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 2001a) and various other European Union policies (EC 1998, 2001b, 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. 2003a) is one example. The European Bird Census Council (EBCC) has used a similar approach to develop the pan-European...
common bird index for farmland and forest birds (Gregory et al. 2003b, 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 2003a). 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 ‘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). Parts of Russia, Ukraine and Turkey were not included in these statistics.

<table>
<thead>
<tr>
<th>Biogeographical region</th>
<th>Alpine</th>
<th>Atlantic</th>
<th>Black Sea</th>
<th>Boreal</th>
<th>Continental</th>
<th>Macaronesian</th>
<th>Mediterranean</th>
<th>Panonian</th>
<th>Steppic</th>
</tr>
</thead>
<tbody>
<tr>
<td>EUNIS habitat type</td>
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<td>marine habitats</td>
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<tr>
<td>coastal habitats</td>
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<td></td>
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<td></td>
<td></td>
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<tr>
<td>freshwater habitats</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>marsh, bog and fen habitats</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>heathland, scrub and tundra habitats</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>woodland and forest habitat and other wooded land</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>inland unvegetated or sparsely vegetated habitats</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>constructed, industrial and other artificial habitats</td>
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<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>farmland</td>
<td>146</td>
<td>6</td>
<td>30</td>
<td>539</td>
<td>8</td>
<td>300</td>
<td>354</td>
<td>121</td>
<td>298</td>
</tr>
<tr>
<td>total</td>
<td>2,028</td>
<td>11.2</td>
<td>101</td>
<td>2,009</td>
<td>18</td>
<td>27</td>
<td>11</td>
<td>198</td>
<td>2,009</td>
</tr>
</tbody>
</table>

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. The approximate area of each ecoregion was calculated from GIS overlays of biogeographical regions (Roekaarts 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.
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 Environment 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 universities, herbaria and botanical gardens, hunters’ 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.

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 autecological 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

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

<table>
<thead>
<tr>
<th>species group</th>
<th>NGO</th>
<th>website</th>
</tr>
</thead>
<tbody>
<tr>
<td>birds</td>
<td>BirdLife International</td>
<td><a href="http://www.birdlife.net/">http://www.birdlife.net/</a></td>
</tr>
<tr>
<td></td>
<td>European Bird Census Council</td>
<td><a href="http://www.ebbc.info">http://www.ebbc.info</a></td>
</tr>
<tr>
<td></td>
<td>Wetlands International</td>
<td><a href="http://www.wetlands.org/default.htm">http://www.wetlands.org/default.htm</a></td>
</tr>
<tr>
<td>butterflies</td>
<td>Butterfly Conservation Europe</td>
<td><a href="http://www.vlinderstichting.nl/">http://www.vlinderstichting.nl/</a></td>
</tr>
<tr>
<td>mammals</td>
<td>Large Carnivore Initiative Europe</td>
<td><a href="http://www.lcie.org/">http://www.lcie.org/</a></td>
</tr>
<tr>
<td></td>
<td>Large Herbivore Foundation</td>
<td><a href="http://www.largerherbivore.org/">http://www.largerherbivore.org/</a></td>
</tr>
</tbody>
</table>

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*Phil. Trans. R. Soc. B* (2005)
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. 2003b, 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 use of national databases on the habitat preferences of the species, in combination with expert judgement from the national and international expert groups (Van Swaay 2004). For mammals the link between species and 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

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

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

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.)

<table>
<thead>
<tr>
<th>group</th>
<th>data source(s)</th>
<th>number of species</th>
<th>lowest spatial resolution</th>
<th>coverage</th>
<th>time-interval for which trends are available</th>
<th>reference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>country or region within country</td>
<td>varies by country</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>country or region within country</td>
<td>varies by country; from a few years to since 1976 (UK)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>mammals, large carnivores</td>
<td>species action plans and many data sources residing with individual researchers and institutes</td>
<td>5</td>
<td>country</td>
<td>all pan-European countries</td>
<td>1960–1970</td>
<td>LCIE (2004)</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>species group</th>
<th>number of species</th>
<th>number of time-series</th>
</tr>
</thead>
<tbody>
<tr>
<td>butterflies</td>
<td>119</td>
<td>1359</td>
</tr>
<tr>
<td>birds</td>
<td>142</td>
<td>1389</td>
</tr>
<tr>
<td>mammals</td>
<td>12</td>
<td>62</td>
</tr>
<tr>
<td>total</td>
<td>273</td>
<td>2810</td>
</tr>
</tbody>
</table>

Phil. Trans. R. Soc. B (2005)
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
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.
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.

### 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.

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

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.
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.

**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 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).**
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. 2003a,b). Excluding data on fluctuating species is common

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.
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 2003a,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. 2003a), 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 scales, 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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