



Species Diversity in Landscapes

One of the core BDM indicators, Z7 monitors species numbers of vascular plants, breeding birds and butterflies occurring in Switzerland's landscapes. The number of species populating each 1-km² sampling area covered by the indicator depends on numerous factors, since species ranges are defined not only by biogeographical distribution patterns and physical features such as geology, relief and climate, but also by land uses. The more different habitat types like grassland, arable land or forest add up to form a landscape and the better their quality, the more species will find a suitable site to thrive in.

Human impact on species diversity through altering habitat diversity and quality becomes evident when comparing species numbers recorded in the Jura and on the Central Plateau. Maximum species diversity evidenced in a sampling area is almost identical for both regions, ascertaining their natural potential to be equivalent. Nevertheless, mean species numbers per sampling area are higher for the Jura than for the Central Plateau. As regards butterflies, differences are so manifest that even Jura areas relatively poor in species harbor approximately the same species diversity as average sampling areas on the Central Plateau. Obviously, the intensive land use common on the Central Plateau has already destroyed many valuable habitats, driving away plant and animals species that depend on just these habitats. Hence, in landscapes heavily shaped by human use, a high—or at least increasing—Z7 value is generally very welcome.

In the meantime, change values have become available for all species groups monitored by the Z7 indicator. Results show that vascular plant species numbers in Switzerland's landscapes have been increasing in the past ten years. The biggest advances were registered for warm-site plant species that are drought-resistant and tolerate disturbances well. Some neophytes have spread extensively, too, for example the Annual Fleabane (*Erigeron annuus s.l.*) and the Tree of Heaven (*Ailanthus altissima*). Butterfly species numbers have increased as well, at least in the short term and in certain regions, particularly the Central Plateau and the Northern Alps. Still, the increase observed might not yet reflect a longer-term trend. Breeding bird species diversity in landscapes has largely remained constant in that period of time.

However, since Z7 results are based on just three select species groups and merely examine a partial aspect of biodiversity, they must be considered in common with other information such as species composition in habitats (Z12 indicator) or the development of individual species (Z8 indicator).

Status: May 2015

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Development of species diversity: synopsis

The Z7 indicator is designed to document change in the species diversity of vascular plants, breeding birds and butterflies within landscape sectors encompassing 1 square kilometer each. Vascular plant data collected so far show species diversity in some of Switzerland's regions to be increasing. Increases have been statistically ascertained for two biogeographical regions (the Central Plateau and the Central Alps) and Switzerland overall. Rising numbers recorded for the Southern Alps in previous years have been easing off in the meantime.

In the past 10 years, butterfly species numbers have been rising both on the Central Plateau and in the Northern Alps. Still, due to the marked annual fluctuations typical for this species group, BDM has not yet collected sufficient data to postulate a longer-term trend. Nationwide butterfly species numbers have remained the same.

During the past 10 years, breeding bird species numbers did not undergo significant changes in either Switzerland as a whole or the majority of its biogeographical regions. Only the Central Alps feature an increase in bird species diversity.

Switzerland being a mountain country, it is particularly important to keep an eye on high altitudes, which comprise distinctly alpine regions above the timber line in the Alps and partly in the Jura¹ (cf. tab. 3). Alpine ecosystems are considered to be especially susceptible and might, therefore, change substantially in decades to come, for example as a result of climate change. In line with this hypothesis, vascular plant species have already been recorded to increase in numbers at high altitudes, whereas it has been impossible to detect any trends for breeding birds and butterflies so far.

Trends observed to date are commented in greater detail below. Tables 1 to 3 show current 10-year trends for mean species numbers of the three species groups monitored by Z7 based on the analysis of data gathered from 2005 to 2014. Figures 1, 2, 5 and 6 illustrate the complete development observed since surveys began in 2001.

In evaluating biodiversity trends, it must be borne in mind that biodiversity is not only a matter of species numbers, but also of differences in the composition of species communities in various sites—a fact taken into account by the Z12 indicator "Diversity of Species Communities". Analyses indicate that the diversity of vascular plant species *communities* in Switzerland's landscapes is declining. In other words, vegetation is increasingly composed of the same species everywhere. The diversity of breeding bird species communities is developing differently from one region to the next, while butterfly data do not reveal any distinct trend whatsoever.

Species diversity in Switzerland: development in time

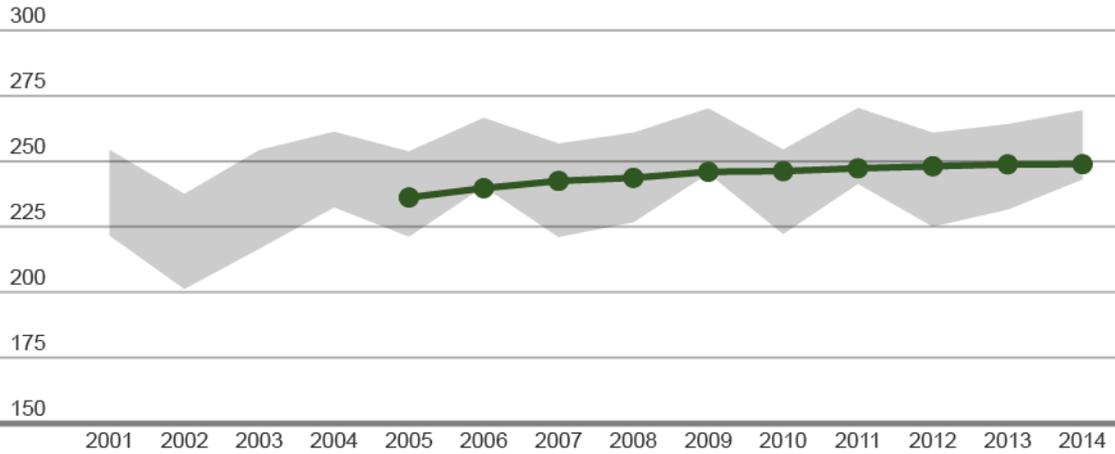
Tab. 1: Species diversity trends nationwide 2005–2014			
	<i>Vascular plants</i>	<i>Breeding birds</i>	<i>Butterflies</i>
Nationwide	↗	→	→
© BDM (Z7 indicator). Data source: BDM field surveys. Status: May 2015			

¹ The term "high altitudes" is used as defined in the *Verbreitungsatlas der Farn- und Blütenpflanzen der Schweiz* by Welten & Sutter (Birkhäuser Verlag, Basel, 1982). It refers to any area in Switzerland located above the timberline, which is why "high-altitude sampling areas" may also be found in the Jura, even though they cannot be attributed to the "alpine level" as such.

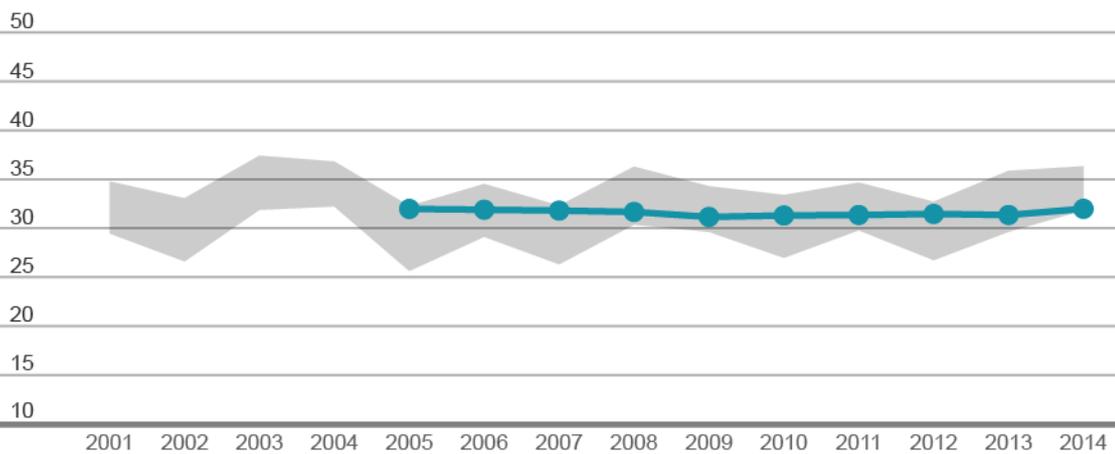
Fig. 1: Development of species numbers in Switzerland 2001*–2014

Mean species numbers in 1-km² sampling areas: 5-year mean line and 95% confidence interval of annual means (gray shading). 5-year means (colored dots) refer to the preceding 5 years each.

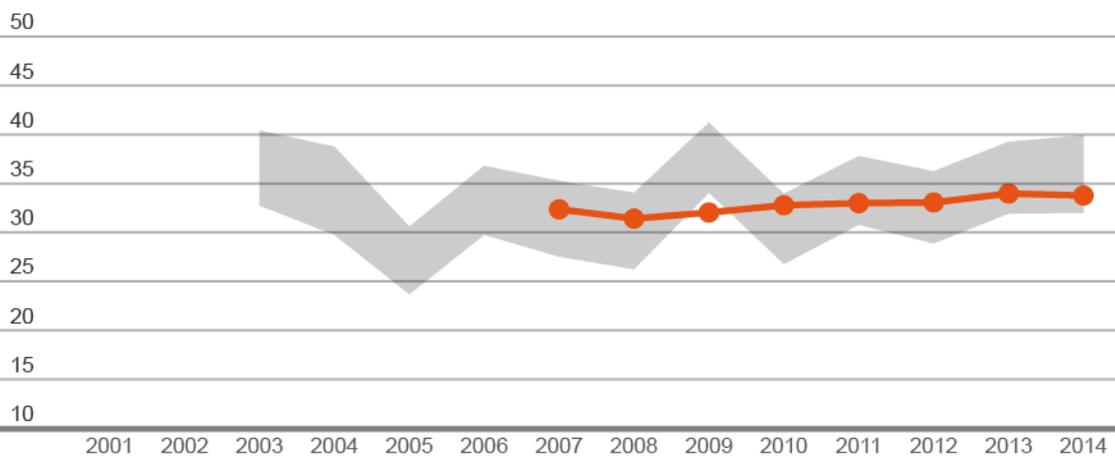
Vascular plants



Breeding birds



Butterflies



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*Butterfly species have not been surveyed until 2003.

Species diversity in the regions: development in time

	<i>Vascular plants</i>	<i>Breeding birds</i>	<i>Butterflies</i>
Jura	→	→	→
Central Plateau	↗	→	↗
Northern Alps	→	→	↗
Central Alps	↗	↗	→
Southern Alps	→	→	→

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Vascular plants

Fig. 2a: Development of vascular plant species numbers in the regions 2001–2014

Mean species numbers in 1-km² sampling areas: 5-year mean line and 95% confidence interval of annual means (gray shading). 5-year means (green dots) refer to the preceding 5 years each. The very wide confidence interval displayed for the Jura in 2003 is the result of an unusually small sample size.

