The European Butterfly Indicator for Grassland species: 1990-2013

The European Butterfly Indicator for Grassland species: 1990-2013

De Vlinderstichting

Butterfly Conservation Europe

The European Butterfly Indicator for Grassland species 1990-2013

Authors

Chris van Swaay, Arco van Strien, Karen Aghababyan, Sandra Åström, Marc Botham, Tom Brereton, Paul Chambers, Sue Collins, Marta Domènech Ferrés, Ruth Escobés, Reinart Feldmann, José María Fernández-García, Benoît Fontaine, Svetlana Goloshchapova, Ana Gracianteparaluceta, Alexander Harpke, Janne Heliölä, Gurgen Khanamirian, Romain Julliard, Elisabeth Kühn, Andreas Lang, Patrick Leopold, Jacqueline Loos, Dirk Maes, Xavier Mestdagh, Yeray Monasterio, Miguel López Munguira, Tomás Murray, Martin Musche, Erki Õunap, Lars Pettersson, Serhiy Popoff, Igor Prokofev, Tobias Roth, David Roy, Josef Settele, Constantí Stefanescu, Giedrius Švitra, Sérgio Marques Teixeira, Anu Tiitsaar, Rudi Verovnik, Martin Warren

Commissioner

This study/report was funded by and is the property of the European Environment Agency (EEA). The opinions expressed therein are those of the Contractor only and do not represent the Agency's official position.

Production

De Vlinderstichting, P.O. Box 506, NL-6700 Wageningen, Netherlands, www.vlinderstichting.nl
Butterfly Conservation Europe, www.bc-europe.eu
Statistics Netherlands, www.cbs.nl

Preferred citation

Van Swaay, C.A.M., Van Strien, A.J., Aghababyan, K., Åström, S., Botham, M., Brereton, T., Chambers, P., Collins, S., Domènech Ferrés, M., Escobés, R., Feldmann, R., Fernández-García, J.M., Fontaine, B., Goloshchapova, S., Gracianteparaluceta, A., Harpke, A., Heliölä, J., Khanamirian, G., Julliard, R., Kühn, E., Lang, A., Leopold, P., Loos, J., Maes, D., Mestdagh, X., Monasterio, Y., Munguira, M.L., Murray, T., Musche, M., Õunap, E., Pettersson, L.B., Popoff, S., Prokofev, I., Roth, T., Roy, D., Settele, J., Stefanescu, C., Švitra, G., Teixeira, S.M., Tiitsaar, A., Verovnik, R., Warren, M.S. (2015). *The European Butterfly Indicator for Grassland species 1990-2013.* Report VS2015.009, De Vlinderstichting, Wageningen

Keywords:

Butterfly, Monitoring, Trend, Index, Europe, European Union, Indicator, Biodiversity

April 2015

Authors and affiliations

Chris van Swaay, De Vlinderstichting/Dutch Butterfly Conservation, Wageningen, Netherlands,
Arco van Strien, CBS/Statistics Netherlands, Den Haag, Netherlands
Karen Aghababyan, TSE NGO Butterfly Conservation Armenia
Sandra Åström, Norwegian Institute for Nature Research (NINA), Trondheim, Norway
Marc Botham, NERC Centre for Ecology and Hydrology, Crowmarsh Gifford, United Kingdom
Tom Brereton, Butterfly Conservation, East Lulworth, Dorset, United Kingdom
Paul Chambers, Jersey, United Kingdom
Sue Collins, Butterfly Conservation Europe, Cambridge, United Kingdom
Marta Domènech Ferrés, Snow and Mountain Research Center of Andorra (CENMA-IEA), Andorra
Reinart Feldmann, Helmholtz Centre for Environmental Research - UFZ, Halle/Leipzig, Germany
José María Fernández-García, Hazi Foundation, Spain
Svetlana Goloshchapova, NGO Grassroots Alliance PERESVET, Bryansk, Russia
Ana Gracianteparaluceta, Hazi Foundation, Spain
Ruth Escobés, ZERYNTHIA Society, Spain
Benoît Fontaine, Muséum National d'Histoire Naturelle, Paris, France
Alexander Harpke, Helmholtz Centre for Environmental Research - UFZ, Halle/Leipzig, Germany
Janne Heliölä, Finnish Environment Inst., Natural Environment Centre, Helsinki, Finland
Romain Julliard, Muséum National d'Histoire Naturelle, Paris, France
Gurgen Khanamirian, TSE NGO Butterfly Conservation Armenia
Elisabeth Kühn, Helmholtz Centre for Environmental Research - UFZ, Halle/Leipzig, Germany
Andreas Lang, Büro Lang, Germany
Patrick Leopold, Landeskoordinator Tagfaltermonitoring NRW, Wachtberg, Germany
Jacqueline Loos, Leuphana University Lüneburg, Germany

European semi-natural grasslands are very rich in butterflies. This indicator therefore represents a large variety of species, including this Pyrgus sidae.

Dirk Maes, Research Institute for Nature and Forest (INBO), Brussels, Belgium
Xavier Mestdagh, Luxembourg Institute of Science and Technology, Belvaux, Luxembourg
Yeray Monasterio, ZERYNTHIA Society, Spain
Miguel López Munguira, Universidad Autónoma de Madrid, Spain
Tomás Murray, National Biodiversity Data Centre, Carriganore, Co. Waterford, Ireland
Martin Musche, Helmholtz Centre for Environmental Research - UFZ, Halle/Leipzig, Germany
Erki Õunap, University of Tartu, Estonia
Lars Pettersson, Swedish Butterfly Monitoring Scheme, University of Lund, Lund, Sweden
Serhiy Popoff, Uzhgorod, Ukraine
Igor Prokofev, NGO Grassroots Alliance PERESVET, Bryansk, Russia
Tobias Roth, Hintermann & Weber AG, Reinach, Switzerland
David Roy, NERC Centre for Ecology and Hydrology, Crowmarsh Gifford, United Kingdom
Josef Settele, Helmholtz Centre for Environmental Research - UFZ, Halle/Leipzig, Germany
Constantí Stefanescu, Butterfly Monitoring Scheme, Museu de Granollers de Ciències Naturals, Spain
Giedrius Švitra, Ukmerge, Lithuania
Sérgio Marques Teixeira, Madeira Fauna & Flora, Portugal
Anu Tiitsaar, University of Tartu, Estonia
Rudi Verovnik, University of Ljubljana, Ljubljana, Slovenia
Martin Warren, Butterfly Conservation, East Lulworth, Dorset, United Kingdom

Correspondence can be directed to Chris van Swaay (chris.vanswaay@vlinderstichting.nl)

Acknowledgements

Our special thanks goes to all the volunteers for their data collection. They are vital in producing overviews and indicators on the state of Europe's butterflies.

The BMS in the Basque Country is funded by the Environmental Department of the Basque Government.

Jo Loos (INBO, Belgium) helped in producing the dataset for Flanders. A. Anaksimovich was so kind to provide a lot of count data for the Bryansk region in Russia.

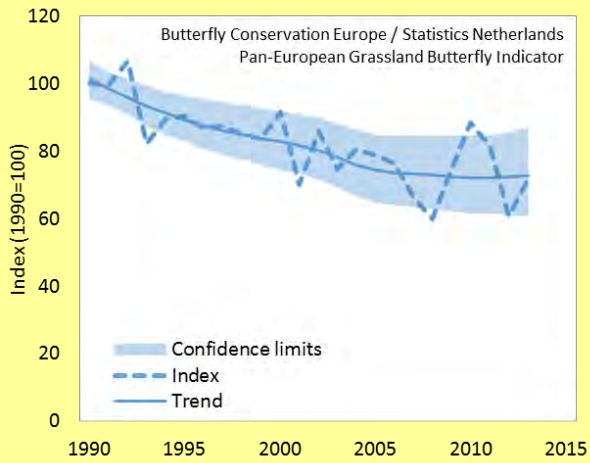
Michiel Wallis de Vries assisted with the TRIM calculations of national trends.

We thank Katarzyna Biala and Ivone Pereira Martins (European Environment Agency) for the pleasant co-operation.

Contents

Summary

- This report presents the fifth version of the European Grassland Butterfly Indicator, one of the EU biodiversity indicators of the European Environment Agency.
- The indicator is based on national Butterfly Monitoring Schemes in 22 countries across Europe, most of them active in the European Union.
- Fluctuations in numbers between years are typical features of butterfly populations. The assessment of change is therefore made on an analysis of the underlying trend.
- The underlying analysis of the indicator shows that since 1990, grassland butterfly abundance has declined by 30%.
- The rate of loss has slowed in the last 5-10 years and the priority now is to halt further losses and support recovery.
- Such a slowing in declines is good news if it can be sustained and losses begin to be reversed.
- This can only come about with greater protection and more sustainable management of semi-natural grassland.
- Of the seventeen widely occurring and characteristic grassland species included in the indicator, ten have declined in the EU, three have remained stable and three increased. For one species the trend is uncertain. The overall abundance of these grassland species is low and unacceptable losses are still occurring in many species.



The Pan-European Butterfly Indicator for Grassland species 1990-2013.
The indicator is based on Butterfly Monitoring Schemes in 22 European countries and seventeen characteristic grassland butterfly species.

- On a Pan-European scale, nine species have declined, three remained stable and three increased. For two species the trend is uncertain.

- It is vital to extend the protection and sustainable management of remaining semi natural grasslands across more of Europe's farmed landscape. New initiatives are also needed to support restoration and recovery of the ecological quality of grasslands that have become degraded.

- Three Grassland Butterfly Indicator species show some signs of recovery; research to determine the causal factors would help the design of effective recovery plans.

- The main driver behind the decline of grassland butterflies is the change in rural land use: agricultural intensification where the land is relatively flat and easy to cultivate; and abandonment in mountains and wet areas, mainly in Eastern and Southern Europe.

- Agricultural intensification leads to uniform, almost sterile grasslands for biodiversity. Fertilisation reduces plant diversity (both host-plants and nectar sources) and the cessation of haymaking in favour of more profitable silage regimes is particularly detrimental. Grassland butterflies thus mainly survive in traditionally farmed low input systems (High Nature Value Farmland) as well as nature reserves, and marginal land such as road verges and amenity areas.

- It should be noted that the biggest loss of butterflies in the intensified grasslands of Western Europe occurred before the 1990s and therefore don't show up in the indicator.

- Abandonment is caused by socio-economic factors. When farming on low productivity land brings only small incomes, and there is little or no support from the Common Agricultural Policy (CAP), farmers give up their enterprises and the land is left unmanaged. The grass quickly becomes tall and rank and is soon replaced by scrub and woodland.

