Protected Areas in Europe

Principle and Practice

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Systematic conservation planning provides a structured, target-driven approach to ensuring the long-term maintenance of biodiversity. However, reviews of how well the steps of such a planning process are applied in different regions are scant; some steps may be implemented although there is no formal systematic conservation planning process taking place. Here we conduct such a review for Europe. Taking in turn the six recognized steps of systematic conservation planning, for this region: (i) The availability of data on biodiversity remains a significant constraint on conservation planning because, although species occurrences have often been better mapped in Europe than elsewhere, there is a continuing mismatch between the spatial resolution at which data coverage is adequate and that of habitat fragmentation. (ii) Although there are important legal frameworks for conservation planning, explicit quantitative goals for the representation and persistence of biodiversity are largely lacking. (iii) Assessment of the effectiveness of existing protected area systems is patchy and rather ill developed, with a substantial gulf between the work being conducted in more academic and policy-oriented arenas. (iv) Nonetheless, particularly through the Natura 2000 process, there has been an extraordinary program to select additional protected areas. (v) Although it has taken longer than originally envisaged, this program is resulting in a substantial expansion of the protected area system. (vi) There are significant concerns over the extent to which existing protected area systems can maintain their biodiversity values, particularly given the small size of many of these areas and likely impacts of climate change.

Key words: **biodiversity; conservation planning; Europe; Natura 2000; protected areas**

Introduction

Areas have long been set aside to protect natural habitats, species, and populations. However, the importance of a structured and target-driven approach to ensuring both the adequate representation and the maintenance of biodiversity within sets of such areas, and especially those features considered to be at greatest risk of regional or global loss, has emerged much more recently (Margules & Pressey 2000; Groves 2003; Possingham *et al.* 2006). In particular, the substantial mismatch between the resources required to attain such goals and what is available has highlighted the need for careful targeting of those resources in order to maximize the gains that can be achieved (James *et al.* 1999; Balmford *et al.* 2003).

For a focal region, such a systematic conservation planning process has usefully been separated into six different stages (Margules & Pressey 2000; Gaston *et al.* 2002): (i) compile data on biodiversity; (ii) identify conservation

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goals; (iii) review existing conservation areas; (iv) select additional conservation areas; (v) implement conservation actions; and (vi) maintain the required values of conservation areas. Although execution of the process will broadly involve moving sequentially through these stages, in practice there are likely to be many feedbacks. For example, later steps potentially generate fresh biodiversity data that may cause several earlier steps to be revisited.

While widely accepted as providing a logical and, from a biodiversity conservation perspective, necessary approach, in some quarters it has been vigorously maintained that systematic conservation planning is largely irrelevant in much of the world. This, it is argued, is because practical constraints, resulting from resource, political, and other considerations, simply prevent the effective execution of such a process (e.g., Prendergast *et al.* 1999). Although they persist, such criticisms have been effectively rebuffed, principally on the grounds that they themselves are consequences of too narrow a view as to how systematic conservation planning can be implemented (Pressey 1999; Margules & Pressey 2000; Pressey & Cowling 2001; Groves 2003; Smith *et al.* 2006). Indeed, while the majority of conservation planning has doubtless not been systematic, and the full process of systematic conservation planning is somewhat idealized, it has formally been employed in a growing number of cases (e.g., Cowling 1999; Davis *et al.* 1999; Cowling *et al.* 2003; Fernandes *et al.* 2005; Pierce *et al.* 2005). Equally tellingly, considering the whole systematic conservation planning process and not simply those parts concerned with the identification of priority areas for conservation and acting on those priorities, many of the steps are widely conducted, albeit frequently they may not be "joined up" in quite the manner that is envisaged as most desirable. However, debate about the usefulness of the systematic conservation planning approach has largely taken place in the face of rather few explicit reviews as to how these various steps are, or are not, being applied in different parts of the world (but see Cowling & Pressey 2003).

In this paper, we review progress across Europe in the several steps of a systematic conservation planning process, with particular reference to protected areas (rather than conservation areas more broadly). This is a region in which, while no formal attempt has been made to conduct such a process on a large scale, many of the components are nonetheless recognizable. We focus principally on the existing Member States of the European Union (EU; Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, United Kingdom), recognizing that at present there are some candidate countries for membership (Croatia, former Yugoslav Republic of Macedonia, Turkey) and that other countries also lie within Europe, in their entirety or in substantial part (Albania, Andorra, Armenia, Azerbaijan, Belarus, Bosnia & Herzegovina, Georgia, Iceland, Liechtenstein, Moldova, Monaco, Montenegro, Norway, Russia, San Marino, Serbia, Switzerland, Ukraine, Vatican City State).

This region provides an interesting case study. The EU Member States (EU27) alone cover a total land area of c. 4.25 million km^2, have extensive territorial waters, and have an overall human population of approaching 500 million (Table 1). The biodiversity of the region includes c. 30,000 recognized marine species (excluding viruses and bacteria), c. 12,500 species of vascular plants, and c. 130,000 recognized nonmarine animal species (Costello *et al.* 2001; Fontaine *et al.* 2007). As well as containing parts of two global biodiversity hotspots (the Caucasus and the Mediterranean basin; Mittermeier *et al.* 2004), several of the Earth's most biologically valuable ecoregions (Olson & Dinerstein 1998), and centers of plant diversity (Davis *et al.* 1994), many habitat types and species only occur in Europe, have restricted ranges in the region (often being endemic to single countries), and a high proportion are at high risk of loss (European Environment Agency 1999a; BirdLife International

2004a; Fontaine *et al.* 2007; Temple & Terry 2007). For example, Europe is home to 560 animal species that are globally red listed, and was home to 62 animal taxa that have undergone global extinctions in recent times (Fontaine *et al.* 2007).

Compiling Biodiversity Data

Systematic conservation planning requires information on the distribution of biodiversity, from which to identify priority areas for conservation and determine their relative importance. Invariably, given the magnitude and complexity of biodiversity (particularly its hierarchical structure from molecules to ecosystems; Gaston & Spicer 2004), the available data are in major part incomplete. Planning has therefore to be based on surrogate measures that likely capture the overall complexity of biodiversity to varying degrees. Two approaches have commonly been employed: (i) using data on environmental variation, land cover, or vegetation types, and (ii) using data on the occurrences (and perhaps the abundances) of species. In general, heavy reliance has frequently to be placed on the former, because of the greater ease of obtaining consistent data over large areas (increasingly through remote sensing), and because of the paucity of species data. There has been substantial debate about the advantages and disadvantages of using these different approaches for conservation planning (Araújo *et al.* 2001; Faith 2003; Brooks *et al.* 2004a, 2004b; Cowling *et al.* 2004; Higgins *et al.* 2004; Molnar *et al.* 2004; Pressey 2004; Bonn & Gaston 2005; Rondinini *et al.* 2006). Even where species data are directly available, these are invariably only for a taxonomically highly biased subset, and usually result from spatially biased collecting efforts, leading to much concern as to how well these capture the distributions and priority areas for conservation both of the species in question and those in other groups (Gaston 1996; Borges *et al.* 2005).

