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Biodiversity trends in Europe: development and testing of a species trend indicator for evaluating progress towards the 2010 target

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This paper presents a trial of a species population trend indicator for evaluating progress towards the 2010 biodiversity target in Europe, using existing data. The indicator integrates trends on different species (groups), and can be aggregated across habitats and countries. Thus, the indicator can deliver both headline messages for high-level decision-making and detailed information for in-depth analysis, using data from different sources, collected with different methods.

International non-governmental organizations mobilized data on over 2800 historical trends in national populations of birds, butterflies and mammals, for a total of 273 species. These were combined by habitat and biogeographical region to generate a pilot pan-European scale indicator. The trial indicator suggests a decline of species populations in nearly all habitats, the largest being in farmland, where species populations declined by an average of 23% between 1970 and 2000.

The indicator is potentially useful for monitoring progress towards 2010 biodiversity targets, but constraints include: the limited sensitivity of the historical data, which leads to conservative estimates of species decline; a potential danger of ambiguity because increases in opportunistic species can mask the loss of other species; and failure to account for pre-1970 population declines. We recommend mobilizing additional existing data, particularly for plants and fishes, and elaborating further the criteria for compiling representative sets of species. For a frequent, reliable update of the indicator, sound, sensitive and harmonized biodiversity monitoring programmes are needed in all pan-European countries.

Keywords: biodiversity indicator; monitoring; species trends; 2010 target; Europe

1. INTRODUCTION

In response to global concern over the rapid loss of the world's biodiversity, the sixth Conference of the Parties of the Convention on Biological Diversity (CBD) adopted a global target to reduce the rate of biodiversity loss by 2010 (CBD 2002). This target, which was later endorsed by the World Summit on Sustainable Development (United Nations 2002), has also been adopted by a number of regional scale policies and processes. The European Union Sustainable Development Strategy (EC 2001*a*) and various other European Union policies (EC 1998, 2001*b*,*c*) set similar or even more ambitious biodiversity goals. The pan-European Ministerial 'Environment for Europe' process adopted a resolution on halting the loss of biodiversity by 2010 (UN/ECE 2003).

This widespread adoption of targets for reducing the rate of biodiversity loss has highlighted a need for indicators that will allow policy-makers to track progress towards these ambitious goals. Recognizing this need, the Conference of the Parties of the CBD identified a series of biodiversity indicators for immediate testing (UNEP 2004). Such indicators are needed at national, regional and global levels. In June 2004 the Environment Council of the EU adopted a set of 15 headline indicators for biodiversity to evaluate progress towards the 2010 target (Council of the European Union 2004). This set was recommended by the EU Biodiversity Expert Group and its *ad hoc* Working Group on Indicators, Monitoring and Assessment, at the Malahide stakeholder conference (Anon. 2004).

Both the CBD decision and the European documents recommend, among other indicators for immediate testing, indicators of trends in abundance and distribution of selected species. Species trend indicators are considered a sensitive measure of biodiversity change (Balmford *et al.* 2003; ten Brink *et al.* 1991; ten Brink 2000), and one such approach, composite species trend indicators, has been increasingly widely applied. In addition to the global-scale Living Planet Index (Loh 2002, 2005) there are several instances of the successful implementation of such indicators, principally at national scales (Jenkins *et al.* 2004). The UK Headline indicator of wild bird populations (Gregory *et al.* 2003*a*) is one example. The European Bird Census Council (EBCC) has used a similar approach to develop the pan-European

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common bird index for farmland and forest birds (Gregory *et al.* 2003*b*, 2004).

To address the need for regional scale biodiversity indicators in (pan-) Europe, this study set out to identify suitable data and build upon existing methods to develop an appropriate indicator of trends in species abundance and distribution for use at the pan-European scale (the whole of Europe west of the Ural mountains and including the Anatolian part of Turkey; i.e. the European Union plus 18 other European countries). The target audience for the indicator is policy-makers on the pan-European and national levels, who will use the indicator to support high-level decision-making on the environment and biodiversity-related sectoral activities. The indicator should also be suitable for informing the general public on biodiversity trends. It should match the set of requirements as listed in the CBD general guidelines and principles for developing national-level biodiversity monitoring programmes and indicators (UNEP 2003*a*). These principles require that an indicator be, among other characteristics: policy and biodiversity relevant, scientifically sound, broadly accepted, affordable to produce and update, sensitive, representative, flexible and amenable to aggregation.

In this paper, we present a proposed method for calculating such a composite indicator to evaluate progress towards the 2010 target for terrestrial biodiversity in Europe, an evaluation of the existing data available for the purpose and our experience of mobilizing them, and the results of a trial application of the proposed method to some of the available data. We also offer recommendations as to how the data and the methodology can be improved based upon this pilot experience.

2. METHODS

The challenges in developing an indicator on the trends in abundance and distribution of selected species lie in finding appropriate data, and in identifying how best to select the component trends and how to combine them in a way that is representative of the system and trends of interest. These require choices on the classification of the study area, selection of the species and the procedure for calculation and aggregation.

