The European Butterfly Indicator for Grassland species: 1990-2015

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De Vlinderstichting

Butterfly Conservation Europe

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***European semi-natural grasslands are very rich in butterflies. This indicator therefore represents a large variety of species, including this Spanish Festoon*, Zerynthia rumina.**

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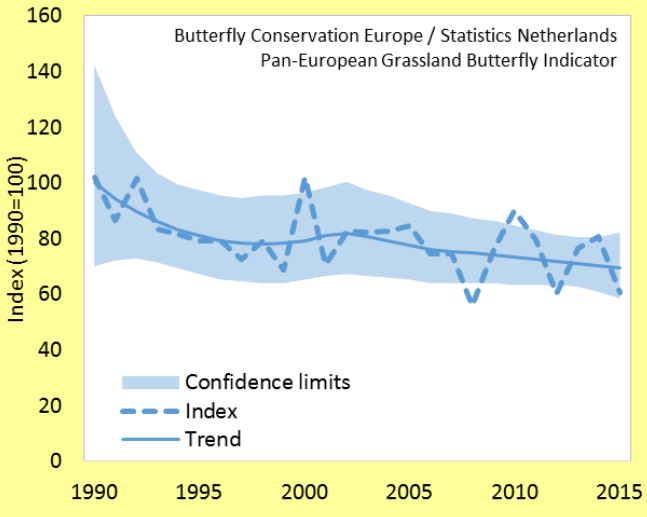
Contents

Summary

- This report presents the sixth version of the European Grassland Butterfly Indicator, one of the EU biodiversity indicators of the European Environment Agency.
- The indicator is based on more than 9200 transects in national Butterfly Monitoring Schemes covering 22 countries across Europe, most of them active in the European Union. In 2015, counts were made in more than 4500 transects.
- Butterflies represent the largest animal group (insects), highly included in food webs, having a high impact on ecosystem services and stability. This report does not represent only the patrimonial conservation of some species, but indicates the changes in biodiversity on grasslands and discusses underlying causes.
- 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.
- Indicators were produced on EU, European (EU plus Norway and Switzerland) and pan-European level (including Ukraine, Russia and Armenia).
- 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. Part of this slowing down might be caused by climate warming, as this favours cold-blooded animals like butterflies, thus masking the effects of intensification. In 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.
- The priority now is to halt further losses and support recovery. This can only come about with greater protection and more sustainable management of semi-natural grassland.



The Pan-European Butterfly Indicator for Grassland species 1990-2015.
The indicator is based on Butterfly Monitoring Schemes in 22 European countries and seventeen characteristic grassland butterfly species.

- Of the seventeen widely occurring and characteristic grassland species included in the indicator, five have declined in the EU, eight have remained stable and four increased. The overall abundance of these grassland species is low and losses are still occurring in many species.
- On a European and Pan-European scale the trends are similar. This can be expected as there is a high overlap in countries, with most countries in the indicator in the EU.
- In a new analysis of trends by country (Fig 8), most declining widespread grassland species are found in the United Kingdom, Ireland, France, Luxembourg and Catalonia. In Armenia all widespread species are in decline. In other countries the situation is more balanced, with some widespread species increasing and some declining, e.g. Netherlands, Belgium, Sweden and Germany.
- Specialist grassland species are rare or do not occur in some schemes (e.g. Belgium, Netherlands, Finland and Luxembourg). Most declining specialist species are found in Armenia, Ireland, Catalonia and France, while both increases and decreases are found among specialists in the United Kingdom and Germany.
- 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.
- The main driver of decline in grassland butterflies is the change in rural land use: agricultural intensification has increased where the land is relatively flat and easy to cultivate; and abandonment has occurred in recent years 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.

Agricultural intensification leads to uniform, almost sterile grasslands for biodiversity.

- It should be noted that the biggest loss of butterflies in the intensified grasslands of Western Europe occurred before the 1990s and is therefore not shown in this 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.

Grasslands are replaced by scrub and woodland after abandonment, as here in Catalonia (Spain).

- For the conservation of grassland butterflies, priorities are to reduce 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.
- 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.
- In nature reserves, including Natura 2000 areas, large scale uniform management (e.g. for birds or vegetation) without accommodating the needs of butterflies or other insects, should be avoided.
- 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 the impacts of other pressures such as climate change.
- To facilitate this, Butterfly Conservation Europe (BCE) started a new initiative with the Centre for Ecology & Hydrology (CEH) during 2016 to develop a European Butterfly Monitoring Scheme (eBMS) and a single database containing all European monitoring data from which we could produce a range of indicators.
- Butterflies belong to the few species groups for which Europe-wide monitoring is possible. Butterfly monitoring, the building of indicators on a regular basis and the further development of the European Butterfly Monitoring Scheme (eBMS) should be supported by the EU and its Member States.
- BCE has published guidance and specific advice for effective management of grassland for butterflies (the *Do's and Don'ts*, Van Swaay *et al*., 2012). It would be highly beneficial if EU and Member State Farm Advisory Services could adopt and disseminate this advice to help farmers improve effectiveness of grassland management.
- Although this is already the sixth version of the Grassland Butterfly Indicator, the indicator is still produced in the same ad-hoc way as the first one in 2005. The eBMS offers the chance for the long-term investments needed to ensure continuity and further improvements in indicator quality.
- The authors urge the EU to ensure proper and structural funding to further develop the eBMS and 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. All governments should aid in securing the continuance of the regional or national BMS.
- Additional research is needed to reveal the details of the drivers behind the reported changes.

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 sixth version of this indicator now covering 26 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 increase 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 have been established specifically to assess biodiversity. The status indicators on species only cover birds, bats and butterflies, 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.

The Marsh Fritillary,* Euphydryas aurinia, *is one of the indicator species of the European Grassland Butterfly Indicator. The species is listed as a protected species under the EU Habitats Directive.

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). While 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 yet 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 2015 field seasons now included, but also the method of calculating the indicator has been improved and enhanced. For 2015 more than 4500 transects were used (Figure 1). Since 1990 more than 9200 transects have contributed to the indicator.