As well as climatic variables, considerable efforts have been made to map land cover, land use, and their change across Europe at a fine resolution and in a reasonably consistent fashion (European Environment Agency 1995). Indeed, there has been continued development of the Coordination of Information on the Environment (CORINE) program land-cover maps by the European Environmental Agency (1999b), which cover most European countries. While the smallest mapped area of each land-cover type remains at 25 ha (with smaller patches being generalized to the type of larger surrounding areas), important thematic and technical updates have been made between the two main versions of the database (CORINE land cover 2000 and 1990). The level of detail in the resulting database justified the creation of easy-to-process derived products (250 and 100 m grid data), disseminated, together with the original vector data, through the European Environmental Agency's website (DG JRC 2005). Such data have, and will likely continue, to play a key role in conservation planning in the region. However, perhaps most significantly, they have revealed the extreme fragmentation of natural and seminatural vegetation over much of Europe (Figs. 1 and 2; principal exceptions being mountainous and/or forested areas of low human population density). Made yet more complicated by the geopolitical fragmentation and projected to increase (European Environment Agency 1999a), the fragmentation of vegetation is an issue that dominates many conservation considerations.

The approximate marine equivalent of CORINE data could be considered to be seabed maps, such as the UK Seamap project (Connor *et al.* 2006). These are based on geological survey data and have a resolution of approximately 1.9 km, although some of the underlying data are at a coarser scale. The destructive impact of some fishing activities on marine habitat structure and distribution is a major concern for conservation planning in European waters (Jennings *et al.* 2001).

TABLE 1. Size and protected area coverage of countries of Europe[a]

Country	Total area	Human pop.	% Protected area		SPAs		SCIs		Sufficiency index
			All	I-IV	Terrestrial	Marine	Terrestrial	Marine	
EU Member States									
Austria	83.9	8.3	26.4	1.3	95 (11.2)	—	165 (10.6)	—	88.32
Belgium	30.5	10.5	16.2	0.2	229 (9.7)	0	278 (10.0)	1	99.59
Bulgaria	110.9	7.7	8.9	4.3					
Cyprus	9.3	0.8	9.9	7.5	7 (13.4)	1	36 (11.5)	5	25.04
Czech Republic	78.9	10.3	16.0	0.5	38 (8.8)	—	864 (9.2)	—	59.47
Denmark	43.1	5.4	9.6	3.3	113 (5.9)	59	254 (7.4)	118	100.00
Estonia	45.2	1.3	24.0	7.0	66 (12.8)	26	509 (15.9)	34	84.24
Finland	304.5	5.3	10.0	3.0	467 (7.5)	66	1715 (12.7)		68.53
France	544.0	63.0	14.0	1.0	369 (7.7)	62	1305 (7.9)	90	90.73
Germany	357.0	82.5	23.4	1.9	568 (8.9)	14	4617 (9.9)	48	99.26
Greece	131.6	11.1	5.9	1.5	151 (10.0)	16	239 (16.4)	102	99.07
Hungary	93.0	10.1	7.4	2.0	55 (14.5)	—	467 (15.0)	—	85.61
Ireland	70.3	4.2	11.1	0.5	131 (2.9)	66	413 (14.2)	92	85.95
Italy	301.3	58.8	9.4	1.9	566 (11.3)	18	2286 (13.9)	160	98.75
Latvia	64.6	2.3	16.8	10.6	97 (9.6)	4	331 (11.0)	6	89.38
Lithuania	65.3	3.4	4.8	3.1	77 (8.1)	1	267 (10.0)	2	61.22
Luxembourg	2.6	0.5	29.4	0.4	12 (5.4)	—	47 (14.8)	—	96.67
Malta	0.3	0.4	10.1	9.3	12 (4.5)	0	27 (12.6)	1	92.64
Netherlands	33.9	16.3	12.6	2.0	77 (12.5)	7	141 (8.4)	9	100.00
Poland	312.7	38.1	21.8	1.0	72 (7.8)	3	192 (4.2)	0	16.98
Portugal	91.9	10.6	8.2	1.4	50 (10.1)	10	94 (17.4)	23	87.74
Romania	237.5	21.6	5.0	1.8					
Slovakia	49.0	5.4	21.3	5.2	38 (25.1)	—	382 (11.8)	—	72.34
Slovenia	20.3	2.0	10.3	3.7	27 (23.0)	1	259 (31.4)	3	72.61
Spain	504.8	43.8	11.6	3.1	512 (18.3)	20	1380 (22.6)	88	95.46
Sweden	410.9	9.0	11.8	8.6	530 (6.2)	107	3981 (13.7)	327	92.35
United Kingdom	243.8	60.4	23.3	0.8	258 (5.8)	3	613 (6.5)	41	92.54
Candidate EU Member States									
Croatia	56.5	4.5	11.5	1.5					
Former Yugoslav Republic of Macedonia	25.3	2.0	5.8	4.0					
Turkey	770.8	72.5	2.0	0.6					
Non-EU Countries									
Albania	28.7	3.6	1.6	1.3					
Andorra	0.5	<0.1	14.7	0					
Armenia	29.8	3.0	14.9	8.0					
Azerbaijan	86.6	8.1	7.2	6.8					
Belarus	207.6	9.7	9.7	7.0					
Bosnia & Herzegovina	51.1	4.6	0.6	0.4					
Georgia	69.7	4.6	4.3	3.0					
Iceland	103.0	0.3	10.0	2.7					
Liechtenstein	0.2	<0.1	21.3	1.4					
Moldova	23.8	4.3	4.1	0.6					
Monaco	<0.1	<0.1	0	0					
Montenegro	14.0	0.7	25.2	3.5					
Norway	323.8	4.6	7.0	4.7					
Russia	17075.2	141.4	10.7	6.6					

Continued

TABLE 1. *Continued*

Country	Total area	Human pop.	% Protected area		SPAs		SCIs		Sufficiency index
			All	I-IV	Terrestrial	Marine	Terrestrial	Marine	
San Marino	<0.1	<0.1	0	0					
Serbia	88.4	10.2	2.9	1.0					
Switzerland	41.3	7.6	24.5	6.6					
Ukraine	603.7	46.3	4.1	2.9					

[a]Total area of country (thousands of km^2; http://epp.eurostat.ec.europa.eu, Central Intelligence Agency 2007); human population (millions in 2006/2007; http://epp.eurostat.ec.europa.eu, Central Intelligence Agency 2007); coverage by all protected areas and by those in IUCN categories I to IV (percentage of land area; derived from WDPA Consortium 2006[b]); SPAs (number and percentage of land area for terrestrial, number for marine; DG ENV 2007); SCIs (number and percentage of land area for terrestrial, number for marine; DG ENV 2007); and, sufficiency index—degree to which The European Commission's Environment Directorate-General regards Member States as having proposed sites that are considered sufficient to protect the habitats and species mentioned in Habitats Directive Annex I and II (as of January 2007; http://dataservice.eea.europa.eu/atlas/viewdata/viewpub.asp?id=2640).

