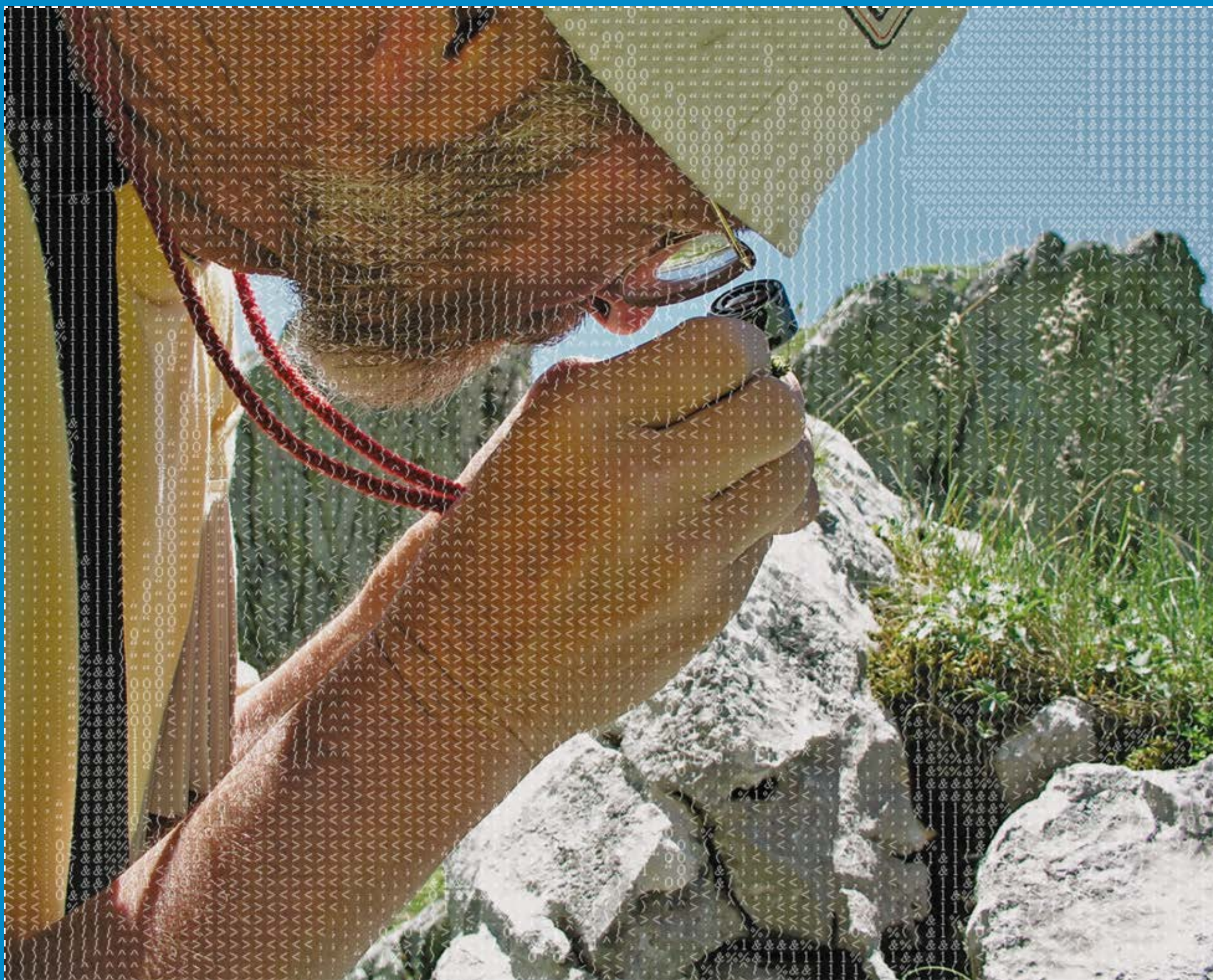
> Swiss Biodiversity Monitoring BDM

Description of Methods and Indicators



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> Abstracts

Switzerland has been monitoring its biological diversity since 2001 through the Swiss Biodiveristy Monitoring BDM programme. This report summarises the concept behind this programme of the Federal Office for the Environment FOEN in a straightforward and comprehensive way. It does not contain any data but provides an in-depth explanation of the data collection methodology used. It also explains the organisation and communication aspects of the programme. The appendix to the report contains a detailed description of all of the BDM indicators.

Keywords:
species diversity, biodiversity, biological diversity, data collection, monitoring, long-term monitoring, methodology, indicators, BDM

Seit 2001 überwacht die Schweiz ihre biologische Vielfalt mit dem Biodiversitätsmonitoring Schweiz BDM. Vorliegende Publikation fasst das Konzept des BAFU-Programms auf leicht verständliche und umfassende Weise zusammen. Der Bericht enthält keine Daten, sondern erläutert eingehend die Methodik der Datenerhebung. Beleuchtet werden zudem die Organisation und Kommunikation des Programms. Im Anhang findet sich überdies eine komplette Beschreibung aller Indikatoren des BDM.

Stichwörter:
Artenvielfalt, Biodiversität, Biologische Vielfalt, Datenerhebung, Monitoring, Langzeitüberwachung, Methodik, Indikatoren, BDM

Depuis 2001, la Confédération helvétique surveille sa biodiversité au moyen du monitoring de la biodiversité en Suisse. La présente publication résume le concept du programme de l'OFEV de manière compréhensible et globale. Le rapport ne contient pas de données, mais explique dans le détail la méthodologie du recueil des données. Il éclaire également l'organisation et la communication du programme. Une description complète de tous les indicateurs du MBD est en outre proposée en annexe.

Mots-clés:
diversité des espèces, biodiversité, diversité biologique, recueil de données, monitoring, surveillance sur le long terme, méthodologie, indicateurs, MBD

Dal 2001 la Svizzera sorveglia la propria diversità biologica mediante il programma Monitoraggio della biodiversità in Svizzera (MBD). La presente pubblicazione riassume in modo comprensibile e completo gli elementi alla base del programma dell'UFAM. Il rapporto non contiene dati, ma spiega in dettaglio la metodologia di rilevamento dei dati. Inoltre illustra l'aspetto organizzativo e comunicativo del programma. Nell'allegato viene infine fornita una descrizione completa di tutti gli indicatori dell'MBD.

Parole chiave:
diversità delle specie, biodiversità, diversità biologica, rilevamento dei dati, monitoraggio, sorveglianza sul lungo periodo, metodologia, indicatori, MDB

> Foreword

Biodiversity is the sum of all ecosystems, species and genes to be found on this planet. In short, it is life itself. Biodiversity produces food, affects the climate, preserves air and water quality, is essential for soil formation, and accommodates recreation seekers. Through its provision of key services to society, biodiversity is a vital resource for us all. This is why it is of utmost importance for Switzerland to obtain reliable information on the way biodiversity is developing in the country.

The Federal Office for the Environment FOEN, which is obliged by law to monitor the development of biodiversity in all its shapes and forms throughout the country, has launched several programmes to this end, including Biodiversity Monitoring Switzerland BDM. The purpose of BDM is carry out long-term observation with a view to supplying sound data that will enable the establishment, orientation and evaluation of biodiversity conservation policies. Using its own customized surveying methods, BDM makes a significant contribution to improving knowledge about biodiversity and provides research with well-founded and, therefore, highly sought-after data.

At the end of 1995, the FOEN commissioned a working group to develop a concept for biodiversity monitoring. The first field surveys began in 2001 and an interim report on the programme's planned methods (Environmental Series No. 342) was published a year later. Since then, the conceptual work has been completed and comprehensive results are now available for most indicators for the first ten years. Although the methods have stood the test of time, they are adapted to the latest findings as required.

The field survey methodology developed and optimized by BDM in this country in recent years is now also being used in several neighbouring regions and countries. Moreover, various Swiss environmental monitoring bodies have come to rely on BDM for both data collection and special analyses.

This report summarises the conceptual approaches and methods of the programme with a view to sharing knowledge and providing a wide audience of specialists with access to the expertise that has been gained in more than a decade. To this end, the central indicators that monitor species diversity and form the core of BDM are described in detail. All other indicators are summarised in the appendix. This publication replaces the interim report of 2002 and provides an updated overview of the now more mature Swiss Biodiversity Monitoring programme.

Although the programme and its methods and have been fully established and implemented, BDM continues to develop. Not only do new questions continually emerge and need to be answered, but the instructions given to the field team have to be refined and adapted to new situations. This is why it is a good idea to visit *www.biodiversitymonitoring.ch*. It contains the latest data on biodiversity in Switzerland and more detailed and continuously updated information about the field methods which are outside the remit of this publication

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1 > The Goals of BDM

BDM is intended to show how biodiversity in Switzerland changes over time. However, it is obvious that a programme that monitors all species and habitats in Switzerland equally intensively would not serve either biological or economic purposes. Furthermore, a variety of other programmes exist in addition to BDM that also collect data on various species groups or habitats. For this reason, analyses carried out in the 1990s concluded that BDM should be designed to close some of the gaps in the data observed at the time. In conjunction with data from other projects and data centres and current research results, BDM was intended to contribute to providing a complete picture of biodiversity trends and biodiversity policy challenges in Switzerland.

The concrete goals of the BDM programme are to:

> *Demonstrate long-term biodiversity trends;*
BDM is a long-term environmental monitoring project comparable to other FOEN programmes, such as the Swiss National Forest Inventory (LFI), the National River Monitoring and Survey Programme (NADUF) and the Swiss Soil Monitoring Network (NABO). Therefore, it is designed to provide a series of statistics that are compiled using identical methods and in compliance with high quality comparability standards.

> *Make it possible to draw representative conclusions about Switzerland as a whole;*
Much of the earlier data apply to specific sites or regions in Switzerland. Given such a restricted basis, it is often impossible to draw conclusions on developments at national level. However, BDM is expected to provide data that are representative of the trends in Switzerland as a whole. These data are also intended to enable differentiated conclusions to be drawn about the various biogeographical regions and the main types of land use, provided this is realistic and can be done at justifiable expense.

> *Include normal landscapes;*
In the past, nature conservation projects often focused on conserving valuable residual areas in Switzerland's intensively used landscape. As a result, the existing data on species and habitats predominantly concern a small section of Switzerland and most of the country's biodiversity has scarcely been monitored. BDM is intended to ensure that biodiversity development is measured across Switzerland, including in intensively used areas.

> *Integrate rare and common species;*
Thanks to various interest groups, specialised species conservation projects and data centres, Switzerland has a strong tradition of documenting occurrences of species which are valuable for nature conservation purposes. However, effective biodiversity policy cannot focus solely on currently threatened species and habitats, it must also recognise developments in widespread and common species in good time. Where possible, BDM is expected to fully monitor developments in taxonomic

groups, including all species, and use its systematic surveying networks to complement existing knowledge about rare and threatened species.

> *Primarily monitor species diversity;*
Biodiversity is generally described at three levels: “genes”, “species” and “habitats”. However, BDM currently focuses on monitoring developments in species diversity. From a biological point of view, the differentiation of species is generally fairly simple and species diversity is the unit of biodiversity that is easiest to convey. Although the monitoring of genetics is equally important, the cost of doing so representatively is high. The monitoring of habitats is also important, however it has not yet been possible to complete the methodological work required for a simple habitat survey. For these reasons, BDM does not adequately cover genetic or habitat diversity.

> *Monitor various levels of species diversity;*
Ecologists differentiate between three different spatial or functional levels of species diversity: 1) diversity within a habitat; 2) diversity within a habitat mosaic or a landscape; and 3) diversity within biogeographical regions or a country. Since different influences affect these levels, different developments should be expected. This is why BDM has been designed to monitor developments at all three levels in a differentiated manner.

> *Ignore effectiveness monitoring;*
Monitoring the effectiveness of concrete projects is expressly not the objective of BDM; this is the task of specific effectiveness monitoring programmes. Monitoring must not identify causalities either; this is achieved by targeted (research) projects. Long-term monitoring programmes like BDM, effectiveness monitoring programmes and targeted (research) projects complement each other.

> *Demonstrate the most important trends in relation to pressures and responses;*
Although BDM does not need to demonstrate causalities, it must show trends in relation to major pressures and responses in accordance with established international indicator systems. This makes it possible, at least, to formulate hypotheses and investigate them later in the context of more detailed projects. Accordingly, BDM is designed to use existing data to identify developments in potential pressures and responses which can be directly correlated with biodiversity trends on the basis of current scientific knowledge.

2 > Indicator Concept

2.1 PSR model

In recent years, the European Environment Agency's (EEA) DPSIR (*Driving Forces, Pressures, States, Impacts and Responses*) model of has been applied in international monitoring programmes. BDM is based on the PSR model (OECD, 1994), which is somewhat older and simpler, but still serves its purpose. In this model, indicators are selected and grouped so that they express the most important pressures (i.e. threats such as the use of mineral fertiliser) and the state (i.e. number of plant species on managed grasslands) of biodiversity or reflect responses aimed at safeguarding it (i.e. eco-subsidies for extensive grasslands).

Although the PSR model provides a useful grid for ordering data, it also has its risks as the design and selection of indicators suggests certain causalities between them. Hence, it is necessary to keep in mind that correlations between data sets over time do not automatically prove the existence of causalities. For example, biocide use and the European hare population both decreased at the same time in the 1980s, in Switzerland while the size of protected areas increased. However, it cannot not be concluded from this that European hares are positively affected by the decline in biocide use and negatively affected by the increase in protected areas.

2.2 Selecting the indicators

Indicators must fulfil a range of criteria so that they can be used by BDM:

> *State indicators …*
  – record major changes in biodiversity: the complexity of biodiversity – different spatial levels of species diversity (see Tab. 3), genetic diversity and habitat diversity – must be covered as comprehensively as possible. However, for financial reasons, all potential changes cannot be monitored.
  – identify changes as quickly as possible: results must be capable of being used in policy making. Statements about what happened 20 or 50 years ago do not give rise to concrete measures.
  – clearly interpret them: changes in the indicator values must be clearly assessable. Values should rise as biodiversity increases and be positively assessed (and vice versa).
  – allow general conclusions to be drawn about Switzerland as a whole: the indicators must be selected and designed so that conclusions can be drawn about the entire country.
  – can be communicated effectively: the results must also be comprehensible to a general audience and elicit concern. This means that the indicators are under-

stood, at least a few of the selected species groups are known and charismatic, and that the results are documented with convincing examples.
- can be recorded and calculated as cost-effectively as possible: the currently available funding is so limited that cost constitutes a decisive criterion in the selection process.

> *Pressure and response indicators …*
- relate to biodiversity as directly as possible: the temptation to try to monitor and later account for all conceivable variables despite the lack of causalities is great. particularly in the case of the pressure indicators. However, this would require too many resources.
- be based mainly on existing data: due to limited funding, it is necessary to use a wide range of comprehensive, existing primarily pressure and response indicators and develop them in a suitable form.

2.3 Structure of the indicator set

2.3.1 Thematic grouping

The BDM concept currently includes 32 indicators. In Table 1 they are grouped in accordance with the PSR model. Despite the fact that the pressure indicators dominate numerically, BDM funds are mainly allocated to state indicators. Data for pressure and response indicators are mostly adopted from third-party sources and processed for BDM.

Tab. 1 > Thematic grouping of indicators based on the PSR model

Pressures		States		Responses	
14 indicators:		12 indicators:		6 indicators:	
• Valuable habitats	1	• Genetic diversity	2	• Protected areas	3
• Landscape structures	4	• Species diversity	8	• Areas under contract	1
• Open-land use	2	• Habitat diversity	2	• Agriculture	1
• Forest use	3			• Finances	1
• Watercourse use	3				
• Landscape fragmentation	1				

Table 2 provides an overview of all indicators, which are described in more detail in the appendix. The updated data for 31 indicators are currently available on the Internet.

Tab. 2 > Overview of BDM indicators

E1=Z10	Size of Valuable Habitats
E2	Size of Areas of Defined Use
E3	Size of Wilderness Areas
E4	Length of Linear Landscape Features
E5	Diversity of Land Use and Land Cover
E6	Nutrient Supply in the Soil
E7	Intensity of Agricultural Land Use
E8	Forest Area Dominated by Non-Indigenous Trees
E9	Area of Artificially Regenerated Young Woodland
E10	Dead Wood
E11	Volumes of Water Withdrawn from Watercourses
E12	Proportion of Adversely Affected Watercourses
E13	Water Quality
*	
E15	Landscape Fragmentation
Z1	Number of Livestock Breeds and Plant Varieties
Z2	Proportion of Livestock Breeds and Plant Varieties
Z3	Species Diversity at National and Regional Levels
Z4	Number of Species in Switzerland Facing Global Extinction
Z5	Change in the Endangerment Status of Species
Z6	Population Size of Endangered Species
Z7	Species Diversity in Landscapes
Z8	Population Size of Common Species
Z9	Species Diversity in Habitats
Z10	Size of Valuable Habitats
Z11	Quality of Valuable Habitats
Z12	Diversity of Species Communities
M1	Size of Protected Areas
M2	Size of Secure Protected Areas
M3	Number of Endangered Species Living in Protected Areas
M4	Ecological Compensation Areas
M5	Organically Farmed Areas
**	
M7	Financial Resources for Nature and Landscape Conservation

Z: state indicators; E: pressure indicators; M: response indicators.
* Indicator E14 was integrated into E13
**M6 could not be implemented in the planned form

To ensure the optimal use of the limited funding, several workshops were organised at the beginning of the programme to establish the type of data and information that the future beneficiaries of BDM would require. In addition to the needs of the future users, the recommendations of UNEP (1993), the OECD (1994), the WCMC (Reid et al., 1993) and Noss et al. (1992) were also taken into consideration. The BDM report from 1996 contains detailed information about the composition of the set of indicators developed at the time (Hintermann et al., 1996).

Other indicators were evaluated in the course of the further development of the programme. Indicator Z12 was also added as a result of these evaluations. In addition, changes were made to the originally planned indicators. Indicator E14 was integrated into E13. The content of several definitions was adjusted (e.g. E10 and E15). It became clear that indicator M6 could not be calculated as planned.

2.3.2 State indicators

Most authors differentiate between the three levels of biodiversity: genetic diversity, species diversity and habitat/ecosystem diversity. These three levels are also used in BDM, however reservations exist in relation to the habitat diversity level (see, inter alia, Reid at al., 1993).

Genetic diversity

To attain the overriding goal of biodiversity conservation, efforts must begin below the species level. Genetic diversity may be lost long before a species becomes extinct.

For financial reasons, BDM only monitors genetic diversity in crop plants and livestock (Z1, Z2). Representative surveys, such as those conducted by the programme conducts on the diversity of widespread and common species (Z9), cannot be financed for genetic diversity.

Species diversity

Species diversity is undoubtedly the most popular level of biological diversity. Indeed, biodiversity is often equated with species diversity. Species diversity is easy to describe and its value is evident to the public. It is generally easy to distinguish species from each other.

Species diversity can be measured on various spatial levels. Table 3 shows how these scales differ from each another.

Various authors refer to the three levels as alpha, beta and gamma diversity. However, these terms are not used consistently in the literature (Jurasinski et al., 2009), therefore they are not used here.

Tab. 3 > The three spatial/functional levels of species diversity

	Diversity within a habitat	Diversity in landscapes	Diversity in biogeographical regions/in a country
BDM core indicators	Z9	Z7	Z3
Greatest pressures	• nutrients • structure • land use • management	• heterogeneity • length of boundary lines • size of production land units	• range shifts • species evolution • species extinction
Key protection strategies	• developing/optimising land-use methods	• habitat conservation • compensation areas • habitat networking	• species conservation • reintroduction • large-scale corridors • possible isolation
Sensitive species	common, widespread species	widespread, uncommon species	rare species (threatened species on Red Lists)
Rate of development	moderate	rapid	slow at first, then rapid
Appropriate frame of reference	• land-use units • habitats	• regions • altitudinal zones	• biogeographical regions

In addition to the actual numbers of species, changes in species composition on various spatial levels also play a central role. Indicator Z12 shows how species communities develop within individual habitats and different regions of Switzerland. As a result, this indicator makes it possible to track whether biodiversity homogenisation, a topic of international discussion, is also making inroads in habitats and landscapes in Switzerland.

Indicators Z9, Z7, Z3 and Z12 cover developments in the three spatial levels and in homogenisation, and form the core of BDM surveys as a result. Other indicators that highlight specific aspects also exist, of course, in addition to these.

Z4 (“Number of Species in Switzerland Facing Global Extinction”) documents the extent to which Switzerland fulfils its international responsibility. Z5 shows the net change in the endangerment status of threatened species. To provide an overall impression of the trend in this area, the number of species whose endangerment status has increased according to Red Lists is subtracted from the number of species whose endangerment status has decreased.

Z6 is an ideal indicator of developments in the populations of a few rare species. BDM obtains the data used for the calculation of this indicator from third-party programmes. For example, charismatic species, i.e. species with popular appeal, are included here. The field data recorded for Z7 and Z9 can also be used to calculate changes in the spread or population of around 1500 common and widespread species. Indicator Z8 provides an overview of this information.

Habitat diversity

Habitat diversity is very complex and difficult to record, and its significance is disputed. Reid et al. (1993) point out that the preservation of natural communities – and of different types of habitats that are, in fact, primarily defined in terms of plant communities – is not an end in itself. Instead, the aim is to preserve species that make up the community in question and ensure that the ecosystem can function. Neither objective precludes the possibility that communities may change. This makes it difficult to define ideal states and desirable and undesirable changes. In addition to the reservations about the concept, there are methodological problems; it is extremely difficult to delineate certain types of biotypes in a way that ensures that the results can be reproduced and that methodological error is small enough.

BDM restricts itself to one quantitative and one qualitative indicator for the habitats that have been defined as valuable under Swiss law (Z10 and Z11). Changes in size and structure can have a major impact on species diversity. Other changes are also measured by the E indicators.

2.3.3 Pressure indicators

As shown in Table 3, diversity is affected by various pressures on all three spatial levels. Habitat diversity (measured by Z9) is specifically affected by the nutrient supply, the structure of the defined area type, access techniques and management. These pressures are reflected mainly by indicators E6, E7, E8, E9, E11, E12, E13 and E15. Landscape diversity is determined by the heterogeneity of the habitat, the length of boundary lines and the size of the area used for a defined purpose, which are particularly illustrated by indicators E2, E4, E5, E11, E12 and E15. Finally, regional diversity is also affected by factors such as area shifts and the arrivals or disappearances of species, which are reflected to some extent by E1 and E3.

Not all relevant pressures are covered by indicators. BDM was purposely designed to reflect most, but not all, of the major pressures in the indicator set. What is more, there is no appropriate data basis for some indicators which might otherwise be useful to have. Various aspects that are also of interest in relation to biodiversity are partly already covered by the indicators used in other programmes. Any correlations can be analysed by linking these data (see the analysis of the Swiss National Forest Inventory, Brändli et al., 2007).

2.3.4 Response indicators

The selection of response indicators is also largely determined by the available data. Changes in legally protected areas (M1 and M2) and changes in the proportion of threatened species in protected areas (M3) are important for species diversity in the regions of Switzerland. In contrast, indicators M4 (changes in the total size of ecological compensation areas) and M5 (changes in the share of areas farmed organically) primarily affect habitat and landscape diversity. Indicator M7 (changes in resources for nature and landscape conservation) affects all three levels.

3 > The Most Important BDM Indicators

The central question tackled by BDM concerns how the state of biodiversity changes over time. As explained in the previous chapter, BDM is specifically focused on changes in species diversity. This is the area in which BDM invests most of its financial resources.

This chapter presents the indicators of species diversity in greater detail. Thus, the core indicators of the various spatial levels are the main focus. A full list of indicators with a brief description of their definition, significance (including the limits of the interpretation) and survey method can be found in the appendix.

3.1 Indicators of species diversity in regions

The number of different species in a biogeographical region or a country depends on the geographical location, the topography, the soils, the climate and the pressures created by human civilisation. Changes in this number are largely determined by changes in the populations of rare species. It decreases when the last representatives of a species disappear from a region and increases when species succeed in re-establishing themselves, in returning to a region or when new species evolve (which is a rather rare phenomenon in normal timeframes).

3.1.1 Indicator Z3

> **Definition Z3:** *"Changes in the numbers of free-living species of certain taxonomic units whose presence can be evidenced or demonstrated as being probable for at least nine out of ten consecutive years using standardised methods."*
> **Significance:** *Indicator Z3 provides an overview of changes in the number of species of the best known animal groups in Switzerland. To obtain this overview, the occurrences of species are balanced out with each other, regardless of their protection status or nature conservation value. For a more in-depth analysis from the perspective of nature conservation, the reasons for these increases and decreases in species groups need to be considered individually. This can be carried out using the additional information in the indicator sheet.*

The change in the total number of species in Switzerland is recorded using indicator Z3. Although Z3 is not explicitly described as an indicator of rare species, it is affected in the short term by the processes of "extinction" and "recolonisation" of rare and threatened species (see Tab. 4). These species primarily inhabit isolated patch habitats or marginal regions. For this reason, Z3 reacts to changes in isolated patch habitats (e.g. nature conservation activities), (re-)introductions and changes in the size of species areas. However, small-scale changes, such as in agricultural and forest land use, have little impact on Z3 unless they occur over a longer period of time at a multitude of sites.

In addition to the gradual processes described above, the spread of species ("introduced species") by vectors can lead to an increase in the number of species.

Reliable evidence of presence and absence

Z3 is intended to document the disappearance or emergence of species. Therefore, it can only consider groups whose presence and absence in Switzerland can actually be recorded. Like the discovery of new species shortly after they emerge, the latter criterion is especially difficult to fulfil for many groups. In any case, changes in rare species can only be reliably documented using a full-record method as sampling can never illustrate the presence or absence of rare species with sufficient accuracy (rare species slip through the gaps in a sampling grid). Due to the lack of financial resources, the comprehensive observation of the presence/absence of all species in Switzerland is not possible in practice. For this reason, Z3 can only be calculated by using and optimising existing reporting networks staffed by volunteers. However, this presupposes that the reporting networks are dense enough to detect changes. This is particularly applicable to charismatic groups as nature enthusiasts tend to report rarities. Hence, indicator Z3 is limited to providing a representative view of the total number of species in one sector of biodiversity.

Only wild species considered

Z3 explicitly considers only those organisms that occur in the wild in Switzerland. It excludes seed banks and animals kept in zoos as the conservation strategies used for organisms in purely ex-situ populations are different to those used for wild species.

For a species to count as wild in Switzerland and thus qualify for consideration by Z3, as a general rule, evidence that it reproduces outside of captivity must be available. In some cases, direct evidence of reproduction is not required, particularly if it is very hard to obtain or other information indicates that the species reproduces successfully. The exact minimum requirements are defined and documented for each species.

Exclusion of major fluctuations

Z3 only counts species that regularly occur in Switzerland. The criterion "recorded in 9 out of 10 years" was adopted from the Swiss Ornithological Institute in Sempach (Schmid, 1994). This requirement of constant evidence plays a central role for mobile species that do not always reproduce in Switzerland ("vagrants", "irregular breeders") because their territories are near to the political and geographical borders of Switzerland, or they extend beyond their biogeographical region in Switzerland. Species that are not very mobile are considered to meet the criterion with sufficient reliability if they are recorded once every 10 years at a sufficient distance from the border of the territory under observation. The reference period of 10 years is in line with the criteria used to assign species to the categories of the Red Lists (IUCN, 2001).

