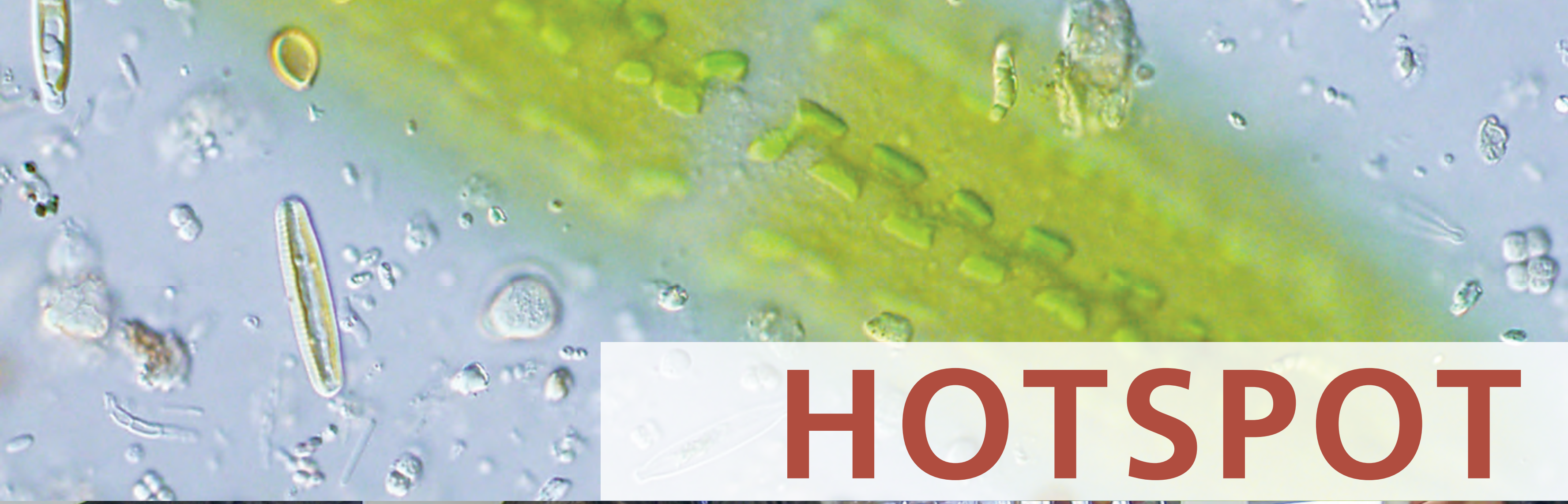

HOTSPOT

Measuring biodiversity

Research and practice in dialogue
Bulletin of the Swiss Biodiversity Forum

28 | 2013

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IMPRINT The Swiss Biodiversity Forum promotes the exchange of knowledge between biodiversity research, administrations, practitioners, policy-makers and wider society. HOTSPOT is one of the tools facilitating this exchange. HOTSPOT is published twice a year in German, English and French. It is available for download at www.biodiversity.ch. HOTSPOT 29|2014 will be published in May 2014 and will address the topic of Energy and Biodiversity. **Publisher:** © Forum Biodiversität Schweiz, Bern, November 2013. **Editors:** Dr Gregor Klaus (gk), Dr Daniela Pauli (dp). **Translation into English:** Christopher Hay. **Graphic design:** Esther Schreier, Basel. **Photos:** Photo credits are listed with the captions. **Printing:** Print Media Works, Schopfheim im Wiesental. **Paper:** Circle matt 115 g/m2, 100% recycled. **Print edition:** 3,300 copies in German, 1,100 copies in French, 1,000 copies in English. **Contact:** Forum Biodiversität Schweiz, Schwarztorstr. 9, CH–3007 Bern, Switzerland, Tel. +41 (0)31 312 02 75, biodiversity@scnat.ch, www.-biodiversity.ch. **Managing Director:** Dr Daniela Pauli. **Cost of production:** 15 CHF/copy.

Sharing biodiversity knowledge with all those who are interested in these matters is important to us. We would therefore like to continue to offer HOTSPOT free of charge. Any financial support will be greatly appreciated. HOTSPOT donations account: PC 30-204040-6. Manuscripts are subject to editorial revision. Authors' contributions do not necessarily reflect the opinions of the Swiss Biodiversity Forum.

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Science and Policy
Platform of the Swiss Academy of Sciences
Swiss Biodiversity Forum

Cover (top to bottom):
1. Diverse micro-organisms (photo credit: Edward A. D. Mitchell); 2. Determining the diversity of fruit varieties (photo credit: ProSpecieRara Basel); 3. Archived butterfly diversity (photo credit: Beat Ernst Basel); 4. Biologists working in the field (photo credit: Edi Stöckli)

Editorial

During the International Year of Biodiversity in 2010 it became clear just how difficult it is to measure biodiversity. The Year involved an effort to assess whether the loss of biodiversity had at least slowed, but the search for biodiversity metrics proved extremely difficult. It was impossible to create a satisfactory set of indicators that could be used in all the countries involved. In Switzerland, around 80 scientists working under the aegis of the Biodiversity Forum compiled the best available data in an elaborate collection process. The data covered population development and species distribution as well as habitat size and quality. This work showed that, despite gaps, Switzerland is in quite a comfortable position compared to other countries when it comes to biodiversity data. This is due in part to the many species experts who notify their records to the data centres, largely in a voluntary capacity. It is also owed to the existence in Switzerland of numerous monitoring programmes measuring biodiversity, both directly and indirectly, and allowing for statistically valid assertions. Yet some unease remains. Could it be that, despite all the data collected, we are missing important developments in biodiversity? Are we truly measuring that which is relevant? It is important to review monitoring programmes from time to time and, where necessary, to supplement and refine them in line with new scientific findings. The Swiss Federal Office for the Environment (FOEN) is in the process of developing an integrated monitoring system which will bring all the different programmes under one roof and close existing gaps. Switzerland is on track, at least as far as monitoring its biodiversity is concerned.

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Measuring biodiversity

Institutional notes

Keynote article
Look what's out there

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Humans dominate the earth, but they are not alone. Their survival depends on ecosystem services which are driven by biodiversity. But we do not even know yet how many species live in the soil under nutrient-poor grassland. Photo credit: Beat Ernst, Basel

At the end of 2012, almost exactly 8,036,900 people lived in Switzerland; of these, 49.4% were men, 35.5% were aged between 40 and 64 and 7.9% were divorced. While there are four official languages, a proportion of immigrants continue to speak their own language (9% of the population). A quarter of the population lives in the mountainous regions covering two thirds of the country's territory. We know our average life expectancy, how many children there are in the average household, the age at which most people get married, and the most popular first names given to babies. We have an incredible amount of knowledge about Homo sapiens, but what do we know about the tens of thousands of other species living here, the species living all around us, our biological environment? To be honest, it is quite astonishing just how little we know about them.

This is despite the fact that the recording and monitoring of biodiversity is the basis for its conservation, enhancement and sustainable use. Without data and factual evidence on the status and development of biodiversity there would be no early-warning about emergent problems, no objectives, no required action, no protection measures. The Swiss Biodiversity Strategy (SBS) adopted by the Federal Council in 2012 is the political answer to the warnings from the scientific community: for years, scientists have tirelessly pointed to the unfavourable condition and ongoing decline of biodiversity in Switzerland and have backed up their claims with hard figures.

What to measure?

In Switzerland there are a whole range of long-term monitoring programmes and results-based monitoring programmes for conservation measures which directly or indirectly record biodiversity data. They all have one thing in common: they only measure a small segment of the overall biodiversity. This is not really surprising, however, given that biodiversity is enormously complex. In Switzerland alone, and micro-organisms aside, there are at least 46,000 species in millions of populations and with billions of individuals; genetic diversity within and between populations of the same species is also surprisingly great. These species inhabit no less than 235 different habitat types, such as pubescent oak woodlands, rocky steppe heath of the inneralpine valleys, moorgrass meadows, or underwater stonewort swards where they form complex communities.

Given that it will be impossible to ever record biological diversity in its entirety, records of representative aspects allowing for assertions to be made with respect to the development of biodiversity must suffice for purposes of assessing the status quo. Such biodiversity metrics (or indicators) include, for example, the genetic diversity within or between populations, crop genetic diversity, the number of species in a given area, population size, a species' range, temporal patterns of abundance and distribution, the composition or variability of biocoenoses, habitat quality or functional diversity (see article on p. 15). To this end it is usually the more conspicuous and easily identifiable groups of organisms such as plants or birds that are being recorded. The vast majority of inconspicuous species remains just that: inconspicuous. When habitat quality declines, a whole range of aspects of biodiversity is affected. However, it is normally sufficient to focus on certain groups of indicator organisms.

What are the factors impacting on biodiversity? What type of changes result from these? What impacts result from these changes? How do humans react to these changes? The internationally adopted DPSIR modelling framework "Drivers – Pressures – State – Impact – Responses" allows for the selection and grouping of potential parameters and indicators for monitoring programmes.

Species as core currency

At the core of most monitoring programmes, at present and into the near future, is the species as the most easily measured unit. The "species richness" indicator is therefore often used to describe biodiversity change. It is however not always a meaningful indicator. While worldwide the number of known species is increasing all the time as taxonomists describe new species, an increase in species richness can also be the result of allochthonous species moving into new areas or previously locally extinct species being reintroduced. An increase in species richness in a country does not therefore necessarily signal positive change. If at the same time most of the rare species loose populations and see a decline in abundance, if habitats deteriorate both in terms of quality and extent, and if genetic diversity is lost, it is clear that biodiversity is indeed being lost. Only the analysis of various indicators of different aspects of biodiversity allow for assessments of the overall development.

In order to monitor the situation of individual species, changes in their populations are recorded. Since usually not all individuals of a population can be counted, surveys are based on sampling. Samples must be selected very carefully and based on scientific criteria to allow for statistically valid assertions to be made (see article on p. 8f). And even though these surveys only measure a segment of the overall biodiversity they are extremely time-consuming and labour-intensive and therefore expensive. For this reason, other data are usually taken into account that provide indirect indications of biodiversity change such as the area covered by nature reserves or airborne inputs of nitrogen into ecosystems.

Powerful indicators

The parameters and indicators in modern monitoring programmes are usually derived from models describing the causes of losses, adverse impacts on ecosystems, the status of biodiversity, impacts on people and the environment, and measures for the conservation and enhancement of biodiversity (see Figure). The various indicators allow for statements to be made on complex issues; they shed light on interconnections and trends and enable these to be communicated (see article on p. 7). Not only do they indicate general developments in biodiversity but they also highlight areas where action is needed.

Results-based monitoring differs in that it provides information as to whether certain measures have been implemented, funds have been used efficiently, and set objectives have been met. In contrast to monitoring programmes, results-based monitoring is targeted to specific projects and normally only continues to the end of the project concerned. In ideal cases, results-based monitoring supplements monitoring programmes.

Future-proofing biodiversity monitoring

The Swiss Ordinance on the Protection of Nature and Cultural Heritage (NHV) explicitly calls for biodiversity monitoring to be undertaken and for it to be integrated with other programmes (NHV Article 27a): "The FOEN shall be responsible for the monitoring of biological diversity and shall coordinate this with other environmental observation measures. This monitoring may be supplemented by cantonal measures." Switzerland, in contrast to most other countries, has had a dedicated biodiversity monitoring programme (BDM) since 2001.

For the purposes of monitoring species diversity in landscapes and habitats, the BDM programme maintains two different sampling grids covering the whole of Switzerland. One grid covers 500 sampling areas, each measuring one square kilometre, while the other grid comprises 1,600 sampling areas of 10m² each. Playing a globally pioneering role, Switzerland has taken a scientifically sound approach to biodiversity monitoring. The two sampling grids can shed light on long-term developments concerning common and widespread species. In addition, other mostly independent monitoring programmes provide data on some 30 pressure, state, and response (PSR) indicators.

For example, data on rare species are obtained from the red lists which are available for 27 groups of organisms and focus on those 36% of species at risk of vanishing from our country. Since the year 2000, the red lists have been compiled in multiannual process cycles based on IUCN (World Conservation Union) criteria and involving some very elaborate field surveys (see article on p. 16).

Twelve years after its establishment, the BDM is set to undergo some course corrections and see some additions in connection with the Swiss Biodiversity Strategy (see interviews on p. 20ff). The FOEN is currently working on a coordinated biodiversity monitoring system which is to be implemented from 2014 onwards. The aim is to ensure monitoring of ecosystem, species and genetic diversity by 2020. There is indeed room for improvement in the Swiss system of biodiversity monitoring. Suitable indicators for important aspects of biodiversity are missing. Moreover, there is a degree of duplication between different programmes and data acquisition by data centres and organisations is not standardised. Overall, there is a lack of coordination, including coordination in communication. This has led to a situation where messages about the status of biodiversity in Switzerland appeared somewhat contradictory, not just to the layperson.

An important first step on the path to a coordinated monitoring system is the amalgamation of data centres into the Info Species network (see article on p. 10f).

The revamped programme "Monitoring the Effectiveness of Habitat Conservation in Switzerland" and the new agri-environmental indicators ALL-EMA (see article on p. 17f) will plug two significant gaps in the monitoring network. FOEN also developed indicators for selected ecosystem services. New methods for measuring microbial diversity are at hand (see article on p. 14). All these offer opportunities to integrate additional aspects of biodiversity into the monitoring system with a view to answering questions that had not even been conceived when the BDM was established.