(a) *Geographical scope and classification of the study area*

This study focused on the whole of Europe west of the Urals, including the Anatolian part of Turkey. The area was categorized (table 1) by combining the 11 pan-European biogeographical regions (Roekaerts 2002) with the 10 top-level habitat types from the EUNIS habitat classification adopted by the European Environment Agency (Davies & Moss 2002). The EUNIS classes 'Grassland and tall forb habitats' and 'Regularly or recently cultivated agricultural, horticultural and domestic habitats' have been merged into a single class, called 'Farmland'. By combining the biogeographical regions and the major habitat types we aimed to cover the main variation in Europe's biodiversity. We have termed the combination of a habitat type and a biogeographical region an *ecoregion*.

Table 1. The approximate areas (in thousands of square kilometres) of the pan-European ecoregions defined for this study by combining biogeographical regions with EUNIS habitat types. Those ecoregions selected for the pilot study are in italics. Note that the EUNIS classes 'grasslands' and 'cultivated habitats' have been merged into a new category: 'farmland'. The approximate area of each ecoregion was calculated from GIS overlays of biogeographical regions (Roekarts 2002) with habitat maps derived from the CORINE land-cover map (ETC/TE 2000) and the Global Landcover 2000 map (Batholome *et al.* 2002). Parts of Russia, Ukraine and Turkey were not included in these statistics.

	Biogeographical region											
EUNIS habitat type	Alpine	Anatolian	Arctic	Atlantic	Black Sea	Boreal	Continental	Macaronesian	Mediterranean	Pannonian	Steppic	total
marine habitats	?	?	?	?	?	?	?	?	?	?	?	?
coastal habitats	<1	?	<1	2	<1	<1	1	<1	2	<1	<1	6
inland surface water habitats	15	?	3	8	<1	61	17	<1	6	2	3	116
mire, bog and fen habitats	26	?	6	*18*	1	23	4	<1	2	1	2	83
heathland, scrub and tundra habitats	21	?	*13*	*53*	<1	1	16	2	*136*	2	2	246
woodland and forest habitat and other wooded land	*336*	?	10	*133*	9	*669*	*534*	1	*299*	27	11	2,028
inland unvegetated or sparsely vegetated habitats	*107*	?	*62*	13	<1	2	13	1	9	<1	16	222
constructed, industrial and other artificial habitats	6	?	<1	41	<1	8	66	<1	15	8	3	148
farmland	*146*	?	30	*539*	8	*177*	*1198*	2	*581*	*121*	*101*	*2909*

Table 2. The seven large non-governmental organizations (NGOs) used as the principal data providers for this study and their focal taxonomic groups.

species group	NGO	website
birds	BirdLife International	http://www.birdlife.net/
	European Bird Census Council	http://www.ebbc.info
	Wetlands International	http://www.wetlands.org/default.htm
butterflies	Butterfly Conservation Europe	http://www.vlinderstichting.nl/
mammals	Large Carnivore Initiative Europe	http://www.lcie.org/
	Large Herbivore Foundation	http://www.largeherbivore.org/
plants	Planta Europa	http://www.plantaeuropa.org/html/about_pe.htm

In this pilot study we have focused on the 22 ecoregions shaded in table 1, which were selected based on an *a priori* estimation of the availability of relevant data, their size and their perceived importance for biodiversity.

(b) *Locating, mobilizing and compiling data*

The various studies that have investigated ongoing biodiversity monitoring in Europe have concluded that the many monitoring activities existing at international, national and local scales are patchy and scattered among places and organizations, and there is little coordination among them (Delbaere & Nieto in preparation; ETC/NPB 2003; Fischer 2002). Moreover, with some exceptions, most of the monitoring programmes have been running for only a limited number of years. Compiling a European database of long-term trends is therefore a significant challenge.

Much of the coordination that does exist is provided by species-oriented non-governmental organizations (NGOs), which mostly have wildlife conservation as their main objective. To help direct their conservation activities, these NGOs rely on networks of experts and organizations from (nearly) all pan-European countries, which are involved to varying degrees in monitoring and surveying programmes. The NGOs help to coordinate monitoring activities and to bring together the resulting data. In many countries the NGOs have access to information that cannot easily be obtained from more formal focal points, for example the CBD or the European Evironment Agency (EEA). This is because the information has often not been collected in the framework of a formal governmental biodiversity monitoring programme. Thus these NGOs are European nodes that, with their networks, can provide a unique overview of, and access to, large amounts of data on status and trends in their focal species groups.

For this study, seven of the largest and best established NGOs involved in species trend data collection throughout Europe were identified as the most promising providers of species trend data (table 2). These NGOs work with a broad range of partners (local NGOs, research institutes and universities, herbaria and botanical gardens, hunters' organizations, forestry organizations, etc.) and accordingly draw on data collected in many different contexts (conservation, research, game management, policy support, public information, etc.).

The NGOs made available a number of major data sources (table 3; Burfield *et al.* 2004; Van Swaay 2004; Van de Vlasakker Eisenga 2004; LCIE 2004), including both existing European databases, where data from many sources in many countries had already been brought together, and data that were still held by the original researchers and brought together for this project. For breeding birds and butterflies in pan-Europe, population trend data were available for *all* species and *all* countries. For mammals, data availability was best for five species of large carnivores and seven species of large herbivores in most of the relevant countries. However, for mammals, in quite a few countries, the data are available for only one point in time and no trends can be calculated. For all three species groups, data were mobilized for as many species as possible, with the exception of invasive species and species with highly fluctuating populations that would hide long-term trends. The principal source of bird data, the European Bird Database, has its own definition for this category, and the NGOs and experts applied similar filters for the other taxonomic groups. In the context of this (pilot) project, it was not feasible to collect data on plants and wintering water birds.