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

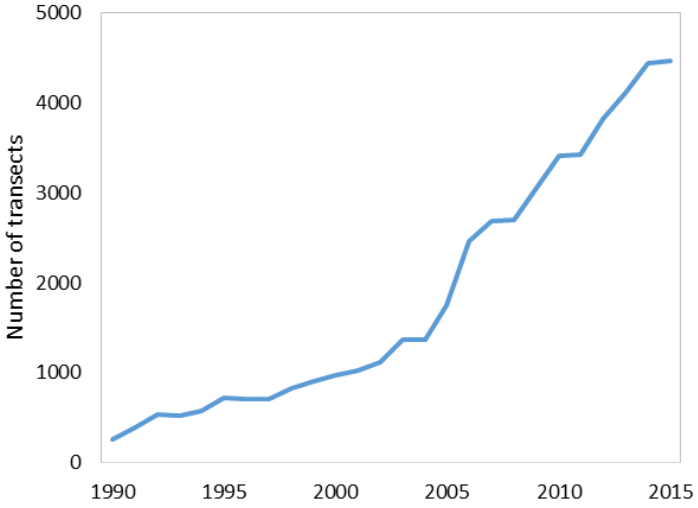
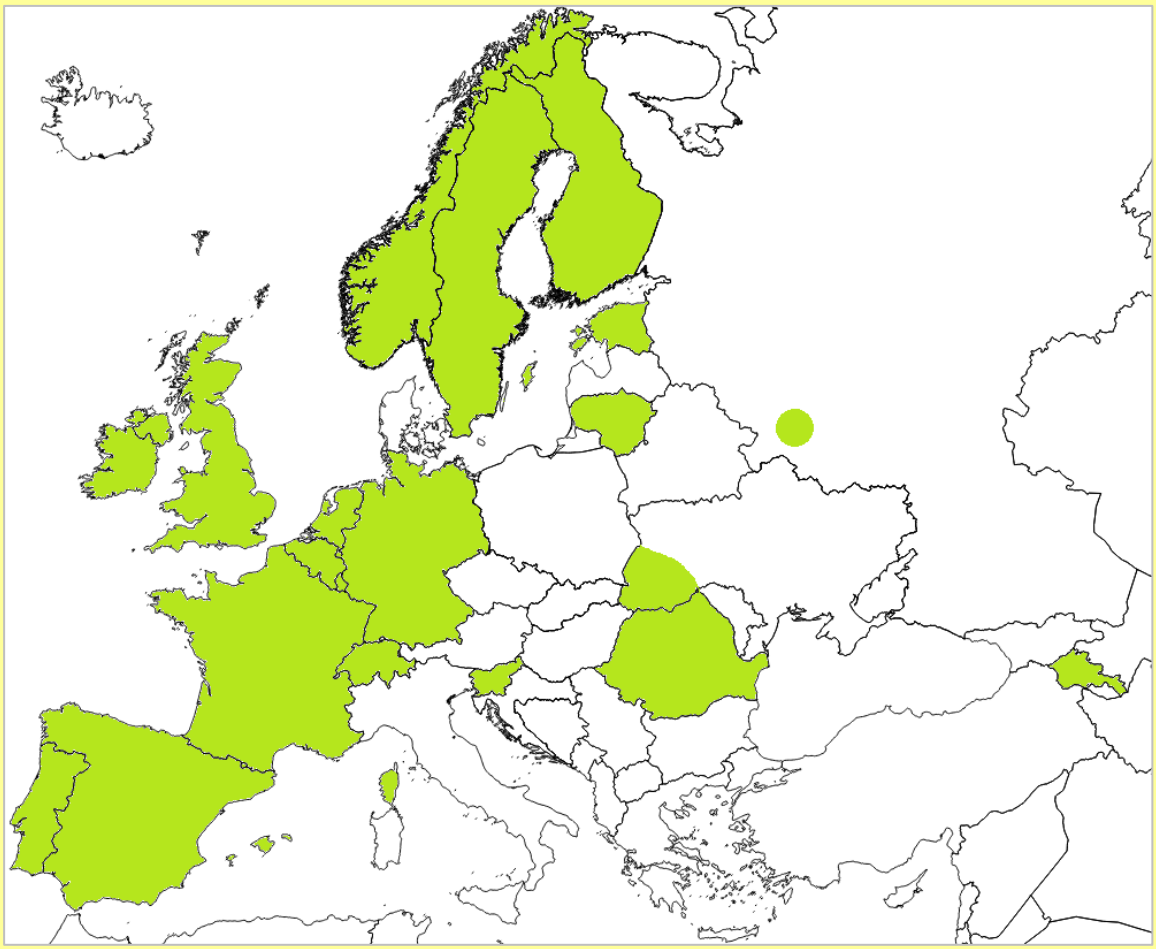


Figure 1: *Number of transects used in the European Grassland Butterfly Indicator per year. Since 1990 more than 9200 transects have contributed to the indicator.*



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

Andorra: since 2004
Armenia: since 2003
Belgium (Flanders): since 1991
Belgium (Wallonie): since 2010
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 1974
United Kingdom: since 1976

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

Since 1990 more than 9200 transects have been counted at least one year, more than 4500 of them in 2015.

Fieldwork

The Butterfly Indicator is based on the fieldwork of thousands of trained professional and volunteer recorders, counting butterflies on more than 4500 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.

In 2015 more than 90,000 km of transect walks were made (twice around the earth!), more than 90% of them by volunteers. This is a considerable contribution from individuals to EU policy.

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 2.

The Mazarine Blue (*Cyaniris semiargus*) is a typical butterfly of semi-natural grasslands.

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

Population trend

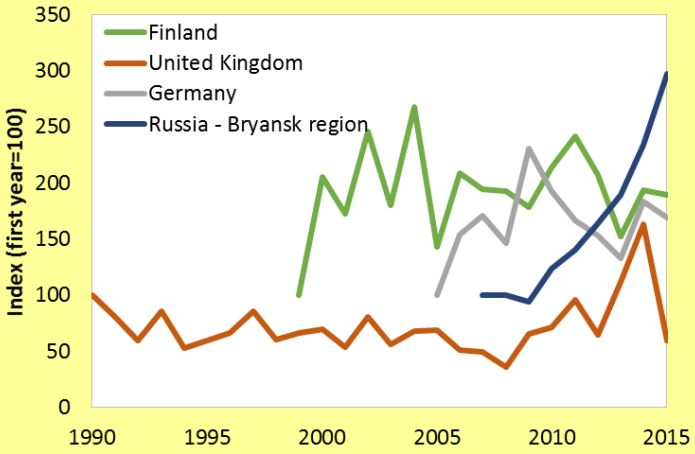
National population trends from the Butterfly Monitoring Schemes (map 1), calculated by the program TRIM (Pannekoek & Van Strien, 2003) are combined to form supra-national species trends (chapter 3). These trends per butterfly species are then combined into an indicator: a unified measure of biodiversity 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 their mean would be expected 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 among countries 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 the EU, Europe and pan-Europe.

