were triggered by peculiar, historically shaped reasons in different countries. "Natural monuments" (*Naturdenkmäler*) were a high priority in Germany, whereas the preservation and management rules of public lands dominated in North America. Such a difference is well understandable: intensely culturally marked landscapes in the one, and perceived vast wilderness in the other. Probably the relative weight of nationalistic ideology versus promotion of public good varied across countries, but this aspect would require a separate analysis.

Legislation on national parks started to take shape variably in different countries but generally quite late. In Britain, for instance, an important year was 1938 with the publication of a founding document, *The Case for National Parks in Great Britain*, and a corresponding bill was drafted in the following year (Evans 1992, 62-3). An administrative body, *The Nature Conservancy* was established in 1948. No doubt, the delay with granting a legal status to national parks was due to opposition from the side of land-owners and agriculture and forestry communities, in quite parallel forms across the industrialized world.

Establishing a network of targeted preserves dubbed *Sites of Specific Scientific Interest* (SSSIs) was an innovation of English ecologists who promoted nature conservation in the 1930s. The network got an established legal status in 1948. In the early 1990s, SSSIs numbered 6700 (Evans 1992). Originally the selection of the sites was based on ecological criteria, but geological formations were also included later on. However, the legal protection of the sites was weak, and valuable sites were lost from the network (Evans 1992, Adams 1996).

The task attributed to authorities by conservation legislation was to develop new instruments for nature conservation, in addition to managing existing preserves. It was not sufficient to argue for the uniqueness of specific sites or species, as was the case in the first half of the 20th century (Adams 1996 is a good analysis of the case of Britain). Typically, common natural types were not covered by the first inventories of areas requiring protection. For instance in Finland, typical taiga forests were included in the national park network only in the 1990s. To improve the systematic character of protection measures, conservation authorities started to compile lists based on general criteria.

The initiative to compile lists of endangered species came from NGOs (WWF in particular): Red Data Lists acquired a systematic form in the 1960s. The first organisms covered were vertebrates (birds, mammals, fishes, reptiles and amphibians) and vascular plants in single countries. Then, since something like the early 1990s, the lists have become international and cover increasingly also invertebrates and other less well-known taxa. Mace (1995) tells the story.

A crucial event in the stabilization of nature conservation across Europe was the European Conservation Year of 1970, celebrated on the initiative of the Council of Europe. In a relative late-comer such as Finland, the influence of the year was decisive: the first national-level planning body, a governmental committee, was established to organize events of the year as well as to plan future measures. By then, the only authority in charge of nature conservation on the national level comprised a three-person staff sitting in a tiny little office located in the Forest Research Institute. Sweden got a well-funded Nature Conservation Authority (*Naturvårdsverket*) in the 1960s. The envious then head of the Finnish office wrote an editorial in the journal of the Finnish Nature Conservation Association with the title “A Letter to Santa Claus” in which he uttered a wish that a strong governmental authority be established also in Finland to further nature conservation.

Comprehensive conservation

Identification of conservation targets using explicit criteria gave rise to new, more systematic methods of assessing conservation values (see Usher 1986 for an overview). Assessments became ever more comprehensive in the sense of covering all species in a particularly taxon in a country, a continent, or in the whole world. I have used the term ‘comprehensive conservation’ for this new approach: not only the preservation of particular targets is at issue, the main concern of conservation is the viability of ecological systems and, ultimately, the biosphere (Haila et al. 2007).

‘Biodiversity’ was adopted as a catch-all term for this theme in the 1980s. The invention of biodiversity was a deliberate political process (Takacs 1996), and the biodiversity concern was deliberately constructed as a big, crisis-driven issue. The main events are familiar: BioDiversity convention in Washington DC in 1985 and the publication of the material of the conference (Wilson and Peter 1988), the declaration of the UN conference in Rio in 1992, and then the adoption of national action programs of various types. The Endangered Species Act of the US (1973) was an early precursor. In the EU, comprehensive conservation is epitomized by the Habitats Directive (1992) which includes statutes both on a network of protected areas dubbed Natura 2000 and on the strict protection of specifically listed endangered species. The Habitats Directive was predated by the Birds Directive (1979) and the Berne Convention on the conservation of European wildlife and habitats (1979). On the international scene, an important step was the Ramsar Convention on wetlands (1971).

Growing scare for a human-caused extinction wave was a straightforward trigger of the biodiversity concern. The perception of extinction underwent an upheaval. Extinction is about the disappearance of single species (or populations), one by one. However, theoretical development in ecology modified extinction into a statistical concept. The trigger was the *Theory of Island Biogeography* of MacArthur and Wilson (1967) with its demonstration of a positive relationship between area and species number on islands and suggestion that this be true of patches of land of relatively uniform environmental types on mainlands as well. Turned the other way round, the relationship became evidence that a decrease in area of an environmental type inflates numbers of local extinctions. A statistical expectation was calculated from the species-area relationship (Preston 1962 made the point prior to MacArthur and Wilson). A statistical concept of extinction elevates the risk of extinction onto an abstract level: the threat of extinction is everywhere present, no matter whether it can be actually demonstrated or not.

This is problematic in several ways. The framing of human-caused extinction threat in statistical terms is based on a reification of the species-area relationship (Haila 2002, 2004). Demonstrating extinction empirically is well-nigh impossible, so, one has to resort to indicators and surrogates of various sorts (*area* remains the single most important), but using such indicators and surrogates as arguments in policy advice opens up new problems (Haila 2004). Maclaurin and Sterelny (2008) assess thoroughly the problems that arise when using surrogates for measuring biodiversity.

Important theoretical developments have taken place, of course, in conservation science which has grown exponentially since the 1980s. In this context, only a few short remarks are possible. *Landscape ecology* originated in the English-speaking world largely as a move away from the black-and-white image of islands versus unfavourable matrix, postulated by island biogeography. Landscape ecology promotes a multidimensional understanding of landscape patterns and processes; good expositions include Wiens and Moss (2005), Lindenmayer and Fisher (2006) and Lindenmayer and Hobbs (2007); for the older Central-European tradition of landscape ecology see Hard (2011). Secondly, it belongs to the logic of comprehensive conservation that the concern over biodiversity loss has joined hands with the perception of human ecological dependencies. This idea caught attention under the heading *ecosystem services* which gained currency in the 1990s, but again with precursors. *Millennium Ecosystem Assessment* has been a major effort to assess the deterioration of ecosystem services on the global level.

Toward conservation governance

A new field of public policy

In the previous section I described the main historical layers of conservation thought up to the 21st century. The political nature of conservation demands has become more articulate during the process. Modern nature conservation implies conservation governance, built upon competent administrative bodies with sufficient authority. However, it is in the nature of the field that the goal is difficult to realize; Keulartz and Leistra (2008) present good case studies of governance problems in the context of nature conservation.

First of all, nature conservation drifts regularly into conflicts with other aspirations within politics of nature. As a consequence, conflicts abound on proper framing of the goals. The controversy between John Muir's preservationist fundamentalism and the wise-use conservationism of Gifford Pinchot's US Forest Service in the early 20th century is a paradigmatic example.

Furthermore, nature conservation faces difficulties in creating workable closures as regards policy goals. A policy closure requires that the targets and the means to reach the targets can be formulated using similar concepts; this view draws upon Dyke (1988), see Haila (2008). A particular difficulty is that nature conservation aims at a moving target: when conservation succeeds, new types of problems will show up as a consequence. The protection of large predators against persecution by local farmers and hunters has given rise to conflicts all over the world. Policy closures are temporary and will be opened up by one stakeholder group or another when the situation changes.

Administrative scientists Charles Fox and Hugh Miller introduced the term *public energy field* for exploring tensions in the dynamic interplay among various actors and interests in to-day's public administration. The term 'field' in their formula refers to "the complex of forces that bear on the situation" and 'energy' "implies that the field is sufficiently charged with meaning and intention that people are aroused, alert and attentive." (Fox and Miller 1996, 9-10). Conservation policy fits these characterizations. In the rest of this section I follow the lead of Fox and Miller and list main factors and actors that have energized the field of conservation policy, in variable forms in different historical contexts.

Organized opposition

Narratives of the early stages of nature conservation take up the opposition it came across, motivated by imaginations of harms and economic losses that efficient conservation might cause. From our present vantage point, some of them seem truly ludicrous, for instance, protests against the first efforts to restrict trade on colourful feathers (Evans 1992, 48). Hunting restrictions provide similar examples. On the other hand, some of the protests against conservation lie on more credible grounds. A well-known source of controversies has been the establishment of national parks, typically opposed by land owning classes.

Conservation controversies have become more intensive in the era of comprehensive conservation. The Habitats Directive has triggered conflicts all over Europe, both on local and national levels. Such conflicts are often understandable: comprehensive conservation intrudes in unexpected ways onto other domains of politics of nature such as local sustenance, productive practices and infrastructural development.

The specific forms of conflicts vary enormously from case to case, depending on socio-ecological particularities. Species that have got an emblematic status in different parts of Europe include the loggerhead sea turtle *Caretta caretta* (Greece), the European hamster *Cricetus cricetus* (Germany and France), and the flying squirrel *Pteromys volans* (Finland); Haila et al. (2007) analyze structural similarities between the conflicts around the turtle and the squirrel. Other famous cases include conflicts over the protection of species such as seals, the otter (*Lutra lutra*) and the great cormorant (*Phalacrocorax carbo*) which cause, either potentially or actually damages to coastal fishery and fish-farming (Varjopuro and Kettunen 2008; Rauschmayer and Behrens 2008). Sometimes, on the local scale, conservation may intervene also with culturally deeply entrenched subsistence practices. Theodossopoulos (2003) presents a culturally sensitive analysis of conflicts with local inhabitants that the protection of the loggerhead sea turtle has brought about on the island of Zakynthos, off the western coast of Greece.

Turf struggles

As a newcomer in the sphere of public policy, nature conservation has intruded into the domains of established administrative sectors responsible for the exploitation of renewable resources, such as forestry, agriculture, range-land management and fisheries. The relative weight of different sectors naturally varies across countries depending on natural conditions and economic history. Professionalism among specialists within the sectors has fuelled the conflicts. Andrews (2006) gives an example: In the US the Progressivist era brought into existence a wide range of specialized agencies in charge of resource use, but in the 1940s and 1950s they were one after the other subjected to criticism for acting on behalf of narrow and particularistic interests instead of public good. Andrews (2006, 456 [fn 27]) lists the Tennessee Valley Authority, the Army Corps of Engineers, The Bureau of Land Management, the Soil Conservation Service, and the Forest Service, and gives references to primary sources.

Infrastructure projects such as road construction and waterway management have been important sources of turf conflicts. Some development projects, for instance the construction of new harbour facilities, are by their very nature targeted to potentially valuable sites; the extension of the harbour of Rotterdam into a Natura 2000 site is a recent example. Ministries responsible for trade, industry and energy are typically in key positions.

Tensions between conservation and environmentalism

Public initiatives in nature conservation were channelled into international organizations and associations in the course of the 20th century: International Council for Bird Preservation (ICBP; established 1922) and International Union for the Conservation of Nature (IUCN; established 1948) as well as NGOs such as World Wildlife Fund (WWF; established 1961) and Friends of the Earth (established in the US in 1969) have been increasingly visible on the international scene.

The new environmentalism of the last third of the 20th century did not originally provide unconditional support for older conservation movements; Hays (1998) and Jamison (2001) are good guides. Friction has been caused by deviating views concerning proper framing of the human environmental predicament. "New" environmentalists were originally suspicious of the "old" conservationists imprisoned in their socially and politically naïve – as it seemed – traditional associations. In the era of comprehensive conservation, however, the topology of the situation has been turned upside down. The protection of nature in the guise of halting the loss of biodiversity is nowadays viewed as one of the main global challenges, comparable to the prevention of climate change.

There has been oscillation between "crisis framing" and "control framing" as regards specific issues. Focused and well-defined environmental problems are amenable to a policy closure and, hence, control framing. On the other hand, crisis framing tends to dominate conservation thinking. Green parties have been major actors on the political scene of environmental concerns since the 1980s, but they have mainly had ambivalent relations with traditional conservation organizations. Green parties are vulnerable to maximalism in their goal-setting, driven by a perceived need to build up a sharp political profile.

Who are the public?

Promulgators of the cause of nature conservation have included from early on both special interests such as big game hunters and the public opinion at large. The role of the public, in the shape of actual movements, has varied and fluctuated in intensity. The constellation of the movement has varied as well, but some aspects are obvious. First of all, the environmental awakening of the 1960s-1970s brought about a confluence of an exceptionally broad range of movements and interests from different sectors of the civil society. As a demonstration, Andrews (2006, 225) gives an impressive list of organizations and groups that participated in the first Earth Day in the US on April 22, 1970. But such a broad constellation was a once-only phenomenon. Second, nature conservation has been propped up among the public at large by emblematic species such as whales and seals. Third, conservation associations and international NGOs have become increasingly professional, particularly in the context of international negotiations (Jamison 2001; Chatterjee and Finger 1994 report on lobbying at the Rio Conference, 1992).

Accusations thrown at conservationists about urbanized elitism abound, but the situation is far from one-dimensional. For instance, movements that defend old-growth forests in northern Finland have been supported by Sami reindeer herders: lichen growing in old forests is the main forage of their animals in the winter. Similar examples abound from all parts of the world. In other instances local populations have turned into supporting nature conservation demands for other kinds of reasons ranging from game management, gathering berries and mushrooms, and recreation. Local municipal politicians have commonly turned their stakes and started to support the establishment of national parks; this transition took place in Finland in the 1990s.

On the other hand, the era of comprehensive conservation has brought forth new challenges for the legitimacy of nature conservation among the public at large. Top-down initiatives, particularly the establishment of Natura 2000 protected areas have given rise to popular opposition in many member countries of the EU (examples in Keulartz and Leistra 2008). Engelen et al. (2008) note that the nature of legitimacy of conservation has changed, from substantive to procedural. Procedures of drawing up and implementing conservation plans matter more than before, and public participation is increasingly held necessary.

Prospects: stabilization and ambivalence

Politics easy, policy difficult

Nature conservation is politicized on the ground, as the example of EU Habitats Directive shows. Problems arise because decisions regarded as technical on an upper administrative level have unexpected distributional consequences on the ground (Engelen et al. 2008). An analogous pattern is apparent on the global scale as well: it is possible these days to come to agreement about ambitious general declarations on biodiversity preservation, but efficient policy is an entirely different matter. The previous goal of halting the decline by 2010, and the new goal-setting agreed upon in Nagoya in 2011 as well as the 2020 program of the EU, published in 2011, serve as examples. The problem is that it is difficult to specify policies that could possibly halt the deterioration of biodiversity. There simply is no straightforward way of halting the expansion of the material basis of the current world society.

As a reflection of this state of affairs, gloomy assessments abound. A typical example is provided by the 20th anniversary issue of *Conservation Biology*: "(I)t is clear that although we may be winning a few battles, we are still loosing the war. With perhaps 20 years or so left to turn the tide, it is worth asking why." (Balmford and Cowling 2006).

In these terms, the task appears daunting. However, the dilemma can be opened up from a different angle; I follow political scientist Giandomenico Majone (1989). First of all, the rhetoric of battles and war has to go. Instead, a closer look is needed at the nature of the problems. Current conservation goals are built upon scientific arguments, but problems met in implementation touch upon political conflicts that cannot be solved by science alone. Majone refers to the concept of 'trans-scientific issues' of Alvin Weinberg (1972), that is, "questions of fact that can be stated in the language of science but are, in principle or in practice, unanswerable by science." (Majone 1989, 3). Silvio Funtowicz and Jerome Ravetz have carried further this line of thinking with their notion of 'post-normal science' (Funtowicz and Ravetz 1990), but there is no space to go deeper into their approach.

Feasibility analysis is the first step recommended by Majone. "(I)t is often more fruitful to ask what cannot be done and why, rather than what can be done" (p. 71). Feasibility analysis involves charting the constraints and impossibilities that restrict the space of action in a given field. It is not difficult to identify constraints faced by nature conservation: the long temporal horizon required for achieving changes in infrastructure and people's ways of life; sustenance necessities of local populations; conflicts with other fields of politics of nature; and so on.

The next step is to scrutinize the constraints to widen the action space of conservationists. Majone supports what he calls "the theorem of the second-best" (Majone 1989, 77): "(I)f suboptimal or second-best solutions are the only feasible ones, then it follows that feasibility, rather than optimality, should be the main concern of policy analysts, and that they should be as occupied with political and institutional constraints as with technical and economic limitations." The implementation of second-best solutions opens up a new round of exploring constraints and finding ways to modify them (p. 87): "The iterative process of discovering constraints and modifying goals or strategies accordingly is the essence of policy implementation."

As Majone emphasizes, developing good arguments and testing the arguments through practical experience is a precondition of any progress. Setting goals and constructing instruments for reaching the goals is a dialectic process; and the realism of the goals is essential from the processual point of view. I leave the last word in this context to Majone (1989, 69): "To try to do something that is inherently impossible is, to borrow from Oakshott, always a corrupting exercise."

Normative background versus evidence

The significance of economic and socio-cultural constraints in nature conservation brings into the open a major ambivalence concerning science: Science aims at analytic generalizations but actual conservation problems are contextual and change shape when situations change. This dilemma is at the background of the strained relationship of ecologists to environmental problems. Early on, ecologists were commonly enthusiastic about the ability of their science to address environmental problems, but they got disillusioned. Eugene P. Odum's widely read 1950s textbook *Fundamentals of Ecology* was a good demonstration of the optimism. McIntosh (1985) comments upon the disillusionment in his US-centred history of modern ecology; Boucher (1998) presents a personal narrative.

The relationship is strained at present, too. Kinchy and Kleinman (2003) conducted interviews with 18 prominent members of the Ecological Society of America and concluded that ecologists tend to maintain a boundary between science and politics because of a perceived necessity to guard the independence of their science.

The dilemma is made more serious by the all-encompassing nature of the concepts of biodiversity and ecosystem services. Biodiversity is a concept very few people can comprehend; also biologists are confused, as testified by the interviews conducted by David Takacs (1996). One of the main promulgators of the concept, Edward O. Wilson has remarked that “biodiversity is, in a sense, everything.” (Wilson 1997, 1). This is a singularly unhelpful remark: how do you protect “everything” to begin with.

My view has been for some time that all-encompassing goal setting in nature conservation is counterproductive. There is no closure, and no reliable metrics. The ideal turns upon itself, as it were. If reliable reference points in external reality are missing, conservation thinking becomes self-referential.

Of course we humans need to care for nature on her own terms, and of course we need standards. However, it is not “pristine” or “untouched” nature that we can resort to for deriving standards. We have to focus on nature on which our existence on the Earth depends: the second nature that we have modified to be as benign to us as ever possible. Our only reasonable hope is in creating a mutualistic relationship between ourselves and the rest of nature. Mutualism is interdependence: the nature we depend on depends on our care and stewardship (Haila 2009). In general terms, we might promote ‘harmony’ as a normative standard (Haila and Dyke 2006), but what harmony means in specific situations requires close scrutiny. It is precisely at this point that moralistic purism turns harmful.

Being hooked on all-encompassing conservation norms creates another misperception: everything that people do starts to look as a threat to the rest of nature. Instead, we need a more precise imagery of such factors that bring about biodiversity loss. An ultimate paradox of biodiversity is that strictly speaking, there is no need to know it. What we need to understand is, what processes in nature support the functionality and diversity of living systems. And more importantly: Which of our actions are most harmful, and which are benign?

The standards we adopt need to be congruent with knowledge of how nature changes. In nature conservation this could be achieved by adopting a dynamic perspective; I have previously used the label *dynamic conservation* for efforts to get human-induced change in the environment to parallel with natural dynamics that take place without human influence (Haila et al. 2007, Haila 2007). Rauschmayer and Behrens (2008) characterize such a perspective as a shift from species protection to species management.