[b]Coverage by protected areas in each country was calculated by intersecting a base map of Europe with maps compiled from WDPA Consortium (2006) for (i) all available sets of protected areas and (ii) those areas with IUCN categories I to IV. Only designated areas were included, with exclusions comprising sites with status Degazetted, Proposed, Recommended, Unset and Voluntary–recognized. The sets include sites with known boundaries (polygons) and point records. Protected areas with only point locations and area data were converted to circular shapes of the correct size centered on the coordinates provided in the database (this will somewhat inflate or reduce the protected area coverage of some regions). Prior to calculations of coverage for each country, overlapping areas were dissolved to avoid overestimates. Analyses were conducted using ESRI ArcMap™ 9.2. Note, although only parts of some non-EU countries occur in Europe, protected area coverage is given for their entire extent.

The Flora Europaea and Fauna Europaea programs have respectively documented the occurrences of plant and nonmarine animal species across Europe at the resolution of countries, and large islands or archipelagos (Tutin *et al.* 2001; Fauna Europaea 2004). However, data at finer resolutions have also improved dramatically in recent decades, particularly with the production of regional atlases for selected terrestrial and marine groups (plants: Jalas & Suominen 1972–1994; Jalas *et al.* 1996, 1999; amphibians and reptiles: Gasc *et al.* 1997; seabirds: Stone *et al.* 1995; birds: Hagemeijer & Blair 1997; cetaceans: Reid *et al.* 2003; mammals: Mitchell-Jones *et al.* 1999). The terrestrial atlases are all based on the occurrences of species on a grid of approximately 50 × 50 km (the marine ones are at coarser resolutions). While in global terms this constitutes a notable achievement, these data thus remain of limited direct value for most practical conservation planning exercises, principally because such areas are simply too large to serve as conservation planning units, and the high degree of fragmentation of land cover and thus of species distributions across much of Europe makes it difficult directly to infer from them occurrences at finer resolutions. Moreover, even at this resolution, the quality of the data inevitably remains uneven, being notably poorer in much of eastern Europe.

More detailed information on terrestrial species occurrences in Europe is also available in atlas format (e.g., Gibbons *et al.* 1993; Schmid *et al.* 1998; Asher *et al.* 2001; Preston *et al.* 2002; Estrada *et al.* 2004; Šťastny *et al.* 2006). This is typically at a 10 × 10 km resolution, although sometimes finer. However, the coverage is quite patchy and tends to be biased particularly toward areas of western Europe. Given that these areas are also those in which the level of fragmentation of land cover tends on average to be greater, a substantial mismatch between data resolution and practical planning units tends to remain (Araújo 1999; Hopkinson *et al.* 2000; Lund 2002; Dimitrakopoulos *et al.*

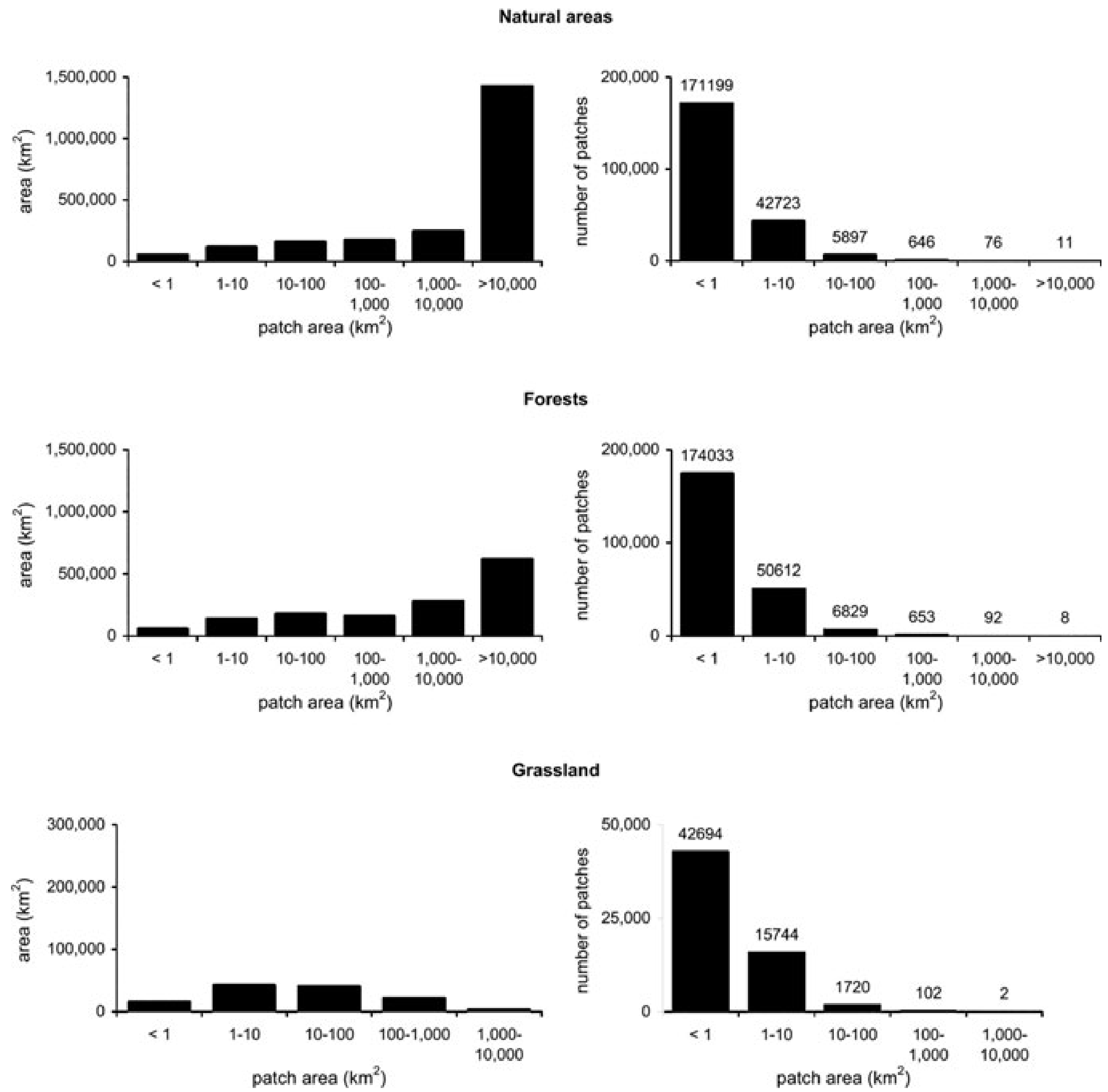

Figure 1. Fragmentation of natural areas and key habitats in Europe. Results cover all 27 countries of the European Union, plus Liechtenstein, Serbia, Croatia, Former Yugoslav Republic of Macedonia, Montenegro, Bosnia and Herzegovina, and Albania. The latest CORINE Land Cover 2000 map version was used for analyses (European Environment Agency 2007) at a resolution of 250 × 250 m. When identifying contiguous habitat patches, full cell neighborhood was considered (both orthogonal and diagonal neighbors). Natural areas refer only to terrestrial environments.