First, we calculate the trend in each country and for each species separately. Figure 3 shows four of the national trends for the Orange Tip (*Anthocharis cardamines*). The European trend is calculated for this species by a weighted combination of all national trends. The results show that this butterfly declined in the early 1990s, and started to recover after 2000. In the EU as well as Europe (EU plus Norway and Switzerland), five species show a decline and eight are stable. Four species show an increase (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 pan-Europe (Europe plus Ukraine, Russia and Armenia) five species are declining and seven are stable. Four species show an increase and the trend for the remaining species is uncertain (table 2).



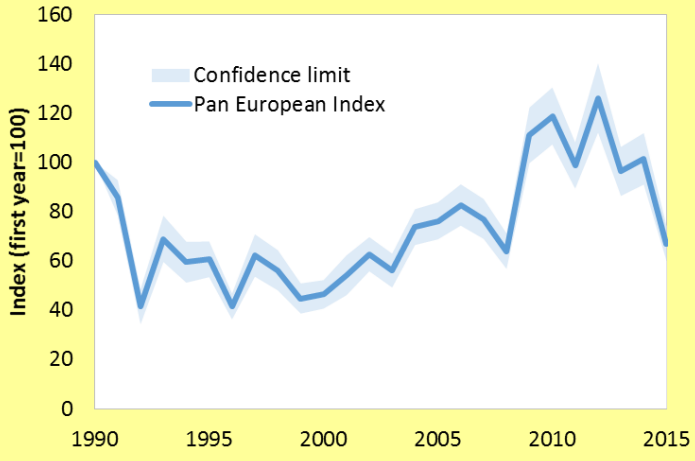


***Figure 3: National and Pan-European trends for the Orange Tip* (Anthocharis cardamines).** *The upper graph shows the trend for four selected Butterfly Monitoring Schemes. Note that the starting year (see also map 1) for each scheme is different. All indices are set to 100 for the first year of a scheme.*
The lower graph shows the European trend, resulting from the four Butterfly Monitoring Schemes in the upper graph plus twenty other schemes.

Table 1: EU and European (EU plus Norway and Switzerland) 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	Species	Trend classification
Decline: 5 species	*Phengaris arion* [N2000]	strong decline
	Lasiommata megera	strong decline
	Thymelicus acteon	moderate decline
	Phengaris nausithous [N2000]	moderate decline
	Ochlodes sylvanus	moderate decline
Stable: 8 species	*Euphydryas aurinia* [N2000]	stable
	Coenonympha pamphilus	stable
	Erynnis tages	stable
	Polyommatus coridon	stable
	Maniola jurtina	stable
	Cyaniris semiargus	stable
	Cupido minimus	stable
	Lycaena phlaeas	stable
Increase: 4 species	*Polyommatus icarus*	moderate increase
	Anthocharis cardamines	moderate increase
	Spialia sertorius	moderate increase
	Polyommatus bellargus	moderate increase

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 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, which means they are based on a wide range of countries, including the larger ones as France, Germany and the United Kingdom. However extra data from the countries in the east of the EU would make the results more representative.
- Apart from the EU countries, the European trend is determined by Norway and Switzerland, and the pan-European trend also by the western part of Ukraine, the Bryansk area in Western Russia and Armenia. 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 European and 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: Pan-European trends (EU plus Norway, Switzerland, Ukraine, Russia and Armenia) 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

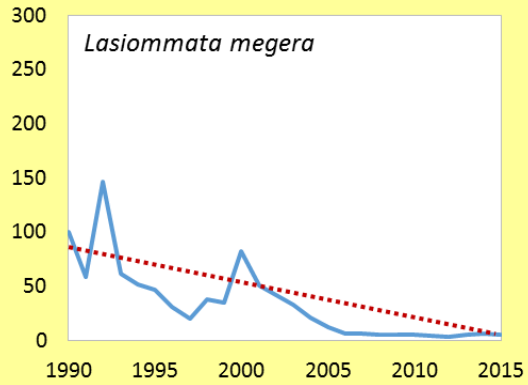
Pan-European trend	Species	Trend classification
Decline: 5 species	*Lasiommata megera*	strong decline
	Phengaris arion N2000	moderate decline
	Thymelicus acteon	moderate decline
	Phengaris nausithous N2000	moderate decline
	Ochlodes sylvanus	moderate decline
Stable: 7 species	*Euphydryas aurinia* N2000	stable
	Erynnis tages	stable
	Polyommatus coridon	stable
	Coenonympha pamphilus	stable
	Maniola jurtina	stable
	Cupido minimus	stable
	Lycaena phlaeas	stable
Increase: 4 species	*Polyommatus icarus*	moderate increase
	Anthocharis cardamines	moderate increase
	Spialia sertorius	moderate increase
	Polyommatus bellargus	moderate increase
Uncertain: 1 species	*Cyaniris semiargus*	uncertain

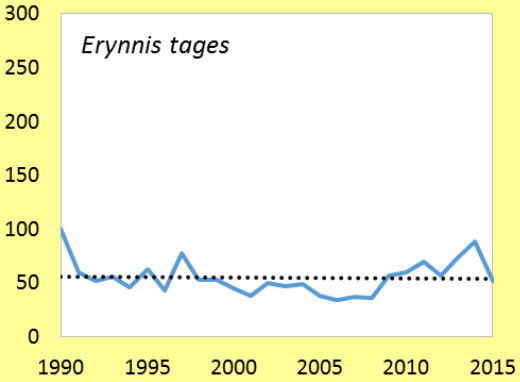
- New countries joining in, new data becoming available in existing schemes and the addition of two extra years can lead to changes in trends as compared to previous versions of the indicator. In some cases this even can lead to a change in the direction of the trend, e.g. for *Polyommatus icarus*.

The Dusky Large Blue (*Phengaris nausithous*) is declining both in the EU and in Europe.

Figure 4 shows some examples of Pan-European butterfly trends:

- The Wall Brown (*Lasiommata megera*), a species strongly declining on dry grasslands
- The Dingy Skipper (*Erynnis tages*) is stable. This species is mostly found on dry grasslands.
- The Adonis Blue (*Polyommatus bellargus*) is a spectacular butterfly of calcareous grasslands. It is a species increasing in Europe. The butterfly may have benefited from targeted conservation measures aimed at improved grazing of grasslands in nature reserves.





