Developing butterflies as indicators in Europe: current situation and future options

Butterfly
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De Vlinderstichting

Butterfly Conservation
Saving butterflies, moths and our environment

Butterfly Conservation Europe

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The Chequered Skipper (Carterocephalus palaemon) thrives in open woodland.

Contents

Many other species profit from the Conservation of butterflies.

Executive summary

1. Butterflies are good biological indicators: they are well-documented, easy to identify and monitor, and are popular amongst the general public. This report explains the current situation with regard to butterfly monitoring in Europe and gives recommendations for its development.
2. Butterflies are a prominent group of insects which comprise over 50% of terrestrial biodiversity. They react quickly to change and occur in a wide range of habitat types across Europe. They have been proposed as a good and viable indicator in the Streamlining EU Biodiversity Indicators (SEBI 2010) process and are considered to be a valuable way of monitoring progress towards the EU target of halting the loss of biodiversity and degradation of ecosystem services by 2020.
3. A standard method of monitoring based on regular walks along butterfly transects has been well described and proven to be scientifically sound. This has been adopted in at least 19 countries or regions across Europe. As a result butterflies are the only invertebrate taxon for which it is currently possible to estimate rates of decline among terrestrial insects in many countries.
4. Butterfly Monitoring Schemes (BMS) have been active since 1976 and are used to produce national species trends and national indicators. Most schemes rely on volunteers to collect data in the field making them highly efficient and cost effective. This also helps with the broad acceptance for butterflies and butterfly friendly management in local communities.
5. Most schemes are run by a co-ordinator who is a vital hub between the scientific demands (validation, quality control, research uses) and the volunteers.
6. Several regions and countries still have only very limited butterfly monitoring, and there is huge potential to increase the number of schemes and improve the coverage of butterfly monitoring across Europe. BC Europe gives advice on how best to start a scheme and decide on which priority species and habitats to cover.

Butterflies are easy to find and count, which makes them an ideal group for volunteer based assessments.

A high butterfly diversity is a good indicator for a healthy environment.

7. So far, the existing schemes have been used to generate two indicators.
   1) The ***indicator on European grassland butterflies*** was first developed in 2005 and is based on the European trend of 17 grassland butterflies. The most recent update (1990-2011) showed that grassland butterflies have declined by almost 50% since 1990. The Grassland Butterfly Index makes a good complement to the Farmland Bird Index, because butterflies are far more specific to grasslands and are more sensitive to changes in quality of these crucial habitats for biodiversity. They also operate at smaller spatial scales and are highly sensitive to site management.
   2) The ***Climate Change Indicator*** shows that butterfly communities have shifted northwards by an equivalent of 75 km in 20 years, whereas the temporal trend in temperature has shifted north by 246 km, showing that butterflies are lagging significantly behind climate change.

8. Three recommendations are made for urgent investment by the EU to develop the use of butterflies as indicators as part of the EU Biodiversity 2020 Strategy:
   1) Construction of a central European database as well as a standard data entry system for butterfly monitoring data. This is essential to produce an efficient and more representative monitoring network that would allow regular updates as well as the development of a wide range of indicators in the future.
   2) Extension of butterfly monitoring schemes to regions and countries that currently lack them, with training, advice and support for individuals and countries who want to start schemes.
   3) The development and testing of new indicators such as an agricultural intensification indicator, an agricultural abandonment indicator, Butterfly Grassland Indicators for different Natura 2000 priority grassland types as well as a Woodland Butterfly Indicator.

1. Introduction

Butterfly monitoring makes it possible to assess the trends of butterfly populations and to track population changes on a range of spatial scales: local, regional, national, or European. National and regional trends are especially valuable as they can be used as indicators of biodiversity and environmental change. As butterflies are good biological indicators, they are a valuable way of monitoring progress towards the EU target of halting the loss of biodiversity and degradation of ecosystem services in the EU by 2020. The monitoring is based on standard methods that can be used in the field (Van Swaay *et al*, 2012). This report explains the current situation with regard to butterfly monitoring in Europe and gives recommendations as to how it could be developed.

Why monitor butterflies

Insects are by far the most species-rich group of animals, representing over 50% of terrestrial biodiversity. Contrary to most other groups of insects, butterflies are well-documented, easy to recognize and popular with the general public. Although many people think of butterflies as the adult form flying in summer, most species occur as herbivorous caterpillars for a large part of the year, occupying all seral stages and terrestrial niches, except for dead wood. Butterflies use the landscape at a fine scale and react quickly to changes in land use, intensification or abandonment.

Butterflies have specific habitat requirements. Females lay their eggs only on specific native plants, often in a particular type of habitat. Without these plants growing in this specific habitat they are unable to produce a succeeding generation. Because they have one or more generations per year, butterfly populations can change quickly and trends can be detected in a short period of time.

For these reasons, butterflies are widely regarded as sensitive indicators of the environment and have been used to assess factors ranging from climate change and land use policies (see below). Trends in numbers on individual sites can be used to assess the impact of land management and make improvements to maximise benefits to biodiversity. Finally, habitat loss due to human activities has had a devastating impact on the viability of butterfly populations and monitoring can help assess overall conservation effort aimed at reversing these downward trends.

*The Small Pearl-bordered Fritillary (*Boloria selene*) needs Violets (*Viola *ssp.) as foodplants for its larvae.*

Butterflies as indicators

Butterflies are valuable wildlife indicators and can be used to report on progress towards meeting biodiversity targets. Contrary to most other groups of insects, butterflies have considerable resonance with both the general public and decision-makers (Kühn *et al*., 2008). Butterflies are also relatively easy to recognize and data on butterflies has been collected in some regions for a long time, often involving many hundreds of voluntary observers. A standard method of monitoring based on regular walks along butterfly transects has been well described, extensively tested and proven to be scientifically sound (Pollard 1977; Pollard and Yates, 1993). This has been adopted in over 19 countries to produce national trends (see Section 2). As a result butterflies are the only invertebrate taxon for which it is currently possible to estimate rates of decline among terrestrial insects in many parts of the world (de Heer *et al*. 2005; Thomas 2005).