The original data were obtained by a wide variety of methods, including:

- standardized monitoring schemes with fixed sampling sites;
- estimates of total population size, either by direct observation or indirectly, for example inferred from the total number of animals shot;
- counts of number of populations or meta-populations;
- repeated distribution atlases (especially for butterflies) which were used to obtain a proxy of population decline (see also Thomas *et al.* 2004);
- expert judgement.

Therefore, the original data were expressed in different units and were associated with varying degrees of uncertainty.

The two largest data sources for butterfly and bird counts, as well as the earliest mammal counts, date back to the 1970s. Very few data are available for the 1980s, while data collection became far more common practice in the 1990s. Trends are therefore often given for a larger time-interval of two or three decades, that is without intermediate years.

To address this variability, all data were re-expressed as the proportional change between a pragmatic baseline, the year 1970, and an approximation of the present, around the year 2000. In most cases the data were provided in classes (e.g. 30–50% decline), or indicated as 'greater than' or 'less than' (e.g. greater than 50% increase). In these cases the index was assigned respectively as the middle of the class (e.g. 40% decline) or the specified boundary value (e.g. 50%). The value 1 was added to all indices to avoid calculation problems generated by zero values when taking logarithms.

The NGOs also supplied an indication of the data quality for each of the time-series according to a standard set of categories developed for this project and provided aut-ecological information for each of the species.

Ideally the data on species trends would be collected at the level of ecoregions within countries, but nearly all the data

Table 3. The principal data sources used by the NGOs to provide time-series data for this study.
(Data derived from these sources were standardized as indices of population change between 1970 and 2000.)

group	data source(s)	number of species	lowest spatial resolution	coverage	time-interval for which trends are available	reference
birds	European bird database I and II (EBD), incorporating data from the pan-European common bird monitoring scheme	515	country	all pan-European countries	1970–1990, 1990–2000	BirdLife International/ European Birds Census Council (2000), BirdLife International (in prep.)
butterflies	Red Data book of European butterflies (and underlying database)	576	country	all pan-European countries	1970–2000	Van Swaay & Warren (1999)
	national and regional atlases	many	country or region within country	many pan-European countries	varies by country	Van Swaay (2004)
	national monitoring schemes	many	country or region within country	Finland, The Netherlands, Spain, UK, Ukraine	varies by country; from a few years to since 1976 (UK)	Van Swaay (2004)
mammals, large carnivores	species action plans and many data sources residing with individual researchers and institutes	5	country	all pan-European countries	varies by species and by country; between 1960–1970	LCIE (2004)
mammals, large herbivores	many data sources residing with individual researchers and institutes	7	country	all pan-European countries	varies by species and by country; between 1960–1970	Van de Vlasakker Eisenga (2004)

Table 4. The total number of unique species and total number of time-series obtained.

species group	number of species	number of time-series
butterflies	119	1359
birds	142	1389
mammals	12	62
total	273	2810

provided by the NGOs were available only at the level of countries (table 3). Therefore, for each ecoregional index we included the national trends of those species using the focal habitat within the biogeographical region (the ecoregion) as their primary habitat. This approach is similar to that used for the European indicators of farmland and woodland birds (Gregory *et al.* 2003*b*; 2005). For *breeding birds* the link between species and ecosystems was made through the use of existing databases on the habitat preferences of the species, in combination with expert judgement from the international NGO (Burfield *et al.* 2004). For *butterflies* the link between species and habitats was made through the judgement of national experts and the international NGO (Van Swaay 2004). For those bird and butterfly species considered to be specific for a certain habitat, but occurring in more than one biogeographical region in a country, the same national trend was assigned to all biogeographical regions. For *mammals*, the link between the species and the habitats was based on the information provided by the NGOs (LCIE 2004; Van de Vlasakker Eisenga 2004) and additional expert judgement. The mammal species were assigned to the habitats and biogeographical regions where the majority of the populations occur.

(c) *Calculation and aggregation*

For each ecoregion, species population trend data are incorporated for each country. The combination of an ecoregion and a country is termed a *building block* and is the lowest level for the data of this indicator. For each of the building blocks the indicator is calculated as the geometric mean of the trends (indices) of the selected species. Species from all species groups are taken together; every species has equal weight. The results can then be aggregated on an area-weighted basis. Thus, for a given ecoregion, the index is the average of each of the building block indices in the ecoregion, weighted by the area of the building block. For example:

Atlantic Forest (AF) ecoregion index

$$= \{\sum[(\text{AF index Ireland})(\text{area AF in Ireland})] + [(\text{AF index UK})(\text{area AF in UK})] + \ldots\}/\text{Total area of AF}.$$

The resulting ecoregional indices can then be similarly aggregated towards the habitats. Thus, a European Forest

Table 5. The number of (unique) species incorporated into the pilot indicator per ecoregion. Only those habitat types and biogeographical regions addressed in the pilot indicator are included.