Framing, reframing, and reframing!

Richard Andrews (2006) opens his history of American environmental policy with the sentence: “Every society develops particular patterns of relationships between its members and their natural environment.” This, no doubt, is a historical fact and close to what I have called politics of nature. One could further argue that any society that approaches the limits of its own subsistence base has had to develop methods of taking care of critical aspects of the environment, one way or another. This arguably is a historical fact, too, although, of course, expansion and plunder have been prevalent ways of dealing with local environmental shortages in the past; Barbier (2011) is a good guide to this unpleasant and abhorrent legacy.

There are no ready-made answers as to how critical elements and processes in the environment should and could be protected. The task has to be viewed within a proper framing in each case separately. Large-scale tensions about politics of nature are constantly constraining the range of available alternatives. The constraints are serious, to say the least. It is largely an open question whether a sustainable future is feasible at all, when considering the projection of human population size and the necessity to improve the lot of the poor. There are no magic bullets for matching conservation goals with such Protean tasks.

Perhaps a wise rule in the sphere of politics would be: Instead of composing over-ambitious declarations, identify real crimes and do something to prevent them. Contextual specifications help. We are well aware of practices in forestry, agriculture, fisheries and so forth that bring about threats of immediate eco-social collapse: Why not address them, to begin with?

A major task is framing and reframing conservation issues in such a way that conservation policy be brought into a positive resonance with other human endeavours – and thus open up chances to change those endeavours. In this sense, the visionary goals formulated by the romantic movement from European path-breakers to North American transcendentalists are continuously valuable, no matter how utopian they perhaps seem. The ”wild” in Thoreau is my personal favourite (see Bennett 1994, Haila 1997).

From this perspective, the symbolic weight of conservation issues is good news. The possibility of companionship in local contexts is an interesting perspective: a rare species or a specific natural area can become a matter of pride for a particular local community. But for this to happen, people need to get into touch with those creatures and areas. The closer to habitation a protected natural area is, the fewer “no trespassing” signs there ought to be.

The big picture

The social praxis of nature conservation is heterogeneous – in agreement, in fact, with the heterogeneity of the historical heritage. Several conclusions follow from this fact.

First of all, a vision of nature conservation as a “pure-bred” activity is misplaced. Nature conservation has to open up space for itself within the framework of politics of nature. This cannot happen through an oppositional stance toward everything else. Conservationists have to get involved with economic and socio-cultural endeavours mingled together with nature conservation in conflicts and struggles over politics of nature.

Let's be honest about the ecological predicament of the current world society: It is simply impossible that damage to ecological systems of the Earth could be completely avoided. We can only hope that the damage will not turn out to be fatal for the continued existence of human societies. This situation induces serious uncertainties and dilemmas into the specification of conservation goals. One set of uncertainties pertains to inconsistencies between normative goals and research practice, as I already noted above. Another set of uncertainties arises when the significance of specific conservation losses has to be evaluated.

It is useful to draw a conceptual distinction between 'risk' and 'uncertainty': the probability of a risk can be quantitatively calculated whereas the degree of uncertainty cannot be. Maclaurin and Sterelny (2008) note that in general, the probability of specific losses can be assessed quite reliably but evaluating the consequences of specific losses is much more difficult. They suggest (p. 171) that option value be used as an evaluative perspective, as follows: "It is one thing to suppose that endangered species and rare ecosystems have option value; it is quite another to show that they will typically have sufficient option value to make them worth a major conservation effort."

I agree: It is reasonable to evaluate the worth of particular elements of biodiversity within a broad range of option values instead of resorting to strictly ecological considerations and calculations. This suggestion may seem like blurring specific concerns into an impenetrable tangle of economic, political, social and cultural controversies, but this is not the case. Rather, the perspective of option value opens up a pragmatic pathway. As political, social and cultural aspects are critical for the success of nature conservation in any case, it is best to take them into account from early on. It is then possible to specify the foci of particular goals in such a way that mutually exclusive alternatives become explicit. When specific alternatives are weighed against one another, their different implications as regards the future can be made explicit, too. Developing argumentation opens space for social and political learning.

The challenge for conservationists is to increase the action space of nature conservation, against odds that often seem insurmountable. The action space is heterogeneous. This is good news: heterogeneity makes possible that unexpected alliances take shape. Following Dyke (1993), we can explore the heterogeneity of the action space by a procedure including two steps. The first step is to identify the main dimensions of the space. I suggest, preliminarily, that these number four: [1] conservation science, [2] conservation governance, [3] civic action, and [4] conservation ethos. Quite obviously, each one of these corresponds to a semi-independent field of expertise and action.

The second step is to chart critical interactions between these specialized fields. Fruitful ambiguities are located at sites of intensive interactions. A rough criterion for identifying fruitful ambiguities is offered by the notion of contrast space (Garfinkel 1981; see Dyke 1988, 1993). A contrast space is a device for making basic background alternatives visible. I summarize this idea by taking up four key notions that imply ambiguities as regards an appropriate background:

[1] *Evidence* pertains to the credibility of scientific claims, but credibility can be assessed against alternative grounds.

[2] *Feasibility* pertains to the identification and evaluation of institutional constraints, but real and imagined constraints are blurred together.
[3] *Popular support* pertains to the degree to which the aspirations and interests of ordinary people have to be taken into account, but distinguishing real aspirations and interests from pretensions is ambiguous.
[4] *No-compromise goal-setting* pertains to such specific goals that conservationists have to stick to no matter what, but there is no sharp edge between valid knowledge claims and fundamentalist convictions.

In the worst case the kind of ambiguities listed above would be paralyzing. Paralysis is by no means necessary, however. In the course of clarifying alternative grounds for evaluation and assessment, and arguing about the respective merits of the alternatives, better arguments may win.

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RESEARCH ARTICLE

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Road effects on habitat richness of the Greek Natura 2000 network

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Abstract

The road network has both positive and negative ecological effects, and understanding these helps identify environmentally preferable solutions for transportation policy and planning. We investigated the relationship between road density and habitat type richness of Greek protected areas. We used digital vector maps of 214 sites included in the Greek Natura 2000 network. We calculated road density for the terrestrial part of each site and correlated it with habitat type richness. Average road density of protected areas (0.377 km/km^2) was significantly lower than the national road density of Greece (0.446 km/km^2). We identified 32 sites that were not intersected by roads. These roadless sites were located at mountain tops, at islets, or in remote coastal zones. Overall we found no significant correlation between road density and habitat type richness. We suggest that the effect of road networks on habitat type richness is less apparent at landscapes with long history of human presence, because the landscape (and its habitat diversity) has coevolved with human activities over the past millennia. Our analysis provides a step towards quantifying the effect of road density on the diversity of habitats and consequently on species of conservation interest in international networks of protected areas such as the European Natura 2000 network.

Keywords

Habitat diversity, Natura 2000 network, Protected areas, Road ecology, Road network, Roadless areas, Greece

Introduction

Biodiversity loss has settled to one of the major environmental problems of the twenty first century, consequently countries worldwide have proceeded to establish protected areas in order to halt the loss and preserve species and habitats of high conservation value. In the European Union, the Natura 2000 network is the largest network for nature conservation extending to all member states. However despite the effort so far, the biodiversity crisis in Europe continues to deepen (EU 2010). Human activities, like habitat destruction and pollution, are considered a compelling driver of biodiversity loss (Salafsky et al. 2008). In particular, one of the major human activities affecting biodiversity in protected areas is transportation (Forman and Alexander 1998; Sherwood et al. 2003).

Roads have been reported to have both positive and negative effects on society, whilst reports on the negative impacts on ecological impacts have been widespread. Roads function as ecological corridors for dispersal for many species, but this implies the inclusion of alien and invasive species (Zhu et al. 2006). On the other hand, roadsides in intensive agricultural landscapes have a positive effect by maintaining native grassland plants and nesting sites for wildlife (Forman 2000). In urban landscapes roads function as a major driver for socio-economic changes (Zhu et al. 2006). Less recognized is the ecological protection resulting from 'bundling traffic' i.e. the concentration of traffic on main roads permitting the surrounding environment to be undisturbed. Nevertheless, recent studies indicate that the design of new road systems should take into account the bundling of roads instead of the uniform distribution across the landscape (Selva et al. 2011).

Among the negative road impacts are situations of altered animal behaviour due to roads (reviewed in Trombulak and Frissell 2000), landscape impermeability to small (Richardson et al. 1997; Gerlach and Musolf 2000) and larger mammals (Hansen 1983; Thiel 1985; McLellan and Shackleton 1988; Romin and Bissonette 1996) and increased amphibian mortality (Fahrig et al. 1995; Carr and Fahrig 2001, Cushman 2006). Physical and chemical conditions in areas subjected to road construction are altered (Trombulak and Frissell 2000) as are the hydrologic and geomorphologic attributes of a site (Jones et al. 2000). Moreover, vehicle collisions and increased human access to natural areas and reserves contribute to the decline of many species' populations (Benn and Herrero 2002; Kaczensky et al. 2004; Eigenbrod et al. 2008).

The majority of studies on biodiversity loss due to road networks emphasize the effects on species movement (e.g. Merriam et al. 1989; Vos and Chardon 1998), increased mortality (Rosen and Lowe 1994; Fahrig et al. 1995; Barthelmess and Brooks 2010), habitat fragmentation and edge effects (Mader 1984; Andrews 1990; Soulé et al. 1992; Thiollay 1993' Henjum et al. 1994; Wigley and Roberts 1994; Jaeger et al. 2007; Roedenbeck et al. 2007; Spellerberg 1998), invasion by exotic species (Lonsdale and Lane 1994), or increased human access to wildlife habitats (Graham et al. 2010), all of which are expected to increase local extinction rates or decrease local recolonization rates.

Compared to other land use alterations, roads may be the leading mechanism of fragmentation and habitat reduction in protected areas (Alkemade et al. 2009; Benítez-Lόpez et al. 2010). In addition, many studies have emphasized the effects of roads on fragmenting wildlife populations (Riley 2006; Strasburg 2006).

Over the past two decades an increased interest in the importance of roadless areas in biological conservation has been observed (DeVelice and Martin 2001; Selva et al. 2011). Although there has been a recent attempt in Europe to address roadless and low-traffic areas as conservation targets (Selva et al. 2011), most of research on the topic originates in the US and Australia (e.g. Strittholt and Dellasala 2001; Gelbard and Harrison 2003; Watts et al. 2007; Chen and Roberts 2008). In the US roadless areas play an important role in the conservation of biodiversity due to their size and location, but also to the adoption of the Roadless Rule environmental impact statement of the Forest Service (Crist et al. 2005). In Australia, on the other hand, nature conservation authorities have developed techniques for wilderness identification and analysis to assess the impact of roadless areas in management strategies (Lesslie 1991). In other parts of the word with longer history of human activity, as in Greece, roads mostly follow the tracks of ancient pathways, and several roads are known to have been in operation since ancient times (Faloso 2003). For the assessment of the road system in the Natura 2000 network, in this study, roadless areas denote protected sites not intersected by roads.

There is pressing need for protected areas' management to take into account road networks, since the ecological influences of roads may extend hundreds—or thousands—of meters from the roadside, suggesting a direct ecological road effect on most protected areas (Forman and Alexander 1998). The increase of protected areas in Europe following the implementation of the EU Habitats Directive (92/43/EEC) and in particular the Natura 2000 network (Council of European Communities 1992) saw an increase of roaded protected areas, which however has not been ensued by a corresponding increase of research regarding road effects on biodiversity (Colchester 1994; Apostolopoulou and Pantis 2009). Therefore, it is of utmost importance that the European Union includes roadless areas in its conservation policies (Selva et al. 2011). The Mediterranean basin is one of the world's biodiversity 'hotspots' containing a great variety of plant and animal taxa (Gaston and David 1994; Médail and Quézel 1999). In Greece, a country rich in biodiversity, the most important and actively managed protected areas prior to the designation of Natura 2000 network were National Parks, found mainly in mountainous areas with limited road network and human presence. However, with the implementation of Natura 2000 network many sites now include roads or are located in close proximity to intensively farmed land and coastal areas with tourist development (Papageorgiou and Vogiatzakis 2006). As a result, the majority of Natura 2000 sites in the country are inhabited and dissected by roads of variable traffic load.

Our goal was the interpretation of road effects on the ecology of protected areas in Greece, thus we focused on the effects of road density on habitat richness in Natura 2000 network. Since the study covers the entire country we considered a landscape level approach (Forman 2000; Forman and Deblinger 2000), which reflects landscape pattern analysis in relation to habitat suitability and ecological assessment (Riitters et al. 1996). The main objectives of this study were: a) to investigate which landscape characteristics (e.g. ecosystem type, altitude) influence road density in the protected sites and b) to examine if habitat richness within the Natura 2000 network is affected by road density.

Methods

Study area

Greece occupies an area of 131,990 km^2 and has a population of approximately 11 million. Nearly one third of the land comprises lowland plains, valleys and foothill country that is generally fertile and productive. The remaining two-thirds are mostly mountainous terrain. Variation of climatic conditions and geomorphologic characteristics as well as its geographic position create an impressive variety of vegetation types and habitats. In these habitats breed a diversity of terrestrial species (60% of which nest in Greece), reptiles, amphibians and freshwater fish (HZS 1992). Greece has also a rich flora, according to Dimopoulos et al. (pers. comm. 2012: Checklist of the Vascular Plants of Greece, currently in progress) which consists of c. 7000 vascular taxa (indigenous and naturalized aliens), while according to Strid and Tan (1997, 2002), Tan and Iatrou (2001), the estimated number of native plant taxa is 6437 or c. 5800 species. The plant diversity of Greece rates among the highest in Europe and the Mediterranean and includes 913 endemic species (Georghiou and Delipetrou 2010).

Greece, as a member state of the European Union, designated a national network of protected areas to be included in the European Natura 2000 network and by 2011 a total of 419 sites was included in the Greek Natura 2000 database. The study area includes the entire Natura 2000 network in Greece, after taking into account the overlaps of sites designated under the Birds (SPAs) and those under the Habitats (SCIs) Directives, which includes 371 sites and covers more than 22% (29,249 km^2) of the national terrestrial area. These sites cover most geological formations present in Greece (Higgins and Higgins 1996) and range in elevation from 0 to 2,917 m.

Datasets

We studied 214 terrestrial sites included in the Greek Natura 2000 network, for which digital habitat maps were available (60.45% of Natura 2000 terrestrial sites). For these sites the total terrestrial area was calculated after omitting any aquatic (marine or freshwater) areas. A map of the road system (1:500,000 scale) was overlaid on the Natura 2000 network and GIS analyses were performed using ArcGIS software (ESRI 2005).

The road map included all tarmac roads (high quality carriageways, dual carriageways, regional and local roads). Information on forest roads was not available and therefore not included in the analysis. We calculated road density for all sites and had access to similar data for the country as a whole. Based on the Natura 2000 database, we derived information regarding the number of habitat types in the 214 selected sites. In total, 101 different habitat types were recognised. The habitat type richness in our case corresponds to habitats listed on Annex I of the Habitats Directive (92/43/EEC) which identifies habitat types as aspects of biodiversity for which SCI have to be proposed to be monitored (Dimopoulos et al. 2006; Evans 2006; Drakou et al. 2011). It is acknowledged that the habitat type affects ecosystem function, and thus it could be considered as an indicator of biodiversity (Thies and Tscharntke 1999). Finally, a topographic map of Greece (scale 1: 100000) was also used in order to assess the altitudinal distribution of Natura 2000 sites in relation to road density.

Data analysis

The 214 sites of the Natura 2000 network were characterised as either coastal, forest or freshwater based on the dominant land use and habitat types according to the EU Habitats Directive (92/43/EEC). This information was derived from the Natura 2000 and CORINE Land Cover databases.

We also employed Vector-based Landscape Analysis Tools (version 1.1, Lang and Tiede 2003) to calculate three major fragmentation indices namely landscape division, splitting index, effective mesh size as well as the number of patches due to roads for each Natura 2000 site. Landscape division, splitting index and effective mesh size are three quantitative measures that characterize landscape fragmentation in a geometric perspective (Jaeger 2000). Explanatory information regarding fragmentation metrics is shown in Appendix.

To investigate for any potential relationship between road density across Natura 2000 sites and fragmentation metrics we used non parametric Spearman correlation coefficient; the analysis was repeated by grouping sites within each ecosystem type (i.e. coastal, forest, freshwater). We further used Kruskal-Wallis test to investigate the potential differences between the fragmentation metrics in the three ecosystem types. The relationship between road density and the surface of the sites was assessed by means of linear regression.

Mixed-model regression was applied to analyse the relationship between the road density (dependent variable), habitat richness and altitude (covariates) and their interactions. Ecosystem category was entered as a random factor.

Variables were transformed (log or square root) as necessary to meet assumptions of normality and homoscedasticity of residuals.

A linear regression was applied to provide a more thorough investigation of the relationship between road density and habitat richness.

All statistical analyses were performed with SPSS 18.0 (SPSS 2009).

Results

The total length of roads in the Natura 2000 network is 8,625 km while the total surface of Natura 2000 sites intersected by roads is 23,199 km^2. Average road density for the whole 214 sites was 0.37 km/km^2 (Fig. 1). 32 sites were found to be roadless, 17 of which are coastal, 9 are forest and 6 are freshwater ecosystems. The total area of roadless sites ranged from 1.29 to 109.33 km^2 (mean: 26.87 ± 29.01 km^2), which was significantly smaller compared to the remaining 182 roaded sites of the network (mean: 127.46 ± 151.87 km^2) ($P<0.01$). The mean altitude of roadless areas was 257.51 m (± 464.67 m) while the mean altitude of roaded sites was 566.26 m (± 522.90).

Road density in these sites ranged from 0.0004 km/km^2 to 2.46 km/km^2. The mean road density of the protected areas was significantly lower than the national road density (0.44 km/km^2) (all sites: $P<0.01$; roaded sites: $P<0.01$). The distribution of road density values in studied sites (n=214) was right skewed; half the areas had low road densities (less than 0.3 km/km^2) and only three had road densities greater than 1.50 km/km^2 (Fig. 2). Most roaded sites (97%) were intersected by regional roads and/or local roads (76%) and less than half of the protected areas (46%) were crossed by dual carriageways. Roaded sites within the Natura 2000 network

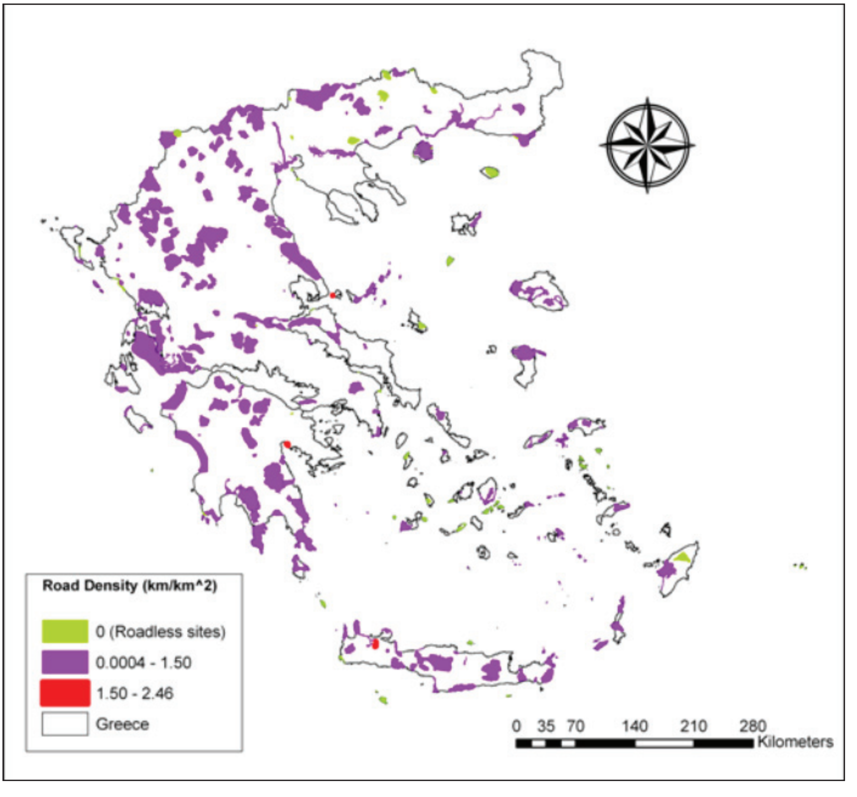

Figure 1. Road density at the Greek Natura 2000 network. Road density values (km/km^2) for each one of the 214 studied sites of the Natura 2000 network in Greece. Values ranging from 0 to 2.46 km/km^2.