Volunteer engagement

In Europe there is a large volunteer butterfly recording community base, which makes it possible to generate and produce distribution maps and trends of many of Europe's butterflies. In some north-western European countries (e.g. United Kingdom, Netherlands, Germany and Sweden) volunteers provide nearly all the data. In other regions volunteers are also potentially very important for collecting data on distribution and numbers of butterflies, although the activity is far less developed in many regions, when compared with north-western Europe. This volunteer involvement has multiple benefits: it makes the schemes very cost-effective to run; it helps raise awareness of biodiversity in the areas where butterflies are being counted; it builds local expertise to help inform site management; and the results help conservationists put local trends in a national context.

Volunteer engagement is a key factor for the success of butterfly monitoring.

Rare and endemic butterflies, like this Macedonian Grayling (*Pseudochazara cingovskii*), deserve our attention and conservation efforts.

EU Biodiversity Strategy and relevance

The main 2020 target of the EU Biodiversity Strategy (European Commission, 2011) is to halt the loss of biodiversity and the degradation of ecosystem services in the EU by 2020, and restore them in so far as feasible, while stepping up the EU contribution to averting global biodiversity loss. This strategy aims at reversing biodiversity loss and speeding up the EU's transition towards a resource efficient and green economy, and includes specific action to improve monitoring and reporting.

One of the headline indicators being used to monitor the trends in Europe's biodiversity and progress towards the above targets is the European Indicator on Grassland Butterflies (European Environment Agency, 2010; Van Swaay, 2012). As butterflies are monitored on a regular basis in many countries, they provide sound direct and indirect indicators for our biodiversity. However, current coverage of monitoring is incomplete, and improvements are needed in some regions of exceptional biodiversity importance, especially in southern and eastern Europe. So far indicators have only been developed for grasslands and climate change, and many more could easily be developed from the same data source that would be relevant to other aspects of EU policy, including monitoring of woodlands and agricultural abandonment (see section 5).

2. Existing monitoring schemes and indicators in use

Since the start in 1976 butterflies have been monitored in a growing number of countries. This chapter provides an overview of the present European situation.

Butterfly monitoring enjoys a growing popularity in Europe. Map 1 shows the current Butterfly Monitoring Schemes (BMS) and the countries where they are expected soon. Although Butterfly Monitoring Schemes are present in a growing number of countries and new ones are being initiated in many places, long time-series are only available for a limited number of countries. The spatial and temporal coverage improves every year, but more development work is needed to give complete geographical coverage.

***Map 1: Countries with Butterfly Monitoring Schemes**:*
Andorra (part of the Catalan scheme): since 2004
Belgium (Flanders): since 1991
Estonia: since 2004
Finland: since 1999
France: since 2005 (Doubs area 2001-2004)
Germany: since 2005 (Nordrhein-Westfalen since 2001, Pfalz-region for P. nausithous since 1989)
Ireland: since 2007
Jersey: 2004-2009
Lithuania: since 2009
Luxemburg: since 2010
Norway: since 2009
Portugal:1998-2006
Romania: starting up
Russia - Bryansk area: since 2009
Slovenia: since 2007
Spain (Catalonia: since 1994, Andalusia, Extremadura and Basque country starting up)
Sweden: since 2010
Switzerland: since 2003 (Aargau since 1998)
The Netherlands: since 1990
Ukraine (Transcarpathia): since 1990
United Kingdom: since 1976

In 2011 approximately 3500 transects were counted.

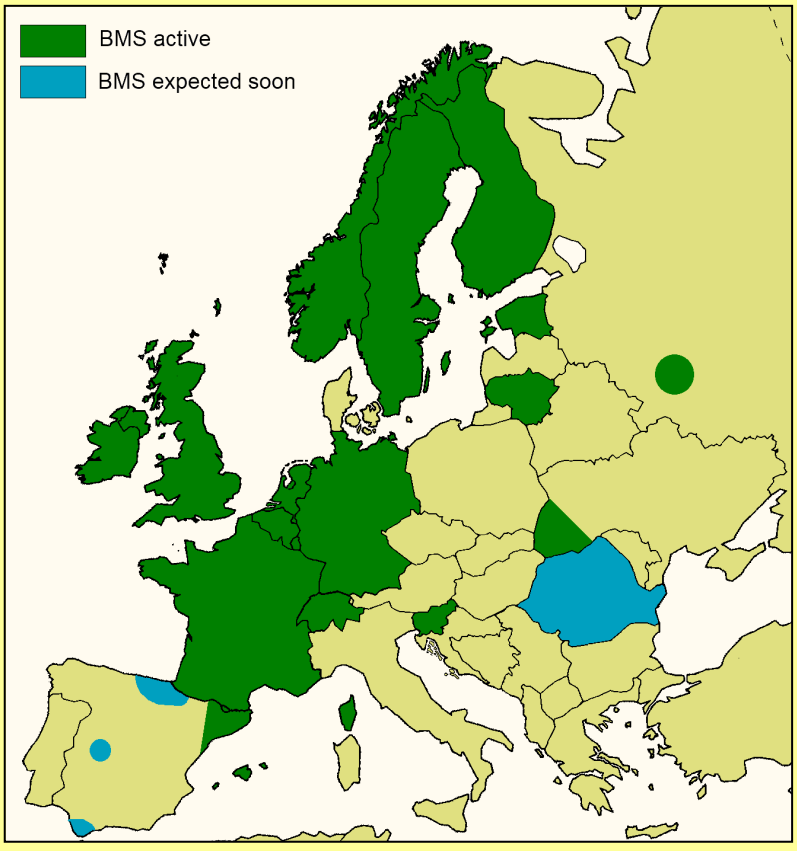


Table 1: Characteristics of Europe's Butterfly Monitoring Schemes (BMS).