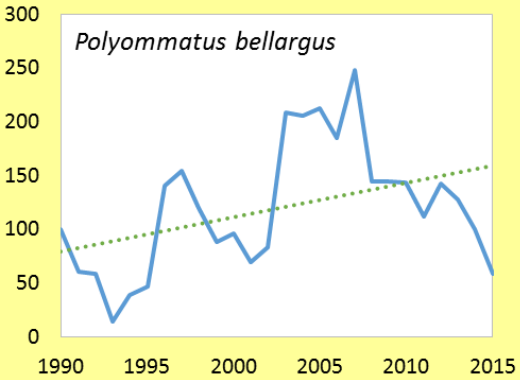


Figure 4: Pan-European population-trends of three butterflies in Europe.
The graphs present indices of abundance per year, where 1990 is set to 100.
*Top: The Wall Brown (*Lasiommata megera*) shows a significant strong decline.*
*Middle: The Dingy Skipper (*Erynnis tages*) is stable.*
*Bottom: In spite of large fluctuations the Adonis Blue (*Polyommatus bellargus*) is increasing.*

Chapter 4 / The indicator

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

Figure 5a shows the European Grassland Butterfly Indicator for the EU-countries. The indicator is based on the 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 decline of 33%, 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 5b) several species are still declining while a growing number appear to have stabilised and four are showing some improvement albeit from a very low base.

So far, 1990-1992 represent the best years for butterflies in the smoothed indicator, with 2008, 2012 and 2015 as the years with the lowest population-indices on average.

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.

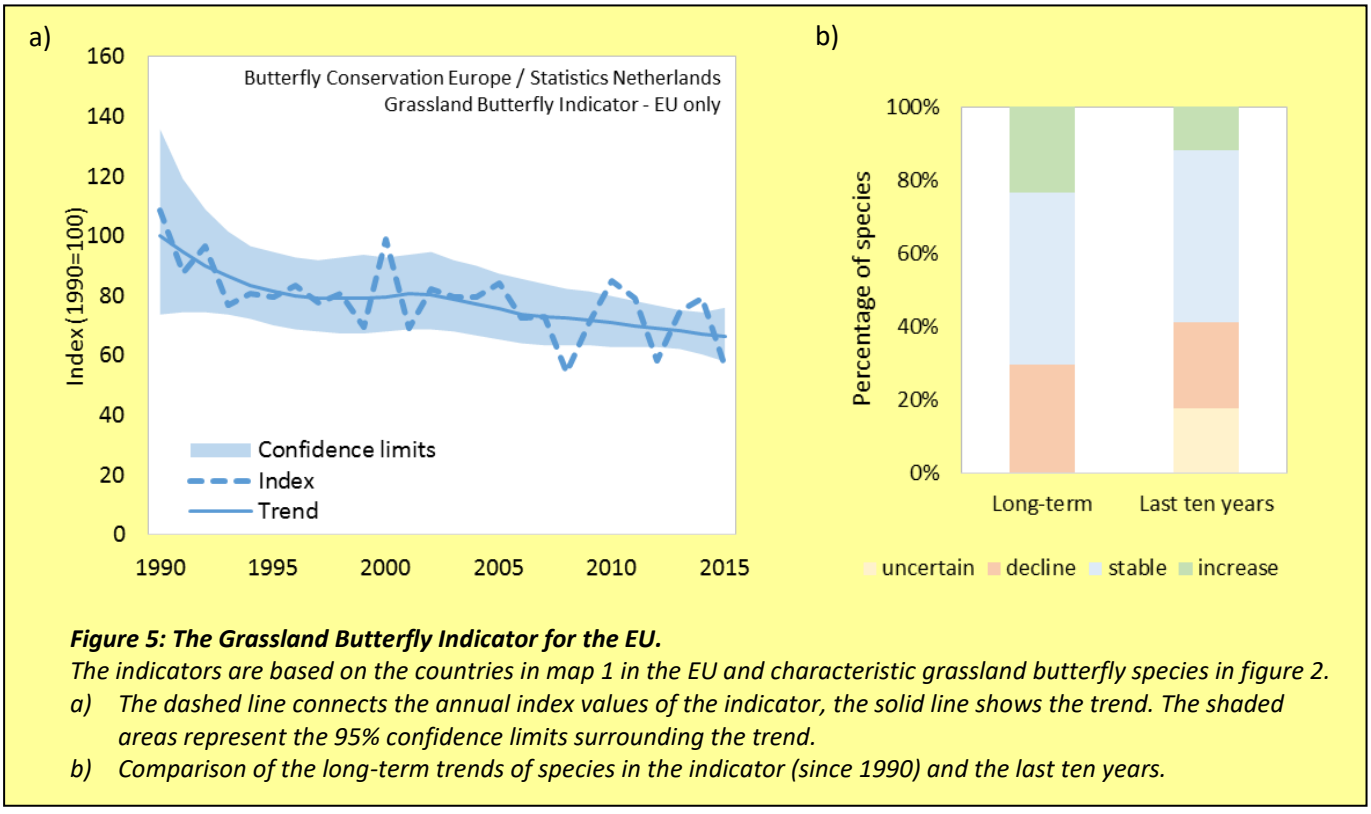


Figure 5: The Grassland Butterfly Indicator for the EU.
The indicators are based on the countries in map 1 in the EU and characteristic grassland butterfly species in figure 2.
a) The dashed line connects the annual index values of the indicator, the solid line shows the trend. The shaded areas represent 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 6a 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 almost 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 6b) shows that in the last ten years fewer species are declining compared to their trend since 1990, and more species are stable or uncertain 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 5 and 6). It would be of great value for the Pan-European indicator if butterfly monitoring could be started in more regions in Eastern Europe, the Mediterranean and the Balkans. To facilitate this, Butterfly Conservation Europe (BCE) and the Centre for Ecology and Hydrology (UK) together with the five largest and oldest BMS's have started up a central database and online portal in 2016 for the new eBMS scheme (www.butterfly-monitoring.net). All other European schemes are invited to join in.