- Reducing the abandonment of grasslands and greater financial support for HNV farming needs to be a key goal of EU agriculture policy and reflected in the implementation and further development of the Common Agriculture policy. Member States can choose to identify, designate and protect "Environmentally Sensitive Grasslands" under the CAP 2013 reforms. This flexibility needs to be used by all Member States, both inside and outside Natura 2000 sites, to help prevent further losses of HNV grasslands and support restoration.

Abandoned grasslands get overgrown by scrubs and trees leaving no habitat for grassland butterflies.

- The EU Biodiversity Strategy and Reports from EU Member States, under Article 17 of the Habitats Directive, recognise the poor conservation status of grasslands and of their characteristic butterflies. The actions set out in the EU Strategy need urgent implementation. Appropriate management is vital both within grasslands designated as Natura 2000 areas and on HNV farmland outside these areas. Better support for the farmers who manage these areas is needed.
- Without such changes to agricultural support under the CAP, rural communities which depend on low intensity farming will continue to decline, cultural landscapes will be lost and butterflies, moths and other pollinators will disappear.
- Butterflies belong to the few species groups for which Europe-wide monitoring is possible. Butterfly monitoring and the building of indicators on a regular basis should be supported by the EU and its Member States.
- The time contributed by volunteers in collecting and reporting this data amounts to more than 170,000 hours in 2013, which equates to over €1.7 million at €80 a day. This is a considerable contribution from individuals to EU policy.
- Butterflies offer the possibility to be used as a structural headline indicator, not only for grasslands, but also for other habitats and help evaluate agriculture policy and track other pressures such as climate change.

Chapter 1 / Introduction

The European Grassland Butterfly Indicator is one of the status indicators on biodiversity in Europe. It is based on the population trends of seventeen butterfly species in 22 countries. This report presents the fifth update of this indicator now covering 24 years.

At the Convention on Biological Diversity meeting in Nagoya (Japan) the Strategic Plan for Biodiversity 2011–2020 was adopted. It proposed five goals and 20 so-called Aichi biodiversity targets. In line with this plan a new EU biodiversity strategy was adopted by the European Commission in May 2011. This provided a framework for the EU to meet its own biodiversity objectives and its global commitments as a party to the CBD. The Headline Target 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. Under Target 3A the EU is committed to increasing the contribution of agriculture to biodiversity recovery. Europe now has five years left to intensify action to achieve this.

The strategy includes the development of a coherent framework for monitoring, assessing and reporting on progress in implementing actions. Such a framework is needed to link existing biodiversity data and knowledge systems with the strategy and to streamline EU and global monitoring, reporting and review obligations.

Some of the EU biodiversity indicators provide specific measurements and trends on genetic, species and ecosystem/landscape diversity, but many have a more indirect link to biodiversity. Very few were established specifically to assess biodiversity. The status indicators on species only cover birds and butterflies, recently expanded with bats (Van der Meij *et al.*, 2014), since these are the only taxa/species groups for which harmonized European monitoring data are available (EEA, 2012).

For the Grassland Butterfly Indicator the trends of seventeen widespread and characteristic grassland butterflies were assessed in 22 countries in Europe and the European Union. This report gives an overview of the results and presents the indicator.

Cyaniris semiargus ***is one of the indicator species of the European Grassland Butterfly Indicator.***

Chapter 2 / Building the European Grassland Butterfly Indicator

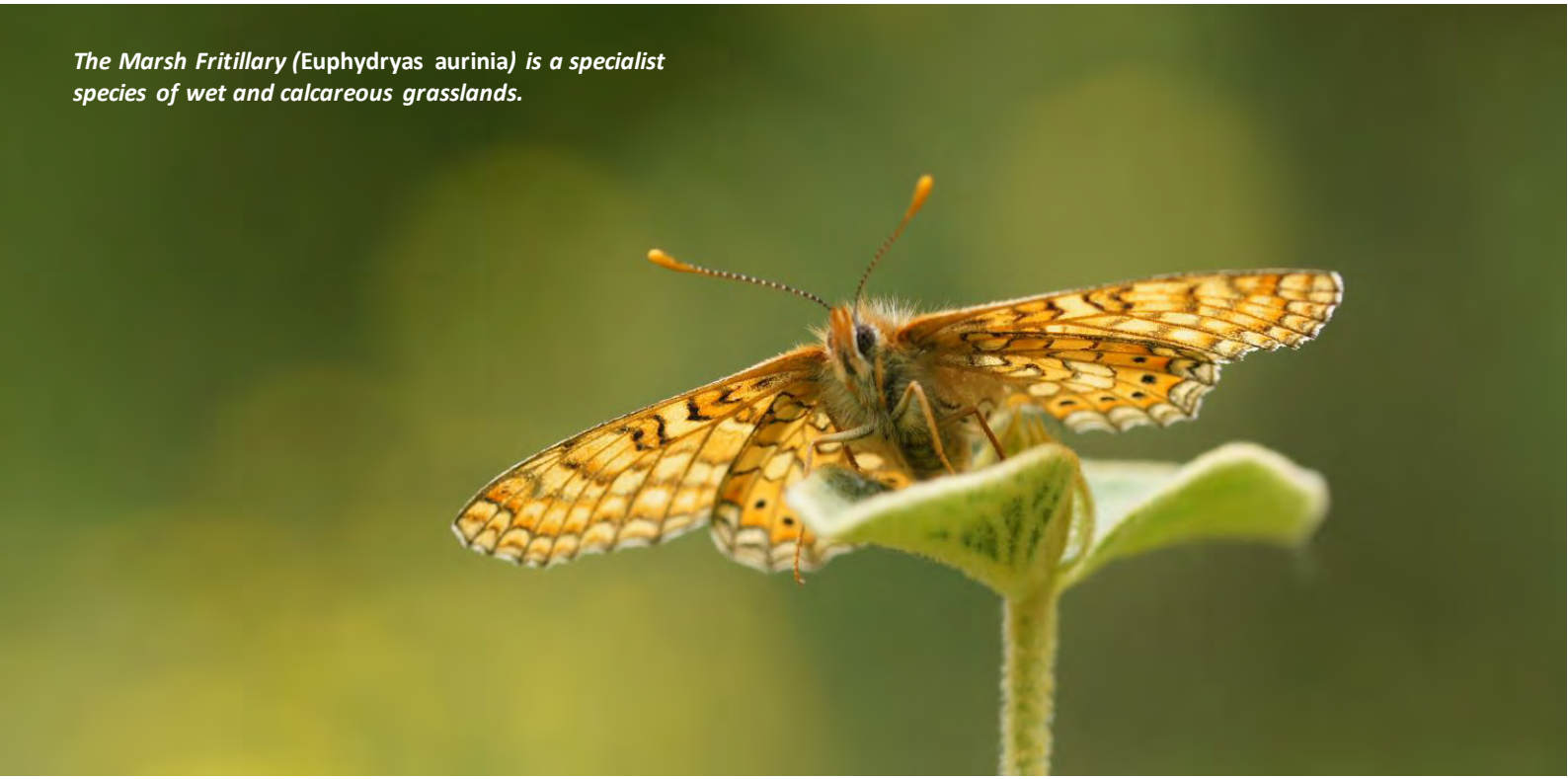
The European Grassland Butterfly Indicator shows the population trend for seventeen typical grassland butterflies. This chapter gives a brief overview of the methods.

Countries

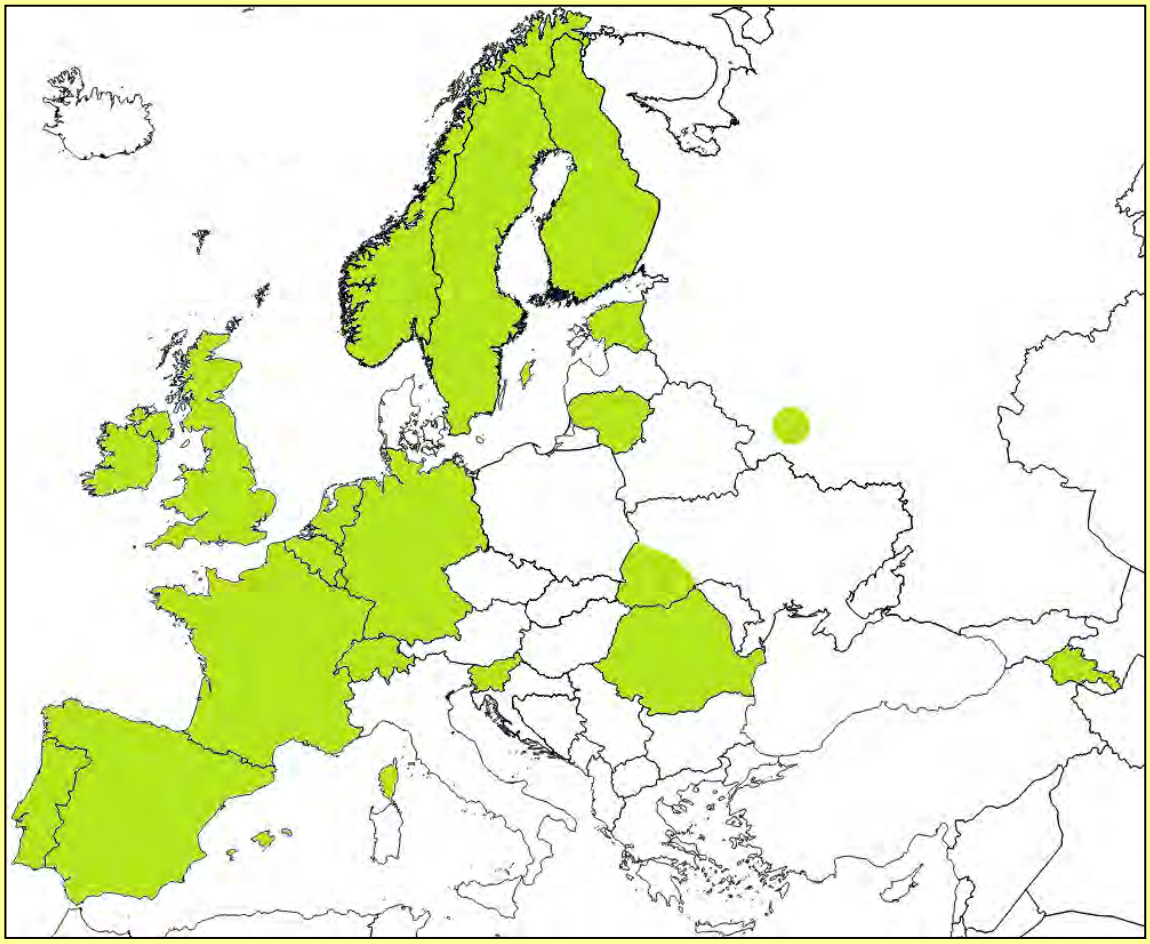
Butterfly monitoring enjoys a growing popularity in Europe. Map 1 shows the current Butterfly Monitoring Schemes (BMS). Although Butterfly Monitoring Schemes are present in a growing number of countries and new ones are being initiated in many places, long time-series are only available for a limited number of countries. For this new indicator data were used from 22 countries: Armenia, Andorra, Belgium, Estonia, Finland, France, Germany, Ireland, Jersey, Lithuania, Luxembourg, Norway, Portugal, Romania, Russia (Bryansk region), Slovenia, Spain, Sweden, Switzerland, The Netherlands, Ukraine (Transcarpathia) and the United Kingdom. Although there is a dataset available from Madeira, none of the grassland butterfly indicator species occur on this island.