Country	Starting year	Area represented (w=whole country, r=region)	Average transect length	Number of transects per year 2009-2011 (average or range)	Number of counts on a transect per year (average or range)	Counts by (v=volunteers, p=professionals)	Method to choose sites (f=free, c=by coördinator, g=grid, r=random
Andorra	2004	w	1,5	6	20-30	v	f
Belgium - Flanders	1991	r	0,8	10	15-20	v	f
Estonia	2004	w	1,8	11	7	p	c
Finland	1999	w	3	65-67	ca 11	v ~70%, p ~30%	free for v
France	2005	w	1	611-723	4,4 (1-15)	v	half r, half f
France - Doubs	2001-2004	r	1	0	10-15	p	c
Germany	2005	w	0,5	400	15-20	v	f
Germany - Nordrhein Westfalen	2001	r	1	0	15-20	v	f
Germany – Pfalz (Phengaris nausithous only)	1989	r	0,5	50-87	1	p	c
Ireland	2007	w	1,5	190	16.3	v	f
Jersey	2004-2009	w	1	0	15-25	v	f
Lithuania	2009	w	1,3	14	6-9	v	f
Luxemburg	2010	w	0,34	30	8.2 (3-11)	v ~10%, p ~90%	r
Norway	2009	r	1	9-18	3	v ~42%, p ~58%	g
Portugal	1998-2006	w	1	0	3-5	v	f
Romania	starting up						
Russia - Bryansk area	2009	r	1,2	2-14	3-5	v ~90%, p ~10%	f
Slovenia	2007	w	1,3	9-14	6.25 - 7.53	v	c
Spain - Catalonia	1994	r	1	60-70	30	v	f
Sweden	2010	w	0,65	90	4	v	f
Switzerland	2003	w	2 x 2.5	90-95	7 (4 alpine region)	p	g
Switzerland - Aargau	1998	r	2 x 0.250	101-107	10	p (civil service)	g
The Netherlands	1990	w	0,7	430	17 (15-20)	v	f
Ukraine – Carpathians and adjacent parts	1990	r	1	158	5 (2-10)	p	f
United Kingdom	1973 (1976)	w	2,7	819-977	19	v	f

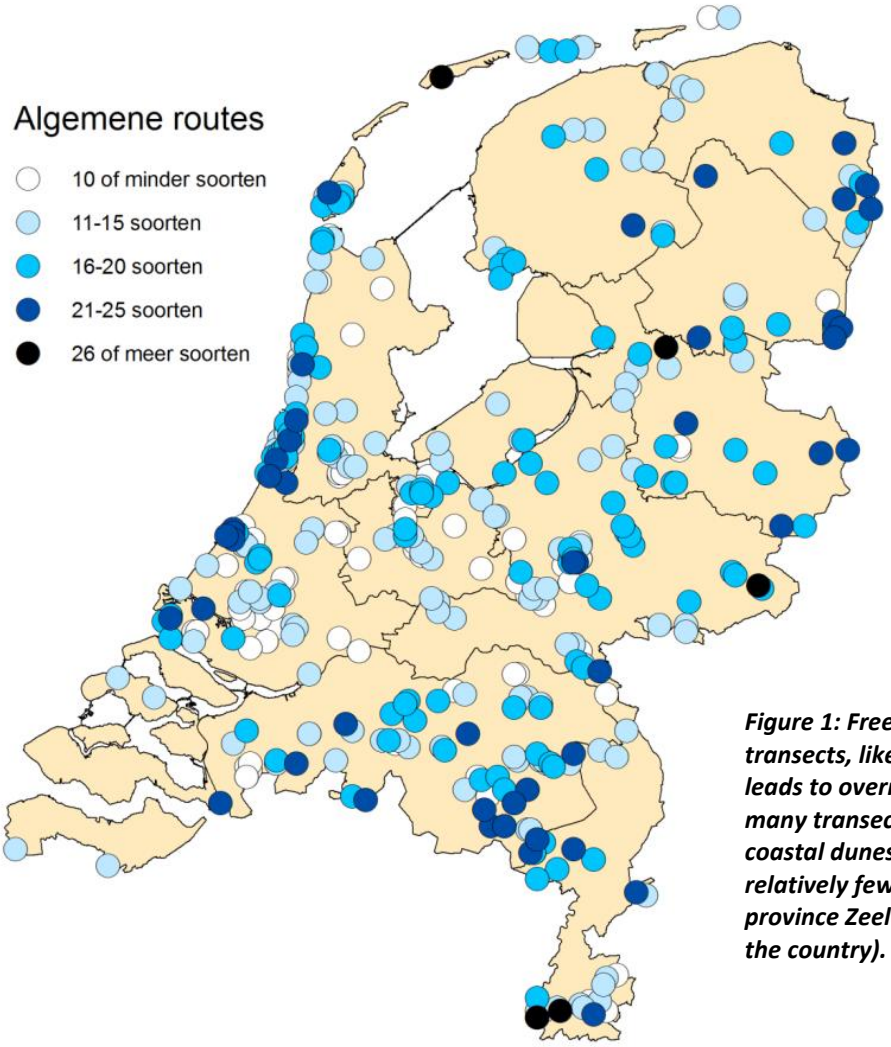


Figure 1: Free choice of the location of transects, like here in the Netherlands, leads to overrepresented areas with many transects (e.g. the western coastal dunes) and areas with relatively few transects (e.g. the province Zeeland in the southwest of the country).

Most schemes are counted on a weekly or two-weekly basis by volunteers (table 1). There are three ways of choosing the location of a transect:

- Free choice. This is used mostly in the older schemes (e.g. the Netherlands, figure 1). The location of the transect is chosen by the recorder (sometimes together with the co-ordinator).
- Random. Once a recorder registers, a random site in the neighbourhood is provided to them.
- Grid. Locations are placed along a grid over the country. So far this is only done in Switzerland, where all counts are made by professionals (figure 2).