Unclear distinction between "native" and "alien"

The processes illustrated by Z3 are by their very nature relatively slow. However, exceptions to this rule include significantly anthropogenic changes in plants or animals (deliberate or accidental introduction in a habitat, removal of barriers to dispersion, targeted eradication). Article 8h of the Convention on Biological Diversity explicitly stipulates that "native" species be preserved. Therefore, a monitoring programme should also focus on autochthonous species or at least separately document the changes in the populations of these species.

In a small, landlocked country like Switzerland, plants and animals undergo constant change simply as a result of climate and biogeographical processes and without human intervention. Many now widespread species only arrived in Switzerland in the last 10 000 years. However, species are still considered "native" if they arrived in Switzerland just 6000 years ago, for example the European Beech. Species that were artificially introduced less than 1000 years ago are considered "native" today, for example the European Crayfish. By today's standards, the year 1492 is usually considered the year that differentiates "native" from "alien", although it is often rounded up to 1500.

Despite this clear distinction, considerable problems still exist in relation to the definition of certain species – e.g. species released abroad, spontaneous settlement in Switzerland (Muskrat, Raccoon Dog, Raccoon); releases of species that do not lead to a new settlement, but merely forestall or accelerate them (Marsh Frog); inadvertent introduction with crop plants (weeds, phytophagous insects). Because of these difficulties, BDM records all species in a taxonomic group for indicator Z3, irrespective of their origin. However, separate analysis can always be carried out retrospectively for species of different origin.

Slow reaction

Z3 reacts slowly to developments. Between 1900 and 2007, only 65 permanent changes (42 arrivals, 23 disappearances) were recorded in a total of about 700 monitored animal species, which represents a rate of around 1 per cent per year (Martinez et al., 2009). The theoretical biogeographical models also predict that Z3 will have constant values within the politically relevant time span. Even major landscape changes have little impact on this indicator. Three biogeographical theories that predict this fact include the equilibrium theory of island biogeography (MacArthur & Wilson, 1967), the theory of "species saturation" (Terborgh & Faaborg, 1980), and that of "carrying capacity for species richness" (Brown et al., 2001).

Because Z3 depends on a small number of rare species, with the exception of distinguishing between occurring and no longer occurring, in general, it is not very sensitive: for example, whether or not a single pair of breeding bird species still brood regularly is of vital importance. Despite these limitations, leading international efforts for monitoring biodiversity clearly rely on data such as those used by Z3 (cf. Reid et al., 1993: "…one of the most useful indicators of status and trends…"). This is why it is indispensable for biodiversity monitoring.

In order to increase the sensitivity of the indicator, Z3 is calculated not only for Switzerland as a whole but also separately for various biogeographical regions. This also makes it possible to demonstrate regional disappearances and migration in the six regions of the Jura, Central Plateau, Northern Alps, Southern Alps and Western and Eastern Central Alps.

Data from third-party programmes

In the initial phase, Z3 was operated for the taxa, about which considerable information had been provided by existing reporting networks. As Table 4 shows, the necessary information on vertebrates (excluding bats) and several popular groups of large insects (in some cases excluding subgroups that were difficult to define) can be obtained for Z3. Other groups, such as vascular plants, mosses and lichens, cannot be included in Z3 as it is possible to record their presence but not their absence. For example, changes affecting vascular plants are mainly due to impermanent adventitious species – species introduced by humans or invasive species. The absence of such species, which do not occur locally on a constant basis, cannot be demonstrated at a justifiable cost. Due to the rapidly growing quantity of information on their occurrence, several groups of species may also be included in Z3 in the next project phase.

Tab. 4 > Various species groups included in the calculation of Z3

As of December 2012. other groups were not assessed.

Taxon	Comments	Species	Included in Z3
Mammals	excluding bats	59	included
Bats	absence not verifiable	26	not included
Birds	all breeding birds	177	included
Reptiles		15	included
Amphibians		18	included
Fish and cyclostomes	excluding species in garden ponds	88	included
Dragonflies	excluding several migratory species	67	included
Butterflies	butterflies (including Hesperiidae, but not Zygaenidae)	190	included
Grasshoppers		103	included
Mayflies	rapid increase in information density at this time	87	may be feasible in the future
Stoneflies	rapid increase in information density at this time	111	may be feasible in the future
Caddisflies	rapid increase in information density at this time	302	may be feasible in the future
Vascular plants	absence not verifiable	about 3100	not included
Mosses	absence not verifiable	1 078	not included
Fungi	only edible fungi	about 150	not included (no taxonomic group; distinction unclear)
Lichens	absence not verifiable	about 1 600	not included

3.1.2 Indicator Z4

Switzerland has made international commitments to conserve globally threatened species. These are given top priority in species conservation measures as in contrast to species which are “merely” threatened at national level, the disappearance of these species would represent an irreversible loss. Indicator Z4 shows only a very small snapshot of Switzerland’s biodiversity, however it provides a great deal of information about Switzerland’s contribution to the success of international species conservation efforts.

- **Definition Z4:** *“Changes in the sum of all species facing global extinction whose occurrence in Switzerland during at least nine out of ten years can either be established or demonstrated as probable using standardized methods.”*
- **Significance:** *Z4 provides an indication of the significance of Switzerland’s efforts to protect globally threatened species. The overview is still incomplete as not all species groups have been assessed for global endangerment status and/or there are not yet enough data available on all species of relevance to Switzerland.*

Global endangerment is assessed according to quantitative, consistent category criteria developed by the IUCN (IUCN, 2001). The various categories express the global risk of a species becoming extinct. The term “occurring in the wild” is defined similarly to Z3. The indicator is only updated every five years.

Almost without exception, endemic species in Switzerland meet the IUCN criteria the “vulnerable” status at least. They are categorised independently of IUCN activities but using identical criteria. This makes it possible to include several mollusc species in Z4, even though IUCN has not yet fully assessed this group.

In theory, Z4 ought to be a subset of Z3. However, only a very small portion of all taxa can be recorded for Z3. Since Z4 contains a manageable number of individual species (i.e. the globally threatened species), it can include more groups of species than Z3, for example bats, molluscs, several groups of invertebrates, vascular plants and mosses.

Although the long-term goal of BDM is to record all globally threatened species in Switzerland, the indicator is being gradually extended as the work done by IUCN progresses and data becomes available within Switzerland. Many data become available “as a by-product” of the process of compiling indicator Z3 (and to some extent Z5 and Z6). Where data are not generated by these indicators or other independent programmes, a wide range of different methods have to be used to check the presence of relevant species (reporting network of amateur nature-watchers, targeted professional searches for potentially new species or missing species). However, methodological problems (limited ability to verify presence over a wide area, difficulties in defining species) make it necessary to exclude some species (e.g. the grass species Whiskered Brome, or *Bromus grossus*, as its absence cannot be demonstrated reliably).

Although BDM has added endemic representatives of other species groups to the existing IUCN Red Lists (IUCN, published on the Internet at www.redlist.org, 2010 version) in accordance with IUCN criteria (IUCN, 2001), the list of globally threatened species for Switzerland contains only the better known taxa (Tab. 5). It may be assumed that it will be possible to add other species to the list of species monitored by Z4 in the years to come.

Tab. 5 > Species groups with globally threatened species that are currently included in the calculation of Z4.

The "Z4 species" column shows how many globally threatened species are currently known to exist in Switzerland and can be monitored using Z4.

Taxon	Comments	Z4 species
Mammals		1
Birds		0
Reptiles		0
Amphibians		1
Fish	11 species not yet categorised by the IUCN	8
Molluscs	Groups not yet categorised by the IUCN, only endemic species in Z4 for the time being	5
Decapods		3
Butterflies	One additional species is not verifiable	6
Hymenoptera	15 threatened ant species are not verifiable	0
Beetles	Data processing incomplete	4
Grasshoppers		1
Dragonflies		0
Spiders	Data processing incomplete	1
Vascular plants	One additional species is not verifiable	27
Mosses		2

3.1.3 Indicator Z5

- **Definition Z5:** *"Number of species in Switzerland whose endangerment status has decreased by one level minus the number of species whose endangerment status has increased by one level. Species whose endangerment status has changed by two or three levels are counted twice or three times respectively."*
- **Significance:** *Z5 shows the net change in the endangerment status of species on the official Red Lists over 10 to 20 years. However, a comparison can only be made if the Red Lists concerned were compiled in accordance with the same IUCN criteria and the taxonomy has not significantly changed. Since these conditions are only fulfilled for breeding birds, for the time being, Z5 provides a current overview of the Swiss federal authorities' different Red Lists.*

Z5 shows the net changes in the endangerment status of plant and animal species in Switzerland. The number of threatened species for each taxon can be found on the Red Lists. However, the interesting parameter is not usually the number or proportion of threatened species per species group, but instead the changes in these numbers in a given area or timeframe. To document these types of changes, species must first be assigned to endangerment categories based on uniform, transparent criteria. The IUCN has already developed a system for estimating global endangerment status (IUCN, 1994) and even adjusted the criteria for use in national Red Lists (IUCN, 2003). This uniform system was adopted in Switzerland in 2001 so that net changes in the endangerment status of species can be determined as the Red Lists are gradually revised. The first time this occurred was in 2010 with breeding birds, which made it possible to calculate Z5 accordingly. Z5 is defined as the "number of species in Switzerland whose endangerment status has decreased by one level minus the number of species whose endangerment status has increased by one level. Species whose endangerment status has changed by two or three levels are counted twice or three times respectively."

3.1.4 Indicator Z6

> **Definition Z6:** *"Changes in population sizes of selected species that are threatened or potentially threatened in Switzerland, Europe or worldwide."*
> **Significance:** *Indicator Z6 is not representative of biodiversity as a whole since the selection is determined by the small amount of data available. However, using various examples, Z6 does show how populations of threatened or potentially threatened plant and animal species change within a period of ten or more years. In a way, it lends a "face" to the abstract figures provided by other indicators (particularly Z5).*

In order to illustrate trends in threatened or rare species, using Z6, BDM provides examples of developments in the populations of a few particularly well-documented or charismatic species. Species at high risk of extinction are particularly important to the conservation of species diversity. The information used by Z6 comes from third-party projects such as species conservation programmes. In principle, annual estimates of population sizes (abundance) are used for Z6. Since it is generally very difficult and costly to estimate abundances, appropriate data series are only available for very few species of Swiss plants and animals. At present, Z6 primarily includes data on breeding birds and individual representatives of mammals, amphibians, vascular plants and one insect species.

3.2 Indicators of species diversity in habitats

Species diversity within a habitat is affected by the quality and quantity of existing resources such as nutrients, food supply and structures. In agriculturally used areas, the nature and intensity of the land use or land management has a decisive impact on biological diversity.

However, when assessing the trends in biodiversity, it should be noted that it is not only the number of species found but also the differences in the composition of species communities (see Chapter 3.4) that contribute to diversity.

3.2.1 Indicator Z9

Species diversity, measured as the number of species per unit of area, is one of the most conclusive and persuasive indicators as it can be understood intuitively.

- **Definition Z9:** *“Changes in the mean species diversity of selected species groups in small sampling areas of standardised size.” This indicator measures the species diversity of vascular plants, mosses and molluscs (snails) in areas of ten square metres. As is the case for aquatic insects, indicator Z9 measures the species diversity of Mayflies, Stoneflies and Caddisflies in sections of watercourses.”*
- **Significance:** *Z9 characterises small-scale species diversity within habitat types. This makes it possible to analyse species diversity trends for the most important of the main types of land use in Switzerland. Since data are collected within a regular sampling grid across Switzerland, Z9 shows how species diversity is developing in our everyday landscape, i.e. in Switzerland’s “normal” grassland, arable land, forests and water bodies. Isolated patch habitats that are designated as valuable for nature conservation are of no consequence for Z9.*

Monitoring types of land use

Z9 illustrates the changes in species diversity in different types of habitats. In order to produce representative data for Switzerland, the raw data are collected using a systematic sampling grid with approximately 1600 land and 570 water sampling areas (see Chapter 4.2). In principle, it would be conceivable to apply Z9 to all types of habitats, even if they accounted for only a certain proportion of the total land area in Switzerland. However, in order to identify reliable trends for a certain type of habitat, a minimum number of sampling areas needs to be monitored. Since the financial constraints only enable a limited number of areas to be monitored, it is not possible to record data for rare habitats (e.g. raised bogs) using the current sampling grid. Changes in these types of isolated patch habitats are monitored in specific success evaluation projects, such as in the monitoring of the effectiveness of the FOEN’s federal inventories. These projects are recorded to a lesser extent by indicators Z3 and Z5 (see Chapter 3.1).

In contrast to isolated patch habitats, species diversity in areas subject to common types of land-use is strongly affected by the type of intervention carried out. Z9 focuses on the land-use types forest, arable land, permanent grassland, settlements and non-productive Alpine areas, in some cases subdivided by altitude (see Tab. 6). Watercourses were added as a habitat type in 2010. A more detailed sub-division into land-use types is not possible for financial reasons.

Tab. 6 > Breakdown of terrestrial sampling areas evaluated for Z9

In addition to these land strata, BDM also samples watercourses.

Types of land use	colline	montane	subalpine	Switzerland
Forest	X	X	X	X
Arable land				X
Grassland Alpine pastures	X	X	X	X X
Settlements				X
Non-productive Alpine areas				X

The subdivision of land-use types for evaluation may appear rough at an initial glance. However, these are the strata, in which changes are most likely to occur. Accordingly, increasingly organic and extensive use of the kind foreseen in Switzerland's current agricultural policy will have an impact on this indicator. For example, an evaluation of ecological compensation areas based on the data from Z9 surveys has provided a clear indication of the success of this ecological programme (Roth et al., 2008). This indicator also illustrates the consequences of climate change.

Changes in common species

Heavily used areas such as settlements, arable land and forest areas are inhabited predominantly by "trivial species". For this reason, Z9 is intended to complement other indicators by specifically demonstrating trends in common species. The indicator is designed to respond primarily to changes in the species typically found in habitats subjected to land use. The sensitivity can be adjusted through the data collection method (for example, the number of times an area is surveyed) and the size of the areas surveyed. The smaller the sampling area is, the smaller the number of species that can be observed in it. Z9 surveys always show a "baseline" of very common species. However, the change in the number of species is predominately determined by the "moderately common" species that are not found in every sample. However, rare species have no impact on the mean species diversity in small areas as they are hardly ever found in the areas sampled.

Small sampling areas

Small sampling areas were chosen based on the following considerations:

> *Clear assignment of the sampling area to an evaluation stratum:* it should be possible to assign each sample as clearly as possible to a single type of land use or watercourse. The assignment should be made to at least one of the strata in Table 6 and, ideally, even more specifically for subsequent special analyses.

- *Sensitivity for common species:* Z9 is designed to reflect changes in common species. The probability of encountering predominantly common species is greater in small areas than in large ones.
- *Taxon-dependent size of sampling area:* the size of the sampling area must be adjusted to the biology of the surveyed species. A sample area of 10 square metres has been empirically defined for vascular plants and mosses, and soil samples for determining molluscs are also taken from an area of 10 square metres (see Fig. 1). With regard to aquatic insect surveys, the length of the watercourse survey section is determined on the basis of the width of the particular body of water: the length of the section is ten times the width of the watercourse.
- *Good reproducibility of the data* (cf. also Chapter 4.1): for trend calculations to be reliable, it is essential that the sampling error be constant. Only then can trends be linked to biological and ecological processes with certainty. The more completely the occurrence of species at a site can be recorded, the more constant the systematic error will be. It is easier and faster to obtain a full record of the species present in small sampling areas than on large ones.
- *Raw data for the frequency calculations of individual species:* while Z9 records only the presence/absence of species, these results alone are sufficient to point to regional or national population trends as the sampling areas are relatively small.
- *Not too many blank samples:* a sampling area must not be too small for statistical reasons. Too many sampling units that do not contain the species group being sampled ("blank samples") make it difficult to evaluate a fixed number of sampling units.

Fig. 1 > Sampling area for Z9 data collection

A circular sampling area of 10 square metres has been empirically defined for vascular plants and mosses with soil samples for identifying molluscs also being taken from an area this size.

Marking areas so that they can be found again

Data are periodically collected from a specified sampling grid to determine the changes in species diversity in habitats (see Chapter 4.2). It is critical for BDM that sampling always occurs in the exact same areas. A high degree of precision must be guaranteed in locating very small areas of just 10 square metres in size. Hence, the centres of the sampling areas (located at the intersections of the kilometre grid used by Swiss Grid) are identified using GPS. In forests, the site can be identified by the markers of the National Forest Inventory (LFI), which operates a similar yet limited measuring network in forest areas. The sampling area is “secured” by describing it in a detailed report (surface marking) and burying a magnet in at the centre of the area (the upper surface of the magnet is 60 centimetres under the soil). In places in which it is not possible to bury a magnet, the centre is marked with a steel pin or colour marker. The report and a magnet detector enable the identification of the exact centre of the area again at a later date.

Colour markers are placed on the shore of the areas in which aquatic insects are sampled. Drawings of the site facilitate the re-identification of the areas.

Robust and reproducible field methods

The surveying methods for Z9 are designed in such a way that the species in a group can be determined over a small sampling area at little cost or effort. The data from one sampling area are part of the sample of an evaluation stratum (e.g. “non-productive Alpine areas”) and can only be interpreted in conjunction with the samples of other areas in the same stratum. However, the surveying method is not designed to show the biodiversity in the surroundings of a single sampling area. For example, plants sampled at one single site, e.g. in the Bremgarten forest near Bern at 560 metres above sea level, is one of many measurements that provide representative insights into changes in the mean species diversity of plant species in the entire “montane forests stratum of Switzerland”. However, data collected from a ten-square-metre area do not adequately reflect the plant diversity of the Bremgarten forest itself.

Field and laboratory methods for each species group are described in detail on the website at *www.biodiversitymonitoring.ch*. They are so precisely defined that the scope for individual interpretation by the field workers is minimal. Qualified personnel must be employed to collect the data. Nature enthusiasts have some of the required expertise, however they are generally difficult to recruit for Z9 surveys since the field method they must use is very restricted and they usually only encounter trivial species that are of little interest. In order to reduce surveying costs, methods have been established to allow trained individuals to record data for several species groups in one sampling area. Species determination, however, is always carried out by specialists. Samples of moss and molluscs, for example, are collected by the botanists who carry out the surveys of vascular plants. These samples are then sent to specialists for identification.

BDM field workers also take soil samples in a precisely defined radius from the centre of each Z9 sampling area. These samples are submitted to the Swiss Soil Monitoring Network (NABO) and analysed as part of that monitoring programme. In this way, NABO receives a large, representative sample from the sampling grid while BDM obtains information about soil quality and composition at the particular site.

A single team is dedicated to recording data on aquatic insects. These field workers go on site to record the ecomorphology of water bodies, take samples and identify the genera of the animals according to their appropriate level on the "Indice biologique CH" (Stucki, 2010). The species are then precisely determined by taxonomic specialists in the laboratory. The data recorded for aquatic insects are methodologically comparable to the EAWAG Swiss Federal Institute's "Modular Stepwise Procedure" (Stucki, 2010).

Diversity indices are not used

The scientific literature offers a wide range of possible indices for calculating diversity in habitats (e.g. Magurran, 1988). The most commonly used index is probably the Shannon-Weaver diversity index. This index considers both the number of different species and their relative frequency in an area. The advantage of this type of calculation is that it considers not only the presence but also the dominance of species within a species community. However, in order to calculate the index, it is not only necessary to know whether a species is present or absent, but also how large its population size is (see comments on Z7 in Chapter 3.3 for difficulties in reproducing individual counts). Another disadvantage of using this type of index for Z9 is that no clear conclusions can be drawn from the changes in the figures. For example, the Shannon-Weaver Index increases when common species become rare. Depending on their distribution, however, a number of species may die out without the index showing any relevant change. The calculation of evenness provides results that are equally difficult to interpret (evenness measures the constancy of the share a species has in a sample). This is why, with the exception of indicator Z12 which has purposely been designed to compare species compositions, BDM does not use such indices.

Selection of species groups

Like other indicators, Z9 only provides a representative view of biodiversity based on a small number of selected species groups. Only groups, in which several individual species occur in each of the land-use types shown in Table 6 are suitable here (i.e. groups with several species living in the open countryside, settlements, forests, etc.). The same applies to watercourses. In addition, the occurrence of a species in a taxon must differ in response to the various land-use pressures on an area, or the value recorded for the indicator will never change. Since Z9 provides "point information" to some extent, only groups that have a natural affinity for the area being surveyed can be considered. For example, large mammals have extensive ranges and cannot, therefore, be used to represent habitat diversity in landscapes. When the programme projections were made, over a dozen species groups were taken into consideration. The criterion of cost played an important role in these projections. In the end, groups that could be surveyed at a low cost were chosen as this would enable more species groups to be included in the calculation within a fixed budget. Low-cost taxa require only a few field surveys of an area and contain species that can be readily identified.

Table 7 shows the species groups that were selected based on methodological, ecological and economic considerations. Data for vascular plants, mosses and molluscs have been recorded since 2001 and for butterflies since 2003. Data collection for aquatic insects (Mayflies, Stoneflies, Caddisflies) began in 2010.

Tab. 7 > Species groups that are currently included in Z9 and Z7 (see Chapter 3.3)

Taxon	Z7	Z9
Vascular plants	X	X
Mosses		X
Molluscs (excluding slugs)		X
Breeding birds	X	
Butterflies (excluding skipper butterflies)	X	
Aquatic insects		X

3.2.2 Indicator Z8

> **Definition Z8:** *"Changes in the frequency of selected widely distributed or common species occurring in BDM sampling areas."*
> **Significance:** *Z8 records how the populations and the distribution of common plant and animal species change over time. Common species are ecologically significant: they make up the major share of the living biomass, supply an abundant food source for other organisms and contribute considerably to ecosystem services. With their large populations and extensive distribution, they influence the appearance of their habitats and even entire landscapes.*

In theory, the only information required to calculate Z9 is the number of species per survey and not the identity of each species (see Chapter 4). However, identifying the individual species in the taxa operationalised to-date does not involve a great deal of extra work. Nevertheless, the species names provide important additional information that can be used to interpret the observed changes. Although the abundance of the species is not recorded for the individual areas, the frequency at which individual species occur in all the sampling areas of a region can be used to calculate a population trend. The only condition is that the species should occur at a certain frequency in the samples so that statistically ascertained conclusions can be drawn. Together with the data recorded for Z7, the data collected for Z9 show population trends for approximately 1500 common species in Switzerland. Indicator Z8 provides this information for selected species.

3.3 Indicators of species diversity in landscapes

The number of species in specific parts of the landscape is determined by the heterogeneity of the different habitats involved, the length of the borders between habitats, the quality of the habitats and transitional areas (ecotones), and the sizes of land-use units. Since high species diversity in habitats may go hand in hand with low diversity at the landscape level (and vice-versa), it is vital to observe both levels separately.

Furthermore, assessing developments in biodiversity must always take into account that it is not only the number of species found, but also the differences in the composition of species communities (see Chapter 3.4) that contribute to diversity.

3.3.1 Indicator Z7

> **Definition Z7:** *"Changes in the mean species diversity of select species groups in 1-km² sampling areas (grid cells)." To date, data for vascular plants (since 2001), breeding birds (2001) and butterflies (2003) have been recorded.*
> **Significance:** *Z7 shows how the species diversity of vascular plants, breeding birds and butterflies develops in the normal landscape. Z7 values are high or on the increase when landscapes have diverse structures and thus provide a habitat to many different species in a relatively small space. Z7 uses its regular sampling grid to provide a representative overview of the Swiss landscape and is therefore influenced predominantly by the occurrence of common and widely distributed species.*

Z7 measures species diversity in landscapes. Z7 focuses on vascular plants, butterflies and breeding birds to measure the changes in the number of species in the landscape. Its results can be easily understood and effectively communicated. Richly structured landscapes with various types of habitats and well-developed transitional areas can be home to a large number of species. The public perceives these types of landscapes as diverse and views landscapes whose structure has been destroyed as monotonous. Not only is the diversity of the habitats a critical factor, but also their quality. For example, whether an area being surveyed contains only rich meadows or also rough grasslands is relevant. When highly valuable habitats disappear, the species typically found in them no longer have a habitat in which they can live.

Influence of widespread species

This indicator measures the entire species diversity of a taxonomic group in the sampling area. Similar to Z9, the indicator value is primarily determined by widely distributed but not common species as these are the most heavily affected by large-scale changes in the landscape. Examples of such "relatively common" species include the Meadow Sage (*Salvia pratensis*), the Marbled White (*Melanargia galathea*) and the Eurasian Skylark (*Alauda arvensis*). The indicator value decreases, for example, when populations of widespread species cease to exist locally in the normal landscape. However, a trend for more ecological compensation areas and improved interconnectivity between biotopes will improve the living conditions of such species and thus lead to an increase in the indicator value. Conversely, very common species can be found in almost all sampling areas and, hence, have little impact on the results. Likewise, very rare species that are not widespread have little impact on Z7 since they occur either by chance or only in a few of the BDM sampling areas.

3.3.2 Insights about biogeographical regions

Landscape changes can be illustrated for Switzerland as a whole. However, the developments in individual regions are of particular interest. In line with the federal government's spatial classification system (Gonseth et al., 2001), BDM assesses the changes in the biogeographical regions of the "Jura", "Central Plateau", "Northern Alps", "Southern Alps" and "Central Alps" separately. The "Eastern Central Alps" and "Western Central Alps" regions are assessed in combination.

3.3.3 Selection of species groups

During the preparatory work for the programme, over a dozen species groups were examined for their suitability for inclusion in Z7 at the same time as Z9. At the beginning of the field work in 2001, two groups were included: vascular plants and breeding birds. Butterflies were added in 2003. In addition to biological considerations, financial and organisational factors also played a critical role in this selection process. The cost of the data collection for the various organism groups differs depending on the number of field surveys required. For example, up to 20 field surveys of the same square kilometre may be necessary for reptiles. However, organisational bottlenecks, such as a lack of species experts, also had to be taken into account.

3.3.4 Sampling areas of one square kilometre

The indicator is recorded using a nationwide sampling grid of approximately 520 square-kilometre areas (see Chapter 4.2). Field workers record the presence of species from selected taxonomic groups in these sampling areas. Since the same reference areas apply to all organism groups, aggregated evaluations of several species groups and correlations between different taxa can be carried out. The following considerations were instrumental in defining the uniform size of sampling areas as a square kilometre:

> *Habitat mosaic:* in Switzerland, the size of a defined area type is generally small, and a unit of one square kilometre contains enough different habitat mosaics to record landscape diversity effectively. Furthermore, there are very few one square kilometre areas that contain just one type of habitat.
> *Sensitivity:* since Z7 is an indicator of landscape quality, the impact of species that are widespread but not common is fundamental. Analyses have shown that in one square kilometre areas, these species primarily determine the variability of the indicator. The variability of Z7 is heavily dependent on the development of species in the "vulnerable" category of the Red Lists. Common species constitute the baseline of the Z7 value but do not contribute much to its variability since they occur in all areas surveyed.