2004). Moreover, covariation between taxa in richness hotspots, overall species richness variation, and more importantly complementary sets of sites, tends often to be weak at the finer scales of primary importance (Prendergast *et al.* 1993; Prendergast & Eversham 1997; Williams & Gaston 1998; Virolainen *et al.* 2000; Kati *et al.* 2004).

A relative paucity of information on species occurrences is frequently mentioned in marine biodiversity assessments for conservation planning (Anon 2007). In particular, even existing information for algae and invertebrates is highly fragmented, although a number of databases and Web-based tools are being developed to integrate this

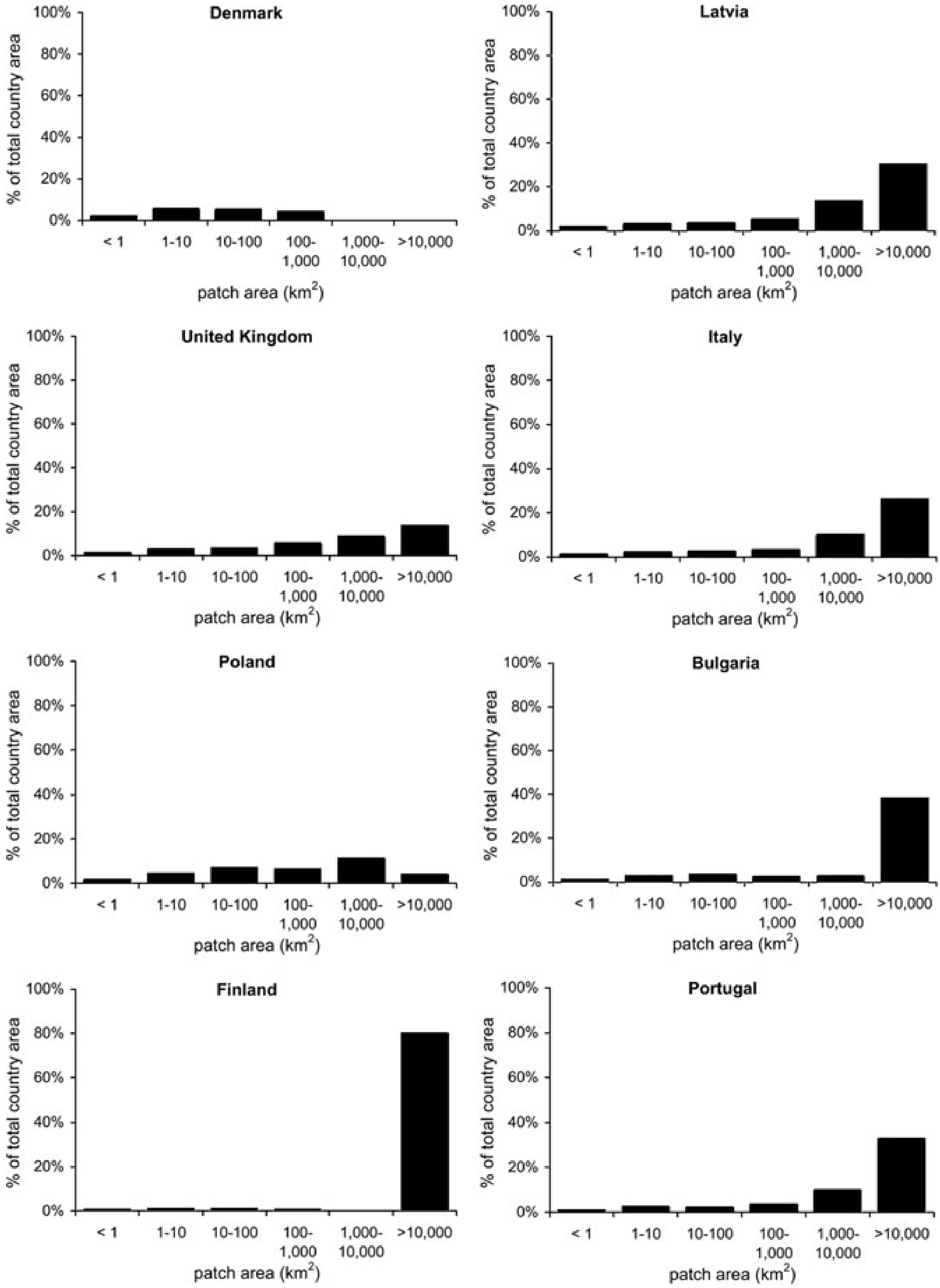

Figure 2. Fragmentation of natural areas for eight European countries, chosen to reflect the variation in patterns observed. Total area of patches within each size-category is expressed as a proportion of total country area, in order to control for differences in the latter when comparing results. See legend to Figure 1 for details.

information (e.g., European Ocean Biogeographic Information System [EurOBIS]; MarBEF 2006).

In consequence of the general lack of fine-scale species-occurrence data over large areas, effort has been invested in exploring the possibilities of downscaling coarse resolution data to such scales (Araújo *et al.* 2005) and of exploiting the large quantities of locality occurrence data that do exist to generate inductive models to predict the fine-scale occurrences of species over wider regions or to test the predictions of finescale occurrences made by deductive models (Corsi *et al.* 1999; Chefaoui *et al.* 2005; Maiorano *et al.* 2007). However, progress to date has been surprisingly limited, and there is a great need for: (i) concerted efforts to ensure that databases of existing locality records are as complete (in terms both of historical and contemporary records), well maintained, and available as possible; and (ii) robust models to be generated for the occurrences across Europe of species from a wide diversity of higher taxa. Mostwork to date has concerned modeling coarser-resolution occurrences of species with already reasonably well-documented distributions against which predictions can directly be tested, typically with a view to then exploring responses to climate change (e.g. Huntley *et al.* 1995, 2006; Sykes *et al.* 1996; Skov & Svenning 2004; Levinsky *et al.* 2007).

In addition to occurrence data, a growing number of monitoring schemes are providing information on the abundances of species at numerous sites across Europe, particularly for birds (Van Strien *et al.* 2001; Gregory *et al.* 2005). Methods are being developed for using these to interpolate abundances at intervening locations (Newson & Noble 2005; Godet *et al.* 2007), thus potentially also rendering them much more valuable for conservation planning exercises.

Identifying Conservation Goals

Systematic conservation planning requires the identification of explicit conservation goals for the representation and persistence of biodiversity. Particularly if these targets are quantitative, they enable the levels of conservation achievement from existing protected areas to be gauged and the best approaches to improving those levels to be formulated. In Europe, explicit quantitative goals for conservation planning have largely been missing, as is usually the case elsewhere (Tear *et al.* 2005).