	Biogeographical region									
EUNIS habitat type	Alpine	Arctic	Atlantic	Black Sea	Boreal	Continental	Macaronesian	Mediterranean	Pannonian	Steppic
coastal habitats			27					16		
inland surface water habitats			20			21				
mire, bog and fen habitats			6							
heathland, scrub and tundra habitats		12	17					17		
woodland and forest habitat and other wooded land	31		23		36	35		23		
inland unvegetated or sparsely vegetated habitats	15	3								
farmland	27		36		14	37		38	20	5

species trend indicator would be obtained by averaging all of the forest ecoregion indices on an area-weighted basis.

The data on area of the building blocks were obtained from GIS overlays of countries with biogeographical regions (Roekaerts 2002; downloaded from EEA website) and habitats. Habitat maps were derived from the CORINE land-cover map (ETC/TE 2000) or from the Global Land Cover 2000 map (Bartholome *et al*. 2002) for those countries not included in the CORINE assessment. For remap tables see De Heer *et al.* (2005).

Finally, the results can be aggregated towards an index for Europe as a whole, by aggregating across the habitats. All habitats are given equal weight, using a non-weighted averaging of the values per habitat. The results can also be aggregated by individual countries or clusters of countries.

3. RESULTS

(a) *Evaluation of the available data*

In total the NGOs mobilized data on 2810 time-series for 273 unique species, which are mostly birds and butterflies, but also include some large mammals (table 4). The number of species per ecoregion ranged from six in Atlantic mires, bogs and fens to 38 for Mediterranean farmland (table 5), with an average of 22 species per ecoregion. The data come from 43 countries, with an average of around five ecoregions per country (see Electronic Appendix).

Generally the data are well distributed across the habitats, biogeographical regions and countries. Countries with a large area of a given ecoregion usually have a fairly large number of time-series for that ecoregion. There are more than 50 time-series available for most habitats, with the exception of the EUNIS class 'Mires, bogs and fens' for which only 8 time-series are available. Over 900 time-series were available for farmland. Over 100 time-series were available for all but three biogeographical regions, the Steppic, Arctic and Pannonian. Only very few data could be obtained for Bosnia and Herzegovina, Yugoslavia (Serbia and Montenegro) and some of the very small countries.

The autecological information provided by the NGOs showed that the species set, both as a whole and for most ecoregions, includes representatives of most guilds (herbivores, carnivores, piscivores, insectivores, omnivores), species with a wide range of dispersal distances and area requirements, and migratory as well as sedentary species. Both rare and common species, and both threatened and non-threatened species were included in the data for all countries, and some endemic species were included for all ecoregions. The NGOs' assessments of the causes of change indicate that the dataset includes species with different sensitivities to all major human pressures as well as species that seem not to be very sensitive to human activities.

The categorization of data quality provided by the NGOs (table 6) shows that the majority were based on limited quantitative data with some corrections and interpretation by experts. Especially for butterflies, these include measures of change in distribution, which are often relatively conservative measures of overall change. A minority of the time-series were based on complete quantitative data.

(b) *A first trial of the indicator*

The data described above were the basis for the first trial of the indicator. From the total of 2810 time-series, we excluded the 513 time-series with class c quality (limited quantitative data, no corrections and interpretations applied). These were mainly butterfly data, derived from repeated atlases but without corrections for changes in recording intensity, and therefore potentially misleading. Most of the remaining 2297 time-series showed either stable or decreasing populations within a building block (figure 1), while a minority (19%) represented increasing populations.

Table 6. The quality of the data included in the pilot indicator, shown as the number of time-series belonging to each data quality category for each taxonomic group.

category	description	frequency				
		birds	butterflies	mammals: carnivores	mammals: herbivores	overall
a	complete quantitative data	163	25		7	11
b	limited quantitative data, some corrections and interpretations applied	810	207	1	13	1018
c	limited quantitative data, no corrections and interpretations applied	11	504	9		513
d	extensive expert judgement	412	1	6	3	422
e	limited expert judgement		36	9		45
f	red data book for butterflies (no quality indication obtained)		586			586
g	unknown	4		9	5	20
	total number of time-series	1389	1359	34	28	2810

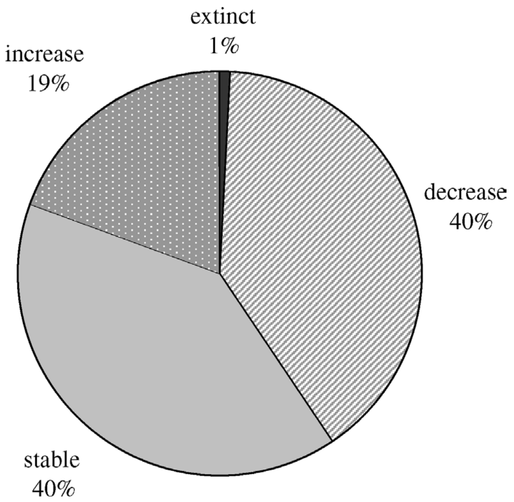

Figure 1. Distribution of the direction of change among the 2297 time-series obtained. Those classed as stable showed no net change in population between 1970 and 2000 (0 was the midpoint of the range of possible change). Those classed as decreasing or increasing had non-zero change, and a few time-series showed the species becoming extinct within the building block.