There are pros and cons for each system. Free choice schemes are good for engaging large numbers of volunteers and for covering high quality sites where recorders can see a wide range of butterflies, including rare ones. They are good at detecting site-related trends to inform management on protected sites (e.g. nature reserves). Random or grid schemes give a more representative sample but often miss rare or threatened species. They are best for recording trends in more widespread species. They are also less suitable for using volunteers and are therefore often more costly. Combinations of the two are also possible.

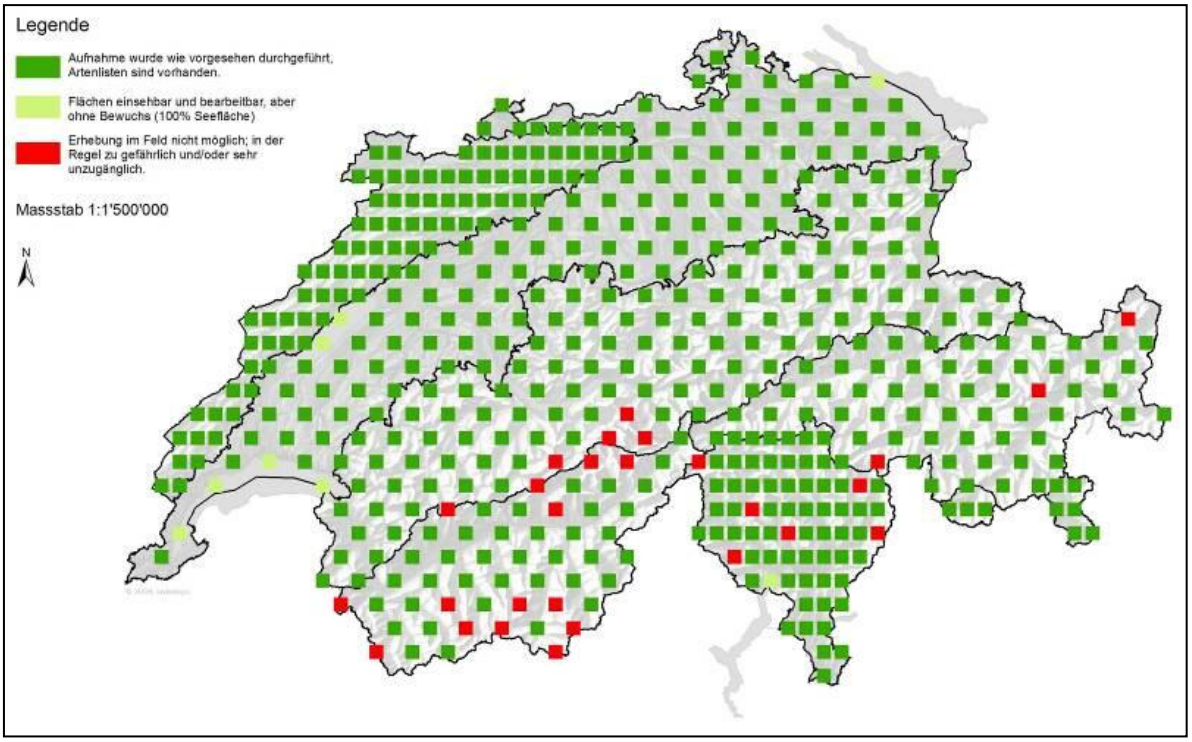


Figure 2: In Switzerland transects are selected in a grid. In some regions the density of locations is higher because of regional initiatives (Plattner & Nobis, 2009).

To be able to draw proper inferences on temporal population trends at national or regional level, transects are best selected in a grid, random or stratified random manner (Sutherland, 2006).

Several recent schemes, e.g. in Switzerland (figure 2) and France, have been designed in this manner (Henry *et al.*, 2005). However, if a scheme aims to monitor rare species, random sampling will miss most colonies and will be very inefficient at detecting trends of these species. Scheme coordinators therefore often locate transects in areas where rare species occur, leading to an over-representation of special protected areas. In the older schemes, such as in the UK and the Netherlands, but also in the recently established scheme in Germany, transects were selected by free choice of observers. In some cases this has led to the overrepresentation of protected sites in natural areas and the under-sampling of the wider countryside and urban areas (Pollard and Yates, 1993), although in Germany this effect was not that pronounced (Kühn et al., 2008). With free choice sampling, there is a risk that the trends detected may only be representative of the areas sampled and their extrapolation to national trends may produce biased results. Such bias is low where sample size is high and can be minimized by post-stratification of transects. This implies an a posteriori division of transects e.g. by habitat type, protection status and region, where counts per transect are weighted according to their stratum (Van Swaay *et al.,* 2002).

Nearly all BMS cover all species and habitats. There are a few exceptions, for example the Finnish scheme which is targeted at agricultural areas and the German – Pfalz (*Phengaris nausithous* only) scheme which focuses on grasslands with this target species.

3. Developing monitoring in counties without schemes

Butterflies are attractive insects and once a scheme is set up, it is usually relatively easy to attract recorders. There are however some common elements to running a successful scheme.

Field method

The field methods are described in detail in the Manual for Butterfly Monitoring (Van Swaay *et al.,* 2012). At present all schemes apply the basic method developed for the original British Butterfly Monitoring Scheme (Pollard and Yates 1993). The counts are conducted along fixed transects of about 1 kilometre, consisting of smaller sections, each with a homogeneous habitat type. The fieldworkers record all butterflies in an imaginary box 2.5 metres to their right, 2.5 metres to their left, 5 metres ahead of them and 5 metres above them (Van Swaay *et al*. 2002). Butterfly counts are conducted between March-April to September-October. Visits are only conducted when weather conditions meet specified criteria. In the Dutch and German schemes this means temperature above 17°C, or 13–17 °C in sunny weather, wind less than 6 on the Beaufort scale, and no rain (Van Swaay *et al.,* 2002). Most transects are recorded by skilled volunteers, but their results are usually checked by butterfly experts.