> *Compatibility:* various other data collection systems also use sampling areas of one square kilometre. The area size ensures the highest degree of comparability with other data (i.e. with the results of earlier surveys). The data collected for breeding birds, for example, are compatible with the "Common Breeding Bird Survey (MHB)" project of the Swiss Ornithological Institute in Sempach.

3.3.5 Transect surveys instead of censuses

In principle, BDM strives to prepare a comprehensive list of species in the monitored organism groups for every area surveyed. However, due to the methodological and financial restraints, alternatives to large-scale surveys had to be found for some taxa. A great deal of time and money would be required to create an exhaustive list of vascular plant species in an area of one square kilometre. In addition, this type of census would be much more difficult to standardise, which would have a major impact on the comparability of the data recorded. For this reason, vascular plants are surveyed in accordance with precise methodological specifications on transects within sampling areas (see Fig. 2). The same applies to data recorded for butterflies.

Fig. 2 > Transect for surveys of plants and butterflies included in Z7

A 2.5-kilometre-long transect was defined for vascular plants and butterflies in each Z7 sampling area.

Accordingly, transect surveys over distances of 2.5 kilometres do not enable the determination of the total number of species in that square kilometre. However, method tests have shown that, depending on the species group, between two-thirds (vascular plants) and 90 per cent (breeding birds) of all species in the square kilometre are recorded, and that this number is closely correlated with the total number of species. Since the transect provides a good representation of the habitat diversity in an entire grid square, evaluations using wide-ranging surveys of other species groups are still permissible. In any case, transects can be used to statistically record ascertained changes over time, provided the systematic error in the survey is kept constant.

The reproducibility of the data is vital to monitoring. In the interest of achieving the highest possible precision in measurements, BDM tries to provide detailed specifications for collecting data in order to restrict the individual field worker's freedom of interpretation as much as possible. In addition, BDM limits itself to recording only the presence of vascular plant species and not their abundance within individual sampling areas. Method tests have revealed that recording the abundance of species within individual sampling areas leads to considerable scattering of values because of variations in field worker methods. Statistically ascertained trends could only be calculated from abundance figures if dependence on field worker impact was minimised through considerably more cost-intensive data collection methods. Reliable evaluations of population developments for very widespread species can be carried out on a national and regional level by calculating the change in kilometre squares with occurrences of the appropriate species.

> Transect surveys are carried out once in the spring and once in the late summer for *Z7 vascular plants* over a distance of 2.5 kilometres (only one midsummer survey is carried out in high Alpine areas). The surveys are carried out in defined time windows which are selected to suit the phenology predominant at the altitude in question. The transects are predetermined by the BDM Coordination Office and, where possible, coincide with the existing network of paths as shown on the 1:25 000 maps.
> The same transects are used for *Z7 butterflies*. However, due to the extreme seasonality of many butterflies, between four (at high altitudes) and seven field surveys (in the lowlands) must be carried out. Another major difference from vascular plants is that the butterfly activity greatly depends on weather conditions. Surveys are only possible, therefore, when the weather conditions include a temperature of at least 13 degrees Celsius, little wind and more than 80 per cent sunshine.
> The surveys for *Z7 breeding birds* are coordinated with the Swiss Ornithological Institute's "Common Breeding Bird Survey (MHB)". For that purpose, observers choose a trail of approximately 5 kilometres in length, along which the sampling area can be comprehensively surveyed for the presence of breeding birds (provided the topography allows this). Three morning excursions within predetermined time windows are carried out in the lowlands and two in the uplands.

3.4 Indicator for biodiversity homogenisation

The biodiversity of a habitat or a landscape cannot only be described in terms of its species diversity. The composition of species communities is just as relevant to biodiversity. Habitats or landscapes may become increasingly similar due to human activities, such as the introduction, planting or release of alien species. This causes a convergence of species communities and a loss of local diversity. Among experts, the phenomenon is known as homogenisation ("biotic homogenisation": Olden, 2006). BDM developed indicator Z12, which was not included in the original plans, to record the gradual standardisation or homogenisation of species communities.

3.4.1 Indicator Z12

Definition Z12

> *"Changes in the similarity values calculated based on pairwise comparisons of species lists compiled for individual Z7 and Z9 sampling areas:*
  - *For data provided by the Z7 indicator "Species Diversity in Landscapes": changes in the mean Simpson's Index (similarity value) calculated on the basis of all pairwise comparisons of species lists compiled for 1-km² areas in the surveyed space, expressed in percent (between 0 and 100).*
  - *For data provided by the Z9 indicator "Species Diversity in Habitats": changes in the mean Simpson's Index (similarity value) calculated on the basis of all pairwise comparisons of species lists compiled for 10-m² areas in the surveyed type of land use, expressed in percent (between 0 and 100)."*

Significance

> *Indicator Z12 examines whether habitats and landscapes in Switzerland are becoming increasingly similar. Rationalised land-use methods (e.g. fertilisation, irrigation) and landscape designs lead to similar living conditions across large distances. This poses the risk that characteristic species that are typical of a local site will disappear and species communities in different areas will no longer be distinguishable from each other. Even if numbers of species remain constant or possibly increase, this type of homogenisation of species communities signals a clear loss of biological diversity. Ultimately, this process will result in normal meadows, forest borders and hedges looking the same across Switzerland.*

> *Z12 provides essential information that aids in the interpretation of BDM core indicators Z7 and Z9. Rising species numbers can be interpreted as a positive development only if they are not caused by alien or indiscriminate species that are at home in many different habitats.*

The "Diversity of Species Communities" indicator (Z12) describes how species compositions develop within individual types of land use and different regions of Switzerland. If the same species spread throughout Switzerland as a result of uniform land uses and other processes, species numbers may rise on a small scale, however on a wider scale, the result would be a loss of diversity and the homogenisation of species communities. Conversely, sites that are relatively species-poor can contribute to diversity by accommodating species that are missing elsewhere. For this reason, the "Diversity of Species Communities" indicator highlights the typical characteristics of local species communities. Particularly important species in this context are those which are typical of a region or have similar ecological needs that are typical of a habitat. Such species lend distinctiveness to a site and create a high degree of diversity among species communities.

Similarity index used

The mean diversity of species composition in BDM sampling areas can be expressed using an index. The scientific literature in this area provides a huge selection of such indices (Koleff, 2003). BDM uses the Simpson Index. This index has proved to be particularly sensitive in tests, in which various scenarios for plausible changes in species composition were calculated using BDM data.

The indicator is based on individual comparisons of species lists for two sampling areas. Therefore, it only considers the presence of a species. The similarity of the species lists is expressed by the Simpson Index. The Simpson Index is defined as the proportion of species on combined species lists of both sampling areas that only occur in one of the two areas (see Fig. 3). The more diverse the species communities in a sampling area are, the higher the index value is and vice-versa.

Fig. 3 > The quantitatively recorded diversity of species communities

The three circles represent three sampling areas. Species diversity alone does not convey the degree to which the species communities in the three sampling areas differ from each other. The species diversity (i.e. 3) is identical in all three cases. However, indicator Z12 uses the Simpson Index to show how different the communities are. Comparing a) to b) results in a dissimilarity value of 0.33 or 33 per cent, as opposed to comparing b) to c), which results in a dissimilarity of 0.66 or 66 per cent. The dissimilarity between a) and c) is greatest because of the lack of common species between them and results in a value of 1 (= 100 per cent). The mean dissimilarity of all three areas, therefore, is 0.66 or 66 per cent.

The Simpson Index is calculated for all possible pairwise comparisons of two BDM sampling areas or an evaluation unit (stratum). The mean of all these Simpson Index values equals the value of the Z12 indicator. The indicator value is expressed as a percentage between 0 and 100. If the indicator value decreases over time, this is an indication of the homogenisation of biodiversity.

A high degree of precision

Z12 is calculated using a simple algorithm but it requires many comparisons. A programmed analysis script carries out the numerous index calculations automatically and reliably.

In order to estimate the precision of the indicator value, BDM determines a confidence interval for the indicator using the so-called “Jackknife” method (Jones, 1974). This is highly precise in most of the surveyed evaluation units and the confidence interval for the indicator value is relatively narrow. For example, based on simulations for vascular plants, Z12 is definitely able to record the migration of a new species in meadows and pastures across Switzerland at the expense of another species.

Existing data as a basis

Z12 uses the data from indicators Z7 (“Species Diversity in Landscapes”) and Z9 (“Species Diversity in Habitats”). No additional data need to be collected. While Z7 and Z9 determine species diversity irrespective of the identity of the species, Z12 focuses exclusively on the composition of species communities and records differences in this regard between the sampling areas.

Z12 calculates a value for the diversity of species communities and its development over time for each of the taxonomic species groups that are included in the data collected for Z7 and Z9 (vascular plants, butterflies, breeding birds, mosses and molluscs). This indicator could be calculated for any other clearly defined species group, such as typical types of fen species or mountain plants (Bühler & Roth, 2011).

The indicator uses the same evaluation units as Z7 and Z9 in the routinely published basic data (see Chapter 5.1). Information about the diversity of species communities in landscapes is provided by biogeographical region. Information about diversity of species communities in habitats is provided by altitude and main type of land use.

Interpreting indicator values

The direction of the indicator values can be clearly interpreted. Rising indicator values suggest that the diversity of species communities is growing. Falling values, however, indicate that the sampling areas are becoming more similar. Nevertheless, some caution is advised when interpreting the movements of indicator values. The value of Z12 drops not only when rare species disappear from BDM areas, but also when a common species spreads and appears in additional sampling areas. If the spread of the common species does not lead to the displacement of any rare species in the long term, at the very least, it should not be considered a negative development.

The ecological interpretation of indicator values is also not as unambiguous as it would appear at first glance: for example, the indicator does not distinguish between the disappearance of a Red List species and a recently occurring neophyte. This difference is significant from a nature conservation perspective. Conversely, if a species targeted by nature conservation efforts (such as the Cowslip) spreads across Switzerland, this could theoretically cause the indicator value to fall, which would suggest, in turn, a homogenisation of species communities even though a goal pursued by nature conservation policy had been achieved. For this reason, when noticeable trends emerge in Z12, additional analyses are required to draw conclusions with regard to what they suggest about the environment. For example, Bühler & Roth (2011) pointed out that the homogenisation of Switzerland's grasslands over the past ten years is mainly due to the increase in generalist species and not the decrease in species targeted by nature conservation efforts.

4 > Data Acquisition

The data for calculating the indicators come from a variety of sources. While data collection for indicators Z7 and Z9 was newly established from scratch, the rest of the data used for BDM come from other surveys carried out by the FOEN or other organisations. This applies to both the pressure and response indicators and the calculation of some of the status indicators. BDM partly complements such data by implementing specific measures such as targeted investigations to demonstrate the occurrence of rare species in (biogeographical regions of) Switzerland for indicators Z3 or Z4.

4.1 Data quality of Z7 and Z9

BDM is intended to identify changes in biodiversity with high degree of certainty and statistical accuracy. Therefore, the data must meet high quality requirements. This means:

> *Permanent monitoring of data quality:* real changes in data sets over time can only be demonstrated if systematic errors in data collection are kept constant or their specific changes can be quantified. For this reason, BDM measures the scale of the data collection errors in addition to the data required for the indicator calculation.
> *Consistent application of survey methods:* the objective of a monitoring programme is to describe changes over a certain period of time. In order to generate reproducible time series, once determined, data collection methods must always be used in the same way. This is the only way that individual surveys can be directly compared. Nevertheless, changes in the methods are sometimes unavoidable, especially those that involve making the method more precise. However, such changes may only be made after consultation with the project managers and must always be recorded in detail.
> *Field-worker-independent field methods:* BDM is a long-term project. Hence, the individuals who collect the data will change over the course of time. In order to obtain statistically reliable data sets, field worker impact must be minimal. This is achieved by defining error-tolerant survey methods. Furthermore, individual field workers must be given very little leeway for personal interpretation. In addition, field worker impact is subject to constant control. This is carried out, for example, by means of "blind" double surveys conducted by different field workers or multi-site-occupancy models for the analysis of the raw data. These models make it possible for BDM to estimate the number of species that occur but cannot be demonstrated during individual surveys (Kéry & Royle, 2008). The risk of error is further reduced by having BDM field workers record Z7 and Z9 data electronically in the field. This eliminates potential errors that could arise if data were transferred manually to the data bank. Because field workers will inevitably change, BDM has defined its methods in such a way that they are not only mastered by a few specialists. In a long-term programme like BDM, the only field and laboratory methods that make sense are for which it may be assumed that they can be applied by a sufficient-

ly large number of operators. This restriction has resulted in the exclusion of organism groups (see Chapters 3.2 and 3.3).

- *Neutral collection and archiving of data:* as with all long-term projects, a monitoring programme must always be open to new recording and evaluation systems. To facilitate this, the field methods were defined to be as independent as possible of the subsequent evaluations. For example, the species included in the field survey are not pre-selected. The raw data are stored in a way that accommodates subsequent evaluations.
- *Minimal restriction of possible analytical approaches:* in contrast to effectiveness monitoring, analytical questions are not the main focus of a monitoring programme. Permanent monitoring covers the long-term development of a stratum or a species group independently of any potential causal connections. Perceptions of the type of data analysis required will change in response to new scientific findings over time (such as the definition of spatial reference units). For this reason, data collection in the BDM project has deliberately not been optimised for the currently relevant evaluation strata (e.g. stratified random sampling). Instead, it is largely independent of current trends (post-stratification in a design-based approach, cf. Stevens, 1994).
- *Surveying does not affect the data:* since the BDM project records time series on various aspects of biodiversity, it must be ensured that surveys do not affect data recorded in subsequent surveys. A “monitoring effect” must be avoided. This applies in particular to the surveys carried out for Z9 as the same areas are sampled repeatedly at regular intervals. This is why the coordination of on-site data collection is of crucial importance, for example by having the same person simultaneously collect data for several taxa.

4.2 Sampling concept for core indicators Z3, Z7, Z9

4.2.1 Surveys for Z3

The Z3 value is influenced by rare species. Accordingly, the data collection concept must ensure that these rare organisms are reliably surveyed. Comprehensive surveys are essential for this purpose. Rare species would almost never be recorded in a fixed sampling network. It is very likely that they would quite literally slip through the holes in that network. For this reason, comprehensive or targeted monitoring in known isolated patch habitats is ensured through the use of a very extensive reporting network. Reporters are meant to focus above all on demonstrating a small number of rare species. In order to achieve this, BDM is supported by a number of coordination offices from other programmes. In addition, BDM commissions specific mapping that focuses on individual species.

4.2.2 Surveys for Z7 and Z9

In order to reach representative conclusions for Z7 and Z9 about species diversity in small survey areas, BDM data must be obtained from samples throughout Switzerland. It is extremely important to identify steady changes in the mean number of species per grid unit. This can be ensured by fixed survey areas that are sampled at regular intervals (paired measures).

4.2.3 Systematic sampling grid

Inspired by other surveying programmes (particularly the Swiss National Forest Inventory, LFI), a systematic sampling grid has been chosen for the BDM project (Figures 4 and 5). Provided it is dense enough, this type of uniform grid allows evaluation populations to be formed retrospectively. Since the grid's origin was chosen at random, the data obtained from it can be statistically processed in the same way as random samples. However, compared to randomly distributed samples, the systematic sampling grid offers the advantage that the size of regional subsamples is proportional to the size of the regions. This will remain the case even if the borders of regions are subsequently changed. The sampling grids for Z7 and Z9 (excluding aquatic insects) are spatially compatible with the surveys carried out for the Swiss National Forest Inventory (LFI), Swiss range statistics and the current long-term monitoring of the normal landscape in the canton of Aargau (LANAG). This means that, for example, for every Z9 point there is also information available from range statistics or from LFI surveys in relation to forests. This creates optimal scope for combined analyses. However, the aquatic insect sampling grid could not be defined on the basis of an existing surveying programme (Fig. 6).

Fig. 4 > Sampling grid for Z7

The sampling grid for Z7 is denser in the biogeographical regions of the Jura and the Southern Alps.

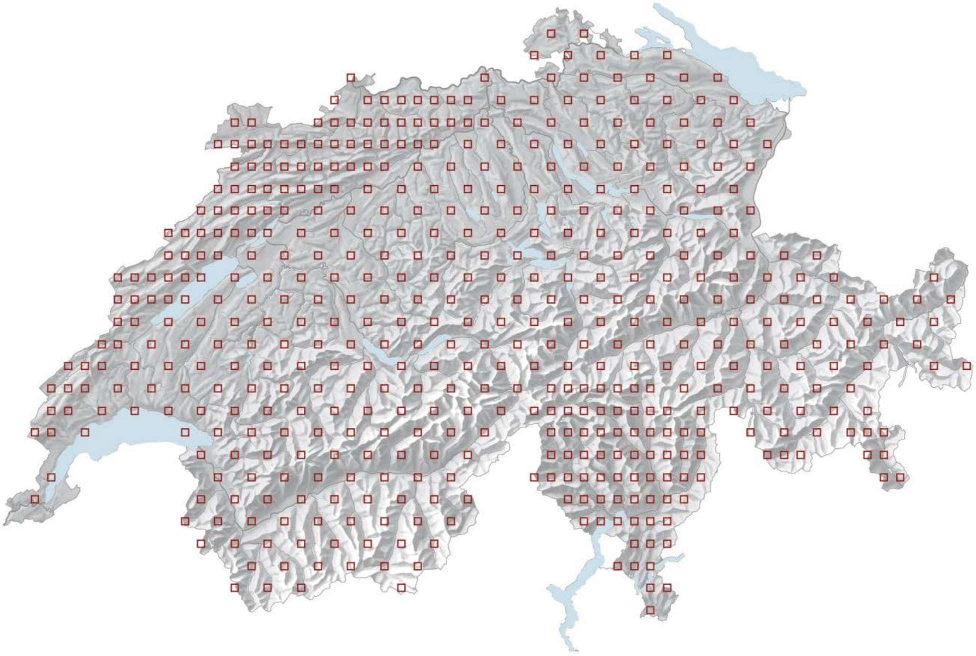
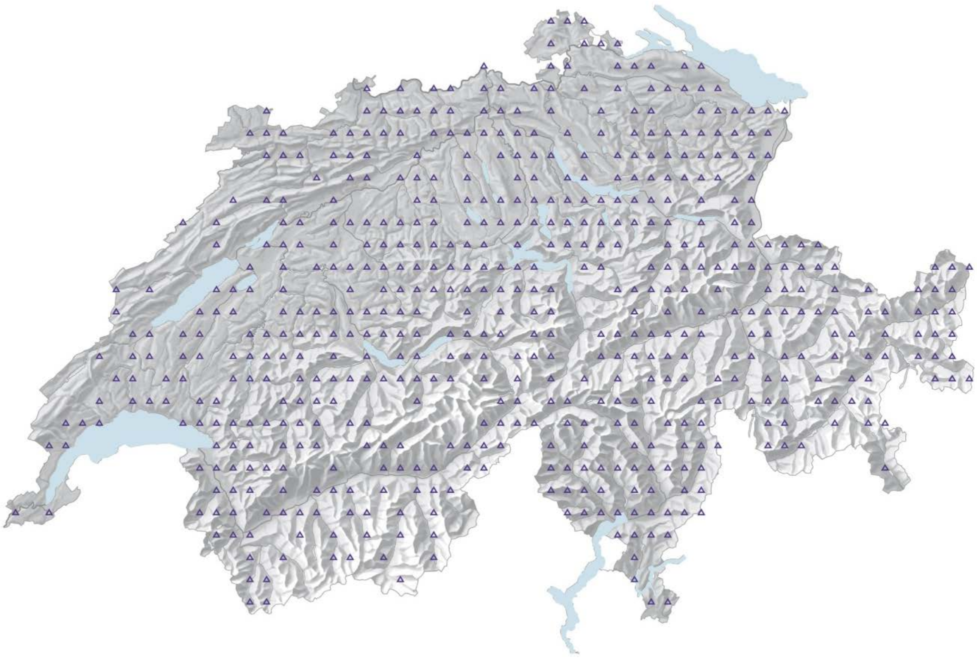


Fig. 5 > Sampling grid for Z9 (vascular plants, mosses and molluscs)

The Z9 sampling grid for land-dwelling species comprises approximately 1600 terrestrial sampling areas.

Fig. 6 > Sampling grid for Z9 (aquatic insects)

The sampling grid for the aquatic insects included in Z9 comprises approximately 570 aquatic sampling areas.



4.2.4 Grid density

The way a sampling grid is defined is determined by the degree of precision required from the information to be obtained on changes in biodiversity. Informative accuracy always depends on the statistical power of the statistical testing process, the variance of individual values and the sample size. The variance of sampled data is determined by the heterogeneity of species diversity in landscapes and land uses in Switzerland, and cannot be influenced by the monitoring programme. Once the most appropriate calculation method has been chosen, the only way to control informative accuracy is by selecting a large enough number of sampling areas. The number of sampling areas, in turn, directly determines the cost of the survey (field surveys are the primary sources of cost – the cost of organising and analysing samples is scarcely affected by the scale of the sampling grid). Therefore, the grid density chosen for indicators Z7 and Z9 represents a compromise between informative accuracy (measured as the identifiably of changes in mean species diversity) and the expense of carrying out the survey.

The 95 per cent confidence intervals were calculated for the taxa to be investigated on the basis of available data. No data were available on the variance of the changes over time. For this reason, an approximation was achieved by extrapolating the confidence interval from the spatial variability. The system of matched samples ensured that the precision of the conclusions is now better than originally estimated. The minimum informative accuracy required for each species group was then roughly estimated on the basis of the biologically conceivable changes. The cost of the data collection was the second most important factor. Both of these factors were taken into account for the definition of a sample size for Z7 and Z9 that would respond sensitively enough to changes in the biodiversity of all of the groups under consideration. However, this national sampling grid was not suitable for drawing some important specific conclusions. As a result, the sampling grid was concentrated in settlement areas and the regions of the Jura and the Southern Alps. The grid for Z7 includes approximately 520 sampling areas and the grid for Z9 has approximately 1600 sampling points for vascular plants, mosses and molluscs and 570 sampling sections for aquatic insects.

The systematic sampling grid also includes areas or sites that are either technically impossible to survey (e.g. inaccessible rock faces) or for which it is immediately obvious that no species will be found (e.g. butterflies on lake areas). These areas are not surveyed in the field and will be identified in the evaluation as "missing" in the first case and zero in the second. Hence, the actual sample size may vary slightly depending on the taxon.

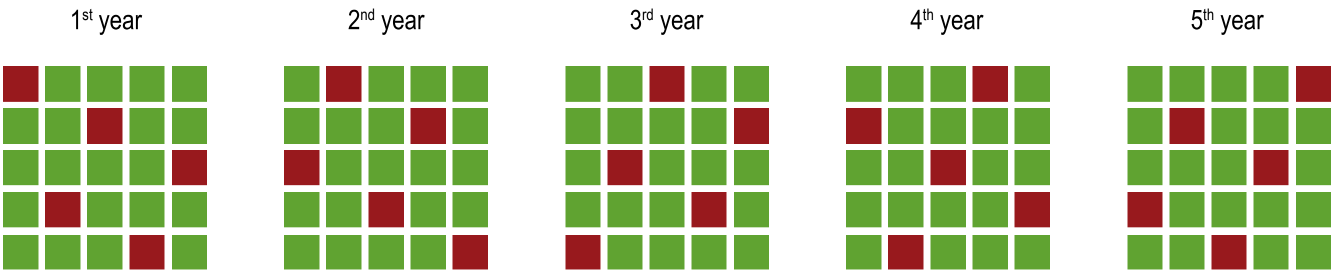
4.2.5 Temporal resolution

BDM is particularly interested in continuous increases or decreases in the recorded data over time. Periods of time that are biologically relevant for obtaining such insights depend on the generation period of the organisms under study. For that reason, it would be advantageous to obtain data at intervals that are as short as possible. However, financial constraints limit surveying frequency. A compromise was found for the Z7 and Z9 indicators by staggering the surveys. Accordingly, each year, one fifth of the entire sample for Z7 and Z9 is surveyed (Fig. 7). This means that the survey produced paired measures for one fifth of the total sample for the first time in the sixth year (excluding butterflies) and for the full range of sampled areas in the tenth year. A staggered survey of this kind has the following advantages:

> Up-to-date reporting is possible every year after a start-up period.
> Extreme annual fluctuations are levelled off.
> Major changes can be identified for the preceding five years (subsamples) while less marked changes can be identified for the preceding ten years (full sample).
> Annual data enable the analysis of trends in common individual species.
> Resources can be evenly distributed over the years.

Fig. 7 > Diagram for the staggering of the raw data surveys for Z7 and Z9

Only one fifth of the total sample is surveyed each year.



5 > Communicating the Results

The nature of the benefits that can be derived from the BDM programme depends primarily on how effectively its results are conveyed. Hence, communication issues were integrated into the concept right from the start, for example when the indicators were selected. The needs of the various target audiences were established while the project was being developed, and a range of products was described to meet those needs.

However, communication technologies and media use have changed since then. BDM has taken advantage of these developments and adapted its tools on a continuous basis. Communication will continue to be flexible in the future. Accordingly, the BDM communication principles and products described below simply reflect the current situation. Unlike data collection methods, data communication should not follow a rigid protocol but be constantly adapted to the current requirements of data users.

5.1 Communication concept

5.1.1 Goals and target audiences

BDM communication is designed to

> make results understandable and accessible;
> provide information about the programme's current activities and progress; and
> describe and explain the BDM concept and methods.

The main target audiences are professional users of BDM data (specialists working for the administration, institutional data users, environmental organisations), all those directly involved in BDM (data providers, clients, personnel), and interested individuals (nature enthusiasts, teachers, students, etc.).

5.1.2 Organisation

The Federal Office for the Environment (FOEN) is in charge of all communication about BDM and its results. It informs the media and the general public through media conferences and releases whenever major progress or breakthroughs need to be communicated.

Because the BDM programme is extensive, it produces a large quantity of data on an on-going basis that is of far more interest to experts than the general public. The programme's basic information needs are met professionally and reliably by the BDM Coordination Office, whose communications experts perform standard communications tasks in close cooperation with scientific experts.

5.1.3 Communication tools

Website

To communicate its results, BDM uses an effective combination of user-friendly and audience-appropriate tools. Its key communication channel is its website at *www.biodiversitymonitoring.ch*. Limited printed material is also available.

The BDM Website has been in operation since early 2001. It is the programme's basic communication channel and provides both lay people and experts with the most important facts about biodiversity and the BDM project. It provides an overview of the data and survey methods used for all indicators and allows users download a wide range of basic data (see below). The site is continuously updated and its approximately 300 pages of information in German, French and English require intensive maintenance.