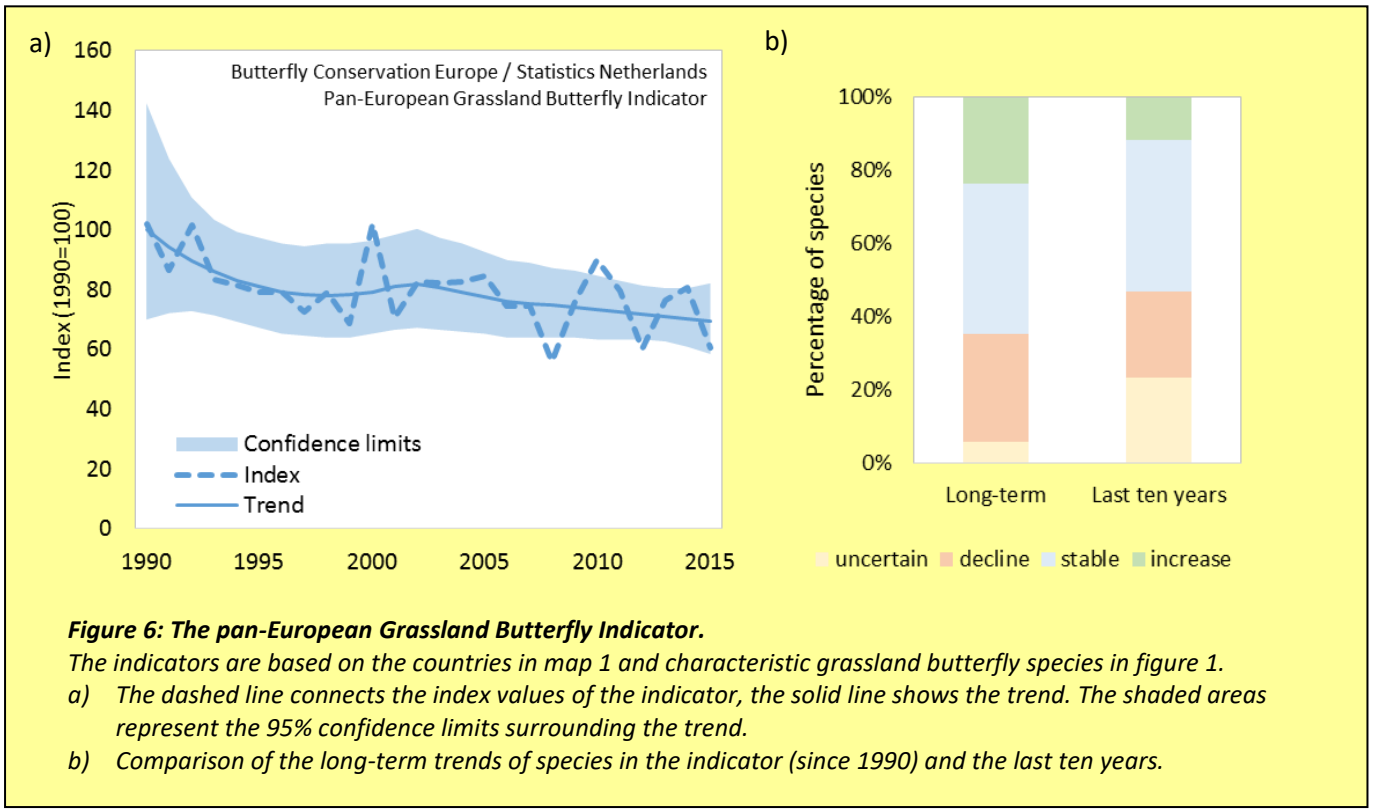


Figure 6: The pan-European Grassland Butterfly Indicator.
The indicators are based on the countries in map 1 and characteristic grassland butterfly species in figure 1.
a) The dashed line connects the index values of the indicator, the solid line shows the trend. The shaded areas represent the 95% confidence 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 Indicator shows a clear negative trend up to 2005 (figures 5 and 6). In the last few years the decline seems to have slowed down. This stabilisation was also visible in the previous version of the indicator (Van Swaay *et al*., 2015a), but the extra years of monitoring have made this more clear.
In the last few years increases for some species have masked the declines of others. Further studies to identify the factors contributing to the improved trends in some species would be useful to help design future recovery plans.

When distinguishing the specialist and widespread species (figure 2) two different trends can be seen (figure 7; EU only):

- Especially in the beginning of the 1990s the widespread species declined severely, but the decline has slowed down since then.
- During the 1990s the specialists remained fairly stable, since 2000 they show a stronger decline.

However it should be kept in mind that in the 1990s almost all BMS's were in North and Western Europe, where the specialist species of the indicator had their largest decline before 1990.
There are only minor differences between the number of increasing and decreasing specialist and widespread species in the EU (figure 7b).

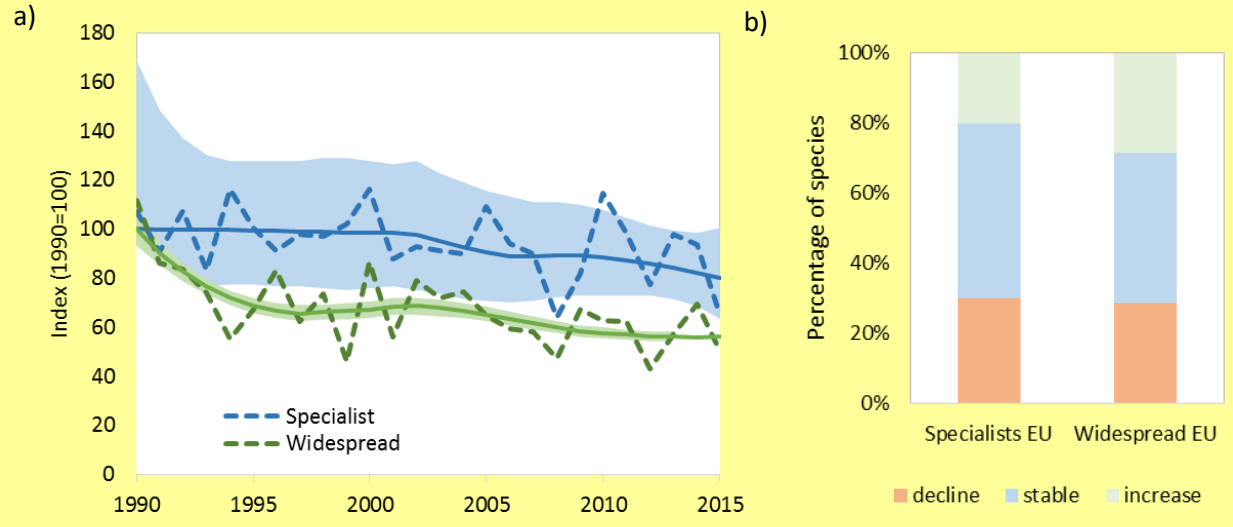


Figure 7: The Grassland Butterfly Indicators in the EU for specialist and widespread species.
The specialist and widespread species as described in figure 2 can be used to separate the indicator into these two groups of species.
a) The dashed line connects the index values of the indicator, the solid line shows the trend. The shaded areas represent the 95% confidence limits surrounding the trend.
b) Comparison of the long-term trends of specialist and widespread species.