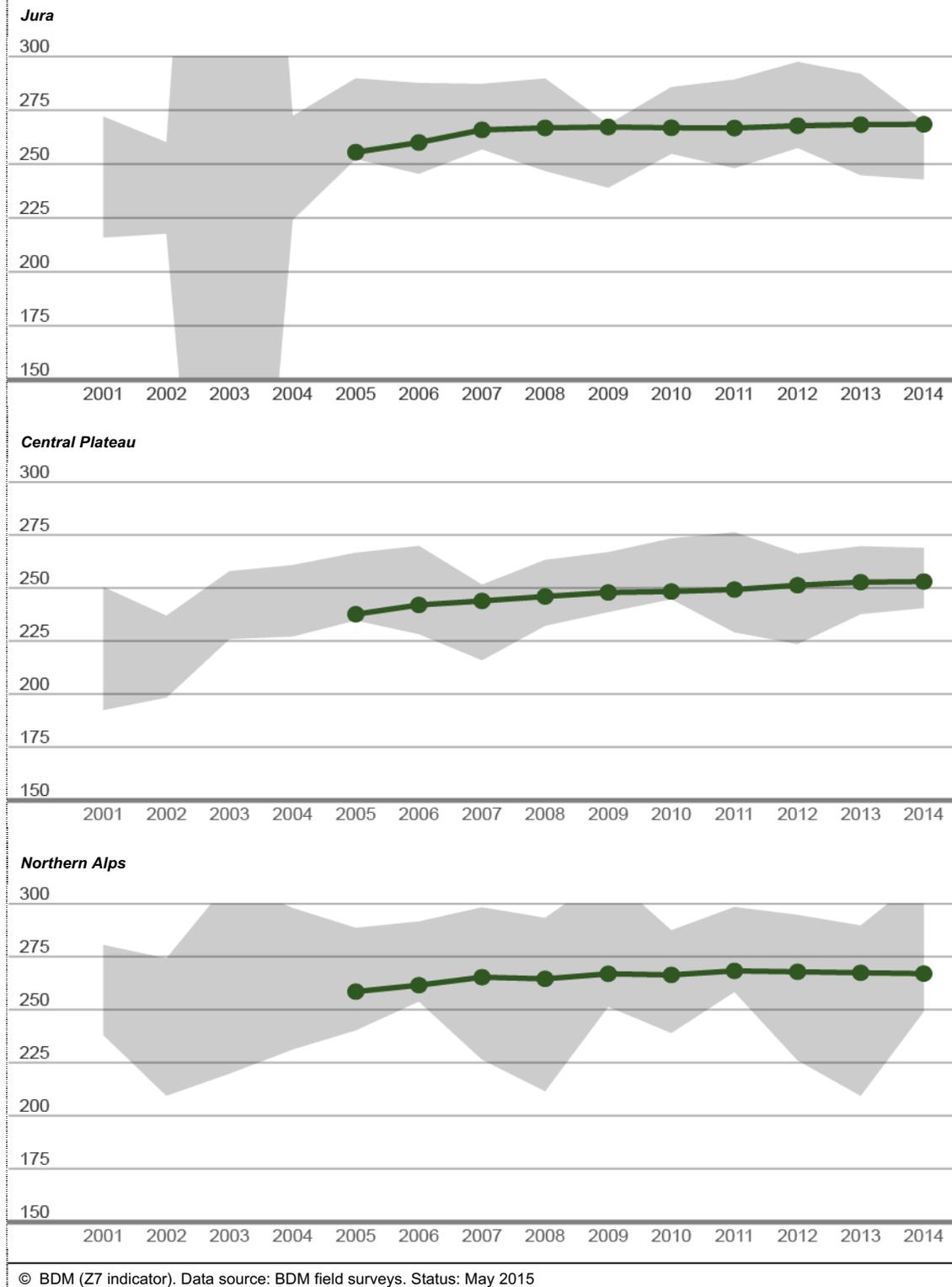
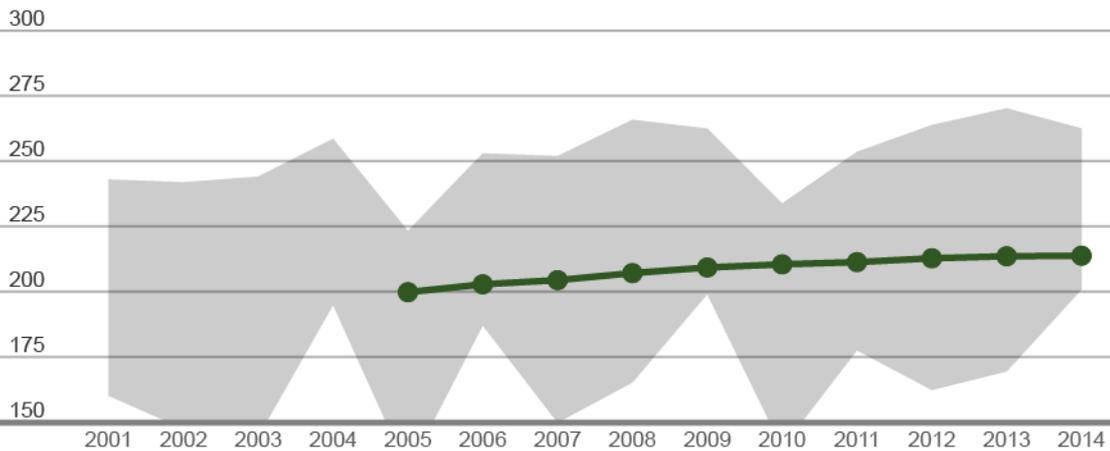
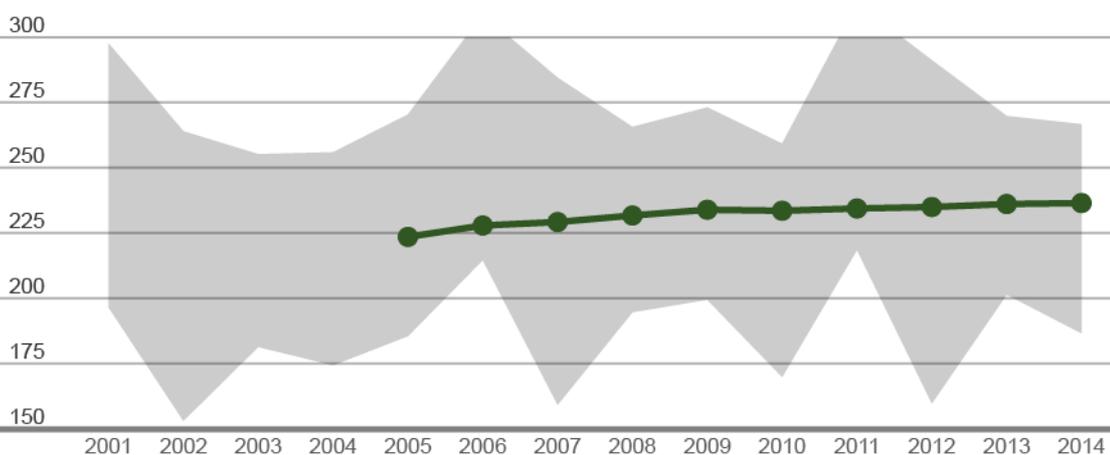


Fig. 2b: Development of vascular plant species numbers in the regions 2001–2014

Mean species numbers in 1-km² sampling areas: 5-year mean line and 95% confidence interval of annual means (gray shading). 5-year means (green dots) refer to the preceding 5 years each.

Central Alps**Southern Alps**

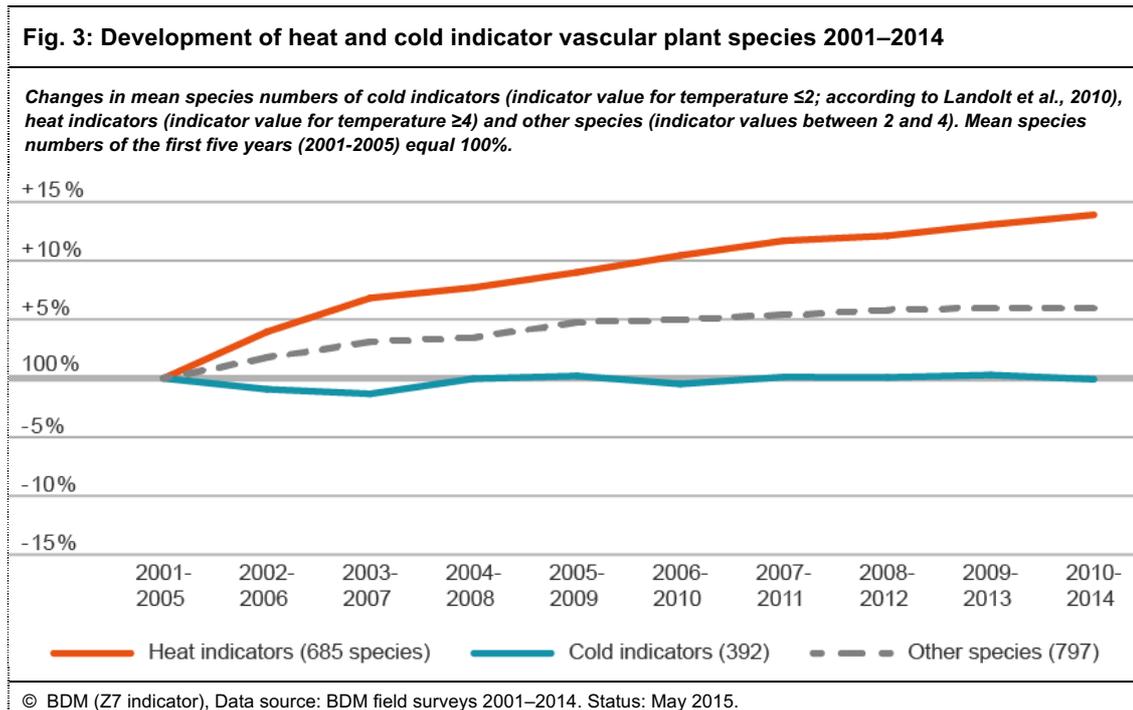
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Comments regarding vascular plants

- Whenever a plant species has newly colonized a 1-km² sampling area, this generally indicates that it settled in a previously unoccupied site after covering a relative large distance. Hence, Z7 provides a good reflection of changes in the geographical ranges of plant species, which differentiates it from the Z9 indicator “Species Diversity in Habitats” and its short-term responses to—primarily—changes in the frequency of vascular plant species in habitats.
- Vascular plant species numbers have increased in the landscapes of the Central Plateau, the Central Alps and the country as a whole. The plant species that spread the most in the past 10 years belong to different ecological groups (guilds), with the guild of lowland ruderal plants that prefer mild climates holding the largest number of plants characterized by a tendency to spread. This group largely consists of plant species with short life cycles that sprout, bloom, form copious seeds and die within merely one or two years. That may be the reason why such species are able to spread faster in a landscape, resulting in the increase being noticed after an observation period of only 10 years. Particularly on the Central Plateau, such species include the Little Lovegrass (*Eragrostis minor*), the Yellow Foxtail (*Setaria pumila*) and the Common Purslane (*Portulaca oleracea*).