In this report we update the European Grassland Butterfly Indicator, first published by Van Swaay & Van Strien in 2005. The updated indicator not only has a longer time-series, with data up to the 2013 field seasons now included, but also the method of calculating the indicator has been improved and enhanced. Furthermore new countries have been added.

The method closely follows the one for the bird indicators (Gregory *et al.*, 2005) and bat indicators (Van der Meij *et al.*, 2014).



*The Marsh Fritillary (*Euphydryas aurinia*) is a specialist species of wet and calcareous grasslands.*



Map 1: Countries contributing their data to the European Grassland Butterfly Indicator.

Andorra: since 2004
Armenia: since 2003
Belgium (Flanders): since 1991
Estonia: since 2004
Finland: since 1999
France: since 2005
Germany: since 2005 (Nordrhein-Westfalen since 2001, Pfalz-region for P. nausithous since 1989)
Ireland: since 2007
Jersey: since 2004
Lithuania: since 2009
Luxembourg: since 2010
Norway: since 2009
Portugal: 1998-2006
Romania: since 2013
Russia - Bryansk area: since 2009
Slovenia: since 2007
Spain: since 2009 (Basque Country since 2010; Catalonia since 1994)
Sweden: since 2010
Switzerland: since 2003 (Aargau since 1998)
The Netherlands: since 1990
Ukraine (Transcarpathia): since 1990
United Kingdom: since 1976

Not on the map: Madeira since 2012 (however none of the grassland indicator species occur there)

In 2013 butterflies were counted on more than 3700 transects.

Fieldwork

The Butterfly Indicator is based on the fieldwork of thousands of trained professional and volunteer recorders, counting butterflies on more than 3700 transects scattered widely across Europe (see map 1). These counts are made under standardised conditions. National coordinators collect the data and perform the first quality control. More details can be found in annex I.

The time contributed by volunteers in collecting and reporting this data amounts to more than 170,000 hours in 2013, which equates to over €1.7 million at €80 a day. This is a considerable contribution from individuals to EU policy.

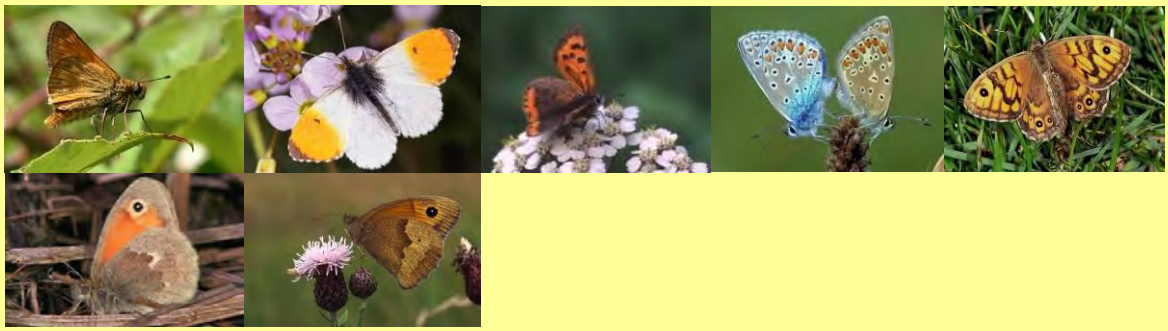
The Common Blue (*Polyommatus icarus*) is a typical butterfly of semi-natural grasslands.

Butterflies are recorded along transects. Most of these counts are done by volunteers, who are vital to the Butterfly Monitoring Schemes and to produce the indicator.

Grassland butterflies

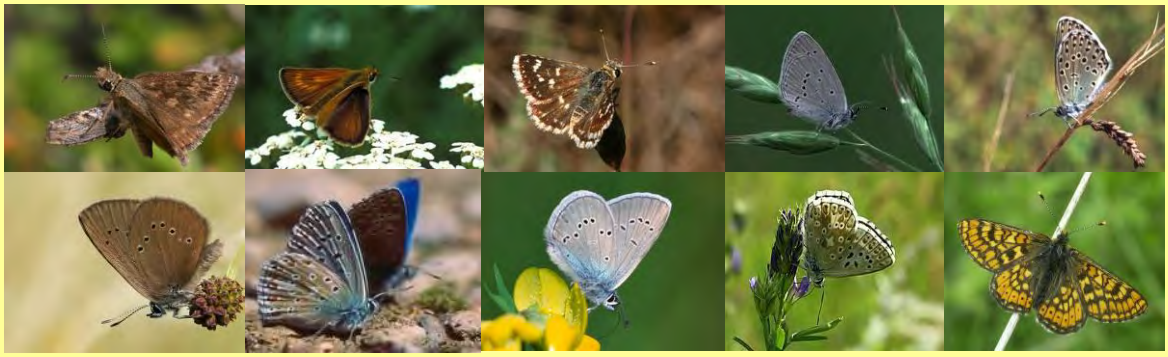
The same selection of grassland butterflies has been used as in the previous versions of this indicator. European butterfly experts selected species they considered to be characteristic of European grassland and which occurred in a large part of Europe, covered by the majority of the Butterfly Monitoring Schemes and having grasslands as their main habitat (Van Swaay *et al.*, 2006). The species are listed in figure 1.

Widespread Grassland butterflies



Widespread species: Ochlodes sylvanus, Anthocharis cardamines, Lycaena phlaeas, Polyommatus icarus, Lasiommata megera, Coenonympha pamphilus and Maniola jurtina

Specialist Grassland Butterflies



Specialist species: Erynnis tages, Thymelicus acteon, Spialia sertorius, Cupido minimus, Phengaris arion, Phengaris nausithous, Polyommatus bellargus, Cyaniris semiargus, Polyommatus coridon and Euphydryas aurinia

Figure 1: *Seventeen butterflies were used to build the European Grassland Butterfly Indicator, comprising seven widespread and ten specialist species.*

Population trend

National population trends from the Butterfly Monitoring Schemes (map 1), calculated by the program TRIM (Pannekoek & Van Strien, 2003) are combined to form supra-national species trends (chapter 3). These trends per butterfly species are then combined into an indicator: a unified measure of biodiversity following the bird indicators as described by Gregory *et al.* (2005), by averaging indices of species rather than abundances 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.

More details on the method can be found in the report of the previous indicator (Van Swaay *et al*, 2012) and in annex II. Although the Butterfly Monitoring Schemes are very similar, there are differences in choice of location, number of counts, etc. These are summarised in annex I.

Chapter 3 / Species trends

The European Grassland Butterfly Indicator is built from European species trends. In this chapter, we give an overview of the trends of grassland butterflies in Europe and the EU.

First, we calculate the trend in each country and for each species separately. Figure 2 shows four of the national trends for the Wall Brown (*Lasiommata megera*). The European trend is calculated for this species by weighted combining all the national trends (figure 2). The results show that this butterfly declined, especially in the early 1990s, and was more or less stable on a low level after that. In the EU, ten species show a decline and three are stable.

Three species show an increase and for one species the trend is uncertain (table 1). This means that overall grassland species are still declining, albeit at a slower rate than before. The challenge now is to halt the losses and start the recovery. In Europe nine species are declining and three are stable. Three species show an increase and the trend for the remaining two species is uncertain (table 2).

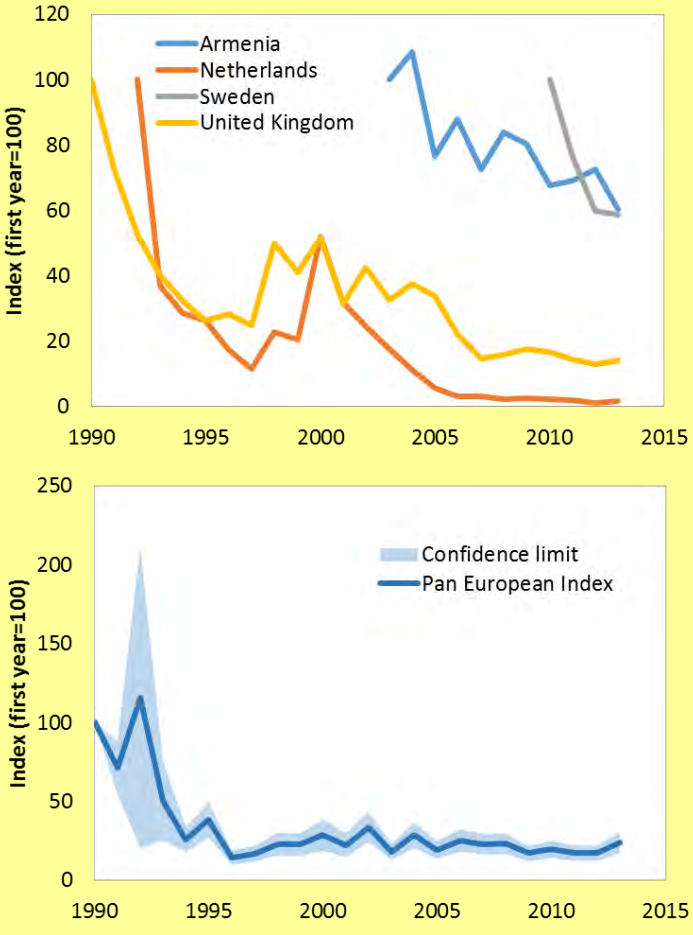


***Figure 2: National and Pan-European trends for the Wall Brown* (Lasiommata megera).**
The upper graph shows the trend for four selected Butterfly Monitoring Schemes. Note that the starting year (see also map 1) for each scheme is different. All indices are set to 100 for the first year of a scheme.
The lower graph shows the European trend, resulting from the four Butterfly Monitoring Schemes in the upper graph plus fourteen other countries.