About 1% of the time-series showed local extinction of the species within a building block.

A further 60 time-series were excluded because they related to building blocks of unknown area (small and fragmented habitats not detected by the land-cover maps). Last, European Russia (72 time-series) was excluded, to avoid the indicator being dominated by one single country. Thus, 2165 time-series were used for this first analysis.

When calculated for each major habitat type at pan-European scale, the indicator shows that populations declined in nearly all habitats between 1970 and 2000. Farmland showed the largest decrease in population index, 23%; all of the natural habitats had much smaller calculated changes (figure 2). The population index for natural habitats collectively showed a decline of only 2%, which contrasts strongly with the index for farmland (figure 3).

Given the strong decline in farmland species at pan-European scale, it is of interest to examine the indicator in a form that may be more directly policy-relevant, for example, in relation to the European Union's Common Agricultural Policy. Figure 4 shows that farmland species have experienced much greater population declines over the past three decades in the 15 member countries of the EU than in the 10 recently (May 2004) acceded countries or in the remaining 18 countries in Europe. The indicator can potentially be calculated for other policy-relevant clusters of countries.

This application shows one way in which the indicator can have strong policy relevance. However, in order for it to be useful in evaluating progress towards policy targets relating to rates of biodiversity loss (e.g. the 2010 target) it would be necessary to calculate average index changes over different time-intervals. At a minimum, three points in time would be needed to determine whether the rates of loss of biodiversity were changing as needed. Within the scope of this project, birds were the only group for which data could be mobilized for an intermediate point in time. The addition of a 1990 data point for the birds (figure 5) gives some indication of changes in the rate of species decline for some habitats, but with the data available it is difficult to say whether the changes in the rate of loss are significant.

Although this pilot project focused on testing the indicator at the European level, the indicator method has also been designed to be suitable for use on the national level, using the same types of data. For example, applying the method at national scale in the UK (figure 6) makes it possible to see clearly the national trends in species within particular habitats; the UK, like the rest of Europe, has experienced major declines in farmland species over the past three decades. Individual countries may find it useful to adopt this approach. Using consistent indicators at different scales can provide insights into trends that may require special attention at particular scales of policy and decision-making.

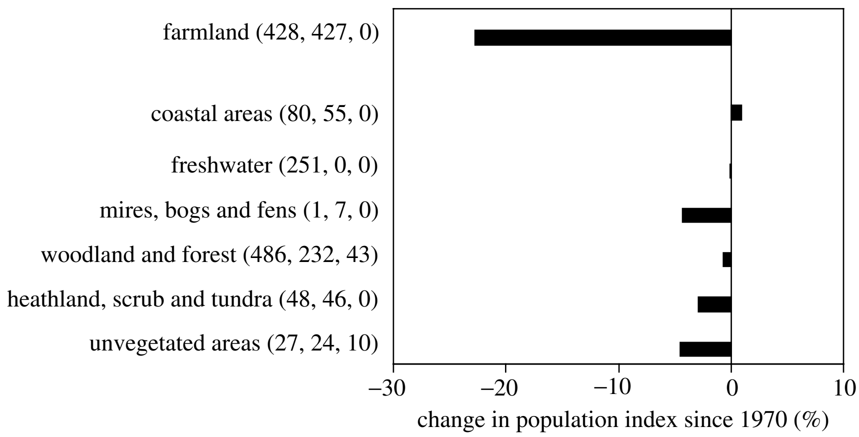

Figure 2. Percentage change in the species population index of each EUNIS habitat between 1970 and 2000. The number of time-series included in the index for each habitat is shown in brackets as (birds, butterflies, mammals).

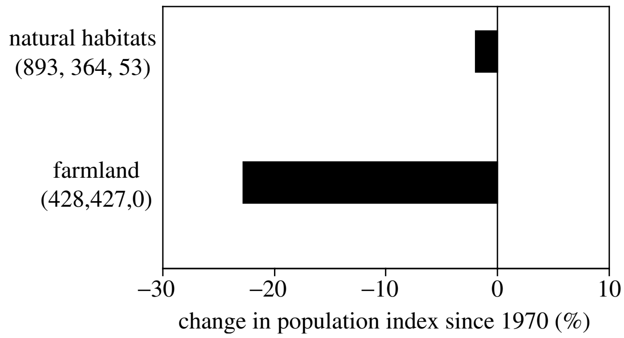

Figure 3. Percentage change in species population index between 1970 and 2000 for natural and farmland habitats at pan-European scale (43 countries). Number of time-series in brackets (birds, butterflies, mammals).

4. DISCUSSION AND RECOMMENDATIONS

In this study we have piloted a species trend indicator, which integrates trends of different species and species groups and can make use of data coming from different sources, collected with different methods. The indicator can be aggregated from its building blocks towards habitats on the European level, biogeographical regions and also towards (clusters of) countries. Thus, the indicator can deliver both headline messages for awareness raising and high-level decision-making and detailed information for in-depth analysis. The method is potentially suitable for evaluating progress towards the 2010 target; the data compiled in this study make it possible to establish a first estimate of the rate of biodiversity loss in the period 1970–2000, with which subsequent estimates for later periods can be compared.