- A BDM special analysis revealed an above-average spreading of drought-resistant heat indicator plants in Switzerland's low-elevation landscapes (fig. 3, see also Bühler, 2012). At least during the past 30 years, winter and spring precipitation have actually decreased as measured by most of the country's weather stations, while average temperatures have increased (<http://www.meteoschweiz.admin.ch/>).
- Dispersal of neophytes surpassed that of other species groups as well. However, the increase in species numbers recorded by Z7 can certainly not be explained by neophytes alone, as they only account for roughly 3% of all vascular plant species monitored by the indicator. Among neophytes, especially species characterized by an affinity for higher temperatures have been found to increase since 2001. Heat-loving neophytes displaying a conspicuous trend to spread include the Witchgrass (*Panicum capillare* bdm-agg.), the Annual Fleabane (*Erigeron annuus* s.l.) and the Tree of Heaven (*Ailanthus altissima*)—a development liable to be correlated with climate warming (Bühler, 2012).
- Whereas mean altitude distribution of typical mountain plants recorded by the Z9 indicator "Species Diversity in Habitats" has been shifting to higher altitudes, Z7 reveals no such trend at the landscape level (Roth et al., 2014). But in alpine landscapes, the pronounced relief causes microclimates to vary enormously at a small scale, possibly allowing species pressurized by climate change to find a new suitable niche close by (Scherrer & Körner, 2011).

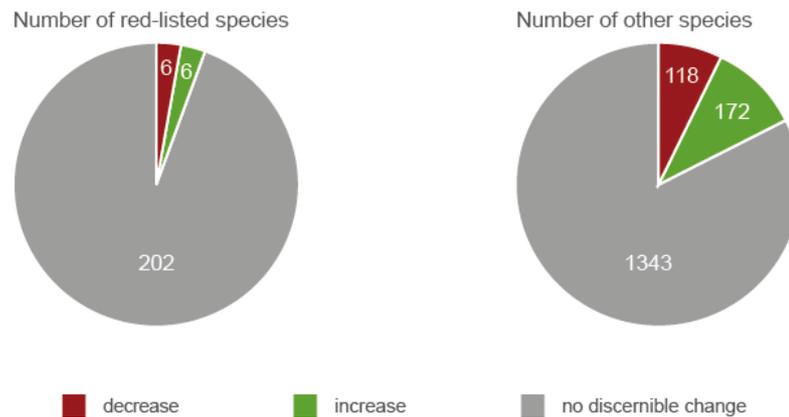
Development of heat and cold indicator species



Development of red-listed species

Fig. 4: Development of red-listed vascular plant species 2005–2014

Share of vascular plant species surveyed by BDM whose range in Switzerland has changed in a significantly positive or negative or in a non-significant manner. The significance of range changes is assessed using the methods of indicator Z8 "Population Size of Common Species". For a species to be considered red-listed, it must belong to either the "critically endangered", "endangered", or "vulnerable" categories.



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Comment

- The Z7 indicator primarily monitors the long-term development of widespread and common species. However, its comprehensive field surveys repeatedly also record rare or even red-listed species. While the amount of evidenced specimens does not suffice to draw conclusions regarding changes in individual rare species, the overall development of all recorded red-listed species as a whole forms an interesting pattern nevertheless. The numbers of red-listed vascular plants increasing or decreasing in landscapes are about the same (fig. 4). In contrast, all other species feature distinctly more range increases than decreases. So, the outlook for red-listed species is less favorable than in general.

Breeding birds

Fig. 5a: Development of breeding bird species numbers in the regions 2001–2014

Mean species numbers in 1-km² sampling areas: 5-year mean line and 95% confidence interval of annual means (gray shading). 5-year means (blue dots) refer to the preceding 5 years each.

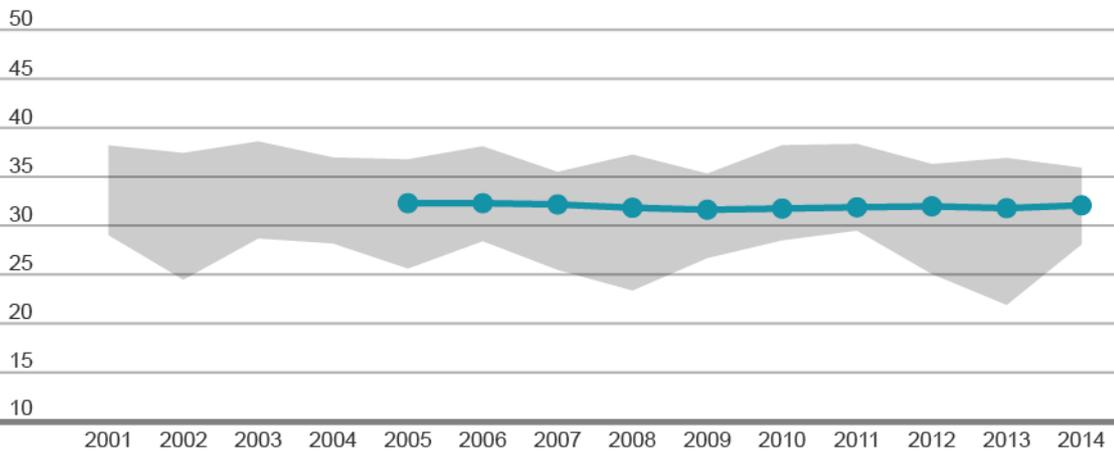


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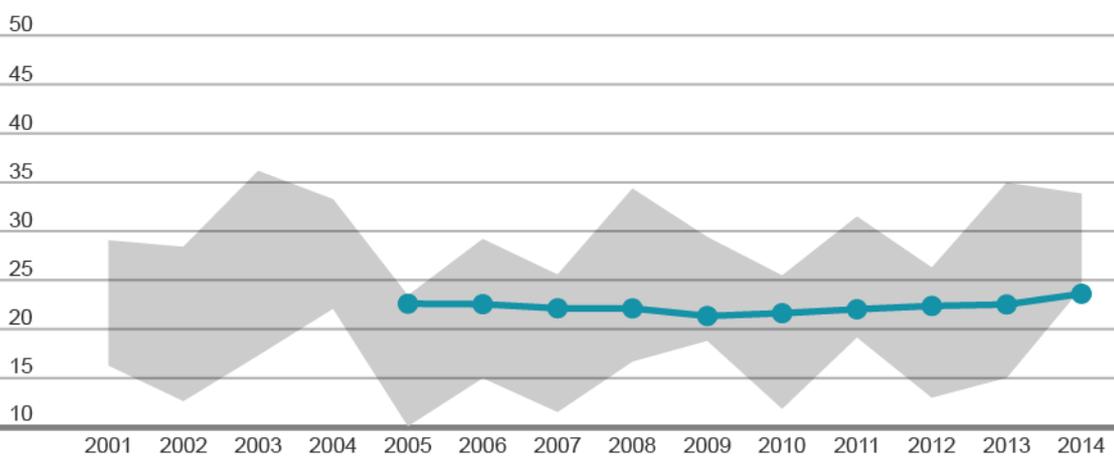
Fig. 5b: Development of breeding bird species numbers in the regions 2001–2014

Mean species numbers in 1-km² sampling areas: 5-year mean line and 95% confidence interval of annual means (gray shading). 5-year means (blue dots) refer to the preceding 5 years each