Networked data

Data consolidation and the coordination of sampling grids are demanding and important tasks, not just within Switzerland. Comprehensive information about the state of the world's biological resources necessitate a globally harmonised observation system for delivering regular, timely data on biodiversity change. Partners involved in GEO BON (Group on Earth Observations – Biodiversity Observation Network) are developing a framework for such a global monitoring programme based on a set of "Essential Biodiversity Variables" (Pereira et al. 2013).

Scientist already analyse biodiversity data from a range of perspectives in order to illustrate global trends and ecological issues. They rely on worldwide data being digitised and accessible (see article on p. 12f). This also allows for thus far undetected synonyms of species names to be consolidated over time. Costello et al. (2013) for example suspect that to date a "mere" 1.5 million species have been named instead of the estimated 1.9 million normally cited; 20% of these are likely to be undetected synonyms.

High-quality biological data obtained in the field are the foundation for the calculation of all indicators and thus for all findings on biodiversity change, the drivers of such change, and the necessary responses. It is therefore regrettable that data gathered in the course of scientific studies tend to serve merely as a basis for statistical analysis. The raw data tend to vanish and are not available to either the science community or policy-makers. All those involved in biodiversity research must urgently be required to submit survey data on any aspect of biodiversity to the data centres so as to make these data available for future analyses by both academics and practitioners.

References and list of important monitoring programmes in Switzerland

biodiversity.ch/index.en.php>Publications

Indicators for biodiversity
Quantification, standardisation, communication

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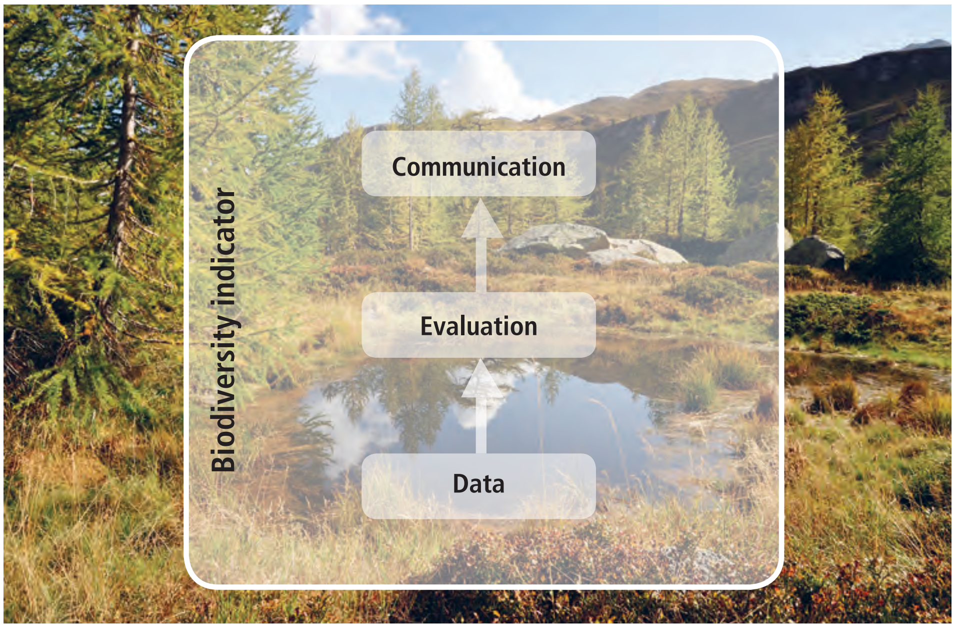
Baseline information on biodiversity including all its elements and interactions is vital to biodiversity conservation and enhancement. It also presents a challenge in that biological diversity entails diversity of information. In order to make assertions about the status and development of biodiversity it is necessary to reduce the complexity of this information. Biodiversity indicators serve this need.



In a wider sense, biodiversity indicators are composed of three components, including the communication of results. Photo credit: Lukas Mathys

Biodiversity indicators are metrics based on verifiable data, delivering integral, scientifically sound information (BIP 2011). Biodiversity information is thus simplified, quantified, standardised in terms of methodology, and communicated in a comprehensible manner (SBSTTA 2003). In a wider sense, biodiversity indicators are composed of three components, i.e. the underlying data, the evaluation of these data and the communication of results (see Figure).

In a narrower sense, biodiversity indicators refer to the data evaluation process producing the resultant figures. However, this must be based on existing data or data to be obtained, and the resultant figures must be communicated in a suitable format. Only then can a biodiversity indicator be considered effective and complete.

There is no single comprehensive and generally valid biodiversity indicator. Different target audiences perceive biodiversity in different ways and their requirements in terms of indicators vary accordingly. A suitable biodiversity indicator must therefore be both comprehensible and relevant to the target audience (SBSTTA 2003, Feller-Länzlinger 2010). For that reason indicator development begins with identifying the intended users and their needs. These in turn determine the most appropriate ways of communicating the indicators, possible methods of analysis, and what underlying data will be needed (BIP 2011).

A variety of biodiversity indicators have already been developed. In Switzerland for example, Biodiversity Monitoring Switzerland (BDM) documents the various aspects of biodiversity using a range of indicators. The core indicators convey information about the diversity of species or groups of organisms. A number of other institutions and programmes in Switzerland produce biodiversity indicators as part of their work in order to be able to provide relevant information to their own target audiences. Internationally the three most common indicators produced to date in the context of the implementation of the Convention on Biological Diversity (CBD) are the extent of protected areas, the extent of forests and forest types, and invasive species (Bubb et al. 2011).

Many biodiversity indicators are targeted at experts and administrations, both of which are significant target audiences. However, there is a large number of other target audiences that are reached with other outputs and especially through other forms of communication. The challenge is to also reach and involve these target audiences with suitable biodiversity indicators.

While analyses and communication should be targeted at the intended users, the underlying data should comprehensively and consistently capture the overall biodiversity system. Only then can the various indicators derived from these data be combined and compared. Therefore, the aim is to have consistent baseline data on biodiversity available which allow for the selection of suitable indicators meeting the needs of specific target audiences.

References
biodiversity.ch/index.en.php>Publications

The scientific basis
Principles of good monitoring

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If monitoring follows certain rules, reliable conclusions can be made about the state of and changes in populations of the organisms concerned. Careful sample selection and minimisation of observational errors are key.

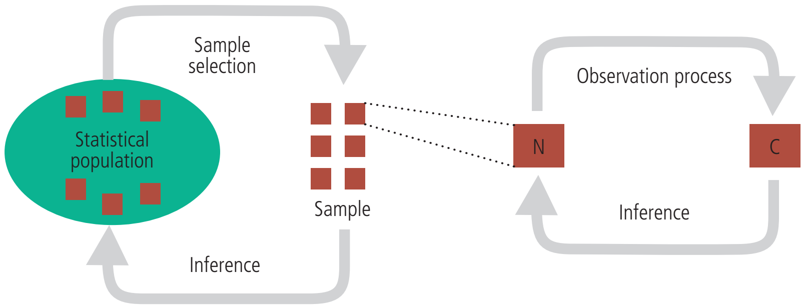


Fig. 1. Every assessment of biodiversity corresponds to a two-step sample survey N = Population; C = Count

Biodiversity is a very broad term encompassing the natural diversity of genes, individuals, populations, species, habitats and biocoenoses. In order to measure biodiversity one must first decide which of its aspects can be determined most usefully, precisely and cost-effectively. The population, i.e. the collection of all the organisms of the same species which live in the same geographical area, is of key significance. A population can most directly be described by its size, also known as abundance, followed by its distribution and by the patterns of abundance and distribution over time (trend). All three of these metrics are of key importance in biodiversity monitoring (Yoccoz et al. 2001). The principles described below are also relevant to species richness, another metric often used to describe biodiversity.

Distribution and abundance are often treated as separate measures even though distribution is simply a less informative summary of abundance: a species occurs at a location if its abundance is greater than zero. If a species' abundance in every location in a given area is known, then the species' distribution is also known, but the reverse is not true. Despite this equivalency it is often useful for practical reasons to treat these two measures separately, as data collection protocols and methods of statistical analysis may vary.

The laws of statistics

It is fundamentally important to recognise that biodiversity metrics such as abundance or distribution should be measured based on the principles of statistical sampling. This means that a researcher selects a proportion of the whole (called a sample), examines and describes it and then, based on the laws of statistics, draws conclusions (i.e. extrapolates or, in statistical terms, makes an inference) about the whole (the "statistical population") from which the sample was drawn. This is not simply a case of "nice to have" or of satisfying academic desires; the aim of this process is solely to ensure that reliable inference can be drawn about biodiversity.

Correcting observational errors

In stark contrast to sampling in other fields, such as economics or sociology, a researcher sampling populations of animals or plants almost always has to deal with systematic observational errors which mostly result from individuals or species remaining undetected. The probability of detecting species in the field is therefore usually smaller than 100% (Kéry 2008). Neither distribution nor abundance can be observed directly and without error. This trivial insight, familiar to anyone who spends time watching nature, has far-reaching implications for the type of sampling employed as well for data analysis. Whenever a researcher uses counts in the field in order to determine the absolute size of a population or the real occurrence of a species, this systematic observational error must be taken into account in the sampling procedure so as to be able to statistically eliminate it at a later stage.

A numerical example

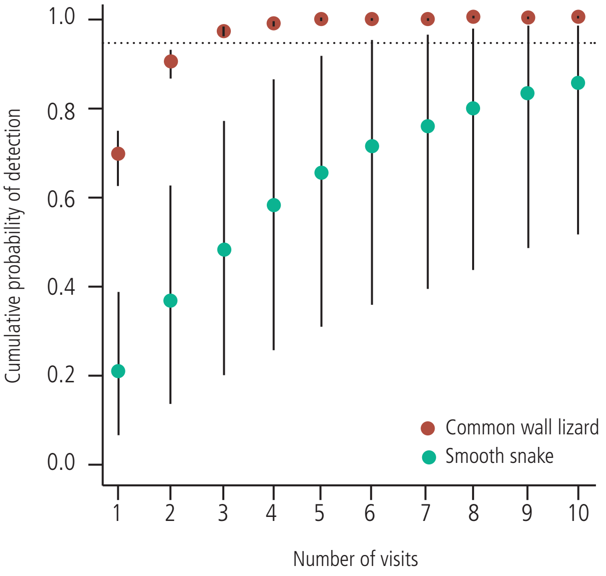
One has to imagine the measurement of biodiversity in a given area as a two-step sampling procedure (Fig. 1). The first step entails the definition of the statistical population about which inferences are to be drawn. This could be, for example, the total population of Great tits in Switzerland. A sampling unit is defined next (e.g. 1 km^2 squares) and a certain number is selected at random, resulting in an initial spatial sample. Each square hosts a population N that can be measured in a second step, e.g. by determining the number of Great tit territories (C). This count represents the second, nested sample. The observability of Great tits is smaller than 100%, therefore $C \leq N$. Consequently, statistical models must be employed to describe the observation process, so that an undistorted estimate of the status N in the sampling square can be derived from measuring C. In a further step the overall national population of Great tits can thus be projected.

Let us take a simple numerical example and assume that we have randomly selected 1000 of the roughly 42,000 km^2 of the Swiss territory. Let us further assume that we found a total of 8000 Great tit territories in these 1000 squares and that on average 2 out of 10 territories would have been missed so that the territories' probability of detection in the sample C is 0.8, and that no other significant factors are associated with the observation process (e.g. duplicate counts). The Swiss Great tit population can therefore be projected to comprise $((8000:1000):0.8) \times 42,000 = 420,000$ territories. It is also important to calculate the confidence interval which indicates the reliability of the estimate.

The sample

The explicit portrayal of measuring populations and their distribution as a sam-

Fig. 2: Probabilities of detection for Common wall lizard and Smooth snake (incl. Bayesian confidence interval). The two species have different probabilities of detection per visit (approx. 0.7 and 0.2). If an area is visited multiple times, there is a cumulative probability of 0.95 that the Common wall lizard will normally be detected after three visits, given the species does occur in the area. A significantly greater number of visits will be needed for the Smooth snake. The necessary number of visits per site is scarcely affordable; the risk that the species will not be detected despite being present is high. This makes statistical methods worthwhile that correctly estimate abundance and distribution.



Smooth Snake. Photo credit: Thomas Ott, Bubendorf

pling process shows that the selection of both samples must follow certain rules to allow for conclusions to be drawn based on the laws of statistics. The most important principle to be applied in the first step is that of random sampling which is the only way to ensure that a representative sample is being obtained.

The adequate treatment of the observation process must also follow certain rules. There must be a certain degree of standardisation in measurements, for example with respect to spatio-temporal sampling, the method used, and the conditions under which observations are recorded. However, standardised methods alone are not sufficient to guarantee reliable measurements of biodiversity. Experience has shown that many other influences can not fully be eliminated (e.g. variation in the recorders' levels of experience or variation in population density) and that even in highly standardised monitoring programmes the probabilities of detection are not constant. Normally several site visits are needed to be able to estimate the probability of detection. A simplified example can illustrate this: If one finds a species known to occur in the area on the first visit but not on the second it can be said that the probability of detection is 0.5. Figure 2 shows empirical probabilities of detection for the Common wall lizard and the Smooth snake; the data were collected as part of the field work undertaken to update the 2005 Red list of reptiles.