The percentage of increasing widespread species is smallest for the Butterfly Monitoring Schemes starting in the 1990's (average of 19%), with 29% both for the BMS's starting between 2000 and 2009 and the ones starting in 2010 or later. This supports the decline of widespread species in the beginning of the 1990's, which was missed by the BMS's starting in the 21st century.

Split by country (figure 8) most declining widespread species are found in the United Kingdom, Ireland, France, Luxembourg and Catalonia. In Armenia even all widespread species are in decline. In other countries the situation is more balanced, with some widespread species increasing and some declining, e.g. Netherlands, Belgium, Sweden and Germany.
Specialist species are rare or don't occur in some schemes (e.g. Belgium, Netherlands, Finland and Luxembourg). Most declining specialist species are found in Armenia, Ireland, Catalonia and France, while both increases and decreases are found among specialists in the United Kingdom and Germany.

Thomas (2005, 2016) 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 a useful 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.

Intensification (on the foreground) and scrub moving in in the background, both threatening grassland butterflies in the Cantabrian Mountains (photo: Yeray Monasterio - ZERYNTHIA society).

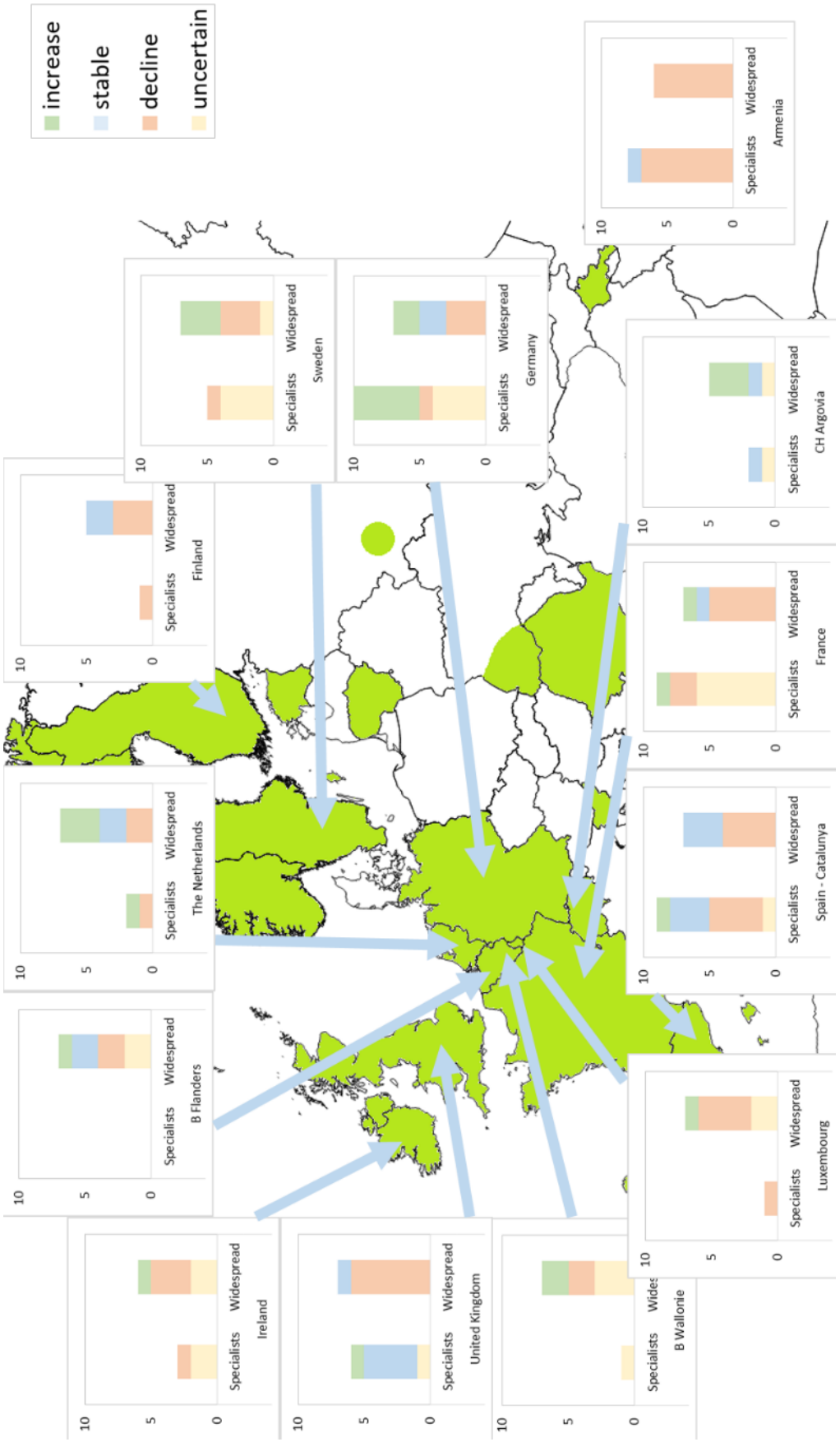


Figure 8: *The long-term trends of widespread and specialist butterflies per country since the start of the BMS in that country. Only countries with less than half of the species trends as 'uncertain' are presented.*

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 may be 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 been an important part of the European landscape. Sustainably managed semi-natural grasslands harbour 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 (Van Swaay *et al*., 2006).