Basic data

Raw data, i.e. data as collected in the field, e.g. species lists for individual samples, are not published. Interested parties can view and use this data on request and after agreeing to the terms of data use. However, the so-called basic data are generally available in German, French and English. Basic data are processed and slightly aggregated data and include comments on their significance for biodiversity. The main target audience for the basic data is specialists. These include cantonal authorities, planning offices, federal organisations, environmental organisations, research institutes and the programme participants. The data are published in PDF portfolios on the BDM website. The portfolios contain data lists, graphics, definitions and comments, as well as some other data, such as species lists. The data can be directly copied by the user and further used without difficulty.

BDM-Facts

"BDM-Facts" summarise the results of special analyses of BDM data and explain them to a wider audience. They are published around twice yearly based on a flexible schedule and contain three to five pages of information in German and French with a specific layout including pictures and graphics. These fact sheets are published exclusively as PDF documents and can be downloaded from the website.

E-newsletter

The BDM newsletter is a simply-designed e-newsletter that informs its target audience about the publication of new and updated indicators and major advances in the programme. This e-newsletter is available in German and French and is sent three to six times yearly by e-mail to a mailing list of all interested parties who subscribe to it on the BDM Website.

In-house newsletter

In addition to the aforementioned e-newsletter, BDM also sends an in-house newsletter (in German only) to its list of in-house recipients as required. In this way, the Coordination Office provides all those involved in BDM, from the mandating body at the FOEN to the experts in the field, with important information from the project management. The in-house newsletter is dispatched as required, e.g. at the beginning and end of the field season.

Biodiversity situation report

The roughly 80-page situation report published about every three to five years as part of the FOEN’s Environmental State series discusses the state of and trends in biodiversity in Switzerland (cf. Biodiversity Monitoring Switzerland Coordination Office, 2009). This attractively designed brochure contains all important BDM results and evaluations in German and French and provides an overview of biodiversity developments in Switzerland. The target audience is anyone interested in biodiversity, from the experts involved in the programme to the media.

Leaflet

A small printed leaflet provides a profile of the BDM project in German, French, Italian and English. It contains the most important information about the programme and answers questions such as: What is biodiversity? What is BDM? What does it measure and how? What is the benefit of BDM? It also provides contact information. The target audience is anyone who would like to get in direct contact with BDM. BDM personnel distribute the leaflet in the field and at presentations and conferences.

Contributions to professional journals and scientific publications

BDM publishes occasional and sporadic special analyses of data and papers on methodology in recognised professional journals and scientific publications.

> Literature

Brändli U.-B., Bühler Ch., Zangger A. 2007: Waldindikatoren zur Artenvielfalt: Erkenntnisse aus LFI und BDM. Schweizerische Zeitschrift für das Forstwesen 158: 243–254.

Brown J.H., Ernest S.K.M., Parody J.M., Haskell J.P. 2001: Regulation of diversity: maintenance of species richness in changing environments. Oecologia 126: 321–332.

Bühler C., Roth T. 2011: Spread of common species results in local-scale floristic homogenization in grassland of Switzerland. Diversity and Distributions 17(6): 1089–1098.

Gonseth Y., Wohlgemuth T., Sansonnens B., Buttler A. 2001: Die biogeografischen Regionen der Schweiz. Erläuterungen und Einteilungsstandard. Umwelt Materialien Nr. 137. Federal Office for the Environment, Bern. 48 p.

Hintermann U., Locher R., Rohner J., Weber D., Zangger A. 1996: Biodiversitätsmonitoring Schweiz. Bericht zum ersten Teil der Vorbereitungsphase (Arbeiten 1996). 214 p., unveröffentlicht, deponiert: Swiss Agency for the Environment, Forests and Landscape, Bern.

International Union for the Conservation of Nature and Natural Resources (IUCN) 1994: IUCN Red List Categories. Prepared by IUCN Species Survival Commission. Gland, IUCN. 21 p.

International Union for the Conservation of Nature and Natural Resources (IUCN) 2001: IUCN Red List Categories and Criteria: Version 3.1. IUCN Species Survival Commission. Gland, Switzerland and Cambridge, UK, IUCN. 30 pp.

International Union for the Conservation of Nature and Natural Resources (IUCN) 2003: Guidelines for the Application of IUCN Red List Criteria alt Regional Levels: Version 3.0. IUCN Species Survival Commission. Gland, Switzerland and Cambridge, UK, IUCN. 26 pp.

Jones H.L. 1974: Jackknife estimation of functions of stratum means. Biometrika 61: 343–348.

Jurasinski G., Retzer V., Beierkuhnlein C. 2009: Inventory, differentiation, and proportional diversity: a consistent terminology for quantifying species diversity. Oecologia 159(1): 15–26.

Kéry M., Royle A. 2008: Hierarchical bayes estimation of species richness and occupancy in spatially replicated surveys. Journal of Applied Ecology 45: 589–598.

Koleff P., Gaston K.J., Lennon J.J. 2003: Measuring beta diversity for presence-absence data. Journal of Animal Ecology 72: 367–382.

Koordinationsstelle Biodiversitäts-Monitoring Schweiz 2009: Zustand der Biodiversität in der Schweiz. Umwelt-Zustand Nr. 0911, Federal Office for the Environment, Bern. 112 p.

MacArthur R.H., Wilson E.O. 1967: The theory of island biogeography. Princeton, Princeton University Press. 203 p.

Martinez N., Küttel M., Weber D. 2009: Deutliche Zunahme wildlebender Tierarten in der Schweiz seit 1900. Naturschutz und Landschaftsplanung 41: 375–381.

Magurran A.E. 1988: Ecological Diversity and Its Measurement. Sydney, London, Croom, Helm. 179 p.

Noss R.F., Cline S.P., Csuti B., Scott J.M. 1992: Monitoring and assessing biodiversity. In Lykke E., Achieving Environmental Goals. 67–85. London, Belhaven Press.

Olden J. 2006: Biotic homogenization: a new research agenda for conservation biogeography. Journal of Biogeography 33: 2027–2039.

Organisation for Economic Co-operation and Development (OECD) 1994: Environmental Indicators. OECD core set. OECD, Paris. 77 p.

Reid W.V., McNeely J.A., Tunstall D.B., Bryant D.A., Winograd M. 1993: Biodiversity indicators for policy-makers. World Resource Institute (WRI) / International Union for the Conservation of Nature and Natural Resources (IUCN) / World Conservation Monitoring Centre (WCMC). 42 p.

Roth T., Amrhein V., Peter B., Weber D. 2008: A Swiss agri-environment scheme effectively enhances species richness for some taxa over time. Agriculture, Ecosystems, Environment 125: 167–172.

Schmid H. 1994: Ornitop C.H. Schweizerische Vogelwarte Sempach.

Stevens D.L. 1994: Implementation of a national monitoring program. Journal of Environmental Management 42: 1–29.

Stucki P. 2010: Methoden zur Untersuchung und Beurteilung der Fliessgewässer. Makrozoobenthos Stufe F. Bafu-Schriftenreihe Umwelt-Vollzug Nr. 1026. Federal Office for the Environment, Bern. 61 p.

Terborgh J.W., Faaborg J. 1980: Saturation of bird communities in the West Indies. American Naturalist 116: 178–195.

United Nations Environment Programme (UNEP) 1993: Guidelines for country studies on biological diversity. UNEP, Nairobi. 131 p.

World Conservation Monitoring Centre (WCMC) 1992: Global Biodiversity. Status of the earth’s living resources. London, Chapman, Hall. 585 p.

> Annex

A1 Pressure Indicators

E1 = Z10: Size of Valuable Habitats

E1 corresponds to indicator Z10.

E2: Size of Areas of Defined Use

Definition

Changes in the total size of areas of defined use in Switzerland or in subzones of interest (the E2 indicator may also be expressed as a proportion of the total area of the zone concerned).

Significance for biodiversity

Each of the 13 areas of defined use harbours specific plant and animal communities that have adjusted to the habitat conditions prevalent there. Putting an area to different use changes the number and combination of species living there. For example, if a former agricultural area is developed, the habitat for species that prefer to live in settlements is expanded while the habitat for species that have adjusted to agricultural uses shrinks. In the Southern Alps, “settlement specialists” already find larger habitats than communities adapted to agricultural areas.

In addition to providing information about the uses areas are put to, the E2 indicator also reports on habitat changes. However, it is not possible to directly deduce an increase or decrease in biodiversity from changes in areas of defined use. Such conclusions can only be drawn by taking other BDM indicators into account as well.

Surveying methods

The E2 indicator is based on the Swiss Land Use Statistics surveys. Data are extracted from aerial photos superimposed with a sampling grid consisting of 100x100-metre cells. Using stereoscopic air-photo interpretation, each of a total of 4.1 million sample points is assigned to one of 74 categories of defined use included in the Land Use Statistics. Indistinct points are further verified in the field. The exact definition of these 74 categories is listed in the categories catalogue of the Swiss Land Use Statistics[1].

For the purposes of the E2 indicator, the 74 basic Land Use Statistics categories were grouped into 13 BDM categories. This categorisation allows for the differentiation between ecologically relevant land uses and covers. In addition, it facilitates comparison with the European “CORINE Land Cover” system.

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[1] Bundesamt für Statistik 1992: Die Bodennutzung der Schweiz. Arealstatistik 1979/85. Kategorienkatalog. Reihe Statistik der Schweiz. Bern, Bundesamt für Statistik. 191 S., not available in English

E3: Size of Wilderness Areas

Definition

Changes in the sum of wilderness areas in Switzerland and its biogeographical regions.

Wilderness areas are defined as areas that are not subject to any kind of land use according to FSO range statistics and are located at a certain distance–usually 500 metres–from disruptive infrastructure. Disruptive infrastructure are defined as settlements, roads, train tracks, ski lifts and the like. This definition applies to wilderness areas outside of forests.

Wilderness areas also include forest areas that have either not been harvested for at least 50 years or are located in brushwood or inaccessible forests. Furthermore, in order to qualify as wilderness areas, these forest areas must be at least 500 metres away from the closest forest road and not subject to grazing.

Water bodies are not covered by this definition. Suitable basic data for monitoring water wilderness areas are currently lacking.

Significance for biodiversity

For the purpose of this indicator, "wilderness areas" are defined as areas that are not subject to land use and located at a distance of at least 500 metres from settlements, roads (incl. forest and alpine pasture roads) and other infrastructure. Below 1800 metres above sea level, 95 per cent of the area of Switzerland is built up or less than 500 metres away from infrastructures. Above 1800 metres, this category still reaches 33 per cent. All of these areas are not considered to be "wilderness areas" as natural processes in them could be disturbed. Alpine huts and mountain forests are usually accessible by road, and forests are harvested or maintained as protective forests.

Contrary to what may be assumed, what makes wilderness areas so valuable is not the fact that they harbour an above-average diversity of species but the undisturbed nature of the processes that take place there. Scree and rock faces, for example, are very poor in species. However, these areas develop in accordance with their own laws and offer habitats to specialised species.

Such undisturbed development results in "natural" and sustainable conditions. For example, forest wilderness areas have a larger number of massive trees than productive forests, not to mention a larger share of old and dead wood. Many insects, fungi, lichen and birds are wholly or partly dependent on such structures and low-disturbance forest areas. However, forest wilderness areas tend to be denser and, hence, darker than productive forests as only natural events such as mud flows, avalanches, storms and the falling of old trees will create the open spaces pioneer communities need to establish themselves. Since many plant and animal species need light and warmth, they will not find suitable habitats in such forests. For this reason, an increase in forest wilderness may have a negative impact on biodiversity. The same effect will be caused by forest wilderness spreading onto former dry grassland.

Nevertheless, an increase in forest wilderness areas would essentially be a good thing from the perspective of biodiversity because a mosaic of protective and productive forests in different shapes and forms, forests subject to specialised uses, and, indeed, forest wilderness areas is required to maintain the complete range of forest types and biological forest functions in Switzerland.

It is safe to assume that climate change will affect the composition of high-altitude wilderness areas with rocks and moraines being exposed by melting glaciers and the upward shift in the tree line. Given that the snow line is also rising, winter tourism infrastructure is likely to be extended to higher altitudes. If this happens, the area left to the forces of nature will continue to dwindle.

Surveying methods

Information on wilderness areas (excluding forests) is based on sampling surveys taken for the FSO range statistics by the Federal Statistical Office and on the swisstopo digital landscape model of Switzerland. The FSO range statistics identify areas that are not subject to land use, i.e. “brush and shrub vegetation”, “glaciers, firn”, “wet locations”, “unproductive grass and forb vegetation”, and “rock, sand, scree”.

Information on infrastructure is provided by the digital landscape model of Switzerland (VECTOR25). Infrastructure is categorised for this purpose by range of impact. In order to qualify as wilderness, an area must be located at least 500 metres away from infrastructure with long-range impact or at least 25 metres away from infrastructure with short-range impact. Infrastructure with long-range impact include settlements, roads (down to a width of 3 metres), train tracks, and stations at the bottom and top of ski lifts, cableways, etc. Infrastructure with short-range impact include cabins and isolated inns, antennas, monuments and similar structures, material cableways, and power lines.

The distance between the FSO range statistics sampling points and the closest infrastructure is calculated using the NEAR method in the geographic information system (GIS; ArcInfo or ArcGIS 9.2® workstations). Areas that are not subject to land use and infrastructure impact are classified as wilderness areas.

Information on forest wilderness areas is based on the sampling surveys of the Swiss National Forest Inventory (NFI) in the 1993/95 surveying period (NFI2); calculations were made using data that were representative of the situation observed at the time. The NFI sampling network consists of 23 223 grid points on Swiss soil. For the present analysis, variables were identified on squares of 50x50 metres. Data collection in survey areas was initiated using aerial photographs followed by the collection of additional data in the field. Representatives of the Swiss National Forest Inventory subsequently computed mean values and standard errors relating to Switzerland as a whole and its six biogeographical regions. Standard errors were later converted into 95 per cent confidence intervals by the BDM Coordination Office using a binominal distribution model.

E4: Length of Linear Landscape Features

Definition

Annual changes in the length of open stream courses, hedges and forest edges in kilometres, monitored both nationwide and in individual spatial landscape units.

Significance for biodiversity

As transition zones between different habitats, linear landscape features are often particularly species-rich. Moreover, they typically interconnect various natural landscape units, turning them into migration corridors for a series of animal species. A decline in such features not only results in habitat losses, it also usually prevents many animal species from covering their full potential area of expansion. Conversely, newly created hedges and forest edges and renatured streams may reconnect previously isolated habitats and hence enhance the value of the landscape for plants and animals alike. In certain types of landscapes such as raised bogs, however, hedges, forest edges and open streams do not occur naturally. Allowing such features to develop would have a harmful impact there.

Although a habitat's quality is crucial for its species diversity, due to the lack of suitable data, the E4 indicator cannot evaluate the quality of the landscape features it monitors. Well-structured forest edges, for example, are of great importance both as independent habitats and as connecting features between forests and open grassland. This is particularly applicable to the Central Plateau where forests are divided up into countless forest islands. According to the Swiss National Forest Inventory of 2010[2], however, only around 40 per cent of all forest edges on the Central Plateau and in the mountains display a high level of species and structural diversity.

Regardless of the fact that the ecological quality of individual linear landscape features remains unknown, the increase in hedges on the Central Plateau and conurbations has a favourable impact on species diversity as every new hedge provides an additional structure in a landscape that has been "cleared" by intensive farming and strong settlement pressure. In contrast to the Central Plateau, hedge length in the mountains is stagnating. At the same time, the abandonment of mountain areas that were once extensively farmed and, hence, home to many species leads to shrub encroachment, which, in turn, results in a loss of species diversity as many light-loving species lose their habitat.

The underground channelling of streams depletes the landscape and prompts the decline of its structural and species diversity. The number of watercourses currently disappearing from the national map is around the same as in previous monitoring periods. On the Central Plateau, for example, streams are culverted when agricultural land is developed or residential and commercial buildings are constructed. On the other hand, many formerly culverted streams are also being renatured[3], a measure that has a favourable impact on biodiversity.

Surveying methods

The E4 indicator "Length of Linear Landscape Features" is based on data collected for the *Landschaft unter Druck* ("Landscape under Pressure") project of the Federal Office

[2] Brändli U.-B. (Red.) 2010: Results of the Third Swiss National Forest Inventory 2004–2006. Birmensdorf, Swiss Federal Institute for Forest, Snow and Landscape Research WSL, Federal Office for the Environment FOEN. 312 p. (Abstract available in English)

[3] Bundesamt für Raumentwicklung ARE / Bundesamt für Umwelt BAFU (Hrsg., 2007): Landschaft unter Druck. 3. Fortschreibung 1989–2003. Bern.

for Spatial Development ARE and the Federal Office for the Environment FOEN. Data used for the third project update were extrapolated from changes recorded in the differential layer of the VECTOR25 dataset, which the Federal Office of Topography swisstopo draws on to compile the national maps of Switzerland. Using an automated GIS process, changes in the length of hedges, forest edges and open watercourses recorded in the VECTOR25 dataset were analysed for 112 sampling areas, each covering 12 square kilometres. The application computed the difference between new and missing sections of selected landscape features. The results were then extrapolated for Switzerland as a whole, and annual mean values were calculated. As sampling areas are spread out over different spatial landscape units, it was also possible to carry out a regional analysis. For the first and second updates of the *Landschaft unter Druck* project, which took place before the introduction of VECTOR25, the same analysis process was carried out by reviewing the entries in the differential layer recorded for the update of the national map.

Spatial landscape units were delimited as follows:

> High Alps: agricultural soil suitability map of Switzerland (categories: “very low fertility” and “not suitable for agricultural use”).
> Mountains: standard borders of the agricultural land registration map (montane zones I–IV).
> Central Plateau: region between conurbations and mountains.
> Conurbations: National Census of 1980, Statistical Yearbook of Switzerland 1983 (p. 64) and the “Communities of Switzerland” map.
> Following the completion of the third and latest update of the *Landschaft unter Druck* project, the available analyses cover four monitoring periods:
  – 4th monitoring period: 1989–2003.
  – 3rd monitoring period: 1984–1995.
  – 2nd monitoring period: 1978–1989.
  – 1st monitoring period: 1972–1983.

E5: Diversity of Land Use and Land Cover

Definition

Changes in the frequency of transitions from one type of land use to another within one square kilometre, aggregated by biogeographical region and for Switzerland as a whole.

The indicator is based on the categorisation used in the Swiss Land Use Statistics of the Swiss Federal Statistical Office

Significance for biodiversity

The spatial distribution of habitats within the landscape affects biodiversity. Richly structured landscapes offer more habitats than monotonous ones and this, in turn, makes them suitable for a larger number of species. Many species depend on landscape diversity because they forage, rest, breed and raise their young in different habitats. The Black Grouse, for example, forages in the undergrowth of clear forests but needs open areas for lekking. For this reason, a mosaic of habitats is likely to have a favourable impact on biodiversity. However, the composition of this mosaic is of vital importance. The densification of the road network also creates small habitats as well, however, because it divides formerly cohesive habitats first, it is bad for biodiversity. Hence, increasing the diversity of land use and land cover can have either a positive or a negative impact on biodiversity. As a result, the E5 indicator must be assessed in conjunction with other BDM indicators, particularly Z7: Species Diversity in Landscapes and Z8: Population Size of Common Species.

Surveying methods

The E5 indicator compares the mean number of changes in land use and land cover per square kilometre recorded between 1979/85 and 1992/97 in Switzerland's biogeographical regions and the country as a whole.

The basic data have been extracted from the Swiss Land Use Statistics 1979/85 and 1992/97 compiled by the Swiss Federal Statistical Office using a sampling network characterised by a 100-metre grid spacing on hectometre coordinates. This method results in 100 sampling points per square kilometre or 4.1 million sampling points throughout Switzerland. Using stereoscopic aerial photograph interpretation, each one of these sampling points was assigned to one of the 74 use categories covered by the Swiss Land Use Statistics. BDM experts condensed these 74 use categories into 23 BDM land use categories (see list below).

Using this new categorization system, it is possible to differentiate land uses and land covers of ecologic significance. Furthermore, BDM data can now be compared to the European CORINE Land Cover system. CORINE (Coordinated Information on the European Environment) Land Cover was initiated by the EU Commission and is a classification system designed to deliver standard and comparable data for Europe based on digital satellite photographs.

BDM land uses at sampling points are compared to land uses at neighbouring points in both a horizontal (west-east) and vertical (north-south) direction. Each transition from one type of land use to another is counted and 0 to 200 changes per square kilometre are possible.

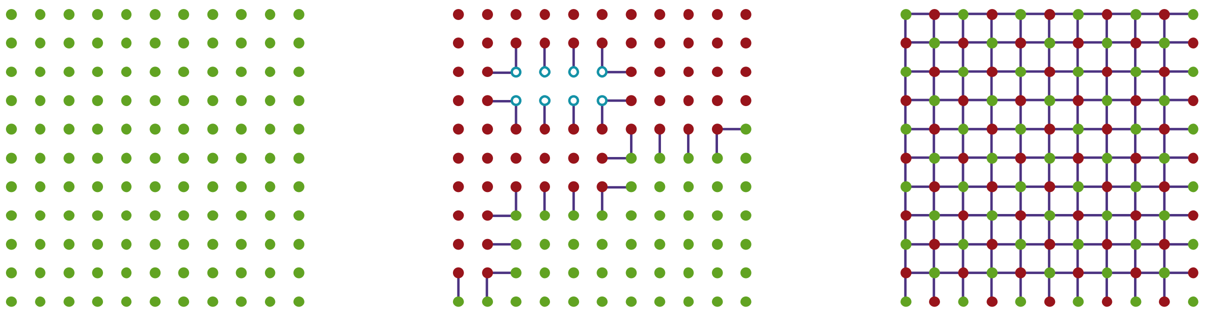
Fig. 8 > Different patterns of land use

Simplified exemplary illustration of different land use patterns per square kilometre.

Number of land use types = 1
Number of changes = 0

Number of land use types = 3
Number of changes = 28

Number of land use types = 2
Number of changes = 200
(improbable pattern)



Types of land use:

- Closed mixed forest
- Grassland
- Standing bodies of water

— Change

List of the 23 BDM land use categories:

> Predominantly urban areas
> Land used by industry, commerce or transport
> Man-made green spaces not subject to agricultural use
> Arable land
> Vineyards
> Fruit plantations
> Standard fruit tree orchards
> Horticultural land
> Grassland
> Permanent pastures
> Small woods, semi-wooded agricultural land
> Closed deciduous forest
> Closed mixed forest
> Closed coniferous forest
> Forest strips and copses
> Semi-wooded land
> Transitional stages between small woods and brush
> Small woods on Alpine pastures
> Natural green spaces
> Open spaces with little or no vegetation
> Wetlands, littoral vegetation
> Watercourses, flood barriers, and riverbanks
> Standing bodies of water

E6: Nutrient Supply in the Soil

Definition

Changes in mean nutrient indicator values of vascular plants occurring in sampling areas of ten square metres. The E6 indicator uses nutrient indicator values as determined by Landolt et al. (2010)[4]. These values express plant preference for low or high nutrient supply in the soil. On a scale from 1 to 5, high values signify soils rich in nutrients while low values stand for soils that are poor in nutrients:

1. Very infertile
2. Infertile
3. Moderately infertile to moderately fertile
4. Fertile
5. Very fertile to over-rich

[4] Landolt E., Bäumler B., Erhardt A., Hegg O., Klötzli F., Lämmler W., Nobis M., Rudmann-Maurer K., Schweingruber F. H., Theurillat J-P., Urmi E., Vust M., Wohlgemuth T. 2010: Flora indicativa. Haupt, Bern, Stuttgart, Wien. 376 S.

Significance for biodiversity

While nitrogen is vital for all plant survival, plant diversity and the world of animals that depend on it begins to dwindle once the nitrogen level in the soil becomes too high. An excess supply of other important nutrients, such as phosphorus and potassium, has a similar effect.

Plants are constantly competing for growth factors like light, water, space or nutrients. When these factors change, other plant species prevail. Given enough nutrients, some plants, for example the Stinging Nettle will grow rapidly as they have few other requirements. In doing this, they displace other species with more refined needs in terms of their environment. For this reason, rich soils support a smaller number of plant species than substrates that are poor in nutrients. Wherever the number of plant species is low, small animal and insect diversity is also reduced. For example, meadows featuring a wide variety of plants attract a much larger number of butterflies than monotonous park areas. Consequently, increasing the soil's nutrient supply is harmful from a biodiversity point of view.

Aside from active fertilisation through agricultural land use, industrial and traffic sources also contribute to boosting soil nutrient supply. Airborne nitrogen reaches near-natural, nutrient-poor ecosystems such as forests, raised and flat bogs, and dry meadows and pastures and even triggers fertilisation and acidification effects there. Over the past century, increasing industrialisation and intensified agricultural use have caused a massive rise in soil nutrient supply throughout Europe.

In some forest areas, for example, up to 50 kilograms of nitrogen per hectare are deposited each year, three times as much as 50 years ago. Deposits of 10 to 20 kilograms are already considered critical as increasing nitrogen fertilization acidifies soils. However, acidified soils diminish the ability of plant roots to develop deterrents against noxious fungi. Furthermore, they harbour fewer earthworms which are important for soil formation.

Surveying methods

The Z9 indicator "Species Diversity in Habitats" surveys plant species composition in roughly 1500 sampling areas of ten square metres. The nutrient indicator values of all vascular plant species found in a sampling area (excluding unidentified species and collective species) are averaged (arithmetic mean). Analysis by altitudinal zones is based on the thermal zones of Switzerland established by Schreiber et al. (1997)[5].

E7: Intensity of Agricultural Land Use

Definition

Change in the yields of various selected crop plants in relation to the corresponding areas under cultivation, and changes in livestock numbers in relation to utilised agricultural areas.

Various commercially significant crop plants are monitored individually.

Numbers of farm animals are converted into livestock units (LUs).

5 Schreiber K.F., Kuhn N., Hug C., Häberli R. 1997: Wärmegliederung der Schweiz. Eidg. Justiz. Und Polizeidepartement, Bern.

Significance for biodiversity

Wherever agricultural land use is intensified, biodiversity tends to suffer. The intensive use of fertilisers and pesticides and keeping of large numbers of livestock depletes grasslands. However, the E7 indicator can only provide a rough representation of land use intensity as crop yields and livestock numbers are also influenced by other factors.

Yields of Switzerland's major crops have been dramatically boosted within the last 100 years. The parameters of agricultural policy did not change until the 1990s and environmental awareness increased among the general public. Farmers began to accept lower yields for the benefit of sustainable land use, and direct payments from the federal government were introduced to make up for the financial losses caused by these lower yields. Once new farming methods, such as integrated production (1993), proof of ecological performance (1999), organic farming and the extensive cultivation of cereals (1992), were subsidised, they reduced the use of nutrients like nitrogen, phosphorus and potassium and this resulted in more moderate yield growth rates. In return, restrained use of fertilisers and pesticides along with small-scale fields and heterogeneous farming promoted biodiversity.

However, yield reduction it is not always necessarily: although they were originally aimed at increasing yields, quite a few new farming methods just happen to promote biodiversity as well. For example, unlike 30 years ago, corn is no longer sown on bare soils but on soils covered with so-called companion plants. Contributing to structural diversity, such plants provide food and habitats for small animals.