Unfortunately most monitoring programmes show deficits in one or both of the sampling components described above. Very good examples of programmes explicitly taking account of both components are Biodiversity Monitoring Switzerland BDM (Weber et al. 2004) and the programme monitoring common breeding birds in Switzerland MHB (Kéry & Schmidt 2008). The work undertaken to update the red list of amphibians similarly observed the principles described above (see article on p.16). In all cases a random spatial sample was or is being surveyed multiple times per season using methods that allow for estimates of probabilities of detection and thus also of total populations and ranges. If the rules described above are followed, a monitoring programme will deliver good-quality information; this is also true for programmes relying on volunteers.

Conclusions

The principles of good monitoring are easily summarised. First one has to consider which question the monitoring programme is intended to answer. In the example used above the question was, "How many Great tits are there in Switzerland?" Next one has to decide which of the biodiversity metrics are suitable to answer this question. Abundance and distribution are metrics of practical relevance in our view. The following step involves careful sample selection and a data collection protocol that allows for unavoidable observational errors to be minimised, be it in the field or later in the course of data analysis. If the sample is taken at random and consideration is given to incomplete observability, then the monitoring programme will allow for reliable inference to be made, resulting in correct decisions being taken in conservation management.

References

biodiversity.ch/index.en.php > Publications

Data centres

Networked knowledge

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The Swiss national data centres have come together under the roof of the Info Species network. Their databases contain a total of more than 15 million records. Joint data use agreements guarantee a targeted and transparent policy on data use.

Over the past few weeks another several thousand records have arrived from the Canton of Zurich. Michael Jutzi of Info Flora scrolls through the table on his computer screen as he scrutinises the datasets. "It is quite remarkable", he says, "just how many voluntary botanists, experts as well as laypersons, use the data centres' new online tools to submit their records!" It is particularly attractive for those involved in the inventory of the flora of the Canton of Zurich. They all have an account with Info Flora and now submit their records for the squares they monitor on a monthly basis. On the map they can not only see their own records but also those submitted by the other recorders involved in the project. So they can see at all times how the inventory is coming along which is not only informative but also motivates them to continue their participation and their search for species.

Thomas Wohlgemuth, one of the managers of the flora inventory, is very satisfied with the cooperation with the data centres. It's a situation of mutual benefit for both the organisations working with volunteers on the inventory and the data centres which can read the data straight into their databases. Within a short period, Info Flora's dataset grew by 60,000 records to a total of four million.

Growing need for information

The data centres maintaining data collections on fauna and on cryptogams (mosses, lichens, fungi) have also seen a continuous increase in submissions. All the data centres together hold a combined 15 million species records. This is great news for data users in conservation management or research facilities. The tighter the web of data coverage is woven the more accurate are the conclusions to be drawn on species richness in a given area. The need for information on all groups of organisms continues to grow.

Birds, fungi, bats, amphibians, butterflies – any species occurring in a canton, nature park or a site listed in the federal inventory of habitats of national importance is of interest to experts in administrations, research facilities, parks management or ecological consultancies. Therefore the data centres have come together in a national umbrella organisation under the name of Info Species (www.infospecies.ch; see Box) to coordinate their efforts and make better use of synergies. Within the Info Species network the centres manage contractual agreements, work on joint standards and guidelines and combine their resources with a view to further improving the existing recording tools.

Vital quality assurance

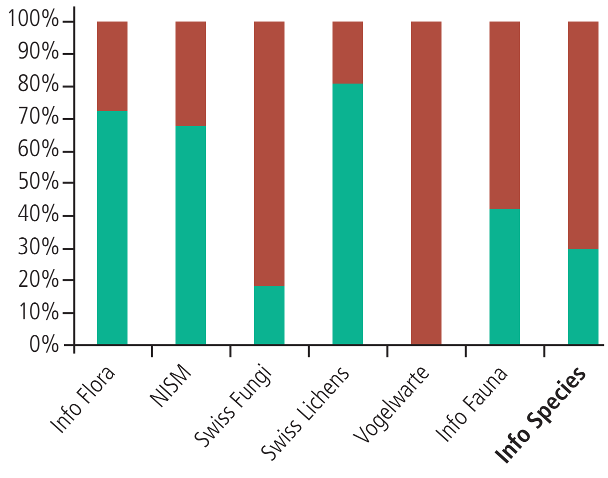
Meanwhile, Michael Jutzi of Info Flora has compiled a table of the latest records as part of the Zurich inventory. He will now once again check all the data for completeness and prepare them for a later plausibility check. The minimum data required by the data centres for a record include the name of the taxon found, geographic coordinates, the recording date, and the recorder's name. Moreover, it is important to know exactly how accurate the coordinates are: Are they GPS recorded coordinates or were they estimated using a map? What is the recorder's estimate of the accuracy of the coordinates? Later on, when it comes to interpreting the data, this information will play an important role. "A short description of the location at which the species was found is also very important", says Jutzi. "This allows us to compare the coordinates with the names of municipalities or specific localities in order to make sure that the coordinates were not accidentally mistyped. So as a first step we check the record's geolocation; the second step is a plausibility check for the taxon."

These data checks are more important than ever. It is fantastic to see how new and attractive recording tools continue to widen the pool of recorders. At the same time the data centres are under increasing pressure to separate false records from correct ones. This is particularly difficult, and in some cases impossible, when it comes to evaluating the accuracy of the species name if the record concerns a species that is difficult to identify correctly, unless evidence was submitted along with the record. But even in cases like these there are options for evaluation because the probability of a certain species occurring in a given location varies. Both impossible and unlikely records are marked in the Info Species database. "Records requiring confirmation also automatically include new records of a species in a region", Jutzi explains. "This is where we take a closer look at who exactly submitted the record. We then contact the person or request evidence."

In the case of numerous species, photographic evidence is an important tool to check for correct identification. Nowadays, photographs taken with a smart phone can be submitted to the data centres via the internet, often directly from the field together with the record itself. So the data centres now do not only save the records themselves in their databases but increasingly include images along with these records. At the Swiss Biological Records Centre (CSCF), for example, the images submitted are immediately compared to the species name in the record – a form of "inspection on receipt". However, for many species groups (insects, mosses, lichens, fungi) photos are not sufficient for correct identification. Individual data centres require additional evidence, such as sonograms for bats, grasshoppers or cicadas, microscopic images for mosses and lichens, or herbarium specimens for vascular plants. In the future it is likely that gene sequences (barcodes) will play a role for difficult groups.

These difficulties in assessing the accuracy of species records is one of the many reasons why the data collected are not simply made available for public download. "It is important that we can advise customers and directly point out sources of errors

Info Species is the network of Swiss data and information centres for fauna, flora and cryptogams. The following centres are part of this network:	
CSCF – Info Fauna	Swiss Biological Records Centre (www.cscf.ch)
Info Flora	Nationales Daten- und Informationszentrum der Schweizer Flora (www.infoflora.ch)
Karch	Koordinationsstelle für Amphibien- und Reptilienschutz in der Schweiz (www.karch.ch)
KOF & CCO	Schweizerische Koordinationsstellen für Fledermausschutz Ost und West (www.fledermausschutz.ch & www.ville-ge.ch/mhng/cco/)
NISM	National Inventory of Swiss Bryophytes (www.nism.uzh.ch)
Schweizerische Vogelwarte	Swiss Ornithological Institute (www.vogelwarte.ch)
SwissFungi	National Data and Information Centre for Swiss Fungi (www.swissfungi.ch)
SwissLichens	National Data and Information Centre for Swiss Lichens (www.swisslichens.ch)



Proportion of private (red) and public data (green) respectively that are held in the individual data centres and in all data centres on average (Info Species).

when they apply for data extracts", Jutzi explains. The other data centres take a similar view. The easier it becomes to upload data, the more important are the targeted selection and filtering of data for further use, as well as aids to their interpretation.

Data protection

Data centres must, moreover, continuously check for data ownership as only projects supported by the public sector deliver public data which may be forwarded without a release agreement. However, about two thirds of the data held by Info Species were collected and submitted by private individuals and some recorders place great emphasis on data protection (see Figure). In most cases these data concern highly sensitive species or ongoing projects (e.g. BDM). "If we did not protect these data many of the records would not arrive for years after the fact – possibly too late for the cantonal conservation authorities", Jutzi explains.

The cantons are major clients of the data centres. As the cantons are in charge of species protection on the ground there is a regular exchange of data with respect to the cantonal territory concerned. A simplification of these exchanges is planned for 2014. Lukas Wotruba of the WSL research institute is in charge of implementing the relevant changes. He runs the Virtual Data Center (VDC) project with the support of the FOEN and Info Species. "Our aim is to integrate the needs of the cantonal authorities as best as possible so that they are in a position to download all the data for all groups of organisms at any time. We will also give them the option of accessing targeted partial datasets. They will be able, within seconds, to check for endangered species of animals, plants or fungi recorded in individual inventory objects. And of course the records also contain a lot of additional information."

Important source of information

Michael Jutzi works on a request for data that is internally coordinated by Info Species. This involves the compilation of all data on national priority species and endangered species of animals, plants, mosses, lichens and fungi recorded in a planned nature reserve. The organisations and consultancies involved sent a global request to Info Species; everything will be dealt with under a single contract with Info Species as the umbrella organisation. Michael Jutzi is in charge of extracting the data on vascular plants. The data extract now also contains – in consultation with the data owners, as always – the records as part of the Zurich inventory which had just been submitted via the internet; these are of course marked as "not yet checked". Thanks to new ways of data acquisition and increased coordination between data centres, important information on endangered species can now quickly and simply be passed on to stakeholders in conservation and to researchers.

References

biodiversity.ch/index.en.php > Publications

Global data collections

A web-based wealth of knowledge

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Numerous bodies are engaging in efforts to store and secure biodiversity data, to link it up and make it freely accessible. Only then is the data of use for research and the conservation of biodiversity; otherwise the repositories would be mere data graveyards.

For over 300 years, biologists have collected animals and plants in the remotest parts of the world in order to study and document the diversity of life. This legacy of dried, mounted, bottled, conserved, frozen or stuffed specimens resides in natural history museums and the cabinets and basements of research institutes. To facilitate access to the individual objects, many collections have now been indexed in databases. Over the Internet these digitized assets can be collated into huge volumes of data. Digitalisation is progressing in Switzerland, too, but only approximately 10 per cent of the estimated 42 million animal and plant specimens known to exist are actually available online.

328 million data items

Most biodiversity data are information on species and their occurrence. These can be individual records, species lists for a region, distribution maps from distribution atlases such as the Atlas of Breeding Birds published by the Swiss Ornithological Institute, Sempach, or the single-species occurrence maps that are the basis for the red lists compiled by the IUCN (International Union for Conservation of Nature) and are continuously updated by experts.
The most common data, however, are individual records or individual observations. 328 million such records are available online at the Global Biodiversity Information Facility (GBIF), a portal that brings together over 10,000 datasets from 450 different institutions worldwide. These datasets vary in size, ranging from over 97 million bird records from the Avian Knowledge Network dataset in the USA up to e.g. 25 edible wild herbs found on a GEO biodiversity day in Aachen, Germany. Switzerland contributes via the GBIF-CH node (at the University of Neuchatel, led by Yves Gonseth) approximately 1.5 million records to GBIF. Of these records, two-thirds are data from the Swiss National Data Centers of the "Info Species" network, for example from the Swiss Centre for the Cartography of Fauna (CSCF), while others are specimen from museums and private collections. At the time of its launch, GBIF mainly featured digitized specimens of herbarium and zoological museum collections documenting also many historical occurrences of species. Since then, a huge number of species records and observations have been added: records of marine organisms supplied by research vessels, for example, or bird observations entered via "e-bird" by bird enthusiasts.
In general, species observations can be recorded more easily and in greater numbers, because this does not involve preserving every individual as specimen. The downside is that the observation cannot be verified later. Citizen science projects like "e-bird" attract a great number of people, sharing their observations online. They represent a huge data source (see article p. 23); but quality control remains a problem, nevertheless.

Numerous platforms and online portals

Linking up data in global online platforms allows to compile a global species collection, the main aim of the "Encyclopedia of Life" project. Encyclopedia of Life (EoL) is an important source of information for anyone interested in biodiversity, as it collates all the information available on a single species in one place: its scientific name and phylogenetic tree, any vernacular synonyms, but also pictures and sounds (e.g. of bats, birds and whales). Anyone can contribute and comment on articles, so that knowledge on each of the 1.3 million species available at EoL is growing constantly. Another major project is GenBank, which collects and compares gene sequences, and is an essential prerequisite for many studies on genetic diversity. Apart from GBIF, EoL and GenBank, a host of other platforms and online portals provide global access to biodiversity data (see Figure). Often these are national initiatives that operate at the forefront of development and are acknowledged as flagship projects, such as the Atlas of Living Australia. Another pioneering project is the "Map of Life" project, linking up different biodiversity data types such as range maps, individual records or species inventories. By combining these, a much more accurate picture emerges of where a species actually occurs.