The principal frameworks within which conservation goals should be formulated for Europe are the Convention on Biological Diversity and the EU Birds and Habitats Directives. The EU is a party to the Convention on Biological Diversity, as are virtually all the non-EU countries of Europe (Convention on Biological Diversity 2007a). Although it contains few directly enforceable provisions, the Convention states that as far as possible and appropriate parties shall “establish a system of protected areas or areas where special measures need to be taken to conserve biological diversity” (Convention on Biological Diversity 2007b). No explicit goals have been set as to what this system should achieve. There have been, much reiterated, worldwide recommendations that protected areas should cover 10% (IUCN 1993) or 12% (World Commission on Environment and Development 1987) of a country’s surface area. However, such targets foremost reflect political expediency, with much greater coverage often being necessary adequately to represent, let alone protect, biodiversity, and the required levels differing from one region to another (Soulé & Sanjayan 1998; Rodrigues & Gaston 2001). The proportional coverage required should emerge from rather than constrain the conservation requirements for biodiversity features (Svancara *et al.* 2005).

In addition to the original provisions of the Convention on Biological Diversity, in decision VI/26, “Parties committed themselves to a more effective and coherent implementation of the three objectives of the Convention [conservation of biological diversity; its sustainable use; equitable sharing of benefits from use of genetic resources], to achieve by 2010 a significant reduction of the current rate of biodiversity loss at the global, regional and national level as a contribution to poverty alleviation and to the benefit of all life on earth" (Convention on Biological Diversity 2001a). The provisional indicators identified to assess progress towards this target included trends in the extent of selected biomes, ecosystems, and habitats; trends in the abundance and distribution of selected species; change in the status of threatened species; and the coverage of protected areas (Convention on Biological Diversity 2001b). Again, no quantitative targets for the coverage of protected areas have been established, nor have any explicit targets been defined by which it could be determined whether protected area systems were adequate in extent and location.

The EU has adopted the yet more ambitious target of *halting* the loss of biodiversity by 2010 (European Union 2001). The EU has two key conservation measures: (i) Council Directive 79/409/EEC on the conservation of wild birds (the Birds Directive)—this directive lists bird species of conservation concern (endangered and vulnerable species, and migratory species), and Member States must designate as Special Protection Areas (SPAs) the most suitable territories in number and size to maintain these in their natural range; and (ii) Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora (the Habitats Directive)—this directive lists natural habitats and several hundred plant and animal species of conservation concern, and Member States must designate as Special Areas of Conservation (SAC) the most appropriate areas to maintain or, where appropriate, restore these to a favorable conservation status in their natural range. The SPAs designated under the Birds Directive and the SACs designated under the Habitats Directive form the Natura 2000 network, an attempt to provide a coherent EU-wide ecological network (Natura 2000 Networking Programme 2007). Without doubt, this has been the most significant initiative for nature conservation in the region.

Again, no formal quantitative targets are identified for the Birds and Habitats Directives. However, the former states that "Member States shall take the requisite measures to maintain the population of the species referred to in Article 1 at a level which corresponds in particular to ecological, scientific and cultural requirements, while taking account of economic and recreational requirements, or to adapt the population of these species to that level" (Article 2); "In the light of the requirements referred to in Article 2, Member States shall take the requisite measures to preserve, maintain or re-establish a sufficient diversity and area of habitats for all the species of birds referred to in Article 1" (part of Article 3); and, "Member States shall classify in particular the most suitable territories in number and size as special protection areas for the conservation of these species, taking into account their protection requirements in the geographical sea and land area where this Directive applies" (part of Article 4). Likewise, the Habitats Directive states regarding Natura 2000 that "This network, composed of sites hosting the natural habitat types listed in Annex I and habitats of the species listed in Annex II, shall enable the natural habitat types and the species' habitats concerned to be maintained or, where appropriate, restored at a favourable conservation status in their natural range"; and, "each Member State shall contribute to the creation of Natura 2000 in proportion to the representation within its territory of the natural habitat types and the habitat types referred to in paragraph 1 [previous clause given here]" (both parts of Article 3).

While the provisions of the Birds and Habitats Directives are implemented under national legislation, both those countries of the EU and of Europe more widely often have other legislation regarding the designation and management of protected areas. However, these also seem seldom to be associated with explicit quantitative conservation targets.

Reviewing Existing Protected Areas

Having established conservation goals, it is important to know how well they are being met

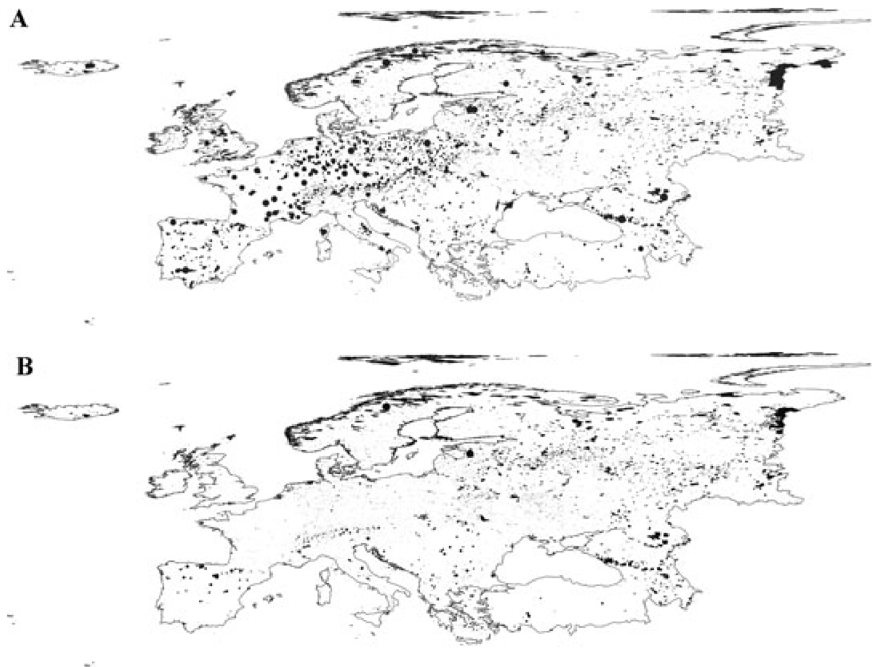

Figure 3. The occurrence of protected areas across Europe, for (**A**) all protected areas, and (**B**) protected areas in IUCN categories I to IV. Data from WDPA Consortium (2006). See footnote to Table 1 for analytical details.

by existing protected areas, and thus what are the shortfalls that have to be resolved through conservation planning. The first problem in so doing is the lack of a complete database of these areas. The World Database on Protected Areas (WDPA Consortium 2006) comprises the best single source available for statutory protected areas, but is undoubtedly incomplete even for Europe. Problems include that information is not readily publicly available for some parts of the region, that the status of some areas is unclear, that there are extremely large numbers of protected areas in the region, that these numbers are constantly changing, and that there are delays in incorporating available data. Taking the existing data at face value, the coverage and structure of protected area systems varies greatly among countries, from less than a hundredth to more than a quarter of land area for all protected areas listed, and from less than a hundredth to more than a tenth for those protected areas listed under IUCN categories I to IV and thus typically of conspicuously greater value for biodiversity conservation (Table 1; Fig. 3).