Table 1: Supra-national EU trends of the 17 butterfly species of the European Grassland Butterfly Indicator. For the trend classification see annex II.
N2000: Species listed on the annexes of the Habitats Directive

Trend in EU	Species	Trend classification
Decline: 10 species	*Phengaris arion* N2000	moderate decline
	Lasiommata megera	moderate decline
	Euphydryas aurinia N2000	moderate decline
	Thymelicus acteon	moderate decline
	Erynnis tages	moderate decline
	Lycaena phlaeas	moderate decline
	Ochlodes sylvanus	moderate decline
	Coenonympha pamphilus	moderate decline
	Polyommatus icarus	moderate decline
	Maniola jurtina	moderate decline
Stable: 3 species	*Polyommatus bellargus*	stable
	Cyaniris semiargus	stable
	Cupido minimus	stable
Increase: 3 species	*Anthocharis cardamines*	moderate increase
	Polyommatus coridon	moderate increase
	Spialia sertorius	moderate increase
Uncertain: 1 species	*Phengaris nausithous* N2000	uncertain

When interpreting the species trends it is important to realise that:

- The coverage of the species' populations and thus the representativeness of the data may be lower at the beginning of the time series (see also map 1). As more countries join in later, the indices improve in accuracy each year.
- Large year to year fluctuations or a low number of transects, can cause large standard errors, leading to uncertain EU or Pan-European trends.
- In almost half of the EU countries there is no Butterfly Monitoring Scheme yet. The trends shown only represent the countries in map 1. However, because they are based on a wide range of countries, including the larger ones as France, Germany and the United Kingdom, we believe that they are reasonably representative of the EU as a whole.
- Apart from the EU countries the Pan-European trend is determined by Switzerland, the western part of Ukraine, the Bryansk area in Western Russia, Armenia and Norway. For many species these non-EU countries in the analysis represent only a minor part (sometimes less than 10%) of the distribution as compared to the EU countries.
- This means that the Pan-European trends in this report are dominated by the trend in the EU. Most of Russia, Ukraine, the Balkans and the Mediterranean are still not covered.
- It should also be noted that Article 17 Reports from EU Member States, in accordance with the EU Habitats Directive, show that the three butterfly species monitored for the Grassland butterfly Index that are listed in the Habitats Directive Annexes are in Unfavourable-inadequate or Unfavourable-bad condition in most biogeographical regions. Grassland habitats on which many European butterflies and other insects depend are also in Unfavourable–inadequate or -bad condition. This corroborates the concern that the overall state of butterflies and their grassland habitats is poor and determined action to halt further losses and support recovery is needed across the European farmed landscape.

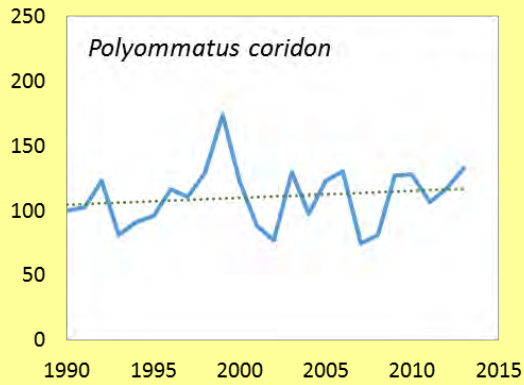
Table 2: Supra-national European trends of the 17 butterfly species of the European Grassland Butterfly Indicator. For the trend classification see annex II.
N2000: Species listed on the annexes of the Habitats Directive

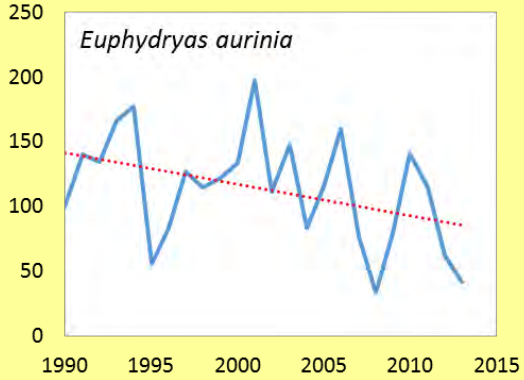
Pan-European trend	Species	Trend classification
Decline: 9 species	*Phengaris arion* N2000	moderate decline
	Lasiommata megera	moderate decline
	Euphydryas aurinia N2000	moderate decline
	Thymelicus acteon	moderate decline
	Lycaena phlaeas	moderate decline
	Ochlodes sylvanus	moderate decline
	Coenonympha pamphilus	moderate decline
	Polyommatus icarus	moderate decline
	Maniola jurtina	moderate decline
Stable: 3 species	*Erynnis tages*	stable
	Cyaniris semiargus	stable
	Polyommatus bellargus	stable
Increase: 3 species	*Anthocharis cardamines*	moderate increase
	Polyommatus coridon	moderate increase
	Spialia sertorius	moderate increase
Uncertain: 2 species	*Cupido minimus*	uncertain
	Phengaris nausithous N2000	uncertain

The Small Copper (*Lycaena phlaeas*) is declining both in the EU and in Europe.

Figure 3 shows some examples of Pan-European butterfly trends:

- The Chalkhill Blue (*Polyommatus coridon*), a species increasing at well-managed calcareous grassland sites.
- The Marsh Fritillary (*Euphydryas aurinia*) shows a significant decline, in spite of large year-to-year fluctuations. This butterfly is mainly found on wet grasslands and on calcareous grasslands.
- The Small Blue (*Cupido minimus*) is one of Europe's smallest butterflies. It shows strong fluctuations making the trend uncertain.





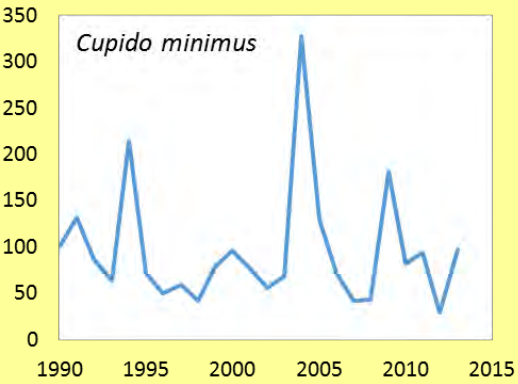


Figure 3: Pan-European population-trends of three butterflies in Europe.
The graphs present indices of abundance per year, where 1990 is set to 100.
*Top: The Chalkhill Blue (*Polyommatus coridon*) shows a significant increase.*
*Middle: The Marsh Fritillary (*Euphydryas aurinia*) is declining, although there are large year-to-year fluctuations.*
*Bottom: Large fluctuations make the trend of the Small Blue (*Cupido minimus*) uncertain.*

Chapter 4 / The indicator

The European Grassland Butterfly Indicator has been updated for the EU and Europe.
In this chapter both indicators are presented.

Figure 4a shows the European Grassland Butterfly Indicator just for the countries in the EU. The indicator is based on geometric mean of the supra-national species trends (as in the bird indicators, Gregory *et al*. 2005) as presented in chapter 3. As well as the yearly index-values of the indicator, a flexible trend with confidence intervals is presented (see annex II). The confidence limits of the indicator are based on the confidence limits from the separate species indices.

The indicator shows a significant rate of decline of 30%, most of which occurred in the period 1990-2005. The rate of decline seems to have slowed in the last 5-10 years compared with the previous period. As can be seen in the bar graph (figure 4b) several species are still declining while a few appear to have stabilised and three are showing some improvement albeit from a very low base.

So far, 1990-1992 represent the best years for butterflies in the indicator, with 2008 and 2012 as the years with the lowest population-indices.

When interpreting these graphs it should be remembered that a large decline of butterflies in NW Europe (countries all already in the EU for a long time) happened before 1990, so abundance was already at a low level at the baseline.

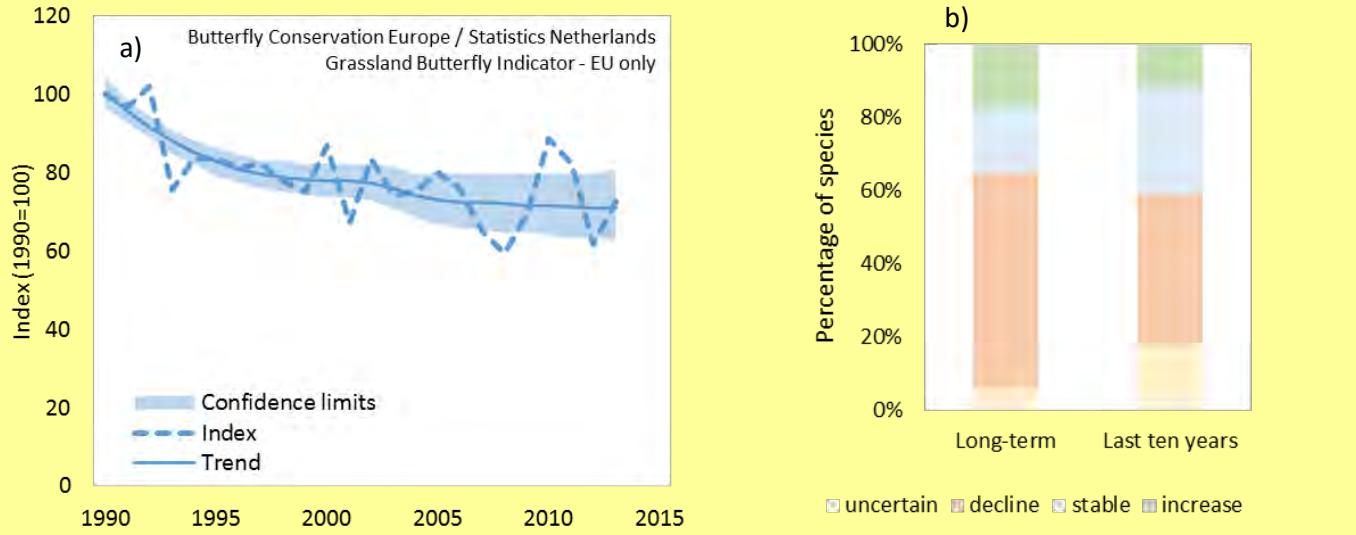


Figure 4: The Grassland Butterfly Indicator for the EU.
The indicators are based on the countries in map 1 in the EU and characteristic grassland butterfly species in figure 1.
a) The dashed line connects the annual index values of the indicator, the solid line shows the trend. The shaded areas represent the 95% confidence limits surrounding the trend.
b) Comparison of the long-term trends of species in the indicator (since 1990) and the last ten years.