Analyses of Z9 ("Species Diversity in Habitats") indicator data will show whether the change in farming methods has actually managed to increase biodiversity on arable land.

From 1999 to 2006, livestock numbers in Switzerland scarcely changed and fluctuated continually between 1.14 and 1.16 LUs/ha of UAA. In 2008, however, livestock numbers increased significantly to 1.24 LUs/ha of UAA. Although numbers declined to 1.19 LUs/ha of UAA in 2009, they increased by 0.01 LUs again the following year and have remained considerably higher than in 1999 ever since. However, biodiversity would benefit from smaller livestock numbers as, aside from lower feed imports, fewer cattle mean less trampling damage and less nitrogen (semi-liquid manure) in the soil (cf. indicator E6 "Nutrient Supply in the Soil"), which is likely to increase plant diversity. Again, analyses of Z9 indicator data will clarify this issue.

Grazing in itself is not essentially bad for biodiversity as it creates valuable habitats. Grazing cows, sheep or goats slows down forest encroachment of semi-open landscapes (e.g. on forest pastures), which harbour a high diversity of typical species.

Surveying methods

Plant production

Mean yields are reported in kilograms per hectare. Yields are calculated for Switzerland as a whole and for its agricultural regions[6]. Seven widely cultivated crop plants were selected for this purpose: wheat, barley, triticale, corn, potatoes, sugar beet and rapeseed. In 2005, these crops were grown on roughly 50 per cent of the country's arable land. As some of these crops are hardly or not at all cultivated in the hills and mountains, the indicator only reports mean values based on data gathered on at least twenty farms.

Plant production data are extracted from a sample: approximately 3500 of a total of more than 60 000 farms subsidised with direct payments by the federal government annually send their farm accounting data to the Agroscope Reckenholz-Tänikon ART federal research station. The ART, which is responsible for the central analysis of farm accounting data, reports on economic development based on reference farms. Reference farms are not selected at random as no farmer can be bound to keep detailed records.

Because farms are not selected randomly but by proportionally stratified quota sampling, normal data distribution cannot be guaranteed, hence confidence intervals will not be computed.

The curves represent moving averages, each formed over five years.

Livestock numbers

To arrive at mean livestock numbers (stocks) per hectare (LUs/ha of UAA), numbers of farm animals are converted into livestock units (LUs; 1 LU ≈ 1 bovine animal weighing 650 kilograms) and reported in relation to hectares of utilised agricultural area in order. Conversion factors for each species of farm animal are determined by the Swiss Ordinance on Agricultural Terminology (OAT) based on the amount of nitrogen and phosphorus produced by each species. LUs/ha measure the intensity of animal husbandry.

Livestock data are extracted from a nationwide farm survey carried out by the Federal Office for Agriculture FOAG and the Federal Statistical Office FSO, and list details on the breeds and numbers of farm animals kept on each farm. Evaluations made by the federal offices are based on standardised questionnaires that must be completed by farmers. Their statements, which refer to an appointed day in early May, are verified by national and cantonal authorities and managed in the FOAG's central database.

Livestock numbers are calculated for Switzerland as a whole and for individual cantons. They are available from 1999 on.

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[6] Article 2 of the Swiss Ordinance on Agricultural Zones lists the criteria used for demarcating agricultural zones. These zones have been grouped into the following three regions:
- plains: plains zone
- hills: hill zone, mountain zone I
- mountains: mountain zones II to IV

E8: Forest Area Dominated By Non-Indigenous Trees

Definition

Changes in the share of forest area dominated by non-indigenous tree species in the overall forest area of the surveyed space.

The following tree species are considered to be non-indigenous for this purpose: Black Locust, Black Pine, Eastern White Pine, Douglas Fir, Thuja, Giant Sequoia, other alien coniferous trees, Northern Red Oak, poplar cultivars, Horse Chestnut, Tulip Tree, other alien deciduous trees.

The expanse dominated by non-indigenous trees consists of forest areas featuring a stand proportion of more than 50 per cent of the above-mentioned tree species.

Significance for biodiversity

Alien tree species may inhibit the development of animal food chains, compete with native tree species for locations or alter habitats. Moreover, non-indigenous tree species may bring other alien organisms into our landscapes – often to the disadvantage of native species as such “stowaways” are not always content with merely infest their original host plants and also attack native species. However, our native species are frequently ill-equipped to fight off such new threats. Switzerland’s elm stands, for example, are being devastated by Dutch elm disease, a fungal infection believed to have been imported from Asia. What is more, whenever introduced forest trees displace native species, insects dependent on specific host plants lose a food source. On the other hand, only a few insect species – mainly those making scarcely specialised demands on their food – are able to benefit from introduced species or cultivars.

However, the E8 indicator shows that cultivating non-indigenous tree species is currently of almost no importance in this country, and no increasing trend is emerging. However, this could change in the future due to climate change and the cultivation of species that are adapted to warmer conditions.

Nevertheless, one does not have to look far to see the effects of the large-scale cultivation of non-indigenous trees. In Spain, for example, entire forests of fast-growing Australian eucalyptus species were planted and such plantations now replace the original Macchia and Garrigue communities in many places. The loss of these thorny plants which thrive in the dry conditions there has altered the affected ecosystems completely.

Of the aforementioned non-indigenous tree species, only the Black Locust is causing major problems, albeit predominantly at forest edges or entirely outside the forest range. Black Locusts may disperse spontaneously, preferably colonising ruderal areas and dry meadows. They compete successfully with the native pioneer vegetation in these locations. Precious dry meadows may undergo bush encroachment within a few years’ time, turning into woodland as a result. The Black Locust is accelerating this process because it enriches soils with nitrogen, which suddenly enables more nutrient-loving forest plants to grow on formerly poor soil. This is the reason why the Black Locust has been blacklisted despite the fact that it supplies food for insects in the form of faboideae.

Surveying methods

Information on forest areas dominated by non-indigenous trees is based on sampling surveys carried out for the Swiss National Forest Inventory (NFI). Surveys were carried out in the periods of 1983/85 (NFI1), 1993/95 (NFI2) and 2004/06 (NFI3).

10 980 sampling areas (NFI1), 6412 sampling areas (NFI1) and 6608 sampling areas (NFI3) respectively were used to gather data on dominant tree species and establish the situation in 1983/85, 1993/95 and 2004/06.

Data collection on survey areas commenced using aerial photographs, followed by the collection of additional data in the field. Non-indigenous tree surveys monitor all tree species within two concentric circles, recording trees with a breast-height diameter of at least 12 centimetres in a circular area of 200 square metres and trees with a breast-height diameter of at least 36 centimetres in a circular area of 500 square metres. If at least one half of the tree stand is non-indigenous in both circles, the area is categorised as “dominated by non-indigenous trees”.

Representatives of the Swiss National Forest Inventory subsequently computed mean values and standard errors regarding Switzerland overall and its six biogeographical regions. Standard errors were later converted into 95 per cent confidence intervals by the BDM Coordination Office using a binominal distribution model.

E9: Area of Artificially Regenerated Young Woodland

Definition

Changes in the proportion of artificially regenerated young woodland in the overall young woodland area of the surveyed space.

Areas are assigned to one of the three categories “artificial regeneration”, “mixed regeneration” or “natural regeneration” by degree of coverage.

> *Natural regeneration:* upgrowth due to natural colonisation by seed rain or stump shoots. Less than 20 per cent of planted species.
> *Artificial regeneration:* upgrowth due to planting. Less than 20 per cent of naturally regenerated species.
> *Mixed regeneration:* any area that cannot be assigned to either of the two other categories.

Significance for biodiversity

Compared to the 1980s, the share of naturally regenerated young woodland has increased while plantations continue to decline in importance. Nowadays, 80 per cent of Switzerland’s forests are regenerated the natural way. If young trees are planted at all, they mostly serve the purpose of increasing protective forests, the selective promotion of biodiversity or the production of quality timber.

In the last century, a large percentage of diverse and site-appropriate forests in the beech forest range were replaced by monotonous spruce plantations for economic reasons. In the meantime, however, the proportion of coniferous species in young woodland has declined again and, by the 1990s, young stands contained a larger proportion of deciduous species than old stands. It appears that owing to a more natural type of silviculture, site-appropriate habitats were increasingly allowed to form and progress through their innate development processes.

Windthrow, fires and forest management create gaps in a forest. If such clearings are left to their own devices, they will soon be colonised by pioneer species that benefit from the light available in open spaces. After a certain period of time, pioneer plants are displaced by other species which, in turn, will be replaced by the slow growing "final vegetation". Hence each phase of this process is characterised by different plant and animal species. Even at an early stage, stands that have grown this way will be rich in structures and–typically–species and will remain diverse if given appropriate care. Moreover, such natural regeneration helps to maintain local tree species which are genetically particularly well suited to site-specific conditions.

Surveying methods

Information on areas of artificially regenerated young woodland is based on sampling surveys taken for the Swiss National Forest Inventory (NFI). Surveys were carried out in the periods of 1983/85 (NFI1), 1993/95 (NFI2) and 2004/06 (NFI3).

For this purpose, only forest stands at an upgrowth/thicket stage were considered to be young woodland. Data collection in survey areas commenced using aerial photographs, followed by the collection of additional data in the field. Young woodland surveys record tree and shrub species with a height of at least 10 centimetres and a breast-height diameter of not more than 11.9 centimetres. The regeneration type is determined if regeneration coverage reaches at least 1 per cent. This applies to 728 sampling areas in NFI1, 380 sampling areas in NFI2, and 389 sampling areas in NFI3. Each land-based inventory unit consists of two circles (so-called satellites) positioned at a distance of 20 metres. Given that the radius of each circle is 2.12 metres, the overall area monitored for upgrowth is 28 square metres per inventory unit.

Representatives of the Swiss Federal Institute for Forest, Snow and Landscape Research subsequently computed mean values and standard errors regarding Switzerland overall and its six biogeographical regions. Standard errors were later converted to confidence intervals.

E10: Dead Wood

Definition

Changes in the volumes of standing and lying dead wood in Switzerland as a whole and its individual regions. Dead wood volumes are separately indicated by forest type.

Dead wood is defined as both trees lying on the ground and dead standing trees reaching a diameter at breast height (130 centimetres above ground) of at least 12 centimetres. Forest types are determined by the "predominant tree species", i.e. the species accounting for the largest proportion of the tree basal area (sum of all cross-sectional areas at breast height). Surveys and analyses cover accessible forest areas, excluding shrub forests.

Significance for biodiversity

Tree trunks rotting on the ground, piles of branchwood and dead trees that are still standing offer food and shelter to many wood-dwelling (xylobiont) organisms, such as fungi, mosses, lichens, insects and birds. Snails are also more numerous in the vicinity of lying dead wood. Approximately one fifth of all living beings occurring in the forest depend on dead wood. Dead wood, which contributes to the nutrient cycle, is part of any natural forest. The kinds of species living in and on dead wood are determined by dead trees standing or lying, the size of rotting tree parts, their degree of decomposition and the tree species from which they originated.

Many xylobionts – for example more than half of all wood-dwelling bug species – are currently threatened. The amount of dead wood required to conserve endangered species is still being determined by research, however one thing is certain: “the more the better” does not apply in this case. After all, a high level of biodiversity requires not only dead wood, but also a large number of living trees. Initial studies[7,8] estimate the optimum dead wood supply to be 20 to 40 cubic metres (≈700 to 1400 cubic feet) per hectare (≈2.5 acres). However, the E10 indicator reveals that Swiss forests only contain an average of around 19 cubic metres (≈671 cubic feet) of dead wood per hectare. There is no denying that, from an ecological point of view, most of today’s forest areas contain too little dead wood. This is particularly true of the “cleaned-up” forests on the Central Plateau and the Jura.

On the other hand, dead wood supplies are markedly bigger in Europe’s so-called natural forests, i.e. forest areas that have not been managed for at least 50 years. Unmanaged deciduous forests, for example, contain an average of 44 to 132 cubic metres of standing or lying dead wood. Similar amounts of dead wood can be found in unmanaged sub-Alpine spruce forests[9].

Most lowland forests, however, are managed – at varying degrees of intensity. One model for nature-compatible forest management is described by a study jointly published by the Federal Office for the Environment and the Swiss Ornithological Institute[10]. According to this study, managed forests on the Central Plateau, the Jura, and the foothills north of the Alps should contain 10 to 15 cubic metres of dead wood per hectare. However, while the forests in these regions have frequently been recorded as containing such volumes of dead wood on average – a considerable share is found in areas devastated by hurricane Lothar – others are almost devoid of deadwood.

Surveying methods

Based on NFI sampling surveys, dead wood data were registered by the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL) for the second and the third Swiss National Forest Inventories in 1993/95 (NFI2) and 2004/06 (NFI3). Dead wood data collected in 6412 sampling areas (NFI2) and 6608 sampling areas (NFI3) respectively were used to compute the situation prevailing during those surveying periods.

In the course of these surveys, the NFI collected data on trees growing in circular sampling areas covering an area of 500 square metres each. These sampling areas, which are distributed throughout all of Switzerland’s forests, are located at the junc-

7 Brändli U.-B., Ulmer U. 1999: Naturschutz und Erholung. In: Brassel P., Brändli U.-B. (Red.) Schweizerisches Landesforstinventar. Ergebnisse der Zweitaufnahme 1993–1995. Birmensdorf, Eidgenössische Forschungsanstalt für Wald, Schnee und Landschaft. Bern, Bundesamt für Umwelt, Wald und Landschaft. Bern, Stuttgart, Wien, Haupt. 279–329.
8 Bütler R., Lachat T., Schlaepfer R. 2005: Grundlagen für eine Alt- und Totholzstrategie der Schweiz. EPFL, Lausanne. 100 S.
9 Bütler R., Schläpfer R. 2004: Wie viel Totholz braucht der Wald. Schweizerische Zeitschrift für Forstwesen 155 2: 31–37.
10 Hahn P., Heynen D., Indermühle M., Mollet P., Birrer S. 2005: Holznutzung und Naturschutz, Praxishilfe. BUWAL-Schriftenreihe Vollzug Umwelt. Bundesamt für Umwelt, Wald und Landschaft und Schweizerische Vogelwarte. Bern und Sempach. 113 S.
[The publications listed in these footnotes are not available in English.]

tions of a grid whose individual cells measure 1.4 by 1.4 kilometres. In addition, so-called “interpretation areas” (50-by-50-metre squares) were also used to record population and surface data. To begin, the NFI surveyed forest sampling areas by means of aerial photos. Field teams then collected data on site.

NFI2 only covered dead wood, for which the tree species could still be identified. As a result, the proportion of lying dead wood was strongly underestimated in part (deliberately).

E11: Volumes of Water Withdrawn From Watercourses

Definition

Volumes of water withdrawn from watercourses for power generation in Switzerland. According to the Map of Residual Flows, water withdrawals amounting to more than 50 per cent of Q_{347} are considered to be environmentally significant. Q_{347} represents the natural minimum river discharge that is reached or surpassed on 347 days of the year on average. In Article 4 litt. h of the Water Protection Act, Q_{347} is defined to be “the discharge that, averaged for ten years, is reached or surpassed on the mean number of 347 days a year without being significantly impacted by stemming, withdrawing or feeding of water”.

Significance for biodiversity

Power generation requires the withdrawal of large volumes of water from rivers and streams and frequently resulting in the water in residual flow stretches below withdrawal sites to run very low. In combination with water pollution and river bank stabilisation, this development has far-reaching consequences. Of 63 native fish and Cyclostomata species, 32 are currently red-listed and 8 are now extinct in around the world (see Z5 indicator, “Change in the Endangerment Status of Species”). In addition to sufficient amounts of water and good water quality, many native fish species need intact watercourses offering them plenty of food, hiding places and spawning sites. In addition to suitable habitats, rivers are also depended on to provide intact migration routes.

Residual flow stretches with low volumes of water are often subject to major temperature fluctuations and become too hot in summer and too cold in winter. In extreme cases, residual flow stretches may even freeze in winter. Such unnatural temperature changes are likely to affect the development of numerous water organisms – in part with fatal results.

Smaller volumes of residual water also mean lower rates of discharge, causing species adapted to strong currents to lose their preferred habitats. Weaker currents allow larger amounts of suspended solids to deposit, which may severely modify the physical and chemical qualities of stream or river bottoms. When this happens, fish species, such as the Brown Trout or Greyling which spawn in gravel, will no longer find suitable spawning sites. Other organisms which live in gaps and cracks in stony river bottoms such as Caddisflies and Stoneflies can lose their entire habitat to this kind of clogging.

Residual water running too low can also cause the groundwater table to drop as less water will seep into the subsoil. Wetlands, such as fens, will eventually dry up due to lack of water-logging, which, in turn, deprives moisture-loving plants of their basis for survival. Hence, they, too, will disappear.

Residual flow stretches that temporarily run dry have lost their value for water organisms. Such stretches are poor in species even if they run water most of the time.

It is not only significant water withdrawals that have an ecological impact on watercourses: very irregular discharges will upset the habitats of numerous water organisms as well. One third of Switzerland's watercourses is affected by the hydropeaking operations of hydroelectric power plants.

In addition to negative ecological impacts, extremely low amounts of residual flow also reduce the attractiveness of rivers and streams for humans.

Surveying methods

Withdrawal data for the E11 indicator "Volumes of Water Withdrawn From Watercourses" are based on the Map of Residual Flows in Switzerland[11]. In accordance with Article 82 of the Water Protection Act, the cantons are legally bound to carry out an inventory of water volumes withdrawn and to pass this information on to the Federal government. The contents of this inventory are stipulated in Art. 36 of the Water Protection Ordinance of 28 October, 1998. Data supplied by the cantons have been entered into the Federal "INVENT" database. Following consultation with the technical offices in the cantons responsible for this task, withdrawal data were updated from the end of 2004 with the cantons being responsible for data quality.

Altitudinal vegetation zones were defined based on *"Wärmegliederung der Schweiz"*[12] ("thermal zones of Switzerland"). Withdrawal sites were assigned to altitudinal vegetation zones in the geographic information system (GIS). Whenever an unambiguous assignment was not possible due to the location of a site (water body, rock, outside the Swiss border), it was assigned to an altitudinal vegetation zone in line with its altitude above sea level.

E12: Proportion of Adversely Affected Watercourses

Definition

Changes in the sum of adversely affected stream and river sections in proportion to the length of all watercourses.

Natural watercourses make up ecomorphological state category I as defined by the Modular Stepwise Procedure for Ecomorphology (level I, regional survey). The channel and the embankment toes of such watercourses have not been altered by flood control structures. Moreover, the width of their water level surface varies, and both banks are sufficiently wide with their plant cover natural or near natural in character. The more a watercourse has been modified by control structures, the more adversely it is affected. A watercourse categorised as "little impacted", "heavily impacted", "not natural/artificial" or "culverted" belongs to ecomorphological state category II, III, IV or V respectively. Watercourses assessed to be "natural" or "little impacted" are in a

[11] Kummer M., Baumgartner M., Devanthéry D. 2007: Restwasserkarte Schweiz. Wasserentnahmen und -rückgaben. BAFU-Schriftenreihe Umwelt-Zustand Nr. 0715. Bern, Bundesamt für Umwelt. 90 S. Stand: 2009

[12] Schreiber K.F., Kuhn N., Hug C., Häberli R., Schreiber C. 1997: Wärmegliederung der Schweiz. Eidg. Justiz- und Polizeidepartement, Bern. 69 Seiten und 5 Karten.

good state from an ecomorphological point of view, while rivers or creeks found to be "heavily impacted", "not natural/artificial" or "culverted" are considered to be in a bad state. A small proportion of adversely affected sections is favourable for biodiversity.

Significance for biodiversity

Watercourses with natural beds and banks are rich in structures and offer important habitats to a large number of species, particularly fingerlings and their prey. In the past, however, many of these habitats were destroyed as watercourses were corrected, straightened, stabilised and culverted for almost two centuries. Measures such as these were intended to allow rivers and streams to be used as transportation routes, for energy generation or to protect settlements and agricultural land against flooding.

Artificial river beds and banks are devoid of the microhabitats needed by fishes and small animals. Furthermore, obstacles such as cross-river sills, river power plants, dams and other transverse structures obstruct or prevent the migration of aquatic organisms, in particular that by many fish species which need to migrate to the upper reaches of a watercourse to spawn. Most fish cannot overcome obstacles higher than 50 centimetres, and some species find a height of even 20 centimetres to be insurmountable. Artificial habitat segregation also has a considerably negative impact on non-migratory species as it prevents populations from extending their ranges and interbreeding. However, isolated subsize populations cannot survive in the long run.

Surveying methods

The ecomorphological state of Switzerland's watercourses was surveyed in 24 cantons along just under 30 000 kilometres of rivers and streams between 1997 and 2008. However, survey density varied greatly with mapping in the Central and Southern Alps restricted to major watercourses. Watercourses were surveyed using the Modular Stepwise Procedure for Ecomorphology (level I, regional survey) developed by the FOEN which assesses the variability of the width of their water level surface, the width of the channel bed, bed and embankment toe control structures as well as the width and nature of the bank area. Based on these parameters, watercourses were then assigned to ecomorphological state categories. Results were subsequently transferred to the VECTOR25 network of watercourses and the mapped watercourse sections were extrapolated. For each watercourse section, the difference between the mapped bank width and the required bank width was determined. This was followed by the extrapolation of this data to compute the size of bank areas and the number of bank areas lacking. The big Swiss rivers such as Aare, Reuss, Rhine and Rhone were not included in the calculations because the method fails to do sufficient justice to the complex situation that characterises rivers that are 15 metres wide or more. Data recorded for Switzerland, the Jura and the Central Plateau was extracted from the publication entitled *Strukturen der Fliessgewässer in der Schweiz*[13]. Data recorded for the Northern Alps was analysed accordingly for the E12 indicator.

[13] Zeh Weissmann H., Könitzer C., Bertiller A. 2009: Strukturen der Fliessgewässer in der Schweiz. Zustand von Sohle, Ufer und Umland (Ökomorphologie), Ergebnisse der ökomorphologischen Kartierung. Stand April 2009. BAFU-Schriftenreihe Umwelt-Zustand Nr. 0926. Bern, Bundesamt für Umwelt. 100 S.

E13: Water Quality

Definition

Changes in the levels of problematic organic substances and in the water temperature of Switzerland's watercourses and standing water bodies, and changes in groundwater nitrate concentrations.

Significance for biodiversity

Switzerland has not only a large variety of watercourses and standing water bodies, but also substantial groundwater resources. Accordingly, the country is entirely responsible for preserving these bodies of water and the organisms living in them. The quality of water habitats, however, is determined by more than water quality in itself: water withdrawals (cf. E11), flood control structures on river bottoms and riverbanks, ground sills, river power plants and barrages (cf. E12) are also of crucial importance.

Up to the mid-20th century, wastewater was simply discharged into watercourses without any treatment whatsoever, a practice that noticeably impaired water quality. Once Switzerland started to build water treatment plants in 1957, water quality was on its way to recovery. The use of state-of-the-art treatment techniques resulted in a significant improvement in overall water quality in recent decades[14].

Nitrate found in water primarily originates from agricultural practices, wastewater and various combustion processes (nitrogen oxide emissions). Vascular plants mainly absorb nitrogen in the form of nitrate (cf. E6). If it ends up in the groundwater, this points to a kind of land use that is not compatible with the local environment. To this day, increased nitrate concentrations are detected through groundwater monitoring; just under 20 per cent of cases even exceed the legal limit of 25 milligrams of nitrate per litre. This applies in particular to regions with intensive agricultural use or dense settlement, such as the Central Plateau and the valleys of the Jura.

Phosphate has been banned from use in laundry detergents since 1986, a measure that has prompted a marked decline in phosphorus and phosphate concentrations in the water. As is the case for nitrate, the primary sources of phosphorus and phosphate are, again, wastewater and agriculture. This decline in phosphate concentrations is positive as phosphate is the limiting nutrient for algae and other aquatic plants in Switzerland. High phosphate concentrations can result in the abundant growth of plant biomass. Microorganisms breaking down dead plant biomass require oxygen, which will then not be available to animals like fish. Moreover, the degradation products of plant biomass include cytotoxins such as ammonium. Both the lack of oxygen and the presence of toxic degradation products may cause a water body to die, i.e. become inhabitable for most aquatic organisms. Lake Sempach, Lake Hallwil and Lake Baldegg have been aerated with either oxygen or air for more than 20 years to keep them alive[15].

For certain organisms, ammonium has the effect of a neurotoxin, which makes it very harmful even at low levels. Furthermore, ammonium (NH_4^+) is at a chemical equilibri-

[14] Zeh Weissmann H., Könitzer C., Bertiller A. 2009: Strukturen der Fliessgewässer in der Schweiz. Zustand von Sohle, Ufer und Umland (Ökomorphologie), Ergebnisse der ökomorphologischen Kartierung. Stand April 2009. BAFU-Schriftenreihe Umwelt-Zustand Nr. 0926. Bern, Bundesamt für Umwelt. 100 S.

[15] Zeh Weissmann H., Könitzer C., Bertiller A. 2009: Strukturen der Fliessgewässer in der Schweiz. Zustand von Sohle, Ufer und Umland (Ökomorphologie), Ergebnisse der ökomorphologischen Kartierung. Stand April 2009. BAFU-Schriftenreihe Umwelt-Zustand Nr. 0926. Bern, Bundesamt für Umwelt. 100 S.

um with ammonia (NH_3), a dangerous fish poison. This equilibrium depends on water temperature, among other things. Increasing water temperatures cause the equilibrium to shift towards ammonia, potentially wreaking havoc on fish populations.

In general, over-fertilisation is no longer a major problem for most bodies of water. However, water quality is impaired by pesticides, fuel additives and micropollutants, particularly in small to medium-sized bodies of water on the heavily used Central Plateau. Micropollutants are residues from countless man-made products used in everyday life, such as body care products, medications, hormones, detergents, disinfectants and wood preservatives. These substances are detected in the water at very low levels – as low as micrograms or nanograms per litre. However, even at very low concentrations, some of these substances can have a negative effect on aquatic ecosystems.

High water temperatures not only have an influence on water chemistry, but also directly affect the biology of aquatic organisms. Any increase in ambient temperature results in an increase in activity, which, in turn, increases energy and oxygen requirements. However, increases in temperature also cause oxygen concentrations in the water to decline. The Brown Trout and Greyling, which are dependent on a cool and oxygen-rich environment, are easily affected by increases in water temperature, above all in the warmer watercourses of the Central Plateau. Because watercourses are warming, Brown Trout habitats are shifting to higher altitudes[16]. Conversely, an increase in water temperature in the cold streams and rivers of the foothills of the Alps and the Alps themselves may have a positive effect on Brown Trout population development, as it creates more favourable habitat conditions.

Deteriorations in water quality and increases in water temperature may be reflected in macroinvertebrate species composition. Species that are less demanding from an ecological point of view (ubiquitists) dominate large sections of watercourses and standing water bodies while species with more specific requirements disappear[17].

Surveying methods

The E13 indicator surveys the development of nitrate and phosphorus concentrations and of water temperatures, and records the trends in the water quality of watercourses, standing water bodies and groundwater in Switzerland. For further information, please consult the Hydrological Atlas of Switzerland. Measured values are reported in milligrams per litre.