The number of visits varies from weekly through the main butterfly season (26 weeks) in the UK and the Netherlands to 3-5 visits annually in France. In the Netherlands, transects dedicated to rare species need only be visited during the expected flight period of the species.

Butterflies are counted following standardised protocols.

In normal transects, weekly counts cover the entire flight period of every species and can be used to estimate population trends per transect over time. However, weekly visits may be too demanding for observers. If the only objective is to produce large scale (e.g. national) trends, the amount of effort may be reduced by having fewer visits (Heliölä and Kuussaari 2005; Roy *et al*. 2007). Such a reduced-effort scheme is now active in the UK for the Wider Countryside Butterfly Survey which is based on random 1km squares to detect trends in mainly common butterflies. It is based on only a few annual visits, targeted to the period when most information can be gathered, i.e. three visits in July–August plus in some cases an additional one in May (Roy

et al. 2005; 2007). This reduced sampling makes it possible to use volunteers, but only in this case because of pre-existing networks organised by Butterfly Conservation (UK) and British Trust for Ornithology. In general, many more transects will be needed in a reduced effort scheme than in a traditional scheme.

Number of transects

The power of a Butterfly Monitoring Scheme to detect trends depends on many things, the most important ones being (after van Strien *et al*., 1997):

- The year-to-year variance: some species, like the Painted Lady (*Vanessa cardui)*, show large fluctuations from year to year, where other species, such as the Meadow Brown (*Maniola jurtina)*, only show minor changes in abundance from year to year. This means that for some species it is possible to calculate significant trends much earlier than for other species. Furthermore for species with more than one generation a year, Van Strien et al. (1997) show that for such species in the UK and the Netherlands, the power of the BMS rises when the counts of the first generation are used instead of those of the second generation, as the year-to-year variance of the first generation of most species is considerably lower.
- The number of sampling sites: the more transects there are for a species, the better a trend can be detected.
- The detection period: the longer a scheme is running, the more species trends can be detected.
- The abundance: the higher the number of butterflies counted (the more abundant a species is), the sooner a significant trend can be found.

As a rule of thumb 20 transects seem to be a good minimum to pursue for each species in each stratum that needs to be measured. A stratum can be a country, habitat type, land use or management type, designation category, etc., or combinations of these. For species that are present at more than 50 sites, a further increase in the number of transects hardly improves the power to detect trends (Van Strien *et al*., 1997). This means that when starting a new country or regional BMS, the focus should be on gaining as many transects as possible. Once the number of transects is over 50, the co-ordinator could focus on other species or start with stratifying the country (e.g. in habitat types or geographical regions) and try to obtain at least 20 transects for each stratum.

For some species there are simply not enough populations to conduct 20 transects. In such cases the co-ordinator should aim at getting as many populations covered as possible. Where some of these populations occur in remote locations, single-species monitoring can be used, in which only a few counts are made in the peak of the flight period of the species (Van Swaay *et al*, 2012).

The Scarce Swallowtail (*Iphiclides podalirius*) is one of Europe's most spectacular butterflies.

Butterfly rich grasslands often rely on the Natura 2000 network or on High Nature Value farmland.

Priority habitats and species

The first BMS in volunteer-rich countries like the UK and the Netherlands focused on obtaining as many transects as possible. This soon gave good coverage of most species and habitats. However in other countries with fewer volunteers, it is preferable to focus on some target habitats and species. The following are some options for targeting:

- **Natura 2000 sites**: in the European Union the Natura 2000 network provides a backbone for nature conservation based on a selection of habitats and species mentioned in the annexes of the EU Habitats Directive. Many of the important areas for butterflies will be in those Natura 2000 areas, although many other areas will fall outside Natura 2000. By focusing on these areas and the often rare and specialised species in them, most common and widespread species will also be included. The disadvantage is that the resulting trends do not give any information on the situation in the wider countryside, which would be desirable from a policy perspective.
- **High Nature Value Farmland:** it is clear that the highest number of butterflies and species is found on semi-natural grasslands, typically on High Nature Value Farmland (Opperman *et al.,* 2012). By focusing on these habitats and landuse types, many of the rarer and specialised butterflies will be covered and with them the more widespread and common species.
- **Selected species:** The other way round would be to focus on a selected group of species such as the species listed in the annexes of the Habitats Directive (in the European Union) or Bern Convention (non EU); or the species considered rare and threatened in the European Red List (Van Swaay *et al*., 2010).

Organising a BMS

Butterfly monitoring can be done and used at any level: from a single transect to a national or continent-wide scheme.

Nationally organised schemes.

A national BMS will often aim to obtain trends for (almost) all butterfly species, though there might be a focus on policy relevant species like those listed on annexes II and IV of the EU Habitats Directive. Such large schemes require a co-ordinator who is familiar with the species and has a good overview of the possibilities of working with either volunteers or professionals. Working with volunteers has large advantages, however it requires a co-ordinator who gives them the attention they need.

In a relatively small country (up to 50 000 km^2) a half-time co-ordinator can manage to set up a BMS and run it over the years (e.g. in Catalunya and Netherlands). In larger countries more time is needed to create and support regional groups and local validators and co-ordinators. The co-ordinator travels through the country to recruit new volunteers by giving lectures, writing short papers in journals and magazines, and visiting most of the volunteers to discuss the best location of the transect, the method and the species to be expected, and to resolve their problems. All data has to be validated and analysed and reports published. It is also essential to provide feedback to the volunteers to keep them motivated. Many countries have annual meetings of co-ordinators and regular newsletters as well as maintaining a website with the latest data. Once a scheme is up and running, there are also typically a stream of inquiries from people who want to use the data, for example they are a rich source of data for University researchers.

Regional schemes.

For local nature organisations (e.g. National Parks, Natura 2000 areas) the information on the distribution and trends of butterflies in their region can be important in evaluating management and planning new projects. In such a case it is important that there is a local co-ordinator who will plan and direct the work of the recorders (either professional or volunteer) and analyse the results.

Individuals/groups.