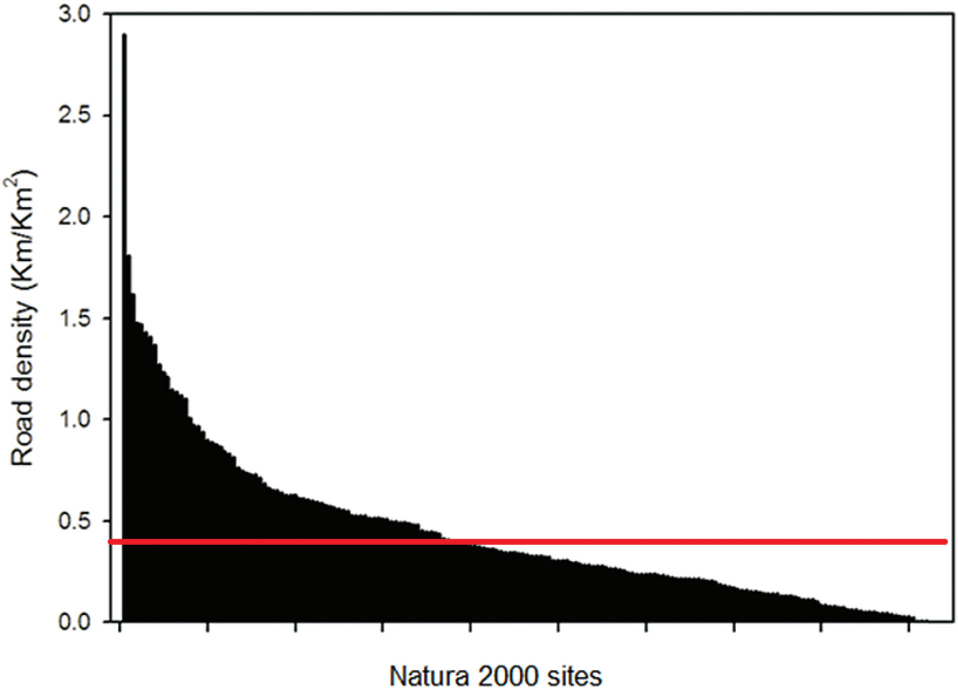

Figure 2. Distribution of road density at Greek Natura 2000 sites. The distribution of road density values (km/km^2) in descending order at the 214 studied sites of the Greek Natura 2000 network. The red line depicts the overall national road density, including Natura 2000 sites.

demonstrated a significant lower mean density of local (mean= 0.23±0.32 km/km^2) and regional (mean= 0.09±0.14 km/km^2) roads compared to the country as a whole (in both cases P<0.01). Road density of forested and coastal sites was significantly lower than the national average road density (P<0.01). In contrast, we found no significant difference between road density in freshwater aquatic sites and national road density (P=0.46).

We found no significant correlation between a site's surface area and road density (P = 0.09).

Our analysis revealed positive and significant correlations between road density and landscape division (r_s= 0.59, P<0.01), splitting index (r_s= 0.58, P<0.01) and number of patches (r_s= 0.46, P<0.01). Similar results were obtained when repeating the analysis by grouping protected sites as coastal, forest and freshwater ecosystems. In contrast, road density was negatively correlated with effective mesh size (r_s= -0.17, P<0.05); which however, was not significantly associated with road density when grouping our data into the three ecosystem types.

Effective mesh size was significantly different among the three ecosystem types (Kruskal-Wallis test H=11.29, P<0.01) with higher values supported at the forested sites. No other significant difference was indicated for the fragmentation metrics among the studied ecosystems types (in all cases P>0.05) (Table 1).

Table 1. Descriptive landscape characteristics of road fragmentation in Natura 2000 network based on the three ecosystem types.

Ecosystem Type	mean Landscape division	mean Splitting index	mean Effective mesh size (km^2)	mean Number of pathes	mean Surface area (km^2)	mean Habitat types/ site	mean Road density (km/km^2)	mean Altitude (m)
coastal	34.32 (± 29.18)	2.09 (± 1.51)	45.29 (± 105.23)	12.25 (± 13.08)	84.33 (± 148.29)	11.6	0.36 (± 0.42)	131.67 (± 156.66)
forest	28.15 (± 25.83)	1.65 (± 0.78)	102.77 (± 94.02)	13.90 (± 14.47)	154.88 (± 137.42)	8.47	0.29 (± 0.29)	971.50 (± 468.42)
freshwater	34.86 (± 27.06)	1.94 (± 1.14)	44.4 (± 61.65)	15.27 (± 21.56)	84.55 (± 139.78)	9.8	0.49 (± 0.30)	309.8 (± 378.58)

When the mixed-model regression was implemented road density was not related to either habitat richness (P=0.29), mean site altitude (P=0.32) or their interaction (P=0.73). Road density was found to be related to ecosystem type (P<0.05) with a higher value observed at freshwater ecosystems (mean=0.49 km/km^2) than in coastal (mean=0.36 km/km^2) and forests (mean=0.29 km/km^2).

In Figure 3 the relationship between habitat richness and road density is illustrated. Sites with low road density values could support either low or high habitat

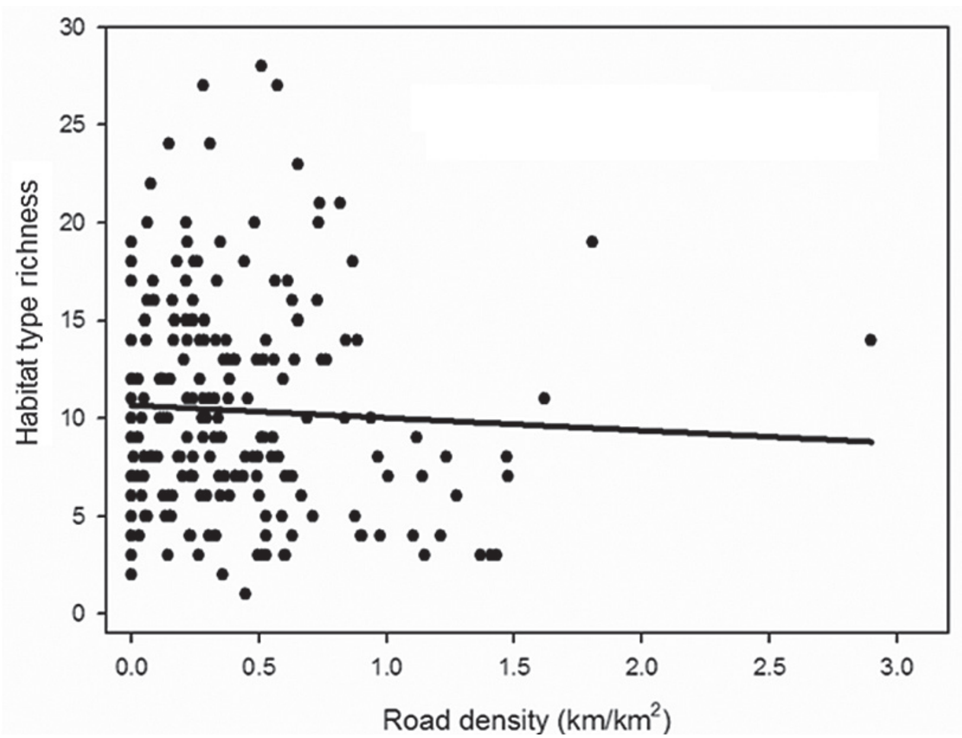

Figure 3. Road density in relation to habitat richness. The relationship of road density (untransformed values) with habitat type richness for the 214 studied sites of the Greek Natura 2000 network.

diversity. But as road density increases the variance in habitat richness values among sites decreases. At high road density values, medium habitat richness was observed. Finally, we did not identify any significant correlation between road density and habitat diversity within any of the three ecosystem types.

Discussion

Although Europe is considered to be the most highly fragmented continent (Selva et al. 2011), the majority of ecological research on the effects of roads and the importance of roadless areas for conservation biology comes mainly from the US. Greece shows an overall low average road density (0.44 km/km^2) compared to the US (1.2 km/km^2) (Forman 2000). Even greater divergence is shown when comparing Greece to the Netherlands (3 km/km^2) (EEA 2002). These differences are even more striking considering the greater population density in Greece (85.3 persons/km^2) in comparison to the US (31 persons/km^2). Such differences in road density (Forman and Alexander 1998, Spellerberg 1998) are likely to reflect national policies (Apostolopoulou and Pantis 2009), urbanization, development and infrastructure (Georgi and Dimitriou 2010) but are probably also influenced by topographic factors as well as different historic paths in road planning and construction. Especially in Greece, roads mostly follow the tracks of ancient pathways, and several roads are known to have been in operation since ancient times (Faloso 2003). The range of road density values observed in protected areas in Greece is comparable to that of the northern Great Lakes Region in North America (Saunders et al. 2002) and the native forest ecosystems of the US, which also include protected areas (Heilman et al. 2002). On the other hand, the high road density values (>1.5 km/km^2) found in certain Greek Natura 2000 sites are comparable to those of densely populated countries such as the US (Forman and Alexander 1998), which is surprising considering their high conservation value. For instance, Olympia the original home of the Olympic Games is a Natura 2000 site (sitecode GR 2330004) with high road density (1.43 km/km^2).

Considering the conservation value of roadless areas and the sparse road network in Greece, one might intuitively expect that the majority or at least a high proportion of Greek protected areas would be roadless. Surprisingly though, protected areas without roads represent 15% of the studied sites, covering less than 3% of the area protected under the Greek Natura 2000 network. Nevertheless, these 32 roadless sites might play a significant role in future conservation efforts (Selva et al. 2011).Many roadless protected sites are in mountainous areas. Although topography does not favour road construction in mountains, nevertheless this could be an artefact since no data on forest roads was available. There are also numerous coastal roadless areas which actually represent rocky islets or remote and possibly inaccessible coastal zones. Similarly, roadless wetlands are either of limited accessibility (located alongside a freshwater aquatic ecosystem subjected to seasonal rises in water level) or cannot be accessed at all (sites with riparian ecosystems whose deltas are large areas covered by sediment).

Our results regarding the representation of roadless areas at different elevation ranges are in agreement with similar work in the US, where in many cases roadless areas occur at lower to mid-elevations (DeVelice and Martin 2001; Strittholt and Dellasala 2001) as well as at mid to higher elevations (Crist et al. 2005). Similarly, road density in roaded sites showed no significant difference with altitude. The lack of correlation suggests that a combination of topographic features and anthropogenic factors influence the development of road networks, leading to complicated patterns (Turner 1989). However, human needs chiefly dictate road construction in Greece whilst topography or landscape characteristics are of less importance (Tzatzanis et al. 2003).

Several studies on road effects have used road density as an indicator for species presence or persistence and they have reported a significant range of critical values for different species (Van Dyke et al. 1986; Mech 1989; Minor and Urban 2010). However, in the present study we focus on habitat type richness, not species presence. In reality, critical values could vary among landscapes depending on the scale of analysis, differences in history and evolution. Landscapes with long history of human presence, as in our case study, have coevolved with humans and currently support complex compositional and structural components of ecological biodiversity making the effects of roads less apparent (Angelstam 1997). Almost all Greek landscapes have been shaped, to a certain extent, by human activities, and semi-natural landscapes are often recognized as highly diverse areas (Papanastasis et al. 2011). In fact, part of the Greek road network, which intersects a large number of Natura 2000 sites, is known to have been in operation since antiquity (Dinsmoor 1975). Biodiversity conservation at the ecosystem level is advocated as a means to sustain both ecological processes and the species present (e.g. Noss and Cooperrider 1994). Therefore, we have focused on habitat types which include vegetation structure, biodiversity and ecosystem functions. Moreover, the Natura 2000 network was established explicitly for the preservation of natural and semi-natural habitats (see Habitats Directive 92/43/EEC). A better understanding of the effects of roads on habitat richness would result from an investigation of the habitat types in relation to non protected areas. However, such data is not available for Greece.

A closer analysis for the sites with dense road network (>1.5 km/km^2) revealed that their high road density values are mainly attributed to their spatial characteristics (extent, shape) and intense human activity. These three sites are of relatively limited extent (0.4 to 4.96 km^2) and have an elongated shape. One of these sites is a canyon, with elongated shape and small area (4.96 km^2). The other two sites are located in the coastal zones of two highly populated islands popular with tourists. In these latter cases, the intense and permanent human activity in the area has resulted in a dense road system, without apparently affecting the area's ability to support a rich biodiversity. Nine out of the thirteen sites with road densities greater than 1km/km^2 are areas where no conservation status was assigned prior to their incorporation in the Natura 2000 network. This might imply that natural areas which host important habitat types but are not protected under national or European legislation, have been vulnerable to the expansion of the road network in Greece.

Fragmentation metrics are advocated as a powerful tool for the quantification of landscape patterns (Corry and Nassauer 2005). Landscape division, splitting index effective mesh size and number of patches depict the process in a geometric perspective and they respond well to dissection as caused by roads (Jaeger 2000). Road density showed a strong relationship with all fragmentation metrics. Landscape division, splitting index and number of patches constitute patch-based indicators, which actually describe the degree of fragmentation in a landscape (Schneider and Woodcock 2008). These are found positively correlated in our study area indicating landscape's degradation in terms of ecological processes (Millington et al. 2003). In contrast, as road density increases, effective mesh size decreases; this also emerges landscape's degradation due to fragmentation (Girvetz et al. 2008). Fragmentation metrics were differentiated in the case of effective mesh size as far as the ecosystem types are concerned. As already mentioned by Jaeger (2000), effective mesh size is an expression of the probability that two places in the landscape can be connected. In our case, it seems that forest sites constitute a separate category, with unfragmented areas, while freshwater and coastal ecosystem types follow a similar pattern, with a higher degree of degradation due to fragmentation. To sum up, our findings regarding road fragmentation come in accordance to relevant previous studies (Heilman et al. 2002; Li et al. 2004) highlighting however, the diverging pattern of road fragmentation in forest ecosystem types.

As far as the ecosystem types are concerned, we found that road density is associated with specific land use types. The classification of the 214 Natura 2000 sites in three basic ecosystem types was based on the prevailing habitat type (according to Annex I of the Natura 2000 database) in relation to the main land use type (according to CORINE Land Cover database) of each site. There are many cases where habitats present in a site might not be listed in Annex I. Thus we also used CORINE Land Cover database in order to identify the dominant ecosystem type in each site. Freshwater sites showed higher road density values compared to forest sites. Freshwater sites in Greece are frequently under human pressure since they share borders with fertile agricultural lands (Drakou et al. 2008, Kallimanis et al. 2008a). Extensive cultivated fields require a dense network of roads, for both the access of heavy agricultural machinery and the transport of agricultural goods. Similarly, they indicate the existence of economically active local communities, thereby a high associated need for transportation and road infrastructure (Hawbaker and Radeloff 2004). Intense human activity in many areas in Greece has resulted in dense road systems in certain sites included in the Natura 2000 network, without however an apparent effect on the areas' ability to support a rich biodiversity, since road density is not significantly correlated to habitat richness. Despite the dense road network, the continuous human presence, lack of protection status and absence of management measures, the studied sites support numerous habitat types of conservation interest.

According to our findings, a correlation between road density and habitat richness is lacking, which comes to contradict other studies (Andrews 1990; Noss and Cooperrider 1994; Trombulak and Frissell 2000). Nevertheless, in these cases countries with high road densities were examined, while, in our study Greece demonstrates a low road density possibly explaining the absence of correlation. Alternatively, the choice of temporal and spatial scale for analysis might have influenced the patterns observed. Many authors have stressed the importance of identifying the right scale in time and/or space for ecological monitoring and impact assessment (Underwood 1994; Findlay and Zheng 1997). Findlay and Bourdages (2000) stress that there is usually a lag between road construction and ecosystem response, therefore considering the time dimension is essential when studying the effects of roads. Information on changes in habitat richness over time would allow a more detailed evaluation of possible road effects. However, such information was not available. In addition, we suggest that information regarding habitat richness in areas outside of the Natura 2000 network, might have also been valuable regarding the nature of the identified spatial patterns, therefore, similar studies should provide such analyses if this type of information is available.

Another facet of consideration is the component of biological diversity that we chose to study (i.e. genetic, species, ecosystem, landscape level) (CEQ 1993). Whilst previous work has shown that richness of a particular taxon may react immediately to anthropogenic changes (e.g. Karr et al. 1987), responses to the effects of road construction on a higher level such as species richness may not be immediately apparent (Findlay and Bourdages 2000). We know that habitat richness in these sites affects species richness (Kallimanis et al. 2008b); however, this does not necessarily mean that road effects are not manifested at the species level.

Our focal area of interest in this paper has been habitat diversity, so we did not analyze habitat fragmentation, which in other cases has proven an important effect of the road network (Jaeger et al. 2007). Finally, due to the lack of data we were not able to investigate the effects of traffic volume and speed, which often are of influence (Eigenbrod et al. 2008). Perhaps road density *per se* is not a sufficient measure of the impacts of roads; traffic load information might have resulted in different findings (Van Langevelde and Jaarsma 2004). This remains an open research question for future work.

Conclusions

Overall and despite the possible adverse effects of roads on species, we found that in Greek protected natural areas road density was not correlated to a site's habitat richness. This might indicate that currently the road density of Greek Natura 2000 areas is below a critical level and thus any adverse effects are not apparent. Alternatively, this could suggest that the long history of human presence might have ameliorated the adverse effects and through co-evolution a new semi-natural landscape of high diversity has been established.

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Appendix

Fragmentation metrics used to quantify the structure and the fragmentation of the road system in "Natura 2000" network.

Landscape metrics (units)†	**Description**
Number of fragments (none)	Equals the number of patches of the corresponding patch type (site).
Division (proportion)	Equals 1 minus the sum of patch area divided by total landscape area, quantity squared, summed across all patches of the corresponding patch type.
Splitting Index (none)	Equals the total landscape area squared divided by the sum of patch area squared, summed across all patches of the corresponding patch type.
Effective Mesh Size (km^2)	Equals the sum of patch area squared, summed across all patches of the corresponding patch type, divided by the total landscape area.

† VLATE reference

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Dos and Don'ts for butterflies of the Habitats Directive of the European Union

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Abstract

Twenty-nine butterfly species are listed on the Annexes of the Habitats Directive. To assist everyone who wants or needs to take action for one of these species, we compiled an overview of the habitat requirements and ecology of each species, as well as information on their conservation status in Europe. This was taken from the recent Red List and their main biogeographical regions (taken from the first reporting on Article 17 of the Directive). Most important are the Dos and Don'ts, which summarize in a few bullet points what to do and what to avoid in order to protect and conserve these butterflies and their habitats.

Keywords

Butterfly, Europe, European Union, Biodiversity, Natura 2000, Habitats Directive

Papilio alexanor. Photo: Tom Nygaard Kristensen.