Information on the development of Swiss watercourses is based on data acquired at 12 measuring stations of the National River Monitoring and Survey Programme (NADUF). NADUF has been measuring the concentrations of substances found in major watercourses since 1972. Its network of measuring stations are operated by the Federal Office for the Environment FOEN, the Swiss Federal Institute of Aquatic Science and Technology EAWAG, and the Swiss Federal Institute for Forest, Snow and Landscape Research WSL. As part of the NADUF programme, 14-day bulk sam-

16 Zeh Weissmann H., Könitzer C., Bertiller A. 2009: Strukturen der Fliessgewässer in der Schweiz. Zustand von Sohle, Ufer und Umland (Ökomorphologie), Ergebnisse der ökomorphologischen Kartierung. Stand April 2009. BAFU-Schriftenreihe Umwelt-Zustand Nr. 0926. Bern, Bundesamt für Umwelt. 100 S.
17 Zeh Weissmann H., Könitzer C., Bertiller A. 2009: Strukturen der Fliessgewässer in der Schweiz. Zustand von Sohle, Ufer und Umland (Ökomorphologie), Ergebnisse der ökomorphologischen Kartierung. Stand April 2009. BAFU-Schriftenreihe Umwelt-Zustand Nr. 0926. Bern, Bundesamt für Umwelt. 100 S.

ples are tested for various chemical parameters. Based on the availability of datasets, BDM selected two parameters – nitrate and orthophosphate concentrations – as representative of the total substance load of Switzerland's watercourses. All information published refers to 90^{th} percentiles. Measuring values are colour coded in accordance with the classification system of the Modular Stepwise Procedure for Chemistry.

For the purpose of monitoring water quality in Switzerland's lakes, BDM analyses data acquired by cantonal measuring sites located at six lakes. Every spring, 2 to 12 samples are taken at various depths. Total phosphorus is indicated in mean annual concentrations.

Groundwater data are surveyed as part of the National Groundwater Monitoring programme (NAQUA), which has been monitoring groundwater quality at just under 550 measuring sites representatively distributed throughout Switzerland since 2002. Individual measuring sites are sampled one to four times a year. The indicator records the maximum nitrate concentrations measured.

Water quality in terms of the nutrient loads in watercourses on the Central Plateau is assessed by analysing data acquired at 57 cantonal measuring sites. These measuring sites have supplied continuous measurement series on ammonium, nitrate and orthophosphate concentrations for the years 1986 to 2005. Watercourses are either individually sampled four, 12 or more times a year, or monitored taking 12 to 365 24-hour bulk samples a year with 90^{th} percentiles computed for every five-year period. Values are indicated in mean 90^{th} percentiles with 95 per cent confidence intervals. Measuring sites are located in the cantons of Aargau (5), Bern (5), Lucerne (13), St. Gallen (1), Thurgau (1), Waadt (6) and Zürich (26).

Water temperatures measured at measuring stations are converted into mean daily values (load graph data supplied by the FOEN). With moving averages formed over periods of 5 years, temperatures are subdivided into three temperature ranges:

≥9° C between 1 November and 31 May of the following year (212 days).
>19° C between 1 June and 31 October (153 days).
>25° C between 1 June 1 and 31 October (153 days).

This subdivision corresponds to temperature ranges that are directly related to the biology of the Brown Trout (see above).

Data on the five-day biochemical oxygen demand (BOD_5) are acquired by the Zurich Cantonal Office for Waste, Water, Energy and Air (AWEL). Daily composite samples have been replaced by weekly composite samples since 2007.

The Modular Stepwise Procedure, which aims to develop standardised methods for examining and assessing the condition of Switzerland's watercourses, is a joint project of the Federal Office for the Environment FOEN and the Swiss Federal Institute of Aquatic Science and Technology EAWAG. The Modular Stepwise Procedure for Chemistry is used to assess water quality based on substance concentrations using five categories ranging from very good to bad. The individual stages have been colour coded, with blue representing the best quality and red the worst. Values that are colour coded blue or green meet the requirements stipulated by the Ordinance on Water Protection, provided a substance is covered by the Ordinance.

Tab. 8 > Substance classification system of the Modular Stepwise Procedure for Chemistry

Quality assessments	Nitrate level (mg/l N)	Orthophosphate (mg/l P)	Ammonium (<10° C) (mg/l N)	Total phosphorus (mg/l P)	BOD_5 (mg/l O_2)
Very good	<1.5	<0.02	<0.08	<0.035	<2.0
Good	1.5–5.6	0.02–0.04	0.08–0.4	0.035–0.07	2.0–4.0
Fair	5.6–8.4	0.04–0.06	0.4–0.6	0.07–0.105	4.0–6.0
Unsatisfactory	8.4–11.2	0.06–0.08	0.6–0.8	0.105–0.14	6.0–8.0
Bad	≥11.2	≥0.08	≥0.8	≥0.14	≥8.0

 Data source: Liechti 2010.

E15: Landscape Fragmentation

Definition

Changes in the landscape fragmentation of the terrestrial area below 2100 metres above sea level in Switzerland and its biogeographical regions.

Significance for biodiversity

Switzerland’s landscape has been increasingly fragmented by a growing number of infrastructure facilities over the past 70 years. The more barriers are erected in a landscape, the more restrictions are placed on the freedom of movement of animals.

New structures reduce the size of the habitats available to wild animal and plant species as roads, railway tracks, residential buildings and factories need space (see also BDM indicator E2: “Size of Areas of Defined Use”). In addition, a large number of vertebrates and countless insects end up as road kill every year.

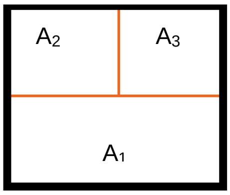
Furthermore, infrastructure facilities not only deprive plants and animals of habitats, they also have an indirect impact on the landscape, generating noise, light and air pollution, and alter microclimates. Some species avoid man-made structures and this reduces their potential habitats even more. As a result, areas in which animals feel undisturbed are becoming increasingly scarce due to landscape fragmentation.

As habitats are trimmed down and cut up, existing animal populations are decimated and isolated. This increases the risk that species might disappear at local level. The effect of habitat diminution and fragmentation is not known for most species, and, in many cases, there is a substantial time delay to be observed between the process and a species’ response to it.

Infrastructure prevents a great many animal species from spreading, for example because they shy away from crossing human settlements. For species living on the ground, roads may be impassable as they are either too dry, too wide, too busy or fenced in. Landscape fragmentation particularly affects species that require a lot of space, for example the European Lynx, which has been observed as covering average action ranges of 150 square kilometres in Switzerland. Seasonal migrators are often confronted with sizeable obstacles too. Red Deer, for example, are used to travelling dozens of kilometres from their summer pastures in the mountains to milder winter quarters in the valleys below. Frogs and toads are known to cover several kilometres to reach their spawning sites.

Surveying methods

Landscape fragmentation is measured by effective mesh size (m_{eff}), which is calculated using the following formula:



Area A_{total}	4 km^2
A_1	2 km^2
$A_2 = A_3$	1 km^2
Effective mesh size:	1,5 km^2

$$m_{eff} = \frac{1}{A_{total}} \left(A_1^2 + A_2^2 + A_3^2 + A_4^2 + A_5^2 + \ldots + A_n^2 \right)$$

Applied to the above example, the effective mesh size is:

$$m_{eff} = \frac{1}{4} \left(2^2 + 1^2 + 1^2 \right) = \frac{4+1+1}{4} = \frac{3}{2} = 1,5 \ km^2$$

For 2007 and 2001, the data are based on original digital 1:25 000 National Maps of Switzerland (VECTOR25), while 1:100 000 National Maps and Dufour Maps were digitised for 1980, 1960 and 1935, respectively. Barriers are considered to be formed by highways, 1st and 2nd class roads, railway tracks, dams and pressure lines, settlement and industrial areas (including airports and railroad stations). With the exception of the enclaves of Büsingen and Campione, Switzerland’s national border also counts as a barrier. Artificial fragmentation by regional boundaries is avoided by using the Cross-Boundary Connections (CBC) procedure[18].

[18] Moser B., Jaeger J.A.G., Tapppeiner U., Tasser E., Eiselt B. 2007: Modification of the effective mesh size for measuring landscape fragmentation to solve the boundary problem. – Landscape Ecology 22(3): 447–459.

A2 State indicators

Z1: Number of Livestock Breeds and Plant Varietes

Definition

Changes in the numbers of all livestock breeds and crop plant varieties recognised in Switzerland. For reasons of practicability relating to livestock breeds (available data), the indicator is restricted to cattle, pigs, sheep and goats for the time being.

The indicator is calculated to represent both the total number of all livestock breeds and individual livestock species.

A livestock breed is considered to be any homogeneous group of farm animals differentiated from other groups within the same species by predefined visible features.

For the purposes of the Z1 and Z2 indicators, farm animals are considered to belong to a certain livestock breed or species if they are registered in a herdbook kept by a federally recognised breeders' organization.

With regard to crop plants, the indicator is calculated as representing the total number of varieties of selected species deemed to be worthy of preservation by the National Action Plan for the Preservation and Sustainable Use of Plant Genetic Resources in Nutrition and Agriculture (NAP-PGRNA) and covered by preservation measures.

Significance for biodiversity

Conserving livestock breeds and crop plant varieties conserves the genetic diversity of the organisms we depend on for food production. Genetic diversity provides important response potential in the event of parasite infestations, infectious diseases or epidemics as some breeds/varieties are better equipped to overcome certain diseases than others. The same goes for changes in the climate: certain breeds/varieties display a better capacity for adjusting to changing climatic factors than others.

Once a breed or variety goes extinct, it disappears forever, unless germinal cells, seeds, tissue, plants or plant parts have previously been preserved. The extinction risk currently faced by a breed/variety and whether that risk has increased or diminished is reflected by a breed's/variety's population size (cf. Z2 indicator). Switzerland's farmers used to keep only 18 different hoofed livestock breeds (4 cattle breeds, 2 pig breeds, 4 sheep breeds, and 8 goat breeds), all of them official Swiss breeds subsidised by the federal government. When Switzerland ratified the Convention on Biological Diversity and put it into force in 1995, the country committed itself to supporting the conservation of genetic resources. Since then, rare and endangered cultural breeds/varieties, either originally or traditionally bred in Switzerland, are monitored and subsidised by specific programmes. At the same time, the GATT treaty of 1995 made it easier to import new breeds/varieties; a special permit is no longer required for each and every import. Moreover, the new Swiss Ordinance on Livestock Breeding, which took effect in 1999, brought about a crucial change in terms of the relaxation of breeding regulations. Recognised breeders' organizations now receive subsidies for breeding any breed rather than a select few, which increases the incentive to introduce new breeds. In addition, breeders' organizations are now allowed to determine breeding objectives themselves, which makes for more diverse breeding. Finally, people have gradually realised that production performance should not be the only criterion highlighted when selecting animals for breeding and have become aware of the fact that they will also benefit from genetic diversity within a breed. For all of these reasons, provided the population is not too small, it is unlikely at present that any of the livestock breeds covered by the Z1 indicator will go extinct in Switzerland.

However, genetic diversity depends not only on the number of breeds, but also on the number of sires involved in the reproduction of a breed. In the old days, for example, every village used to have its own bull, which literally formed the local herd. Today, anybody can order the semen of any bull as artificial insemination has become the rule since the 1980s. However, as farmers throughout Switzerland tend to prefer the same bulls, i.e. those labelled “best of breed”, the number of sires is decreasing and with it genetic diversity.

Apart from having specific genetic properties, breeds or varieties may also be of particular ecological, economic or cultural/historical significance. Eringer cow fighting, to name but one prime example, is a sociocultural event that takes place in the canton of Wallis each spring.

The situation in relation to crop plants is completely different as the number of varieties surpasses the number of breeds by far, making it all the more challenging to identify, describe, and conserve them. However, by ratifying the International Treaty on Plant Genetic Resources for Food and Agriculture, which entered into force in this country in 2005, Switzerland has also assumed an obligation in this area. Among other things, it will take part in developing and constructing a global information system on plant genetic resources used in nutrition and agriculture.

Surveying methods

Breeders’ organizations that keep records of the population size of a breed must be recognised by the federal government. Such herdbooks need to contain statistical and historical information on bloodlines, identification, performance and quality features as well as the physical appearance of a breed’s or breeding population’s breeding animals. The Federal Office for Agriculture FOAG collects and compiles this data on an annual basis. Additional data is supplied by Swiss Beef Cattle, Pro Specie Rara and Swissherdbook.

Crop plant data is based on the Swiss National Database (*www.bdn.ch*) of the FOAG’s National Action Plan for the Preservation and Sustainable Use of Plant Genetic Resources in Nutrition and Agriculture (NAP-PGRNA) as managed by the Swiss Commission for the Conservation of Cultivated Plants CPC. Evaluations are made using positive lists posted on the web, which include all varieties intended for preservation by the NAP-PGRNA programme (VARCONSERSTAT descriptor must read “yes”) provided their identity has been verified (VARVALIDITY descriptor must read “yes”) and accessions are available in primary plant collections (descriptor GLOBACCVAR >0).

Z2: Proportion of Livestock Breeds and Plant Varieties

Definition

Changes in the proportion of various livestock breeds and crop plant varieties in relation to the total population/production of the corresponding species in Switzerland.

A livestock breed is considered to be any homogeneous group of farm animals differentiated from other groups within the same species by predefined visible features.

For the purposes of the Z2 and Z1 indicators, farm animals are considered to belong to a certain livestock breed or species if they are registered in a herdbook kept by a federally recognised breeding organisation.

Significance for biodiversity

Overall genetic diversity increases along with the total number of breeds/varieties. Within a breed/variety, genetic diversity increases along with the size of the population/crop area as every individual generates a new genetic variation – unless it has been cloned (reproduced asexually). Clones are genetically identical. Vines, apples, pears and other crop or ornamental plants are mostly produced by vegetative propagation. However, Switzerland's biodiversity would benefit from large populations/crop areas with the greatest possible number of livestock breeds/crop plant varieties, above all breeds/varieties that occur predominantly in this country. The reason for this is simple: genetic diversity provides a kind of life insurance, allowing breeds/varieties to adapt to changes in their environment. If, for example, the climate or geographic conditions in a region were to change, it is likely that some individuals within a given population will be better equipped to adjust, which improves their chances of reproducing and passing on their genes to the next generation. This enables the species as a whole to adjust. The same applies in case of parasite infestations, infectious diseases and epidemics. Cloned organisms, however, fail to follow this pattern, as their hereditary information is identical.

Nevertheless, survival of the fittest tends to be the exception in the case of livestock and crops as most breeds/varieties are created by human selection. By breeding livestock/crops, people select for the optimum fulfilment of certain human requirements such as milk or meat production. Most farmers prefer the kinds of breeds/varieties that offer the best input-output ratio, hence livestock/crop farming is restricted to a small number of breeds/varieties with correspondingly large populations. In contrast, low-performance breeds/varieties will be found at best on niche production or enthusiasts' farms, which results in smaller populations or crop areas. Nevertheless, both animal/plant breeding and biodiversity would profit if populations of rare breeds/varieties were to increase. Not only would this provide breeders with a larger pool to select from, but the sustained development of new and improved breeds/varieties does not necessarily have a negative impact on biodiversity in general. For example, fungus-resistant vine varieties require fewer or no fungicide treatments, which, in turn, benefits other organisms living in vineyards.

The situation has been improving for some time now. Breed diversity within total species populations has been increasing since before 1999 as import regulations were relaxed in 1995, thereby enabling farmers to keep a great variety of breeds for niche production purposes (see Z1 indicator). However, The proportions of various breeds within the total populations of their respective species have remained almost unchanged since 1999. While new breeds are constantly being added, increasing genetic diversity in the process, their shares of the total populations remain negligible. Nonetheless, the populations of some rare breeds are growing at a substantial rate. However, their representation in the total species populations remains very small because populations of main breeds are a hundred or even a thousand times bigger than the populations of all other breeds. Traditional breeds continue to be more widespread than newcomers.

While cereals and potatoes are undergoing a change in varieties, at least as far as the dataset used for this indicator is concerned, the trend observed in crop plants is mixed: perennial crop plants, such as vines, apples and pears, follow a development similar to that of livestock breeds.

Diversity may be lost within a breed/variety as well. If a breed/variety is selectively bred for a single feature only, its genetic base will progressively narrow and it will lose part of its diversity over the course of time. Fortunately, the characteristics targeted by breeding also change constantly as the requirements to be fulfilled by livestock and crop plants change as well. Moreover, breeders are aware of the dangers of inbreeding nowadays, hence they continuously try to refresh breeding populations. Since the federal government relaxed livestock breeding regulations in 1999, animals of one and the same breed may be selected for different performance traits (e.g. beef cattle and dairy cattle). As a result, genetic diversity increases.

However, genetic diversity not only depends on the population size of a breed, but also on the number of sires/pollinators involved in the reproduction of a breed/variety. In the old days, for example, every village used to have its own bull, which literally shaped the local herd. Today, anybody can order the semen of any bull as artificial insemination has become the rule since the 1980s. However, farmers all over Switzerland tend to prefer the same bulls, i.e. those labelled “best of breed”. Consequently, a large percentage of animals within a breed may have the same father. For example, a bull by the name of “Pickel” (Spotted Cattle, Red-Holstein section) fathered 30 000 female offspring over a period of little more than ten years. A dominating influence such as this will inevitably cause genetic diversity to suffer. Hence, breeders’ organisations will inform breeders of potential inbreeding problems that may occur if a certain bull were to be used with a certain bloodline.

Maintaining and encouraging genetic diversity within populations is especially important in the case of endangered breeds and varieties. For this reason, the federal government supports projects that monitor the genetic range within the populations of four endangered sheep breeds (Bündner Oberland Sheep, Red Engadine Sheep, Valais Red Sheep and Mirror Sheep), and within populations of Evolene Cattle and Booted Goats.

Animals that are not listed in a herdbook represent a genetic potential that may be more diverse than that of pure-bred herdbook animals specifically selected for certain features. However, this potential is being neglected as only herdbook animals are used for breeding.

Surveying methods

Livestock breeds

Federally recognised breeding organizations keep records of livestock populations. Such herdbooks contain surveys and records on bloodlines, identification, performance and quality features as well as the physical appearance of a breed's or breeding population's breeding animals. The Federal Office for Agriculture FOAG keeps a list of the populations of all breeds entitled to federal subsidies.

Switzerland's overall population of farm animals is subject to an annual survey by the Federal Statistical Office FSO. This survey records all farm animals kept on farms that meet a certain minimum standard. This minimum standard is defined as follows: 1 hectare of arable land, or 30 ares of special crops, or 10 ares of greenhouses/tunnels, or eight brood sows, or 80 fattening pigs or fattening pig spaces, or 300 poultry. Farm animals kept on farms that do not meet the minimum standard will not show up in any statistics. This frequently applies to sheep, hence the specified total sheep population is estimated as being several thousand animals lower the actual count. However, cattle, pigs and goats are largely covered by the survey.

Crop plant varieties

The Z2 indicator covers crop plant species and their varieties provided there are reliable datasets available for all of Switzerland. In principle, it would be best to obtain data categorised by variety-specific crop areas. Corresponding datasets are at least partially established for perennial crops, such as fruits and vines. The Federal Office for Agriculture conducts an annual statistical survey of fruit plantations in Switzerland, which is published under the heading of *Obstkulturen in der Schweiz* (not available in English). At 38 and 31 per cent respectively (data collected in 2011), a rather large percentage of both cherry and plum/damson plantations are not recorded by variety. Since there is no way of knowing what is hidden behind these generalised data, it is impossible to obtain a conclusive impression of the situation. For this reason, the Z2 indicator only considers apples and pears at present.

Z2 data on vine varieties are also based on an annual statistical survey compiled by the Federal Office for Agriculture and published under the heading *Das Weinjahr* (not available in English). Data are provided by the official grape harvest controls which are carried out by the cantons.

With regard to potatoes and cereals, there are no variety-specific crop area data from direct surveys available for all of Switzerland. Hence, the Z2 indicator uses seed potato and cereal seed sales figures supplied by the Swiss Seed Producers' Association SWISSSEM. The Z2 indicator information assumes, without verification, that the sales figures for seed potatoes and cereal seed strongly correlate with crop areas as it would not make any sense to buy seed in order to stockpile it. This is even less likely in the case of seed potatoes. Seed sold by other organisations is not taken into account, however doing this would not distort the overall picture of a small number of varieties accounting for large market shares.

Z3: Species Diversity at National and Regional Levels

Definition

Changes in the numbers of free-living species of certain taxonomic units whose presence can be evidenced or demonstrated as being probable for at least nine out of ten consecutive years using standardised methods.

This definition is characterised by three intentional restrictions:

1. The indicator is limited to certain species groups. Very reliable data on the presence or absence of species within these groups in a given region are available each year.
2. The indicator only covers animals living in the wild. For a species to be considered free-living, it must reproduce independently of human care.
3. The “nine out of the ten years” criterion is intended to disqualify mobile species which only occur at irregular intervals without building stable populations (“vagrants”, “irregular breeders”).

Significance for biodiversity

Both vertebrate species numbers and monitored insect species numbers have remained comparatively stable in Switzerland in recent years. Species numbers may change, for example, whenever isolated patch habitats change, thereby affecting or benefiting rare species. However, they are also affected by large-scale developments, such as area dislocations (natural changes in range) and accidental introductions. It is generally beneficial for any region to accommodate a large number of species as long as rare endemic species are not crowded out by new arrivals that are very common to begin with. Nevertheless, this is not a threat posed by newcomers such as the Nutria or the Bee-Eater. The same might be true for the Large-Scale Loach, judging by what has happened so far, at least. However, things could be different as regards the Topmouth Gudgeon. This small fish, which originates in Eastern Asia like the Large-Scale Loach, may – in the case of mass propagation – become a food competitor for other fish species, especially for indigenous fry.

Several regions are being recolonised by species that had either been actively exterminated in those regions or had simply lost their habitats. Examples for this development include the Eurasian Lynx, the Common Heron, the Corncrake, the Edible Frog, the Hoopoe, the Wild Boar and the Wolf. A striking feature of this trend is the fact that the return of large predators, in particular, will upset existing predator-prey relationships.

Other species, such as the Eurasian Ruffe, the Scarlet Grosbeak, the Black-Necked Grebe, the Black Kite, and the Tufted Duck, have extended their natural ranges into new regions.

Unfortunately, it is still not possible to completely prevent endangered species from disappearing in Switzerland. The loss of typical bogland species, which used to be quite widespread, is a painful failure of Swiss nature conservation. Bogland protection measures were initiated too late for several species, such as the Curlew and the Common Snipe.

From a regional perspective, in many areas of Europe species numbers have shown a tendency to increase in recent decades. There are several reasons for this development:

first, in many cases, residual populations of endangered species were saved on the brink of extinction by well-targeted nature conservation measures; second, new species were accidentally or intentionally released into many regions; and third, various reintroduction projects have proven successful.

Surveying methods

Verifying whether or not a species fulfils the criterion of "living in the wild in nine out of ten consecutive years" requires an entire series of methodological definitions which answer questions such as:

> What is an acceptable indication of successful reproduction?
> Which features are used to identify a species?
> Which assumptions regarding the presence of a species are applied in years, in which no successful reproduction is observed?
> Which conditions must be met for a species to be considered absent from a region?

To this end, exact minimum requirements have been defined for each species.

BDM makes an effort to provide evidence in accordance with these definitions, which is updated annually for each of Switzerland's regions. Surveys monitor all species of select taxonomic units which have been evidenced at least once since 1998. To do this, BDM largely relies on existing reporting networks maintained by amateur faunists, such as members of the Swiss Ornithological Institute, the KARCH (Coordination Centre for Amphibian and Reptile Protection) and the CSCF (Swiss Biological Records Center). In addition, specialists are called in from time to time to close specific information gaps, for example by dealing with "tricky" groups, such as small mammals, or by looking for missing species.

New findings sometimes reveal that certain species have been misclassified at a regional level. This results in total species numbers being changed as compared with the Z3 information published in previous years without the new arrival or disappearance of any species. Likewise, new taxonomic insights may bring about a change in total species numbers, however they do not usually affect developments.

The collection of data for the 1900–2000 monitoring period necessitated the adoption of a special method. Due to data deficiency at regional level, species numbers for this period are only presented for Switzerland as a whole.

To begin, a list of all species that possibly fulfil the required BDM occurrence criteria at least once between 1900 and 2000 was compiled for each taxonomic group. Second, each of those species was investigated regarding the number of years it fulfilled species-specific and group-specific Z3 criteria. Species that were only present in Switzerland in isolated years and never fulfilled species-specific BDM criteria in at least nine out of ten consecutive years were dropped.

The remaining species were subdivided into different categories (permanently occurring, disappeared, newly arrived, changed status more than once). If possible, the status of rare species was determined on an annual basis between 1900 and 2000 in order to pinpoint any status changes with yearly precision.

In the case of certain species, it was not possible to find conclusive evidence of their status or the time of any status changes in the literature and available databases (Swiss Ornithological Institute, CSCF, BDM). In these cases, we solicited expert opinions and accepted the conclusions they reached. Due to a lack of data, four bird species (Little Crake, Collared Flycatcher, Pallid Swift, Red-Crested Pochard) have not yet been classified despite the fact that they certainly fulfilled BDM criteria for certain periods of time.

With the quality of available data varying widely from one species group to the next, particularly in the first half of the 20th century, it usually proved impossible to pinpoint status changes with annual precision. For this reason, we have chosen to indicate a qualifying year, based on ten-year stages and the following procedure:

Whenever a species newly fulfils BDM criteria, it is classified as present in Switzerland from the beginning of the following decade. For example: the Bee-Eater has been breeding in Switzerland on an annual basis since 1991. In other words, the bird had been present in this country for nine out of ten consecutive years by 1999 and hence met the Z3 requirements for permanent occurrence. Consequently, the Bee-Eater is classified as permanently occurring from 2000.

Likewise, if a species disappears from Switzerland, it is classified as having disappeared from the beginning of the following decade.

However, as a result of the application of this procedure, species that only meet BDM requirements for a short amount of time would end up being classified as newly arrived and disappeared in one and the same decade. Hence, in this case, new arrivals are classified as permanently occurring from the beginning of the preceding decade and as having disappeared again from the beginning of the following decade. This rule was applied to the European Green Toad, Cetti's Warbler and the European Penduline Tit.

While invasive alien species are taken into account, migratory species that do not breed in this country or only do so on an exceptional basis are disregarded. In terms of breeding birds, this concerns winter guests and migrants, the European Eel among fishes, and various butterfly and dragonfly species.

Z4: Number of Species in Switzerland Facing Global Extinction

Definition

Changes in the sum of all species facing global extinction whose occurrence in Switzerland during at least nine out of ten years can either be established or demonstrated as probable using standardised methods.

Whether or not a species is classified as facing global extinction is determined by the IUCN in accordance with precisely defined, consistent and reproducible criteria. This classification expresses the risk of global extinction as communicated by the IUCN on April 26, 2010 (additional invertebrates facing global extinction and occurring in Switzerland have not yet been assessed by the IUCN).