Figure 5a shows the Pan-European Grassland Butterfly Indicator. The indicator is based on the supra-national species trends as presented in chapter 3, but with five additional countries participating. Next to the index-values of the indicator, a flexible trend with confidence intervals is presented. The indicator also shows a significant decline of 30%, mainly occurring in the period 1990-2005. The rate of decline seems to have slowed in the last 5-10 years, but losses are still occurring.
The bar graph (figure 5b) shows that in the last ten years fewer species are declining compared to their trend since 1990, and more species are stable. However the trend for the last ten years is also uncertain for five species due to large yearly fluctuations.

Although many species have a wide distribution outside the EU, the area represented by the BMS's outside the EU is still relatively small as compared to the ones inside the EU. For this reason the Pan-European indicator strongly resembles the EU indicator (figure 4). It would be of great value for the Pan-European indicator if butterfly monitoring could be started on more places in Eastern Europe, the Mediterranean and the Balkans. A major goal of Butterfly Conservation Europe (BCE) is to help new schemes develop in these and other countries.

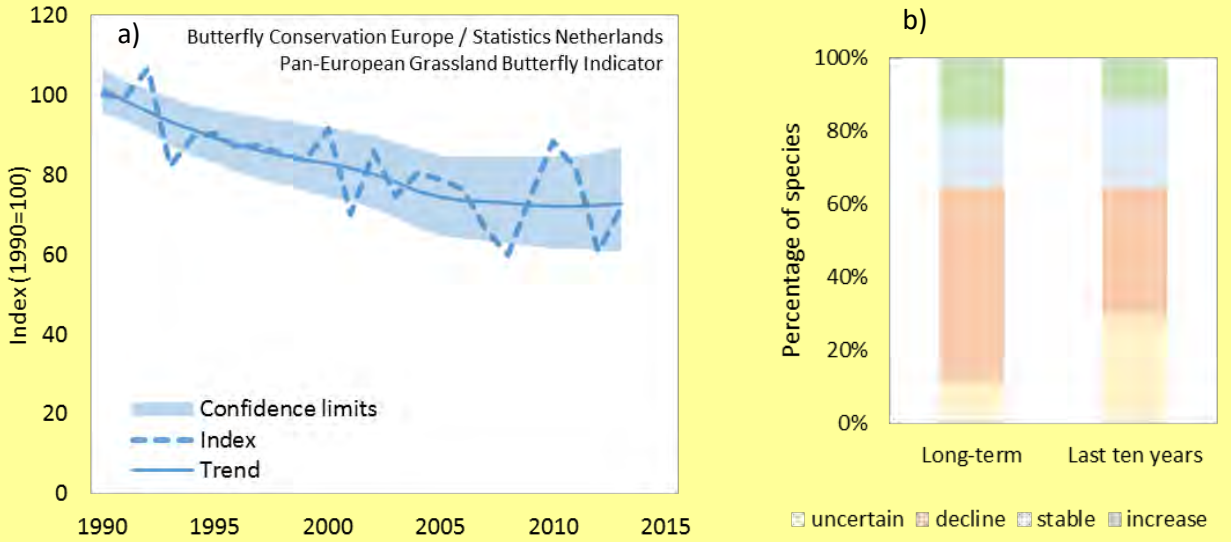


Figure 5: The pan-European Grassland Butterfly Indicator.
The indicators are based on the countries in map 1 and characteristic grassland butterfly species in figure 1.
a) The dashed line connects the index values of the indicator, the solid line shows the trend. The shaded areas represent the 95% confidence limits surrounding the trend.
b) Comparison of the long-term trends of species in the indicator (since 1990) and the last ten years.

Chapter 5 / Implications

The European Grassland Butterfly Indicator shows that butterfly numbers on grasslands have decreased by 30%. What does this mean for Europe's biodiversity?

The European Grassland Butterfly Indicators shows a clear negative trend up to 2005 (figures 4 and 5). In the last few years the decline seems to have slowed and stabilised somewhat. This stabilisation was also visible in the previous version of the indicator (Van Swaay *et al.*, 2012), but the extra years of monitoring have made this more clear.
Most of the species show a marked decline since 1990 (tables 1 and 2). However in the last few years increases for some species have masked the declines of others. Further studies to identify the factors contributing to improvements would be useful to help design future recovery plans.

When distinguishing the specialist and widespread species (figure 1) two different trends can be seen (figure 6; EU only):

- Especially in the beginning of the 1990s the widespread species declined severely, but remained more or less stable since then.
- During the 1990s the specialists remained fairly stable, since 2000 they show strong fluctuations.

Thomas (2005) argued that butterflies are good indicators of insects (but see Musters *et al.*, 2013), which comprise the most species rich group of animals in Europe. The trend in grassland butterflies is thus an indicator for the health of grassland ecosystems and their component biodiversity. As such, butterflies are complementary to birds as indicators (Thomas, 1994). Insects play a crucial role in pollination services and the health of the ecosystems on which they depend is important for Europe's future economic and social wellbeing.

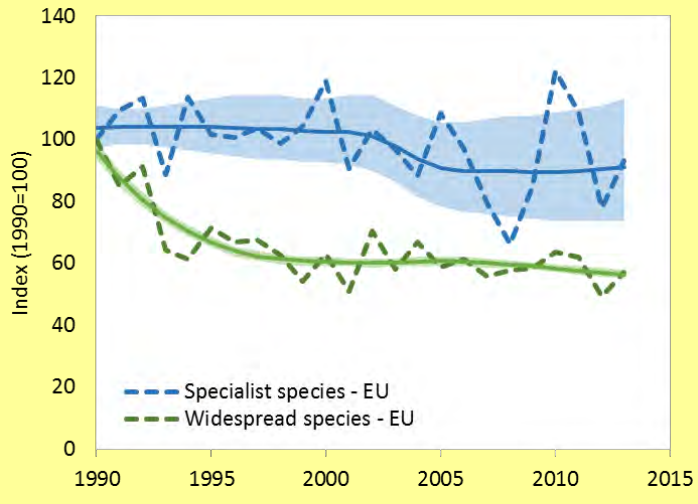


Figure 6: The Grassland Butterfly Indicators in the EU for specialist and widespread species.
The specialist and widespread species as described in figure 1 can be used to separate the indicator into these two groups of species.

Chapter 6 / Intensification and abandonment

Grassland butterflies have undergone an overall decrease in numbers. Their abundance declined by 30% since 1990. Although the precise causes for the decline are different for each species and country, the two main drivers are agricultural intensification and abandonment of grasslands.

Large parts of Europe are used for agricultural purposes, and grasslands are a major land-cover type within these areas. For centuries, grasslands have formed an important part of the European landscape. Sustainably managed semi-natural grassland harbours a high biodiversity, especially of plants, butterflies and many other insect groups (Collins & Beaufoy, 2012).

Grasslands are the main habitat for many European butterflies. Out of 436 butterfly species in Europe for which information on habitat type is available, 382 (88%) occur on grasslands in at least one country in Europe, and for more than half of the species (280 species, 57%) grassland is their main habitat.

Grasslands are the home for many European butterflies (Swallowtail, **Papilio machaon).**

Intensification

Until a few decades ago, semi-natural grasslands with a wide variety of flowers and butterfly food-plants were widespread and common all over the continent. Since the 1950s grassland management has undergone huge changes. In Western Europe, farming has intensified rapidly and over the last fifty years semi-natural grasslands have become greatly reduced in area. In some countries they are more or less confined to nature reserves or protected areas. In Eastern and Southern Europe semi-natural grasslands remained a part of the farming system until more recently. However, in the last few decades, these are also being lost and there has been a clear shift towards intensification, especially on relatively flat and nutrient rich areas.

Intensification comprises a wide range of activities, including the conversion of unimproved grasslands to arable crops, heavy use of fertilisers, drainage, the use of pesticides (Brittain *et al.*, 2010) including neonicotinoids, enlargement of fields, and the use of heavy machines. In its most extreme form the remaining agricultural land is virtually sterile with almost no butterflies. In such situations, butterflies can survive only on road verges, in remaining nature reserves and urban areas. Even then butterflies are not safe, as wind-drifted insecticides kill many larvae in road verges next to sprayed fields (Groenendijk *et al.*, 2002). Furthermore nitrogen deposition fertilises nutrient-poor meadows. This speeds up succession and leads to the paradox of micro-climatic cooling in combination with climate warming (WallisDeVries & Van Swaay, 2006).

As a consequence the biggest loss of butterflies in the intensified grasslands of Western Europe occurred **before the 1990s and therefore don't show up in the indicator**. As a result butterfly populations in these areas are already at a low level and are vulnerable to further losses of sustainably managed grassland and habitat fragmentation. As the Western European Butterfly Monitoring Schemes dominate the indicator in the 1990's and the first years of the 21st century, intensification is likely to be the main driver for the indicator trend in that period.

On intensively farmed grasslands there are no suitable breeding habitats for butterflies.

Abandonment

In most of Europe, grasslands are not the climax vegetation. Without any form of management, they would gradually change into scrub and forest. This means that grasslands and their butterflies are highly dependent on activities such as grazing or mowing. Traditional forms of farming management, such as extensive livestock grazing and hay-making where fertiliser and pesticide use are minimal, provide an ideal environment for these butterflies (Dover *et al.*, 2010).

In recent decades large areas of grassland have been abandoned, especially in areas that are too wet, steep, rocky or otherwise unsuitable for intensive farming. Furthermore, many villages in the European countryside have become abandoned for social reasons, often leading to young people moving to cities and only old people remaining. Following abandonment, some butterfly species flourish for a few years because of the lack of management, but thereafter scrub and trees invade and the grassland disappears, including its rich flora and butterfly fauna. Eventually, the vegetation reverts to scrubland and forest, eliminating grassland butterflies.

Additional threats

In addition to these two main drivers, there are other threats to grassland butterflies in Europe, including fragmentation and climate change. The intensification and abandonment of grassland leads to the fragmentation and isolation of the remaining patches (Van Strien *et al.*, 2011). This not only reduces the chances of survival of local populations but also makes it more difficult for butterflies to recolonise if they become locally extinct.

Climate change is also expected to have a serious effect on the distribution and population sizes of grassland butterflies in the future as grasslands face extreme weather events such as droughts or fire, or change their composition. In montane habitats, as temperatures rise, sensitive butterfly species may not be able to move to higher altitudes as there may be no further land to colonise or no suitable grassland habitats there. Flat areas could be even more affected by climate change, as butterflies have to move larger distances to follow the shift of their climatic niche. This could be a problem if no suitable habitat network exists with allows dispersal.

Abandoned grassland still can harbor butterflies for a few years, however these disappear as shrubs come in (as here in Northern Greece).