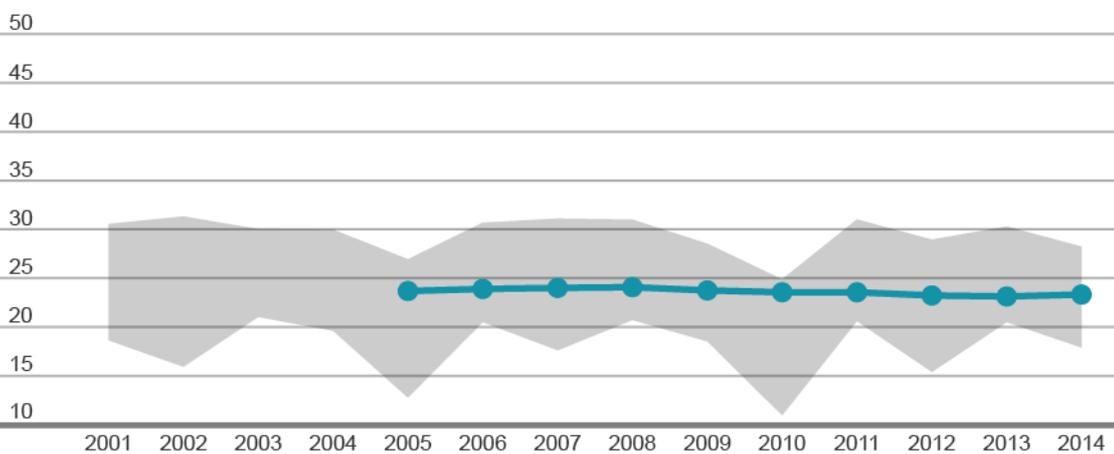
Northern Alps



Central Alps



Southern Alps



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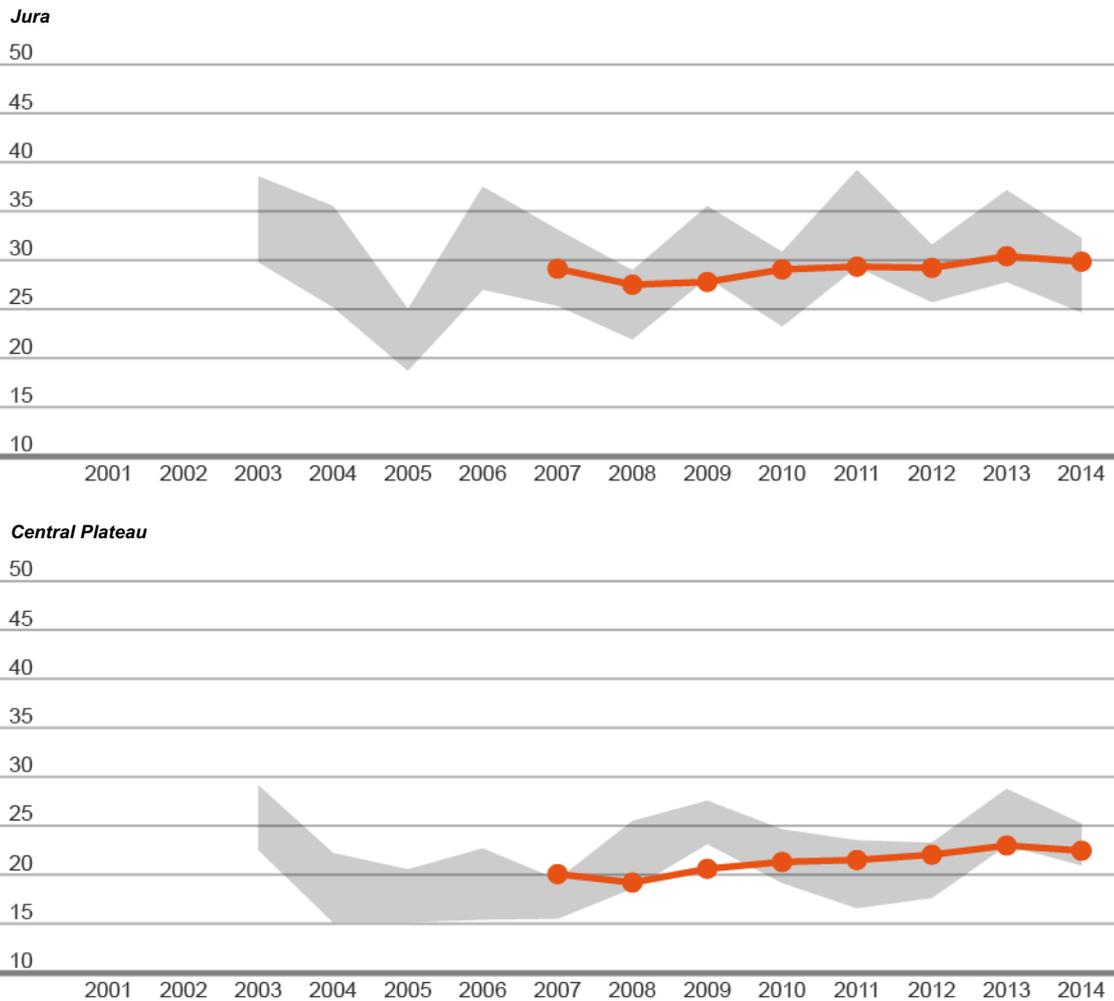
Comments regarding breeding birds

- Even though in Switzerland, the average number of breeding bird species per square kilometer is constant, some significant changes in distribution have been observed regarding individual species (see Z8 indicator "Population Size of Common Species"). At +15%, the largest increase has been recorded for the Common Treecreeper (*Certhia familiaris*). The Red Kite (*Milvus milvus*) also extended its range quite considerably compared to the first survey. Since 2008, however, its population size has remained the same. This range extension is very good news, as conservation and recovery of the Red Kite are a national-priority goal in Switzerland (FOEN, 2011). Furthermore, populations of this raptor are plummeting in surrounding countries. With 22 additional sampling areas, the Mistle Thrush (*Turdus viscivorus*) has made considerable progress as well (+9%), closely followed by the Song Thrush (*Turdus philomelos*) that was observed in 23 additional sampling areas (+8%).
- Evidenced by 15 sampling areas (-16%) found abandoned, the biggest decline was observed for the Common House Martin (*Delichon urbicum*). At 14 abandoned sampling areas (-16%) each, the Common Swift (*Apus apus*) and the Spotted Nutcracker (*Nucifraga caryocatactes*) have become distinctly less widespread than only a few years ago as well.
- Meanwhile, the decrease in mean breeding bird species numbers on the Central Plateau BDM observed in previous years has eased off and can no longer be evidenced statistically. To name just one example for the development: After declining in numbers at the beginning of the 21st century, the Fieldfare (*Turdus pilaris*) has been slightly reincreasing its population size in recent years.
- In the Central Alps, the number of breeding birds per 1-km² sampling area has increased significantly in the past ten years. Just under two thirds of all species surveyed are currently more widespread than they were ten years ago. Having colonized at least ten additional sampling areas each, the Alpine Chough (*Pyrrhocorax graculus*), the Eurasian Treecreeper (*Certhia familiaris*) and the Eurasian Siskin (*Carduelis spinus*) attained the biggest range extensions.
- As one fifth of BDM sampling areas is surveyed per year, variations in annually recorded species richness result in fluctuations of annual values, which repeat themselves at a 5-year rate. In addition, bird populations are also subject to natural annual fluctuations.
- Computed since 1990 by the Swiss Ornithological Institute, the Swiss Bird Index SBI reflects trends observed for birds in Switzerland. Unlike the Z7 indicator "Species Diversity in Landscapes", the SBI also considers territory densities of breeding birds within sampling areas.

Butterflies

Fig. 6a: Development of butterfly species numbers in the regions 2003–2014

Mean species numbers in 1-km² sampling areas: 5-year mean line and 95% confidence interval of annual means (gray shading). 5-year means (orange dots) refer to the preceding 5 years each.

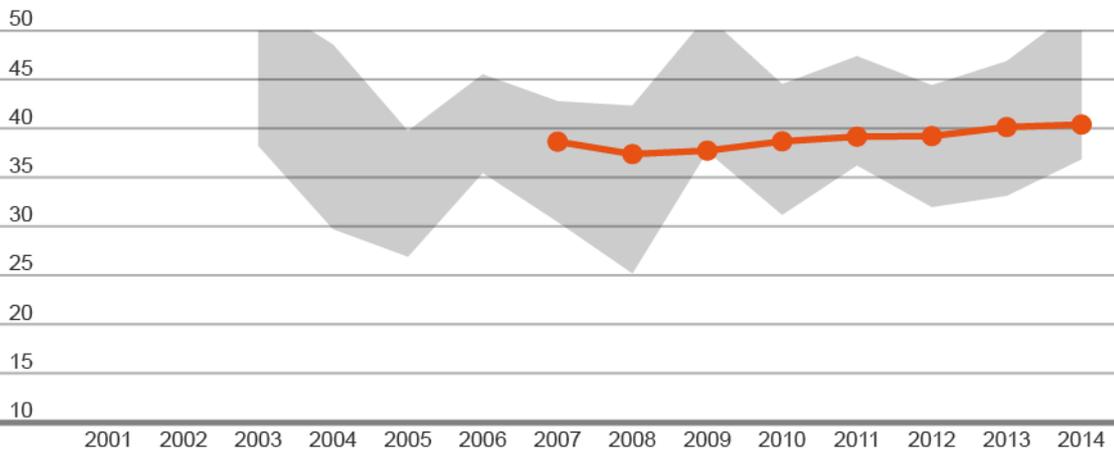


© BDM (Z7 indicator). Data source: BDM field surveys. Status: May 2015

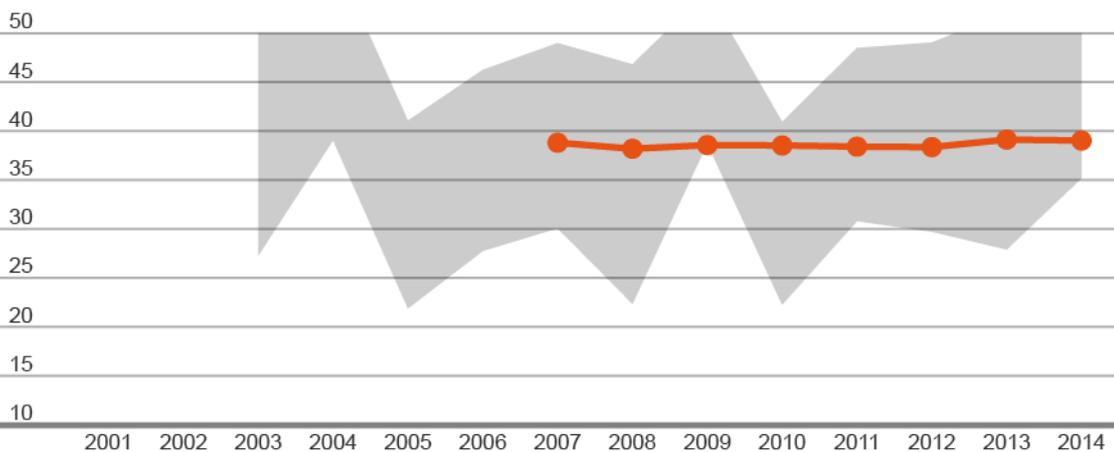
Fig. 6b: Development of butterfly species numbers in the regions 2003–2014

Mean species numbers in 1-km² sampling areas: 5-year mean line and 95% confidence interval of annual means (gray shading). 5-year means (orange dots) refer to the preceding 5 years each.