(a) *Data mobilization*

We have demonstrated that international, species-oriented NGOs, with their European-wide networks, are effective mechanisms for mobilizing the substantial quantity of existing data on species trends, at least for breeding birds, butterflies and large mammals. Within the taxonomic groups and ecoregions covered in this trial, data are available for nearly all species, covering a broad range of ecological characteristics, and making it possible for the indicator to represent a broad cross-section of biodiversity in Europe. Targeted efforts are now needed to identify and mobilize historical trend data for other taxonomic groups, and for those ecoregions not included in this (pilot) study. Species groups that have not been covered in this pilot study, but for which substantial amounts of data are probably available, include vascular plants, freshwater and marine fishes, water birds (Gilissen *et al.* 2002) and marine mammals. In addition, specific efforts are needed to obtain data from countries and regions, such as European Russia and the Arctic region, which were not effectively targeted by the data mobilization strategy of this study. Additional data from intermediate points in time (e.g. 1990) would increase the utility of the indicator for monitoring progress towards the 2010 target. International NGOs and national sources both have vital roles to play in mobilizing existing data.

(b) *Habitats and biogeographical regions*

The top-level of the EUNIS habitat classification, has generally proven to be a useful basis for stratifying the species trend indicator. We adopted the farmland category because it was difficult to link species data clearly to either of its component classes ('grassland' and 'cultivated area'). This category will continue to be useful for future work. Additional merging between EUNIS classes may be advisable in the future because some classes have few, if any, species strictly limited to them. This is especially the case for the class 'Mires, bogs and fens'. In addition, an improved approach is needed for handling habitat associations for those species, especially large mammals, which usually use more than one habitat.

Further difficulties in aggregation arose because of the limited precision of habitat maps derived from landcover mapping, which made it difficult to obtain areas for relatively fragmented habitats and ecoregions such as mires, bogs and fens, and those which are less easily detected via remote sensing. The use of biogeographical regions, though ecologically and politically useful, added to the demands on the data; working with only habitats and countries would be more straightforward and is recommended for future work.

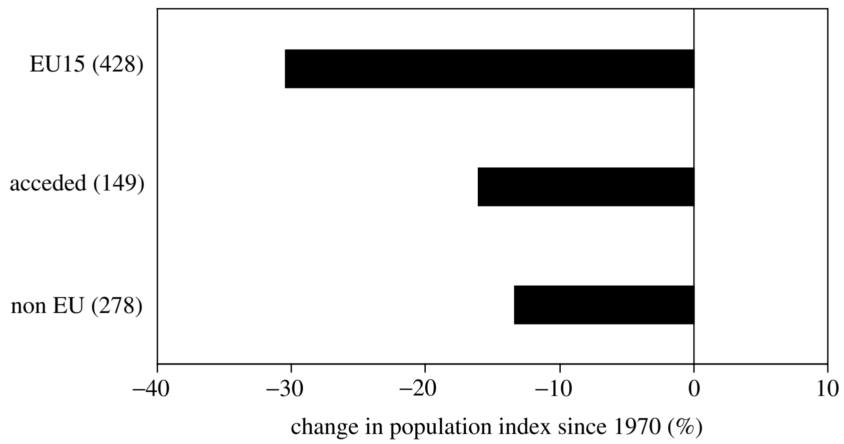

Figure 4. Percentage change in species population index of farmland species between 1970 and 2000, showing that declines were much larger in the 15 EU countries than in the 10 countries that acceded to the EU in May 2004 or the non-EU countries. Number of time-series in brackets.

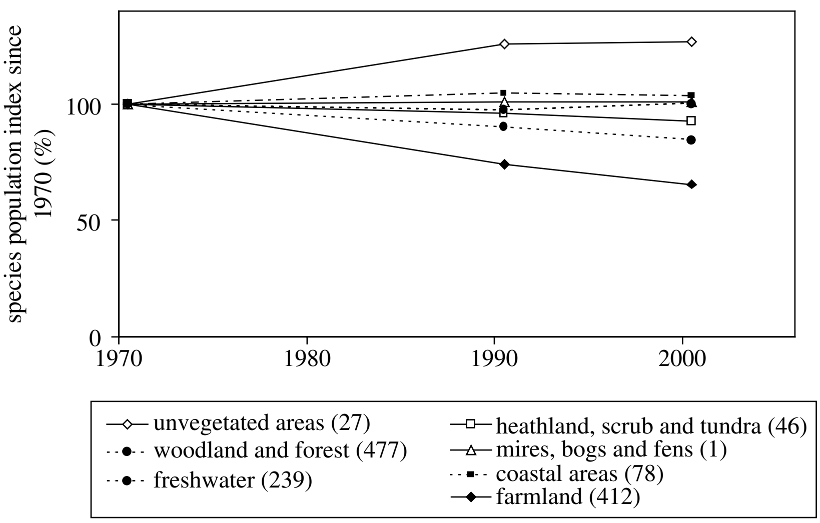

Figure 5. The average percentage change in bird species population index between 1970, 1990 and 2000. Little evidence of change in the rate of decline is visible for most habitats. Number of time-series for each habitat in brackets.