Data quantity and quality to improve

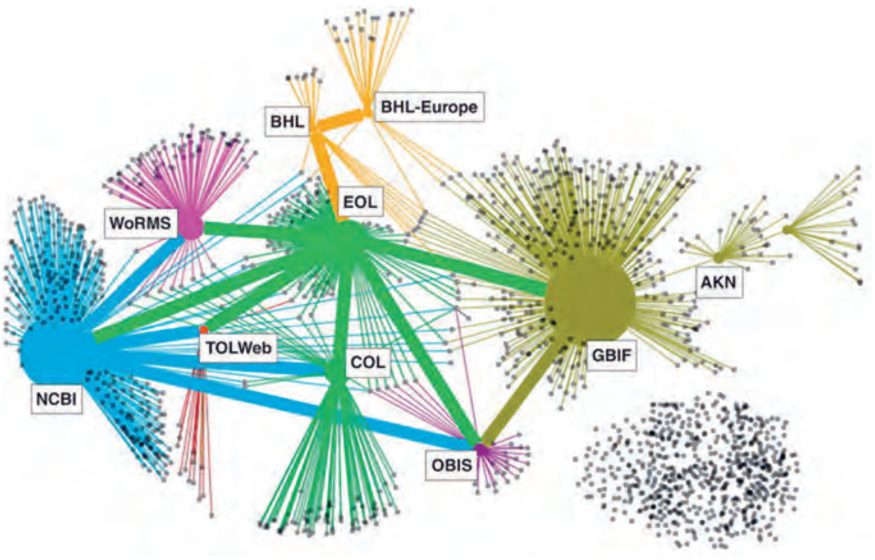
Major gaps in knowledge still exist. Until now data collections have been rather a reflection of people's collecting activities than a documentation of the biodiversity that really exists. Whereas North American and European bird species are very well documented, only a small fraction of the diversity in the Amazon has been recorded so far. Numerous organizations, as well as the GEO BON group (Group on Earth Observations biodiversity observation network) aim to improve biodiversity monitoring worldwide. A special event on Biodiversity will take place at the next GEO meeting in Geneva in January 2014 (see Box).
An important objective is, that all recorded biodiversity data should be secured and made freely online accessible to experts and the public. Only then is it useful for others. The more complete the available digital biodiversity data is, the more reliable the results of scientific studies based upon it will be. Nevertheless, a great deal of data is still inaccessible and large amounts of data still get lost, even data generated by publicly funded projects. Quality standards are there, but often not implemented. However, a publication culture for data equivalent to the conventions for scientific papers is now in the process of being established.

Rising interest

Biodiversity research based on publicly accessible databases is growing steadily, as shown by the number of studies. In the year 2012, for instance, no less than 230 studies were published which made use of

GBIF data. These focused on themes ranging from the impacts of climate change on biodiversity (e.g. using niche models to model a species' future distribution areas), to modelling the distribution of invasive organisms or pathogens, to improving the planning of nature reserves. Many studies are also using biodiversity data to answer fundamental scientific questions from the disciplines of evolutionary research, macroecology or biogeography.

An overview of the most important international data collections can be found at biodiversity.ch/index.en.php > Publications > HOTSPOT



A network of biodiversity-related databases with online platforms (e.g. GBIF and OBIS as "nodes"). Each of the 1,631 dots represents a project (i.e. the collection is incomplete but representative). In 1,704 cases the data are "shared", i.e. reused, associated with hyperlinks, or indexed. The size of the coloured dots represents the number of such hyperlinks

OBIS = Ocean Biogeographic Information System; WoRMS = World Register of Marine Species; AKN = Avian Knowledge Network; COL = Catalogue of Life; EOL = Encyclopedia of Life; BHL = Biodiversity Heritage Library; NCBI = GenBank; TOLWeb = Tree of Life Web.

Source: Trends in Ecology and Evolution, Vol. 27, No. 2, Parr et al. Evolutionary informatics: unifying knowledge about the diversity of life, pp. 94-103, Copyright (2012). Reproduced by kind permission of Elsevier.

Global biodiversity indicators

In January 2014 Switzerland will be hosting the Tenth Plenary Session of GEO, the Group on Earth Observations. As part of this, a parallel event will take place on global biodiversity monitoring. Scientific knowledge and scenarios informing international biodiversity policies are becoming increasingly important. Within the framework of the Convention on Biological Diversity (CBD), the Strategic Plan for Biodiversity 2011– 2020 including the 20 Aichi Biodiversity Targets were adopted in autumn 2010 in Nagoya, Japan. Progress towards achieving these targets will be assessed with the help of global indicators.

The individual parties to the Convention have to report on the progress they have made. This imposes major demands on individual countries, since appropriate national indicators must be developed.

The reports of individual countries will be supplemented with regional or global data sources. Important partners to help countries reporting to CBD are institutions that cooperate under the auspices of the Biodiversity Indicators Partnership (BIP) and the Biodiversity Observation Network (GEO-BON): UNEP (GRID and WCMC), IUCN, the CBD Secretariat and other partners.

The development of various biodiversity parameters is of great importance. In future, the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) will certainly have an important role to play in addressing these tasks.

The FOEN supports various projects of the CBD and the World Conservation Monitoring Centre (WCMC) of the United Nations Environment Programme (UNEP) which should help to make use of globally recorded remote sensing data for local monitoring purposes. The work will put countries in a position to improve their own biodiversity monitoring. These projects will be discussed at the next CBD meeting and will also be presented at the Tenth Plenary Session of the Group on Earth Observations (GEO-X).

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Species diversity in Switzerland
50,000, 70,000 or 500,000?

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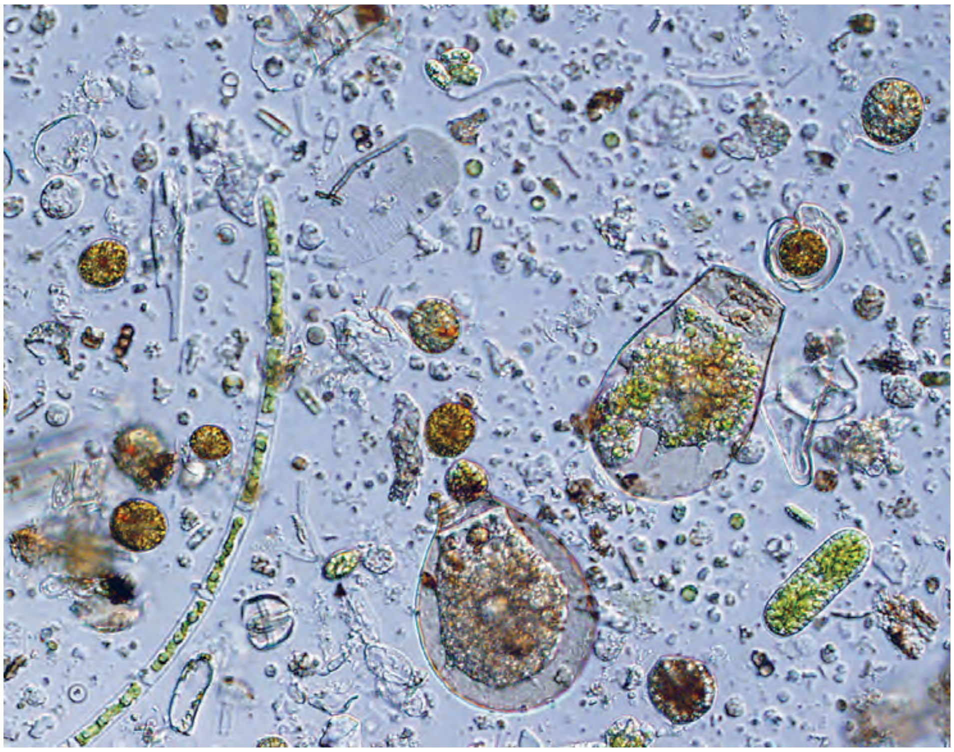
It has been estimated that Switzerland hosts between 50,000 and 70,000 species (Baur et al. 2004). But just how reliable is this estimate? We are of the opinion that species diversity is greatly underestimated, as current inventories neglect many groups of organisms.



Micro-organisms are the poor relations in biodiversity research. Photo credit: Edward A. D. Mitchell

In estimating species diversity, the first challenge concerns the definition of the biological concept of "species". The classic definition is not applicable to the greater part of the phylogenetic tree of life. Many micro-organisms are considered to reproduce asexually – undoubtedly an incorrect generalization (Lahr et al. 2011). Their life cycles are rarely the subject of scientific research, whether they reproduce sexually or not. The molecular approach circumvents this problem, though it does not preclude errors.

The first step in determining the genetic diversity of organisms is to select a marker (entire gene or gene fragment) which is sufficiently variable to allow for differentiation between species but which, if at all possible, also occurs in all living organisms. As there is no one ideal marker gene, different genes are used for different groups of species. An arbitrary range is defined, termed the molecular taxonomic unit. Numerous studies have shown that each morphological species represents a number of "molecular" species (often as many as several tenths or hundreds!).

Especially in the case of parasites it is likely that the actual diversity in existence is hugely underestimated. If each animal species hosts on average at least two specific species of parasites or symbionts (unicellular organisms or bacteria), higher animals (the parasites' hosts) can not constitute more than one third of the global biodiversity.

Parasites are in general less well researched than other species (with the exception of human parasites as well as plants and animals of economic significance). There is a similar shortfall when it comes to micro-organisms. It is highly probable that there are numerous species that have not been described for Switzerland. This raises the question: Is this number low ($<10^4$) or quite high ($>10^5$)?

Nineteenth-century naturalists were very interested in free-living organisms but research progress on these microbes was very slow. Micro-organisms are clearly the poor relatives in biodiversity research today. The emergence of the molecular methods however now offers new research prospects. They allow for investigations into the diversity, biogeography, temporal dynamics and ecological role of these micro-organisms.

But what about viruses? Are they living organisms? This is a contentious issue as they lack proper metabolic activity and depend on hosts for reproduction. Should viruses therefore be included in biodiversity inventories? If the answer was yes, on which of the species concepts would their inclusion be based? These are questions of both a biological and philosophical nature.

And where should this search for these new species begin? Soil micro-organisms have thus far been given particularly little attention, especially unicellular organisms and the mesofauna; comparatively more research has been devoted to bacteria, fungi and macro-invertebrates. Taxonomists who are specialised on unicellular organisms and mesofauna are few and far between.

References

biodiversity.ch/index.en.php>Publications

SwissBOL: Creating an inventory of Swiss biodiversity

The Swiss Barcode of Life (SwissBOL, www.swissbol.ch) project was established in order to capture more accurately the diversity of life in Switzerland. It is the project's aim to create a complete inventory of all living organisms in Switzerland in the long term. As a first step, a number of pilot projects have been established, covering a broad range of different groups of organisms – microscopic and macroscopic, parasitic, well-known and lesser known groups.

Functional aspects of biodiversity
Why investigate – and how?

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Which aspects of biodiversity are especially significant for the functioning of ecosystems and the provision of ecosystem services, and how do they vary through time and space? Indicators of functional diversity have proved suitable to quantify the consequences of land-use changes.

Species can exhibit the utmost diversity in terms of traits that are important for one or more functions of ecosystems and which determine their response to environmental changes. Trait-based approaches in biodiversity research therefore often allow more precise predictions of the functional consequences of global change upon ecosystem functions and services than taxonomic approaches (e.g. species numbers). Since most ecosystem functions are heavily influenced by biotic interactions, it is important to understand the significance of functional diversity across the different levels of the food web.

Studies show that species communities with a high functional diversity can provide stable ecosystem services by virtue of functional redundancy and inter-species complementarity. Different pollinating insects, for example, exhibit temporally (over the course of the day or year) or spatially (flower, plant, landscape level) divergent, and to some extent complementary, patterns of activity – including pollination – which can have a positive impact on plant pollination success (Albrecht et al. 2012).

New studies led by the Swiss Federal Institute for Forest, Snow and Landscape Research WSL have shown that the influence of grasshoppers on plant biomass, and hence on the nutrient cycle in the soil, is dependent not only on the dominant biomechanical characteristics of plant communities but also on their functional diversity as regards the quality of food for this group of herbivores (Ibanez et al. 2013; Moretti et al. 2013).

A European project (www.quessa.eu) is currently investigating how beneficial organism and pollinator communities in seminatural habitats in agricultural landscapes are structured by functional vegetation traits. The researchers are also interested in the extent to which the traits of both groups overlap, and which functional traits of beneficial organisms and pollinators are particularly significant for the ecosystem services they provide. The aim is to derive trait-based indicators for biodiversity and ecosystem services (see illustration). These offer an as-yet unexploited potential to integrate functional aspects of biodiversity into evaluations of the success of nature conservation, restoration and monitoring programmes. Biodiversity research must clarify which easily measurable functional traits of organism groups are the most pivotal with regard to their sensitivity to environmental changes, on the one hand, and their impacts on ecosystem functions and services, on the other, and how these traits correlate. Apart from the mean value of trait-values, their variation and diversity within the biotic communities (functional diversity) are also important indicators.