Of course, in addition to statutory protected areas, there are many others across Europe that have no legal status as such, but which may nonetheless in practice provide equivalent or even greater levels of protection. These may be owned or managed by nongovernmental organizations or by private individuals. Although some of these also have statutory designations, in the U.K., for example, the Royal Society for the Protection of Birds (RSPB) manages c. 200 protected areas covering c. 1300 km^2, the Woodland Trust manages c. 270 areas covering c. 95 km^2, and the Wildlife Trusts manage c. 2500 areas covering c. 800 km^2 (Gaston *et al.* 2006).

The High Seas are beyond the boundaries of the Habitats Directive, but still covered by the obligations of individual European states (for example, through the OSPAR Commission for the Protection of the Marine Environment of the North-east Atlantic, and

ACCOBAMS, The Agreement on the Conservation of Cetaceans in the Black Sea, Mediterranean Sea, and Contiguous Atlantic Area). There are legal issues in establishing marine protected areas outside Exclusive Economic-Zones, but some protection occurs through fishery closures for conservation purposes. The North East Atlantic Fisheries Commission has closed up to 42,700 km^2 of seabed to protect deep water corals and sea mounts.

A number of studies have sought to assess the performance of the protected area system (usually just the statutory component) across the whole, or more typically within parts, of Europe. Inevitably, given that formal quantitative conservation goals are lacking for the region, these are often based on comparison with more ad hoc proposals. Nonetheless, it has variously been shown that with regard to the representation of biodiversity:

(i) The extent of coverage of different environments and land cover types by protected area systems in particular regions of Europe varies markedly, with common biases being toward higher elevations and lands of low agricultural potential (Nilsson & Götmark 1992; Stokland 1997; Oldfield *et al.* 2004; García *et al.* 2005; Maiorano *et al.* 2007; Jackson & Gaston 2008a). It seems likely that the extent of these biases in different regions declines with the proportion of overall land area that is covered by protected areas, although this has not formally been demonstrated. A bias toward including large, contiguous areas of land of limited economic value in protected area systems has historically been particularly marked in parts of eastern Europe. Generally recognized as including some of the largest unspoiled natural areas of Europe (Witkowski *et al.* 2003), large protected areas in this part of the region are often restricted to places with very low human densities, while key habitats (particularly grasslands) are often left unprotected in lowlands of higher economic value (Nagy 2005).

(ii) Some, and under particular schemes a notable proportion of, priority areas for biodiversity conservation are not covered by protected areas (BirdLife International 2004b).

(iii) High proportions of overall species richness, and of species and populations of conservation concern, can occur in protected area systems, but at least some are almost invariably not, or only poorly, represented (Virkkala *et al.* 1994; Gómez-Campo 1997; Araújo 1999; Rodrigues *et al.* 1999; Hopkinson *et al.* 2000; Zurlini *et al.* 2002; Jackson *et al.* 2004; Maiorano *et al.* 2006, 2007; Martínez *et al.* 2006; Godet *et al.* 2007; Traba *et al.* 2007; Virkkala & Rajasarkkä 2007; Jackson & Gaston 2008b).

(iv) All or a high proportion of the populations of some species occur only within protected areas (Sólymos & Fehér 2005; Maiorano *et al.* 2006; Jackson & Gaston 2008b).

(v) Higher proportions of individuals of some species in marked decline occur within protected areas than occur outside them (Devictor *et al.* 2007).

(vi) Species richness is higher in areas with greater coverage by protected areas than expected on the basis of broad environmental trends (Jackson *et al.* unpublished analyses).

Likewise, with regard to issues of persistence, it has been shown that there are many ecoregions in Europe with high levels of habitat conversion and low levels of coverage by protected areas (Hoekstra *et al.* 2005) and that bird species populations are more likely to be increasing in regions with greater coverage by protected areas (Donald *et al.* 2007).

Undoubtedly, the results of some of these analyses are highly contingent both on the spatial extent and the spatial resolution at which they have been conducted. In particular, it is known that conservation goals may often best be met in different ways (e.g., by prioritizing different sets of areas) depending on whether one is designing a protected area system for a region as a whole (e.g., Europe) or separately for its component parts (e.g., individual countries; Erasmus *et al.* 1999; Rodrigues & Gaston 2002). The overall picture is, however, one of a patchy and ill-developed assessment of the effectiveness of protected area systems in Europe.

Selecting Additional Protected Areas

Having reviewed the attainment of conservation goals through existing protected areas, additional areas should be identified which, were they to be included in the protected area system, would reduce or ideally resolve the shortfalls. A range of formal tools exist for carrying out such analyses, all of which employ direct or indirect measures of the biodiversity value of sites across a land or seascape, but which may variously also incorporate more detailed considerations of, for example, persistence, connectivity, cost, and timing of implementation (Rodrigues *et al.* 2000; Meir *et al.* 2004; Moilanen *et al.* 2005; Williams *et al.* 2005; Nicholson *et al.* 2006; Sarkar *et al.* 2006; Wilson *et al.* 2006; Moilanen 2007).

A number of studies have been published aimed at identifying priority areas for the expansion of protected area systems in Europe (Sætersdal *et al.* 1993; Parga *et al.* 1996; Stokland 1997; Araújo 1999; Rodrigues *et al.* 1999; Siitonen *et al.* 2002; Borges *et al.* 2005; Sólymos & Fehér 2005; Richardson *et al.* 2006; Araújo *et al.* 2007; Traba *et al.* 2007). In the main, these have (i) been associated with developing and demonstrating various methodologies for so doing, (ii) often cautioned implicitly or explicitly against the direct implementation of their findings without the consideration of additional important factors, and (iii) tended to be for individual countries or subregions of Europe. In the main, these seem to have had little if any direct influence on the actual selection of protected areas within the region.

Undoubtedly, the Natura 2000 process has been the most important attempt actually to select additional protected areas across Europe. Indeed, it is arguably the most ambitious supranational initiative for nature conservation to have ever been undertaken (Weber & Christophersen 2002), and in some countries it has provided the first coherent framework for conservation planning at national levels. In order to fulfill the objectives of the Habitats Directive, each Member State of the EU proposes Sites of Community Interest (pSCIs), in accordance with the lists of habitats and species of concern in the Directive. Following consultation and revision, these sets of sites are subject to the approval of the European Commission. The Commission then adopts them as Sites of Community Importance (SCIs). Finally, Member States must implement these sites by designating them as SACs and introducing measures to ensure their favorable conservation state. In order to fulfill the objectives of the Birds Directive, Member States also nominate a set of sites to be designated as SPAs, and which come into force immediately that this listing is sent to the Commission.