***Grasslands are the home for many European butterflies (Scarce Large Blue,* Phengaris teleius).**

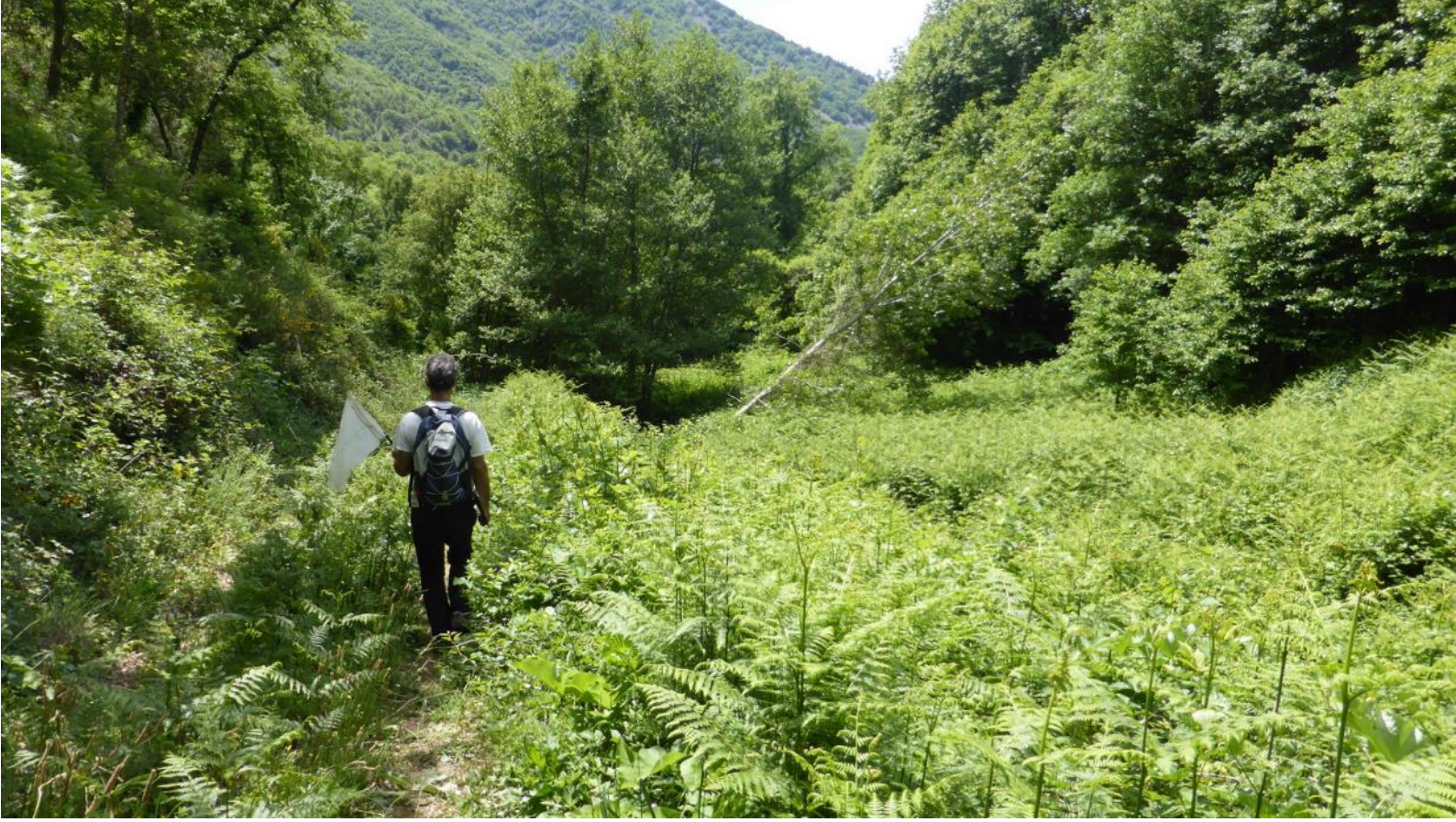
Intensification

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 1950's grassland management has undergone huge changes. In Western Europe, farming has intensified rapidly (with the Common Agricultural Policy - CAP - as one of its main drivers) and over the last fifty years semi-natural grasslands have become smaller. 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 on neighbouring croplands, enlargement of fields, changing mowing techniques (Humbert *et al*., 2010) and the use of heavy machines. The cessation of haymaking in favour of more profitable silage regimes is particularly detrimental (Nilsson *et al*., 2013). 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 doesn'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.



A transect of the Catalan Butterfly Monitoring Scheme in the Massis del Montseny. The grasslands became abandoned and butterfly numbers crashed after ferns, scrubs and trees moved in. Although the most sensitive species,* Phengaris arion*, has disappeared, others have undergone severe declines, but their populations could be restored with proper management.

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 human 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 (Herrando *et al*., 2015). 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, as well as changes in land-use, like afforestation replacing the former mosaic of grasslands and patches of forest by commercial forest plantations, 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 strongly 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 which allows dispersal.

Further pressures can come from shifts in the grazing system, like changes in breed or species composition. If sheep grazing is substituted by cattle, or lighter races by heavier ones, degradation of pasturelands can take place. In the north of Spain, where pastures are the dominant landscape, there is a combination of overgrazing, mowing excess and the use of fire for the maintenance of open areas (or creating new ones) which puts an additional pressure on grassland butterflies.

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 such as 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 drop further. Additionally we still miss butterfly monitoring in many of the countries in the eastern part of the EU. As the process of intensification is still in full motion in countries like Poland, the decline in grassland butterflies might be much larger there, making the results of the present indicator too conservative. In nature reserves, including Natura 2000 areas, a lot of efforts have been made to restore nature and improve the habitat 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. Both *Phengaris* (former *Maculinea*) *nausithous* and *arion* show a decline, both in the European Union and across Europe. In spite of strong fluctuations, the long-term trend for *Euphydryas aurinia* is stable, both in Europe and 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; Bourn *et al*., 2013), 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 crucial 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 Oppermann *et al*. (2012). Concerns that the last CAP2013 reforms does 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.

HNV farmland, as this steppic area in Spain, can be vital for the survival of grassland butterflies.

Improving Knowledge

BCE has published guidance and specific advice for effective management of grassland for butterflies (the *Do's 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.

Other measures

In some regions of North-western Europe, where intensification is the main driver, grassland butterflies are now almost restricted to nature reserves, rail or road verges, rocky or wet places and urban areas. 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.

The Large Blue (*Phengaris arion*) depends on targeted management.

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.

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.

With an increasing coverage of European countries, the geographical scope of the indicator is improving rapidly, especially in the EU (see map 1). This makes butterflies, after birds, the next 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 population trends among terrestrial insects (de Heer *et al*. 2005; Thomas, 2005), though distribution trends for the aquatic dragonflies are expected soon.

Although many national and regional Butterfly Monitoring Schemes are funded as part of Governmental conservation programmes 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 such as 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*., 2015b) and it is urgent that schemes are established in these countries, supported by national and regional governments.

Butterfly Conservation Europe (BCE) has started a new initiative called eBMS (www.butterfly-monitoring.net), which is hosted by CEH in the UK. The main aim is to start collecting data from all existing European Butterfly Monitoring Schemes and make them available for research and indicator development. So far the largest and oldest Butterfly Monitoring Schemes have already added their data and we look forward for the smaller schemes to join in soon as well. Another new development is that the eBMS offers an online input module, which makes it easy for new schemes to take part. Schemes are needed urgently in Eastern Europe as well as the Balkans and the Mediterranean, and would further improve the indicator.