(c) *Composition and aggregation*

The degree to which the index is representative of overall biodiversity trends is obviously a function of the species composition and the way the data are aggregated. In this trial application the lack of inclusion of taxonomic groups other than mammals, birds and butterflies has implications that vary by major habitat type. For example, incorporating data on freshwater fishes or amphibians would increase the validity of the indicator for inland surface water habitats. The addition of data on plants would potentially improve the representation of all habitats. Furthermore, at present the species are combined without regard to whether particular taxonomic groups are represented by greater numbers of time-series than others. This could mean that a particular group dominates the indicator and leads decision-makers to draw conclusions that are more applicable to it than to other groups. A solution to this might be to adopt a staged aggregation procedure, whereby species are first averaged across their species groups (e.g. plants, invertebrates and vertebrates) and the groups are then combined with equal (or potentially other) weightings applied between the groups. However this approach is dependent on having sufficient data for each species group for each building block to produce a meaningful average. Problems of the same type are discussed elsewhere in this issue by Loh *et al.* and Buckland *et al.*

The composition of the indicator with respect to the ecological characteristics of the species is also important. At present no quantitative criteria are applied to specify the balance among species with different characteristics, for example how many sedentary species versus how many migratory species and how many threatened (Red List) species versus how many non-threatened species. The linking of species to habitat types may have in some cases effectively excluded habitat generalist species. Rare species are included alongside common ones and only species with widely fluctuating populations are excluded. The inclusion of data on rare species contrasts with the approach taken by others for other purposes, for example, in the UK and European bird indicators (Gregory *et al.* 2003*a*,*b*). Excluding data on fluctuating species is common

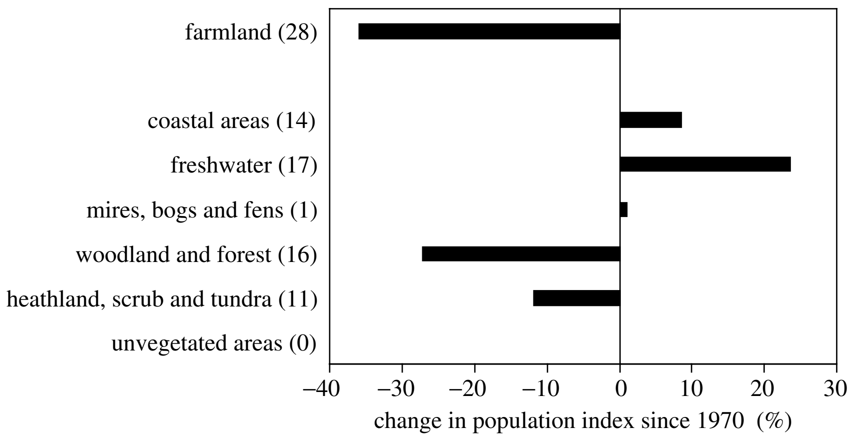

Figure 6. Example of the indicator for a single country. The graph shows the percentage change in species population index per habitat, for the United Kingdom. Number of time-series (in this case equal to the number of unique species) in brackets. For details on species, time-series and sources for the UK indicator, see De Heer *et al.* (2005).

practice. While reducing noise in the dataset, it risks failing to detect and incorporate any long-term trend in these species.

All of these factors suggest that it would be useful to devote more effort to developing further the criteria for building the set of species included in the indicator and to considering how best to combine species within the indicator. Such criteria could usefully include guidelines for the minimum number of species within a building block for which the indicator generally can be considered robust, and should also address alternative approaches for aggregation and weighting. We used area-weighted aggregation in this pilot because weighting building blocks by the proportion of the total population size within them is not feasible across all taxonomic groups. It is more rigorous than applying no weighting during aggregation from one spatial scale to another.

(d) *Reliability and sensitivity*

The pilot indicator covers such a large number of species and time-series over such a long period, that it is expected to be fairly robust. For the ecoregions covered by the pilot study, we do not believe that the patterns shown by the indicator would be altered significantly by the inclusion of additional species or time-series from the same taxonomic groups. A statistical analysis of the reliability and sensitivity of the indicator has yet to be carried out. It should include the calculation of confidence intervals, which would best be done using bootstrapping techniques.

The limited sensitivity of many of the data included limits the sensitivity of the indicator. Not only are many of the estimated trends relatively conservative (e.g. those derived from distribution changes), but they are provided in relatively coarse classes so that they will tend not to pick up changes of less than 15%. This limitation can best be overcome by establishing monitoring programmes that will generate consistent quantitative data (see below).

The different categories of data quality have different implications for the different taxa. The exclusion of time-series based on limited quantitative data without correction (data quality c) has eliminated the most uncertain data for butterflies, and also significantly reduced the quantity of carnivore data that could be included. It had little effect on the bird or herbivore data included. For these taxa, expert judgement contributed a significant proportion of the time-series data, and the implications of this may need to be explored further.

(e) *Relation between the indicator and biodiversity loss*

The basic assumption behind this indicator is that, in addition to telling the user something about the trends in the component species, it represents wider trends in biodiversity. These are of interest in the context of policy- and decision-making that affect progress towards the 2010 target on biodiversity loss.