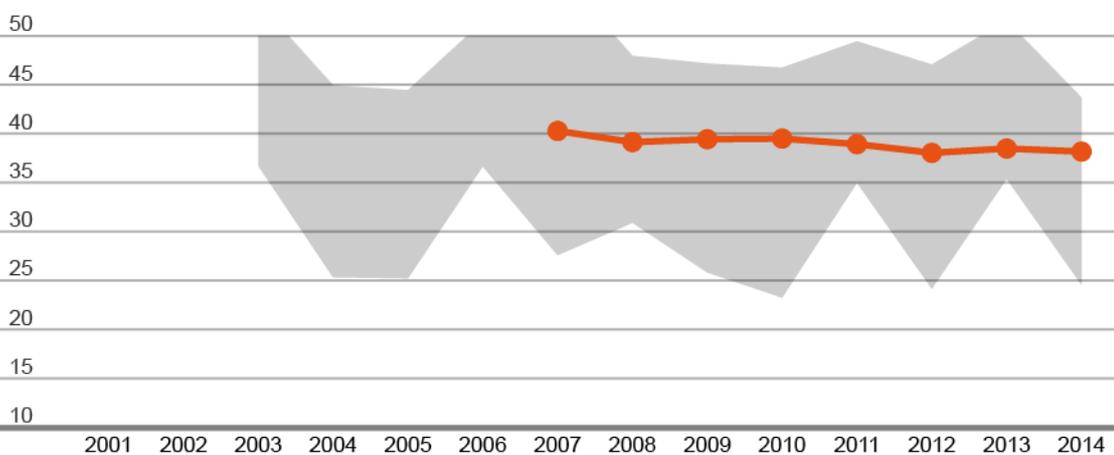
Northern Alps



Central Alps



Southern Alps



© BDM (Z7 indicator). Data source: BDM field surveys. Status: May 2015

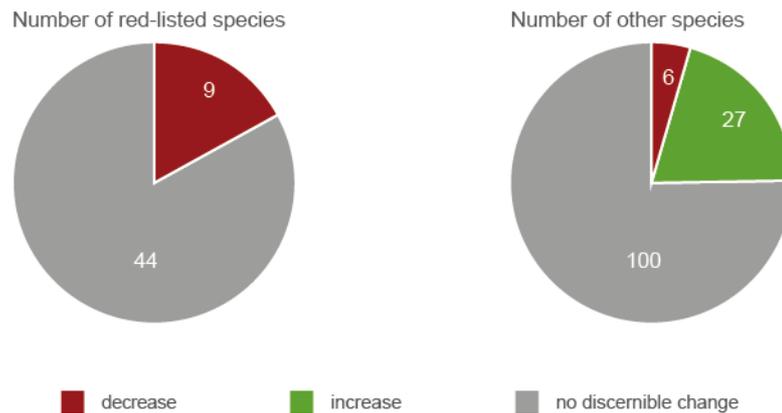
Comments regarding butterflies

- In the past 10 years, butterfly species numbers in landscapes have not changed on a nationwide level. However, they did increase on the Central Plateau and, to a lesser degree, in the Northern Alps (tab. 2).
- Changes recorded in the past ten years might not reflect longer-term trends. Considering the whole surveying period of 12 years (BDM has been monitoring butterflies since 2003), there were no significant changes detected either for Switzerland as a whole or for individual regions. But looking at the usual Z7 observation period of 10 years, there is an increase in species numbers, as the record values recorded in the scorcher summer of 2003 are disregarded in favor of data newly collected in 2013, which turned out to be an exceptionally good year for butterflies.
- The increase in butterfly species numbers on the Central Plateau and in the Northern Alps is a general phenomenon that cannot be reduced to individual ecological species groups (guilds), even less to individual species. While the winners do include the odd "climate profiteer", they comprise just as many typical grassland or forest species, along with some ubiquitous and migratory butterflies.
- It suffices to turn to the Southern Alps to see that changes evidenced for the short term do not necessarily result in a longer-term trend. The total 12 years of BDM butterfly surveys reveal a decline in mean species numbers for that region. Again, this trend is caused by the year of 2003, in which surveys started and which was exceptionally favorable to butterflies due to dry weather. With the observation period restricted to the past ten years, i.e. excluding 2003, there is no change in butterfly species diversity discernible in the Southern Alps.
- The population size of 42 individual species has changed significantly in the course of the past 10 years. Except for 15 species, all changes are increases. Whether or not these changes reflect a longer-term trend remains to be seen for the time being.
- Among the species distinguished by marked increases in range, fieldworkers identified two closely related heat-loving Blues: the Short-tailed Blue (*Cupido argiades*) and the Provençal Short-tailed Blue (*Cupido alcetas*). Starting out from Western Switzerland, these two species have been considerably extending their areas of occupancy on the Central Plateau and in lowland Jura sites since 2003. Another butterfly now distinctly more widespread is the Six-Spot Burnet (*Zygaena filipendulae*), a species typical of poor grassland.
- Responding more susceptibly to environmental factors such as annual weather conditions, butterfly populations are subject to much wider fluctuations than bird and plant populations. For this reason, positive or negative species diversity trends are mainly determined by environmental and living conditions for butterflies being good or bad in any two surveying years compared. Regarding individual butterfly species, sustained trends relevant for the development of biodiversity are expected to emerge after extended periods of time only.

Development of red-listed species and national priority species

Fig. 7: Development of red-listed butterfly species 2005–2014

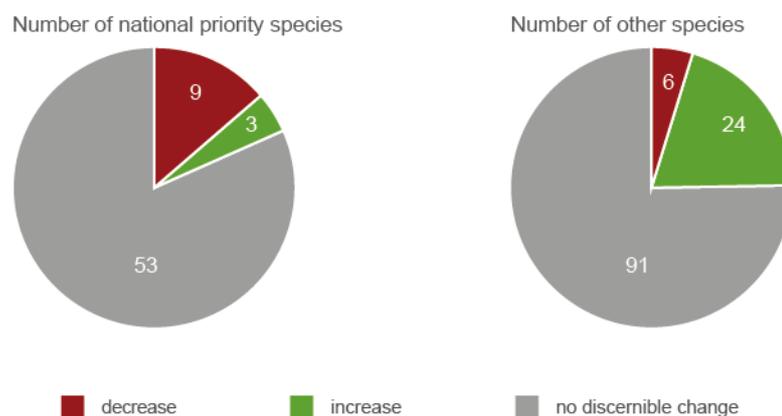
Share of butterfly species surveyed by BDM whose population size in Switzerland has changed in a significantly positive or negative or in a non-significant manner. The significance of changes in population size is assessed using the methods of indicator Z8 "Population Size of Common Species". For a species to be considered red-listed, it must belong to either the "critically endangered", "endangered", or "vulnerable" categories.



© BDM (Z7 indicator). Data source: BDM field surveys 2005–2014. Status: May 2015

Fig. 8: Development of national priority butterfly species 2005–2014

Share of butterfly species surveyed by BDM whose population size in Switzerland has changed in a significantly positive or negative or in a non-significant manner. The significance of changes in population size is assessed using the method of indicator Z8 "Population Size of Common Species". For a species to be considered a national priority species, it must belong to categories 1–4 of Switzerland's National Conservation and Recovery Priority Species Lists as established in 2010.



© BDM (Z7 indicator). Data source: BDM field surveys 2005–2014. Status: May 2015

Comment

- Overall, increases in population size are mostly being evidenced for common and widespread butterfly species (cf. Z8 indicator "Population Size of Common Species"). Focusing on threatened butterfly species as classified in Switzerland's latest Red List, however, reveals a significant decline in

population sizes of this “species group” so important to nature conservation politics. At the same time, it becomes obvious that there are distinctly more red-listed and national priority species declining than increasing in numbers.

Species diversity at high altitudes: development in time

Tab. 3: High-altitude species diversity trends 2005–2014			
	<i>Vascular plants</i>	<i>Breeding birds</i>	<i>Butterflies</i>
High altitudes	↗	→	→
© BDM (Z7 indicator). Data source: BDM field surveys. Status: May 2015			

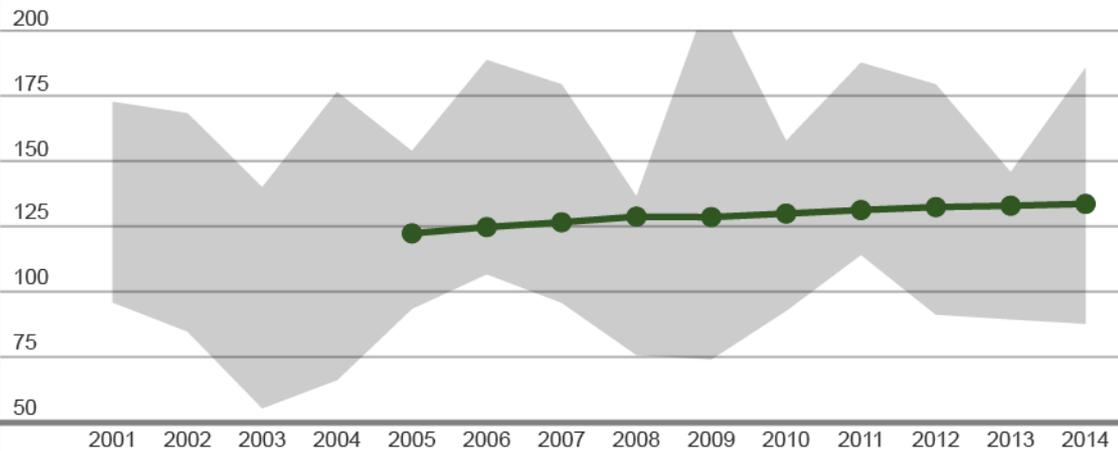
Comments regarding high altitudes

- Alpine ecosystems are considered to be especially susceptible and might, therefore, undergo considerable changes in decades to come, for example due to climate change.
- BDM special analyses show heat-loving plant species increasingly spreading to higher altitudes (see fig. 3 and Bühler, 2012). This result is also reflected by increasing species numbers at high altitudes.
- Breeding bird and butterfly species numbers at high altitudes have not been found to be changing in a significant manner at this time.

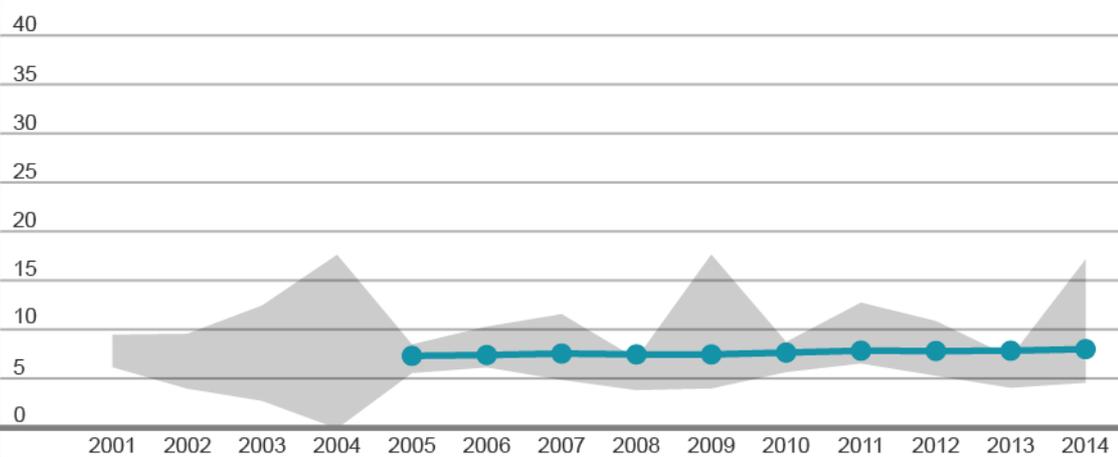
Fig. 9: Development of species numbers at high altitudes 2001*-2014

Mean species numbers in 1-km² sampling areas: 5-year mean line and 95% confidence interval of annual means (gray shading). 5-year means (colored dots) refer to the preceding 5 years each.