One or a few transects can be helpful to assess the status and distribution of local butterflies and the effect of local land management. It can also be a good way of engaging local people and raising awareness of biodiversity. It is easy to organise this with a group of friends or butterfly enthusiasts. At present there is no centralised system of data gathering, but if there were then such transects could still make a valuable contribution to pan European trends and our understanding of trends across the continent (e.g. climate change).

4. Indicator methods and analysis

Indicators are important tools to assess environmental change and the impact of Government policies. They are particularly important to assess progress with the EU Biodiversity Strategy and the goal of halting biodiversity loss by 2020.

Good indicators to measure biodiversity changes should have the following qualities (European Environment Agency, 2007):

1. Policy relevant
2. Biodiversity relevant
3. Measure progress towards target
4. Well-founded methodology
5. Broad acceptance and intelligibility
6. Data routinely collected
7. Cause-effect relationship achievable and quantifiable
8. Spatial coverage, ideally pan-European
9. Show temporal trend
10. Country comparison possible
11. Sensitivity towards change

Butterflies meet most if not all of these criteria and have been selected as a high priority for the development of European indicators under the SEBI 2010 process (European Environment Agency, 2007). Butterfly Conservation Europe has tested the development of a pan European Butterfly Indicator and has so far produced two indicators:

Butterflies are good indicators to measure changes in biodiversity.

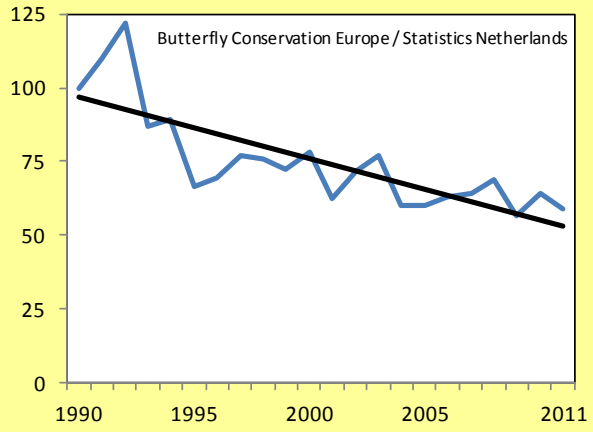
1. The ***indicator on European grassland butterflies*** was first developed in 2005. It is based on the European trend of 17 grassland butterflies: species that European butterfly experts considered to be characteristic of European grassland and which occurred in a large part of Europe, covered by the majority of the Butterfly Monitoring Schemes and having grasslands as their main habitat (Van Swaay *et al*., 2006). National population trends from the Butterfly Monitoring Schemes are combined to form supra-national species trends. These trends per butterfly species are then combined into an indicator: a unified measure of biodiversity by averaging indices of species in order to give each species an equal weight in the resulting indicators. When positive and negative changes of indices are in balance, then we would expect their mean to remain stable. If more species decline than increase, the mean should go down and vice versa. Thus, the index mean is considered a measure of biodiversity change.

   The most recent update showed that grassland butterflies have declined by almost 50% since 1990 (van Swaay *et al*., 2012). Because the indicator is constructed from national trends of typical grassland species, it cannot be disaggregated into grassland types, though this would be a useful development (see Section 5).

   The Grassland Butterfly Index makes a good complement to the Farmland Bird Index, because butterflies are far more specific to grasslands and are more sensitive to changes in the quality of these habitats, which are crucial for biodiversity. They also operate at smaller spatial scales and are thus sensitive to site management. In comparison, farmland birds are better indicators of arable and mixed farms, and large spatial scales.

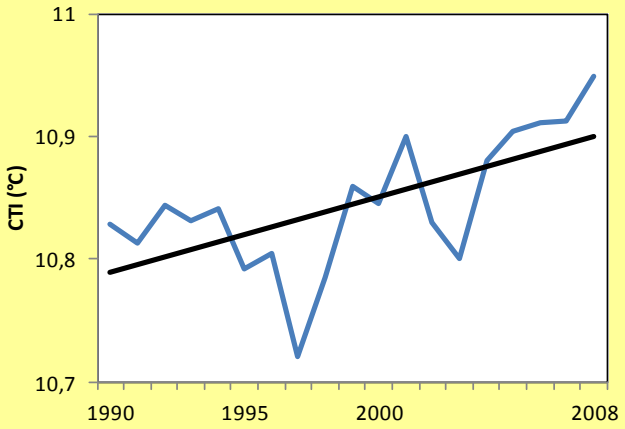
2.

The European Butterfly Indicator for Grassland species 1990-2011.
The indicator is based on Butterfly Monitoring Schemes in nineteen European countries and seventeen characteristic grassland butterfly species. The indicator shows a marked decline (Van Swaay et al., 2012).



The ***Climate Change Indicator*** uses the principle of the Climate Temperature Index (CTI, Devictor *et al*., 2008). With a few exceptions, all butterflies have a distribution which is restricted to a certain part of the world. In Europe, some species are restricted to the colder northern regions, whereas others occur primarily in the warm, southern part of our continent. The preference of a species for a specific climate can be expressed by the long term average temperature over its entire range. This is called the **Species Temperature Index (STI)**. The STI was calculated for each European species using the European distribution atlas of Kudrna (2002) and the Climatic Risk Atlas of European Butterflies (Settele *et al.*, 2008). The number of butterflies of each species occurring at a certain site in a certain year can be described as a community. As each species has its own specific STI (Species Temperature Index), a **Community Temperate Index (CTI)** can be calculated as the average of each individual's STI present in the assemblage. A high CTI would thus reflect a large proportion of species with a high STI, i.e. of more high-temperature dwelling species. This way, the CTI can be used to measure local changes in species composition. If climate warming favours species with a high STI, then the CTI should increase locally (Devictor *et al*., 2008; Devictor *et al*., 2012). The latest analysis shows that butterfly communities have shifted northwards by an equivalent of 114 km in 20 years, whereas the temporal trend in temperature has shifted north by 249 km, showing that butterflies are lagging significantly behind climate change (Devictor *et al*, 2012).