Only when large enough pollinators like bumblebees (left) visit yellow archangel flowers, pollen is transferred to the right parts of their bodies to enable efficient pollination. Smaller wild bee species with shorter tongues, on the other hand (right), are often more efficient pollinators of flowers with short corolla tubes offering more easily accessible resources. Therefore the body size and tongue length of visiting organisms as well as the corolla tube width and the length of flowers can be important functional traits for the pollination of plants. To test the hypothesis of whether the pollination service for a diverse plant community is influenced overall by the functional complementarity of the traits "body size" and "tongue length" in the pollinator community, a "functional divergence" indicator could be applied. For example, this could be calculated as the sum of the weighted deviations in the body size of the pollinators or from the weighted mean body size in the community. To investigate whether pollinator communities with a high proportion of large species provide high pollination services, for example, the average body size weighted according to the frequency of the flower-visitors could be used as a trait-based indicator. Photos: Beat Wermelinger, WSL (left); Matthias Tschumi, Agroscope (right)

References

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Red lists

Measuring threat status

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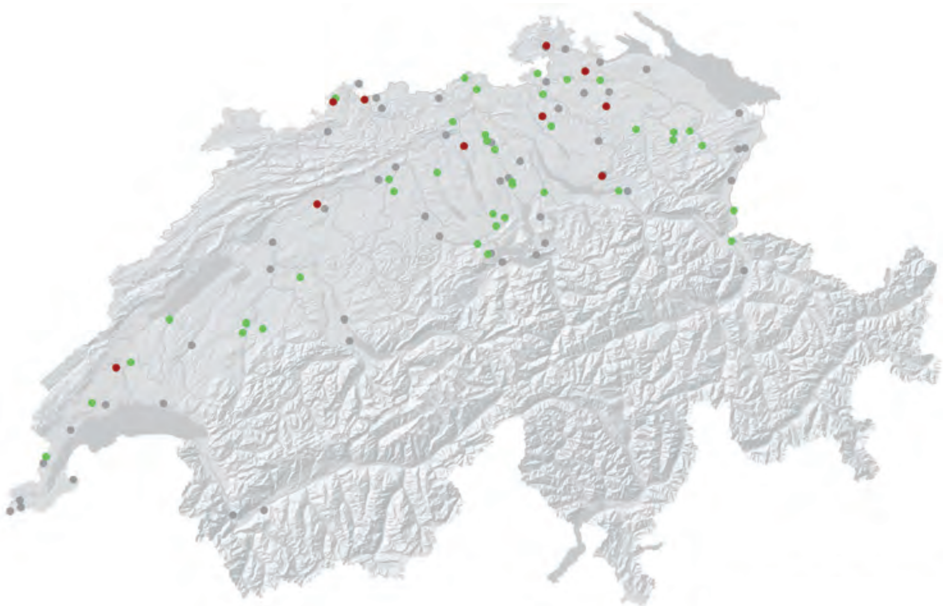
What does it mean if a species is "endangered and red-listed"? Using the example of the 2005 Red List of Amphibians, this article aims to demonstrate how a species' threat status is assessed.



The map shows, for the Yellow-bellied toad *(Bombina variegata),* the results of field work undertaken to update the red list. Green dots denote past records which were confirmed, while gray dots denote past records which could not be confirmed. Red dots denote new populations.

The contracting authority of the 2005 Red List of Amphibians, the Swiss Federal Office for the Environment FOEN, specified that the methodology used by the World Conservation Union (IUCN) should be applied. The IUCN has defined both red list categories as well as quantitative criteria which determine to which of the categories a species is assigned. An examination of the IUCN's methodology showed that for amphibians native to Switzerland only the criteria "geographic range" and "declining population" can meaningfully be applied. As karch – Swiss Amphibian and Reptile Conservation Programme – maintains a distribution database which provides information on the number of populations of species of amphibians in Switzerland, and given that changes in the number of populations may be used to infer a population reduction, the "declining population" criterion appeared appropriate.

For all pond-dwelling species (except common species, namely the European common frog, European toad and Alpine newt), 25 breeding sites (i.e. populations) each were selected at random. As each of the breeding sites often hosts several species, the resulting sample sizes were in the order of 25 to 100 breeding sites per species. A total of 300 breeding sites of amphibians were sampled, each being visited four times by specialists. The aim was to record the amphibian species (still) present. Four visits were needed due to the species' phenology; these multiple visits also allowed an estimate of species' detection probability. The estimates of detection probability allowed calculation of the number of populations overlooked. It was shown that, thanks to the four visits to each site, practically no population remained undetected.

The calculations for the "declining population" criterion were based on the population decline as determined from field survey data. For example, if a species previously had 100 populations in the overall sample and only 50 populations could be confirmed it was deemed to have suffered a 50% population decline.

It would also have been possible to record a population increase. In addition to breeding sites in which the species had been recorded in the past, sites were included in the sample at which the species had not been observed in the past, including some newly created wetlands. If a species was recorded at breeding sites where it had not previously been present, this would indicate a population increase. However, relatively few such populations were detected and mostly only concerned common species such as the European common frog or Alpine newt.

The "effective range" was determined by first calculating the number of current populations (number of populations in database multiplied by population decline) and then determining the area inhabited by each of the populations. For frogs this area was taken to cover a circle with a radius of one kilometre while for newts an 0.5 kilometre radius was applied. The number of current populations multiplied by their individual range gives the species' "effective range" in Switzerland.

For a reliable estimate of population decline and range size, and to assign the species to IUCN red list categories, it is crucial that the karch database held good records of species distribution in Switzerland, that random sampling of populations in the field was undertaken, and that the data were analysed using modern statistical methods (also see the article on p. 8).

Agri-environmental indicators

Measuring biodiversity in agricultural landscapes

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With its ALL-EMA programme, Agroscope is devising agri-environmental indicators for Switzerland to measure the development of species and habitat diversity in the agricultural landscape and assess the achievement of environmental objectives in the farming sector.

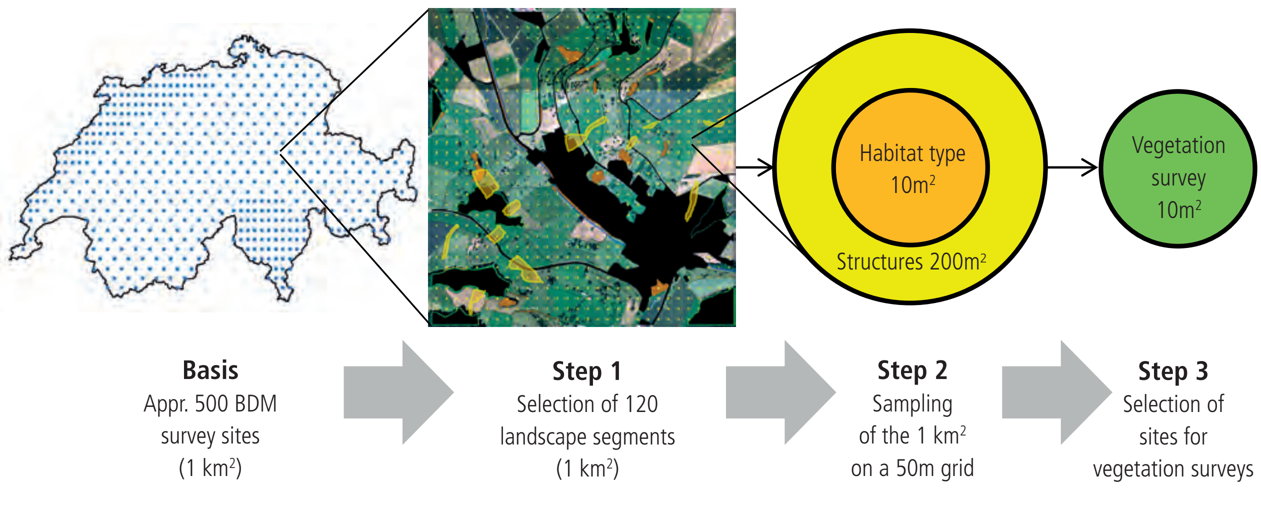
What are the biodiversity trends in the agricultural landscape? Are the species and habitats conserved for which farmers have a special responsibility under the country's agriculture-related environmental objectives? Do the ecological compensation areas supported financially by the Swiss Confederation make the desired contribution? To answer these questions, the Swiss Federal Offices for Agriculture (FOAG) and the Environment (FOEN) commissioned Agroscope Reckenholz-Tänikon to develop a long-term monitoring programme entitled ALL-EMA, which translates as "Farmland species and habitats". ALL-EMA is integrated into the FOAG's system of agri-environmental indicators and is designed to complement the FOEN's national monitoring programmes.

ALL-EMA specifically records habitats of medium frequency to medium rarity. The sampling method was developed by experts at the Swiss Federal Institute WSL and Neuchâtel University. In landscape segments of one square kilometre, farmland habitat types are recorded in the field on a 50 metre grid (see Figure). Habitat types are identified using a vegetation-based key developed in cooperation with Hintermann & Weber AG and other experts. This key allows reproducible identification of the approx. 90 habitat types present in Switzerland's agricultural landscapes, and will be made freely available to other projects. Using the information on habitat types, vegetation surveys are conducted in a selection of approx. ten per cent of the sites sampled. The data obtained allow nuanced statements on the status and development of a wide range of so far rarely documented habitat types and the species they host. They also allow assessments of the quality of ecological compensation areas in the agricultural landscape.

ALL-EMA is embedded into the national monitoring system (see Figure on p. 21), utilising important synergies with Biodiversity Monitoring Switzerland BDM. The surveys are carried out in a selection of the 1 km² landscape segments of BDM Indicator Z7, allowing BDM data on butterflies and breeding birds to be used to calculate faunistic indicators even though only botanical surveys are undertaken within ALL-EMA itself. The BDM programme will in turn benefit from the ALL-EMA habitat data, allowing improved interpretation of its own data on plant and animal species. As the vegetation surveys conducted under the BDM and ALL-EMA programmes as well as those monitoring the effectiveness of habitats of national importance apply a unified methodology (p. 18), data can be readily compared.

After two years of methodology development, ALL-EMA is now in its pilot phase with routine work due to commence in 2015. Applications for electronic recording of field data are being programmed to allow the extensive survey work to be carried out efficiently and verifiably. In 2014 routine operations will be simulated in a larger-scale field test to check the methodology.

ALL-EMA will provide data on 34 indicators for the diversity and quality of species, habitats and ecological compensation areas from valleys to high-altitude summer pastures and will thus illustrate the status and development of biodiversity in the open cultural landscape. These indicators can provide answers to the questions posed at the outset of this article on the degree to which agri-environmental measures have achieved their objectives and on the status of agricultural biodiversity.



ALL-EMA's three-step sampling strategy

Monitoring the effectiveness of habitat conservation
Making changes visible

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Habitats of national importance are an important tool for biodiversity conservation in Switzerland. A long-term monitoring project will identify changes in habitats of national importance. Aerial photograph interpretation and field surveys provide the necessary data.

The habitats of national importance are pivotal to the Swiss protected area network. They include raised bogs, transition mires, fens, dry grasslands managed as meadows and/or pastures, alluvial areas, and amphibian spawning grounds (Fig. 1). While such habitats only cover two per cent of the country's territory they are vital to the conservation of many rare and endangered habitats and species (Lachat et al. 2010).

However, legal protection does not necessarily ensure the maintenance of ecological quality or conservation value.

A programme monitoring the effectiveness of peatland conservation conducted between 1995 and 2007 showed that the quality of peatland habitats continues to decline despite the protection measures taken. Peatlands became drier and more nutrient-rich and scrub encroachment increased (Klaus 2007; Bergamini et al. 2009). However, there have also been positive developments in peatlands. Drainage ditches were closed off in many raised bogs in order to re-wet the peat body (Staubli 2004). Major investments are also being made in the restoration of other habitats of national importance, notably alluvial floodplains (Göggel 2012).

The FOEN project "Monitoring the Effectiveness of Habitat Conservation in Switzerland" straddles the divergent forces of insidious habitat quality loss on the one hand and positive developments on the other. The primary aim is to ascertain whether the habitats of national importance are developing in keeping with set conservation objectives and whether they are being maintained in both size and quality. The project also provides an early warning system, detecting adverse developments as early as possible and allowing the authorities to be informed and respond in time. As demands upon a monitoring system can change, for example due to new societal or environmental policy conditions, the system must be highly flexible in its options for data analysis. The data should also be compatible for use across habitats and projects. This is achieved through methodological harmonisation between different habitat types within the project as well as between the project and Biodiversity Monitoring Switzerland BDM and the ALL-EMA system of agri-environmental indicators (see p. 17 and Figure p. 21). The project's pilot phase started in the spring of 2011 and will continue to the end of 2014. From 2015 the project will move into routine operation.

The monitoring project has a modular organisation. The three modules at present are "Remote sensing", "Vegetation" and "Amphibians". A fourth module is currently being tested with a view to including further faunal groups such as butterflies or dragonflies and damselflies. A data collection cycle will be completed once every six years for all modules.

Powerful aerial photographs

In the "Remote sensing" module all 6,000 objects in the four habitat inventories are assessed by aerial photograph interpretation using digital aerial imagery produced for the entire country by Swisstopo at six-year intervals. To interpret objects, a grid of 50×50 m cells is placed over each object and intersected with the object perimeter. For each grid square, aerial photography interpreters assess indicators such as the percentage of tree cover, open ground, or the presence of buildings or roads. Using such indicators, comparisons between two photographs taken at different times can reveal processes of change such as scrub encroachment or erosion as well as the reasons for such changes, e.g. the abandonment of farmland.

Aerial photograph interpretation started in summer 2012. The first phase, to conclude in 2017, examines changes since the inventories of habitats of national importance were first compiled. This will soon allow statements about the changes that have occurred. From thereon, aerial imagery of the objects will be compared at six-year intervals. As the "Remote sensing" module covers the entire country, it reveals trends at national and regional levels as well for individual objects. It is therefore possible to detect adverse changes in individual objects at an early stage. This early warning function allows cantons to prioritise responses and swiftly take action to protect such objects.