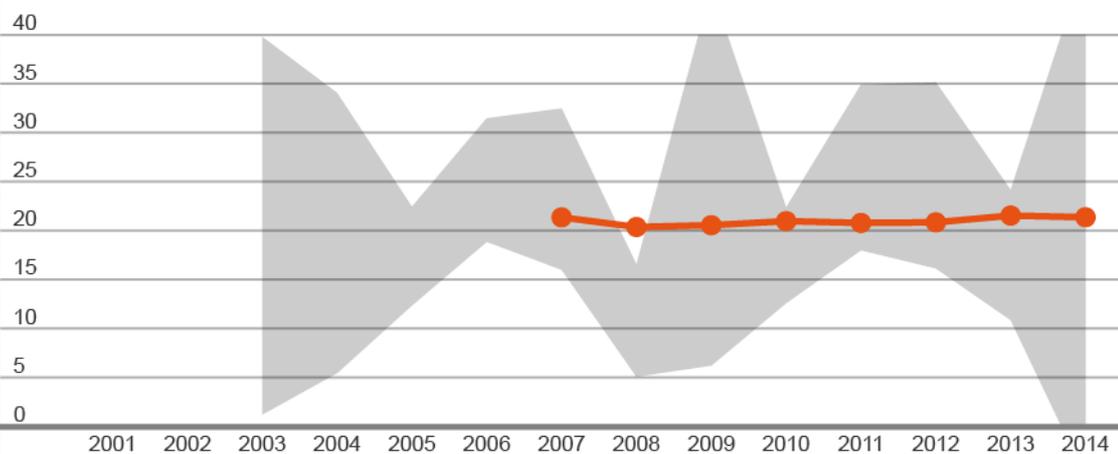
Vascular plants



Breeding birds



Butterflies

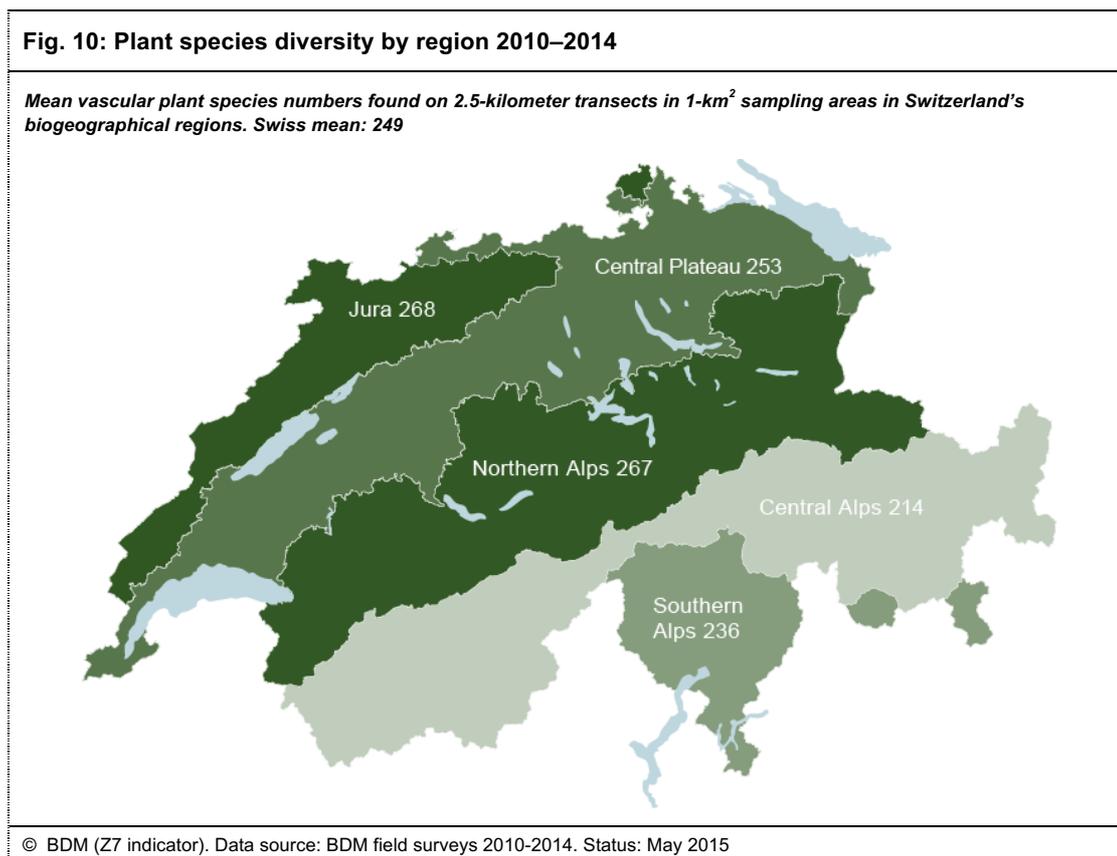


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*Butterfly species have not been surveyed until 2003.

Plant species diversity: current situation

Figure 10 below illustrates mean vascular plant species numbers per square kilometer found on 2.5-kilometer transects in Switzerland's different biogeographical regions², with the Swiss mean situated at 249 species. Sampling areas harboring the most species—on average more than 265 per square kilometer—are located in the Jura and the Northern Alps, while the lowest average number of species was found in sampling areas in the Central Alps.



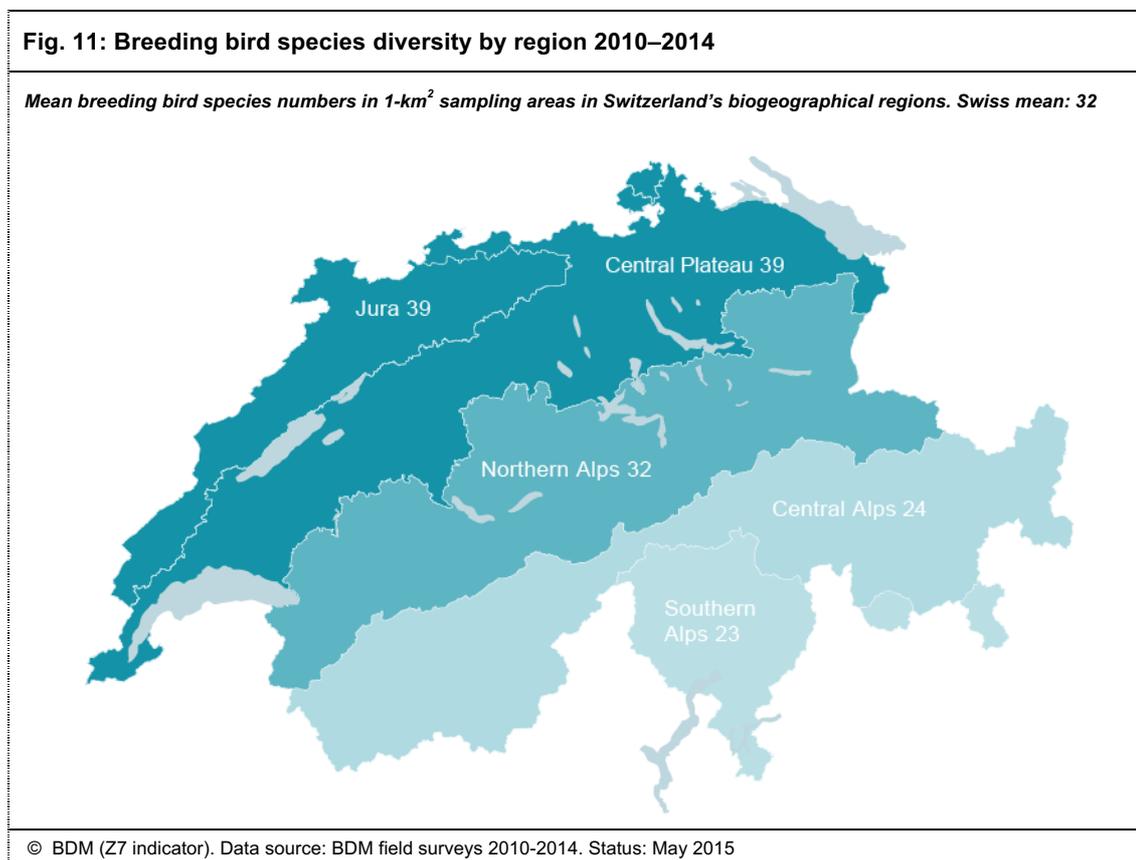
Comments

- Due to the comparatively high share of species-poor sampling areas at high altitudes, the Central Alps present a low average of 214 vascular plant species. However, regions at lower altitudes in the Central Alps include extremely species-rich areas as well. For example, BDM fieldworkers found more than 350 plant species per square kilometer in several lowland sampling areas in the cantons of Wallis and Graubünden, with as many as 395 species in one particular area on the southern slope of the Rhone river valley.
- For frequency and development data on individual species as well as additional information please refer to the Z8 indicator "Population Size of Common Species".
- For complete data please refer to Appendix 1.

² Regions defined as in *Die biogeographischen Regionen der Schweiz* (Gonseth et al., 2001). For the purposes of this indicator, the Western and Eastern Central Alps have been merged into one region.

Breeding bird species diversity: current situation

Figure 11 below illustrates mean breeding bird species numbers per square kilometer found in Switzerland's different biogeographical regions.