This indicator shows that there are important 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 state 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 sixth version of the Grassland Butterfly Indicator, the indicator is still produced in the same ad-hoc way as the first one in 2005. The eBMS offers the chance for the long-term investments needed to ensure continuity and further improvements in indicator quality.

The authors urge the EU to ensure proper and structural funding to further develop the eBMS and 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.

The purple-edged copper (*Lycaena hippothoe*) is an example of a characteristic butterfly of moist meadows presently not in the indicator.

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.
- 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, grassland butterflies can 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.

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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*., 2008). 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 coridon, Polyommatus bellargus, Cyaniris semiargus and Euphydryas aurinia*). See also figure 2.

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 of counts per generation	Number of transects per year 2013-2015 (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*
Andorra	2004	w	1.3	3	7	20-30	v	f	yes	yes
Armenia	2003	w	0.4	1	37	1-4	p	f	yes	yes
Belgium - Flanders	1991	r	0.8	3	11	15-20	v	f	no	no
Belgium - Wallonie	2010	r	0.8	3	38	4-5	p	c	yes	no
Estonia	2004	w	1.8	2.5	13	6	p	c	no	no
Finland	1999	w	3	3	54	ca 11	v ~80%. p ~20%	f for v	yes	no
France	2005	w	1	2	961	4.4 (1-15)	v	half r, half f	yes	no
Germany	2005	w	0.5	3	376	15-20	v	f	yes	yes
Germany - Nordrhein Westfalen	2001-2007	r	1	3	0	15-20	v	f	no	yes
Germany – Pfalz (only *Phengaris nausithous*)	1989	r	0.5	1	35-49	1	p	c	yes	no
Ireland	2008	w	1.5	7	122	14.6	v	f	yes	no
Jersey	2004	w	1	2	27	18-20	v	c	yes	no
Lithuania	2009-2011	w	1.3	3	3-4	6-9	v	f	no	no
Luxembourg	2010	w	0.34 - 1.216	2.5	36	8.2 (3-11)	v ~10%. p ~90%	r	yes	no
Netherlands	1990	w	0.7	5	504	17 (15-20)	v	f	yes	no
Norway	2009	r	1	1	46	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	10-110	3-5	v-60%. p-40%	c	yes	no
Russia - Bryansk area	2009	r	1.2	3	41	1-9	v ~90%. p ~10%	f	yes	no
Slovenia	2007	w	1.3	7	27	6.25 - 7.53	v	c	yes	no
Spain - Basque Country	2010	r	1.7	2	34	10	v 70%. p 30%	f	yes	yes
Spain - Catalonia	1994	r	1	3	75	30	v	f	yes	no
Spain (excl. Catalonia and Basque Country)	2014	w	1.5	3	54	10-30	v ~50%. p ~50%	f	yes	yes
Sweden	2010	w	0.65	3	395	4	v ~90%. p ~10%	f	yes	no
Switzerland	2003	w	2 x 2.5	1	92	7 (4 alpine region)	p	g	yes	no
Switzerland - Aargau	1998	r	2 x 0.250	1.5	95	10	p (civil service)	g	yes	no
Ukraine – Carpathians and adjacent parts	1990	r	1-3	1	82	5 (2-10)	v	f	yes	yes
United Kingdom	1973 (1976)	w	2.7	5	1174	19	v	f	yes	yes

**: assessed by expert's 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 / Statistical 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.
- For three countries (Finland, Spain-Catalonia and United Kingdom) an abundance index following Schmucki *et al*. (2015) was provided from the eBMS.
- 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 or based on a few sites or observations only.
- 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. Four different types of data were received from the national coordinators; (i) the yearly abundance index following Schmucki *et al*. (2015), (ii) a linear interpolation of the number of butterflies per transect (Van Swaay *et al*., 2002; Schmucki *et al*., 2015), (iii) the yearly sum of the number of individuals seen during all visits as well as the associated number of visits for each site and (iv) the yearly sum of the number of individuals seen during all visits but without exact information on the number of visits per site. The third data type was made equivalent to the first and second 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 following Soldaat *et al*. (in prep.).
- 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*. (2015a). 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.
- The indicator trends are very similar to the one in the previous report (Van Swaay *et al*., 2015a).
- 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 of the multiplicative slope <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 tends to be 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 sixth 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 using data provided from national schemes. Butterfly Conservation Europe (BCE) has recently started a new initiative with a research organization in the UK, the Centre for Ecology & Hydrology (CEH), to develop a long-term solution for research and the building of indicators - called the European Butterfly Monitoring Scheme (eBMS). This is a collation of datasets from national Butterfly Monitoring Schemes on behalf of Butterfly Conservation Europe, managed by the Natural Environment Research Council (acting through Centre for Ecology & Hydrology (CEH)). The aims are to facilitate research using the dataset; the production of a suite of butterfly indicators; and to promote the conservation of butterflies and wider biodiversity.

As of the initiation of the eBMS in 2016, the national partners are Finland, Germany, Spain (Catalonia), The Netherlands and the United Kingdom. However, we intend to collate data from all other national schemes as well as encouraging butterfly monitoring in regions currently lacking a national scheme.

The eBMS forms a solid basis to develop new initiatives and improvements:

- A full and standardized quality control. Until now all controls have been made on an ad-hoc basis, which is relatively time-consuming and offers the chance that controls are forgotten or misinterpreted. In the eBMS validation will be standardized and analyses can be performed far more easily on demand. These could also include checks for all existing combinations of species and country and a comparison with species trends per country of earlier assessments. However, this would involve additional long-term investment.
- As described in annex II, national data are weighted to build supra-national trend. Using the eBMS, the input could be standardised as much as possible and weighting could be performed as much as possible per species (now often done only per country). With additional funding, this could be built into eBMS as a long-term investment.
- Once all data runs through the eBMS it will be much faster and easier to generate indicators, including new ones such as a woodland butterfly indicator or the climate change indicator.
- The original method for producing the European Butterfly Indicator for grasslands is based on a few species only, collecting summary data from each country and then generating an indicator from supra-national indices. Using the eBMS this could be greatly improved, for example by using

more species and bringing data together on a basis of Biogeographical region or climatic zone. This would generate a much stronger indicator that better reflects changes in the butterfly fauna of grasslands, and wider biodiversity.

- A detailed report on the options for developing the eBMS and indicator production are explored in a BCE report (Van Swaay & Warren, 2012).