Introduction

Since its introduction in 1994, the Habitats Directive (Council Directive 92/43/EEC on the Conservation of natural habitats and of wild fauna and flora) has become a fundamental and increasingly important way of implementing nature conservation in the European Union. It aims to protect some 220 habitats and approximately 1,000 species listed in the Directive's Annexes. Annex II covers species whose conservation requires designation of Special Areas of Conservation while Annex IV lists species of community interest in need of strict protection. The Directive led to the establishment of a network of Special Areas of Conservation, which together with the existing Special Protection Areas under the Birds Directive form a network of protected sites across the European Union called Natura 2000.

Twenty-nine butterfly species are listed on the Annexes of the Habitats Directive[1]. To assist everyone who wants or needs to take action for one of these species, Butterfly Conservation Europe has produced the present document in collaboration with many species experts. General principles of management that apply to most if not all Natura 2000 sites are provided. This is specified by an overview of the habitat requirements and ecology of each species, as well as information on their conservation status in

[1] The Habitats Directive actually lists 31 butterfly taxa. One of them (*Hesperia comma catena*) is currently only viewed as a local Arctic Scandinavian form of the widespread *Hesperia comma* (LINNAEUS, 1758) (Kudrna et al. 2011). Another one (*Polyommatus eroides*) is currently viewed as a Balkan subspecies of the alpine *Polyommatus eros* (OCHSENHEIMER, 1808) (Kudrna et al. 2011; Wiemers et al. 2010). These two taxa are therefore not treated in this article.

This document aims at describing what to do (and what not to do) to preserve butterflies and their habitats, listed on the annexes of the Habitats Directive. This *Zerynthia polyxena* on a flower rich meadow in Greece is one of them. Photo: Tom Nygaard Kristensen.

Europe taken from the recent Red List and their main biogeographical regions (taken from the first reporting on Article 17 of the Directive). Most important in each species account are the Dos and Don'ts, which summarize in a few bullet points what to do and what to avoid in order to protect and conserve the butterflies and their habitats.

We hope this overview will help member states, nature wardens, farmers, civil servants, butterfly enthusiasts and everyone who wants to help Butterfly Conservation Europe in preserving the natural heritage of Europe, especially its butterflies. As butterflies are good indicators of wildlife rich habitats, the guidelines will help conserve overall biodiversity.

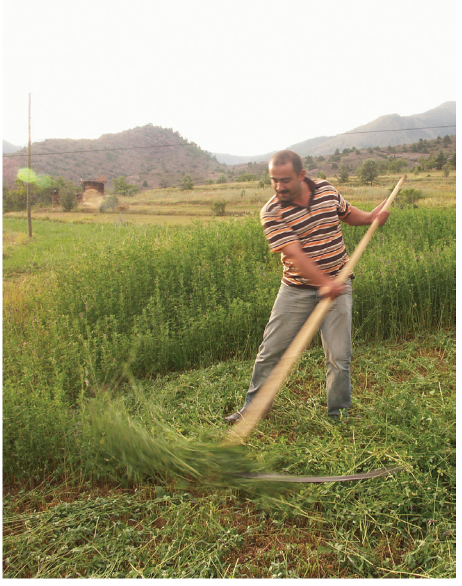
Managing Natura 2000 sites for butterflies and biodiversity

1. Manage at the landscape scale

Butterflies usually exist in a network of local populations with some exchange of adults between them to form a metapopulation. Management should aim to maintain this population network across the landscape, accepting that not every locality may be suitable at any one time (though some core sites will be). Progressive loss of habitat suitability across a landscape, or new barriers to dispersal, can lead to loss of local populations and eventually regional extinction of a species through the breakdown of metapopulations.

2. Maintain active pastoral systems

Grassland is the single most important habitat for butterflies and abandonment is the biggest single threat in much of the EU, although the fundamental destruction of (especially moist) 'unimproved' meadows and pastures though agricultural



Traditional hay making provides optimal conditions for many butterflies. Photo: Chris van Swaay.

intensification still causes major losses and is a particular threat to member states in eastern Europe, e.g. Poland and Hungary. Abandonment can temporarily lead to good conditions for many species, but will soon lead to scrub encroachment and eventual loss of suitable breeding conditions as open grassland turns to woodland. The maintenance of open grassland is thus essential, usually by the maintenance of active traditional pastoral systems, including livestock grazing and hay cutting. The extensive use of fertilizers should be avoided. Socio-economic conditions will need to be considered to ensure such pastoral systems survive.

3. Manage for variety

Grassland butterflies each have their own specific habitat requirements, especially in the typically inconspicuous larval stage, so management should aim to provide a range of conditions, often based around traditional land use patterns. Some species require short vegetation for breeding, while others require higher vegetation. Others still require mosaics of vegetation types. Managing for habitat variety across a landscape is thus essential to conserve the full range of typical species.

4. Avoid uniform management (especially in hay meadows)

Butterfly populations can be badly damaged, or can even become extinct, following intensive and uniform management, notably hay cutting. Cutting dates should be varied as much as possible across each Natura 2000 site so that not all areas are cut within a narrow time window. Ideally a mosaic of small scale cutting should be implemented, replicating traditional management before mechanisation. This variation in management, both in time and in space, should also be applied in other habitats, like wet meadows at the edges of peat bogs, moors and shallow bogs.

5. Habitat mosaics are crucial

Many butterflies use resources found in a range of habitat types and require mosaics of different habitats in the landscape. For example, some species breed along scrub or wood edges and need a mixture of scrub and grassland. Other species may lay eggs in one type of habitat and use nectar resources in another. The spatial scale of the mosaic will vary from region to region, and will often depend on the traditional land use pattern. Sometimes it will be small fields with small blocks of scrub or woodland, while in more extensive landscapes the mosaic may be very large scale. Many, if not all butterfly species prefer some wind-shade, especially in more windy areas.

A mosaic of management combined with a flower rich road verge provides a wealth of butterflies. Photo: Chris van Swaay.

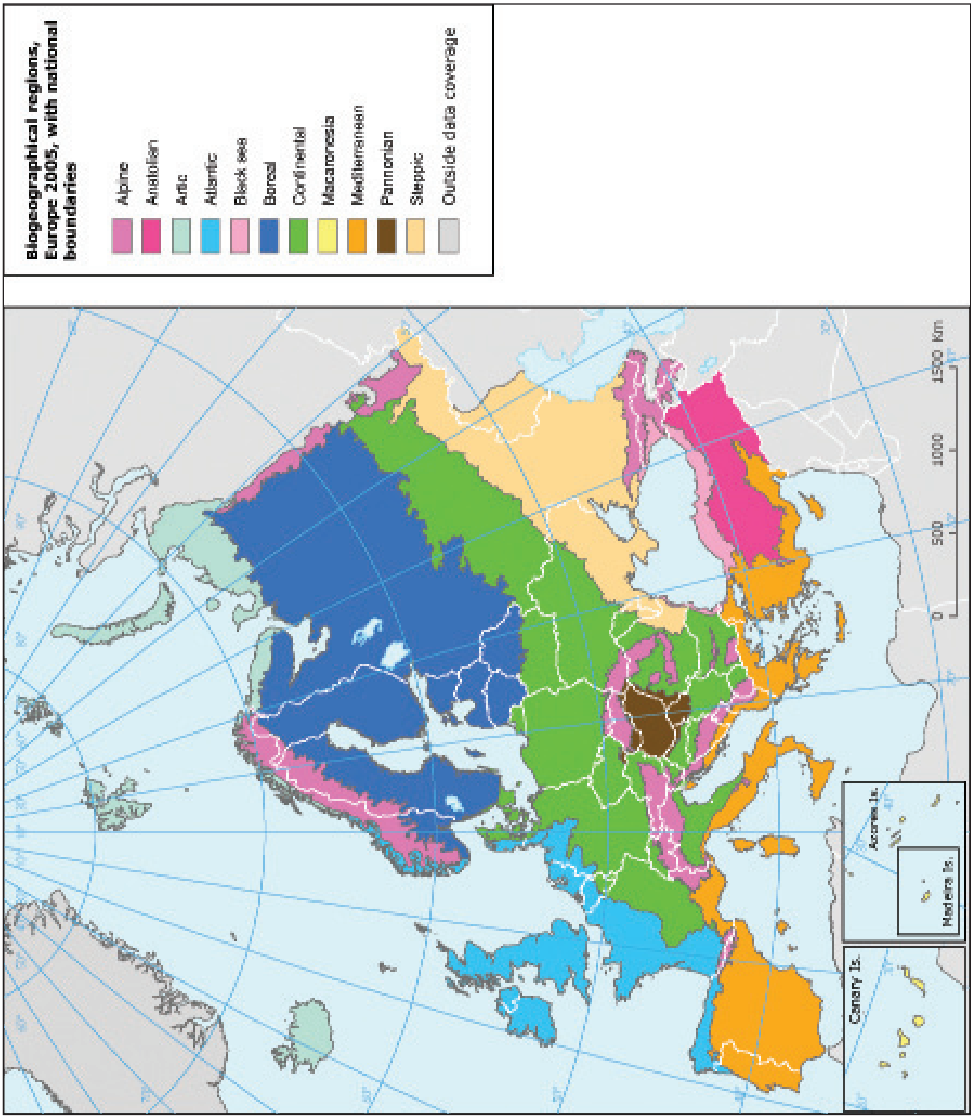
6. Active woodland management is often essential

Most woodland butterflies require some form of active management and this is essential for the survival of several threatened species. Management can either be regular thinning or rotational coppicing or planting. Some species also require the maintenance of open habitats within woodland, such as sunny clearings or paths/tracks. Traditional management is often a useful guide to suitable management, but may need to be adapted to suit modern timber markets. In Nordic countries as well as in many countries in Eastern Europe, woodland areas with plenty of wide open corridors with natural vegetation are important not for woodland species only, but are also inhabited by the majority of grassland species.

7. Monitoring is essential

Some form of biological monitoring of Natura 2000 sites is essential to ensure management is maintaining the designated features or will improve degraded habitats. Butterflies are a sensitive indicator group that can be used to assess change (both positive and negative) and inform decision making. Many butterflies are easy to identify and there are often local volunteer groups or societies who can help provide data. Monitoring can be as simple as successive species inventories, or can be structured around formal sampling procedures such as butterfly transects. The latter are more time consuming but can provide accurate population trends that can show deleterious changes at an early stage.

Red List Link:
http://ec.europa.eu/environment/nature/conservation/species/redlist/downloads/European_butterflies.pdf


Biogeographical regions, Europe 2005, with national boundaries
Alpine
Anatolian
Artic
Atlantic
Black sea
Boreal
Continental
Macaronesia
Mediterranean
Pannonian
Steppic
Outside data coverage
0
500
1000
1500 Km
Azores Is.
Madeira Is.
Canary Is.

Selected references

(Dover and Settele 2009; Dover et al. 2011a; Dover et al. 2011b; Paracchini et al. 2008; Settele et al. 2008; Settele et al. 2009; van Helsdingen et al. 1998; van Swaay et al. 2010; van Swaay et al. 2011; van Swaay et al. 2006; van Swaay 2002; van Swaay et al. 2009; van Swaay and Warren 2006).

Species of the Habitats Directive

Zerynthia polyxena (Denis & Schiffermüller, 1775)

E: Southern Festoon
F: La Diane
D: Osterluzeifalter

Habitat and ecology

The caterpillars of the Southern Festoon live on various birthworts, such as *Aristolochia clematitis*, *A. rotunda*, *A. pallida* and *A. pistolochia*. Because their foodplants grow in different habitats and the caterpillars also have different foodplants in different areas, this spring butterfly can be found in quite different habitats. In the western part of its range, it can be seen in open places along rivers with the foodplant *A. rotunda*. In the mountains, the butterflies can be seen in dry, sunny, rocky places, where *A. pallida* and *A. pistolochia* grow. In the Pannonian region, the species is found on sites with ruderal vegetation, e.g. along the Danube, but also in vineyards on sunny slopes, where *A. clematitis* grows as a weed. In Greece, the butterfly occurs in damp areas, as well as on dry slopes, according to the species of birthwort used as foodplant. The eggs are laid singly or in small groups on the underside of the leaves, where the caterpillars are usually also found. The caterpillars have a striking appearance. Mostly beige with black spots, they have some orange tubercles on each segment, each ending in a black, spiny tuft. The Southern Festoon has one generation a year and hibernates as pupa. Habitats: dry calcareous grasslands and steppes (14%), humid grasslands and tall herb communities (12%), mesophile grasslands (12%), heath and scrub (9%), dry siliceous grasslands (7%), sclerophyllous scrub (7%), alluvial and very wet forests and brush (7%).

Red List link: http://www.iucnredlist.org/apps/redlist/details/174351/1

Red List Status

Europe: Least Concern
EU-27: Least Concern

Conservation Status in EU in 2007 (Article 17 assessment)

Alpine region: not assessed

Continental region: bad
Mediterranean region: not assessed
Pannonian region: favourable

Threats in Europe

This species is not believed to face major threats at the European level in this part of its distribution. However, after 1960 a drastic population decrease started due to the intensification of agricultural practices and the use of pesticides.

Conservation actions

The species is listed on the Habitats Directive Annex 4 and Bern Convention Annex 2. This species occurs in a number of protected areas across its range. No specific conservation actions are needed at a European level, but in countries where the species is in decline important habitats should be protected and managed. The effects should be monitored by Butterfly Monitoring Schemes.

Zerynthia polyxena. Photo: Kars Veling.

Zerynthia polyxena

Dos

- Support the proliferation of its foodplants by keeping and creating ruderal "wasteland" in suitable areas.

Don'ts

- Destroy sites with the foodplant or completely cut the vegetation.
- Mow before the time of pupation (April to July, depending on location).
- Spray insecticides or herbicides in vineyards with the foodplant.

Selected references

(Batáry et al. 2008; Dapporto 2010; Höttinger 2003; Örvössy et al. 2005)

Parnassius mnemosyne **(Linnaeus, 1758)**

E: Clouded Apollo
F: Le Semi-Apollon
D: Schwarzer Apollo

Habitat and ecology
The Clouded Apollo occurs in rocky regions on damp to moderately dry grasslands and sparse deciduous woodland, forest clearings and edges in the neighborhood of large stands of the larval foodplants of the genus *Corydalis*. The butterflies can often be seen nectaring on red or purple flowers. Larvae are usually found feeding on foodplants that occur on sunny margins or clearings in the forests. The egg hibernates. In spring, as soon as it has hatched, the small caterpillar starts its search for a suitable foodplant. When fully-grown, it pupates in a closely spun cocoon of fine threads, situated above the ground in the leaves of the foodplant or litter. The Clouded Apollo has one generation a year. Habitats: broad-leaved deciduous forests (22%), alpine and subalpine grasslands (19%), mesophile grasslands (14%), humid grasslands and tall herb communities (10%), mixed woodland (8%), dry calcareous grasslands and steppes (8%).

Red List link: http://www.iucnredlist.org/apps/redlist/details/174210/1

Red List Status
Europe: Near threatened
EU: Least concern

Conservation Status in EU in 2007 (Article 17 assessment)
Alpine region: inadequate
Boreal region: inadequate
Continental region: inadequate
Mediterranean region: unknown
Pannonian region: inadequate

Threats in Europe
This species is especially threatened by changes in the management of semi-natural grasslands and woodland. Both intensification and abandonment will have a negative impact on this butterfly. In light-penetrated rupicolous forests with abundant *Corydalis* it can survive under natural conditions, without management.

Conservation actions
The species is listed on the Habitats Directive Annex 4 and Bern Convention Annex 2. In countries where the species is in decline important habitats should be protected

Parnassius mnemosyne. Photo: Kars Veling.

and managed. The effects of conservation actions should be monitored by a Butterfly Monitoring Scheme.

Parnassius mnemosyne

Dos

- Continue traditional low-intensity management.
- Maintain semi-open woodland by keeping a mosaic of woodland and meadows.
- Create woodland gaps e.g. by coppicing.
- Maintain wide and diverse woodland edges and preserve wide open corridors along forest roads.
- Restore previously occupied localities.
- In Nordic countries maintain meadows with alder strips along rivers and streams that create plenty of suitable habitats for *C. solida*, and thus indirectly for the butterfly.

Don'ts

- Intensify the management of grasslands where they occur.
- Intensification of forestry should be avoided.
- Abandon management. After abandonment the species can survive for some years, but will disappear soon.
- Replace deciduous forest with coniferous trees.

Selected references

(Bergström 2005; Brommer and Fred 1999; Gorbach and Kabanen 2010; Gratton et al. 2008; Konvička et al. 2001; Konvička and Kuras 1999; Konvička et al. 2006; Luoto et al. 2001; Meglecz et al. 1999; Välimäki and Itämies 2003)

Parnassius apollo (Linnaeus, 1758)

E: Apollo
F: l'Apollon
D: Apollo

Habitat and ecology

The Apollo occurs in mountainous areas on steep, sunny slopes with sparse vegetation. In Europe, there are many different subspecies, forms and aberrations, because of the fragmented distribution and consequently, isolation of populations. However, their ecology is similar. The butterflies are found visiting thistles and other flowering plants. The female lays its eggs singly or in small groups on or near the foodplant Stonecrop (*Sedum* spp.). The eggs develop but the tiny caterpillar hibernates inside the eggshell or as newly hatched larva in its close vicinity. In spring it starts feeding on the buds of the foodplant. The caterpillars of later instars also eat the leaves. When it is time to pupate, the caterpillars look for a safe place between the stones, where they then spin a flimsy cocoon in which to change into a pupa. The Apollo has one generation a year. Habitats: alpine and subalpine grasslands (23%), dry calcareous grasslands and steppes (19%), inland cliffs and exposed rocks (11%), screes (9%), coniferous woodland (7%), broad-leaved deciduous forests (7%).

Red List link: http://www.iucnredlist.org/apps/redlist/details/16249/1

Red List Status

Europe: Near threatened
EU: Near threatened

Conservation Status in EU in 2007 (Article 17 assessment)

Alpine region: inadequate
Atlantic region: unknown
Boreal region: bad
Continental region: bad
Mediterranean region: unknown

Threats in Europe

This species is declining in areas of low altitude. Many lowland populations have gone extinct in the last fifty years. They suffer from fragmentation and isolation. Still large and strong populations are found in the high parts of the Alps and other high mountain ranges. The species is attractive to collectors, especially the subspecies of small lowland populations.

Conservation actions

The species is listed on the Habitats Directive Annex 4, Bern Convention Annex 2 and CITES Appendix II. In Poland, the species only occurs in protected areas. The species

Parnassius apollo. Photo: Albert Vliegenthart.

is legally protected in many countries. In spite of this legal protection, there is often no special attention to the habitat management. As a consequence many small lowland populations are in decline. The production and implementation of local species action plans are urgently needed.

Parnassius apollo

Dos

- Keep traditional land uses (i.e. extensive stock grazing and hay-cutting) in mountain areas.
- Maintain traditional extensive grazing management and hay-cutting regimes in alpine regions.
- Allow *Sedum*-species to grow in between orchards, fields, vineyards, along streets and on rocks.
- Leave room for nectar plants, e.g. thistles.
- Prevent succession of steppe-like habitat to scrubland and forest by removing scrub.
- Monitor populations.
- Restore afforested areas in places where the butterfly lived prior to these plantations.
- Mitigate the effects of climate change that is causing the extinction of populations living in the highest areas of mountain ranges.

Don'ts

- For lowland populations: don't use pesticides on a large scale, as the larvae that live in between the orchards, vineyards and fields will be killed.
- Remove all herbs, as they are important nectar sources.
- Afforest open areas in mountains of Southern Europe.

- Build new tourist developments, especially related to ski sports in mountain areas and roads facilitating access of tourists to areas with the butterfly.
- Collect specimens, particularly those from rare or isolated subspecies or populations.
- Abandon the sites.