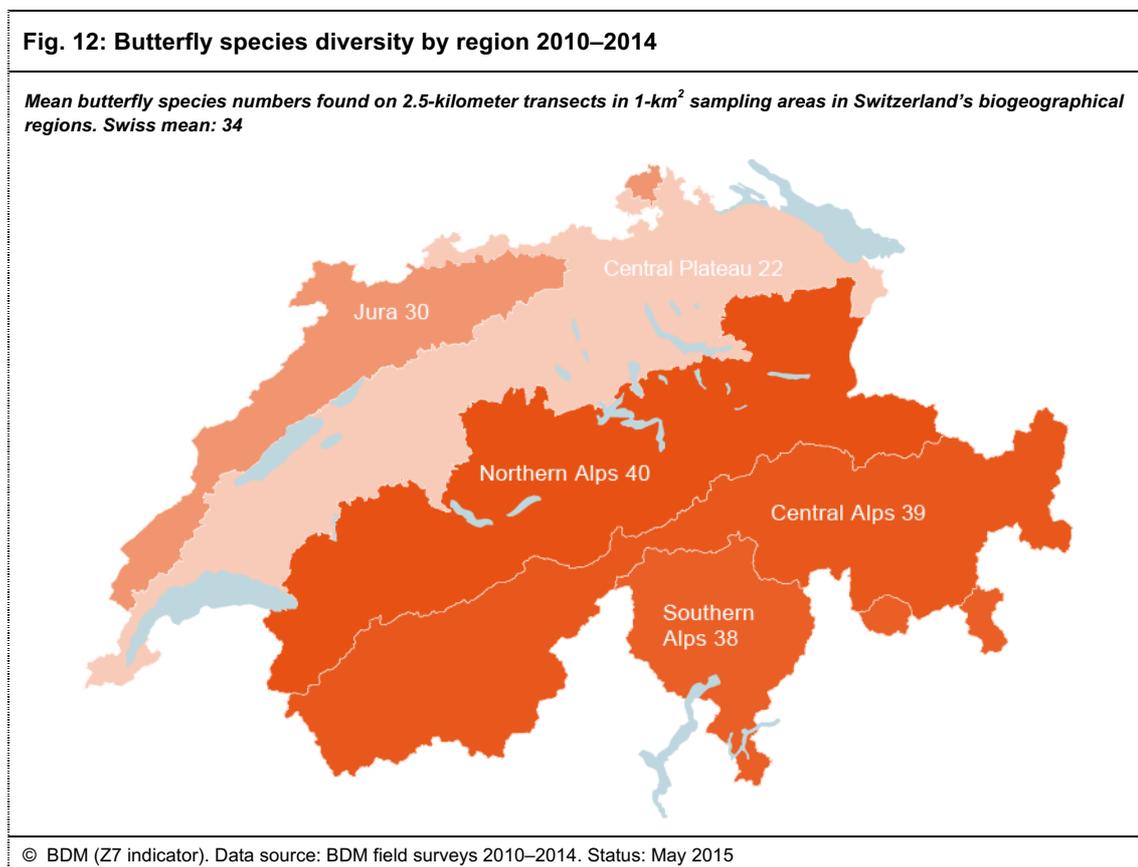


Comments

- As evidenced by some sampling areas harboring more than 50 breeding bird species, the Central Plateau holds a considerably higher potential for bird species diversity than species numbers recorded for this region might suggest. Moreover, numerous species typical of cultivated land—such as the Little Owl (*Athene noctua*) and the Hoopoe (*Upupa epops*)—are documented to have been widespread in the 1950s, even though nowadays mostly absent from the Central Plateau.
- In the second half of the 20th century, landscapes changed to an enormous extent, especially in the lowlands. As documented by the *Historische Brutvogelatlas* (Knaus et al., 2011), this transformation had a negative impact on breeding bird species diversity.
- Both featuring 39 species of breeding birds per square kilometer, the Jura and the Central Plateau are distinctly richer in species than the Central Alps or the Southern Alps, where some isolated extremely low numbers established on high-mountain sampling areas result in a low species average.
- For frequency and development data on individual species as well as additional information please refer to the Z8 indicator “Population Size of Common Species”.
- For complete data please refer to Appendix 1.

Butterfly species diversity: current situation

Figure 12 below illustrates mean butterfly species numbers per square kilometer found on transects in Switzerland's different biogeographical regions.



Comments

- The Swiss mean for butterflies comes to 34 species per square kilometer. On average, the Central Plateau holds only about half as many butterfly species (22) as the Alps. An average of 30 species places the Jura in the intermediate position. With their mean species diversity just as high as in the Central and the Southern Alps, the Northern Alps harbor a surprisingly large number of species.
- Compared to the rest of Europe, butterfly species richness found in the Swiss Alps is exceptional. Even in southern European countries otherwise richer in species, regions characterized by comparable butterfly species diversity at higher altitudes can only be found in isolated sites, e.g. in the Pyrenees or the Balkan mountains. Among the few countries presenting comparable transect data, only the Catalan Pyrenees present similarly high species numbers. Consequently, Switzerland takes major responsibility for helping to maintain butterfly species diversity in Europe.
- Butterfly species diversity on the Central Plateau is strikingly low considering the two other Z7 species groups. On average, it holds only about half as many species as the Alps do, although some high-alpine sampling areas are also characterized by a very low number of species.
- Subjected to intensive land use, large parts of the Central Plateau have become devoid of species-rich habitats nowadays. However, isolated sampling areas yielding more than 30 different species reveal the region's potential to be considerably higher. Furthermore, records show that numerous butterfly species—such as the Small Blue (*Cupido minimus*)—used to be widespread on the Central Plateau, even though they have all but disappeared today.

- The surprisingly large butterfly species diversity found in the Northern Alps can be explained by the mosaic of dry and humid habitats prevalent in that region and benefiting butterflies: On a small scale, poor grassland facing South is within flitting distance of slopes moistened by seepage water and still vast expanses of fenland. However, it must be taken into account that the Central Alps feature a higher share of species-poor high-mountain sampling areas.
- For frequency and development data on individual species as well as additional information please refer to the Z8 indicator "Population Size of Common Species".
- For complete data please refer to Appendix 1.

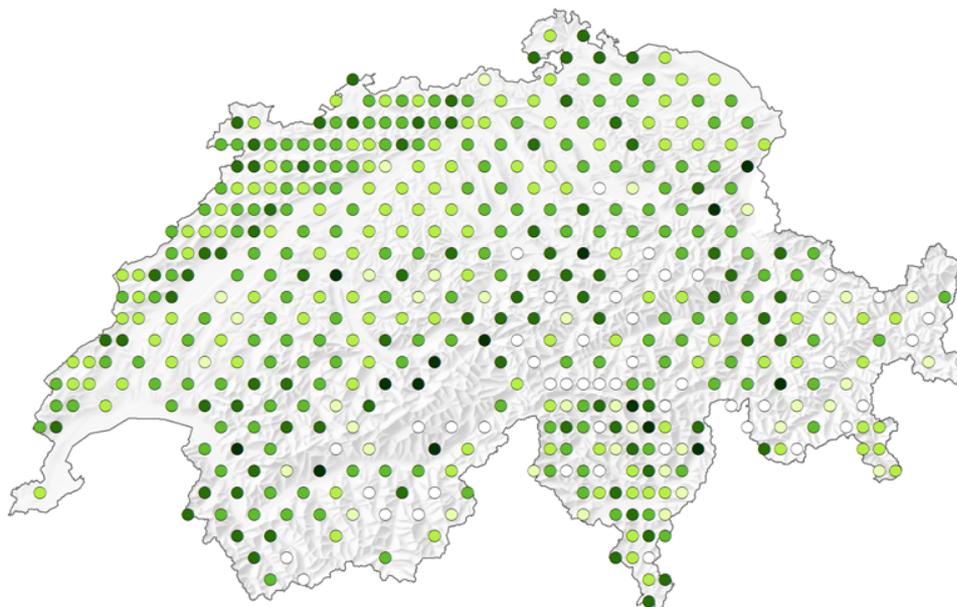
Species diversity in sampling areas

Figures 13 to 15 below illustrate species numbers registered in BDM sampling areas of 1 square kilometer using the BDM method. With locations of sampling areas in the landscape being determined by a rigid grid, survey data must be interpreted with caution. In particular, individual results cannot be used to extrapolate species diversity found in the vicinity of sampling areas. Nevertheless, it is possible to recognize certain patterns that reflect regional circumstances.

One thing is immediately obvious looking at the dot patterns: In the Alps, species-poor sampling areas are located side by side with very species-rich areas. This wide variety is a result of the marked relief. In contrast, the Central Plateau and the Jura look much more uniform, even though they also hold the odd sampling area that is either particularly rich or poor in species.

Fig. 13: Plant species diversity in sampling areas 2008–2012

Vascular plant species numbers per square kilometer in surveyed BDM sampling areas

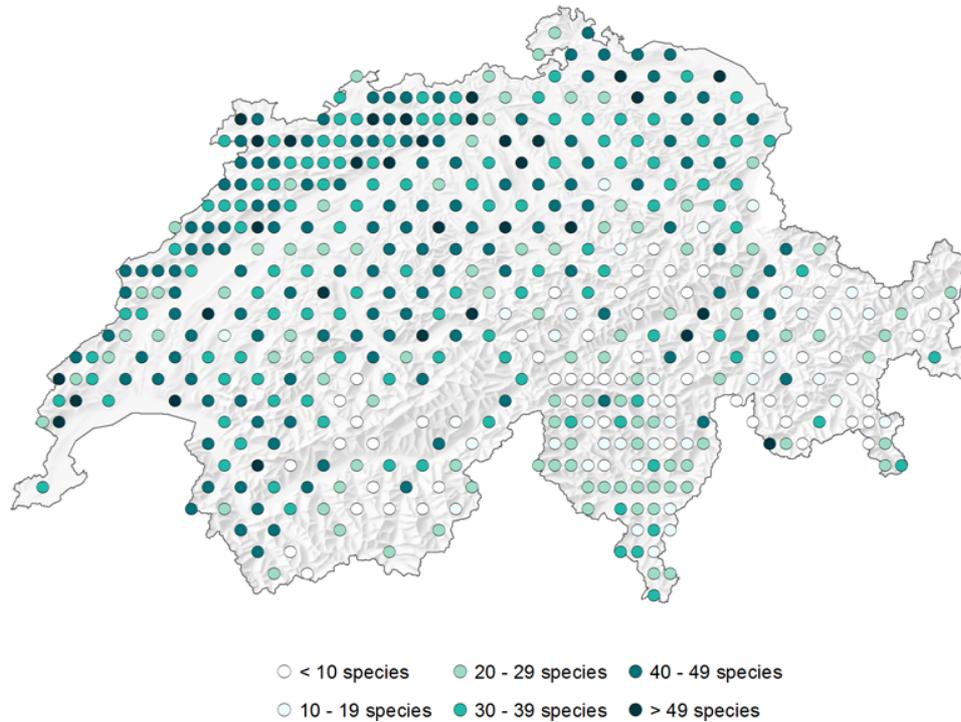


○ < 150 species ● 200 - 249 species ● 300 - 349 species
 ● 150 - 199 species ● 250 - 299 species ● > 349 species

© BDM (Z7 indicator). Data source: BDM field surveys. Status: May 2013

Comments

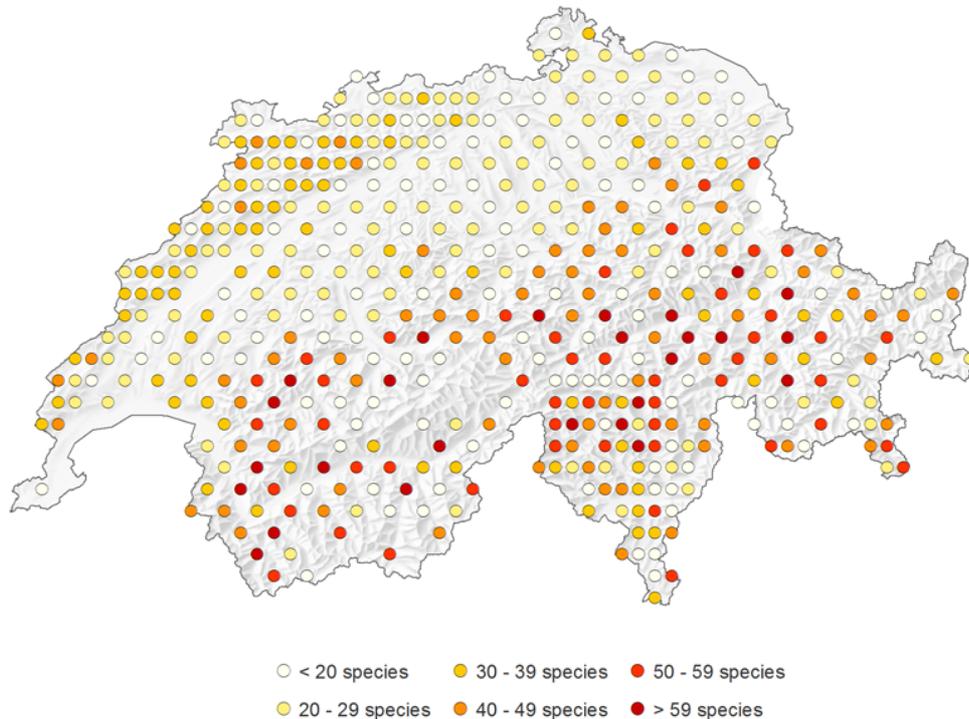
- Sampling areas featuring the lowest numbers of vascular plant species are located in high alpine regions at more than 2'500 meters above sea level. Largely composed of rock, glacier or firn, these areas are characterized by extremely harsh conditions only few plant species can tolerate.
- The highest numbers of plant species were found growing in sampling areas in the Northern Alps and in the Wallis. Areas richest in species are marked by great differences in altitude and a large variety of habitats combined within a tight space.