The recent slowing of the rate of loss and possible stabilisation of the indicators (figures 4 and 5) should be treated with great care. In general, climate warming favours cold-blooded animals like butterflies, which could mask for the effects of intensification. Furthermore in the most intensely used parts of Western Europe, butterfly numbers outside nature reserves have come to an absolute minimum, meaning it is unlikely for the indicator to further drop. In nature-reserves, including Natura 2000 areas, a lot of efforts have been made to restore nature and improve the quality. It is unclear if the stabilisation of the indicator in recent years can be attributed to this.

Future updates of the indicator will make clear how the grassland butterflies will develop in future. It is important to keep investing in Butterfly Monitoring Schemes to make this possible, as well as in research to reveal the underlying mechanisms.

Chapter 7 / Reversing the trend

The European Butterfly Indicator for Grassland species shows a clear decline, and the main drivers behind this are identified: intensification and abandonment. This chapter describes what can be done to reverse this trend.

As the majority of grasslands in Europe require active management by humans or sustainable grazing by livestock, butterflies also depend on the continuation of these activities. The main driver behind the decline of grassland butterflies is thought to be changes in rural land use. In some regions, grassland habitats have deteriorated due to agricultural intensification, while in other regions (such as more remote mountain areas) the main problem is land abandonment. In both cases, the situation for butterflies is the same, as their habitats become less suitable for breeding. When land use is intensified, host-plants often disappear or the management becomes unsuitable for larval survival. In the case of abandonment, the grassland quickly becomes tall and rank, and is soon replaced by scrub and eventually woodland (Collins & Beaufoy, 2012).

Natura 2000 network

In the intensively farmed parts of the European Union, the **Natura 2000 network**, as part of the **Habitats (92/43/EEC) and Bird (79/409/EEC) Directive,** is one of the most important tools to prevent further loss of grassland biodiversity. The network should give a positive lead with the conservation of the butterfly fauna of grasslands. Of the species listed in the Annexes of the Habitats Directive, three species were included as specialist species in the European Grassland Butterfly Indicator. One of them (*Phengaris nausithous,* formerly *Maculinea nausithous*) shows a decline, both in the European Union and across Europe. *Phengaris (Maculinea) arion* is declining in Europe, but the trend is uncertain in the EU. For *Euphydryas aurinia* it is uncertain in Europe and declining in the EU. Although there are signs that directed conservation effort can in some circumstances reverse a negative trend for these species (e.g. Wynhoff, 2001; Thomas *et al.*, 2009), it is also clear that small patches supporting specialised species that are not part of a wider metapopulation are very vulnerable to local extinctions. If such sites are isolated from nearby grasslands supporting healthy butterfly populations, there is little chance of recolonisation from surrounding or nearby patches. This is often the case in an intensified or abandoned landscape. Although the Natura 2000 network is vital to the survival of many species, management must guard against losses due to intensification and abandonment, and this instrument must be seen in the context of the wider landscape.

It is also vital that management measures within protected areas take the specific needs of butterflies into account (Van Swaay *et al.*, 2012). Large-scale management, for example targeted at birds or vegetation types without accommodating the needs of butterflies or other insects, might not benefit their populations and in some cases may actually harm them (e.g. large-scale, uniform management).

High Nature Value Farmland

Baldock *et al*. (1993) and Beaufoy *et al*. (1994) described the general characteristics of low-input farming systems in terms of biodiversity and management practices and introduced the term **High Nature Value (HNV) Farmland.** A first overview of the distribution of HNV farmland in Europe has been produced by Paracchini *et al*. (2008). Examples of HNV farmland areas are alpine meadows and pastures, steppic areas in Eastern and Southern Europe and dehesas and montados in Spain and Portugal. Such areas are vital for the survival of grassland butterflies across Europe and their maintenance provides the best long-term and sustainable solution. This will require the support of small farmers and their traditional way of life over relatively large areas, so they do not have to resort to intensification or abandonment as their only options.

The EU Biodiversity Strategy recognises the poor conservation status of grasslands and of their characteristic butterflies. The actions set out in this EU Strategy need urgent implementation. Appropriate management (through sustainable grazing or mowing) is vital both within grasslands designated as Natura 2000 areas and on High Nature Value Farmland outside these areas.

This will only be possible if there is a redirection of some Common Agriculture Policy funding into a new scheme to support such sustainable management and livelihoods in HNV areas. Such reform would have to address the socio-economic factors leading to abandonment and would address social as well as biodiversity problems. Reducing the abandonment of active meadow management and more financial support for HNV farming thus needs to be a key goal of EU agriculture policy and reflected in future reform of the CAP. A full discussion of the issues and case studies can be found in Opperman *et al*. (2012). Concerns that the CAP2013 reforms do not ensure agriculture will make an increasing contribution to biodiversity recovery are highlighted in Pe'er *et al*. (2014).

Without these changes to the CAP, rural communities which depend on low intensity farming will continue to decline, cultural landscapes will be lost and butterflies and other pollinators will disappear. Butterflies belong to the few species groups for which European wide monitoring is possible. Therefore butterfly monitoring and the building of indicators on a regular basis should be supported by the EU and its Member States.

Improving Knowledge

BCE has published guidance and specific advice for effective management of grassland for butterflies (the *Dos and Don'ts'*, Van Swaay *et al.*, 2012). It would be good if EU and Member State Farm Advisory Services could adopt and disseminate this advice to help farmers improve effectiveness of grassland management.

The Meadow Brown (Maniola jurtina) is one of the most widespread grassland butterflies.

Other measures

In some regions of North-western Europe, where intensification is the main driver, grassland butterflies are now almost restricted to rail or road verges, rocky or wet places, urban areas and nature reserves. For the common and widespread species verges can be an important habitat, certainly if the management of these areas consist of traditional mowing and hay making.

Although the management of nature reserves is mostly targeted at achieving a high biodiversity, butterflies still suffer from fragmentation of habitat. When a species disappears from a locality, even if this is by natural causes, the site often cannot be recolonised, as the nearest population is too far away. There are many examples of such isolated grassland habitats where species have disappeared one by one, leaving an impoverished fauna.

It is clear that, on its own, the Natura 2000 network will not be sufficient to halt the loss of grassland butterflies. Additional measures are needed urgently to encourage butterfly friendly grassland management across the EU. Abandonment is mostly caused by socio-economic factors, leading to farmers giving up marginal livestock farming and young people moving to cities and other urbanised areas. Often only older people remain in the villages, and one by one grasslands become abandoned. In other cases the landscape does not allow for intensive farming, and as farmers feel they cannot make a proper living, they leave the area, abandoning the grasslands. The conservation of grassland butterflies thus requires the creation of a viable European countryside where people can obtain sustainable livelihoods from grassland farming. To stop abandonment, we need to give farmers with High Nature Value Farmland much better support and give young farmers in these areas a future, while at the same time respecting long established farming traditions, as prescribed by the geography and landscape (see e.g. the case study for Romania: Loos *et al.*, 2014).

Chapter 8 / Developing butterfly monitoring and improving indicator production across Europe

Butterflies are among the few species groups where large-scale, continent-wide monitoring is feasible. We urge the European countries, the EU and its institutes to stimulate butterfly monitoring and secure butterfly indicators.

In this fifth version of the European Grassland Butterfly Indicator, new countries have joined in and thus the geographical scope of the indicator is improving rapidly, especially in the EU (see map 1). This makes butterflies, after birds, the first group for which European trends can be established and used for the evaluation of changes in biodiversity. The bird and butterfly indicators are now used in the indicator 'abundance and diversity of groups of species' (European Environment Agency, 2012). This is in fact one of the few 'direct' core biodiversity indicators, as most of the others represent pressures on biodiversity or social responses to biodiversity loss (Levrel *et al.*, 2010).

Butterflies appeal both to the general public and decision-makers (Kühn *et al.*, 2008). They are also fairly easy to recognize and therefore data on butterflies have been collected for many years and by thousands of voluntary observers. The method for monitoring butterflies is well described, extensively tested and scientifically sound (Pollard 1977; Pollard & Yates, 1993; Van Swaay *et al.*, 2008). As a result, butterflies are the only invertebrate taxon for which it is currently possible to estimate populationtrends among terrestrial insects (de Heer *et al.* 2005; Thomas, 2005).

Although the national and regional Butterfly Monitoring Schemes are often well founded in the national administration and monitoring results are used for many purposes, this is certainly not the case for all countries, including many EU member states. The basis for butterfly monitoring in countries like Lithuania and Slovenia depends completely on voluntary work without financial or personnel support by the governments. In most other countries in Eastern and Southern Europe there is no standardised butterfly monitoring at all despite their richness in butterflies. Information on how to establish a Butterfly Monitoring Scheme is now available (Van Swaay *et al.*, 2012) and it is urgent that schemes are established in these countries, supported by national and regional governments.

Together with the Spanish BC Europe partner ZERYNTHIA and the Andalusian butterfly conservation NGO Plebejus, BC Europe has been able to extend butterfly monitoring in Spain also outside Catalonia. The inclusion of BMS from Basque country, Norway and Armenia increases the representativeness of the indicators in the EU and throughout Europe. However additions in Eastern Europe, the Balkans and the Mediterranean would be welcome and will further improve the indicator.

This indicator shows that there are huge changes in butterfly diversity on European grasslands. It is therefore crucial that butterflies are incorporated into EU policy and monitored through changes with this indicator. The indicator gives a deeper insight in the wellbeing of not only butterflies, but also other insects and small animals.

Given the evidence of declines, we urge decision makers to act swiftly to integrate biodiversity concerns into sectoral policies and invest more in habitat protection, restoration and recreation, where feasible. If existing trends in land management continue, there will inevitably be further declines in butterflies, which in time will be catastrophic for the whole food chain that depends on invertebrates. EU Heads of Government recently committed themselves to avoiding such consequences and the time to act is now.

Although this is already the fifth version of the Grassland Butterfly Indicator, the indictor is still produced in the same ad-hoc way as the first one in 2005. The construction of indicators in this way, leaves no room for the long-term investments needed to ensure continuity and further improvements in indicator quality. However, in every updated version of the European grassland butterfly indicator, new countries join in and more 'old' data become available. The enlargement of the number of transects and countries, as well as better knowledge, greatly improves the quality of the indicator. The same process has happened for the bird indicators. However, the system of ad-hoc indicators, which has been followed so far, is not a solid basis to produce such important indicators. The authors urge the EU to ensure proper and structural funding to further develop the indicators and their quality, thus ensuring a robust product which can be used for multiple purposes. Adding butterfly indicators to the monitoring and indicator programs of the EU would also add the important group of insects to the structural indicators of biodiversity. Additional research is needed to reveal the details of the drivers behind the reported changes.