The Butterfly Climate Change Indicator 1990-2008.
The indicator is based on Butterfly Monitoring Schemes in four European countries. The indicator shows a significant and rapid increase in European butterfly communities becoming more and more composed of species associated with warmer temperatures(Devictor et al., 2012).



5. Building a European database and data entry system

To produce butterfly indicators routinely it is important to collect the results of all existing Butterfly Monitoring Schemes and provide a data entry system to make it easier for new schemes to start. This would create an efficient and cost effective system of data collation and a far more representative indicator.

Building a European database

So far butterfly indicators have been developed on an ad-hoc basis. For each version of each indicator, data was collected, analysed and a report produced with the results. It would be much more efficient to collect all data routinely into a database and produce indicators from that on a regular basis. This would also make it much easier to test and produce new indicators.
Building such a database would be a major step in making the indicators available annually and would be comparable with the one developed for breeding birds (EBCC).

Data entry system

In some countries the butterfly monitoring data are collected on paper or via computer programmes. However it would be far more efficient to collect the results through an online web-application or an app on a smartphone. The results could be readily available and validation of the data could be instantaneous. Furthermore this would make it much easier for new schemes to start up as well as for individuals or small groups to join in with their transects. The data entered in such a system would be readily available for analysis and could feed into the European database for indicator calculation. Once again, an investment now would yield huge benefits later in an efficient system of biodiversity monitoring.

Online data entry systems make it possible to collect data in a much more efficient way. The combination with mobile devices, such as smartphones, will add extra new features in future.

6. Possible new indicators

As Butterfly Monitoring data is routinely collected in at least sixteen European countries and regions, the data has enormous potential to produce a wide range of other highly relevant indicators, including:

- Agricultural intensification indicator: butterflies could show the influence of the intensification of agriculture in Europe. Such an indicator could be developed out of the species' preferences for Nitrogen rich or poor situations.

- Agricultural abandonment indicator: we assume that after abandonment grassland butterflies are replaced by species with a preference for shrubs and woodland. Using the habitat preferences of butterflies we could give a grassland or shrub preference indication to all species, thus making it possible to test this indicator.

- Butterfly Grassland Indicators for different Natura 2000 priority grassland types (e.g. lowland dry calcareous grassland (*Festuco-Brometalia*) and Molinia meadows (*Molinion Caeruleae*).

- Woodland Butterfly Indicator: after grasslands, woodlands are the most important habitat for Europe's butterflies. Woodland butterflies can be divided into the canopy dwelling species and the species which prefer open woodland, where a lot of sun reaches the ground. The relative abundance of each group can be used to indicate changes in woodland structure and abandonment. Many threatened European butterflies occur in open woodland and populations are declining as these woodlands become more and more scarce all over Europe, partly due to the decline of livestock grazing in woodlands.

The development of such new indicators would require additional funding so that they are rigorously tested and the methods published. A system is also needed to streamline annual data collection from across Europe (see below). When this is completed, the production of the indicators would still require regular funding, but at a lower level.

After grasslands, woodlands are the most important habitat for butterflies in Europe. Especially open woodlands, like this one in Sweden, can be very rich in butterflies, both in species as in total numbers.

7. Conclusions and recommendations

- Butterfly Monitoring is enjoying a growing popularity and regular counts are being made in at least sixteen countries or regions across Europe.
- A standardised field method of butterfly transects is well described, has been tested scientifically and is accepted and used all over the continent.
- Butterfly Monitoring Schemes (BMS) have been active since 1976 and there is a broad experience and ability to help establish new schemes to improve coverage.
- Volunteers are important for collecting the data as well as for promoting a positive attitude towards butterflies and butterfly friendly land management in local communities.
- A co-ordinator is an important hub between the scientific demands (validation, quality control, research uses) and the volunteers.
- Butterflies are useful as biodiversity indicators for reporting on the development towards biodiversity targets.
- So far two indicators have been developed : the European Grassland Butterfly Indicator and the Climate Change Indicator.
- The ***indicator on European grassland butterflies*** was first developed in 2005 and is based on the European trend of 17 grassland butterflies. The most recent update (1990-2009) showed that grassland butterflies have declined by almost 70% since 1990.
- The Grassland Butterfly Index makes a good complement to the Farmland Bird Index, because butterflies are far more specific to grasslands and are more sensitive to changes in quality of these crucial habitats for biodiversity. They also operate at smaller spatial scales and are thus sensitive to site management. In comparison farmland birds are better indicators of arable and mixed farms and large spatial scales.
- The ***Climate Change Indicator*** shows that butterfly communities have shifted northwards by an equivalent of of 75 km in 20 years, whereas the temporal trend in temperature has shifted north by 246 km, showing that butterflies are lagging significantly behind climate change.
- **Recommendations**: Three recommendations are made for urgent investment by the EU to develop the use of butterflies as indicators as part of the EU Biodiversity 2020 Strategy:
  1. ***Construction of a central European database*** as well as a ***standard data entry system*** for butterfly monitoring data. This is essential to produce an efficient and more representative monitoring network that would allow regular updates as well as the development of an even wider range of indicators in the future.
  2. ***Extension of butterfly monitoring schemes*** to regions and countries that currently lack them, with training, advice and support for individuals and countries who want to start schemes.
  3. ***The development and testing of new indicators*** including an agricultural intensification indicator, an agricultural abandonment indicator, Butterfly Grassland Indicators for different Natura 2000 priority grassland types, and a Woodland Butterfly Indicator.

Literature

De Heer M, Kapos V, Ten Brink BJE, 2005. Biodiversity trends in Europe: development and testing of a species trend indicator for evaluating progress towards the 2010 target. *Proc. R. Soc. B* ***360***, 297-308.

Devictor V, Julliard R, Jiguet F, Couvet D, 2008. Birds are tracking climate warming, but not fast enough. *Proc. R. Soc. B* ***275***, 2743-2748.