Selected references

(Ashton et al. 2009; Deschamps-Cottin et al. 1997; Fred and Brommer 2003; Fred and Brommer 2005; 2010; Fred et al. 2006; Geyer and Dolek 2001; Nakonieczny et al. 2007; Todisco et al. 2010; Witkowski et al. 1997)

Papilio hospiton Guenée, 1839

E: Corsican Swallowtail
F: Le Porte-queue de Corse
D: Korsischer Schwalbenschwanz

Habitat and ecology

The Corsican Swallowtail is a butterfly of open, grassy slopes, often with some scattered rocks and bushes and of slopes with low-growing scrub. Just as the Swallowtail, *P. machaon*, these butterflies show hill-topping behaviour, the males assembling on hilltops or other prominent features in the landscape, waiting for the females to arrive. In Corsica, they are found on three different foodplants, Giant Fennel (*Ferula communis*), *Ruta corsica* and *Peucedanum paniculatum*, different populations being strictly bound to one type of foodplant. However, in Sardinia, the caterpillars are only found on Giant Fennel (*Ferula communis*). The Corsican Swallowtail has one generation a year and hibernates in the pupal stage. On Corsica reported to do well after forest fires. Habitats: heath and scrub (16%), sclerophyllous scrub (16%), phrygana (16%), dry calcareous grasslands and steppes (16%), dry siliceous grasslands (16%), alpine and subalpine grasslands (16%). This is a European endemic species.

Red List link: http://www.iucnredlist.org/apps/redlist/details/15993/0

Red List Status

Europe: Least concern
EU: Least concern

Conservation Status in EU in 2007 (Article 17 assessment)

Mediterranean region: inadequate

Threats in Europe

This species is not believed to face major threats at the European level.

Papilio hospiton in its habitat. Photo: Tom Nygaard Kristensen.

Conservation actions

The species is listed on the Habitats Directive Annexes 2 and 4, Bern Convention Annex 2 and CITES Appendix I. This species occurs in a number of protected areas across its range. No specific conservation actions are needed at a European level. In France and Italy, not all populations are in Natura 2000 areas.

Papilio hospiton

Dos

- Continue traditional land use characterized by heavy grazing and controlled burning.

Selected references

(Aubert et al. 1997; Aubert et al. 1996; Cianchi et al. 2003; Manil and Diringer 2003)

Papilio alexanor Esper, 1800

E: Southern Swallowtail
F: l'Alexanor

Habitat and ecology

The Southern Swallowtail is mostly found on warm, dry calcareous slopes with flower-rich vegetation and low-growing bushes. The butterflies prefer slopes that are steep and rocky. They are especially active during the hottest hours of the day. Different foodplants are known, all of them umbellifers. *Ptychotis saxifraga* is the most important one in the western part of its range, but eggs are also laid on *Opopanax chironium*, *Seseli montanum* and *Trinia glauca*. In the Eastern part, the caterpillars feed mostly on various fennels (*Ferula* spp.) and also on *Opopanax hispidus*, Burnet saxifrage (*Pimpinella saxifraga*), *Scaligeria cretica* and Wild Parsnip (*Pastinaca sativa*). The caterpillars eat the flowers and ripening seeds. They seem to prefer plants growing in very sparse vegetation near bare patches. The Southern Swallowtail has one generation a year and passes the winter in the pupal stage. Habitats: phrygana (40%), sclerophyllous scrub (20%), heath and scrub (20%), dry calcareous grasslands and steppes (10%), dry siliceous grasslands (10%).

Red List link: http://www.iucnredlist.org/apps/redlist/details/174220/1

Red List Status
Europe: Least concern
EU: Least concern

Conservation Status in EU in 2007 (Article 17 assessment)
Alpine region: favourable
Mediterranean region: unknown

Threats in Europe
Although this species shows a decline in a part of its European range, it is not believed to face major threats at the European scale.

Papilio alexanor. Photo: Albert Vliegenthart.

Conservation actions

The species is listed on the Habitats Directive Annex 4 and Bern Convention Annex 2. This species occurs in a number of protected areas across its range. No specific action is needed at a European level, but in countries where the species is in decline important habitats should be protected and managed. The effects should be monitored by Butterfly Monitoring Schemes.

Papilio alexanor

Dos

- Maintain traditional extensive management for example with light goat grazing and/or controlled burning.

Don'ts

- Abandon the sites.

Selected references

(Bollino and Sala 2004; David and Sanetra 1994; Freina 1983; Kahlheber 1976)

Leptidea morsei (Fenton, 1881)

E: Fenton's Wood White
D: Östlicher Senfweißling

Habitat and ecology

Apart from its greater size and slightly falcate forewings the species can be separated from the other Wood Whites in Europe (*Leptidea* spp.) by the conspicuous gliding flight displayed by the males. Fenton's Wood White can be seen on damp, grassy vegetation at the sunny edges of woods, in grassy woodland clearings and on regenerating woodland on grassland. They occur almost exclusively in oak forest and mixed deciduous woods. This butterfly has two generations a year and hibernates in the pupal stage. The larvae feed on Peas, in Europe on *Lathyrus niger* or *L. vernus* with ova being laid almost exclusively on the plants in the shade. In Transylvania, an important larval food plant is the endemic *Lathyrus hallersteinii*. Habitats: broad-leaved deciduous forests (40%), mesophile grasslands (15%), humid grasslands and tall herb communities (10%), coniferous woodland (10%), mixed woodland (10%).

Red List link: http://www.iucnredlist.org/apps/redlist/details/174284/1

Red List Status

Europe: Near threatened
EU: Endangered

Conservation Status in EU in 2007 (Article 17 assessment)

Alpine region: bad

Continental region: inadequate
Pannonian region: bad

Threats in Europe
In Europe the species is restricted to Central and Eastern Europe, where it is never common and mostly declining. Main threat is change of woodland management, resulting in a decline of the traditional light-penetrated forest structure.

Conservation actions
The species is listed on the Habitats Directive, Annexes 2 and 4. More research is needed on the distribution and ecology of the species. Suitable habitats should be protected and appropriately managed. The effects of conservation actions should be monitored by a Butterfly Monitoring Scheme.

Leptidea morsei
Dos

- Continue traditional low-intensity management to maintain mosaic woodland habitat with large stands of the main larval foodplant *Lathyrus niger*.
- Maintain sparse woods or create woodland gaps by coppicing.
- Maintain wide and diverse woodland edges and preserve wide open corridors along forest roads.
- Keep flower rich meadows near larval habitats with late season hay-cutting.

Leptidea morsei. Photo: Rudi Verovnik.

Don'ts

- Abandon management of light woods.
- Intensify forestry or produce closed monocultures.
- Remove road edge vegetation mechanically during larval development.
- Replace deciduous forest with conifer trees.
- Intensify the management of nearby flowering meadows.
- Allow woodland grazing.

Selected references

(Gascoigne-Pees et al. 2008; Höttinger 2004; Lorković 1993)

Colias myrmidone (Esper, 1781)

E: Danube Clouded Yellow
F: Le Danubien
D: Orangeroter Heufalter

Habitat and ecology

The Danube Clouded Yellow occurs in dry, warm grassland where its foodplant, species of the genus *Chamaecytisus,* are always abundant. However, the amount of shelter from bushes can vary considerably. While the female lays its eggs on the foodplant, the caterpillars hibernate in the litter layer. It has two to three generations a year. The species shows serious declines, especially at the western edge of its range. Within the last years it disappeared most probably from Germany, the Czech Republic, Austria, Hungary, Slovenia and Serbia. Habitats: dry calcareous grasslands and steppes (30%), mesophile grasslands (21%), dry siliceous grasslands (21%), coniferous woodland (8%), mixed woodland (8%).

Red List link: http://www.iucnredlist.org/apps/redlist/details/174283/1

Red List Status

Europe: Endangered
EU: Critically endangered

Conservation Status in EU in 2007 (Article 17 assessment)

Alpine region: bad
Continental region: inadequate
Pannonian region: bad

Threats in Europe

This species is threatened both by intensification and abandonment of semi-natural grasslands, its main habitat. Furthermore, especially for the westernmost parts, climate change is considered as one of the most important reasons for the decline, but it cannot fully explain the situation over this scale. It is certain that in some cases land-use changes even under Agri-Environmental Schemes have led to drastic declines. In general, loss of habitat and habitat connectivity, unfavourable grassland management (wrong timing or intensity) and climate change (less continental climate) must be considered. At this moment abandonment and intensification of grazing and burning are probably the largest threats to the populations in Eastern Europe.

Conservation actions

The species is listed on the Habitats Directive, Annexes 2 and 4. More research is urgently needed on the distribution and ecology of the species. Important habitats should be protected and appropriately managed. The effects of conservation actions should be monitored by a Butterfly Monitoring Scheme. It benefits from proper management of semi-natural grasslands. The species will benefit from the establishment of areas of High Nature Value Farmland. In Hungary the species used to occur only in protected areas. However, there are no recent records from Hungary despite deliberate surveys.

Colias myrmidone

Dos

- Maintain herb-rich meadows with scattered stands of the foodplant by mosaic management with light grazing or rotational mowing.
- Maintain wide range of habitats with nectar sources (herb-rich meadows, broad forest edges and very open forests).
- Maintain traditional extensive land-use to encourage mobility across the landscape.
- Implement national action plans with site- and specific actions.
- Follow up the actions in the Species Action Plan (see http://bc-europe.org/SpeciesActionPlans/EUSAP_Colias_myrmidone_final_draft.pdf)

Don'ts

- Intensify land-use on a large scale, e.g. by reforestation.
- Carry out intensive mowing on meadows.

Colias mymidone. Photo: Tom Nygaard Kristensen.

- Carry out intensive grazing on pastures (overgrazing by sheep is harmful as they eat the fertile shoots of *Chamaecytisus*!).
- Change the management leading to the closure of the forest and loss of the woodland pasture mosaic landscape.
- Abandon management which leads to overgrowing of grasslands.
- Burn the sites in spring or fall.

Selected references

(Dolek et al. 2005; Freese et al. 2005; Konvička et al. 2008a)

Lycaena helle (Denis & Schiffermüller, 1775)

E: Violet Copper
F: Le Cuivré de la bistorte
D: Blauschillernder Feuerfalter

Habitat and ecology

The Violet Copper is a rare butterfly that is often confined to very small sites, where it may be seen in large numbers. It is found in swampy, wet grassland with suf-

Habitat *Lycaena helle*, Eifel, Germany. Photo: Chris van Swaay.

ficient wind shelter (shrub, forest edges) and rough vegetation bordering streams and lakes. In Central Europe, eggs are laid on the underside of the leaves of Bistort (*Polygonum bistorta*). In Transylvania mostly humid or damp oak forest clearings with mosaic-like vegetation. In the north of its range Viviparous Bistort (*Polygonum vivipara*) is also used as larval foodplant. The young caterpillars eat the lower epidermis, thus making the characteristic "windows". It passes the winter as a pupa. Its western populations have one, the eastern populations mostly two generations a year. Habitats: humid grasslands and tall herb communities (37%), alpine and subalpine grasslands (10%), water-fringe vegetation (8%), fens, transition mires and springs (8%), dry calcareous grasslands and steppes (5%), mesophile grasslands (5%).

Red List link: http://www.iucnredlist.org/apps/redlist/details/174383/1

Red List Status
Europe: Endangered
EU: Least concern

Conservation Status in EU in 2007 (Article 17 assessment)
Alpine region: bad
Boreal region: bad
Continental region: bad

Threats in Europe
Land drainage and agricultural improvements and afforestation are the most important threat for this species. In some cases, because of agricultural abandonment, meadows get covered with rough vegetation and finally trees and shrubs. Central European populations are often small and isolated, making it hard for the species to re-colonise former sites. These populations also sometimes suffer wrong management, e.g. mowing at the wrong time of year. In Northern Europe the species is threatened by abandonment of peripheral agricultural grounds, fertilization and afforestation, the species has lost more than half of its habitats (and continues to lose) during the last 30 years.

Conservation actions
The species is listed on the Habitats Directive, Annexes 2 and 4. In Belarus and Poland, it only occurs in protected areas. None of the populations are in Natura 2000 areas in Austria. In spite of legal protection of important butterfly habitats special management of these habitats for *L. helle* is only conducted in few countries (e.g. in Belgium). It requires sensitive management of semi-natural grasslands and would benefit from the establishment of areas of High Nature Value Farmland. Populations should be monitored closely, for example by Butterfly Monitoring Schemes. There is an action plan for monitoring of this species under construction in Sweden.

Lycaena helle. Photo: Chris van Swaay.

Lycaena helle
Dos

- Maintain a low-intensity management: grazing with very light stocking rates (< 0.2 Lifestock Units ha^{-1}), preferably used in a rotational way, and avoiding sensitive periods of the butterfly life cycle (April to July, best is starting in August, accompanied by periodic clearing and outrooting of shrub (mainly *Salix*).
- Preserve humid forest clearings and protect them from re-forestation. Some fringe vegetation is needed for roosting butterflies.
- Selectively cut encroaching scrub if necessary.
- Maintain or reconstruct the natural water regimes of brooks and small rivers to keep the soils in an oligotrophic state (which is supported by high water ground level).

Don'ts

- Drain the habitats where the species occurs.
- Abandon the areas: instead try to maintain a low level of management.
- Fertilize the habitats.

Selected references

(Bauerfeind et al. 2009; Finger et al. 2009; Fischer et al. 1999; Habel et al. 2010a; Habel et al. 2011a; Habel et al. 2011b; Habel et al. 2010b; Martín Cano et al. 2009; Meyer 1981; Meyer and Helminger 1994; Steiner et al. 2006)

Lycaena dispar (Haworth, 1802)

E: Large Copper
F: Le Grand Cuivré
D: Grosser Feuerfalter

Habitat and ecology

The Large Copper occurs in marshy habitats and on the peaty banks of lakes, rivers and streams and more to the East also on waste lands. Nectar plants are important, especially

Habitat *Lycaena dispar*, Netherlands. Photo: Jaap Bouwman.

for the females. Eggs are laid on docks (*Rumex* spp.) like *R. crispus*, *R. obtusifolius* and *R. hydrolapathum*, but never on sorrels (like *R. acetosa* or *R. acetosella*). The young caterpillars first eat from the underside of the leaves, making the characteristic 'windows'. Later caterpillars feed on the whole leaf. They hibernate when half-grown between withered leaves at the base of the foodplant. They are sometimes associated with ants (*Myrmica rubra* and *Lasius niger*). The Large Copper has several subspecies in Europe. The largest of them, *L. d. batavus*, is confined to the extensive wetlands in the north of The Netherlands. The males of this subspecies occupy territories in the warmest places in depressions in the vegetation. Their caterpillars feed only on Water Dock (*Rumex hydrolapathum*). There are two smaller (and less threatened) subspecies, *L. d. rutilus* and *L. d. carueli* that use also other docks as foodplants. The subspecies *L. d. batavus* has one generation a year and the other subspecies one, two or sometimes even three. Habitats: humid grasslands and tall herb communities (26%), water-fringe vegetation (14%), fens, transition mires and springs (11%), mesophile grasslands (8%), broad-leaved deciduous forests (7%), blanket bogs (5%), dry calcareous grasslands and steppes (5%).

Red List link: http://www.iucnredlist.org/apps/redlist/details/12433/1

Red List Status
Europe: Least concern

EU: Least concern

Conservation Status in EU in 2007 (Article 17 assessment)
Alpine region: inadequate
Atlantic region: inadequate
Boreal region: favourable
Continental region: inadequate
Mediterranean region: unknown
Pannonian region: inadequate

Threats in Europe
Where the species lives in marshland it is threatened by reclamation, groundwater extraction or desiccation. Grassland and wasteland habitats become unsuitable if they are abandoned and become invaded by shrubs and trees.

Conservation actions
The species is listed on the Habitats Directive Annexes 2 and 4 and Bern Convention Annex 2. More research is needed on the distribution and ecology of the species. Suitable habitats should be protected and appropriately managed. The effects of conserva-

Lycaena dispar. Photo Chris van Swaay.

tion actions should be monitored by a Butterfly Monitoring Scheme. In The Netherlands, the species only occurs in protected areas. In Estonia, Finland and Germany, it populations also occur outside Natura 2000 areas.

Lycaena dispar

Dos

- Manage wet grasslands by extensive mowing or grazing to maintain larval habitats (e.g. docks as foodplants) and maintain rarely used sites (with higher stands of wetland grasses and sedges) for adult interactions (mating).
- Particularly in the Netherlands maintain stands of *Rumex hydrolopathum* along dike and pond margins.
- Create and maintain wastelands and sites with ruderal vegetation in the eastern and southern part of its range.

Don'ts

- Use drainage or any other action that sinks the water level.
- Intensify or abandon the area. The species needs regular management, but at a very low level.

Selected references

(Bink 1986; Duffey 1968; Kühne et al. 2001; Lafranchis et al. 2001; Lai and Pullin 2004; Loritz and Settele 2006; Martin and Pullin 2004a; b; Nicholls and Pullin 2000; 2003; Pullin 1997; Pullin et al. 1998; Strausz et al. in press; Väisänen et al. 1983; Webb and Pullin 1996; 2000; Werner and Möller 2003)

Pseudophilotes bavius (Eversmann, 1832)

E: Bavius Blue

Habitat and ecology

The Bavius Blue occurs in small isolated populations on flower-rich, dry grassland, on dry, stony slopes and on open patches in shrub and in vineyards on calcareous soil. Various species of *Salvia* are used as foodplant, including Sage (*S. officinalis*), *S. nutans*, *S. verbenaca* and Whorled Clary (*S. verticillata*). Most important food plant in Romania is *S. nutans* as character species of steppic grasslands. The caterpillars feed mostly on the flowers, but sometimes also on the leaves. They are frequently found with ants. The Bavius Blue usually has one prolonged generation a year. In Peloponnesus, a partial second generation may occur. The pupa hibernates. In Eastern- and South-Eastern Europe there are many different endemic subspecies. In Transylvania the subspecies *hungarica* occurs, in South-East Romania it is the subspecies *egea*. In Peloponnesus the subspecies *casimiri* is found, while in Macedonia another subspecies *macedonicus* has been described. The habitat structure, ecology and biology was studied on populations of the subspecies *hungarica* in Transylvania. The largest of these populations has been monitored since 1977. In this period large natural population fluctuations have been recorded. The butterflies do not disperse easily; they hardly ever leave their breeding ground. Habitats: dry calcareous grasslands and steppes (50%), phrygana (20%), dry siliceous grasslands (10%), sclerophyllous scrub (10%), screes (10%).

Red List link: http://www.iucnredlist.org/apps/redlist/details/174375/1

Red List Status
Europe: Least concern
EU: Least concern

Conservation Status in EU in 2007 (Article 17 assessment)
Mediterranean region: unknown
Continental region (not assessed for article 17, BCE expert opinion): inadequate (Transylvania)
Black Sea region (not assessed for article 17, BCE expert opinion): unknown

Threats in Europe
Although this species shows a decline in a part of its European range, it is not believed to face major threats at the European scale. However, according to recent studies, the species is within the EU 27 probably more endangered than its threat category suggests.

Conservation actions
The species is listed on the Habitats Directive, Annexes 2 and 4. It is unknown if all populations are in Natura 2000 areas in Greece. Not all populations are in Natura 2000 areas in Romania. More research is needed on the distribution and ecology of the species. Suitable habitats should be protected and appropriately managed. The effects of conservation actions should be monitored by a Butterfly Monitoring Scheme.

Pseudophilotes bavius
Dos
- Manage dry grasslands by traditional extensive grazing and mowing once a year.
- Maintain connectivity between habitat patches.
- It is necessary to extend the protected area over the habitat of all known populations.
- Implement national action plans for local conservation of the subspecies and its habitat.