Chapter 9 / Conclusions

- This report gives an update of an indicator for Grassland Butterflies, which gives the trend of a selection of butterflies characteristic of European grasslands.
- The indicator is based on national Butterfly Monitoring Schemes from across Europe, most of them members of the European Union (see map 1).
- The results show that the index of grassland butterfly abundance has declined by 30% since 1990, indicating a dramatic loss of grassland biodiversity. Since some of the monitoring schemes are biased towards natural and species-rich areas, this trend is probably an underestimate.
- The indicator seems to indicate that the rate of decline has slowed in the last 5-10 years. However, ten of the seventeen characteristic grassland species included in the indicator have declined in the EU, while three have remained stable, three increased, and one species the trend is uncertain. The priority now is to halt further losses and support recovery.
- In North-western Europe intensification of farming is the most important threat to grassland butterflies. Protecting remaining semi natural grasslands in these areas and reversing fragmentation is essential to halt further losses.
- In many parts of the rest of Europe, abandonment is the key factor in the decline of grassland butterflies. Only if young farmers see a future for their families, while at the same time respecting long established farming traditions, can grassland butterflies be saved. Redirection of CAP funding to support sustainable farming of HNV areas is vital.
- The completion of the Natura 2000 network across Europe is an important way to help these butterflies. In addition restoration or recreation of mosaics of habitats at a landscape scale, both inside and outside Natura 2000 areas, are needed.
- EU Member States can now designate and protect 'Environmentally Sensitive Grassland" under CAP 2013. Much more use needs to be made of this instrument.
- BCE has published guidance and specific advice for effective management of grassland for butterflies (the '*Dos and Don'ts'*, Van Swaay *et al.*, 2012). It would be good if EU and Member State Farm Advisory Services could adopt and disseminate this advice to help farmers improve effectiveness of grassland management.
- The European Grassland Butterfly Indicator should become one of the headline indicators for biodiversity in Europe. It should also be used as a measure of the success of agriculture policies. Core funding of this and other butterfly indicators can guarantee the development of more robust indices and their extension to other habitats. This would assist with the validation and reform of a range of sectoral policies and help achieve the goal set by European Heads of Government to halt biodiversity losses and by 2020 restore, in so far as feasible, biodiversity and ecosystems.

Literature

Baldock D., Beaufoy G., Bennett G. & Clark, J. (1993). *Nature conservation and new directions in the common agricultural policy*. IEEP London.

Beaufoy G., Baldock D. & Clark, J. (1994). *The nature of farming. Low intensity farming systems in nine European countries*. Report IEEP/WWF/JNRC, London, Gland, Peterborough.

Brittain, C.A., Vighi, M., Bommarco, R., Settele, J. & Potts, S.G. (2010). Impacts of a pesticide on pollinator species richness at different spatial scales. *Basic and Applied Ecology* **11,** 106–115.

Collins, S. & Beaufoy, G. (2012). Improving the targeting, monitoring and management of semi-natural grasslands across Europe – essential steps to achieving EU Biodiversity Strategy targets on farmland. http://www.efncp.org/download/grasslands_report_2012.pdf

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

Dover, J.W., Spencer, S., Collins, S., Hadjigeorgiou, I. & Rescia, A. (2010). Grassland butterflies and low intensity farming in Europe. *Journal of Insect Conservation* **15 (1/2),** 129-137

European Environment Agency (2012*). Streamlining European biodiversity indicators 2020: Building a future on lessons learnt from the SEBI 2010 process*. EEA Technical report No 11/2012.

Gregory, R.D., Van Strien, A.J., Vorisek, P., Gmelig Meyling, A.W., Noble, D.G., Foppen, R.P.B. & Gibbons, D.W. (2005). Developing indicators for European birds. *Phil. Trans. R. Soc. B.* **360**, 269-288.

Groenendijk, D., Van Mannekes, M., Vaal, M. & Van den Berg, M. (2002). Butterflies and insecticides: a review and risk analysis of modern Dutch practice. *Proceedings of the Section Experimental and Applied Entomology of The Netherlands Entomological Society (N.E.V.)* **13**, 29-34.

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

Levrel, H., Fontaine, B., Henry, P-Y., Jiguet, F., Julliard, R., Kerbiriou, C., Couvet, D. (2010). Balancing state and volunteer investment in biodiversity monitoring for the implementation of CBD indicators: a French example. *Ecological Economics* **69**, 1510-1586.

Loos, J., Dorresteijn I., Hanspach J., Fust P., Rakosy L. & Fischer J. (2014). Low-Intensity Agricultural Landscapes in Transylvania Support High Butterfly Diversity: Implications for Conservation. *Plos One* **9(7)**, e103256.

Musters, C. J. M., Kalkman, V. & Van Strien, A. (2013). Predicting rarity and decline in animals, plants, and mushrooms based on species attributes and indicator groups. *Ecology and Evolution* **3**, 3401-3414.

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.

Pannekoek, J. & Van Strien, A.J. (2003). *TRIM 3 manual. Trends and Indices for Monitoring data.* CBS, Statistics Netherlands, Voorburg, Netherlands.

Paracchini, M.L., Petersen, J.E., Hoogeveen, Y., Bamps, C., Burfield, I, Van Swaay, C.A.M. (2008). *High Nature Value Farmland in Europe. An estimate of the distribution patterns on the basis of land*

cover and biodiversity data. European Commission, Joint Research Centre, Institute for Environment and Sustainability.

Pe'er, G., Dicks, L.V, Visconti, P., Arlettaz, R., Báldi, A., Benton, T.G., Collins, S., Dieterich, M., Gregory, R.D., Hartig, F., Henle, K., Hobson, P.R., Kleijn, D., Neumann, R.K., Robijns, T., Schmidt, J., Shwartz, A., Sutherland, W.J., Turbé, A., Wulf, F. & Scott, A.V. (2014). EU agricultural reform fails on biodiversity. *Science* **344 (6188)**, 1090-1092.

Pollard, E. (1977). A method for assessing changes in the abundance of butterflies. *Biological Conservation* **12 (2)**, 115-134.

Pollard, E. & Yates, T.J. (1993). *Monitoring Butterflies for Ecology and Conservation*. Chapman & Hall, London.

Sutherland, W.J. (2006). *Ecological Census Techniques*. 2nd edition Cambridge University Press, Cambridge.

Thomas J.A. (1994). Why small cold-blooded insects pose different conservation problems to birds in modern landscapes. *Ibis* **137**, 112-119.

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

Thomas, J.A., Simcox, D.J., Clarke, R.T. (2009). Successful conservation of a threatened Maculinea butterfly. *Science* **325**, 80-83.

Van der Meij, T., Van Strien, A.J., Haysom, K.A., Dekker, J., Russ, J., Biala, K., Bihari, Z., Jansen, E., Langton, S., Kurali, A., Limpens, H., Meschede, A., Petersons, G., Presetnik, P., Prüger, J., Reiter, G., Rodrigues, L., Schorcht, W., Uhrin, M. Vintulis, V. (2014). Return of the bats? A prototype indicator of trends in European bat populations in underground hibernacula. *Mammalian Biology*. http://dx.doi.org/10.1016/j.mambio.2014.09.004

Van Strien, A., Van Swaay, C.A.M., Kéry, M. (2011). Metapopulation dynamics in the butterfly Hipparchia semele changed decades before occupancy declined in the Netherlands. *Ecological Applications* **21 (7)**, 2510-2520.

Van Swaay, C.A.M., Plate, C.L. & 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, C.A.M. & Van Strien, A.J. (2005). *Using butterfly monitoring data to develop a European grassland butterfly indicator*. In: Kuehn, E., Thomas, J., Feldmann, R. & Settele, J. (eds.) 2005. Studies on the Ecology and Conservation of Butterflies in Europe. Proceedings of the Conference held in UFZ Leipzig, 5-9th of December, 2005.

Van Swaay, C.A.M. & Warren, M.S. (1999). *Red data book of European butterflies (Rhopalocera).* Nature and environment ; no. 99, Council of Europe Publishing, Strasbourg.

Van Swaay, C.A.M., Warren, M.S. & Loïs, G. (2006). Biotope use and trends of European butterflies. *Journal of Insect Conservation* **10 (2)**, 189-209.

Van Swaay, C.A.M., Nowicki, P., Settele, J. & Van Strien, A.J. (2008). Butterfly monitoring in Europe: methods, applications and perspectives. *Biodiversity and Conservation* **17 (14),** 3455-3469

Van Swaay, C.A.M.; Cuttelod, A.; Collins, S.; Maes, D.; López Munguira, M.; Šašic, M.; Settele, J.; Verovnik, R.; Verstrael, T.; Warren, M.; Wiemers, M.; Wynhoff, I. (2010). *European Red List of butterflies*. IUCN Red List of Threatened Species - Regional Assessment - Office for Official Publications of the European Communities, Luxembourg.

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., Prokofev , I. 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.

Van Swaay, C.A.M., Collins S., Dusej G., Maes D., Munguira M.L., Rakosy L., Ryrholm N., Šašić M., Settele J., Thomas J.A., Verovnik R., Verstrael T., Warren M.S., Wiemers M. & Wynhoff I. (2012). Do's and Don'ts for butterflies of the Habitats Directive of the European Union. *Nature Conservation* **1**: 73-153.

WallisDeVries, M.F. & Van Swaay, C.A.M. (2006). Global warming and excess nitrogen may induce butterfly decline by microclimatic cooling. *Global Change Biology* **12 (9)**, 1620-1626.

Wynhoff, I. (2001). *At home on foreign meadows: the reintroduction of two Maculinea butterfly species*. Thesis Wageningen University.

Annex I / Butterfly Monitoring Schemes in the indicator

Since the start of the first Butterfly Monitoring Scheme in the UK in 1976 more and more countries have joined in. This annex summarizes the most important features of the schemes used for the European Grassland Butterfly Indicator.

Field methods

All schemes apply the method developed for the British Butterfly Monitoring Scheme (Pollard & Yates, 1993). The counts are conducted along fixed transects of 0.5 to 3 kilometres, consisting of smaller sections, but the exact transect length varies among countries. The fieldworkers record all butterflies 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.*, 2012). Butterfly counts are conducted between March-April to September-October, depending on the region. Visits are only conducted when weather conditions meet specified criteria. The number of visits varies from every week in e.g. the UK and the Netherlands to 3-5 visits annually in France (table 3).