Under the Habitats Directive, broad criteria were specified for the selection of pSCIs by Member States (Annex III). These involve a two-step process: first of assessment at national level of the relative importance of sites for each natural habitat type (based on representativity, area, degree of conservation of structure and function, and value for conservation of habitat type) and species (based on size and density of population, degree of conservation of features of habitat important for species, degree of isolation of population, and value for conservation of species) in the associated Annexes, and second of assessment of the community importance of the sites included on the national lists. The particular methodologies employed for the listing of sites as pSCIs and SPAs are, however, left to individual Member States to determine and have varied substantially between them (e.g., Alphandéry & Fortier 2001; Stroud *et al.* 2001; McLeod *et al.* 2005). In common with the tenor of the Directives, selection has almost invariably focused on the properties of individual sites, with little or no emphasis on issues of, for example, complementarity between sites. It has also predominantly been based on expert opinion (albeit often informed by available data) rather than formal analytical tools. Two official committees, the Ornis Commission (Birds Directive) and the Habitats Committee (Habitats Directive), bring together the administrative and scientific representatives of the Member States to develop and agree procedures for implementation of the two Directives including protected area selection. In the case of SPAs, the criteria of the Ramsar Convention are *de facto* used by many states in site selection.

The adequacy of the lists submitted to the Commission in representing habitat types and species, and whether additions are required, has also been assessed based on expert opinion rather than against formal targets, with mechanisms to ensure consultation with the Member States concerned (DG XI.D.2 1998a). The European Court of Justice has, however, ruled that in the absence of other adequate procedures used by a Member State, the set of sites that have been listed as Important Bird Areas (IBAs) in Europe (Heath *et al.* 2000) may be used by the Commission as a bench mark for assessing whether it has classified as SPAs all of the sites which are of importance under the Birds Directive (DG XI.D.2 1998b). Simplifying greatly, the criteria used for identifying IBAs center on whether they support significant populations of one or more given bird species.

The general lack of quantifiable targets has been recognized as making it difficult to answer the question of how close the Natura 2000 network is to being complete (DG ENV 2004).

In a tangible demonstration of how conservation planning is not a simple sequential process but has many feedbacks between steps (see Introduction), the tasks of setting objectives and of selecting and implementing additional protected areas have had repeatedly to be revisited as the Member States of the EU have grown in number, and particularly as the EU has expanded eastwards.

Implementing Conservation Actions

Having identified priority areas for expansion of existing protected area systems, this expansion needs to take place. In contrast to the great attention that has been paid to methods for identifying these priority areas, the conservation biology literature has paid rather little to how best to implement conservation actions (Knight *et al.* 2006). This may be because the implementation phase is more concerned with the details of local and regional legislation, planning, and negotiations and other societal processes that lie more firmly in the domain of social sciences. Nonetheless, the success of the implementation phase is vital, and any tendencies towards disconnection between prioritization and implementation could usefully be reduced.

The implementation of the Natura 2000 network would provide a valuable case study of some of the issues that arise. It has taken place at a much slower pace than originally envisaged. In part this has been because, at least in some areas, features of the site listing, identification, and designation process have proven highly contentious with local people (Alphandéry & Fortier 2001; Hiedenpää 2005; Rosa & da Silva 2005). Much of this contention seems to have resulted from public misconceptions about the nature of the network and the constraints that it might impose on other activities that had been, were or might be conducted on proposed sites (e.g., agriculture, hunting, recreation; DG XI.D.2 1998c). This has highlighted the central tension in implementation between the biodiversity values of sites and the sometimes competing interests for their use.

The consultation process for pSCIs has often led to Member States being forced to nominate more sites, and some have been taken to the European Court of Justice to force them to protect more SPAs (European Commission

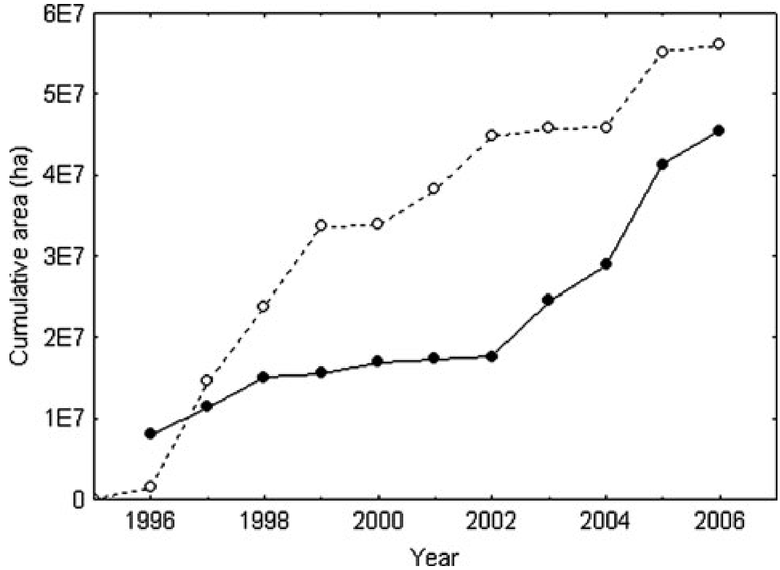

Figure 4. Cumulative growth in the area of the EU covered by SPAs designated under the Birds Directive (closed circles), and SCIs designated under the Habitats Directive (open circles), across Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, and United Kingdom (data from http://dataservice.eea.europa.eu/atlas/viewdata/viewpub.asp?id=2638; http://dataservice.eea.europa.eu/atlas/viewdata/viewpub.asp?id=2639).

2006). Moreover, the designation of SPAs remains incomplete, and many SCIs remain just that, as they have yet to be formally implemented as SACs. Nonetheless, as of December 2006, across the EU some 4617 sites covering 454,723 km^2 have been designated as terrestrial SPAs (c. 10% of the region) and 484 sites covering 65,111 km^2 as marine SPAs. Some 20,862 sites covering 560,445 km^2 have been designated as terrestrial SCIs (c. 12% of the region) and 1248 sites covering 77,807 km^2 as marine SCIs (note, numerous sites have been designated in part or whole under both directives; DG ENV 2007). This is a notable achievement (FIG. 4).

The number and coverage of Natura 2000 sites varies greatly among the different Member States (Table 1). But more significantly, the impact of the process on overall protected area coverage has also been highly variable, depending in part on how well pre-existing protected area systems were developed and thus the extent to which key sites were already designated for conservation. In those regions in which pre-existing systems were relatively poor, some of the expansions have been substantial, in some cases increasing coverage by an order of magnitude (e.g., Papageorgiou & Vogiatzakis 2006). In consequence, it has also resulted, or will do so, in better representation of important biodiversity features within national protected area systems (Bessa-Gomes & Petrucci-Fonseca 2003; Chefaoui *et al.* 2005). In some regions, notably parts of eastern Europe, marked expansions of national protected area systems have, however, occurred against a background of rather poor biological data. As these data improve, there will be a need for continued review of the achievements of such systems, and further to develop them accordingly.

Under the principle of subsidiarity, Member States of the EU have been given a broad choice in the mechanisms that they could use to implement conservation measures on SACs, which may variously include statutory designation of a nature reserve, making finances available to carry out conservation measures, and agreeing management measures with a land owner. The focus is on measures for the conservation of those species and habitats which justified the listing of the site, with the aim of maintaining or restoring the favorable conservation status of those features. This is particularly important because, rather than being foremost a matter of wildlands, conservation in much of Europe is based on the continuation of traditional land-management practices, such as grazing, hay making, burning, coppicing, and hunting.