Don'ts
- Abandon traditional management of dry grassland.
- Intensify grazing and mowing of dry grasslands by higher stocking rate and longer grazing periods.
- Allow afforestation of dry grassland areas with *Pinus sp*. and *Robinia pseudoacacia.*
- Use terrace-shaped slopes as vineyards.

Pseudophilotes bavius. Photo Albert Vliegenthart.

Selected references
(Coutsis 2008; Crisan et al. 2011; Dincă et al. 2011; Jutzeler et al. 1997b; König 1992; Tolman 1992)

Phengaris arion **(Linnaeus, 1758)**

Name in the Habitats Directive: *Maculinea arion*
E: Large Blue
F: l'Azuré du serpolet
D: Schwarzgefleckter Bläuling, Thymian-Ameisenbläuling

Habitat and ecology
The Large Blue occurs locally on dry, open grasslands on limestone and sandy areas. It is one of the larger, more conspicuous blues. The females lay their eggs on different species of thyme (*Thymus* spp.), and on warmer sites also on Marjoram (*Origanum vulgare*). The caterpillars feed on the buds and flowers of the foodplant. After a few weeks they leave their foodplant and allow themselves to be taken by workers into the nests of any species of *Myrmica* ant, although over most of Europe survival is high only with *Myrmica sabuleti*, which must adopt at least 67% of larvae for a population to persist; in north-east Europe there is some evidence of a host switch to *M. lobicornis*. The caterpillars feed on the ant grubs, hibernating and pupating

Habitat *Phengaris arion*, Eifel, Germany. Photo: Chris van Swaay.

there as well. Habitats: dry calcareous grasslands and steppes (20%), dry siliceous grasslands (15%), mesophile grasslands (9%), coniferous woodland (7%), alpine and subalpine grasslands (7%), humid grasslands and tall herb communities (7%), heath and scrub (6%).

Red List link: http://www.iucnredlist.org/apps/redlist/details/12659/1

Red List Status
Europe: Endangered
EU: Endangered

Conservation Status in EU in 2007 (Article 17 assessment)
Alpine region: bad
Atlantic region: unknown but not favourable
Boreal region: bad
Continental region: bad
Mediterranean region: unknown
Pannonian region: bad

Threats in Europe
In many parts of Europe this species is restricted to nature reserves. Here the main threat is inappropriate management, as this species is very susceptible to small changes in grazing pressure or other changes in management. Where the species is more widespread, loss of habitat by agricultural intensification and abandonment, as well as afforestation, are the main threats.

Conservation actions

The species is listed on the Habitats Directive Annex 4 and Bern Convention Annex 2. *P. arion* is one of the best investigated butterfly species in Europe. Ecological demands are relatively well known especially in W-Europe, but special attention for the species in habitat management is only given in a few, mainly Western European countries (e.g. United Kingdom). Suitable habitats should be protected and appropriately managed. The effects of conservation actions should be monitored by a Butterfly Monitoring Scheme. In Belgium, Denmark and in the United Kingdom, the species only occurs in protected areas. The species and its habitat are legally protected in many countries. *P. arion* has been reintroduced in the United Kingdom. It benefits from proper management of semi-natural grasslands. It requires sensitive management of semi-natural grasslands and would benefit from the establishment of areas of High Nature Value Farmland. In central-southern France (Dordogne, Rhone valley) *P. arion* supports a beautiful, probably host-specific (and hence more endangered) parasitoid *Neotypus coreensis* whose ecological requirements are unknown.

Phengaris arion

Dos

- Manage grasslands by grazing to maintain open, sunny conditions. The level of grazing will depend on latitude and local micro-climate. Throughout its range, the aim is to maximize the abundance of the host ant *Myrmica* species in areas where one or more of the initial foodplant grows.

Phengaris arion. Photo Chris van Swaay.

- In the northern part of the species range and at high altitudes, aim for a short turf of 2–5 cm but remove grazing from early May - late July to avoid removal of flower-heads of the initial foodplant, *Thymus* spp. Also maintain some patches of scrub cover to provide shelter and warm conditions.
- In central and southern parts of the species range, grazing can be lighter and more extensive to create a range of turf heights and abundant food-plants such as *Origanum*. On poor soils in southern Europe, *Origanum*-using populations also thrive in abandoned grassland for up to 7 years after abandonment, at which stage periodic clearances are essential to restore the succession.
- Where scrub is present, manage by cutting on rotation and aim for overall cover of less than 20% in core breeding areas.
- Monitor populations of the butterfly and its host ant carefully, and adjust management when needed.

Don'ts

- Intensify or abandon the fields, except temporarily in hot climates.
- Overgraze sites, especially from mid-summer when flower-heads are removed.

Selected references

(Bereczki et al. 2011; Casacci et al. 2011; Elmes and Thomas 1992; Mouquet et al. 2005; Munguira and Martín 1999; Patricelli et al. 2011; Settele et al. 2005b; Spitzer et al. 2009; Thomas and Simcox 2005; Thomas et al. 2009; Wynhoff 1998)

Phengaris teleius (Bergsträsser, 1779)

Name in the Habitats Directive: *Maculinea teleius*
E: Scarce Large Blue
F: l'Azuré de la sanguisorbe
D: Grosser Moorbläuling, Heller Wiesenknopf-Ameisenbläuling

Habitat and ecology

The Scarce Large Blue can be found in moderately nutrient-rich meadows, edges with rough vegetation and parts of shallow bogs with Great Burnet (*Sanguisorba officinalis*). In northern Europe, it occurs in open, short vegetation, but in the warm, southern regions, it is also found in rough vegetation. The butterflies tend to keep near the food-plants. The small caterpillars only feed on the flowerheads for two or three weeks. They then go down to the ground where they wait to be picked up by worker ants of the genus *Myrmica* and carried off to the ants' nest. There they feed on ant grubs. The caterpillars also hibernate and pupate in the ants' nest. The main host over most of Europe is *Myrmica scabrinodis*, with closely related forms or species (with similar management requirements) also used in the south and east. In some regions sufficient individuals also survive with *M. rubra* for this ant (which prefers later successional stages to *M. scabrinodis*) to support a few, perhaps temporary, colonies. The Scarce Large Blue has one generation a year. Habitats: humid grasslands and tall herb communities (38%),

Habitat *Phengaris teleius*, Netherlands. Photo: Chris van Swaay.

mesophile grasslands (16%), blanket bogs (12%), water-fringe vegetation (9%), fens, transition mires and springs (9%).

Red List link: http://www.iucnredlist.org/apps/redlist/details/12664/1

Red List Status
Europe: Vulnerable
EU: Vulnerable

Conservation Status in EU in 2007 (Article 17 assessment)
Alpine region: bad
Atlantic region: bad
Boreal region: favourable
Continental region: bad
Pannonian region: inadequate

Threats in Europe
This species is threatened by changes in agricultural management, like drainage, improvement or abandonment.

Conservation actions
The species is listed on the Habitats Directive Annexes 2 and 4 and Bern Convention Annex 2. Suitable habitats should be protected and appropriately managed. As the species in not mobile, it needs areas with large and well connected patches of habitat. The effects of conservation actions should be monitored by a Butterfly Monitoring Scheme. In The Netherlands, the species only occurs in protected areas. In France, Slovenia and

Germany, not all populations are in Natura 2000 areas. The species has been re-introduced in The Netherlands in 1990. The habitats of *P. teleius* are legally protected in many countries, but since many populations are not in nature reserves no special attention is given to the habitat demands. In Romania, a special Agri-Environment Scheme for the protection of *Phengaris* (*Maculinea*) butterflies was introduced in 2011. Like for other *Phengaris*-species, the ecological demands of the Scarce Large Blue are relatively well known. In Hungary and perhaps elsewhere in Eastern Europe, it supports a highly specialized, probably host-specific species of *Neotypus* (Ichneumonid) parasitoid.

Phengaris teleius

Dos

- In the northern part of the species range, mowing is the best management regime to keep the vegetation open and the soil sunny and warm and to maintain a high *Myrmica* ant nest density.
- Mow fields once every one to three years. In extensive areas, a 3-year rotation of mowing 33% of patches a year is ideal.
- Mowing should be done either before the second week of June or after mid- September, on sites at lower altitudes with a warm micro-climate already after the beginning of September. In the first case females can deposit the eggs on the small regrowth of host plants; in the second case the caterpillars have left the host plant before cutting.
- Maintain 20% of the vegetation per meadow uncut each year on rotation to keep a high level of vegetation structure for a high *Myrmica* ant nest density. Also maintain some patches of scrub cover or hedges to provide shelter and warm conditions.

Phengaris teleius. Photo Chris van Swaay.

- Depending on the productivity of the soil, meadows may be cut once or twice a year. On poor soils best results are achieved by mowing in September or October, except for a cut early June every 5 to 6 years to prevent bush encroachment.
- In the southern part of the species range, grassland habitats may also be managed by low intensity grazing, preferably by cattle or ponies. Monitor the density of the stock to keep the right level of grazing intensity. In general, *Myrmica scabrinodis* (and *M. rubra*) occur in shorter vegetation on cooler northern sites, resulting in reduced shading of their nests.
- At landscape scale, create a mosaic of interconnected (within 5 km dispersal potential of species) patches of low intensity agricultural use with both host plants and host ants for the establishment of a meta-population. Allow patches of fallow land as refuge for the host ants. Preferably distances between patches are below 500 m and do not exceed 1 km.
- Monitor populations of the butterfly and its host ants carefully, and adjust management when needed.
- When the ant nest density is decreasing or at a too low density, apply small scale management, such as sod cutting in 3x3 m patches or in narrow long lines, to increase vegetation structure and habitat for the ants.
- When creating new habitats on former agricultural fields, remove the top soil when the phosphate concentration is too high. Use hay from local origin or local seed mixtures with *Sanguisorba* or plant it into the new habitat.

Don'ts

- Intensify agricultural use or drain the fields.
- Graze habitats in the northern part of the species' range.
- Abandon fields with single populations. Abandonment is only acceptable if temporary and if the abandoned field is part of a meta-population.
- Use manure or biocides.
- Mow the fields when the butterflies are on the wing and the caterpillars are in the buds of the host plant (between mid-June and the end of August).

Selected references

(Batáry et al. 2009; Batáry et al. 2007; Dierks and Fischer 2009; Drechsler et al. 2007; Ernst 1999; Geissler-Strobel 1999; Grill et al. 2008; Johst et al. 2006; Lhonoré 1997; Novak et al. 2007; Nowicki et al. 2007; Nowicki et al. 2005; Settele et al. 2005b; Stettmer et al. 2001a; b; Stettmer et al. 2008; Thomas 1984; Timus et al. 2011; Witek et al. 2010; Witek et al. 2008; Wynhoff 1998; 2001; Wynhoff et al. 2008; Wynhoff et al. 2011)

Phengaris nausithous (Bergsträsser, 1779)

Name in the Habitats Directive: *Maculinea nausithous*
E: Dusky Large Blue
F: l'Azuré des paluds
D: Schwarzblauer Bläuling, Dunkler Wiesenknopf-Ameisenbläuling

Habitat *Phengaris nausithous*, Netherlands. Photo: Chris van Swaay.

Habitat and ecology

The Dusky Large Blue occurs on damp, moderately nutrient-rich grassland and rough vegetation. The butterflies are usually found on or near the foodplant Great Burnet (*Sanguisorba officinalis*). Having lived on the flowerheads of this plant for a few weeks, the small caterpillars go down to the ground, in order to be carried away usually by workers of the ant *Myrmica rubra* to an ant nest. There, they remain feeding on ant grubs, hibernating and pupating in the early summer. The newly-emerged butterflies leave the nest. The Dusky Large Blue is one of the most specialized of the "ant blues" being most adapted to one species of host ant. Populations using *Myrmica scabrinodis* as the main host ant are extremely rare and probably confined to the edge of the range or to east Europe. The Romanian populations belong to the subspecies *kijevensis* and prefer *Myrmica scabrinodis* as host ant. The Dusky Large Blue has one generation a year. Habitats: humid grasslands and tall herb communities (36%), water-fringe vegetation (15%), blanket bogs (12%), fens, transition mires and springs (9%), dry siliceous grasslands (6%), mesophile grasslands (6%). In Germany, the Rhone valley and parts of Poland, it supports a beautiful, highly specialized ichneumonid parasitoid *Neotypus 'pusillus'*, which possibly consists of two cryptic species centred on Germany-Poland and the Rhone valley, each host-specific to *P. nausithous*.

Red List link: http://www.iucnredlist.org/apps/redlist/details/12662/1

Red List Status

Europe: Near threatened

EU: Near threatened

Conservation Status in EU in 2007 (Article 17 assessment)
Alpine region: inadequate
Atlantic region: bad
Continental region: bad
Mediterranean region: bad
Pannonian region: inadequate

Threats in Europe
Main threats on a European scale come from agricultural improvements (like drainage) and abandonment, and to a lesser extent, intensification of hay cutting. As the species also occurs a lot along road verges, changes to the roads and the management of the verges can have a negative impact as well.

Conservation actions
The species is listed on the Habitats Directive Annexes 2 and 4 and Bern Convention Annex 2. In Ukraine and Romania, the species only occurs in protected areas. In France, Slovenia and Germany, not all populations are in Natura 2000 areas. In Romania, a special Agri-Environment Scheme for the protection of *Phengaris* (*Maculinea*) butterflies was introduced in 2011. The species has been re-introduced in The Netherlands in 1990. Like for other *Phengaris*-species, the ecological demands of this species are relatively well known.

Phengaris nausithous
Dos
- In the northern part of the species range, mowing is the best management regime to keep the vegetation open and the soil sunny and warm and to maintain a high *Myrmica* ant nest density.
- In northern Europe it thrives on sites cut every second year or even every year; under warmer climates longer intervals of up to 5–10 years between cutting

Phengaris nausithous. Photo Chris van Swaay.

are ideal, although the foodplant requires periodic mowing to ensure regeneration. Its *Neotypus* parasitoid prefers patches that have been abandoned for longer, where *Sanguisorba* grows in low densities among high densities of *Myrmica rubra*.

- Mowing should be done either before the second week of June or after mid-September. In the former case females can deposit the eggs on the small regrowth of host plants; in the latter case the caterpillars have left the host plant before cutting.
- Allow line-shaped edge structures: leave the vegetation at the edge of the meadow uncut for 1 to 5 years to keep tall and rough vegetation for a high *Myrmica rubra* ant nest density. Also maintain some patches of scrub cover or hedges to provide shelter and warm conditions for the adult butterflies.
- Depending on the productivity of the soil, meadows may be cut once a year, and should be left uncut at regular intervals.
- In the southern part of the species range, grassland habitats may also be managed by low intensity grazing, preferably by cattle or ponies. Monitor the density of the stock to keep the right level of grazing intensity.
- At the landscape scale, create a mosaic of interconnected (within 5 km dispersal potential of species) patches of low intensity agricultural use with both host plants and host ants for the establishment of a meta-population. Always allow patches of fallow land as refuges for the host ants. The distance between patches should preferably not exceed 1 km.
- Try to apply rotational management on tall and rough vegetation at meadow edges and along hedges, bushes and forests, cutting it only every three to ten years depending on the productivity of the soil. Choose the rotation so that there is always tall vegetation with large *Sanguisorba* plants and large *Myrmica rubra* nests within reach of the butterflies.
- When creating new habitats on former agricultural fields, remove the top soil when the phosphate concentration is too high. Use seed mixtures with *Sanguisorba* or plant it into the new habitat.
- Monitor populations of the butterfly and its host ant carefully, and adjust management when needed.

Don'ts

- Intensify agricultural use or drain the fields.
- Graze habitats in the northern part of the range.
- Increase the stocking rate for sheep grazing in the southern part of Europe.
- Mow the fields, road verges or ditches when the butterflies are on the wing and the caterpillars are in the buds of the foodplant (roughly in July and August).
- Allow long term abandonment of fields with single populations. Abandonment is only acceptable if temporary and if the abandoned field is part of a meta-population.
- Use of manure or biocides.

Selected references

(Anton et al. 2008; Anton et al. 2007a; Anton et al. 2007b; Batáry et al. 2009; Dierks and Fischer 2009; Drechsler et al. 2007; Ernst 1999; Geissler-Strobel 1999; Grill et al. 2008; Johst et al. 2006; Lhonoré 1997; Novak et al. 2007; Nowicki et al. 2007; Nowicki et al. 2005; Rakosy et al. 2010; Settele et al. 2005b; Stettmer et al. 2001a; b; Stettmer et al. 2008; Tartally et al. 2008; Thomas 1984; Witek et al. 2008; Wynhoff 1998; Wynhoff et al. 2008; Wynhoff et al. 2011)

Plebejus aquilo (Boisduval, 1832)

Name in the Habitats Directive: *Agriades glandon aquilo*
E: Arctic Blue

Habitat and ecology

In Scandinavia, the Arctic Blue occurs above the timber line, mainly on south facing slopes with slate and shale rocks with patches of low alpine vegetation, particularly in areas with limestone or otherwise mineral rich ground. The females deposit the eggs on Yellow Mountain Saxifrage (*Saxifraga aizoides*) and Purple Saxifrage (*S. oppositifolia*). The small caterpillars first feed on the flower buds and hibernate. Later, they also feed on the leaves. The Arctic Blue is single-brooded.

Red List link: http://www.iucnredlist.org/apps/redlist/details/174249/1

Red List Status

Europe: Least concern
EU: Least concern

Plebejus aquilo. Photo Nils Ryrholm.

Conservation Status in EU in 2007 (Article 17 assessment)
Alpine region: bad
Boreal region: unknown

Threats in Europe
This species is not believed to face major threats at the European level in this part of its distribution. However, it can already be seen that some of the habitats on the lowest altitudes where the species occur are starting to change (the vegetation becomes higher and denser) in a warmer and wetter arctic climate.

Conservation actions
The species is listed on the Habitats Directive Annex 2. In Sweden, it is unknown if all populations are in Natura 2000 areas. A surveillance program is in progress since 2008 in Finland and since 2010 in Sweden.

Plebejus aquilo
Dos
- Monitor the population of the species.
- Search for other populations on suitable mountains.
- Co-ordinate this work across the species' range.

Selected references
(Eliasson et al. 2005; Henriksen and Kreutzer 1982; Välimäki et al. 2011)

Polyommatus golgus (Hübner, 1813)

Name in the Habitats Directive: *Plebicula golgus*
E: Nevada Blue
ES: Niña de Sierra Nevada

Habitat and ecology
In the Sierra Nevada (Southern Spain), the Nevada Blue can be found in open patches in dwarf Juniper scrub and on grassy vegetation growing between acid, slate rocks and schist. In the Sierra de la Sagra, the butterflies are found on dry, open calcareous slopes with short vegetation. Here, the climatic conditions are extreme, the ground being covered with snow for nine months of the year. One of the plants that can withstand these conditions, the kidney-vetch *Anthyllis vulneraria*, is the foodplant. The female lays its eggs singly on the upperside of the leaves. The caterpillars hibernate. They pupate in the ground in June. The later instars are often found in the company of ants. Habitats: screes (30%), alpine and subalpine grasslands (30%), Mediterranean mountain shrublands (40%). This is a European endemic species.

Red List link: http://www.iucnredlist.org/apps/redlist/details/17940/0

Red List Status
Europe: Vulnerable
EU: Vulnerable

Conservation Status in EU in 2007 (Article 17 assessment)
Mediterranean region: unknown

Threats in Europe
This species has a very restricted range. Here its main threat comes from the building of touristic infrastructure and tourist activities. Regarding its limited distribution it might get threatened in the long run by climate change. As the species is not treated in the Climatic Risk Atlas (Settele et al. 2008) there is no information on the possible change of the climate envelope, but as it lives at high altitudes its range would be drastically limited in space if the climate becomes warmer.