Considered to be at risk in the sense of the Z4 indicator are animal and moss species classified as EX (extinct), EW (extinct in the wild), CR (critically endangered), EN (endangered) and VU (vulnerable), as well as vascular plant species classified as Ex (extinct), Ex/E (possibly extinct), E (endangered), V (vulnerable), and R (rare).

The criterion “nine out of ten years” is defined in the way used for the Z3 indicator “Species Diversity at National and Regional Level”.

The indicator is updated every five years.

Significance for biodiversity

The Z4 indicator focuses the spotlight on a small section of biodiversity which is much more important than its mere size suggests. Species not facing global extinction – such as the Tawny Pipit, the European Otter and the Mew Gull (cf. Z3 indicator “Species Diversity at National and Regional Level”) – which disappear from this country may represent a bitter loss for Switzerland, however their disappearance is inconsequential for the overall population of these species. However, populations found in Switzerland are of crucial importance for the survival of some plants and animals. When species like the Brownstripe Red Snapper (*Salvelinus neocomensis*), the Gravenche (*Coregonus hiemalis*) and the Lake Constance Saxifrage (*Saxifraga oppositifolia* ssp. *amphibia*) went extinct in this country over the past century, they also vanished from the face of the Earth.

For this reason, it is very good news indeed that none of the 60 species facing global extinction monitored by Z4 have disappeared from Switzerland in the past 20 years. Better still, BDM is very happy to report that *Tulipa aximensis* – a wild Tulip species classified as globally extinct – has been rediscovered in the canton of Valais. Nevertheless, the populations of several species of worldwide importance are critically endangered in Switzerland, among them the Rhône Streber (*Zingel asper*), Didier’s Tulip *Tulipa didieri,* another Tulip species and the Lake Constance Forget-Me-Not (*Myosotis rehsteineri*).

Surveying methods

In the calculations for the Z4 indicator, changes brought about by species distribution dynamics (extinction, recolonisation, neocolonisation) are strictly distinguished from changes due to IUCN reclassification. Hence, every update involves careful checking of the relevant IUCN Red List for modifications. Given that the IUCN cannot have a detailed knowledge of the current distribution of all species, BDM monitors all species reported as occurring in Switzerland or one of its neighbouring countries.

All monitored species are assessed for occurrence in Switzerland or one of its six biogeographical regions during nine out of ten years. Required information – at least regarding species covered by BDM – is supplied by raw data collected for the Z3 indicator “Species Diversity at National and Regional Level”. For the remaining species, these assessments are made by consulting flora and fauna databases; expert opinions are also solicited in most cases.

Z5: Change in the Endangerment Status of Species

Definition

Number of species in Switzerland whose endangerment status has decreased by one level minus the number of species whose endangerment status has increased by one level. Species whose endangerment status has changed by two or three levels are counted twice or three times respectively.

Significance for biodiversity

National Red Lists (RLs) help assess the endangerment potential of species living in Switzerland.

RLs, which are intended to act as warning signals, also demonstrate the impact made by conservation and support measures. Furthermore, Red Lists have legal significance: under the terms of Article 78, section 4 of the Swiss Federal Constitution of 18 April 1999, Switzerland is legally bound to protect endangered species from extinction. Red Lists are used to verify whether Switzerland is meeting its constitutional obligation in this respect.

The Z5 indicator is designed to show changes in the number of red-listed species and their level of endangerment. The shorter Red Lists become, the better it is for biodiversity. In turn, any additional red-listed species signify a setback. However, the current Red Lists are not directly comparable to their predecessors, which were compiled prior to 2001, as species are now classified applying the new IUCN criteria. For this reason, it will be impossible to indicate changes in a quantitatively exact manner for some years to come. With the exception of fishes/cyclostomes and breeding birds, the information provided here is based on initial data collected thus far. Nevertheless, certain trends are emerging already.

In the case of plants, the risk of extinction has increased with the proportion of red-listed species increasing from approximately 25 per cent in 1991 to just under 33 per cent in 2002. The percentage of moss species classified as endangered remained about the same compared to the 1991 RL. The situation in relation to many dragonfly species has also deteriorated. The loss of large-scale wetlands has had a negative impact on both the Great Reed Warbler and the Grasshopper Warbler. Other species that are dependent on isolated patch habitats are also becoming more rare as these habitats are tending to diminish both in surface area and number. As a result, species primarily occurring in such habitats are more widely represented in Switzerland’s Red Lists. However, the new RLs also include an increasing number of species associated with the normal landscape. For example, populations of the Skylark and the Corn Bunting – both typically found in agricultural areas – have sustained dramatic losses over the last ten years. This implies that the pressure on biodiversity from agriculture has not yet diminished.

However, not all cases of endangered species found in Switzerland are the result of negative developments. The European Bee-Eater, for one, is classified as an endangered species because being a new arrival, it has been breeding in Switzerland for just a few years and has only established a small population to date.

With regard to grasshoppers, current results vary compared to assessments made in 1994[19]. On the one hand, due to improved knowledge about Switzerland's grasshopper fauna, it has been possible to unlist several species. On the other hand, the situation of some endangered species has continued to deteriorate.

Surveying methods

Red List endangerment statuses correspond to the IUCN criteria of 2001 (Version 3.1). Assigning an endangerment status to species is a two-step procedure: first, a species is assessed according to global criteria as though the Swiss population were the world population. Next, an evaluation is carried out to determine whether the extinction risk faced by the species in Switzerland is being increased or decreased by outside populations. Depending on the result, the species is then either reassigned to a higher or lower endangerment status or keeps the status it was assigned in step one.

The procedure used to assign species to an endangerment status is adapted for each species group based not only on available information about the species concerned, but in certain cases also on field surveys.

With the exception of breeding birds and fishes/cyclostomes, the data available at this time merely reflect the current situation. However, due to the different taxonomies used for fishes/cyclostomes (see above), it has only been possible to calculate the change values for breeding birds so far.

Change values are calculated based on movements of species through Red List categories: if a red-listed species deteriorates in status by one level, e.g. from VU (vulnerable) to EN (endangered), this change counts as one point. A change by two levels, e.g. from CR (critically endangered) to VU, counts as two points. Changes from VU to NT (near threatened) or LC (least concern) or from NT/LC to VU count as one point in each case, while transitions (either up or down) between the non-RL categories NT and LC are disregarded completely. For change value calculation purposes, species assigned to an endangerment status for the first time are considered to have been RE (regionally extinct) before.

Species whose systematic classification has changed between two editions of the applicable Red List will be disregarded. This currently only concerns the Yellow-legged Gull (*Larus michahellis*), which was not previously differentiated from the Herring Gull (*Larus argentatus*).

The Red List Index is calculated in accordance with Butchart et al. (2007)[20]. Species that were already extinct (RE or EX) at the time of the first evaluation and species that are data deficient (DD) are not taken into account. First, the number of species in each category is multiplied by that category's weighting. Then all products are added, divided by the maximum possible value (all species N are extinct, N*5) and, finally, subtracted from 1. Weightings range linearly from EX/RE=5 to LC=0.

Definition of endangerment statuses:
www.bafu.admin.ch/tiere/07964/08223/index.html?lang=en

[19] Nadig A., Thorens P. 1994. Rote Liste der gefährdeten Heuschrecken der Schweiz. In: P. Duelli (Ed.), Rote Liste der gefährdeten Tierarten der Schweiz, pp. 66–68. – Bundesamt für Umwelt, Wald und Landschaft (BUWAL), Bern.

[20] Butchart S. M., Akçakaya H. R., Chanson J., Baillie J. E. M., Collen B., Quader S., Turner W. R., Amin R., Stuart S. N., Hilton-Taylor C. 2007: Improvements to the Red List Index. PLoS ONE 2(1): e140. Doi 10.1371/journal.pone.0000140.

Z6: Population Size of Endangered Species

Definition

Changes in population sizes of selected species that are threatened or potentially threatened in Switzerland, Europe or worldwide.

Since populations are usually surveyed on an annual basis, it is also possible to update the indicator on an annual basis.

Alternative comparisons of population sizes at intervals of more than one year are only permissible in exceptional cases (e.g. the number of occupied one-hectare grid areas in the case of perennials). Actual population sizes shall be preferred to other values, such as the extent of surface cover at a site or the number of distinct individual occurrences.

Top priority is given in the selection of Z6 species to species that face extinction worldwide or in Europe. Second priority is given to species whose preservation falls within Switzerland's particular responsibility and to species that are threatened in Switzerland.

Significance for biodiversity

According to internationally applied criteria, plant or animal species are considered to be threatened with extinction if, based on the best available data, they are facing an extremely high risk of extinction in the wild in the immediate future (IUCN 2004). Once the last population has disappeared from a region, that region's species diversity is reduced. For this reason, the group of threatened species is particularly important for species diversity in Switzerland (see also Z3 "Species Diversity at National and Regional Level").

The Z6 indicator focuses on selected threatened or potentially threatened species and the development of their population sizes. This purpose requires special, customised data series for each species. This is why, as a matter of principle and in contrast to the Z7 and Z9 biodiversity indicators, Z6 draws on annual estimates of population sizes (abundances) extracted from specific third-party surveying programmes. However, the estimation of abundances is usually associated with considerable methodological difficulties and is very costly. Hence, the availability of such data series is limited to a very small number of animal and plant species found in Switzerland.

The examples presented here show different possibilities for the development of threatened species. Not every threatened species is bound to be further reduced in numbers. Some populations remain stable for years, and others even increase.

It is crucially important to understand the factors that influence the population sizes of individual species as the causes behind the increase or decrease in the population of a single species and biodiversity are often one and the same. Even though overall species diversity is more resistant to environmental impacts than individual species, rapid changes in species diversity are possible nonetheless – at least when observed in areas in the size range of ares, hectares or square kilometres. Like the population sizes of individual species, biodiversity is subject to both long-term trends and constant fluctuations, short-term collapses and rapid growth.

Z6 species exemplify a wide range of possible causes for these phenomena. A large number of species are easily affected by changes in their preferred habitats. There are numerous reasons for habitats to be altered: changes in land use, changes in the climate, interactions with other species and also support measures implemented through special species conservation programmes. A habitat is often modified due to a complex combination of several causes. This is what makes it so difficult to explain the biodiversity of a certain area or, worse still, predict its development.

Surveying methods

Z6 is based on third-party data only. It presents species whose populations sizes are already being surveyed by external research projects, effectiveness monitoring, species conservation projects, inventories, etc. In other words, BDM uses various data sources for this indicator (cf. data sources and species portraits above).

For a species to be included in the Z6 indicator, available data must meet a number of requirements. They must:

> be representative for the Swiss population;
> refer to the current situation (as a rule, the last population estimate must not be older than five years);
> preferably consist of time series, or, in obvious cases, reference points set at ten-year intervals;
> consist of almost any possible quantifiable population survey value (population size, number of occurrences, occupied grid squares, embankment sections, etc.).

Species are selected using the following priority criteria:

> species facing global extinction according to the IUCN Red List (2005 version);
> species facing extinction throughout Europe;
> species falling within Switzerland's particular responsibility;
> species that are endangered or critically endangered in Switzerland (IUCN criteria EN and CR)*;
> species that are vulnerable in Switzerland (IUCN criterion VU)[21];
> examples of species of great significance in terms of public recognition and policy-making (flagship species).

However, the biggest problem is finding species whose population sizes are monitored on a regular basis and whose surveys are representative for Switzerland. Hence the dominance of breeding birds.

[21] Many species groups have not yet been categorised in the Swiss Red Lists compiled in accordance with the IUCN criteria 2001. In these cases, existing Red Lists were used, i.e. species listed as "threatened with extinction" and "seriously endangered".

Z7: Species Diversity in Landscapes

Definition

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

Sampling areas each cover one square kilometre for all monitored species groups. BDM uses standardised methods to record the species occurring in these areas. The sampling network consists of a regular grid covering Switzerland and emanating from a randomly chosen site. In order to also gather meaningful data on small regions, 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 areas – are so inaccessible that they cannot be surveyed. Furthermore, BDM experts will not survey areas located entirely in lakes or on glaciers. However, survey results include these sampling areas as “free of species” by definition.

Z7 is calculated for both Switzerland as a whole and for its major biogeographical regions. Moreover, separate statements can be made for high altitudes (areas at more than 1400 metres above sea level) and other large-scale parts of the country. Up to now, the surveys have recorded vascular plants (since 2001), breeding birds (since 2001) and butterflies (since 2003).

Significance for biodiversity

Species diversity in the 1-km² sampling areas covered by the Z7 indicator “Species Diversity in Landscapes” is influenced by a variety of 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 characterised by a high natural potential: large differences in altitude and a rough and variable terrain create a wide range of habitats, which, in turn, give rise to correspondingly high species diversity. Hence 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 anthropogenic influence, the more significant the impact that the type and intensity of human land use will have on species diversity. This emerges clearly from the species numbers recorded in the Jura and the Central Plateau: maximum species numbers observed are almost identical in both regions, making their natural potential comparable. However, the mean species numbers recorded 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 and wiped out the plant and animal species dependent on them.

Species richness in landscapes depends on the diversity and quality of the habitats they contain: the more varied a landscape is regarding habitat types such as grassland, forest and cropland, the more species will find a habitat there that suits them. The quality of the habitats is also important. For example, it makes a difference whether a sampling area consists of rich pastures alone or whether it also contains poor grassland. Not only plants and animals appreciate varied and richly structured landscapes, people prefer them, too, if only for reasons of visual beauty. Therefore, high Z7 values or increases in Z7 values are generally very much appreciated.

Species-poor sampling areas differ from species-rich sampling areas mainly by their lack of semi-frequent habitat types, such as poor grassland. When these habitats are lacking, their typical representatives such as the Meadow Clary (*Salvia pratensis*) or the Marbled White (*Melanargia galathea*) will not find a home there either. Common and widespread species may be found in almost any sampling area so they are not considered to be sensitive. Very rare species with limited distribution are also of little relevance for the Z7 indicator 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 extremely hot summer of 2003.

When 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”.

Surveying methods

BDM experts have developed a specific surveying method for each species group which has been customised to be as cost-effective as possible, to yield well-reproducible results and represent each monitored square kilometre as comprehensively as possible. Occurrences of vascular plants and butterflies are surveyed along a 2.5-kilometre transect that follows existing trails wherever possible. The transect routes, the number of field surveys (one or two operations for vascular plants, four to seven for butterflies, depending on altitude) and the time intervals between field surveys are predefined for each sampling area. If no trails exist, field biologists will mark the transect route in the field and plot it on a map. Each species they find is electronically recorded on the spot. Due to the constant level of sampling along standardised transects, changes are easily recognised although not all species occurring in a square kilometre 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 fact that the sampling network covers a mere 0.3 per mil of Switzerland’s territory. This outcome is both surprising and encouraging: it would appear that 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 also forces field workers to look for butterflies in areas presumed to be species-poor. As a result they sometimes discover species that appear to have slipped through the 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 per cent of all Alpine sampling areas. Because of representative sampling, BDM data are very well suited to determining current frequencies of species and as a basis for objective evaluations of changes in frequency over time. Accordingly, BDM butterfly data provide an essential basis for assessing Red List endangerment levels.

Unlike vascular plants and butterflies, breeding birds are monitored over the entire 1-km² sampling area rather than just along a transect. Ornithologists will only deviate from this principle in inaccessible regions. In such cases, any part of an area that cannot be sampled are marked on a map. Depending on altitude, each sampling area is monitored two to three times during a predefined period of time, always in the morning. The surveys and surveying methods use largely tie in with the Swiss Ornithological Institute Sempach's Common Breeding Bird Survey (MHB).

The BDM Coordination Office continuously checks the quality of surveys and the interpretation of raw data. Among other things, roughly 10 per cent of all sampling areas are subject to double monitoring for quality control purposes. Comparative results gained in this way allow for accurate assessment of data reliability and, hence also, data meaningfulness.

Z8: Population Size of Common Species

Definition

Changes in frequency of selected widely distributed or common species occurring in BDM sampling areas.

Significance for biodiversity

Common species are of great ecological importance because they make up the major share of the living biomass and constitute an abundant food resource for other organisms. Ecosystem services are also provided primarily by common species. Furthermore, common species shape the character of individual habitats and even entire landscapes[22]. The most frequent plant species define a habitat's typical appearance: rich pastures, for example, obtain their typical structure from only a few grasses and herbs.

Common species mostly colonise habitats that are part of the "normal landscape", or they are so undemanding that they are able to live in a wide range of different habitats. Changes in the populations of common species point to the transformation of landscapes. Modified grassland uses, for example, can markedly change the species mixture and the appearance of cultivated land, be it through increased or decreased liquid manuring, changes in the timing of grass cutting or in the stocking of pastures, or the choice of a different type of crop rotation. The designation of ecological compensation areas can also affect species diversity.

How small populations of rare or threatened species develop depends largely on the vagaries of the weather or the reproductive success of a single year. Conversely, the populations of common species are robust and tend to respond to change in a sluggish manner. For this reason, common species act as reliable indicators of change in the normal landscape. However, up to now, with the exception of bird and forest tree species, common species were hardly monitored at all. BDM has closed this gap, at least as far as vascular plants, butterflies, snails and mosses are concerned.

[22] Gaston K. J., Fuller R. A. 2008: Commonness, population depletion and conservation biology. Trends in Ecology & Evolution 23: 14–19.

If common species become more common and more widely distributed at the expense of rare species, this has a negative impact from the perspective of biodiversity as it trivialises and standardises species communities in habitats. Whether or not this is actually happening in Switzerland is monitored by the Z12 indicator “Diversity of Species Communities”.

Surveying methods

The Z8 indicator “Population Size of Common Species” uses data gathered for the Z7 and Z9 indicators “Species Diversity in Landscapes” and “Species Diversity in Habitats”. The frequencies of species are calculated on the basis of their presence in or absence from Z7 and Z9 sampling areas.

BDM calculates changes in the frequency of all monitored species from one survey to the next. Significant changes ($0 \leq p < 0.05$) are reported as increases or declines. Significance is determined using McNemar’s test; confidence intervals are calculated using the Adjusted Wald method.

Z9: Species Diversity in Habitats

Definition

Changes in the mean species diversity of selected species groups in small sampling areas of standardised size.

The Z9 indicator “Species Diversity in Habitats” records the species diversity of vascular plants, mosses and molluscs (snails) in sampling areas of ten square metres each, covering all of Switzerland and different types of land use. It also provides information on forests and grassland/pastures located in different altitudinal zones.

With regard to aquatic insects, the species diversity of Mayflies, Stoneflies and Caddisflies is recorded in watercourse sections, the length of which is determined by the width of each watercourse surveyed.

Significance for biodiversity

Nature conservation efforts must not remain limited to designated (protected) areas and need to strive for maximum biological diversity adapted to the ecosystems throughout the country. The Z9 indicator “Species Diversity in Habitats” shows how species richness is developing in our everyday environment, i.e. in Switzerland’s “normal” grassland, arable land, forests, and watercourses and water bodies.

The Z9 indicator is based on surveys covering vascular plants, mosses, molluscs and aquatic insects. It goes without saying that these four species groups cannot reflect the development of biodiversity as a whole, from large vertebrates to tiny microorganisms. What they can do, however, is reveal fundamental biodiversity trends as they are sensitive in their response to environmental influences and, hence, well suited to the role of indicator groups.

Z9 has already yielded some interesting results. As it turns out, for example, the number of plant species in lowland grassland is considerably below the Swiss average, even though the ecological potential of grassland on the Central Plateau is at least equal to that of Alpine pastures. What made biodiversity drop so low is intensive land use. Conversely, Z9 data also document the impressive plant and moss species richness found at higher altitudes where land use is more extensive and hence has a distinctly more favourable impact.

Unlike vascular plants, molluscs become less diverse with increasing altitude. However, their species richness does not decline due to pressures from land use. The reason for this phenomenon is an ecological one: snails tend to avoid higher altitudes by nature.

Regardless of these initial trends, several years will pass before the development of species diversity in various habitats and at different altitudes will lend itself to detailed analysis. Initial change data point to species diversity increasing in all species groups and in various habitats. Future analyses will show how today's land uses and climate change are affecting species diversity throughout Switzerland's habitats.

Above all, the Z9 indicator will establish how sustainably forests are managed and land is farmed in this country. Environmental programmes initiated in the agricultural sector (cf. art. 76 of the Federal Law on Agriculture and the Ordinance on Direct Payments), for example, give reason to hope that species diversity will increase. Time will tell whether this hope is justified or not, just as it will enable the verification of the impact made by Switzerland's new forest management policy.

As only part of the sample had been analysed at the time of publication, no statistically-based conclusions can be drawn in relation to aquatic insects.

Surveying methods

Surveys for the Z9 indicator "Species Diversity in Habitats" have been conducted since 2001. Surveys of aquatic insects began only in 2010. To this end, BDM field workers record vascular plants, mosses, and molluscs (snails) found in a large number of circular 10-metre square sampling areas. Starting from a randomly chosen site, roughly 1650 of these sampling areas form of a regular grid covering all of Switzerland. However, approximately 100 such sampling areas – most of them high Alpine – are so inaccessible that they cannot be surveyed.

BDM experts have developed a specific surveying method for each species group which is customised to yield reproducible results.
(For videos on the subject please visit the BDM website:
www.biodiversitymonitoring.ch/en/background/movie.html.)

In addition to the occurrence of species, habitat types and land uses are also recorded. Due to the small size of the sampling areas, they must be marked with utmost precision. BDM field workers determine the location of each sampling area using a GPS device. Moreover, they bury a magnet at the centre and enter clearly visible points of reference in a so-called "back-up log".

The number of field trips (for plant surveys one or two each year, depending on altitude) and the time intervals between field trips are predefined for each sampling area. Each plant species found in a sampling area is electronically recorded on the spot.

In addition, sampling areas are systematically surveyed for mosses each spring. A sample is taken of each moss species found for subsequent identification in the lab.

Mollusc species diversity is surveyed using a special method: field workers take eight soil samples at the perimeter of each sampling area. These soils samples are sent to the lab where experts elute the shells and identify them under the binocular microscope.

Aquatic insect species diversity is established by kick-sampling the aquatic larvae of Mayflies, Stoneflies and Caddisflies. The length of each watercourse section surveyed is determined by its width, with the length corresponding to ten times a watercourse's width. In 2010, the average section length was 29 metres. Insect larvae caught are sent to the laboratory where species are identified individually by experts.

The BDM Coordination Office continuously checks the quality of surveys and the interpretation of raw data. Approximately 10 per cent of all sampling areas are subject to double monitoring for quality control purposes. Comparative results gained this way allow for accurate assessment of data reliability and, hence also, the meaningfulness of the data.

Z10: Size of Valuable Habitats

Definition

Changes in the size of valuable habitats of national importance as stipulated by Articles 18, 18a and 21 of the Swiss Nature and Cultural Heritage Protection Act.

Federal inventory criteria for habitats of national importance:

Alluvial zones

> An alluvial plain created by a natural or near-natural water body is of national importance if:
  – it covers an area of at least 2 hectares;
  – this minimum area is exclusively populated by intact typical alluvial vegetation or substitute plant communities that emerged and can be regenerated in a near-natural manner; and
  – it is in direct contact with that natural or near-natural water body and is affected by it (groundwater, flooding).

> An alluvial zone separated from its water body by artificial means is of national importance if:
  – it covers an area of at least 5 hectares; or
  – it is connected to a water body by some other means (groundwater, runoff, etc.); and
  – this minimum area (5 hectares) is populated by typical alluvial vegetation.

- Glacier forelands and Alpine floodplains (above 1800 metres above sea level) are of national importance if:
  - they include an alluvial area shaped by glaciofluvial or fluvial processes and cover at least 2500 square metres;
  - they are classified as being "of national importance" on the basis of a dedicated evaluation by geomorphological and biological main and subsidiary criteria; and
  - they are neither damaged nor excessively polluted.

Raised and transitional bogs
Raised bogs are recorded on the basis of the presence of sphagnum mosses and vascular plants that traditionally indicate a raised bog environment. To be considered of national importance, a raised bog must cover at least 625 uninterrupted square metres.

Fenlands
Fenlands of national importance must cover at least one hectare and support typical fenland vegetation. Seven types of vegetation are considered to be typical fenland vegetation. They have been defined by means of their character species: *Phragmition*, *Magnocaricion*, *Scheuchzerietalia*, *Calthion* and *Filipendulion*, *Molinion*, *Caricion davallianae*, *Caricion nigrae*.

Dry grasslands
Dry grassland areas are evaluated on the basis of criteria such as rareness, worthiness of protection and representativity of vegetation types in combination with the degree of habitat networking, the structural elements present and additional factors (for details please refer to *Schriftenreihe Umwelt Nr.* 325: The Cartography and Evaluation of Dry Grassland in Switzerland, FOEN Bern 2001, abstract only in English).

Dates of entry into force of the relevant ordinances

- Raised and transitional bogs:
  1 February 1991 (chronology and details of changes in German at *www.admin.ch/ch/d/sr/c451_32.html*)
- Fenlands:
  1 October 1994 (chronology and details of changes in German at *www.admin.ch/ch/d/sr/c451_33.html*)
- Alluvial zones:
  15 November 151 992 (chronology and details of changes in German at *www.admin.ch/ch/d/sr/c451_31.html*)
- Dry grasslands:
  1 February 2010 (chronology and modification details in German at *www.admin.ch/ch/d/sr/c451_37.html*).

Significance for biodiversity

Habitats are considered to be valuable if they are unique, typical or rare. Without these special types of environment, many plant and animal species would go extinct. Protecting habitats is one of the requirements for long-term conservation of biodiversity in Switzerland.

For the time being, the Z10 indicator only monitors areas listed in the federal inventories of alluvial zones, fenlands, raised bogs and dry grasslands. The corresponding federal ordinances explicitly require that these habitats shall contain and promote indigenous plants and animals and their ecological bases.

For long-term survival and development, such habitats need to cover areas of a certain size, particularly since it is often a reduction in the size and quality of valuable habitats that is the key cause of population decline. Many red-listed species solely occur in a small number of places that have become isolated patch habitats in the normal cultivated landscape. Once the last remnants of these isolated patch habitats are gone, species typical of such special environments disappear along with them. The Curlew and the Common Snipe, for example, are not found among this country's regular breeding birds anymore as the large-scale wetlands, on which they depend no longer exist.

The Z10 indicator only covers a fraction of Switzerland's valuable habitats so far for two reasons:

> On the one hand, Z10 only monitors areas of national importance that are recorded in a federal inventory. However, to name but one example, Switzerland's total fenland area is much larger than the area of inventoried fenlands of national importance as many fenlands fail to meet the federal inventory's criteria because they are either too small or of insufficient quality.
> On the other hand, habitats other than alluvial zones, raised bogs, fenlands and dry grasslands are also considered valuable. Under the Swiss Ordinance on the Protection of Nature and Cultural Heritage (NCHO), the types of habitat worth preserving include, among others, spring and flush plant communities, water habitats, littorals, ravine forests, steep-slope forests and dry forests, seam communities, brushwoods and heathlands, rock, grit, karst and scree plant communities, and segetal and ruderal plant communities. All of these habitats should actually be monitored by Z10 but they are frequently not inventoried in accordance with uniform standards or at all, which makes their monitoring impossible. As a result, the actual total size of all valuable habitats cannot be estimated.