Devictor V, Van Swaay CAM, Brereton T, Brotons L, Chamberlain D, Heliölä J, Herrando S, Julliard R, Kuussaari M, Lindström Å, Reif J, Roy DB, Schweiger O, Settele J, Stefanescu C, Van Strien A, Van Turnhout C, Vermouzek Z, WallisDeVries M, Wynhoff I, Jiguet F, 2012. Differences in the climatic debts of birds and butterflies at a continental scale. *Nature Climate Change* ***8*** JANUARY 2012, DOI: 10.1038/NCLIMATE1347.

European Commission, 2011. *Our life insurance, our natural capital: an EU biodiversity strategy to 2020.* Communication from the commission to the European Parliament, the council, the economic and social committee and the committee of the regions.

European Environment Agency, 2007. *Halting the loss of biodiversity by 2010: proposal for a first set of indicators to monitor progress in Europe*. EEA Technical report No 11/2007, Copenhagen.

European Environment Agency, 2010. *Assessing biodiversity in Europe — the 2010 report*. EEA Report No 5/2010, Copenhagen.

Heliölä J, Kuussaari M, 2005. *How many counts are needed? Effect of sampling effort on observed species numbers of butterflies and moths in transect counts*. In: Kühn ER, Feldmann R, Thomas JA, Settele J (Editors) Studies on the ecology and conservation of butterflies in Europe. Vol. 1: General concepts and case studies. (Series Faunistica No 52) Pensoft, Sofia and Moscow, pp. 83-84.

Henry P-Y, Manil L, Cadi A, Julliard R, 2005. *Two national initiatives for butterfly monitoring in France*, pp. 85. In: Kuehn E, Thomas JA, Feldmann R, Settele J (eds) Studies on the ecology and conservation of Butterflies in Europe. Vol 1: General concepts and case studies. Pensoft Publishers, Sofia, Bulgaria.

Kühn E, Feldmann R, Harpke A, Hirneisen N, Musche M, Leopold P, Settele J, 2008. Getting the public involved into butterfly conservation - Lessons learned from a new monitoring scheme in Germany. *Israel Journal of Ecology and Evolution* ***54***, 89-103.

Opperman R, Beaufoy G, Jones, G, 2012. *High Nature Value Farming in Europe: 35 European countries - experience and opportunities*. European Forum on Nature Conservation and Pastoralism, www.efncp.org.

Plattner, M., Nobis, M., 2009. *From Butterfly monitoring to model-predicted richness maps*. Presentation at: Future of Butterflies in Europe II, 17-19 April 2008. Wageningen.

Pollard E, 1977. A method for assessing changes in the abundance of butterflies. *Biological Conservation **12***, 115-134.

Pollard E, Yates TJ, 1993. *Monitoring Butterflies for Ecology and Conservation*. Chapman & Hall, London.

Roy DB, Rothery P, Brereton T, 2005. *The design of a systematic survey scheme to monitor butterflies in the United Kingdom.* In: Kühn ER, Feldmann R, Thomas JA, Settele J (Editors) Studies on the ecology and conservation of butterflies in Europe. Vol. 1: General concepts and case studies. (Series Faunistica No 52) Pensoft, Sofia and Moscow, pp 102-105.

Roy DB, Rothery P, Brereton T, 2007. Reduced-effort schemes for monitoring butterfly populations*. J. Appl. Ecol. **44***, 993-1000.

Settele J, Kudrna O, Harpke A, Kühn I, van Swaay CAM, Verovnik,R, Warren M, Wiemers M, Hanspach J, Hickler T, Kühn E, van Halder I, Veling K, Vliegenthart A, Wynhoff I, Schweiger O, 2008. Climatic risk atlas of European butterflies. *BioRisk **1***, 1-710.

Sutherland WJ, 2006. *Ecological Census Techniques*. 2ndedition Cambridge University Press, Cambridge.

Thomas JA, 2005. Monitoring change in the abundance and distribution of insects using butterflies and other indicator groups. *Phil. Trans. R. Soc. B **360***, 339-357.

Van Strien AJ, Van de Pavert R, Moss D, Yates TJ, Van Swaay CAM, Vos P, 1997. The statistical power of two butterfly monitoring schemes to detect trends. *Journal of Applied Ecology **34***, 817-828.

Van Swaay CAM, Plate CL, Van Strien A, 2002. Monitoring butterflies in the Netherlands: how to get unbiased indices. *Proceedings of the Section Experimental and Applied Entomology of the Netherlands Entomological Society (N.E.V.) **13***, 21-27.

Van Swaay CAM, Warren MS, Lois G, 2006. Biotope use and trends of European butterflies. *Journal of Insect Conservation (2006) **10***, 189–209.

Van Swaay CAM, Cuttelod A, Collins S, Maes D, Munguira ML, Sasic M, Settele J, Verovnik R, Verstrael T, Warren MS, Wiemers M, Wynhoff I, 2010. *European Red List of Butterflies*. Publications Office of the European Union, Luxembourg.

Van Swaay CAM, Brereton T, Kirkland P, Warren MS, 2012. *Manual for Butterfly Monitoring*. Report VS2012.010, De Vlinderstichting/Dutch Butterfly Conservation, Butterfly Conservation UK & Butterfly Conservation Europe, Wageningen.

Van Swaay, C.A.M., Van Strien, A.J., Harpke, A., Fontaine, B., Stefanescu, C., Roy, D., Maes, D., Kühn, E., Õunap, E., Regan, E., Švitra, G., Heliölä, J., Settele, J., Pettersson, L.B., Botham, M., Musche, M., Titeux, N., Cornish, N., Leopold, P., Julliard, R., Verovnik, R., Öberg, S., Popov, S., Collins, S., Goloshchapova, S., Roth, T., Brereton, T. & Warren, M.S. (2012). *The European Butterfly Indicator for Grassland species 1990-2011.* Report VS2012.019, De Vlinderstichting, Wageningen.