Conservation actions
The species is listed on the Habitats Directive Annexes 2 and 4 and Bern Convention Annex 2. It is also legally protected in Spain (vulnerable in the Spanish List of Endangered Species). More research is needed on the distribution and ecology of the species. Suitable habitats should be protected and appropriately managed. The effects of conservation actions should be monitored by a Butterfly Monitoring Scheme. Not all populations are in Natura 2000 areas and particularly the important populations in the Sierra de la Sagra remain unprotected.

Polyommatus golgus
Dos
- Monitor populations of the butterfly in Sierra Nevada and La Sagra.
- In the Sierra Nevada National Park a recovery plan should be prepared for the species, since this is compulsory for species listed in the Spanish List of Endangered Species.
- More research is needed on the ecology and genetics of the populations from the north of Granada that have recently been ascribed to the species.
- Protect the populations in La Sagra that are not within the Natura 2000 network.
- Restore the areas that were destroyed to build ski runs in Sierra Nevada, favouring the natural vegetation and taking away damaging touristic developments.
- Keep traditional extensive grazing in all the areas where the butterfly has been recorded.

Don'ts
- Develop new tourist infrastructures in the areas where the butterfly is present within the Sierra Nevada National Park and other adjoining valleys.
- Build new roads and footpaths in habitats suitable for the butterfly.
- Overgraze the grasslands where the butterfly lives.

Polyommatus golgus. Photo Miguel López Munguira.

Selected references
(García-Barros et al. 2006; Gil-T. 2007; Mortera et al. 2011; Munguira 1989; Munguira and Martín 1989; 1993; Munguira and Martín 1993; Munguira et al. 2000)

Argynnis elisa Godart, 1823

Name in the Habitats Directive: *Fabriciana elisa*
E: Corsican Fritillary
F: Le Nacré tyrrhénien

Habitat and ecology
The Corsican Fritillary is a mountain butterfly, found on grassy vegetation in clearings in deciduous woods. The small caterpillars hatch out in spring and begin to feed on violets, preferring plants growing under juniper bushes. Among the foodplants mentioned in the literature are various *Viola* species, such as Wild Pansy (*V. tricolor*), Yellow Wood Violet (*V. biflora*), Pale Wood Violet (*V. reichenbachiana*) and *V. corsica*. The Corsican Fritillary has one generation a year. Habitats: dry calcareous grasslands and steppes (50%), broad-leaved deciduous forests (50%).

Red List link: http://www.iucnredlist.org/apps/redlist/details/173291/1

Red List Status
Europe: Least concern
EU: Least concern

Conservation Status in EU in 2007 (Article 17 assessment)
Mediterranean region: inadequate

Threats in Europe
Although this is a European endemic with a restricted range, this species is not believed to face major threats at the European level.

Conservation actions
The species is listed on the Habitats Directive Annex 4 and Bern Convention Annex 2. This species occurs in a number of protected areas across its range. No specific conservation actions are needed at a European level. But since it has a restricted global range, its distribution and trend should be monitored closely, for example by a Butterfly Monitoring Scheme.

Argynnis elisa
Dos
- Maintain traditional management of the habitat.

Don'ts
- Abandon middle and high elevation areas.

Selected references
(Jutzeler et al. 1997a)

Boloria improba **(Butler, 1877)**

Name in the Habitats Directive: *Clossiana improba*
E: Dusky-winged Fritillary

Argynnis elisa. Photo Tom Nygaard Kristensen.

Habitat and ecology

The Dusky-winged Fritillary occurs in the extreme north of Europe on open, grassy expanses above the timber line, often on gentle slopes, some habitats are on slopes sheltered from the prevailing westerly wind. It can occasionally occur in large numbers, in some places with hundreds of butterflies at once. Before they mate, these butterflies behave in a characteristic way, with the male following the female, flying in short spurts and seeming to make grasshopper-like jumps. The eggs are laid on various plants, including Alpine Bistort (*Polygonium viviparum*). The egg takes two years to develop into a butterfly. Habitats: sclerophyllous scrub (20%), mesophile grasslands (20%), heath and scrub (20%), and alpine and sub-alpine grasslands (20%).

Red List link: http://www.iucnredlist.org/apps/redlist/details/174312/1

Red List Status

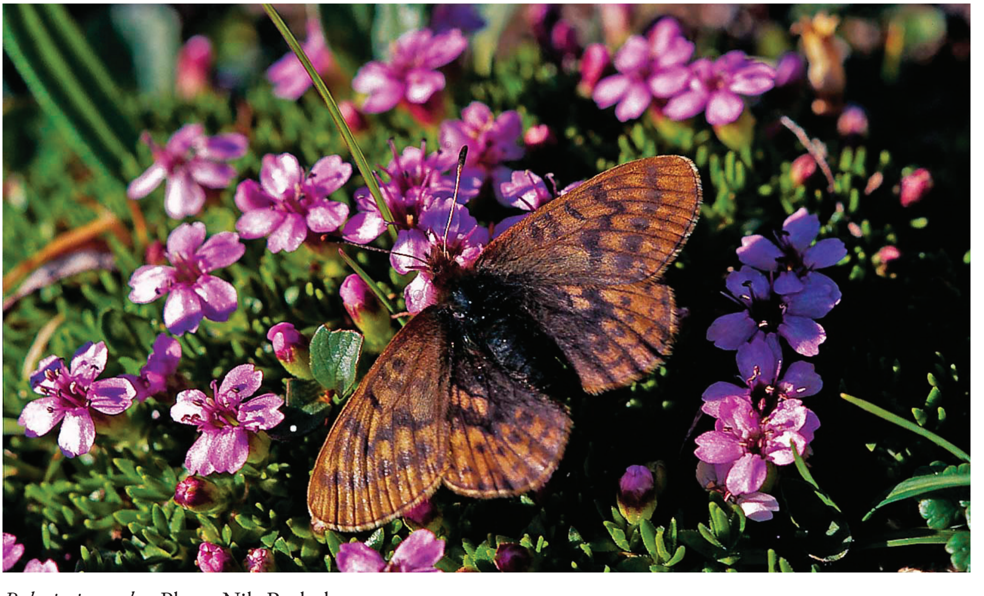
Europe: Endangered
EU: Endangered

Conservation Status in EU in 2007 (Article 17 assessment)

Alpine region: bad

Threats in Europe

The species occurs usually in low densities in a restricted range in Northern Europe. Furthermore it appears to fluctuate more than other arctic butterflies. Climate warming could be a long term threat due to its limited distribution. It can already be seen



Boloria improba. Photo Nils Ryrholm.

that some of the habitats on the lowest altitudes where the species occurs are starting to change (the vegetation becomes higher and denser) in a warmer and wetter arctic climate.

Conservation actions

The species is listed on the Habitats Directive Annex 2. More research is needed on the distribution and ecology of the species. The population trend should be monitored by Butterfly Monitoring Schemes. In Sweden, none of the populations are in Natura 2000 areas. However, a surveillance program is in progress (2010–11). In Finland, all populations are in Natura 2000 areas and a surveillance program started in 2008.

Boloria improba

Dos

- Monitor the population of the species.
- Search for other populations on suitable mountains.
- Co-ordinate this work across the species' range.

Selected references

(Eliasson et al. 2005; Henriksen and Kreutzer 1982; Välimäki et al. 2011)

Nymphalis vaualbum (Denis & Schiffermüller, 1775)

E: False Comma
D: Weißes L

Habitat and ecology

The False Comma is somewhat similar to the Comma (*Polygonia c-album*), but although the wings are strongly toothed, the indentations are much less deep than those of the Comma. It also resembles the Large Tortoiseshell (*Nymphalis polychloros*), but the white patches near the tips of the forewing and on the front edge of the hindwing distinguish it from both these butterfly species. It occurs in Eastern Europe, in deciduous or mixed woods. It prefers damp woods and is found in clearings or at the wood edge. It is a mobile butterfly and a strong migrant. Because of its migratory behaviour, it is difficult to ascertain whether populations are permanent or temporary. The female lays its eggs in spring, clustered around the twigs of the foodplants which may be birches (*Betula* spp.), willows (*Salix* spp.), poplars (*Populus* spp.), or elms (*Ulmus* spp.). The False Comma has one generation a year and because it hibernates as a butterfly, can be seen for much of the year. Habitats: broad-leaved deciduous forests (43%), urban parks and large gardens (12%), towns, villages, industrial sites (12%), tree lines, hedges, small woods, bocage, parkland dehesa (12%), alluvial and very wet forests and brush (12%), mixed woodland (6%).

Red List link: http://www.iucnredlist.org/apps/redlist/details/174215/1

Red List Status
Europe: Least concern
EU: Vulnerable

Nymphalis vaualbum. Photo Tom Nygaard Kristensen.

Conservation Status in EU in 2007 (Article 17 assessment)
No information provided by the member states.

Threats in Europe
It is unclear what causes the declines in its European range. They might be a part of natural fluctuations, but little is known of the population dynamics of this species.

Conservation actions
The species is listed on the Habitats Directive, Annexes 2 and 4. More research on the distribution, ecology and population dynamics is needed.

Nymphalis vaualbum
Dos

- Conduct more research on the distribution, ecology and population dynamics.

Selected references
(Popović and Đurić 2010)

Euphydryas maturna (Linnaeus, 1758)

Name in the Habitats Directive: *Hypodryas maturna*

E: Scarce Fritillary
F: Le Damier du frêne
D: Kleiner Maivogel, Eschen-Scheckenfalter

Habitat and ecology
The Scarce Fritillary occurs in clearings or forest fringes, where young ash trees are growing in open, mixed woodland or where nature-like fringe structures with abundant *Ligustrum* are present. The eggs are laid in one batch on a leaf of Ash (*Fraxinus excelsior*) or Aspen (*Populus tremula*), preferably at a height of 4 to 10 m. In continental mixed oak forests, *Ligustrum vulgare* is the most important initial food plant (eggs on 0,5–1 m). The populations of the Carpathian basin and southeast Europe can use several *Fraxinus* species as larval foodplant. In lowland riverine gallery forests *F. angustifolia* is the most important one, while in white oak forests *F. ornus* is used for oviposition. The butterfly generally has a slow, gliding flight but can speed up when necessary. The caterpillars build a nest of silk and leaves and feed together at first, while still quite small. They go into hibernation, remaining in the nest, which usually falls to the ground onto the woodland floor. In spring, they leave the nest and separate, spreading out in search of food. They use a variety of larval foodplants at this stage, including honeysuckle (*Lonicera* spp.), plantains (*Plantago* spp.), privets (*Ligustrum* spp.), Cow-wheat (*Melampyrum* spp.) or Speedwell (*Veronica* spp.). They pupate in the litter layer and on tree-trunks. The species has one generation a year, although in Northern Europe some of the caterpillars hibernate a second time before pupating. Habitats: broad-leaved deciduous forests (42%), mixed woodland (18%), alluvial and very wet forests and brush (7%), mesophile grasslands (7%), humid grasslands and tall herb communities (5%), tree lines, hedges, small woods, bocage, parkland dehesa (5%).

Red List link: http://www.iucnredlist.org/apps/redlist/details/10713/1

Red List Status
Europe: Vulnerable
EU: Least concern

Conservation Status in EU in 2007 (Article 17 assessment)
Alpine region: bad
Boreal region: favourable
Continental region: bad
Pannonian region: inadequate

Threats in Europe
Typical species of open woodlands and coppice, most threatened by changes in woodland management or the felling or destruction of the forests. A serious potential threat for *E. maturna* could also be the fast spread of Ash dieback in Europe caused by the

fungus *Chalara fraxinea*, although it should be noted that the decline of the butterfly started long before the strong and recent spread of the fungus.

Conservation actions

The species is listed on the Habitats Directive Annexes 2 and 4 and Bern Convention Annex 2. In part of its European range this species depends on specific woodland management. In countries where the species is in decline important habitats should be protected and managed. The effects of conservation actions should be monitored by a Butterfly Monitoring Scheme.

In Italy, none of the populations are in Natura 2000 areas. In Estonia the species occurs both in and outside Natura 2000 areas. In France and Germany, it is not known if all populations are in Natura 2000 areas.

Euphydryas maturna

Dos

- Maintain open woodland habitat, preferably by coppicing.
- Cut part of the ash trees when they reach a height of 5 metres to allow younger saplings to proliferate.
- Maintain wide and diverse woodland edges and preserve wide open corridors along forest roads.
- Protect or re-create natural fringe vegetation around clearings and meadows.
- Keep flower rich meadows near larval habitats with late season hay-cutting.
- Manage habitats across the whole landscape scale with mosaics of woodlands, clearing and low intensity managed meadows.

Don'ts

- Remove all ash-trees or their saplings from clearings.
- Let the forest grow to closed canopy stage.

Euphydryas maturna. Photo Chris van Swaay.

- Remove road edge vegetation mechanically during adult stage (from mid May to mid July).
- Replace deciduous forest with conifer trees.

Selected references

(Cizek and Konvička 2005; Eliasson 1991; Freese et al. 2006; Gros 2002; Konvička et al. 2005; Rakosy et al. in press; Wahlberg 1998; 2001)

Euphydryas aurinia (Rottemburg, 1775)

E: Marsh Fritillary
F: Le Damier de la succise
D: Skabiosen-Scheckenfalter

Habitat and ecology

The Marsh Fritillary occurs in very different types of habitat, like moist, sheltered grasslands, along the edges of raised bogs and on dry, calcareous grasslands. The foodplants are Devil's-bit Scabious (*Succisa pratense*), Small Scabious (*Scabiosa columbaria*), Field Scabious (*Knautia arvensis*) and teasels (*Dipsacus* spp.), on the Iberian peninsula Honeysuckle (*Lonicera* spp.). The eggs are laid in large clumps under the leaves. The caterpillars spin a substantial nest between the leaves of the foodplants, feeding in it and also hibernating communally there. However, later they are solitary and look for places deep in the vegetation in which to pupate. The Marsh Fritillary has one genera-

Habitat *Euphydryas aurinia*, Lithuania. Photo: Chris van Swaay.

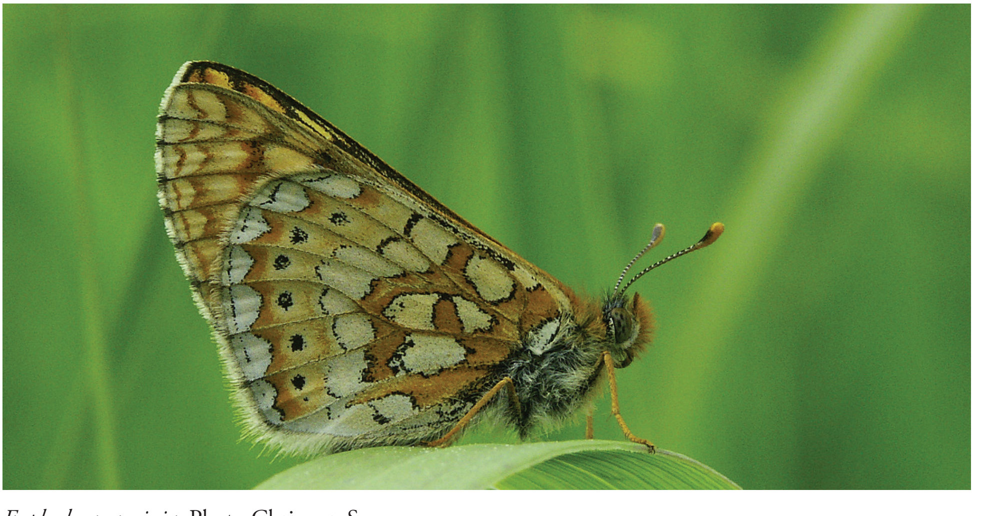
tion a year. This is a very variable species with many subspecies. In Spain and Portugal *E. a. beckeri* is larger and brighter than most subspecies, with bold, black markings. *E. a. debilis* is usually found above 1800 m in the Alps and Pyrenees. It is smaller, with a lot of black markings and hardly any orange. *E. a. provincialis* occurs in the south of France and is pale orange. *E. a. hibernica* occurs in Ireland and is very distinctive with prominent red and heavy black markings. Habitats: humid grasslands and tall herb communities (26%), mesophile grasslands (21%), dry calcareous grasslands and steppes (9%), broad-leaved deciduous forests (7%), heath and scrub (5%), alpine and subalpine grasslands (5%).

Red List link: http://www.iucnredlist.org/apps/redlist/details/174182/1

Red List Status
Europe: Least concern
EU: Least concern

Conservation Status in EU in 2007 (Article 17 assessment)
Alpine region: inadequate
Atlantic region: bad
Boreal region: inadequate
Continental region: bad
Mediterranean region: unknown
Pannonian region: inadequate

Threats in Europe
Although this species shows a decline in a part of its European range, it is not believed to face major threats at the European scale.



Euphydryas aurinia. Photo Chris van Swaay.

Conservation actions
The species is listed on the Habitats Directive Annex 2 and Bern Convention Annex 2. In Denmark, the species only occurs in protected areas. In Estonia the species occurs mostly in Natura 2000 areas, but there are also populations elsewhere. In Finland, France, Germany, Greece and Luxembourg, it is not known if all populations are in Natura 2000 areas. In countries where the species is in decline important habitats should be protected and managed. The effects of conservation actions should be monitored by a Butterfly Monitoring Scheme.

Euphydryas aurinia
Dos
- Manage grassland habitats by low intensity grazing, preferably by cattle or ponies. Sheep grazing is suitable if extensive, especially in high mountains.
- In lowland damp grasslands, aim for a tussocky structure with a turf height of 8–25 cm at the end of the growing season.
- On calcareous grasslands, aim for a final turf height of 5–20 cm with some taller patches.
- In areas where mowing is the main form of management: either cut on rotation so that less than 1/3 of the habitat is cut each year, or prevent the hibernation nests from being damaged by mowing.
- On sites that have a tradition of occasional burning, direct damage can be minimized by burning very early in the year (January- early March) before larvae emerge from hibernation; avoid burning more than one third of each field per year; manage fires by cutting fire breaks or using existing ditches.
- Monitor the density of the stock to keep the right level of grazing intensity.
- In broad-leaved woodland habitats (mainly in Spain, Portugal and southern France), maintain abundant patches of the food-plant (*Lonicera* species) either growing in open woodland or wood pasture with numerous sunny patches, or in mosaics of woodland and grassland.
- Manage habitats across the whole landscape scale, especially where habitats are fragmented. The species has large fluctuations in abundance and needs extensive breeding areas to balance local extinctions with colonisations.

Don'ts
- Intensify or abandon the fields where the species occurs.
- Overgraze the grassland so that vegetation height is uniform and less than 5cm tall.
- Burn or mow the whole site, even during a restoration phase.
- Manage just a single small site.
- Give up hope if the species becomes extinct on a site. If the surrounding landscape is being managed and colonies survive nearby, it will probably recolonize naturally in due course.

Selected references

(Anthes et al. 2003a; Anthes et al. 2003b; Anthes and Nunner 2006; Barnett and Warren 1995; Betzholtz et al. 2007; Botham et al. 2011; Bulman et al. 2007; Hula et al. 2004; Joyce and Pullin 2003; Junker and Schmitt 2010; Konvička et al. 2003; Liu et al. 2006; Munguira et al. 1997; Porter and Ellis 2011; Saarinen et al. 2005; Schtickzelle et al. 2005; Smee et al. 2011; Stefanescu et al. 2006; Wang et al. 2004; Warren 1994; Warren et al. 1994; Zimmermann et al. 2011a; Zimmermann et al. 2011b)

Apatura metis Freyer, 1829

E: Freyer's Purple Emperor
D: Donau-Schillerfalter

Habitat and ecology

Freyer's Purple Emperor is a butterfly of very warm, damp places. The butterflies can be found along wooded riverbanks, with its foodplant, White Willow (*Salix alba*). The males and females meet each other at the tops of tall trees and the females lay their eggs in small batches at the top of the tree, on leaves in the crown. The caterpillars grow quickly and pupate suspended under a leaf or on a twig. The caterpillars from the generation that follows hibernate. The butterflies have a varied diet. The females visit flowers for nectar, aphids for honeydew and ripe fruit for the sugars. The males are often found on damp ground, on dung and on carrion. The butterflies are also attracted to sap oozing from wounded trees. This species has two generations a year. Habitats: mixed woodland (23%), alluvial and very wet forests and brush (23%), broad-leaved deciduous forests (17%), water-fringe vegetation (17%).