The federal inventories list areas that were included because of their particular beauty (raised bogs and fenlands), size and quality at the time the corresponding inventories were carried out. However, inventories provide no information about either the current quality of the areas (Z11 indicator serves that purpose) or on any changes in their size. While the Z10 indicator is intended to record the development of habitat sizes, it cannot truly achieve this objective until the federal inventory effectiveness monitoring programmes provide reliable records on the quantitative and qualitative changes affecting habitats.

Surveying methods

The precise surface area of individual habitat types was delimited from surrounding areas on the basis of surveys. Effectiveness monitoring has yet to establish whether and how individual habitat areas have changed since the original survey was carried out. Up to now, data are only available for bog and fenland habitats (see Z11 indicator).

For the purposes of the Z10 indicator, BDM calculated the total area recorded in the federal inventories of alluvial zones, raised bogs, fenlands and dry grasslands. Areas recorded in more than one inventory were counted only once.

Z10 data are limited to federal inventories as specified in Art. 18a NCHA because only these ensure that habitats are evaluated and inventoried according to uniform criteria throughout Switzerland. For the time being, only current statuses are indicated.

Z11: Quality of Valuable Habitats

Definition

Changes in average quality features of individual habitat types recorded in Federal Inventories subject to the Federal Law on the Protection of Nature and Cultural Heritage

Operational definitions are listed under "Surveying methods".

Significance for biodiversity

Mires are isolated patch habitats but they are not biodiversity hotspots, i.e. sites featuring a particularly high number of species. As a matter of fact, despite being composed of markedly different types of vegetation, mires – above all raised bogs – are rather poor in species. With their permanently high water level, mires are wet and, apart from calcareous small sedge fens, very acidic and nutrient-deficient. Furthermore, despite their increased occurrence in certain regions, mires are rare. Following the disappearance of an estimated 90 per cent of all mires to this day, they now amount to a mere 0.54 per cent of Switzerland's total territory.

Raised bogs and fens of national importance harbour roughly one quarter of all endangered vascular plant species in Switzerland. Each of the wide range of vegetation types contained in mires offer a habitat for specific species, and this makes mires irreplaceable. Particularly high numbers of endangered plant species grow in hollows or shallow basins typical of intact raised bogs. Almost 10 per cent of plant species found in hollows are on Switzerland's Red List of endangered ferns and flowering plants.

Apart from specialised plants, especially various peat mosses and lichens occurring only in these habitats, mires are also home to fungi and very specialised animals. A wide range of dragonfly species, for example, cannot exist without hollows, rills (drainage channels) and bog ponds. If these structures were to disappear, so would such specialised species as they have no alternative habitat to escape to. The same goes for butterfly species whose caterpillars feed exclusively on mire plants.

Moreover, mires – particularly peat bogs – are biodiversity archives. Not only pollen, but also large remains of plants and animals will be conserved by this acidic and water-saturated environment for ten thousands of years. Whenever peat bogs dry up, the peat is mineralised, a process that irreversibly destroys the archives it contains.

Last but not least, mires are important elements of the landscape and, hence also, of biodiversity, albeit on an ecosystem level.

Surveying methods

A representative sample consisting of 102 sample squares located all over Switzerland covers 200 raised bog and fen sites of national importance. Among these sample squares, all size categories, mire types, altitudes, and natural areas are adequately represented. Sites are registered by means of infrared aerial photos, which are then used to delimit homogeneous standard surfaces based on colours and patterns. Sized between 100 and 200 square metres, these sample squares are monitored for vascular plants and mosses as well as their degree of species cover. Combining aerial photo interpretation and field data makes it possible to create site vegetation maps and attribute these maps to certain vegetation types.

Site quality is determined using the following ecologic indicator values:

> moisture value,
> nutrient value,
> humus value,
> light value,
> proportion of woody plants.

For details, please refer to Klaus, G. (ed.)[23] and the literature listed in that publication.

In order to detect changes, we compared initial surveys to second surveys and assessing indicator value changes in relation to the targets set by nature conservation policies. An individual mire is considered to have undergone significant change when net changes affect at least 10 per cent of its area and these changes can be proven with an error probability of less than 10 per cent.

As a matter of principle, the following changes are rated as favourable developments: waterlogging (increasing moisture value), depletion (decreasing nutrient value), peat formation (increasing humus value), thinning (decreasing share of woody plants) and intensification of mire character (increasing mire index, i.e. increasing diversity and dominance of mire species).

[23] Klaus G., (Red.), 2007. Zustand und Entwicklung der Moore in der Schweiz. Ergebnisse der Erfolgskontrolle Moorschutz. Stand: Juni 2007. Bundesamt für Umwelt, Bern, Umwelt-Zustand Nr. 0730. 97 S.

Z12: Diversity of Species Communities

Definition

Changes in the similarity values calculated based on pairwise comparisons of species lists compiled for individual Z7 and Z9 sampling areas:

> For data provided by the Z7 indicator “Species Diversity in Landscapes”: changes in the mean Simpson’s Index (similarity value) calculated on the basis of all pairwise comparisons of species lists compiled for one square kilometre areas in the surveyed space, expressed in per cent (between 0 and 100).
> For data provided by the Z9 indicator “Species Diversity in Habitats”: changes in the mean Simpson’s Index (similarity value) calculated on the basis of all pairwise comparisons of species lists compiled for 10 square metre areas in the surveyed type of land use, expressed in per cent (between 0 and 100).

Significance for biodiversity

All habitats are characterised above all by species that are either typical for a region or make specific ecological demands. Such signature species lend distinctiveness to a location. Species restricted to a very small range may also contribute to regionally exceptional species communities. For this reason, local diversity starts to dwindle as species communities as a whole take on similar compositions. This happens, for example, when habitats or landscapes become increasingly alike due to human activities, such as the accidental introduction or intentional planting/release of alien species.

Rationalised methods of land use (e.g. fertilisation and irrigation) or landscape design are bringing about similar habitat conditions everywhere. With such practices blurring location-related or even culturally-based habitat particularities, it is hardly surprising that species communities scarcely differ anymore from one region to the next. Dubbed “biotic homogenisation”, this phenomenon has been increasingly described and deplored in recent years. The homogenisation of species communities equals a clear-cut loss in biodiversity, despite the fact that species numbers may remain the same or even grow. If this process were to continue, we are bound to end up with standardised meadows, forest edges and hedges that look exactly the same all over Switzerland.

This scenario clearly shows that the Z12 indicator provides essential additional information to the insights provided by the BDM core indicators Z7 and Z9. An increase in species numbers is only positive if such increases are not fuelled by alien or undemanding species that feel at home in many different habitats. As a matter of fact, this kind of increase involves the risk of specialised species being crowded out and, hence also, of the homogenisation and depletion of our landscapes and habitats. To name but one vivid example: we are already used to seeing rich, green, fertile meadows everywhere, which favour nutrient-loving generalists like the Dandelion while vascular plant species typical of flower-rich rough pastures are being displaced.

Surveying methods

The Z12 indicator “Diversity of Species Communities” is based on the same data as the Z7 and Z9 indicators “Species Diversity in Landscapes” and “Species Diversity in Habitats”. Additional field surveys are not required. The Z12 indicator is calculated as follows:

1. The species list of the first sampling area is subjected to pairwise comparison with the species lists of all other sampling areas of a stratum. Each comparison yields its own Simpson’s Index, which is calculated using the following formula[24]:

   $$\textit{Simpson's Index} = \frac{\textit{minimum}\ (b, c)}{\textit{minimum}\ (b, c) + a}$$

   where *a* is the number of species occurring in both sampling areas, and **b** or **c** are the numbers of species occurring in only one sampling area.
2. The same process is applied to the second sampling area: its species list is compared to the species lists of the third and all remaining sampling areas of a stratum. The process is repeated until the Simpson’s Index has been calculated for all possible pairs of sampling areas within a stratum.
3. The mean value of all Simpson’s Indexes calculated in this manner and expressed in per cent (between 0 and 100) corresponds to the Z12 indicator value.

While these calculations are simple in principle, they are also very time-consuming due to the large number of comparisons required. In order to assess the accuracy of the indicator value, a jack-knife method is used to establish a confidence interval for the indicator.

Whenever indicator values undergo a significant change over the survey years, a temporal trend will be reported (increase or decrease).

Surveys conducted for the Z9 indicator often produce findings that cannot be clearly identified, for example if only mollusc fragments or plant seedlings are discovered. These findings are counted nevertheless, provided it is certain that they cannot be classified as belonging to a species that has already been identified in that particular sampling area. Such additional species can also be taken into consideration for Z12 calculation purposes, using simulation calculations based on the assumption that additional species show the same frequency distribution as identified species found in that particular stratum.

[24] Koleff P., Gaston K. J., Lennon J. J. 2003: Measuring beta diversity for presence-absence data. Journal of Animal Ecology 72: 367–382.

A3 Response indicators

M1: Size of Protected Areas

Definition

Changes in the size of nature conservation areas of national importance protected by law.

The M1 indicator only records nature conservation areas that are protected by law at national level and whose conservation goals are aimed at protecting species diversity.

The federal habitat inventories, which provide the basic data for this indicator, are compiled using scientific expertise and by applying standardised methods for all of Switzerland. Their conservation goals are geared to maintaining biodiversity.

Protected areas of regional or local importance are managed by cantons and communities. Their conservation goals vary and – like their locations – are not always designed to promote biodiversity. Moreover, there are no consistent accessible data available on these areas. For these reasons, the M1 indicator does not include them.

Likewise, landscape protection areas such as mire landscapes are not taken into account either as their conservation goals are not primarily geared to promoting biodiversity.

Significance for biodiversity

Protecting rare and endangered habitats on a national level helps to conserve the basic prerequisite for the survival of a large number of animal and plant species. For this reason, any increase in the size of protected areas tends to promote biodiversity and, as a result, should be positively evaluated. The M1 indicator records protected areas of national importance, provided they are guided by conservation goals closely linked to biodiversity and supply analysable data. In doing this, M1 documents the legal implementation of habitat conservation, which is intended to safeguard the environment required by specific species and was explicitly written into law in the 1980s and – even more so – the 1990s.

Covering roughly 31 per cent of the country’s territory, Switzerland’s forest stands are entitled to blanket protection, i.e. freedom of exploitation is limited in favour of sustainable use. While other habitats such as bank-side vegetation and water bodies are also protected by law, they are not recorded by federal inventories, hence there are no consistent data available on them. Protected areas of regional or local importance are not monitored by the M1 indicator either as these were not designated using standardised methods, and their locations and conservation goals are not always primarily geared to maintaining biodiversity. As a result, the total size of protected areas in Switzerland is larger than that documented by the indicator.

Nevertheless, legal (*de jure*) protection does not equal actual (*de facto*) protection. The impact of legal protection depends on whether the initiated measures truly achieve their ends. For example, the Ordinance on Alluvial Zones stipulates that the native plant and animal species typical of alluvial zones be promoted. However, only effectiveness monitoring (cf. M2, Z10 and Z11 indicators) will show whether species typical of alluvial zones actually benefit from such conservation measures.

Surveying methods

Data used to calculate changes in the size of protected areas are extracted from the federal inventories of alluvial zones, raised bogs, fenlands, dry grasslands, amphibian spawning areas, waterbird and migratory bird reserves, the federal game reserves and the information on the Swiss National Park.

The total size of areas protected by law at national level is composed of the sizes of alluvial zones, raised bogs, fenlands, dry grasslands, amphibian spawning areas, waterbird and migratory bird reserves, federal game reserves, and the Swiss National Park. Areas that are protected simultaneously by several federal inventories are counted only once.

To demonstrate the development of strictly protected areas on its own, the indicator also calculates the total size of strictly protected areas alone (excluding federal game reserves and waterbird and migratory bird reserves).

The Federal Inventory of Amphibian Spawning Areas includes both permanent and temporary sites. Temporary sites correspond to perimeters within which actual spawning sites may shift. Only the spawning sites themselves are protected. Hence, only these sites are considered to be protected areas for indicator purposes. Each temporary site is assumed to cover an area of 0.85 hectares. This corresponds to 10 per cent of the mean value of temporary sites recorded in 1994 when the ordinance was being drafted; see Ordinance on Amphibian Spawning Areas of National Importance, Art. 3 (1) (SR 451.34).

The perimeters listed for game damage as listed in the Federal Inventory of Federal Game Reserves are not included in M1 calculations.

All data are supplied by the FOEN. To locate protected areas, please use the FOEN's *map.bafu.admin.ch* application. The figures will change once a new federal inventory has been adopted or an existing federal inventory has been revised.

M2: Size of Secure Protected Areas

Definition

The M2 indicator "Size of Secure Protected Areas" monitors nature reserves that are included in a federal habitat inventory subject to article 18a of the Swiss Nature and Cultural Heritage Protection Act and legally implemented at cantonal level.

The federal habitat inventories, which provide the data analysed by this indicator, are surveyed using scientific expertise and by applying standardised methods for all of Switzerland. Their conservation goals are geared to maintaining biodiversity.

Regional and local nature preserves are administered by the cantons and communes. Their protection goals vary, and they are not always dedicated to promoting biodiversity. Moreover, there is no uniform and accessible data available on these reserves. For this reason, the M2 indicator disregards regional and local nature reserves.

Landscape protection areas such as peatlands are also disregarded as their conservation goals are not primarily geared to promoting biodiversity.

The Swiss National Park is also ignored by the M2 indicator as it would add a constant value to the territory of Switzerland as a whole and the Eastern Central Alps biogeographical region.

Significance for biodiversity

The designation of protected areas is a measure that has been implemented since nature conservation first began. While such nature reserves are mostly or completely dedicated to nature conservation, prioritising nature does not totally exclude any kind of land use, for example for agricultural purposes. However, all types of land use are required to comply with the area's nature conservation goals.

In the 19th century, i.e. in the early days of nature conservation, nature reserves were mostly established to protect individual species. Nowadays, conservation efforts increasingly focus on entire ecosystems or ecosystem complexes. This trend has been emphasised since the revision of the Swiss Nature and Cultural Heritage Protection Act in 1987, through which the federal government's authority in matters of habitat protection was boosted and the legal foundation for habitat inventories laid. An area included in a federal inventory contains the kind of habitat that is considered to be the most valuable in accordance with the intention of that particular inventory. Protecting these habitats is a prerequisite for maintaining the country's biological diversity. However, as they are relatively small, it is vital that they be linked to other areas by migratory axes or stepping stone habitats. Isolated individual reserves are unable to maintain biodiversity. Increasing them in size and linking them to other habitats of the same or even a different type makes them all the more valuable.

The mere act of marking an area included in a federal inventory on a map does not guarantee its protection. Federal inventory habitats need to be effectively protected and maintained on the ground, and for this to happen, landowners must be legally bound to provide that protection. It is the duty of the cantons to implement the required protective measures at a local level or to delegate their implementation to individual communes.

Surveying methods

All information is based on a poll conducted by the Federal Office for the Environment FOEN in 2010 which involved sending a multiple-choice questionnaire to all cantons. For M2 purposes, answers concerning federal habitat inventories were evaluated with regard to the size of protected areas for both Switzerland as a whole and its biogeographical regions. There is only one exception to this rule: because shifting amphibian spawning sites are not recorded by size, all relevant percentage data refers to the number of sites related to the corresponding population.

The following questions and possible responses were used for the M2 evaluation:

> *Protection status*
  The key question was whether an area is covered by protection that is legally binding for landowners. Possible answers:
  – No data
  – Conservation zone subject to communal land-use planning
  – Cantonal nature reserve
  – Agricultural zone with habitat-specific land-use constraints
  – Other
  – No protection that is legally binding for landowners

> *Management/Maintenance*
  Ensuring a the quality of a protected area is of crucial importance and requires corresponding regulations in relation to management and maintenance. Possible answers:
  – No data
  – Area under contract
  – Forestry planning
  – Protection/maintenance/management/action planning
  – Other
  – Management/maintenance are not ensured

> *Implementation*
  Implementation means that an area has been precisely demarcated and that with conservation and maintenance measures are in place. Possible answers:
  – No data
  – Implementation completed
  – Implementation not completed

> *Improvement*
  While habitats of national importance may be of sufficient quality for them to be listed in the corresponding federal inventories, they are often impaired. Legal provisions stipulate that any impairment must be reversed as far as possible whenever the opportunity arises. This includes regenerating impaired elements of a habitat. Possible answers:
  – No data
  – Improvements are being carried out
  – Improvements are being planned
  – Improvements are necessary but have not yet been planned
  – Improvements are not necessary
  – Improvements have been completed

All data have been supplied by the FOEN or its agents.

M3: Number of Endangered Species Living in Protected Areas

From the point of view of species protection, nature conservation areas are most useful if they contain many endangered plant and animal species. This indicator shows whether endangered species benefit from nature conservation areas.

Against this background, this indicator represents a direct link between species protection and habitat protection. However, it is not possible to evaluate changes in this indicator unequivocally as several processes with a varying impact may be responsible for the change: i.e. changes in the threat to individual species, changes in the size of protected areas, changes in the population of endangered species. High values for M3 may be positive or negative depending on the underlying processes.

M3 Data not yet available.

M4: Ecological Compensation Areas

Definition

Changes in the sum of all areas designated to contribute to preserving and promoting species and habitat diversity in agriculture, the adequate use of which is secured by contract. Changes will be monitored for Switzerland as a whole and broken down by area types and by individual cantons.

This indicator is based on the Swiss Ordinance on Direct Payments to Farmers of 7 December 1998 ("Ordinance on Direct Payments").

Significance for biodiversity

Ecological compensation areas are designed to complement nature reserves by providing habitats for plants and animals within agricultural zones. This is meant to promote natural species diversity while preventing further species losses and allowing threatened species to re-expand their ranges. Hence, an increase in compensation areas ought to increase biodiversity.

The M4 indicator shows ecological compensation areas designated in compliance with the Ordinance on Direct Payments increased from their introduction in 1993 to 2002. Since that year, the total size of ECAs has stagnated at around 121 000 hectares. This standstill is regrettable, as two case studies carried out by the Swiss Federal Research Station for Agroecology and Agriculture[25] prove that species diversity is greater in ecological compensation areas than on intensively farmed land. Furthermore, ECAs harbour a larger number of exigent and specialised species. However, their quality still leaves a lot to be desired. Assessed by the standards stipulated in the Ordinance on Ecological Quality (OEQ), 72 per cent of *extensively farmed grassland* and 89 per cent of *low-intensity farmed grassland* located on the Central Plateau fell short of federal quality targets. The situation in the mountains is better; both grassland types there fulfil most of the OEQ requirements, which means that their quality is good. This, in turn, promotes biodiversity.

The importance of ECA quality is illustrated by research carried out by the Swiss Ornithological Institute Sempach[26]. In regions that have been significantly upgraded by high-quality ecological compensation areas, the population sizes of breeding birds started to increase shortly after their designation. As demonstrated by the Swiss Bird Index SBI, bird populations in cropland areas displayed an above-average rate of

[25] Herzog F., Walter T. (eds.), 2005: Evaluation der Ökomassnahmen Bereich Biodiversität. Schriftenreihe FAL 56. 208 S.
[26] Kohli L., Spiess M., Herzog F., Birrer S. 2004: Auswirkungen ökologischer Ausgleichsflächen auf typische Kulturlandvögel und ihre Lebensräume. Sempach, Schweizerische Vogelwarte. 84 S.

decline between 1990 and 2003[27]. Conversely, populations of individual species, such as the potentially endangered Common Stonechat (*Saxicola torquatus*), have increased (cf. Z6 Indicator) due, among other things, to the increasing number of wildflower strips.

Ecological compensation also helps to preserve ecologically valuable habitats located in areas that no longer yield a profit in terms of agricultural production. Direct payments enable farmers to continue cultivating even low-productivity areas in remote mountain locations. This counteracts forest encroachment, a trend that would, for example, destroy the habitats of species that need light. In other regions, ecological compensation enables the preservation of near-natural habitats which are valuable for species diversity, such as standard fruit tree orchards and litter meadows. Moreover, ecological compensation areas coupled with other measures required for Proof of Ecological Performance also have a favourable effect on aquatic species diversity. Since ECAs are subject to little or no fertilisation, the pollution of the soil and surface waters is reduced (cf. E13 Indicator).

Ecological compensation areas are still far from exhausting their potential to promote biodiversity. To enable threatened species to expand their ranges again and to prevent further species losses, the already initiated efforts must be continued and complemented by additional measures.

Surveying methods

Farm data acquisition in Switzerland is carried out jointly by the Swiss Federal Office for Agriculture FOAG and the Swiss Federal Statistical Office SFSO. This data includes information on ecological compensation. The assessments carried out by the federal offices are based on standardised questionnaires which must be completed by the farmers. Their statements, which refer to an specific day in early May, are verified by the national and cantonal authorities and managed in the FOAG's central database.

M5: Organically Farmed Areas

Definition

Changes in areas farmed organically in Switzerland as a whole and in individual cantons.

The M5 indicator covers all areas annual federal for which subsidies are allocated in accordance with the Federal Ordinance on Direct Payments to Farmers of 7 December 1998 (SR 910.13) ("Ordinance on Direct Payments"). The farmers who receive such subsidies meet the criteria of the Swiss Ordinance on Organic Farming and the Labelling of Organically Produced Products and Foodstuffs ("Organic Farming Ordinance") (SR 910.18), which require organic farmers to: respect natural cycles and processes; avoid the use of chemical/synthetic agents and additives; refrain from using genetically modified organisms and resulting products except for veterinary purposes; abstain from treating their produce with ionising radiation or using irradiated products; adapt the number of farm animals to the ability of the farmland they own or lease to absorb the amount of manure produced; keep farm animals in accordance with the requirements of

[27] Zbinden N., Schmid H., Kéry M., Keller V. 2005: Swiss Bird Index SBI. Artweise und kombinierte Indices für die Beurteilung der Bestandsentwicklung von Brutvogelarten und Artengruppen in der Schweiz 1990–2003. Sempach, Schweizerische Vogelwarte. 44 S.
[The publications listed in these footnotes are not available in English.]

the Ordinance on Organic Farming throughout their lives and supply them with forage produced in compliance with this Ordinance.

Significance for biodiversity

The destruction of near-natural habitats and the intensification of agriculture triggered a huge decline in species diversity in agricultural areas in the second half of the 20th century. Slowing down this negative trend is an essential objective of organic farming.

To this end, production cycles on organic farms are kept as closed as possible using environmentally sound production methods. Chemical/synthetic fertilisers and pesticides are banned. As a result, biodiversity benefits from an increase in organic farming. This is evidenced by the fact that the diversity of plants, small animals, and birds tends to be greater in organically farmed areas than conventionally farmed ones. In a long-term study on plots farmed either organically or conventionally, the Research Institute of Organic Agriculture (FiBL) demonstrated that plant and small animal species diversity is greater on organically farmed land[28]. The soil of organically farmed plots features higher soil crumb stability, a larger proportion of microbial biomass and a larger number of earthworms. Furthermore, as stands formed by organic crops are less dense, more light is allowed to penetrate to the soil. This has a favourable impact on the microclimate that favours species diversity.

Adjacent water bodies also benefit from organic farming as they are not be polluted by chemical/synthetic fertilisers and pesticides (cf. E13 indicator "Water quality"). Likewise, efforts to maintain production cycles as closed as possible ensure that the number of cattle on organic farms is adapted to farm size. In other words, organic farmers do not overfertilise the soil and thus prevent water bodies from being polluted through nutrient overload.

Organic farmers are particularly committed to preserving genetic diversity. For example, the Swiss *Pro Specie Rara* conservation organisation relies primarily on these farmers to grow heirloom vegetable and fruit varieties and to keep heirloom livestock breeds (cf. indicators Z1 "Number of Livestock Breeds and Plant Varieties" and Z2 "Proportion of Livestock Breeds and Plant Varieties").

Up to now, most of the comparative studies on organic farming versus traditional farming have been conducted on arable land, causing the positive effect of organic farming on species diversity in grassland and at higher altitudes to go rather under-documented. However, this is precisely where most of Switzerland's organically farmed areas are located. Furthermore, the actual impact of organic farming is largely dependent on location, climate, crop plants and prevailing farming methods. For this reason, the M5 indicator does not directly reflect the extent to which organic farming promotes biodiversity.

Surveying methods

Farm data acquisition in Switzerland is carried out jointly by the Swiss Federal Office for Agriculture FOAG and the Swiss Federal Statistical Office SFSO. This data includes information about organically farmed areas. The assessments carried out by the federal offices are based on standardised questionnaires which must be completed by

[28] Mäder P., Fliessbach A., Dubois D., Gunst L., Fried P., Niggli U. 2002: Soil Fertility and Biodiversity in Organic Farming. Science 296: 1694–1697.

farmers. Their statements, which refer to a specific day in early May, are verified by the national and cantonal authorities and managed in the FOAG's central database.

M7: Financial Resources for Nature and Landscape Conservation

Definition

Changes in the amounts of money spent on nature and landscape conservation by the federal government, cantons and communes. These sums include all spending allocated to the area of "nature and landscape conservation" in the state financial statements of the federal government, cantons and communes. In addition, the indicator considers federal expenses that affect nature conservation but are posted under a different heading in state financial statements. All spending considered as affecting nature conservation by M7 is also defined as such in the Classification of Environmental Protection Activities and Expenditure (CEPA 2000).

Significance for biodiversity

The amount of money spent on nature conservation is an indirect indicator of how well Switzerland looks after nature and reflects the importance attached to nature conservation – and hence biodiversity – by politics. The funds allocated for nature conservation are often cut during times of economic difficulty.

Having continued to increase in the 1990s, the share of total public spending accounted for by nature conservation has remained relatively stable in recent years. As a rule, nature conservation is improved by the availability of funds.

On a small scale, what most people tend to assume is quite true: "It doesn't cost much to protect nature." For example, if dead wood is simply left where it fell, not only is the forest service spared the expense of clearing it away, but nature gains an important habitat. On a larger scale, however, costs can surge quite easily. The discontinuation of land or water use, for example, causes production losses that require financial compensation. And if nature reserves are to be truly effective, they require maintaining. In other words, conserving and promoting biodiversity in Switzerland costs money.

The M7 indicator does not cover all public funds allocated to nature and landscape conservation. While M7 considers all public spending reported as "nature conservation expenses" by federal, cantonal and communal income tax authorities, there are other types of expenditure that also affect nature conservation, despite not being posted as nature conservation spending. Green bridges, for example, are financed out of road building budgets. Nevertheless, the M7 data enable the meaningful comparison of nature conservation spending over the years.

Surveying methods

Each year, the Federal Finance Administration prepares state financial statements for the federal government, the cantons and communes. Its data are based on information supplied by the finance departments of federal offices, cantons and communes. Subject to a predefined classification system, these departments record expenses by sector. Spending for habitat protection, landscape conservation, Switzerland's national park and nature reserves is posted as part of the "nature and landscape conservation" (formerly "nature conservation") sector. The data were rectified retrospectively in the 2008 reference year as part of the revision of public administration financial statistics.

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