Fig. 14: Breeding bird species diversity in sampling areas 2008–2012*Breeding bird species numbers per square kilometer in surveyed BDM sampling areas*

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Comments

- High numbers of breeding bird species have covered the Jura and the Central Plateau in dark-colored dots, while higher altitudes are predominantly marked by light-colored dots representing low species numbers.
- At 59, one of the highest numbers of breeding bird species was recorded in a sampling area in the Vorderrhein river valley. This particular sampling area comprises not only extensive grassland with a large number of hedgerows and woody clumps, but also some riparian forest and part of a settlement. High-alpine or mostly water-covered sampling areas naturally supplied minimum species numbers.

Fig. 15: Butterfly species diversity in sampling areas 2008–2012*Butterfly species numbers per square kilometer in surveyed BDM sampling areas*

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Comments

- Butterfly species numbers recorded vary a great deal, as is exemplified by the extreme values found: In 17 of 464 sampling areas overall, fieldworkers identified less than 10 species. In contrast, 27 sampling areas harbored 60 species or more.
- The record is held by a sampling area in the Val de Bagnes in southwestern Switzerland, where 77 species were identified. Areas yielding less than 10 butterfly species are predominantly located on the Central Plateau (including settlements) and at high altitudes in the Alps.
- Unlike the two other species groups, butterflies stand out by mostly species-poor sampling areas on the Central Plateau, lowering this region's mean species diversity to only half of the Alps'.
- 94% of all butterfly species occurring in Switzerland were registered. Since butterflies are very mobile, surveys also include species that actually reproduce away from the transects.

Additional findings

Both systematic and standardized, BDM surveys ensure representative monitoring of the country as a whole, permitting analyses that are impossible to make using datasets supported by a less wide-ranging basis. For this reason, the complete dataset was closely examined looking for answers to various specific questions.

Influence of migratory butterflies on butterfly species numbers

In a good year, Z7 surveys register droves of migratory butterflies. But how strongly are BDM data impacted by migratory butterfly species?

> For more information please refer to Appendix X.

Butterfly species standing for high species diversity

Which butterfly species typically occur in species-poor sampling areas, and which species are almost invariably found in very species-rich habitats? Of all butterfly species, it is the Eastern Burnet (*Zygaena carniolica*) that stands for the highest species diversity: Wherever the Eastern Burnet was observed, BDM fieldworkers recorded at least another 37 species, with the average as high as 57!

> For more information please refer to Appendix Y.

Species diversity maps

BDM data make it possible to feed mathematical models suitable for predicting nationwide species diversity distributions. Unlike the regional maps shown above, computer-assisted model predictions reveal a diversity pattern that makes allowances for the country's relief, land uses and climatic conditions.

> For more information please refer to Appendix Z.

Significance for biodiversity

Species diversity in the 1-km² sampling areas monitored by the Z7 indicator "Species Diversity in Landscapes" is influenced by various factors. Their natural potential is determined by biogeographical distribution patterns and physical factors such as relief, geology, and climate. Areas on the northern and southern slopes of the Alps are characterized by a high natural potential: Big differences in altitude and a marked relief create a wide range of habitats, which in return make for correspondingly high species diversity. So it comes as no surprise that field biologists discovered the highest numbers of vascular plant and butterfly species in sampling areas located in the Northern and the Southern Alps.

The greater the area claimed by human activities, the more significant the impact that the type and intensity of human land use have on species diversity. This becomes obvious looking at species numbers recorded in the Jura and on the Central Plateau: Maximum species numbers observed are almost identical in both regions, making their natural potential even. However, mean species numbers registered in the Jura surpass those found on the Central Plateau. In the case of butterflies, differences are so pronounced that even Jura areas relatively poor in species still feature roughly the same species diversity as average sampling areas on the Central Plateau. This underlines the fact that the intensive land use common on the Central Plateau has already destroyed many valuable habitats, wiping out the plant and animal species dependent on them.

Species richness in landscapes depends on the diversity and quality of the habitats they comprise: the more varied a landscape is regarding habitat types such as grassland, forest, and cropland, the more species will find a habitat that suits them. In addition, the quality of those habitats is important as well. For example, it makes a difference whether a sampling area consists only of rich pastures or whether it contains poor grassland as well. Therefore, high Z7 values or rather increases in Z7 values are generally very welcome.

Species-poor sampling areas differ from species-rich sampling areas mainly by their lack of semi-frequent habitat types such as poor grassland. Wherever these habitat types are missing, there is no alternative for their typical representatives such as the Meadow Clary (*Salvia pratensis*) or the Marbled White (*Melanargia galathea*). Common and widespread species found in almost any sampling area will respond much less sensitively to changes in a landscape's habitat makeup. Very rare species with limited distribution are of little relevance for the Z7 indicator as well, as their occurrence in BDM sampling areas is extremely uncommon and coincidental.

Since Z7 registers changes in species diversity, changes in land use have just as direct an impact on the indicator as extreme natural phenomena like Lothar, the “hurricane of the century”, or the scorcher summer of 2003.

In evaluating biodiversity trends, it must be borne in mind that biodiversity is not only a matter of species numbers, but also of differences in the composition of species communities—a fact taken into account by the Z12 indicator “Diversity of Species Communities”.

Definition

Changes in the mean species diversity of select species groups in 1-km² sampling areas (grid cells).

Sampling areas each cover one square kilometer for all monitored species groups. BDM uses standardized methods to record the species occurring in these areas. The sampling network consists of a regular grid covering Switzerland emanating from a randomly chosen site. In order to gather meaningful data on small regions as well, additional areas were established in the Jura and the Southern Alps. In total, the sampling network is composed of 519 sampling areas. Just under 30 of these areas—most of them high alpine—are so inaccessible that they cannot be surveyed. Furthermore, BDM experts will not survey areas which are all water or all glacier. However, survey results include glacier sampling areas as “free of species” by definition, while water sampling areas are disregarded.

Z7 is computed both for Switzerland as a whole and for its major biogeographical regions. Moreover, separate statements can be made for high altitudes (areas at more than 1'400 meters above sea level) or other large-scale parts of the country. Up until now, surveys record vascular plants (since 2001), breeding birds (since 2001), and butterflies (since 2003).

Surveying methods

BDM experts have developed a specific surveying method for each species group, customized to be as cost-effective as possible, yield well-reproducible results, and represent each monitored square kilometer as comprehensively as possible. Occurrences of vascular plants and butterflies are surveyed along a 2.5-kilometer transect that follows existing trails wherever possible. The transect routes, the number of field trips (one or two for vascular plants, four to seven for butterflies, depending on altitude), and the time intervals between field trips are predefined for each sampling area. If no trails exist, biologists will mark the transect route in the field and plot it on a map. Every species they find is electronically registered on the spot. Owing to the constant sampling extent along standardized transects, changes are easily recognized even though not all species occurring in a 1km² sampling area are found. This surveying method proved to be effective from the start. For example, of the roughly 200 butterfly species BDM takes into consideration, 189 were recorded at least once along BDM transects—despite the sampling network covering a mere 0.3% of Switzerland's expanse. This outcome is both surprising and encouraging: Apparently, most species are still widespread enough to be detected using non-species-specific surveying methods. As a result of the uniform sampling of Switzerland, even remote areas rarely visited by volunteer observers have been mapped for the first time as part of BDM surveys.

The rigid sampling grid forces fieldworkers to look for butterflies in areas presumed to be species-poor as well, discovering species that seem to have slipped through monitoring grids quite frequently before, such as Thor's Fritillary (*Boloria thore*). Formerly considered to be rare and critically endangered, this species was found in 7% of all alpine sampling areas. Because of representative sampling, BDM data are very well suited to determine current frequencies of species and to make objective evaluations of changes in frequency over time. Accordingly, BDM butterfly data provide an essential basis for assessing Red List endangerment levels.

Contrary to vascular plants and butterflies, breeding birds are monitored covering the whole 1-km² sampling area rather than just along a transect. Ornithologists will only deviate from this principle in inaccessible regions. In such a case, any part of an area that was impossible to sample is marked on a map. Depending on altitude, each sampling area is monitored on the occasion of two to three mornings during a predefined period of time. Surveys and surveying methods largely tie in with the Swiss Ornithological Institute's Common Breeding Bird Survey (MHB).

The BDM Coordination Office continuously checks the quality of surveys and analyzes raw data. Among other things, some sampling areas are subject to double monitoring for quality control purposes. Comparative results gained this way allow for accurate assessment of data reliability and, thus, data meaningfulness.

In order to evaluate the development of species diversity in the past 10 years, BDM uses a generalized linear mixed model (GLMM). GLMMs are often used to compute trends in time because they can be very easily adapted to any data structure. This particular GLMM above all makes allowances for annual fluctuations in species diversity and the impact made by annual samples. For example, annual fluctuations may be influenced by weather conditions, hence creating the impression of false dependencies. Furthermore, the fact that only one fifth of all BDM sampling areas is surveyed each year is taken into account as well. Since the GLMM estimates the impact of this select sampling effect, BDM does not risk to report invalid increases or decreases due to the choice of sampling areas surveyed in any given year.

Further information

In charge of this indicator

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Related indicators

- > Z8 "Population Size of Common Species": data on the occurrence of individual species.
<http://www.biodiversitymonitoring.ch/en/daten/indikatoren/z/z8.html>
- > Z12 "Diversity of Species Communities": data on the similarity of species composition.
<http://www.biodiversitymonitoring.ch/en/daten/indikatoren/z/z12.html>
- > Z9 "Species Diversity in Habitats": data on species diversity in habitats.
<http://www.biodiversitymonitoring.ch/en/daten/indikatoren/z/z9.html>

Additional sources of information

- > www.vogelwarte.ch comprehensive information on the Common Breeding Bird Survey (MHB) and the Swiss Bird Index (SBI) of the Swiss Ornithological Institute Sempach.

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