Extensive field surveys

Vegetation surveys in the field are undertaken in dry grasslands managed as meadows and pastures, peatlands, and alluvial

Fig. 1: Habitats of national importance: Dry meadow in Valais, alpine alluvial floodplain in the Bernese Oberland, raised bog with Swiss mountain pine in Central Switzerland, amphibian breeding site in the Reusstal region. Photo credits: Ariel Bergamini

floodplains. From each of the relevant inventories a weighted random sample was taken to obtain a representative sample of all biogeographic regions, vegetation types, different sizes of objects and different altitudes (Tillé & Ecker, in print). Of the dry grasslands managed as meadows and/or pastures, 400 objects were selected in addition to 250 peatland sites and 120 alluvial floodplains. In each of these objects, between 5 and 40 sampling plots are selected at random and all species present in these plots are recorded (including bryophytes in peatlands) and their cover values estimated. The number of sampling plots for each object depends on the object's size as well as the diversity and rarity of vegetation types occurring therein. Each sampling plot is 10 m² in size (i.e. a circle with a 1.78 m radius). Additionally, in alluvial floodplains shrubs and trees are recorded in a 200 m² circular plot (7.98 m radius). In the field the centre of the sampling plot is located using GPS and then marked as a permanent plot using a magnetic probe. A total of 6,100 vegetation plots are being assessed across the three inventories. In addition, in the dry grasslands a certain proportion of plots, which had already been surveyed when the inventory was established (Eggenberg et al. 2001) are re-assessed. Similarly, some of the plots surveyed by the programme monitoring the effectiveness of peatland conservation are similarly being re-assessed.

The data obtained from the plots allow a wide range of analyses. For example, an analysis of ecological indicator values or of changes in ecological groups (e.g. thermophilic species or neophytes) can point to changes in the habitats in question. In this respect, the focus is on capturing national and regional trends.

The field work for monitoring the effectiveness of protecting amphibian breeding sites builds on surveys conducted for the Red List of Amphibians (Schmidt & Zumbach 2005; see p. 16). A total of 238 amphibian breeding sites of national importance are included in the monitoring project (198 stationary sites and 40 migration sites, i.e. gravel extraction sites) of which 124 had already been surveyed for the Red List. In selecting the sites to be surveyed, attention was paid to ensuring that not only species-rich lowland sites or those containing highly endangered species were included in the set but also sites at higher altitudes. While the latter rarely contain notable species at present, this may well change in the long-term due to climate change.

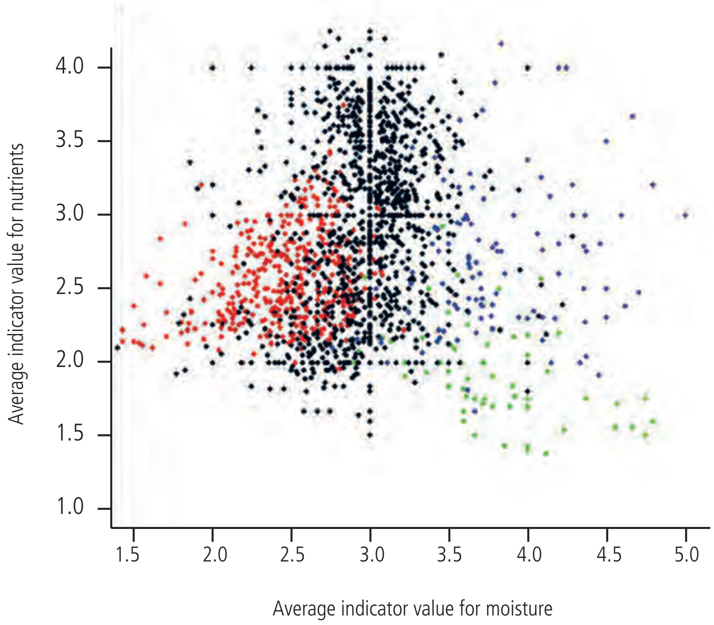


Fig. 2: Mean indicator value for nutrients against mean indicator value for moisture for Z9-plots assessed in the 2nd BDM survey (2006-2010, black dots) and plots of the project monitoring the effectiveness of habitat conservation from the years 2011 and 2012 assessed in dry meadows and pastures (red dots), fens (blue) and raised bogs (green). The plots of the new monitoring project clearly supplement the BDM in the dry, nutrient-poor and wet sectors.

Results-based monitoring and BDM go hand-in-hand

Biodiversity monitoring in Switzerland is a key component and one of the explicit strategic aims of the Swiss Biodiversity Strategy (BAFU 2012). With the BDM programme, an important tool for monitoring changes in biodiversity in Switzerland is already in place (Koordinationsstelle Biodiversitäts-Monitoring Schweiz 2009). However, habitats of national importance are covered by the BDM only by chance, as the proportion of the territory covered by these habitats is so small that they tend to slip through the BDM grid. The project monitoring the effectiveness of habitat conservation therefore supplements the BDM surveys (Fig. 2). These programmes are designed as long-term schemes. Thanks to retrospective aerial photograph interpretation and the inclusion of existing data, initial results can be expected within a few years. The moment of truth however will come as the monitoring programme progresses, i.e. when at least two full surveys are at hand. This will be in about 2023.

Further information

www.wsl.ch/biotopschutz/index_EN

References

biodiversity.ch/index.en.php > Publications

Interview

“The quality of the data is absolutely key”

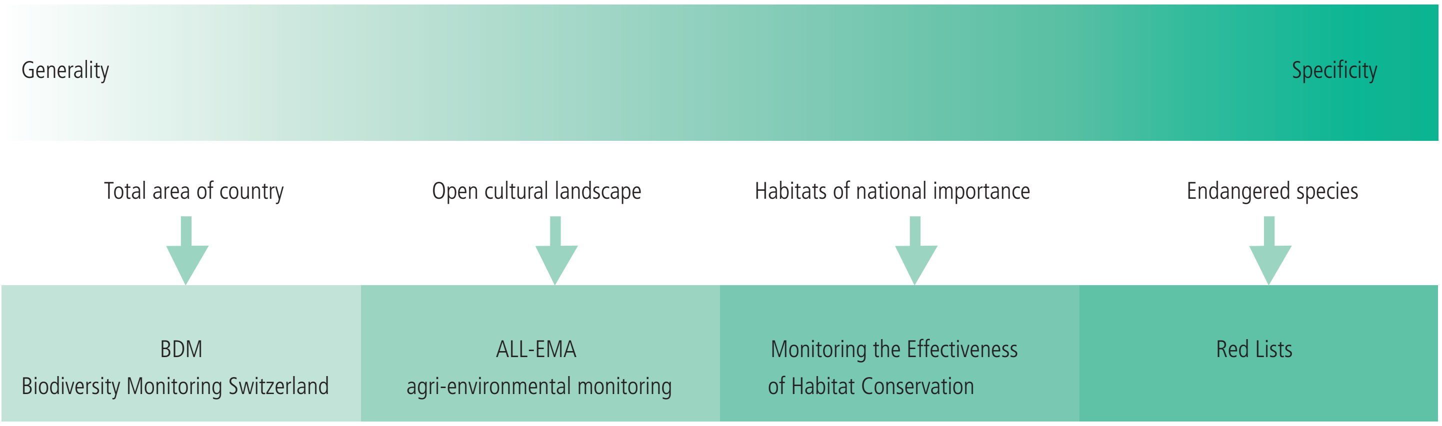
An interview with Sarah Pearson, head of the Species and Habitats Section at the FOEN and in charge of the Swiss Biodiversity Strategy (SBS), and Jean-Michel Gardaz, head of the Species, Ecosystems, Landscapes Division staff unit and head of the SBS action field “Monitoring biodiversity”.

HOTSPOT: The Biodiversity Monitoring Switzerland (BDM) programme was embarked upon in 2001 with the aspiration to “describe the biological diversity of Switzerland”. 12 years on, what has been accomplished by the BDM?
Jean-Michel Gardaz: Switzerland broke new ground with the BDM. Using two different monitoring networks, a survey method was developed which delivers reproducible, reliable and representative data for Switzerland in the field of species diversity. The data is very much in demand by researchers. Every year we receive countless enquiries from universities, not just in Switzerland but also abroad. Staff in the BDM coordination office are called upon regularly to advise other countries – for instance, Germany, France and South Africa – on setting up a monitoring system. Another great success of the BDM is the way that its reporting cycle has raised public and political awareness of the theme of biodiversity at regular intervals.

What does the BDM data tell us about the current status of biodiversity?
Gardaz: Changes in common and widespread species can be captured with a high statistical probability. For instance, in the sample areas a slight overall increase was observed in the numbers of vascular plant species. The first cheers of celebration were already resounding; but the detailed analyses showed that this was not a positive signal. Because mainly common and trivial species like the dandelion are gaining ground, the BDM is actually documenting an insidious homogenisation of biotic communities in Switzerland – and hence a decline in biodiversity. Following the introduction of the additional indicator Z12, “Diversity of Species Communities”, which can provide evidence of the declining diversity of meadows, it was possible to interpret the data correctly.

Sarah Pearson and Jean-Michel Gardaz. Photo Gregor Klaus

As part of the Action Plan on the Swiss Biodiversity Strategy (SBS), the FOEN is discussing setting up an “integral biodiversity monitoring system”. Apparently the BDM is not satisfying this criterion?
Sarah Pearson: The BDM was designed at the end of the 1990s. Since then a great deal has changed. New questions have emerged and new monitoring networks such as “ALL-EMA” and “Monitoring the Effectiveness of Habitat Conservation in Switzerland” have been started (see Figure). These can be direct providers of biodiversity data and, incidentally, many of them have drawn on the BDM’s methodological approaches and considerations. At the same time, there is an increasing demand to base international, national and cantonal-level reporting on indicators. The BDM indicators list must therefore be completely revised and updated.
Gardaz: The aim is to harmonise the methods for recording the different kinds of data and to link up the datasets in order to arrive at an optimal set of indicators. Switzerland’s strength in the field of monitoring is its network of different and out-



Classification of key monitoring programmes operated by the Swiss Confederation (some yet being established, see article). Programmes are increasingly specific from left to right. While the BDM monitors common and widespread species, Red Lists concentrate on endangered species. Source: FOEN

standing monitoring systems! The integral biodiversity monitoring system will be a coherent system to which new modules can be added at any time. How the BDM needs to be developed as part of this future system is something that still needs to be looked at. The preliminary work is in full swing, and provided that the Federal Council approves the Action Plan, the actual reconfiguration will take place as part of its implementation.

Who will coordinate this monitoring system?
Gardaz: The FOEN will have its hand on the reins. Of course, each monitoring network will continue to have its own coordination offices which supervise work in the field and evaluate and analyse the data. These offices are based at the respective institutes and data centres.

In the past the BDM mainly disseminated positive messages such as "biodiversity remarkably high" or "a good hatching year for butterflies" whereas the red lists pointed out the decline in diversity. This created some confusion for the public. Will there also be improvements in communication on the status of biodiversity in future?
Pearson: The FOEN is responsible for communication, at least for those datasets that are financed by us. The monitoring system will deliver an overall picture of the status of biodiversity, giving the ability to send coherent and unanimous messages to policymakers and society. The quality of the biological data remains key. And in Switzerland it is very good indeed – we are the envy of other countries. The analysis of the data and the interpretation of trends, on the other hand, can vary; they are a reflection of political and societal developments. It is important to us, therefore, that the raw data are entered and that the data analyses are carried out separately from the interpretation.

The FOEN is building the new monitoring system on top of existing monitoring networks. Are there any gaps that need to be filled?
Gardaz: That is all a question of finances. Of course there are gaps, and with the existing monitoring networks we will not be able to come up with answers to every conceivable question. Biodiversity is much too complex a phenomenon for that.

And where are the gaps?
Pearson: We have very little data on the condition of habitats that occur in Switzerland. There is no national overview of what still exists and its quality. Moreover, data on the genetic diversity of wild organisms is practically non-existent. Nor do we have any idea where the evolutionary hotspots are located – in other words, the areas of importance for the evolution and adaptability of species. Much too little is also known about the distribution of species. The question that constantly arises is whether we are measuring what is actually relevant for the future development of biodiversity.

But the red lists contain data on the effectively colonised area, on the size of populations and on population changes.
Pearson: But only if they were compiled according to the IUCN criteria. Not all red lists are up to that standard as yet. Added to that, the level of threat has not even been assessed for many important groups of organisms.

All the same, it has been done for a quarter of all Switzerland's known species!
Pearson: We commissioned the IUCN to evaluate Switzerland's red lists programme. The aim was to find out how close we are to having the "right" red lists. Ultimately every red list that exists is an expression of the great commitment of species specialists. If there are no species specialists for a group of organisms, then nor will there be any red list.

And what was the outcome of this evaluation?
Pearson: Switzerland should include yet

more groups of species, for example the soil organisms. Because it is impossible to assess the threat status of all species, however, it was suggested that we should compile one red list for a selection of species from all organism groups rather than multiple red lists. But these are just ideas for the time being.

Will there be a third report on the results of the BDM?