Maintaining the Values of Protected Areas

Protected area systems need not only to fulfill conservation targets at the time those are assessed, but, however recently they have been established, they need to continue to maintain their biodiversity values into the future. For example, Member States of the EU must avoid habitat deterioration and significant species disturbance within SPAs and SACs, and rulings have been made against them in the European Court of Justice when they have failed to do so (European Commission 2006). A first step in ensuring the maintenance of biodiversity values is usually the formulation of a management plan, which sets out the goals for an individual protected area and how these can be realized. It is unclear what proportion of protected areas in Europe have such a plan. The second step is usually a requirement for some kind of monitoring in order to determine how well the goals are being realized. Such monitoring does not occur on the majority of protected areas in Europe (although regular reporting is expected on the conservation status of features for which individual Natura 2000 sites have been designated).

Protected areas in Europe face some key challenges in maintaining their biodiversity values into the future:

(i) Size—The vast majority of protected areas (and indeed, natural or seminatural habitat patches) in Europe are extremely small (e.g., Wallis de Vries 1995; Smith & Gillett 2000; Maiorano *et al.* 2007). For example, the majority of forest areas included in Natura 2000 are less than 100 ha, and many are less than 10 ha (DG ENV 2003). Likewise, the median size of marine Natura 2000 sites in the Atlantic region is less than 1000 ha (Johnson *et al.* 2008). Most importantly, this means that protected areas will be unable to support a full regional complement of species (including the larger-bodied) and maintain landscape- and seascape-scale ecological processes. For example, for many species such terrestrial sites, in isolation, are unable to realize let alone maintain the population sizes of at least a few thousand individuals considered necessary for long-term viability (Reed *et al.* 2003; Traill *et al.* 2007).

(ii) Extinction debt—Many, and perhaps most, protected areas carry extinction debts that have yet to be paid. That is, species occur within boundaries which, even in the absence of additional pressures, do not have viable populations. Understanding of the magnitude of these debts within European protected areas remains limited, although it has been suggested that they may be substantial (Berglund & Jonsson 2005; Báldi & Vörös 2006).

(iii) Climate change—Predictive modeling suggests that the distributions of many species in Europe will be influenced by climate change, with the effects varying greatly between species, from global or regional extinction to very marked range expansions and shifts (Huntley *et al.* 1995, 2006; Sykes *et al.* 1996; Skov & Svenning 2004; Thuiller *et al.* 2005; Araújo *et al.* 2006; Harrison *et al.* 2006; Levinsky *et al.* 2007). For example, for the Hadley Centre's General Circulation HadCM3 model, the potential distributions of 426 European breeding bird species in

2070–2099 have been estimated on average to be 81% of their distributions simulated on the basis of current climate, which combined with spatial displacement means that the overlap between these potential future and current distributions is on average only 40% of the latter (Huntley *et al.* 2006). The consequences of such changes for protected areas, and the role that protected areas will play in the responses, are likely to be profound (Dockerty *et al.* 2003; Hannah *et al.* 2007). The extremely small size of most protected areas in Europe and the associated narrow elevational spans mean that there will be limited opportunities for distributions simply to move within protected areas. The assemblages and species presently occurring in protected areas in the region will in many, and perhaps most, cases thus no longer be able to persist. On the one hand, the large numbers of protected areas in at least some parts of Europe may assist the geographic movement of those species that have at least moderate dispersal abilities. On the other, their small size means that such movements will need frequently to be successful.

(iv) Ecological coherence—With continued landscape fragmentation considered to be one of the major pressures facing biodiversity in Europe (European Environment Agency 1999a), protected areas are likely to become increasingly isolated from patches of similar habitat. Thus, a major challenge is the need to enhance the ecological coherence of the protected area system in Europe through the development particularly of habitat networks and linkages across the region that serve both to increase the net coverage of natural and seminatural habitats and better to connect those habitat patches (including protected areas) that already exist. Much will rest on the extent to which there is substantial realization of such notions of green veining, for which many approaches and initiatives have been proposed (Bani *et al.* 2002; Bruinderink *et al.* 2003; Opdam *et al.* 2003; Grashof-Bokdam & van Langevelde 2004; Jongman *et al.* 2004; Tillmann 2005; Donald & Evans 2006; von Haaren & Reich 2006).

(v) Management—Large-scale conservation frameworks, such as Natura 2000, have greatly accelerated information exchange between nations in Europe. However, the sharing of practices and policies at local levels, which is critical for the effective management of individual protected areas, has remained limited. Indeed, the diversity in structure of national protected area systems is only surpassed by the diversity in practices in managing those areas. The need to establish and maintain administrative structures capable of safeguarding the biodiversity value of protected areas is particularly significant in parts of eastern Europe. Here, a very marked expansion of protected area systems is being accompanied by rapid economic growth and substantial socioeconomic change (e.g., land ownership, infrastructure), presenting a mixture of opportunities and risks. For many countries in the region, protected areas designated in the past decades have been assigned management categories typical of areas of low economic value. This is more and more difficult to sustain, as the human pressure on natural habitats increases and there is a growing emphasis on expanding the representativeness of protected areas by including critical sites for conservation from highly populated areas of significant economic value. The lack of experience often common at local levels in dealing with this new challenge of satisfactorily attaining both conservation and economic goals, could be addressed more easily if practices and experiences at all levels, from policy makers to park managers, were more effectively shared and an international framework for managing protected areas is continuously developed.

Conclusion

Given the extent and heterogeneity of the region, this has inevitably been a rather broad-brush review of progress in the application of a systematic approach to conservation planning across Europe. Nonetheless, some key issues emerge:

(i) Although the Natura 2000 program did not really exploit the benefits that a systematic conservation planning approach could have brought, it has demonstrated that opportunities exist for the application of such an approach on large geographic scales and for substantial growth of protected areas systems, even within such heavily developed regions as Europe.

(ii) The availability of data on biodiversity remains a significant constraint on systematic conservation planning in Europe, despite a greater wealth here than anywhere else in the world of schemes documenting the occurrence and monitoring the abundances of species. There is a particularly pressing need for better and more accessible data bases on the local occurrences of species across the region, and for the development of models that use these data accurately to predict region-wide distributions.

(iii) There has been a continued mismatch in Europe between the analytical tools developed for the purposes of systematic conservation planning and the methods actually applied for determining priorities for conservation. A purposeful closing of this gap would serve biodiversity well, but requires consideration both of the goals of conservation planning and the most appropriate tools for achieving these goals.

(iv) There has been a general failure to determine explicit quantitative targets for conservation across Europe, making it difficult to know how adequate existing protected area systems are, how they need further to be developed, and how well they will perform in the future.

(v) Despite recognition of the great benefits to be gained from a Europe-wide approach to conservation planning and implementation, the conservation biology literature remains lacking in studies at this scale, beyond those concerned with issues of climate change. Arguably, the principal difficulties would be the socio-economic and political implications of implementing a unified approach across such a geopolitically complex area.

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Conflicts of Interest

The authors declare no conflicts of interest.

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