Red List link: http://www.iucnredlist.org/apps/redlist/details/174178/1

Red List Status

Europe: Least concern
EU: Least concern

Conservation Status in EU in 2007 (Article 17 assessment)

Mediterranean region: unknown
Pannonian region: inadequate
Black sea region (not assessed for article 17, BCE expert opinion): unknown

Threats in Europe

Although this species shows a decline in a part of its European range, it is not believed to face major threats at the European scale.

Apatura metis. Photo Kim Huskens.

Conservation actions

The species is listed on the Habitats Directive Annex 4 and Bern Convention Annex 2. This species occurs in a number of protected areas across its range. One of the largest populations occurs in the low Danube region and Danube Delta Biosphere Reserve. No specific conservation actions are needed at a European level, but in countries where the species is in decline important habitats should be protected and managed. The effects of conservation actions should be monitored by a Butterfly Monitoring Scheme.

Apatura metis

Dos

- Conduct more research on the ecology and population dynamics of the species.
- Maintain the riverbanks with White Willow riparian woods and undergrowth vegetation.
- Maintain the seasonal water dynamics of riparian forests.

Don'ts

- Fell *Salix* trees where the species occurs.
- Remove the undergrowth.
- Drain or take any other action that reduces the water level (dam building etc.)
- Maintain constant high water level.

Selected references

(Levente 2005; Slamka 1989; Weidemann 1982a; b)

Lopinga achine (Scopoli, 1763)

E: Woodland Brown
F: La Bacchante
D: Gelbringfalter

Habitat and ecology
The Woodland Brown is found on warm, open places in damp or mesic, deciduous or mixed woods with well-developed shrub and herbaceous layers. These habitats may be flooded in winter. The butterflies rarely visit flowers, preferring to feed on honeydew, moisture on buds and sap that runs from wounded trees. The males often settle on puddles on the ground, while the females tend to stay in the higher scrub. Females and caterpillars are restricted to a narrow zone under the tree and bush canopy along the edges of clearings where the host plant must be present. Eggs are laid on all species of grasses, mostly on false-bromes (*Brachypodium* spp.) but also on fescues (*Festuca* spp.), meadow-grasses (*Poa* spp.), small-reeds (*Calamagrostis* spp.) and on Sedges (*Carex* spp.). The half-grown caterpillar hibernates in a grass tussock, where later in the year it also pupates. The Woodland Brown has one generation a year. Habitats: broad-leaved deciduous forests (45%), mixed woodland (29%), alluvial and very wet forests and brush (8%), coniferous woodland (5%).

Red List link: http://www.iucnredlist.org/apps/redlist/details/174299/1

Red List Status
Europe: Vulnerable
EU: Vulnerable

Conservation Status in EU in 2007 (Article 17 assessment)
Alpine region: bad
Atlantic region: bad
Boreal region: inadequate
Continental region: bad
Mediterranean region: unknown
Pannonian region: bad

Threats in Europe
Changes in woodland or woodland management are the main threats all over the continent. Nevertheless agricultural abandonment and land drainage are important threats in some countries as well, mainly because the habitat was maintained by grazing in a successional change.

Conservation actions
The species is listed on the Habitats Directive Annex 4 and Bern Convention Annex 2. In countries where the species is in decline important habitats should be protected

and managed. The effects of conservation actions should be monitored by a Butterfly Monitoring Scheme. It is important to maintain suitable glades by grazing or clearing at regular intervals to prevent overshading of its habitat. To improve overgrown sites small clearings (10–30 m in diameter) should be created, wide enough to allow the sun to reach the ground (comm. Bergman).

Lopinga achine

Dos

- Maintain open forest and open wood pastures, which are the main habitat, by coppicing or other forms of traditional woodland management.
- Maintain wide and diverse woodland edges and preserve wide open corridors along forest roads.
- Maintain a network of 2–5 year fallow land as breeding habitat in or next to forests.
- Keep large networks of young succession stages of abandoned meadows with occasional removal of bushes and saplings but never remove all bushes.

Don'ts

- Change to a more intensive woodland management, especially replacement of deciduous forest with conifer trees.

Lopinga achine. Photo Kars Veling.

- Let the forest grow to closed canopy closure.
- Remove the bushy gradient zone between forest and grassland.

Selected references

(Bergman 1996; 1999; 2001; Bergman and Kindvall 2004; Bergman and Landin 2001; 2002; Bergman 2000; García-Barros et al. 2006; Jutzeler 1990; Konvička et al. 2008b; Koschuh 2008; Mortera et al. 2011; Seidler 2007)

***Coenonympha oedippus* (Fabricius, 1787)**

E: False Ringlet
F: l'Œdippe, le Fadet des laîches
D: Moor-Wiesenvögelchen

Habitat and ecology

The False Ringlet is a very local species that is declining at an alarming rate in several countries, though more stable in others. It inhabits low-lying, grassy marshes and reedbeds that are usually situated in the shelter of woodland, creating a warm and humid environment, but also in overgrown dry grasslands in the southern part of its range. The butterflies fly very slowly and hardly ever colonize nearby habitats. The eggs are deposited one by one on the blades of grasses, like meadow-grasses (*Poa* spp.), rye-grasses (*Lolium* spp.), hair-grasses (*Deschampsia* spp.), sedges (*Carex* spp.) and Purple Moor-grass (*Molinea caerulea*). The caterpillars hibernate half-grown in the tussock, where they pupate as well. The False Ringlet has one generation a year in June or July depending on altitude. Habitats: humid grasslands and tall herb communities (26%), blanket bogs (20%), raised bogs (13%), fens, transition mires and springs (10%), mixed woodland (6%), broad-leaved deciduous forests (6%), water-fringe vegetation (6%).

Red List link: http://www.iucnredlist.org/apps/redlist/details/5100/1

Red List Status

Europe: Endangered
EU: Least concern

Conservation Status in EU in 2007 (Article 17 assessment)

Alpine region: bad
Atlantic region: bad
Continental region: inadequate
Pannonian region: inadequate

Threats in Europe

Agricultural improvements (incl. land drainage) as well as abandonment of grassland habitats are the largest threats for *Coenonympha oedippus*. Furthermore it

Coenonympha oedippus. Photo Kars Veling.

survives nowadays in small and fragmented habitats where colonies are threatened by isolation.

Conservation actions

The species is listed on the Habitats Directive Annexes 2 and 4 and Bern Convention Annex 2. More research is needed urgently on the distribution and ecology of the species. Suitable habitats should be protected and appropriately managed. The effects of conservation actions should be monitored by a Butterfly Monitoring Scheme. In Hungary, Austria and France, the species only occurs in protected areas.

Coenonympha oedippus

Dos

- Use extensive grassland management with rotational mowing.
- Keep the habitat networks dense to maintain metapopulations.
- Maintain large areas of suitable habitat with minimum level of management (remove bushes and/or reeds every few years).

Don'ts

- Drain or take any other action that sinks the water level at occupied sites.
- Abandon low intensity management of the habitats.

- Mow during flight period of the adults and the entire suitable habitat at once
- Burn dry grass during spring.

Selected references

(Bonelli et al. 2010; Bräu et al. 2010; Čelik 2004; Čelik and Verovnik 2010; Čelik et al. 2009; Dierks 2006; Dušej et al. 2010; Lhonoré and Lagarde 1999; Örvössy et al. 2010; Šašic 2010; Sielezniew et al. 2010)

Coenonympha hero (Linnaeus, 1761)

E: Scarce Heath
F: La Mélibée, le Fadet de l'élyme
D: Wald-Wiesenvögelchen

Habitat and ecology

The Scarce Heath occurs in damp to wet grassy meadows in or at the edges of woods. Sometimes, they occur away from woods in drier places or in flower-rich grassland. The butterflies are fond of settling in grass and do not fly far, nor very often. Among the grasses they use as food are Tufted Hair-grass (*Deschampsia cespitosa*) and Bearded Couch (*Elymus caninus*). When half-grown, the caterpillar hibernates in a grass tussock, later also pupating there. This species has one generation a year. Habitats: humid grasslands and tall herb communities (26%), mixed woodland (19%), broad-leaved deciduous forests (14%), mesophile grasslands (9%), fens, transition mires and springs (7%).

Coenonympha hero. Photo Kars Veling

Red List link: http://www.iucnredlist.org/apps/redlist/details/174391/1

Red List Status
Europe: Vulnerable
EU: Vulnerable

Conservation Status in EU in 2007 (Article 17 assessment)
Alpine region: favourable
Atlantic region: bad
Boreal region: bad
Continental region: bad

Threats in Europe
Chief threats are from drainage, agricultural improvements and changing grassland and woodland management. This has caused strong declines and even local extinctions in many countries in Western and Central Europe.

Conservation actions
The species is listed on the Habitats Directive Annex 4 and Bern Convention Annex 2. This species occurs in a number of protected areas across its range. In Western and Central European countries where the species is in decline, important habitats should be protected and managed. The effects of conservation actions should be monitored by a Butterfly Monitoring Scheme.

Coenonympha hero
Dos
- In areas where the species still occurs: try to continue careful management while taking into account that the species is very sensitive to small changes in the environment and management.
- In case of gradual encroachment, remove bushes in the sensitive wet fallow habitats only once within a decade.
- Maintain "traditional" forms of forest management, such as coppicing and clear cutting.

Don'ts
- Drain the area.
- Intensify or abandon the areas where it occurs.
- Disturb in higher frequencies (e.g. for scrub removal).

Selected references
(Cassel-Lundhagen and Sjögren-Gulve 2007; Cassel-Lundhagen et al. 2008; Cassel and Tammaru 2003; Cassel et al. 2001; Ortner and Lechner 2007; Pretscher 2001; Steiner and Hermann 1999; Thust et al. 2001; Wiemers 2007)

Erebia christi Rätzer, 1890

E: Rätzer's Ringlet
F: Le Moiré du Simplon

Habitat and ecology
Rätzer's Ringlet is found on steep, sunny slopes on acid soil with patches of grassy vegetation and rocks and scattered larches or fir trees. Its one of the rarest European butterflies, having not more than six or seven populations. The butterflies often bask in the sun with their wings wide open. The males congregate regularly on damp ground. The females visit different nectar plants and are especially fond of thyme. They lay their eggs on the dry grass stems of Sheep's Fescue (*Festuca ovina*). Before completing their development, the caterpillars hibernate twice. Detailed habitat descriptions are not available. This is a European endemic species.

Red List link: http://www.iucnredlist.org/apps/redlist/details/39491/0

Red List Status
Europe: Vulnerable
EU: Vulnerable

Conservation Status in EU in 2007 (Article 17 assessment)
Alpine region: bad

Erebia christi. Photo Matt Rowlings.

Threats in Europe

The species has a very limited global range, where it is mainly threatened by habitat destruction. The species is popular with collectors, but this is not the main reason for the decline.

Conservation actions

The species is listed on the Habitats Directive Annexes 2 and 4 and Bern Convention Annex 2. More research is needed on the distribution and ecology of the species. Suitable habitats should be protected and appropriately managed. The effects of conservation actions should be monitored by a Butterfly Monitoring Scheme. In Italy, not all populations are in Natura 2000 areas.

Erebia christi

Dos

- Protect all current and potential habitats and prevent road works or other building development.
- Restore habitats that were destroyed by road construction.
- Maintain traditional management of habitat.
- Monitor of all populations.

Don'ts

- Destroy any of the remaining sites as a result of building activities or road works.
- Collect specimens, in particularly for commercial reasons.

Selected references

(Leigheb et al. 1998; Lepidopterologen-Arbeitsgruppe 1987)

Erebia sudetica Staudinger, 1861

E: Sudeten Ringlet
F: Le Moiré des Sudètes
D: Karpathen-Mohrenfalter

Habitat and ecology

The Sudeten Ringlet occurs on alpine and sub-alpine grasslands, especially those near the tree-line. The butterflies are most numerous on damp grasslands with tall grasses and flowering plants, but they also reproduce on dry grassland. Although Sweet Vernal-grass (*Anthoxanthum odoratum*) is probably the most important foodplant, other grasses, such as Annual Meadow-grass (*Poa annua*), are also used. The species has one generation a year and passes the winter as a caterpillar. Habitats: alpine and subalpine grasslands (37%), coniferous woodland (25%), mixed woodland (12%), inland cliffs and exposed rocks (12%), mesophile grasslands (12%). This is a European endemic species.

Red List link: http://www.iucnredlist.org/apps/redlist/details/39492/0

Red List Status
Europe: Vulnerable
EU: Vulnerable

Conservation Status in EU in 2007 (Article 17 assessment)
Alpine region: unknown
Continental region: bad

Threats in Europe
Main threats are intensified grazing, abandonment and afforestation. In view of its limited distribution it might get threatened in the long run by climate change. As the species is not treated in the Climatic Risk Atlas (Settele et al. 2008) there is no information on the possible change of the climate envelope.

Conservation actions
The species is listed on the Habitats Directive Annex 4 and Bern Convention Annex 2. More research is needed on the distribution and ecology of the species. Suitable

Erebia sudetica. Photo Neil Thompson.

habitats should be protected and appropriately managed. The effects of conservation actions should be monitored by a Butterfly Monitoring Scheme. In the Czech Republic, Poland and Romania, the species only occurs in protected areas.

Erebia sudetica

Dos

- Maintain traditional management of habitat.
- Prevent encroachment, but allow succession in small areas.
- Try to create a mosaic of different land-uses with different mowing regimes, grazing duration, etc.
- On pastures, maintain extensive grazing, or switch to extensive grazing.
- On meadows, mow late after 1 August, but adjust according to altitude.
- Maintain extensive use of marginal areas (steep slopes, inaccessible areas): mowing every two to three years or only one half to one third of the area in a year. Also cut the scrub to prevent over-shading of habitat.
- In countries with isolated occurrence, the populations should be monitored nationwide.
- Important populations should be monitored.
- Local authorities, farmers and other interested parties should be informed of the importance of the species.

Don'ts

- Destroy populations by building activities, road works or winter sport activities.
- Allow intensive or prolonged grazing.
- Permit eutrophication or use of chemical fertilizers. Manure of the huts should not be deployed on the habitats of the species.
- Allow structural changes (e.g. slopes) or other interventions (eg artificial snowmaking) in the current and potential habitats.

Allow afforestation of subalpine and mountainous grasslands.

Selected references

(Kuras et al. 2003; Kuras et al. 2001a; Kuras et al. 2001b; Lepidopterologen-Arbeitsgruppe 1987; Wermeille et al. 2007)

Erebia polaris Staudinger, 1871

Name in the Habitats Directive: *Erebia medusa polaris*
E: Arctic Woodland Ringlet

Habitat and ecology

The Arctic Woodland Ringlet is often found on damp grasslands, but it also occurs on dry grasslands and in waste places, often where there is shelter from birches, or juniper bushes. Unlike the other ringlets in Lapland, the Arctic Ringlet (*E. disa*) and the Lapland Ringlet (*E. embla*), this species does not occur on peat bogs. It lays its eggs on

Sheep's-Fescue (*Festuca ovina*), Wood Millet (*Milium effusum*) and Swamp Meadow-grass (*Poa palustris*). The caterpillars take nearly two years to develop. Habitats: dry siliceous grasslands (100%).

Red List link: http://www.iucnredlist.org/apps/redlist/details/174378/1

Red List Status
Europe: Least concern
EU: Least concern

Conservation Status in EU in 2007 (Article 17 assessment)
Alpine region: inadequate

Threats in Europe
This species is not believed to face major threats at the European level in this part of its distribution.

Conservation actions
The species is listed on the Habitats Directive Annex 2 (under the name *Erebia medusa polaris*).

Erebia polaris
Dos and Don'ts
Unknown, research is urgently needed.

Selected references
(Eliasson et al. 2005; Henriksen and Kreutzer 1982; Rambring 1969)

Erebia calcaria Lorković, 1953

E: Lorkovic's Brassy Ringlet
F: Le Moiré de Carniole
D: Karawanken-Mohrenfalter Lorković's Schillernder Mohrenfalter

Habitat and ecology
Lorkovic's Brassy Ringlet inhabits southern exposed slopes with alpine grassland interspersed with rocks. Screes without vegetation or only a few grass tussocks cannot serve as habitat. These butterflies are only active when the sun is shining. They fly close to the ground, visiting flowers from time to time and spend much of their time on rocks, resting. The female deposits her eggs on dry grass stalks, just above the ground. The caterpillars feed on Mat-grass (*Nardus stricta*) and on different fescues (*Festuca* spp.) and *Sesleria* species. Habitats: alpine and subalpine grasslands (50%), screes (25%), inland cliffs and exposed rocks (25%). This is a European endemic species.

Erebia calcaria. Photo Tom Nygaard Kristensen.

Red List link: http://www.iucnredlist.org/apps/redlist/details/173285/0

Red List Status
Europe: Least concern
EU: Least concern

Conservation Status in EU in 2007 (Article 17 assessment)
Alpine region: inadequate

Threats in Europe
Although this is a European endemic with a restricted range, this species is not believed to face major threats at the European level.

Conservation actions
The species is listed on the Habitats Directive Annexes 2 and 4 and Bern Convention Annex 2. In Slovenia, the species only occurs in protected areas. In Austria, none of the populations are in Natura 2000 areas.

Erebia calcaria
Dos
- Maintain traditional land uses (i.e. extensive grazing with sheep or goats) in mountain areas.

Don'ts
- Build new tourist developments, especially related to ski sports in areas where the species is present.

- Graze with cattle. Even low intensity grazing with cattle makes irreparable damage to short turf vegetation important as the larval habitat.
- Overgraze the sites, especially those with strong populations.

Selected references
(De Groot et al. 2009; Rakosy and Jutzeler 2005)

Melanargia arge (Sulzer, 1776)

E: Italian Marbled White
F: L'Échiquier d'Italie

Habitat and ecology
The Italian Marbled White occurs locally in small populations on rocky, calcareous places on patches of dry, grassy vegetation among loose thickets of Prickly Juniper (*Juniperus oxycedrus*), *Rosa sempervirens*, the Bramble (*Rubus ulmifolius*) and *Thymus capitatus*, with a few scattered trees. The caterpillars feed on grasses such as Feather Grass (*Stipa pinnata*) and the false-brome (*Brachypodium retusum*). The Italian Marbled White has one generation a year which only flies for three weeks. Detailed habitat descriptions are not available. This is a European endemic species.

Red List link: http://www.iucnredlist.org/apps/redlist/details/173235/0

Melanargia arge. Photo Matt Rowlings.

Red List Status
Europe: Least concern
EU: Least concern

Conservation Status in EU in 2007 (Article 17 assessment)
Alpine region: favourable
Mediterranean region: inadequate

Threats in Europe
This species is not believed to face major threats at the European level.

Conservation actions
The species is listed on the Habitats Directive Annexes 2 and 4 and Bern Convention Annex 2. This species occurs in a number of protected areas across its range. No specific conservation actions are needed at a European level. In Italy, not all populations are in Natura 2000 areas.

Melanargia arge
Don'ts
- Large scale burning of habitats.

Selected references
(Nardelli and Benedetto 1994; Russo 1991; 1994)

Material
Information on threats and conservation actions were collected via national experts for the Red List of butterflies in Europe (Van Swaay et al., 2010, 2011), the detailed habitat descriptions from Van Swaay et al. (2006).

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