Gardaz: No. The next status report on biodiversity will incorporate and synthesise all available data. By the way, the comprehensive Environment Report that appears in 2015 will no longer be a FOEN publication but a Federal Council report, and will have to pass through a consultation of the federal offices. We are thus eager to see what its content and tone will be.

Can the next status report also be used for international reporting?

Pearson: Individual countries are not expected to submit such an extensive report, even in the context of the Convention on Biological Diversity. And indeed most countries have no datasets to hand whatsoever. That is why the Convention is currently discussing the development of indicators on which all countries can supply appropriate data. This is important in order to be able to make serious comparisons of different countries' efforts.

Gardaz: The EU's European Environment Agency already has a list of indicators, but as it only reflects the lowest common denominator of all Member States, it is not particularly informative. We are nevertheless trying to supply data on these indicators so that Switzerland does not always appear as a grey smudge on the map of Europe.

Will Switzerland break new ground with the announced "integral monitoring system" and with the BDM?

Pearson: Unfortunately not. With regard to the indicators we are no longer the front runners. Norway, for example, already has a sophisticated monitoring system with indicators. All in all, though, individual countries are following very different paths for the monitoring of biodiversity. The trouble is, nobody really has a complete picture of what is happening where.

In England volunteers play a prominent part in data gathering. In other countries, too, citizen science projects are taking on ever-increasing importance. What does the FOEN think of this kind of data collection?

Pearson: Now that the general public is involved, the data basis on biodiversity is constantly improving. Thanks to smart phones and various apps, the data flow keeps getting faster and smoother than ever. The drawback is the quality of the data. Lack of species expertise is a big problem too. If the data centres make use of this data, filters must be built in so as to keep the error rate under control. Be this as it may, the data collected in this manner in no way replaces systematic data-logging by monitoring systems.

Gardaz: Citizen science projects are an important contribution to raise people's awareness of the conservation and promotion of biodiversity. Everyone has the opportunity to report on whatever seems important to him or her. Of course, people must also take note of the species and identify them correctly. The Action Plan therefore includes a number of measures to promote species knowledge.

Interview: Daniela Pauli and Gregor Klaus

Action Plan on the right track

Broad-based expert input was very much the hallmark of work on the Action Plan for the Swiss Biodiversity Strategy in the first half of the year 2013. Around 650 experts from 250 organisations took part in two dozen workshops and discussed proposals and ideas for safeguarding and promoting biodiversity in Switzerland in the long term.

The phase of technical input was concluded at the end of June. The outcome of this process stands up to scrutiny: the workshops gave rise to 320 proposals. Based on these, the heads of action fields formulated a list of around 180 measures aimed at making sure that the ten strategic objectives are achieved.

In some cases there are major variations among the listed measures with regard to maturity, concretisation and coordination with other measures from other action fields. For that reason the measures are being assessed and reworked for the Action Plan. In spring 2014, the Action Plan is scheduled for submission to the Swiss Federal Council, which will then take a decision on how to proceed from there.

Further information (in German)

www.bafu.admin.ch/ap-biodiversitaet

FOEN newsletter on the Action Plan (in German) www.bafu.admin.ch > Biodiversität > Aktionsplan Strategie Biodiversität Schweiz > Newsletter

Citizen Science
Science or public awareness-raising?

Anne-Laure Gourmand and Lisa Garnier, Muséum national d'Histoire naturelle, F-75005 Paris, gourmand@mnhn.fr

Citizen science is a form of research in which not only researchers but also members of the public get involved. In many cases the data recorded can be used for research purposes. But sometimes raising the people's awareness – of environmental issues, for example – is also a priority.

An observer photographs a pollinator for the "Suivi Photographique des Insectes POLLinisateurs" programme (www.spipoll.org). Photo: SPIPOLL

Conducting research on biodiversity in times of climate and landscape change calls for enormous volumes of data on the occurrence of animal and plant species. It is hardly feasible for scientists to register species across the country's entire land area. In any case, there can be certain places (e.g. private gardens) that are completely inaccessible. Citizen science, which is based on getting the population involved in conducting such studies, is potentially the ideal solution for covering a larger territory. In the same way as with weather stations, participants report their own observations of nature.

However, any scientific approach to ecology must adhere to a methodological procedure for the collection of data by citizens. To ensure that the observers' results can be compared and used in mathematical and statistical models, the target species must be selected with care, a protocol produced, and allowances made for identification errors. The French programme "Vigie Nature" which is run by the Centre for Conservation Biology at the Museum of Natural History, Paris, has been carrying out such scientific observations since 1989. The programme is facilitated by nature conservation organisations.

No observation without scientific compromise: the selection of species depends partly on their function as indicator species but also upon their public appeal. The data-gathering protocol must be meticulous and simple but, at the same time, as comprehensive as possible. It is important that the observers should enjoy their work. It should also be borne in mind that the more competence in natural history is required, the smaller the number of potential participants gets.

The data supplied by non-specialists can contain identification errors, however. In 2009 the study "Butterfly Flowers" required participants to send in photos of butterflies and to identify the animals. On average, five per cent of identifications were incorrect. This is acceptable for scientific evaluation of the data; in any case the rate of errors falls rapidly as the participants grow in practice and training. The error-rate noted is no problem if it remains that low and constant and if the data is used for spatial or temporal comparisons. On the other hand, it is too high if the intended use of the data is to produce precise distribution maps.

Taking part in a participatory scientific programme is not without its consequences for the observers themselves. Many participants start with very little knowledge of natural history. Then, with burgeoning pride in their work, they begin to pay more attention to the species that they are observing daily. They find themselves in an upward spiral: the more they observe, the more attentive they become, the more they learn and the more frequently they talk about it to their families and friends.

In order to arrive at this point, the observers must be convinced that the project is right and important and that they are indispensable to it. But they must also feel a bond with the other observers and with the researchers. This kind of networking arises particularly through the work of facilitators and through day-to-day work with local conservation groups. The greatest difficulty of citizen science is to keep the observers involved over a longer timeframe. But this specific factor is critical, because in the recording of biodiversity, the informativeness of the data depends crucially on the length of the observation period.

Further information

http://vigienature.mnhn.fr

Credit points for diversity on farmland
Farmers measure biodiversity

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To measure species diversity on an agricultural holding directly would require great effort. Therefore, a project was set out to develop an evaluation system that assigns specific credit points to a variety of habitat characteristics and management options. This provides a proxy for all efforts undertaken on a farm to maintain and enhance biodiversity.

The Swiss Ornithological Institute and FiBL are currently developing new instruments to encourage farmers to engage in promoting biodiversity on their land. Our project entitled "Scoring with biodiversity – farmers enrich nature" started off by developing a credit point system which evaluates the efforts made by farmers to promote biodiversity. The system is based on both scientific knowledge and practical experience. It evaluates the quantity, ecological quality, structural diversity and spatial distribution of ecological compensation areas as well as the application of arable and grassland options (e.g. no herbicide application, staggered mowing etc.) and conservation of genetic diversity (heritage breeds) (Jenny et al. 2013).
A richly illustrated handbook helps farmers to correctly complete the forms for the credit point system (Jenny et al. 2011). It also explains the significance of the individual measures in accessible language. The system is designed in such a way that participants only need to enter their data. For each of the 32 measures the credit points are then calculated automatically. The overall point score is an indication of the overall contribution made by a farm holding; the system thus also allows for self-assessment. At the same time, possible further ecological improvements are outlined. For example, experts defined minimum targets for each of the measures. If a holding's score is well below the target value, action may be warranted.
The experience has shown that farmers are open to enhancement measures and that farm conservation advisory services play a key role in this respect (Chévillat et al. 2012). However, it is a prerequisite that farmers are made familiar with the ecological requirements of individual indicator species (plants or animals) on their holding. A supplementary tool was developped that helps farmers in identifying indicator species potentially present on their land. Again the farmer only needs to enter some key farm data (location, existing habitats) in order to generate a list of indicator species. In addition, simple information cards were produced for 115 indicator species (Graf et al. 2010). These selected species are widespread in Switzerland and, taken together, represent all the farmland habitats and habitat elements of conservation importance. Using these cards, farmers can easily and on their own, access information on the biology, distribution and ecological needs of the indicator species characteristic of their land.
A study on 133 farms assessed how far the credit point system actually reflects the diversity of representative groups of organisms (birds, butterflies, grasshoppers, vascular plants) at the individual farm level. 19 biodiversity indicators were defined for this assessment, e.g. the richness of plant species. The evaluation has shown that, for example, an increase of the point score from 10 to 20 goes hand in hand with an average increase of plant species diversity by 30% (see Figure). The credit points are therefore a suitable measure of a farmer's effort for biodiversity conservation and enhancement. Other detailed assessments are underway and will contribute to further improvements in evaluating individual measures. It is encouraging to see that instruments and measures for the assessment of farmers' contributions to biodiversity conservation and enhancement as part of the agriculture section of the Swiss Biodiversity Action Plan have enjoyed widespread acceptance and that they have been shown to hold great potential as supplementary agri-policy measures.

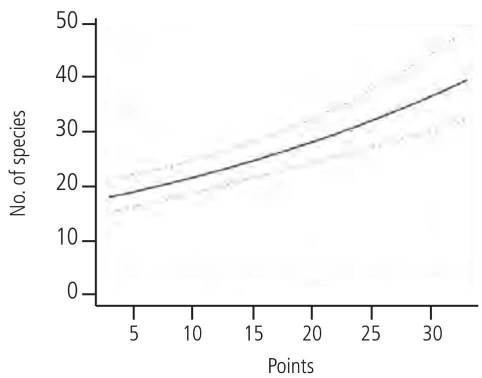
Lukas Pfiffner, agro-ecologist at FiBL, explains the results of the "Scoring with biodiversity" project to farmers. Photo credit: Markus Jenny

References

biodiversity.ch/index.en.php>Publications

Further Information

http://www.vogelwarte.ch/scoring-with-biodiversity-farmers-enrich-nature.html
www.fibl.org>Themen>Biodiversität>Mit Vielfalt punkten (in German)



Correlation between point score and plant species diversity. If the point score increases from 10 to 20, an average increase of plant species diversity by 30% can be expected. Source: FiBL and Swiss Ornithological Institute, Sempach

We make knowledge about biodiversity accessible

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Since the 1990s biodiversity research has steadily intensified (see graph). According to "Web of Science" there were 6,826 scientific publications on the subject in the year 2012 alone. But while knowledge is continually deepening and expanding, biodiversity keeps declining because the conservation of plant and animal species and of ecosystem services has been sidelined in the balancing of interests, or because that knowledge is not accessible to decision-makers.

The Biodiversity Forum of the Swiss Academy of Sciences has set itself the objective of assembling all the available knowledge about biodiversity relevant to Switzerland, grouping it thematically and making it accessible in an appropriate form. To this end we have developed a set of various instruments including HOTSPOT, the Information Service Biodiversity Switzerland (IBS) and the SWIFCOB conference (see panel).

Now a new instrument for knowledge transfer has been added: factsheets on different biodiversity themes. In this format we make scientific findings accessible to the interested public in a concise form. The factsheets are addressed to the media, to the responsible experts, be they administrators or practitioners, and to decision-makers in the spheres of policy, business and society. One of the first factsheets deals with shrub encroachment of the Alpine region by green alder, and was published in August 2013. It shows how rapidly green alder is spreading in the wake of land abandonment in the mountains; what this means for biodiversity, soils, water bodies and climate; and how green alder can be held in check (see photos). The next factsheet will be devoted to the importance of pollinators, their declining numbers, the impacts of this decline, and possible measures to promote pollinators. It will not only talk about honeybees but also about wild bees and other flower-pollinating groups of insects.

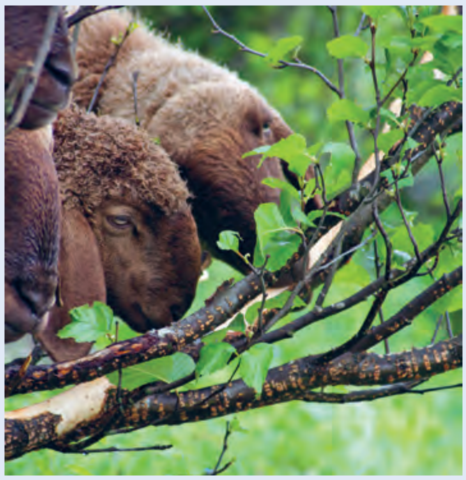
Further information
biodiversity.ch/index.en.php > Publications

SWIFCOB 14:
Biodiversity and Economy: Diversity pays
17 January 2014, UniS, Bern

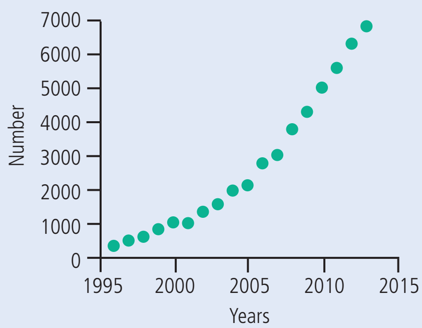
There are numerous interfaces and dependencies between biodiversity and economy, as HOTSPOT 23|2011 (biodiversity.ch/index.en.php > Publications > HOTSPOT) has shown. Often the various stakeholders are unaware of these linkages; the numerous possibilities for cooperation are therefore only rarely taken advantage of. But there is a growing will to integrate biodiversity concerns more effectively into business activities. Potential exists throughout the value chain.