Transect selection

To be able to draw proper inferences on the temporal population trends at national or regional level, transects should best be selected in a grid, random or stratified random manner (Sutherland, 2006). Several recent schemes, e.g. in Switzerland and France, have been designed in this manner (Henry *et al.*, 2005). If a scheme aims to monitor rare species, scheme coordinators preferably locate transects in areas where rare species occur, leading to an overrepresentation 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, which in some cases has led to the overrepresentation of protected sites in natural areas and the undersampling of the wider countryside and urban areas (Pollard & Yates, 1993), though this is not the case in all countries (e.g. Germany, Kühn *et al.*, 2008). Obviously, in such a case the trends detected may be only representative for the areas sampled, while their extrapolation to national trends may produce biased results. Such bias can however be minimized by post-stratification of transects. This implies an a posteriori division of transects by e.g. habitat type, protection status and region, where counts per transect are weighted according to their stratum (Van Swaay *et al.*, 2002).

Species set

The grassland indicator is based on seven widespread grassland species (*Ochlodes sylvanus, Anthocharis cardamines, Lycaena phlaeas, Polyommatus icarus, Lasiommata megera, Coenonympha pamphilus and Maniola jurtina*) and ten grassland-specialists (*Erynnis tages, Thymelicus acteon, Spialia sertorius, Cupido minimus, Phengaris arion, Phengaris nausithous, Polyommatus bellargus, Cyaniris semiargus, Polyommatus coridon and Euphydryas aurinia*). See also figure 1.

Table 3: Characteristics of the Butterfly Monitoring Schemes used for the European Grassland Butterfly Indicator.

Country	Starting year	Area represented (w=whole country, r=region)	Average transect length (km)	Number counts per generation	Number of transects per year 2011-2013 (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 co-ordinator, g=grid, r=random)	representative for agricultural grassland*	Nature reserves overrepresented*
Armenia	2003	w	0.4	1	37-47	1-4	p	f	yes	yes
Andorra	2004	w	1.3	3	7	20-30	v	f	yes	yes
Belgium - Flanders	1991	r	0.8	3	10	15-20	v	f	no	no
Estonia	2004	w	1.8	2.5	11	7	p	c	no	no
Finland	1999	w	3	3	65-67	ca 11	v ~80%. p ~20%	f for v	yes	no
France	2005	w	1	2	611-723	4.4 (1-15)	v	half r, half f	yes	no
Germany	2005	w	0.5	3	400	15-20	v	f	yes	yes
Germany - Nordrhein Westfalen	2001	r	1	3	100	15-20	v	f	no	yes
Germany – Pfalz (*Phengaris nausithous* only)	1989	r	0.5	1	50-87	1	p	c	yes	no
Ireland	2007	w	1.5	7	123-140	14.6	v	f	yes	no
Jersey	2004	w	1	2	24-31	18-20	v	c	yes	no
Lithuania	2009	w	1.3	3	14	6-9	v	f	no	no
Luxembourg	2010	w	0.34	2.5	30	8.2 (3-11)	v ~10%. p ~90%	r	yes	no
Norway	2009	r	1	1	16-52	3	v -100%	g	yes	no
Portugal	1998-2006	w	1	2	0	3-5	v	f	no	no
Portugal - Madeira	2012	r	1	1.5	8	15 - 20	v-70% p-30%	c	no	yes
Romania	2013	r	0.2-1.0	4	8-20	3-5	v-60%. p-40%	c	yes	no
Russia - Bryansk area	2009	r	1.2	3	14-54	1-9	v ~90%. p ~10%	f	yes	no
Slovenia	2007	w	1.3	7	9-14	6.25 - 7.53	v	c	yes	no
Spain - Basque Country	2010	r	1.7	2	25	10	v 70%. p 30%	f	yes	yes
Spain - Catalonia	1994	r	1	3	60-70	30	v	f	yes	no
Spain (excl. Catalonia and Basque Country)	2014	w	1.5	3	100	10-30	v ~50%. p ~50%	f	yes	yes
Sweden	2010	w	0.65	3	289	4	v ~90%. p ~10%	f	yes	no
Switzerland	2003	w	2 x 2.5	1	90-95	7 (4 alpine region)	p	g	yes	no
Switzerland - Aargau	1998	r	2 x 0.250	1.5	101-107	10	p (civil service)	g	yes	no
The Netherlands	1990	w	0.7	5	450	17 (15-20)	v	f	yes	no
Ukraine – Carpathians and adjacent parts	1990	r	1-3	1	196	5 (2-10)	v	f	yes	yes
United Kingdom	1973 (1976)	w	2.7	5	819-977	19	v	f	yes	yes

**: assessed by experts opinion. In case a monitoring scheme is not representative for agricultural grasslands and/or nature reserves are overrepresented, it means that the resulting trends may be biased towards non-agricultural areas (often nature reserves), where management is focussing on the conservation of biodiversity. Such a scheme probably underestimates the (mostly negative) trend of butterflies in the wider countryside.*

Annex II / Method

We used the following procedure to compute the grassland indicator.

- The national coordinators of monitoring scheme provided their count data. More specific, we received yearly counts per site per year in which the results of various visits were aggregated. We used this to calculate national indices for each species for which monitoring data were available. The indices were produced using Poisson regression as implemented in the widely used program TRIM (Pannekoek & Van Strien, 2005). In addition to indices, TRIM calculates overall slopes for the entire time series available or selected parts of the time series, such as from 1990 onwards.
- The national indices were checked on reliability and magnitude of confidence intervals. Indices were not used if the time series were very short, based on few sites or observations only or if standard errors of the overall slopes were extremely large (>0.5).
- Supra-national indices were generated by combining the time-totals in TRIM. To generate these supra-national indices, the differences in national population size of each species in each country were taken into account. This weighting allows for the fact that different countries hold different proportions of a species' European population (Gregory *et al.,* 2005). But we applied area weighting rather than population weighting as in Gregory *et al*. (2005), because no national population estimates for butterflies are available. This implies that we treated the proportions of each country (or part of the country) in the European distribution of a species (based on Van Swaay & Warren, 1999 and adapted according to Van Swaay *et al*., 2010) as weights. The missing year totals in particular countries with short time series were estimated by TRIM in a way equivalent to imputing missing counts for particular transects within countries (Gregory *et al.,* 2005).
- In this updated indicator, we also took into account differences in the number of visits and transect length between schemes. Three different types of data were received from the national coordinators; (i) the average yearly number across all visits per site, (ii) the yearly sum of the number of individuals seen during all visits as well as the associated number of visits for each site and (iii) the yearly sum of the number of individuals seen during all visits but without exact information on the number of visits per site. The second data type was made equivalent to the first data type by applying 1/number of visits for each site as weights in the calculation of *national* indices. The third data type was made equivalent by applying weights in the calculation of the *supranational* indices. These latter weights were based on the estimated average number of visits and the number of generations covered. Differences in transect lengths were also included in the weights in the calculation of supranational indices. The weights to account for the different number of visits and transect length were then combined with the area weights.

- Species indices were combined in a grassland indicator by taking the geometric mean of the supranational indices.
- The confidence intervals of underlying species are taken into account in the confidence interval of the indicator. Therefore, the error propagation is better and the indicator can also be tested. The trend classification of the indicator corresponds to that of the individual species.
- Few species had missing indices for some years at the supranational level. These were estimated using a chain index before calculating the indicator.
- Results of supranational indices per species were checked on consistency with national indices and results in Van Swaay *et al*. (2010). Supranational indicators were compared with national indicators to test if the supranational indicators were mainly based on the results of one or a few countries only. This was not the case.
- For the EU the trend is very similar to the one in the previous report (Van Swaay *et al*., 2012). For Pan-Europe the decline is smaller, mainly because the weight of the BMS in Ukraine has been lowered. In the original indicator of 2005 this scheme was regarded as representative for the whole of Ukraine (which is a large country), now it represents only the very western point of this country. This gives this BMS, where many species are in decline, considerable lower weight.
- Trend classification: the multiplicative overall slope estimate (trend value) in TRIM (Pannekoek & Van Strien, 2003) is used to classify the trend (table 1 and 2):
    - Decline: significant decline where the upper limit of the confidence interval <1.00. A moderate increase or decline means a significant change of less than 5% per year since 1990, in a steep increase or decline this is more than 5%.
    - Stable: no significant increase or decline, and it is certain that the trends are less than 5% per year.
    - Uncertain: no significant increase or decline, lower limit of confidence interval <0.95 or upper limit >1.05.

Potential biases

Although the Butterfly Monitoring Schemes are very similar, there are differences in choice of location, number of counts, corrections for unstratified sampling, etc. These are summarised in annex I. These changes can potentially lead to biases. It is also important to note that in countries where the choice of the location for the transect is free (table 2), there is an oversampling in species-rich sites, nature reserves or regions with a higher butterfly recorder density. The trend of butterflies within nature reserves may be expected to be better than in the wider countryside, since the management of these reserves focuses on reaching a high biodiversity and positive population trends. This suggests that the grassland indicator is probably a conservative measure of the real trend across the European landscape. There is a risk that the decline in the population size of butterflies is actually more severe than the indicator shows. We hope to be able to test this in future.

Annex III / Improving the indicator and building other butterfly indicators

This report presents the fifth version of the European Grassland Butterfly Indicator. In this section we indicate important ways to further improve the quality of the indicator and possibilities for new indicators.

Like the previous versions, this Grassland Butterfly Indicator was produced on an ad-hoc basis. Although this generates a useful indicator, there are many procedures that could be improved if more structural funding would become available. Many of these would lead to the same improvements as the bird indicators have undergone. They include:

- A full and standardized quality control. Although all controls have now been made on an ad-hoc basis, this is relatively time-consuming and offers the chance that controls are forgotten or misinterpreted. We would prefer to build a solid database, in which all possible controls and assessment could be standardized and performed on demand. These controls should also include checks for all existing combinations of species and country and a comparison with species trends per country of earlier assessments. However this involves a long-term investment.

- As described in annex II, national data are weighted to build supra-national trend. Besides a correction for the part of the European distribution, corrections are performed for the average length of a transect (if transects in a country are much longer than in others, the numbers have to be downweighted), the number of counts (if much more counts are made in one country, the numbers have to be downweighted) and the number of generations – if the species has more than one generation per year – (if the numbers of two or three generations are added, they have to be downweighted to compare them with a country where only the data of one generation are given). It would be good to standardize the input as much as possible and to perform the weighting as much as possible per species (now often per country). This can be built into a database as a long-term investment.

- If the data needed to build the indicator were collected from the national co-ordinators in a more standardized way every year (so not on an ad-hoc basis), the preparation of new indicators could be much more flexible. There is already good evidence that butterflies are very suitable to produce a European Butterfly Climate Change Indicator (Van Swaay *et al.*, 2008). It would also be possible to produce valuable indicators of other habitats, including a woodland, heathland and wetland indicator.