Biodiversity loss is characterized by the decrease in abundance of many species and the increase of some—often opportunistic—species, as a result of the environmental impacts of human activities (McKinney & Lockwood 1999; UNEP 2003*a*,*b*). In this pilot indicator, increases in species populations since 1970 contribute to higher values of the indicator; and decreases to lower values. However, this simplistic approach raises two issues.

(i) An increase in population of a species since 1970 cannot always be considered a biodiversity gain, and a decrease cannot always be considered a loss. This can even be the case for species that are considered characteristic of a certain habitat. Examples include the increase of freshwater birds owing to eutrophication of their habitat, the increase of *Molinia* sp. owing to eutrophication of heathlands, and the increase of many bird species in marshes and dune areas which have become overgrown by shrubs owing to nutrient enrichment. Thus, with the approach used, the message of the indicator is potentially ambiguous, which conflicts with the requirement of being meaningful and simple to understand.
(ii) Biodiversity changes before 1970 (often large losses) are not addressed by the indicator. Changes

since 1970 might be very small in comparison to these losses (see also Hutchings & Baum this volume; Pauly *et al.* this volume), and may differ significantly among countries and habitats. Therefore, change relative to the year 1970 provides incomplete information that will not necessarily be appropriately interpreted by policy-makers and the public.

Modelling species abundance under reference (e.g. low human impact) conditions could be used to help resolve ambiguity in the indicator and put recent changes into meaningful context. Building such a scenario would require information on historical and geographical trends and qualitative and quantitative ecological knowledge.

(f) *Potential for use at the national scale*

As demonstrated using the UK as an example, the indicator method and the European database can potentially be used to calculate species trend indicators for individual countries. These may complement biodiversity data and indicators already in use at national level, which in turn could also contribute to European scale indicators. For example, in the UK, several species (trend) indicators in use include: the UK headline indicator for wild bird populations (Gregory *et al.* 2003*a*), trends for butterflies (Asher *et al.* 2001) and trends for plants (Preston *et al.* 2003). Also, trend indicators are available on biodiversity action plan (BAP) priority species. However, there is no indicator in use that combines the trends across species groups. Additional differences in approach, for example, regarding habitat classification, species selection criteria (selecting all species versus focusing on habitat-specialists) and different sources for species-habitat associations mean that no direct comparison of indicator results can be made. In some cases different data sources were used; in those cases usually the European project had access to less precise data. Working towards further harmonization of indicator methodologies and exchange of data, would enhance the synergy between national and European work on indicators.

(g) *Thematic indicators*

A further application of this indicator method and the data available is to generate trend indicators for different subsets of species that address particular issues. Such subsets can, for example, be based on taxonomy, policies, ecological characteristics, or be related to particular pressures. Examples are:

- species of the Habitats and Birds Directives;
- Red List species or Species of European conservation concern (SPEC);
- species for which species action plans are in place, for example large carnivores;
- species that are hunted or otherwise exploited;
- species with particular ecological characteristics, such as water birds with feeding strategies that might be related to their reaction to eutrophication of freshwaters, or sedentary versus migratory species;
- butterflies with northern distribution versus butterflies with a southern distribution, to explore a potential relation with climate change.

The analysis of the population trends of subsets of species, and comparison with the overall-trends or trends in contrasting groups, will have a value on its own for assessments and conservation planning, and will also help to obtain a better understanding of the overall-indicator and the causes of change.

(h) *Towards a European biodiversity monitoring framework*

With the current level of *ad hoc* and structural data collection in Europe we estimate that it will be possible to update this indicator meaningfully and reliably only after approximately another three decades. This is owing to the lack of sensitive and frequent data on species trends. To allow more frequent and reliable updating of the indicator, implementation of long-term monitoring will be needed under a common European biodiversity monitoring framework. Such a framework would provide guidelines and manuals to help countries implement national monitoring schemes that meet their own national needs. The only requirements would be that the design of the monitoring schemes would be such that the results (indices, not raw data) could feed into the European picture. The pan-European common birds monitoring scheme (PECBMS) is a good example of such an approach (Gregory *et al.* 2005). The guidelines should, for example, consider stratification, suitable measuring methods, selection of species and dimensions of monitoring schemes (number of plots and frequency of recording).

The monitoring schemes should be built as far as possible on existing initiatives. They should preferably use direct measures of changes in population size rather than less sensitive proxies, such as changes in distribution area. Furthermore, the number of plots and frequency of measuring (dimensions of the scheme) should be high enough to allow the production of sensitive indices of change. The final decisions on the dimensions of monitoring programmes will of course be based on the balance between costs and benefits at both national and European scales. International, species-oriented NGOs, with their networks of experts and organizations in all European countries, can potentially play a unique and essential role in the design and implementation of European biodiversity monitoring.

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GLOSSARY

BAP: biodiversity action plan
CBD: Convention on Biological Diversity
EBCC: European Bird Census Council
EEA: European Environment Agency
EUNIS: European Nature Information System
NGOs: non-governmental organizations
PECBMS: pan-European common birds monitoring scheme
SPEC: Species of European Conservation Concern

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