With the "Biodiversity and Economy" conference we want to motivate researchers, companies and nature and landscape conservation stakeholders to increase their cooperation. Participants learn where interfaces exist between biodiversity and the economy, and recognise both the opportunities and any potential risks of cooperation. A marketplace serves as a forum for exchanging knowledge and experience. The conference is supported by the Federal Offices FOEN and FOAG.

The programme and registration form for the conference can be found at biodiversity.ch/index.en.php > Events > SWIFCOB. Registration deadline: mid-December



Top: Green alder is spreading rapidly throughout the Alpine region – with negative impacts on biodiversity. Photo: Erika Hiltbrunner
Bottom: Engadine sheep can control green alder encroachment by chewing their branches. Photo: Tobias Zehnder



The number of scientific publications on the theme of biodiversity is rising constantly. Source: Web of Science, topic = biodiversity

Swiss national database

Storing, managing and publishing data

Agnès Bourqui and Christoph Köhler, Swiss Commission for the Conservation of Cultivated Plants (CPC), agnes.bourqui@cpc-skek.ch

Work on the conservation of plant genetic resources in Switzerland for food and agriculture has delivered a flood of information. The data need to be stored, managed and made accessible so that they can be used by the various organisations and projects that help with the conservation and sustainable use of plant genetic resources. The national database fulfils these requirements. It provides a comprehensive overview of the diversity of crop plants in Switzerland and is also publicly accessible.

The genetic resources of crop plants represent a natural resource base for food security and are ecologically and culturally significant. A high level of genetic diversity enhances capacity to respond to pests and diseases and to the impacts of climate change. Furthermore, the conservation of genetic resources is indispensable to breeding programmes, as it makes available desirable characteristics such as drought tolerance. The benefit of genetic diversity is also seen on our plates, because the diversity of forms and flavours imparts pleasurable variety to our diet.

Preserving the diversity of varieties

The diversity of species is in a constant state of flux. In the past, many traditional varieties were suppressed by a few more productive plant varieties. The World Food Summit Plan of Action launched by the United Nations Food and Agriculture Organization (FAO) in June 1996 was implemented in Switzerland through the National Plan of Action for the Conservation and Sustainable Use of Plant Genetic Resources for Food and Agriculture (NAP-PGRFA). The goal of the National Plan of Action is the conservation of varietal diversity in crop plant species. Moreover, it complements agricultural policy objectives in the field of biodiversity and agriculture.

Positive lists and accessions

The first step for conservation of plant genetic resources for food and agriculture is to carry out an inventory of the species and varieties that occur in Switzerland. At present this inventory phase is no longer being driven forward actively; nevertheless the discovery of a new variety is far from unusual. The plant genetic material that remains to be identified is maintained in a collection of introductions. Having been identified and analysed according to the PGRFA-specific conservation criteria, the varieties selected for conservation are added to "positive lists". These lists also contain information on the status of conservation efforts or the number of existing accessions for a particular variety. Accession is the term that is used for a variety linked to the site where it was collected. Thus, each of the seed samples of a cereal variety taken from different fields in a particular region is an accession in its own right. It is an important term because a cultivated variety is conserved specifically as an accession and not as a variety.

Long-term conservation

As soon as the positive lists have been compiled, a start is made at storing the varieties in primary and duplicate collections using appropriate conservation methods. Accessions can be conserved – depending on the characteristics of the species or variety – in a gene bank, in field collections, in vitro, in protected conditions (tunnel, greenhouse) or in situ. Potatoes, for instance, are cloned in vitro and conserved in protected conditions, whereas fruit trees are conserved in the field. Species that reproduce by means of seeds (cereals, vegetables or certain medicinal plants) are conserved in seed form in a seed bank. This conservation method at low temperature (-20 °C) and low humidity (7.5 to 5 per cent) permits storage for a long duration (20 to 50 years). In the case of "crop wild relatives" (CWRs), i.e. wild plants that are related to crop plants, conservation methods must be found for the ecotypes in their natural setting (in situ). This method of conservation makes it possible for the conserved ecotypes to adapt simultaneously to changes in the habitat's environmental conditions. Among the CWRs, for example, the wild relatives of forage plants are of particular value in the Swiss context. Another criterion, as part of conservation measures, is to safeguard the quality of the genetic material.

When is the protection of a variety guaranteed?

It is essential to stipulate the number of plants or seeds that an accession must contain and the minimum number of accessions per variety, if the conservation of the variety is to be guaranteed in the long term. There are standard quantities for every group of crops, which have been laid down according to the characteristics of the variety (Table 1). Given these values, it is also possible to calculate the quantity of material to be conserved.

From Table 1 it is clear that the number of accessions to be conserved is higher for vegetative conservation (clones) than for generative conservation (seeds). For example, to guarantee the vegetative conservation of a grapevine variety, the primary collection and the duplicate collection must contain at least five identical accessions. These figures are adjusted further as a function of the given variety's frequency in Switzerland; for rare varieties the standard quantity of accessions is increased.

Table 1: Standard quantities to ensure long-term conservation

Crop	Number of accessions per variety*	Number of plants per accession
Grapevines	min. 5	1
Raspberries, blackberries, strawberries	1	3 to 10 plants depending on species
Redcurrants / blackcurrants	3	1
Potatoes	1	Tubers (10-100)
Vegetables	1	Seeds, quantity depending on species
Fruit trees	min. 2	1
Cereals	1	Seeds, quantity depending on species
Maize	1	3,000 grains
Aromatic and medicinal plants	1	Seeds, quantity depending on species
Forage legumes	1	Seeds, quantity depending on species
Forage grasses	1	Seeds, quantity depending on species

*equal amounts in a primary and duplicate collection

Table 2: Number of species and varieties on positive lists

Crop	Species	Varieties	Accessions
Grapevines	4	141	3 767
Berries	6	205	1 154
Potatoes	1	38	118
Vegetables	12	482	506
Fruit trees	13	3 063	10 937
Cereals	4	1 498	2 482
Maize	1	311	364
Aromatic and medicinal plants	25	94	37
Forage legumes	2	119	119
Forage grasses	7	195	195
Total	**75**	**6 146**	**19 679**

National database

The conservation of plant genetic resources, of varieties and accessions, generates a large volume of quantitative and qualitative data, creating the necessity for a data administration tool. In the Swiss National Database (NDB) data on the accessions collected by conservation organisations are centrally stored, administered and published. Founded in 2002, the database is financially supported by the Swiss Federal Office of Agriculture (FOAG) and managed by the Swiss Commission for the Conservation of Cultivated Plants (CPC). Although it is addressed to a broad audience, it is primarily consulted by experts from Switzerland and abroad. The organisations implementing the NAP-PGRFA project supply the National Database by depositing their data in it or by annually updating the existing data. The concept is simple: every variety is identified by means of a profile that contains the agronomic, morphological and phenological characteristics.

The database can also be searched by a variety of criteria, e.g. by the number of accessions of a variety, the geographical site where the accession was collected, by the disease resistance of a variety or by the molecular genetics results. Currently around 40,000 accessions collected in Switzerland are searchable. Table 2 lists the data available in the NDB and provides an overview of the number of species and varieties on the positive lists. The 6,146 varieties whose conservation is guaranteed include, for example, 38 potato varieties which all belong to the same species.

Apart from the number of varieties per group, which is generally high, for most crops it is evident that the number of accessions conserved is sufficient. Overall it is reasonable to assert that the survival of these varieties has been safeguarded. The same is not true of the medicinal and aromatic plants, where the number of accessions has been deemed insufficient. This is explained by the fact that the projects dealing with medicinal and aromatic plants are currently still in their recording and identification phases. The data items are still being processed and are not yet available in the National Database. Caution is therefore advisable when interpreting the results; it must not be forgotten that the data available on the platform is in constant development.

Further information

www.bdn.ch and www.cpc-skek.ch

Supported by

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Confederation

Federal Department of Economic Affairs, Education and Research EAER
Federal Office for Agriculture FOAG

Distribution of flora spotters

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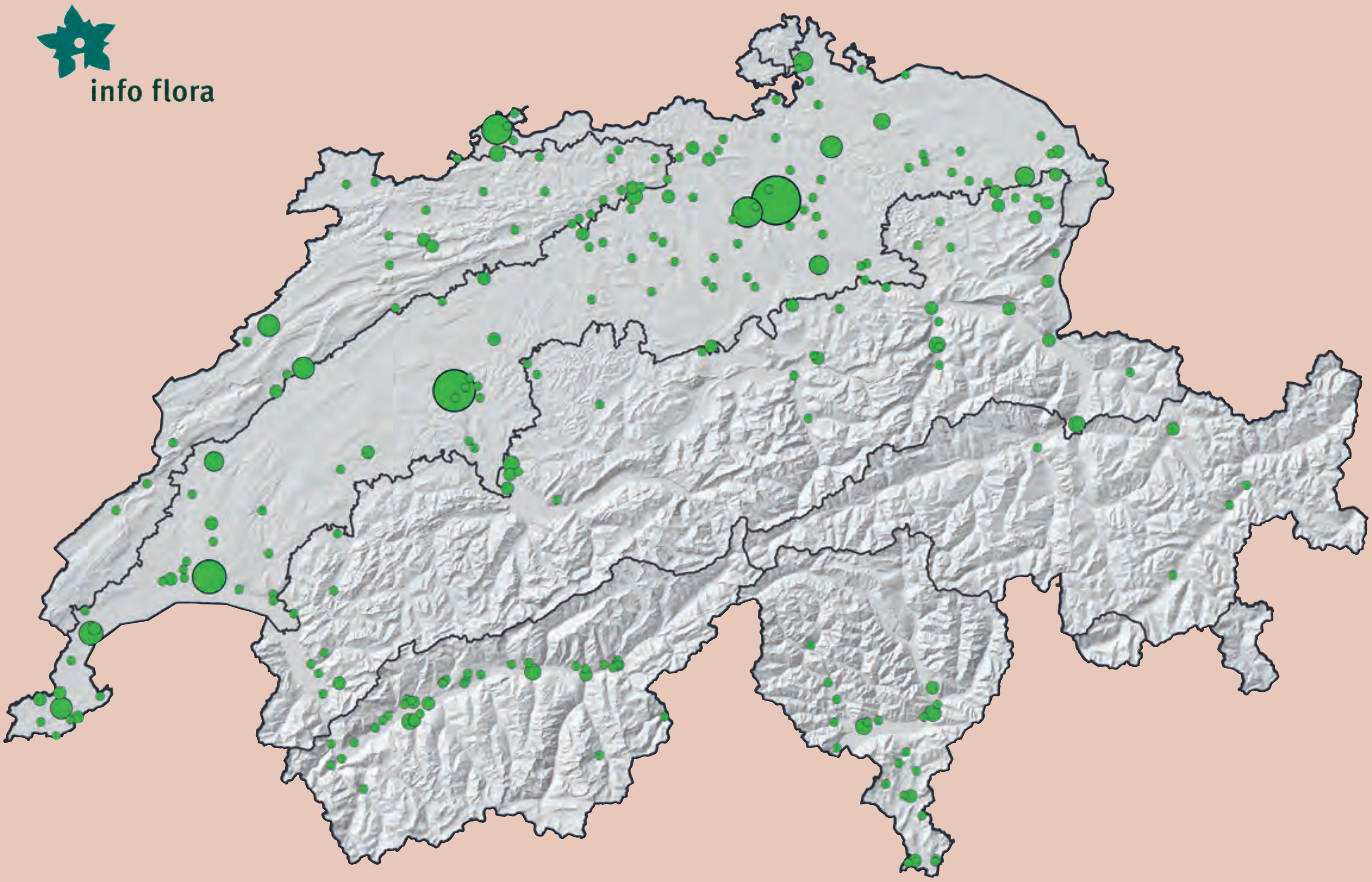

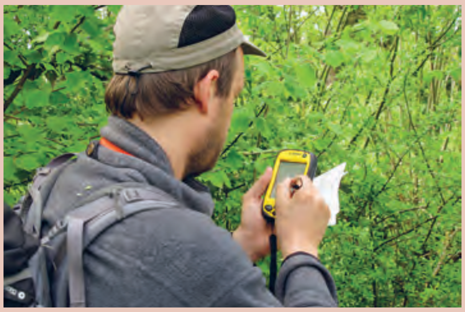

Locations of voluntary field botanists in the biogeographic regions of Switzerland

Info Flora is working on behalf of the FOEN to update the red list of endangered vascular plants. To this end, over 300 volunteers (known as flora spotters) are visiting 8,000 previously recorded sites of 1,000 plant species distributed all over Switzerland in order to ascertain the current status of the individual populations.

The circles on the map do not mark the sites of plant species, however, but the home locations of the flora spotters. The larger the circle, the more flora spotters live there (smallest circle = 1, largest circle = 21 flora spotters). The distribution is extremely heterogeneous: most of the people involved live in cities like Zurich, Bern, Basel, Lausanne, Geneva and Neuchâtel or in Switzerland's Central Plateau and urban agglomerations. The majority of the populations and species to be recorded, on the other hand, are found in the Alpine region and in rural areas. This poses a logistical challenge for the project!

The earliest results of the project give cause for concern: over one-third of sites on which threatened species had been sighted between 1982 and 2002 are devoid of any today. The higher the 2002 red list assessment of a species' extinction risk, the greater the losses that are now being recorded.

Photos: swisslichens, WSL (top); Info Flora (bottom)